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Synthesis of Year Two Outcomes in the Smart Energy Analytics Campaign

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Energy Technologies Area
April 2019

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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. These data do not typically lead to insights or corrective actions unless they are 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 (MBCx) practices for commercial buildings. Monitoring-based commissioning is an ongoing commissioning process that focuses on monitoring and analyzing large amounts of data on a continuous basis. EMIS tools are used in the MBCx process to organize, present, visualize, and analyze the data. 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 summarize information from owners representing over 400 million square feet of floor area that are implementing EMIS. The report presents a preliminary characterization of EMIS products, MBCx services, and trends in the 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 7 percent ($0.19/square foot [sq ft]) for 790 billion Btu/year and $18 million/year, based on 27 participants reporting energy use.[1] These savings figures demonstrate the actual reduction in energy use achieved at buildings that are utilizing EMIS. However, the savings cannot be attributed solely to the operational improvements achieved with the support of the EMIS, since energy savings are reported at the whole building level and various energy-impacting projects may be occurring simultaneously.

With cost reporting from 35 participants, the median base cost for EMIS software installation and configuration was $0.03/sq ft, and the median annual labor cost (internal staff or contracted) was $0.03/sq ft. The median annual recurring software cost was $0.02/sq ft.

Table ES-1 below summarizes Campaign results to date using data collected from 73 participating organizations.

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/.

[1] Energy savings reported compare the most recent year for which data are available and the baseline year before the EMIS was installed.

Table ES-1: Summary of EMIS Use by Smart Energy Analytics Campaign Participants, through July 2018

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 and measurement and verification (M&V)	**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)
Typical installation	Whole building energy meters by fuel for large buildings in a portfolio, either with utility-provided interval data or an owner-installed meter. Submetering is less prevalent.	Installation focuses on fault detection and diagnostics (FDD) for problem HVAC areas (central plant, air handling units (AHUs), or variable air volume (VAV) terminal boxes.
Common analytics *n = 73 organizations* *Floor area:* *400 million sq ft*	• Energy use intensity (kBtu/sq ft) • Heat map • Load profile, filtered by day type • Predictive models for energy use	• 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 = 56 organizations* *Floor area:* *323 million sq ft*	**EIS implementation only** Improved HVAC scheduling Share energy information with occupants Adjustment of space temperature setpoints	**EIS + FDD implementation or FDD implementation only** Improve HVAC scheduling Improve economizer operation Reduce overventilation Reduce simultaneous heating and cooling Adjustment of space temp setpoints Supply air temperature reset Tune control loops to avoid hunting
Energy Savings* *n = 27 organizations* *Floor area:* *94 million sq ft*	Energy savings (whole building, all fuels) since EMIS installed: Median: 7% ($0.19/sq ft); range: -6% to 28% Mean: 8% ($0.28/sq ft) Mean is less representative than median due to the range in savings. **Preliminary results for 27 organizations to be updated annually. These savings are not specifically attributed to operational improvements, retrofits, or other factors. Therefore, savings may include changes to the buildings that are not related to analytics.*	
Cost* *n = 35 participants* *Floor area:* *306 million sq ft*	**Median EMIS base cost (software + installation): $0.03/sq ft**; range: $0.005–$0.54/sq ft **Median EMIS software recurring cost: $0.02/sq ft**; range: $0.0004–$0.10/sq ft **Median annual labor cost/sq ft: $0.03/sq ft**; range: $0.0008–$0.32/sq ft **Preliminary results for 35 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.*	

1. Introduction and Background

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 data analytics.

The cornerstone of successful building data analytics is the ability to extract accurate and actionable insights from large amounts of data. Modern building automation systems (BAS) monitor hundreds of points per building, and an owner may have a portfolio generating many thousands of data points. The BAS can provide alarms for points out of range, but the analytical capabilities fall well short of helping achieve an optimized system. Further, common analysis tools for energy meter data tend to manage the monthly bills but do not support hourly interval data. Energy management and information systems (EMIS) are software that provide the needed analytical horsepower to building owners as they work to find meaning from data. This section highlights the benefits and challenges in using EMIS for continuous energy management.

What are EMIS and MBCx?

EMIS are the broad and rapidly evolving family of tools that monitor, analyze, and control building energy use and system performance. 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.

There is no consensus definition of EMIS but a broad categorization framework has been developed (Granderson et al. 2015). Figure 1 describes a framework for classifying EMIS functionality in meter-level analytics and system-level analytics. An EMIS product may have attributes in multiple categories.

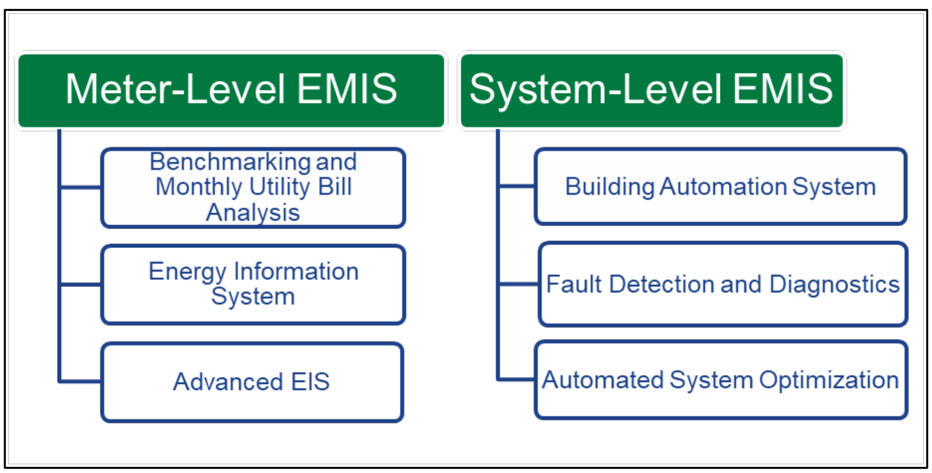

Figure 1: Energy Management and Information System (EMIS) Framework

While monthly bill management software and building automation systems (BAS) are classified as the first tier of EMIS, this paper is focused on these more advanced EMIS as the industry moves toward in-depth analytics.

BAS are used to control building heating, ventilation, and air-conditioning (HVAC) systems, and in some cases, building lighting and security systems. The BAS is excellent at maintaining indoor temperature, humidity, ventilation, and lighting conditions; however, BAS often lack the ability to answer questions such as: how much energy is consumed at different times of the day? Does the economizer behave appropriately? What is the optimal air handling unit supply air temperature setpoint? EMIS tools such as energy information systems (EIS), fault detection and diagnosis systems (FDD), and automated system optimization tools (ASO) can be good supplements to BAS to analyze and manage building energy use.

Descriptions of the more in-depth EMIS technologies that are the focus of this report are as follows:

- **Energy information systems (EIS) / Advanced EIS:** the software, data acquisition hardware, and communication systems used to store, analyze, and display building energy data. EIS are a subset of EMIS that are focused on meter-level monitoring (hourly or more frequent, at whole building or submeter level). These meter data are not yet commonly integrated with BAS. Advanced EIS incorporate automated opportunity analysis that typically includes predictive energy models using interval meter data.
- **Fault detection and diagnostic (FDD) systems:** software that automate the process of detecting faults and suboptimal performance of building systems and help to diagnose their potential causes. FDD are a subset of EMIS that focuses on system-level monitoring (using BAS data). An FDD system is different than a BAS alarm. Alarms typically detect sensor value deviation associated with a specific point based on real-time conditions. They don't typically allow for sophisticated logic that interrelates multiple data streams and performs rule-based or model-based diagnostics. These tools are typically applied as a separate software application that pulls data from the BAS. FDD may provide a report of the duration and frequency of faults, cost and/or energy impacts, and relative priority levels.
- **Automated system optimization (ASO):** software that continuously analyze and modify BAS control settings to optimize HVAC system energy usage while maintaining occupant comfort. These tools 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. Two-way communication with the BAS distinguishes ASO solutions from FDD.

EMIS can be implemented individually or in combination and are intended to support facility staff and management efforts to meet higher levels of comfort and performance. EMIS help to prioritize efforts toward optimal system performance, as opposed to reactively fixing what is broken. Previous research includes a complete description of the components of EMIS and details how organizations can plan and implement for successful EMIS use (Granderson et al. 2015). Case studies document the benefits and lessons learned for specific EMIS installations (Fernandes et al. 2018; Henderson and Waltner 2013).

While EMIS are powerful tools, any tool needs a process that utilizes it to have impact. Monitoring-based commissioning is an ongoing commissioning process that focuses on monitoring and analyzing large amounts of data on a continuous basis, and EMIS are an integral part of streamlining analysis and automating the MBCx process. Existing building commissioning (EBCx) is an umbrella term that includes ongoing commissioning processes such as MBCx and retrocommissioning (RCx) (Building Commissioning Association Best Practices 2018).

The Building Commissioning Association (BCxA) defines existing building commissioning (EBCx) as: "…a systematic process for investigating, analyzing, and optimizing the performance of building systems through the identification and implementation of low/no cost and capital-intensive Facility Improvement Measures and ensuring their continued performance. The goal of EBCx is to make building systems perform interactively to meet the Current Facility Requirements and provide the tools to support the continuous improvement of system performance over time. The term EBCx is intended to be a comprehensive term defining a process that encompasses the more narrowly focused process variations such as retro-commissioning, re-commissioning and ongoing commissioning that are commonly used in the industry." (Building Commissioning Association Best Practices 2018).

MBCx may be used during an RCx process to streamline and automate data analysis during the investigation process and after RCx to track whether energy savings persist and find additional opportunities over time. Figure 2 illustrates the three main elements of MBCx, showing how tools like FDD and EIS are incorporated into the MBCx process.

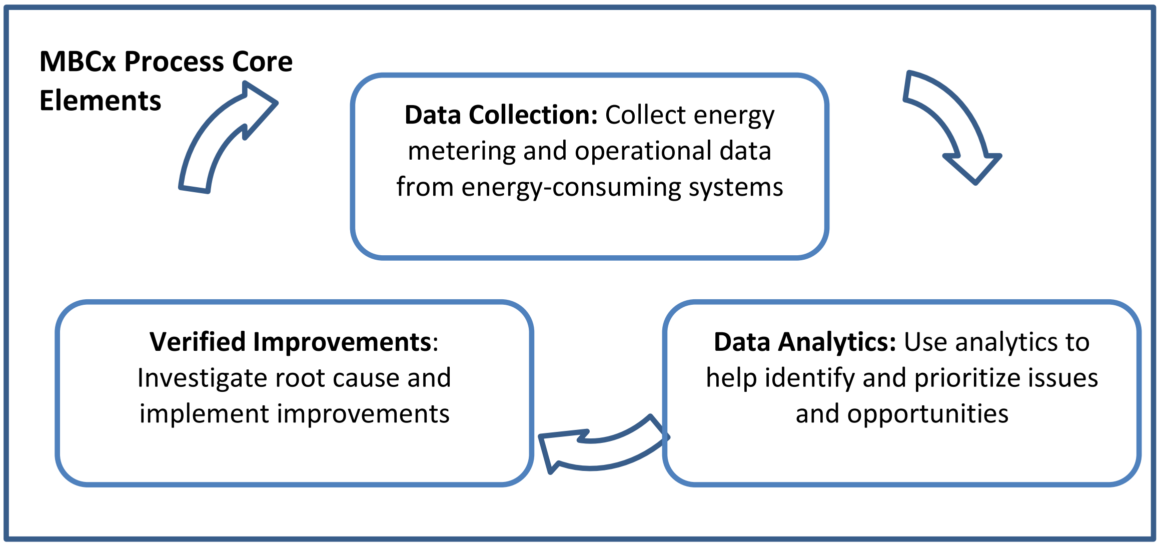

Figure 2: Monitoring-Based Commissioning Process

EMIS Technology Benefits

Energy and cost savings are often a driving factor in the decision to implement an EMIS. The number of commercially available EMIS has increased dramatically over the past decade, driven by the increased availability of higher-granularity energy (generally 15-minute to hourly) and BAS time series data. Building staff can leverage these data to continuously monitor building performance and automate analysis through EMIS, leading to energy savings, peak demand reduction, and reduction in service calls. Further, analytics can help owners move from the reactive to the proactive by detecting equipment cycling issues and avoiding unnecessary wear and tear that can reduce equipment life. To support owners in these aims, a recent paper summarizes how both EIS and FDD can be used to identify energy saving opportunities in commercial buildings (Lin et al. 2017). In addition to operational improvements, EMIS can be used to verify energy savings for many measures.

EMIS are most often implemented as a part of an overall energy management approach that includes retrofits and commissioning. Thus, the benefits of using EMIS are difficult to isolate from other actions. In one EIS-focused study of 28 buildings and 9 portfolios across the U.S., energy savings ranged from -3 to 47 percent with a median of 17 percent for individual buildings, and from 0 to 33 percent with a median of 8 percent for portfolios (Granderson and Lin 2016). Study participants reported that this performance would not have been possible without the EIS. A wide range of costs were also found, with total costs of EIS software ranging over two to three orders of magnitude. Large cost ranges are driven in part by the size of the implementation (costs decreased significantly as the number of points exceeded 300), differences in pricing models, and lack of market maturity.

Research on the costs and benefits of FDD is less available than EIS. A recent study on FDD for commercial buildings provides a thorough characterization of functionality and application for 14 FDD technologies (Granderson et al. 2017), although the study scope did not include quantification of costs or benefits. Based on an analysis of the most common faults in building systems, studies estimate that the energy savings achievable from addressing these faults ranges from 5 to 30 percent whole building savings (Fernandez et. al 2017; Roth et. al 2005). FDD software costs have not been published in research to date. With significant diversity in costs for both EIS and FDD in an evolving market, additional data are needed to better characterize costs. This system-specific cost data will continue to be collected through the research, with initial results available in this report.

Historical Challenges in EMIS Use

With numerous vendors and feature packages available, it becomes difficult for owners to determine which type of EMIS will support their needs and meet thresholds for return on investment. Even if there is adequate energy metering in place, it is common to have problems integrating the data into the EMIS due to legacy data sources, varying communications protocols, and cybersecurity needs. It can be difficult to get disparate data collection systems into a single database to integrate with the EMIS.

In addition to metering and data management hurdles, a common challenge is the lack of staff time to review the EMIS dashboards and reports, and to investigate and implement recommended findings. Staff may experience data overload if their EMIS is not configured properly, or if there is not enough automation of the analytics. With EIS, there is difficulty in pinpointing opportunities in the data, and even with FDD there is the critical step of finding the root cause of problems. As with all enabling tools, the EMIS itself does not directly produce savings, but requires action upon the analytic results. There is a growing body of service providers to help owners manage their data and analytics and implement findings.

Smart Energy Analytics Campaign

In response to these challenges in implementing and utilizing EMIS systems, a research and industry partnership program was formed in 2016 (Smart Energy Analytics Campaign 2018). 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 support energy savings. This program provides expert technical support to commercial building owners in implementing in-depth analytics through EIS/advanced EIS, FDD, and/or ASO, and the program recognizes owners with exemplary deployments.

As a part of the program, participants are offered technical assistance and engagement with a peer network. Participants share data about their progress that is analyzed by the program to report the latest in EMIS savings, costs, and trends in implementation. This research report expands and builds upon previously published research based on an earlier version of the dataset (Kramer et al. 2018). As of July 2018, there were 73 participating commercial organizations across the United States totaling over 400 million square feet of gross floor area and 5,200 buildings, making this the most comprehensive dataset available on analytics installation and use.

2. Methodology

The findings in this paper are based on the results from this research and industry partnership through July 2018. The data originates from two main sources:

- **Survey data:** Updated by participants each year, quantitative data includes floor area with EMIS, annual energy use, and EMIS costs. Participants report qualitative information such as the type of EMIS installed, how the EMIS has been used, and the most frequently implemented improvements in which they utilized the EMIS.
- **Ongoing interviews:** Participants are interviewed to better understand their current EMIS and MBCx implementation, then participate in activities such as individual and group technical support. The information gained from these activities has been used to determine the barriers and enablers to successfully implementing EMIS.

As new participants join the program and existing participants continue their EMIS implementation, new data are added, and the research results are updated each year.

To understand energy and cost savings benefits achieved by owners using EMIS technologies, participants are asked to provide annual energy consumption before and after EMIS implementation. These energy savings achievements are attributable to several energy efficiency activities including, but not limited to, use of the EMIS. Participants provide data only for buildings with active use of EMIS. Energy savings since EMIS installation were determined in four ways.

1. **Interval data analysis**: Pre-EMIS (baseline year) interval data are used to develop a model of building energy use. Energy use is projected using the baseline model and compared actual energy use during the period after installing EMIS. This method utilizes the International Performance Measurement and Verification Protocol (IPMVP) Option C methodology.
2. **Monthly bill analysis:** Pre-EMIS (baseline year) energy use is compared to the most recent full year of energy use. Energy cost savings are calculated using national average energy prices. Sometimes the data were normalized for weather using ENERGY STAR Portfolio manager. When the participant used ENERGY STAR Portfolio Manager for their buildings with EMIS, we asked for their data through standard ENERGY STAR reports, so we could gather weather-normalized usage. If participants did not utilize ENERGY STAR Portfolio Manager, then we did not weather-normalize the change in energy use.
3. **Engineering calculations:** This system analysis approach for estimating energy savings may use BAS trends or short-term measurements as baseline data. Spreadsheet calculations are based on engineering equations that often utilize temperature or load-based bin analysis.
4. **Building energy simulation**: Modeling whole facility energy use is a system analysis approach that uses energy simulation software such as eQUEST, EnergyPlus, Trane TRACE, or Carrier HAP

Costs to implement an EMIS and perform MBCx were gathered from participants in the three categories shown below: base cost, recurring EMIS cost, and in-house labor cost. Cost data were provided by participants in dollars for the base cost and annual software cost, and then normalized by floor area.

Base cost: Costs for the EMIS software installation and configuration, including EMIS vendor and service provider costs. It does not include additional costs such as the cost of energy metering hardware and communications, adding points to the BAS for EMIS monitoring purposes, additional data servers, retrocommissioning, or retrofits.

Recurring EMIS cost: Annual recurring costs broken out into two categories: software cost and MBCx service provider cost.

- **Annual software cost:** The recurring annual cost for a software license or software-as-a-service fees.
- **Ongoing MBCx service provider cost:** The average annual cost to MBCx service providers or other consultants for support in analyzing and implementing EMIS findings.

In-house labor cost: Labor costs broken out into two categories: EMIS installation/configuration and ongoing EMIS use. Cost was determined using estimated hours for the team and $125/hour as an average labor rate.

- **EMIS installation and configuration:** Approximate total labor hours spent by in-house staff to support installation and configuration of the EMIS.
- **Ongoing EMIS use:** Approximate time spent by in-house staff reviewing EMIS reports, identifying opportunities for improvement, and implementing measures (average hours spent per month).

3. Findings

This section provides an overview of the types of activities, analytic tools, and energy management processes that Campaign participants use. The section also summarizes findings on EMIS and MBCx benefits and costs.

3.1 Campaign Participants

A total of 73 organizations participated in the Campaign, and this section summarizes data collected through the Campaign based on reporting to date from 47 participating organizations (64 percent) and interviews with all 73 organizations. Ten percent of participants had not yet implemented their EMIS and therefore did not have data to report, and 26 percent of participants did not report.

3.1.1 Participant Activities

Current Campaign participation includes 73 public and private sector organizations, representing a total gross floor area of 400 million sq ft and more than 5,200 buildings. Participants are mainly in the office and higher education market sectors, with healthcare and government laboratories also represented (Figure 3). The most common portfolio size is between 1 million and 5 million sq ft (Figure 4).

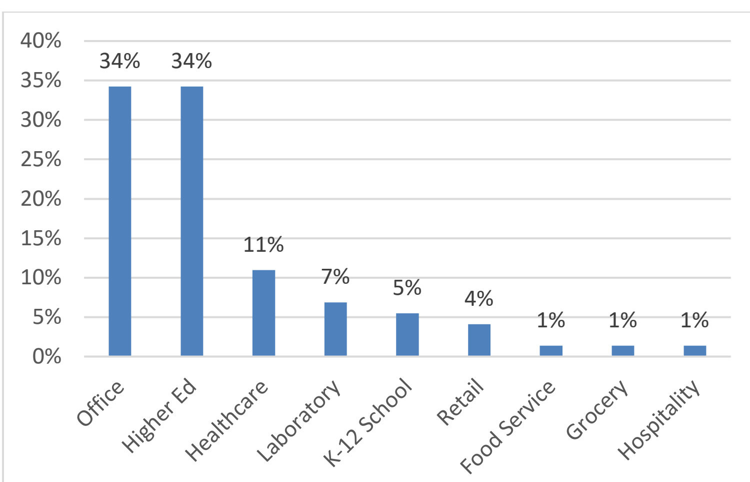

Figure 3: Participants by Primary Market Sector (n = 73)

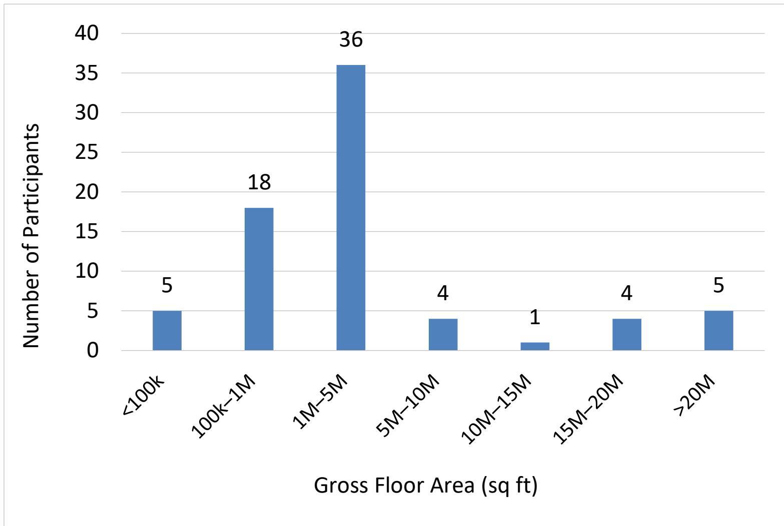

Figure 4: Distribution of Gross Floor Area for Pledged Participants (n = 73)

3.1.2 Data and Tools

Almost all Campaign participants have access or are gaining access to whole building hourly data in addition to their monthly utility bill data, and just over 40 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, spreadsheets, and EIS. Campaign data shows that where EIS and FDD have been implemented, operators benefit from expanded analysis capabilities, well beyond these common analysis tools. About 30 percent of the participants are installing new EMIS during the Campaign, 35 percent are using an existing EMIS, and 35 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 59 percent having incorporated interval meter data into their EMIS (Figure 5). FDD is gaining momentum as integration of BAS data into the FDD software has improved, with almost half 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 these data within the FDD software. Participants with both FDD and EIS tended to use the FDD functionality most often within their building operations teams due to its ability to provide detailed recommendations. ASO is not yet prevalent with Campaign participants, even though the Campaign participants are generally early adopters. One participant is using ASO, and they also have EIS installed. Some participants (21 percent) have not yet installed their EMIS and are either researching and specifying their system or in procurement.

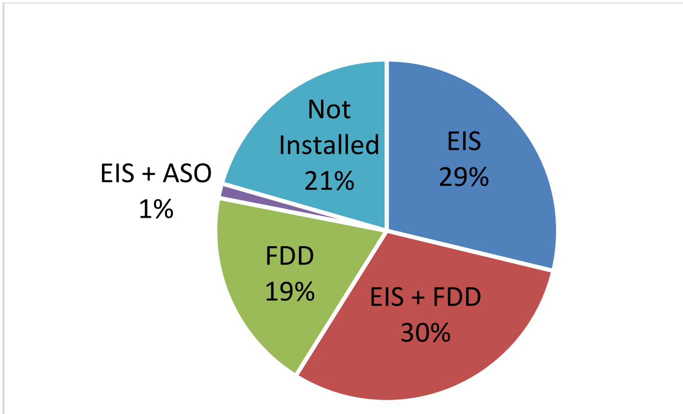

Figure 5: Type of EMIS Installed by Participants (n = 73)

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.

3.1.3 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 6). The energy managers tend to lead the analysis process and are sometimes supported by a consultant or service contractor. Just over half of participants contracted with a service provider to support their MBCx process.

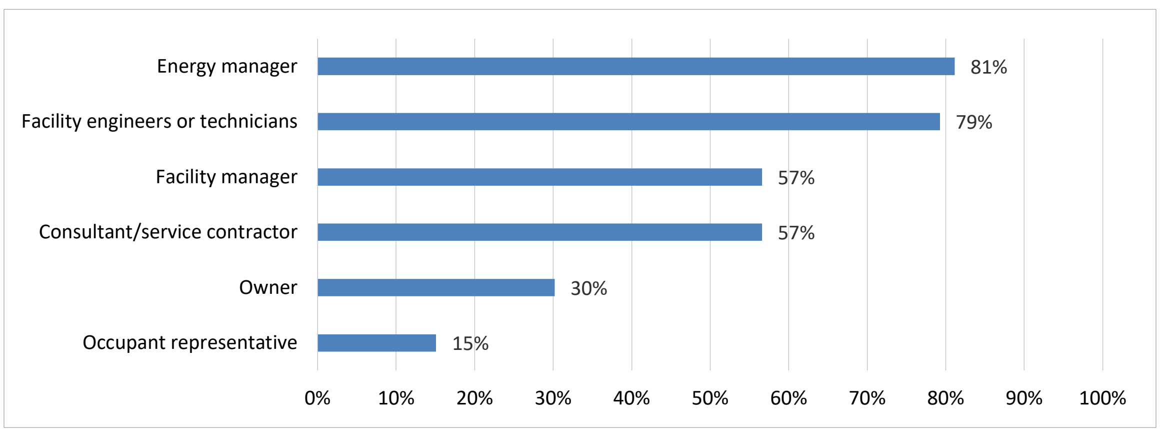

Figure 6: Energy Management Team Members (n = 53)

Most energy management teams are using a periodic performance tracking process (Figure 7) that may not have been as formalized and comprehensive as those implementing monitoring-based commissioning.

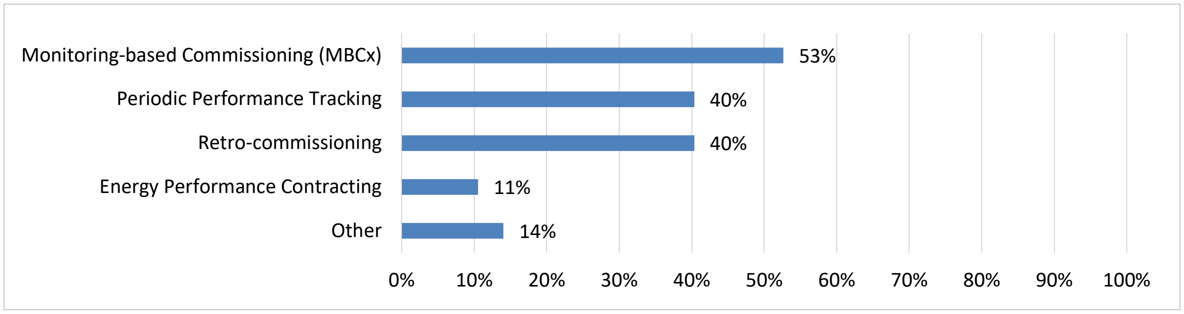

Figure 7: Energy Management Process Implemented (n = 57)

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 for in-house staff to maintain ongoing energy management processes.

An approximately even distribution of participants reviews their EMIS daily or weekly, as shown in Figure 8. FDD reports were reviewed most frequently at the daily or weekly intervals, with some monthly analysis. EIS had an equal distribution of review across daily, weekly, monthly, and quarterly intervals. This finding may point to the lack of consistency in how owners use their EIS. Monthly review of the EIS and FDD results may be driven by preparations for monthly energy team meetings and reporting to management. While a review frequency of daily or weekly is desirable to benefit from the real-time results of analytics, constraints on operations and maintenance (O&M) staff time may lead to monthly review, either in-house or through an MBCx service provider. Since notification of emergency-type faults are generally available through the BAS directly (e.g., a chiller is off-line), the issues found through an FDD may not be urgent from a safety and comfort perspective. The FDD software can assess the severity of the faults and determine how long they have occurred, so that responses can be prioritized for whatever frequency of action is desired.

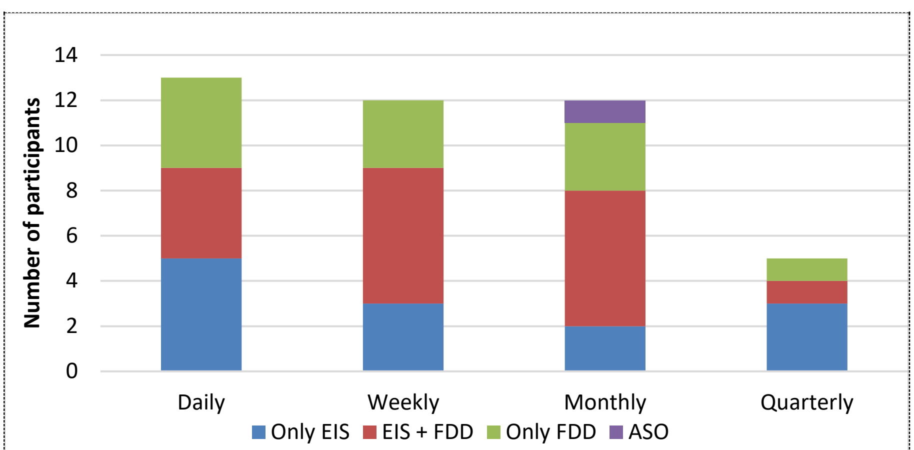

Figure 8: Frequency of EMIS Review by EMIS Type

3.2 Cost and Benefit Findings

This section reports on the results of data collection around motivation for EMIS, measures implemented using the EMIS, energy savings, and costs.

3.2.1 Benefits Motivating EMIS Implementation

Energy and cost savings are often a driving factor in the decision to implement an EMIS, as shown in Figure 9.

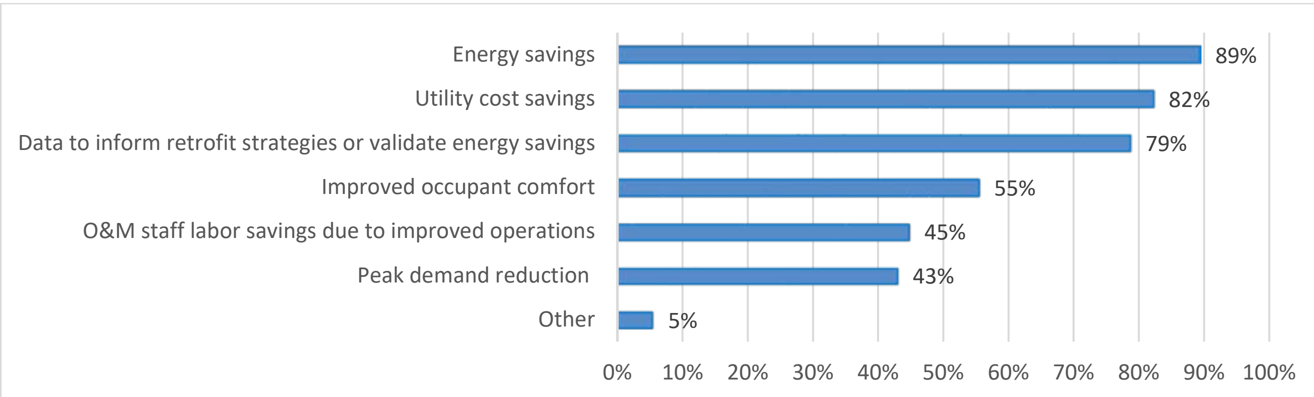

Figure 9: Benefits of Implementing EMIS (Percent of time benefit was chosen by participant, may select multiple benefits)

Energy savings generally were validated by exporting data and analyzing them 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.

3.2.2 Top Measures Implemented

Participants were asked to indicate up to 10 of the most frequently implemented measures identified through the use of EMIS, from a list of 26 common operational improvement opportunities. Table 1 shows the most common measures selected.

Table 1: Measures Implemented with EMIS Support (Respondents may indicate multiple measures; n = 56)

Category	Specific Measure	Percent of Participants Implementing the Measure
Scheduling Equipment Loads	Improve scheduling for HVAC & Refrigeration	71
	Improve scheduling for lighting	23
	Improve scheduling for plug loads	4
Economizer/Outside Air Loads	Improve economizer operation/use	46
	Reduce over-ventilation	45
Control Problems	Reduce simultaneous heating and cooling	48
	Tune control loops to avoid hunting	38
	Optimize equipment staging	38
	Zone rebalancing	14
Controls: Setpoint Changes	Adjustment of heating/cooling and occupied/unoccupied space temperature setpoints	59
	Reduction of VAV box minimum setpoint	36
	Duct static pressure setpoint change	27
	Hydronic differential pressure setpoint change	11
	Preheat temperature setpoint change	9
Controls: Reset Schedule Addition or Modification	Supply air temperature reset	41
	Duct static pressure reset	32
	Chilled water supply temperature reset	23
	Hot water supply temperature reset or hot water plant lockout	20
	Condenser water supply temperature reset	11
Equipment Efficiency Improvements	Add or optimize variable frequency drives (VFDs)	27
	Pump discharge throttled or over-pumping and low delta T	16
Occupant Behavior Modification	Routinely share energy information or guidance on proper use of equipment with occupants through EMIS	25
	Hold an energy savings challenge using EMIS data	20
Retrofits	Lighting upgrade or improve lighting controls	32
	High efficiency HVAC equipment: airside	20
	High efficiency HVAC equipment: waterside	16

These measures were implemented consistently across the market sectors represented in the current measures dataset (higher education, office, 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.

3.2.3 Energy Savings

Twenty-seven participants submitted energy data for all or a subset of their buildings (in total 687 buildings, 94 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).

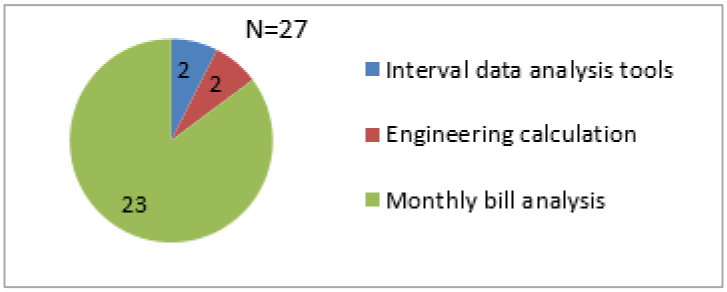

Figure 10: Distribution of Energy Savings Calculation Methods (n = 27)

Two participants reported savings results determined from interval data analysis tools. Two participants estimated savings using engineering calculations. The energy savings from the other 23 participants were calculated by Lawrence Berkeley National Laboratory (LBNL) using monthly bill analysis. None of the participants used building energy simulation to estimate savings.

Figure 11 shows the energy and cost savings results for each participant since the installation of their EMIS. The participant energy savings ranged from -6 to 28 percent, the median was 7 percent, and the mean was 8 percent. The median cost savings was $0.19/sq ft, and the mean was $0.28/sq ft. The mean savings is less representative than the median due to the wide range in savings. In total, these 27 participants are saving 790 billion Btu/year and $18 million/year, comparing the most recent year for which data are available to the baseline year before the EMIS installation. 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; measures beyond these improvements may also have been implemented.

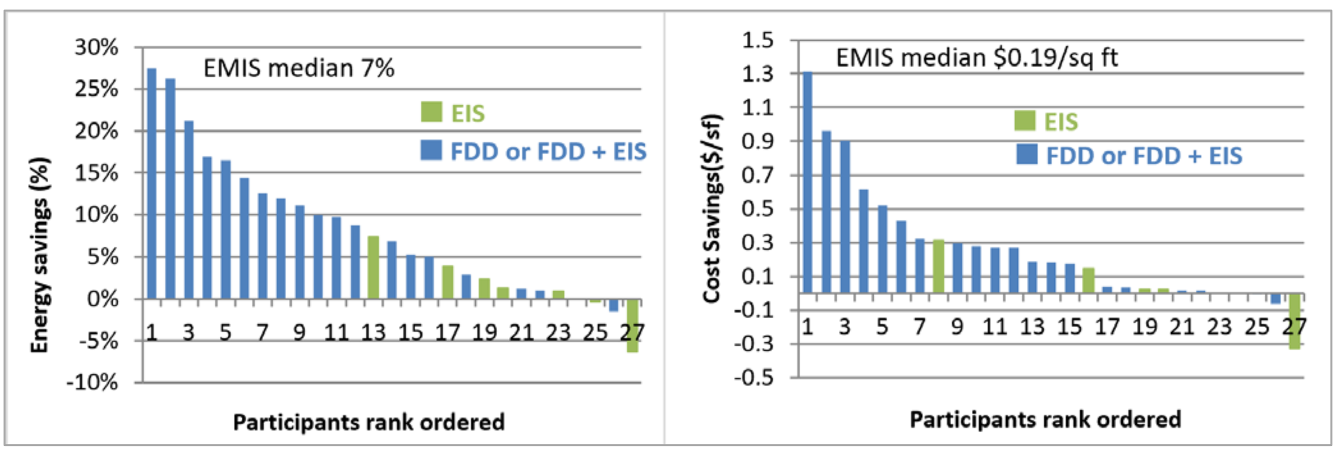

Figure 11: Participant Energy Savings (left) and Cost Savings (right) for Campaign Participants since EMIS Installations (n = 27)

In addition to annual 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 group of participants. Four participants installed EMIS for four years, 6 installed it for three years, 10 installed it for two years and 17 installed it for one year. **This plot shows that savings increased each year for the four participants that had EMIS installed for four years.** The median first year savings was 7 percent, or $0.19/sq ft, and the mean first year savings was 8 percent, or $0.28/sq ft.

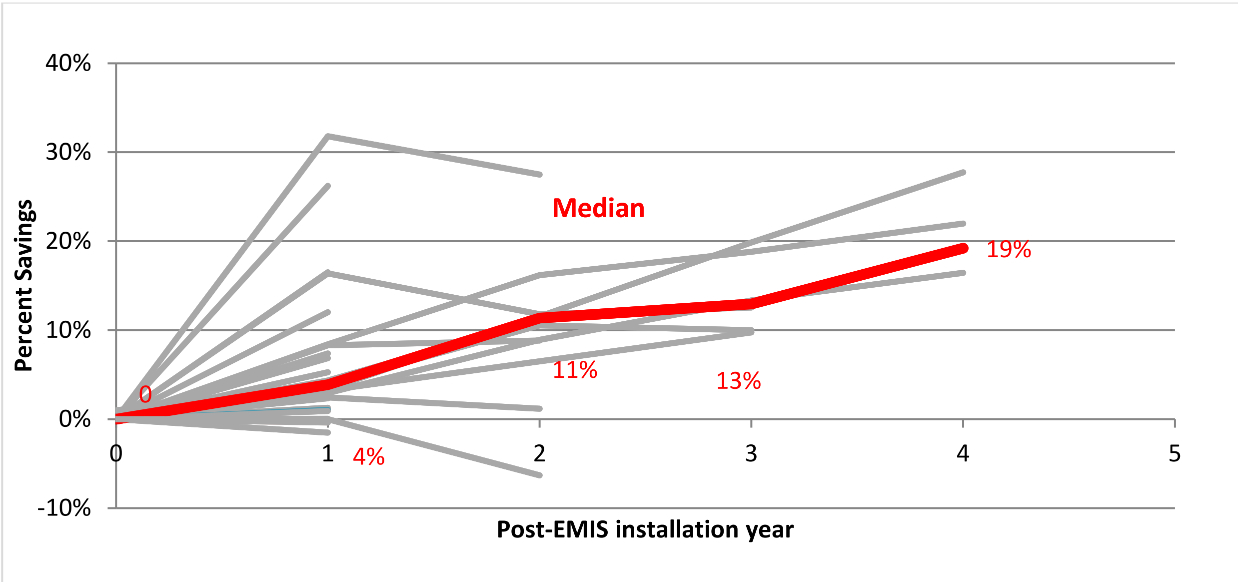

Figure 12: Percent Change in Participant Energy Use, Relative to the Year before EMIS Installation. Gray lines indicate savings for each of 27 participants, and the red line represents median savings across all participants.

With 20 participants implementing FDD (or EIS and FDD) and 7 participants implementing EIS only, the energy savings could be broken out by EMIS type. Table 2 shows median and range of savings by EMIS type since the EMIS was installed (e.g., FDD had been installed for longer than EIS for 11 participants). In some cases, the EMIS had been installed for more years than the energy data were provided.

Table 2: Summary of Energy Savings for Participants with EMIS

EMIS Type	Median Energy Savings since EMIS Installation	Range of Energy Savings	Number of Years Energy Data Were Available since EMIS Installation
EIS (n = 7)	1%	-6% to 7%	1 year (n = 7)
EIS+FDD and FDD (n = 20)	10%	-2% to 26%	1 year (n = 9); 2–4 years (n = 11)
All EMIS (n = 27)	7%	-6% to 26%	1 year (n = 16); 2–4 years (n = 11)

3.2.4 Costs

The median costs from 35 participants are shown for each participant in figures 13, 14, and 15, and summarized in Table 3. 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 smaller scale implementations.

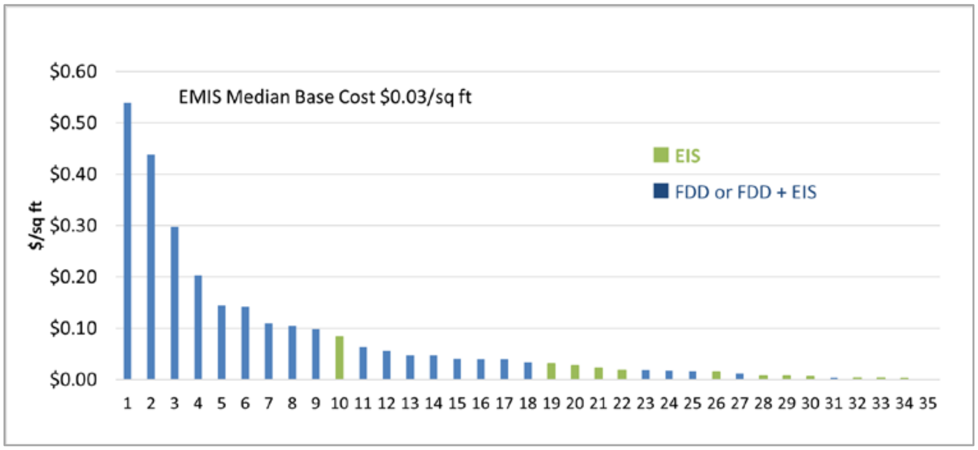

Figure 13: Base Cost by EMIS Type (n=35)

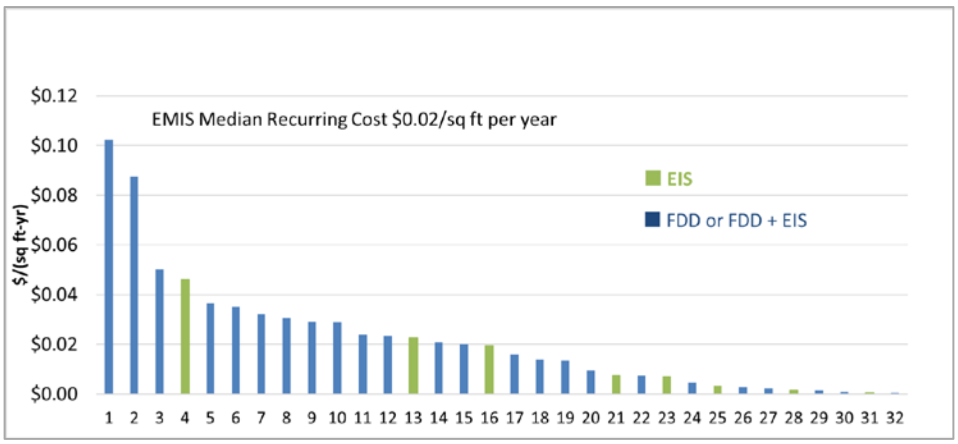

Figure 14: Recurring Software Cost by EMIS Type (n=34)

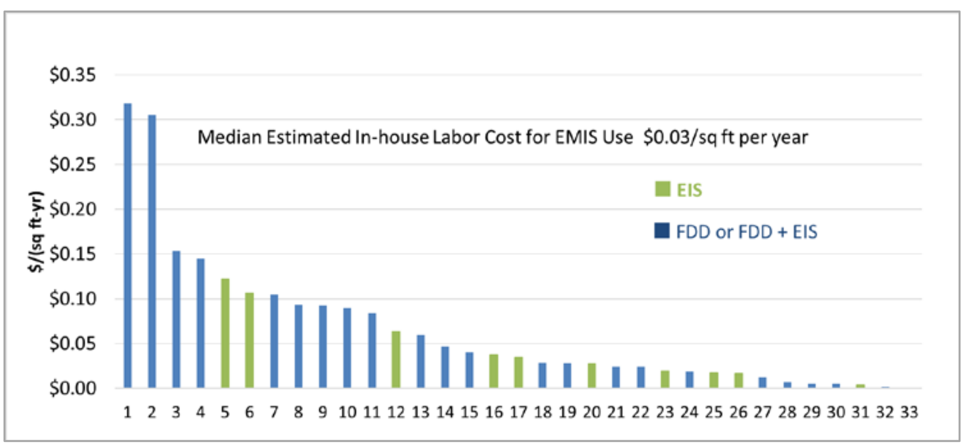

Figure 15: Estimated In-House Labor Cost by EMIS Type (n=33)

Table 3: EMIS Cost Summary

Median Costs	Base Software and Installation Cost ($/sq ft)	Annual Software + MBCx Cost ($/sq ft-year)	Estimated Annual In-House Labor Cost ($/sq ft-year)
EIS (n = 12)	0.01	0.01	0.03
EIS+FDD and FDD (n = 23)	0.05	0.02	0.05
All EMIS (n = 35)	0.03	0.02	0.03

4 Discussion

This section discusses the cost and benefit findings of the research and presents trends in EMIS product and services delivery. Using data gathered through Campaign interactions, enablers and barriers to implementation and industry needs are also summarized.

4.1 Costs and Benefits Discussion

Energy Savings

While a portion of the energy savings documented for Campaign participants may be due to changes in their buildings not related to the use of EMIS, almost all Campaign participants report a decrease in whole building energy use during the time the EMIS has been implemented. FDD users achieved 10 percent median savings, which is significantly higher than the 1 percent median savings for EIS users. However, with seven EIS users reporting first-year post-EMIS energy use, the median from EIS is only a preliminary finding, and may increase as more organizations report their energy data over a longer period of implementation. A prior study (Granderson and Lin 2016) found 8 percent median savings for nine portfolios that implemented EIS; however, seven of these EIS portfolios had implemented EIS for at least three years (and five for 5 to 10 years). Another study of MBCx projects in California found that energy cost savings were $0.25/sq ft-year, for a median simple payback time of 2.5 years (Mills and Mathew 2009). To date in the Campaign, we are generally not seeing EIS used to its full potential. Either participants are not reviewing the data frequently, or their EIS are not yet set up to meet their needs. Over time we will likely see the EIS median savings from Campaign participants increase as these participants engage more deeply with the analysis.

While the research does not include representative market samples, trends show that deeper monitoring using continuous analysis supports increased savings and persistence of savings. In addition to helping identify savings opportunities, EMIS gives owners the ability to monitor their energy savings progress over time, which is invaluable to all energy saving efforts. The Campaign reported 19 percent median savings after the fourth year of EMIS implementation, which points to EMIS as an ongoing path to deeper savings. Through participant engagement, change in energy use relative to a pre-EMIS baseline will be tracked over the next two years, and the findings updated.

Other Benefits

Although non-energy benefits are not the primary motivator for implementing EMIS, operational benefits play a key role in garnering O&M staff support for EMIS use. Analytics can identify issues before they grow into occupant complaints or equipment failures. For example, operators generally do not have time to perform preventative maintenance on all terminal units; operations are checked when there are comfort complaints.

Using FDD, building operators can evaluate terminal unit performance cost-effectively and proactively at a broad scale in a fraction of the time it would take to check all the boxes. Cycling equipment is another common operational issue identified through EMIS; eliminating cycling improves equipment life.

Costs

With 23 owners reporting FDD (or EIS + FDD) costs, and 12 owners reporting EIS costs, we have been able to break out EIS and FDD costs from the overall EMIS cost. The cost data are still a relatively small dataset for drawing robust conclusions, therefore additional cost data will be added in the next reporting year.

- **Base cost:** Among reporting participants, the base cost for installing and configuring FDD software is five times that of EIS. There is significantly more work required to integrate the BAS data into the FDD software than it takes to integrate meter data into EIS software, both because there are more BAS data and a variety of points that must be mapped for use in the FDD software. The high end of the base cost occurred at sites where the FDD was installed at greater depth or on more complex systems. Data integration across the BAS and many devices drove the higher base cost. The low end of the base cost generally occurred when there were fewer points brought into the EMIS.

  The largest installations had significantly lower costs per square foot, which reflects the economies of scale achievable through broad EMIS implementation. For FDD implementations greater than 1 million sq ft in size, costs flattened to $0.02/sq ft to $0.06/sq ft. Large portfolios gain benefits in implementing EMIS across their portfolio, including the ability to use EIS to benchmark their buildings, manage energy use from a single location, and sometimes control building systems remotely through an operations center.

- **Recurring cost**: We observe that EIS recurring software fees are about equal to the median base cost (both are $0.01/sq ft), and FDD recurring software costs ($0.02/sq ft) are about 45 percent of the FDD base cost. These recurring costs include two components: the annual licensing/software-as-a-service (SaaS) fee and ongoing MBCx service provider fees. The breakout of these two components is arbitrary, as some vendors include MBCx services within their SaaS fees, so we have not reported the breakout. For EIS, both the upfront and ongoing effort is lower than FDD, and this is reflected in the pricing. After the FDD is configured and in use, recurring costs decrease as the building operations staff take on more duties in analyzing the results. Typically, participants with only EIS do not utilize MBCx service providers, and about half of participants with FDD are contracting with MBCx service providers for additional support.

- **In-house labor cost**: The time it takes in-house staff to utilize the EMIS is a significant portion of overall EMIS costs. While the labor cost is a different type of cost, since it may be embedded in the existing staff workload (and thus may not be an additional cost of implementing the EMIS), estimates of labor cost from building staff were significantly higher than the recurring software and MBCx costs. The high end of the labor cost was reported from sites in their first year of FDD installation, during which time many faults were detected which may have existed for some time. Not surprisingly, the highest labor costs occurred at sites that implement MBCx in-house without service providers. Some participants' annual labor costs are quite low per square foot, either due to outsourcing to an MBCx service provider or a lack of engaged use with their EMIS. Levels of support from the integrators and vendors in installation and configuration varied widely, from mostly in-house EMIS installation by operations staff with a low level of vendor support to full service installation with vendor support to analyze findings. Both the extent of engagement with the EMIS and the varying level of contracted MBCx support affected the estimated in-house labor cost.

The EIS cost findings from this research are supported by past research. A previous study (Granderson and Lin 2016) reported a $0.01/sq ft base software cost and a $0.01/sq ft annual recurring software cost; the Campaign results are the same for EIS. EIS costs are lower than FDD costs, and it's easier to install, so often EIS is the point of entry for an owner new to EMIS.

While there is not a previous study from which to compare the FDD cost results, FDD implementations have more data streams and complexity in implementing diagnostics, therefore higher costs than those associated with EIS were expected. This research does not break out savings specifically attributed to the EMIS software, therefore we do not compare costs and savings to calculate EMIS cost-effectiveness. However, given many owners' desire to invest in FDD and the cost savings and operational benefits described by those implementing FDD, the value proposition is strong.

The need to use both EIS and FDD technologies is clear. We have seen participants who only implement FDD and do not know how much energy they are using or saving. Conversely, those that implement only EIS tend to focus mainly on schedules, baseload, and peak demand, and may miss the more nuanced operational opportunities identified through FDD. EIS and FDD can work together to provide both a top-down and bottom-up analysis of a building's energy use and systems.

4.2 EMIS Products and 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 with 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 demonstrations. 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.

The Campaign team developed a list, shared on the website, that currently contains 58 EIS products, 28 FDD products, and 7 ASO products.[2] Seventeen vendors offer both an EIS product and an FDD product. To date, Campaign participants have implemented almost half of the products on this list. Through the process of developing and maintaining the EMIS products and services list, several insights emerged.

- New EMIS tools are continually being developed, with only a few vendors consolidating products. The field is crowded, with vendors working to differentiate their products based on feature sets, market-sector focus (i.e., small to medium businesses), and partnerships with other EMIS vendors for integrated suites of products.
- Some EMIS products are being embedded in other EMIS products. For example, SkySpark is the analytic engine for several other FDD products. The white labeled products are generally combined

[2] This products list is a representative snapshot of vendors and providers, and is not comprehensive; inclusion does not indicate endorsement by the U.S. Department of Energy (DOE), LBNL, or the University of California. One year ago, the Campaign's Find a Product or Service List contained 44 EIS products, 20 FDD products, and 6 ASO products.

with the EMIS service provider's ongoing analytic support. The software value-add from the service provider may include enhanced project management and fault prioritization capabilities.

The most commonly used metrics available in EIS are summarized in Table 4 below.

Table 4: Summary of Commonly Used EIS Metrics and Analyses

Common Metrics and Analyses	Used to Identify
Energy use intensity (EUI, kBtu/sq ft)	• High energy use relative to the portfolio
Heat maps	• Scheduling improvements • Baseline reduction opportunities
Load profiles with filtering by day type	• Scheduling improvements • Baseline reduction opportunities • Peak demand reduction opportunities

While almost all participants have hourly whole building energy use available in their EMIS, the use of advanced meter-data analytics such as automated load shape analysis and automated M&V using interval meter data is not yet common. Over a dozen EMIS products in the market currently have automated M&V capability built into their products (Granderson and Fernandes 2017); however, the use of this feature has not been widespread by Campaign participants. Simpler ways to estimate savings are generally used, including monthly utility bill comparisons and use of the ENERGY STAR Portfolio Manager.

Some FDD installations focused their systems on monitoring hundreds of VAV boxes that they otherwise could not monitor manually. Owners with experienced in-house teams often received training from the FDD vendor to program and tune the FDD rules on their own. Some owners develop a "core" set of rules to roll out across a portfolio and tweak them for each unique building's situation. While most FDD software has built-in estimation of the energy cost waste of each fault to use as a means of prioritization, there are not standard ways of assessing impact.

4.3 MBCx Process and Service Providers

A compelling evolution in the industry is the expansion of market delivery of FDD through MBCx 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. 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. The expansion in service offerings has the potential to make the use of EMIS achievable for building owners that do not have large in-house facility teams. Some service providers are national organizations, but most are likely to serve regional markets, as they are the outgrowth of regional engineering firms.

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. Once established across a portfolio, FDD fault alerts can number in the hundreds or even thousands, therefore there is the need to filter and prioritize. While many FDD software platforms have built-in estimation of the energy cost 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 highlighting the most important measures for immediate action. In some cases, the owner might seldom or never access their EMIS directly, only the service provider's reports or online dashboard.

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, 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 (Gregory 2015).

Figure 16 below illustrates different ways to implement EMIS with the support of service providers. 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.

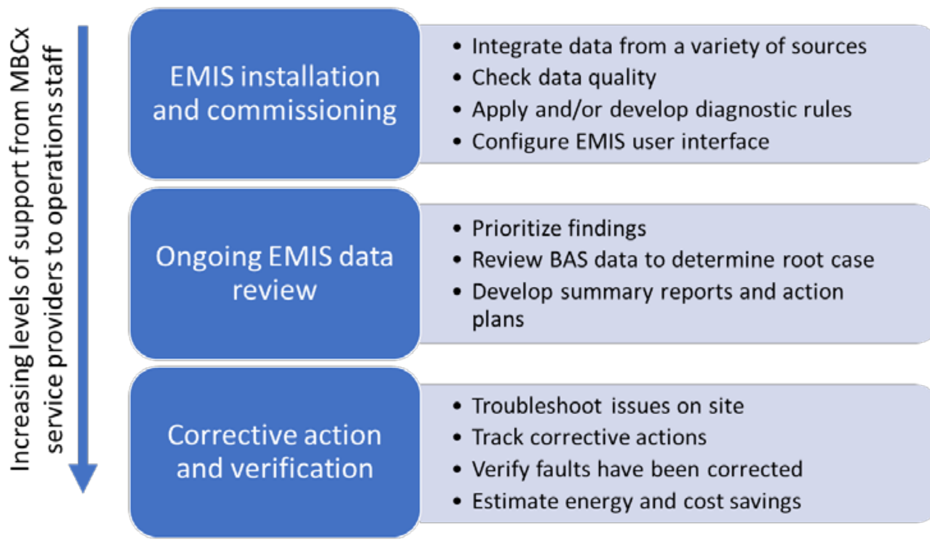

Figure 16: Support Options for the Ongoing Use of EMIS

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.

4.4 Enablers and Barriers to Successful EMIS implementation

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 5. Three of the most significant barriers to successful EMIS software and MBCx process implementation include the following:

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

Beyond securing funding, one of the most important enablers to successful implementation is specifying an EMIS that meets building staff needs and where building operations staff want to (or are incented to) use the EMIS. Participants that have institutionalized the use of data analytics in their standard meeting and reporting processes are finding their MBCx process to be valuable, from both cost savings and building comfort perspectives. In other words, those that use their systems find value in doing so.

Table 5: Enablers and Barriers to Successfully Implementing EMIS and MBCx

Category	Enablers	Barriers
EMIS Specification and Selection	• 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).	• Users are not clear on which EMIS product features they need. • Lack of clarity on differences between EMIS products • Long procurement process through RFP and/or vendor interviews
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 manage the FDD process. • Commissioning the EMIS installation avoids problems later. • Data warehouses provide a single location for all relevant data streams.	• Data integration problems include difficulty extracting data from older BAS, disparate naming conventions, and difficulty bringing all the data into a single database. • Data quality problems (gaps in data, incorrect meter readings) • Lack of existing metering in place
Analytic Process	• Metrics and charts that summarize performance at a glance • Analytics are implemented to address specific operational challenges, rather than implementing all analytics. • Service providers implement an existing FDD rules library.	• Users experience data overload instead of gaining actionable insights. • There is difficulty in pinpointing measures/opportunities in the data. • There is difficulty in finding root causes of fault conditions. • A lack of M&V process are in place to verify savings.
MBCx Organizational Process	• Staff that routinely use EMIS tend to find value. • Energy savings and persistence goals drive EMIS use. • Integration of EMIS with work order systems helps drive implementation. • 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 leads to energy waste.

4.5. Industry Needs

Through understanding what enabled successful analytics implementation and the barriers that hindered participants (see Table 4), 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. Creating a united metadata schema to understand the relationships between points—as well as establishing standard, consistent naming conventions—are key steps toward streamlining the implementation of FDD tools. Project Haystack and Brick are two such schema currently under development.

- **Meeting diverse user needs:** Finding a single EMIS that serves data management, benchmarking, utility bill management, analytics, and project tracking needs is a challenge. There is potential for tool partnerships to meet this need, or the industry may expand tool capability or consolidate tools to provide more comprehensive solutions. MBCx service providers may also serve this integration role as they analyze data streams potentially using multiple tools and supply integrated analysis to owners.
- **Methods for making the business case:** Owners have trouble determining the return on investment for specific EMIS installations since it may not be clear prior to MBCx what the savings will be. Further, it can be difficult to attribute savings to EMIS as an enabling tool that requires actions based on the analysis. Utility incentives programs spur the MBCx market, however there are few such programs currently available to owners. Possibly, over time, EMIS will become a standard accepted operational cost rather than a cap-ex project investment.

Owner Support

- **EIS/meter data analytics:** Organizations need more guidance in how to use meter data to gain diagnostic value. Owners 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.
- **EMIS review and selection:** Determining which EMIS products and services will meet organizational needs and what functionality exists within the vendors' products has been difficult for owners. 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 to. With such a large field of products available, it is difficult to identify this "short list."
- **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.

MBCx is currently in the early adopter phase, with the most significant growth supported by campus EMIS installations in the higher education and commercial office market sectors and a few MBCx-focused utility programs. Addressing the industry needs outlined above will help move ongoing MBCx processes into the mainstream to help achieve lasting operational benefits for owners.

5. Conclusions

There is 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 energy efficiency efforts, and FDD is gaining traction as it helps facility teams track the performance of systems. These research conclusions drew from a dataset of 73 participants updated in July 2018, covering more than 400 million sq ft of commercial floor area and over 5,200 buildings. This is the largest dataset nationally on EMIS technology use, and it will grow over the next two years as the partnership continues.

A subset of participants (27 organizations, 687 buildings, and 94 million sq ft) using an EMIS achieved median cost savings of $0.19/sq ft and 7 percent annually, with savings shown to increase over time. While these savings are not attributable to specific measures, the EMIS users shared their top measures implemented, including improvements to HVAC scheduling, adjustment of setpoints, reducing simultaneous heating and cooling, and improving airside economizer operation. FDD users achieved 10 percent median savings compared to 1 percent median savings for EIS users. The savings achieved by EIS users was lower than in past research results although it is likely to increase as organizations report their energy use beyond their first year of EIS implementation. Energy savings for all EMIS implementations will be updated as the research continues another year.

For 35 participants (306 million square feet and over 3,400 buildings), median base cost to install an EMIS was $0.03/sq ft, with an annual recurring software cost of $0.02/sq ft and estimated annual labor cost of $0.03/sq ft. FDD implementations have more data streams and complexity than EIS; therefore, higher costs than those associated with EIS were expected. The FDD base cost at $0.05/sq ft was five times higher than the EIS base cost, and the FDD ongoing costs ($0.02/sq ft) were double that of EIS. Many of the organizations in the partnership have made the business case to install analytics. There is a growing dataset and group of case studies demonstrating successful EMIS implementation; however, some organizations still find it difficult to make a compelling business case. To date, 14 success stories[3] are available that summarize best practices, savings, and costs of leading owners in their use of EMIS technologies and implementation of MBCx processes.

There are a variety of successful approaches (i.e., using an in-house team or a third party) for utilizing an EMIS to find and fix operational measures. However, there is a need to improve data integration and management, navigate the many EMIS vendor options, and improve prioritization of fault findings. Owners that dedicate adequate staff time to review the analytics and address the opportunities found reap the benefits. In successfully utilizing EMIS tools, owners can move from reactive to proactive building operations that are continuously informed by data analytics.

6. Future Research

The Smart Energy Analytics Campaign expects to enroll approximately 25 more organizations over the course of the Campaign, which will expand the research dataset to 100 organizations. Each year that the Campaign is in operation, this research report will be updated to reflect the most complete dataset and findings. The Campaign is on track to generate the most complete dataset on EMIS tools and MBCx processes available nationally, with detailed reporting on costs and savings. This research will help build awareness of MBCx, a relatively new process in the commercial buildings industry.

[3] Success stories are short case studies on those Campaign participants that received recognition by DOE. The success stories are available for download at https://smart-energy-analytics.org/success-stories.

Additional research and resources in the following areas will advance the state of the art and promote implementation of EMIS tools and MBCx processes.

- **Technical approaches:** Develop automated fault correction techniques, predictive diagnostics, and methods for improving the accuracy of hourly meter data to measure real-time savings.
- **Resources:** Provide targeted resources in areas such as data management, integration, cybersecurity and interoperability to help owners create a robust foundation for analytics, including promoting the benefits of Project Haystack and Brick for data model standardization.
- **Protocols:** Develop a standardized protocol for EMIS assessment to consistently quantify benefits of the technologies.

The use of EMIS tools in MBCx processes has expanded significantly over the last 20 years, yet there is still the challenge of moving these processes beyond the early adopters. While EMIS technology advances will help reduce the time necessary to implement EMIS and the value gained from the analytics, the market also needs a growing infrastructure of service providers and a trained building operations workforce to make the promise of these technologies a reality. And moving into the future, these advancements will help transform the use of EMIS into a standard cost of operation for commercial buildings.

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