

Memo



→ CONSULTANT TEAM

To: **Massachusetts EEAC**
From: **Energy Management System C&I Implementation Working Group**
Date: **July 23, 2020**
Subject: **Energy Management Systems Baseline Opinion Statement**

The Consultant Team, in partnership with the Massachusetts C&I Program Administrator implementation team is pleased to provide this update to the Council on our recent activities.

PURPOSE: CLARIFY EMS BASELINES

This statement documents the implementation perspective on Energy Management System (EMS) baselines based on input from and research by the PA and the EEAC C&I implementation teams (referred to as the EMS implementation work group or EMS-IWG). It includes a review of the EMS event types, the EMS-IWG baseline opinion for each and identifies areas of agreement and differences between evaluator opinion and the EMS-IWG opinion, and a recommended path forward for EMS baselines.

BACKGROUND

- ▶ EMS measures are critical to the MA Energy Efficiency Goals, with increasing importance over the next 5 years as lighting savings diminish. The MA PAs and the MA Energy Efficiency Advisory Council see EMS upgrades in existing facilities as a critical component of the MA Energy Efficiency Programs.
- ▶ On February 15, 2019, DNV GL released an Energy Management Systems Baseline Opinion Memo (referred to as the Opinion Memo)
 - The purpose of the Opinion Memo was to clarify evaluation perspectives on the baselines from which to calculate measure savings for the installation or replacement of energy management systems and components.
 - The effect of the memo was reduced PA support for EMS retrofits due to perceived or real evaluation risk.
- ▶ EMS was identified as a high priority for industry standard practice (ISP) research in July of 2017; evaluation research commenced in spring of 2020 with anticipated completion in fall of 2020, depending on the impacts of COVID-19 on the effort.

EMS OVERVIEW

- ▶ Energy Management System (EMS) is the terminology used by the MA PAs for what ASHRAE calls a Building Automation System (BAS). In this memo, the EMS-IWG uses the term EMS and

consider it synonymous with BAS.

- ▶ As outlined in the Opinion Memo, EMS systems pertain specifically to “systems which control and monitor, cooling, and any other non-lighting energy consuming systems.”
 - EMS includes the automatic centralized control of a building's heating, ventilation and air conditioning, lighting and other systems through a building management system or building automation system (BAS).

EMS IWG APPROACH

The EMS-IWG¹ met regularly for a period of six months to plan and review research and to reach agreement on baselines for EMS. The EMS-IWG conducted research including interviews with EMS energy program implementers and E-source and completed a literature review.

The EMS-IWG has significant direct experience working with EMS design, sales, installation, verification, and operations. The group identified baselines for existing buildings with existing EMS as the area of focus. In particular, the application of a code baseline, including new sequences of operation for replacement of components, partial or full existing EMS is inconsistent with the direct experience of the EMS-IWG and is posing a significant barrier to achieving energy efficiency goals, particularly relative to HVAC systems.

Opinion Memo Impact on Baselines & Current Market Conditions

- The Opinion Memo states that when “the existing system can no longer maintain the required control of the building. The baseline type should be replace-on-failure.” The Memo further states that for such projects “industry standard practice should be the baseline” and it states that “code should be deemed industry standard practice for such replacements.”
- Program Implementers and implementation consultants have observed that some level of EMS capability is quite common in many C&I facilities, but the level of functionality is often impaired by broken hardware, outdated software, overridden controls, lack of staff expertise and/or insufficient time to maintain programming and hardware components.
- The interpretation of the Opinion Memo is that the presence of any EMS system, particularly poorly performing and non-performing systems, precludes the opportunity to claim savings from upgrading and optimizing a that system other than the incremental savings relative to Code.
- The EMS-IWG has observed that many building owners and operators do not prioritize investments in existing EMS resulting in no upgrades. When systems are replaced, they are commonly replaced in-kind, neglecting opportunities for improved efficiency operating sequences.
- The Opinion Memo’s position that replacements to existing EMS and their components is both market driven and results in a code compliant system is not borne out in the EMS-IWG’s experience. The EMS-IWG can cite numerous examples of pneumatics, older digital systems, and packaged systems which, although not capable of efficiently operating a building, are maintained at a minimum level of functionality, and to examples where control has reverted to manual methods due to system deficiencies or failures.
- Another consideration is that for replacement control systems to be code compliant, the underlying HVAC systems would need the capability of being code compliant. Many

¹ Members are listed with brief bios at the end of this memo.

older HVAC systems lack the components and the design necessary to achieve compliance with modern codes. Even if HVAC systems have the components necessary to achieve compliance with modern codes, EMS are not always brought up to code because a simple EMS replacement alone is not a sufficiently large renovation project to be a code-triggering event

Research and Literature Review

The interviews conducted and literature reviewed are documented at the end of the memo. Interviewees were primarily members of engineering firms providing consulting and implementation of controls upgrades for utility EE programs. The results of the research seemed to point toward a predominant market view consistent with that of the EMS-IWG. We found that program implementers in the Midwest and Pacific-Northwest use the as-found condition to establish baselines for EMS replacements and upgrades in existing buildings. California was found to be an exception; there Title 24 is used as baseline for EMS system replacement and sometimes for upgrades.

Taylor Engineering and TRC are currently leading a pilot on the promotion of advanced sequences of operation in CA. The challenges presented by the code baseline in CA have presented significant barriers to achieving the savings potential. As a result of the pilot experience, TRC is preparing an ACEEE paper to address the barriers to achieving significant energy savings² through EMS optimization in California and New York. As Cheng Hwakong from Taylor Engineering states:

For utility incentive programs, as you noted, replacing BAS infrastructure usually puts a project into a category where the baseline becomes the current code minimum (as opposed to a baseline representing the existing condition for RCx-type projects). This is a big missed opportunity to encourage wider use of BAS retrofits/replacements to achieve deep savings in the existing building stock.

EMS Event Types and Baselines

The EMS-IWG created a matrix of EMS event types and defined them as shown in Table 1. In Table 2 the EMS-IWG recommended baseline, the rationale for that baseline and indication of deviation from the Opinion Memo is outlined for each event type.

Table 1 EMS Event Types

EMS Event Type	Event Type Description
Add On	Adding new controls or functionality to an existing system on equipment that is not currently controlled
Component Replacement	Replacing portions of the controls in an existing system (such as updating controllers, increasing capacity of I/O devices and replacing actuators)
Headend update	Updating servers and operating systems for a functioning headend system with the newer version of the same vendor controls package- a non-functioning headend or a change to a new controls vendor would be a system replacement

² *Re-Envisioning RCx: Achieving Max Potential HVAC Controls Retrofits through Modernized BAS Hardware and Software*, Gwelen Paliaga, et al.; the paper's Abstract indicates greater than 20% whole building savings can be achieved through BAS system upgrade and programming.

EMS Event Type	Event Type Description
New control system	No pre-existing EMS on the site, new system installed
Partial System Replacement	Replacing a portion of an existing BAS such as converting pneumatic to digital for VAV box operation
System Replacement	Replacing a legacy BAS system with new equipment - not typically a wholesale replacement - ie. actuators etc. may remain.

Table 2 EMS Baseline Matrix

Building Type	EMS Event Type	EMS Baseline	Savings Mechanism	Baseline Rationale	Agree w/Opinion Memo?
New Construction	New control system	Code or other ISP for new installations	Improved Sequence of Operations (SOO)	New buildings, major renovations and additions are required to comply with applicable codes and controls will be assumed to be code compliant and functional unless and until research indicates otherwise	Yes
Existing	Add On	Pre-existing operating condition	New hardware enables improved SOO and enhanced system control and may increase visibility of operations.	Consistent with current evaluation practice in MA and consistent with implementation market knowledge.	Yes
Existing	Component Replacement			Consistent with implementation market knowledge. Observations include frequency with which 3rd party RCx studies identify the need to replace existing components to implement improved sequences of operations.	Unclear
Existing	New control system; no pre-existing EMS			Consistent with current evaluation practice in MA and consistent with implementation market knowledge.	Yes
Existing	Partial System Replacement			Consistent with implementation market knowledge. High costs associated with these retrofits and the ability to continue to operate buildings with old and non-functioning controls are factors.	Unclear
Existing	System Replacement			Consistent with implementation market knowledge. High costs associated with these retrofits and the ability to continue to operate buildings with old and non-functioning controls are factors.	No
Existing	Headend update			Pre-existing operating condition	No savings expected

Recommendations and Next Steps

The EMS-IWG recognizes that this memo is being issued at a time when EMS ISP research is being undertaken. The EMS-IWG recommends the following be considered for baselines in existing buildings and investigated under the ISP study, recognizing that retrofit does not typically use an ISP baseline.

- ▶ EMS-IWG EMS retrofit baseline recommendation. For existing buildings with an existing EMS system, regardless of condition, the EMS-IWG finds that EMS replacements should qualify as retrofits.
 - For custom EMS measures in buildings with existing EMS – retrofit should be the default event type when an existing EMS or subset of an existing EMS is changed out or upgraded and that project includes energy efficiency improvements
 - In such cases, documentation of the pre/post conditions is necessary to demonstrate that the EMS upgrade delivers savings.
 - Pre/post measurement is recommended for EMS projects, including EMS equipment upgrades as well as obtaining trend data.
 - Rather than constraining EMS retrofits with a list of necessary criteria as suggested in the Opinion Memo, the baseline is the “as operating” condition for EMS, whether that be uncontrolled equipment or equipment with existing EMS controls that fail to optimize the equipment.
- ▶ EMS upgrades/retrofits should be implemented to improve the technology of the underlying hardware thereby enabling optimization of HVAC systems. HVAC system optimization should be the result of such projects

Given the consistency of opinion among the EMS-IWG and the supporting evidence identified in the research, the EMS-IWG Baseline recommendations outlined above should be adopted and allowed for all EMS projects undertaken until such time as a new baseline ISP study is published and approved by the PAs and the EEAC Consultants. Should that study find a baseline that differs from what is outlined in this memo, the projects completed or under contract during this period will not be penalized with a retrospective baseline change.

As has been discussed in evaluation planning calls, the EMS-IWG wants to maximize confidence in the EMS-ISP work. The EMS-IWG requests that early site visits, survey development and interviews include a person who has high EMS market knowledge and limited past involvement in the evaluation work. This industry expert could participate in parallel with the evaluation engineer and provide feedback to the evaluation team. The intent of this participation is to enable the evaluators to vet their findings and conclusions to generate the most rigorous possible findings.

EMS IWG RESEARCH SUMMARY

The research conducted by the EMS-IWG regarding EMS upgrades and replacements in facilities with existing EMS is summarized below. The research focused on three replacement scenarios that can occur when an existing EMS is being upgraded:

1. Full replacement of a legacy EMS.
2. Partial system replacement (such as replacing pneumatic control of VAV boxes with digital control in a building with a central EMS)
3. Component replacement such as replacement of I/O modules or JACEs.

In all cases the EMS-IWG team agree that the fundamental driver for energy savings associated with these

upgrades is not the hardware, but the enabling of improved communication and programming which allows more sophisticated and efficient sequences of operations to be implemented.

Research questions addressed include:

1. What does code require regarding the replacement of EMS?
2. What do other states do regarding EMS replacements?
3. What indicators do we have of standard practice in MA regarding EMS replacements?
4. Is there a threshold question regarding what, if anything, constitutes EMS failure thereby triggering a Replace on Failure (ROF) Baseline?

Code and Enforcement Review

Review of MA code requirements and compliance studies is summarized as follows:

- ▶ MA code: The Massachusetts Commercial Energy Code is based on the International Code Council's (ICC) 2015 edition of International Energy Conservation Code (IECC). Either the 2015 IECC or ASHRAE Standard 90.1-2013 can be used to demonstrate compliance with the Commercial Energy Code.
- ▶ Review of ASHRAE 90.1 Section 2 Scope, Paragraph 2.1a.3. indicates that the standard applies to new systems and equipment in existing buildings.
 - The code does not require an EMS, an EMS is simply a means for meeting some of the control requirements including in the code. These requirements can be met without the use of an EMS in many cases.
 - If this provision is interpreted as requiring PAs to use code baselines for the early replacement of equipment, then all savings would be significantly reduced as all measures would use a replace on failure baseline.
- ▶ Given agreement that program driven retrofits do exist the underlying question for EMS retrofits becomes what are the most common practices regarding replacement of legacy EMS or components of existing EMS? This is not answered in code documents nor in code compliance review documents for MA or other states. Past MA Energy Code Compliance Studies have focuses exclusively on new construction and major building-level renovation. There has been no research on the application or enforcement of Energy Codes regarding system and/or controls replacements.

The code compliance review did not provide any evidence to undermine the EMS-IWG's hypothesis that code is not applied to EMS replacements.

Practices in Other States

Interviews and email surveys were conducted with market actors engaged with EMS initiatives for leading programs across the country including the Pacific Northwest, California and the Midwest. The following table summarizes the findings:

Interviewee	Component Replacement	Partial System Replacement	Legacy System Replacement
Pacific Northwest	As operating	As operating	As operating
California	As operating (varies)	As operating (varies)	Code*

Midwest	As operating	As operating	As operating
<p>*- CA appears to have a uniquely rigorous approach to baseline. The issue is recognized by practitioners and thought leaders in CA. There will be an ACEEE paper on a new approach to this issue for CA utility programs. It is the perception of the CA participants and the PA/EEAC consultant group that Title 24 enforcement is considerably more rigorous than enforcement of energy codes in the Northeast.</p>			

Recent MA Evaluation Findings

The team reviewed recent project evaluations to understand how evaluation is currently treating EMS baseline questions. The following provides anecdotal evidence from recently evaluated projects about how EMS projects are currently being treated in MA custom evaluations:

- ▶ BAG 08032019 - slide 15 “upgrade from pneumatic to DDC + repair of failed dampers” – baseline was pre-existing with measure life constrained to an O&M measure life.
- ▶ 2017EV0030 – RCx project with leaking cooling valve – leak identified by EMS and repaired within one week. Project evaluated as an add-on with the pre-existing condition as baseline. Measure life of 5 years.
- ▶ 2017EVE1131N – laboratory HVAC control project which included the installation of new fume hood controls. Project developed as RCx/P4P. Evaluation baseline was pre-existing conditions with the project classified as a retrofit.
- ▶ 2017EH0168 – This site installed drives on hot and chilled water pumps and a local controller for the chiller plant. The building, which is part of a University, has an existing EMS which was found not working giving the impression that the new measures operate independently of the legacy EMS which was effectively abandoned in place.

The above cases are existing buildings with existing EMS evaluated using the pre-existing baselines. However, none of these projects involved replacement of the EMS.

Threshold Question Regarding EMS Failure

The PA/EEAC working group include multiple individuals with significant experience in the EMS industry. It is the consensus of this group that while there are a smaller subset of building operators who do replace legacy EMS without EE program involvement, in general EMS upgrades are necessary to achieve modern, efficient building operations but not necessary to operate buildings and their systems. This working group’s consensus regarding common practice is that EMS upgrades occur infrequently and are typically triggered by an energy study that identifies the energy, IEQ and maintenance benefits available from an EMS upgrade.

Anecdotal examples of the market’s acceptance of malfunctioning controls include:

- ▶ Project 2017EH0168 noted above – local system-level controls implemented where existing EMS is not functioning.
- ▶ 500,000 Sq. Ft. Energy Star Rated (score of 79) office building with central modern EMS and pneumatic controls on VAV boxes in multiple floors. Project cost to convert the pneumatic portion of the building to DDC controls estimated to be \$220,000. Project simple payback, including electric (primary) and gas (secondary) savings is less than 5 years. No action taken on this opportunity while numerous other EE measures have been implemented by this otherwise motivated customer.

- ▶ Columbia worked with a customer wanting to upgrade their controls system. Their current controls system is old (pneumatics and no programming) and lacks capability for modern, efficient operation. The project cost for software and panel upgrades alone is \$30k, none of which can be incentivized if the code is used as baseline. The project would involve further cost and engineering to develop and incorporate enhanced sequences of operation. The customer decided not to go forward with the project absent incentives.

The EMV team will be attempting to determine if the above scenarios are in fact representative of standard practice with broken, aged, failing EMS systems through the EMS ISP study. The EMS-IWG group views these scenarios as representative of our experience in the market.

Literature Review

The PA/EEAC Working Group undertook a literature review to identify studies that provided insight to the EMS baseline issue. PA team members reached out to E Source and CEE to get references for both studies and program delivery leads for interviews.

Papers reviewed included:

- ▶ 2014 XCEL Energy Process Evaluation of the Energy Management Systems Program – Colorado completed by Tetra Tech. This program offers incentives for new EMS systems for existing large customers. The process evaluation does not specifically state how baselines are established. However, Key Finding 5.2, Bullet 2 indicates that “...baseline conditions of existing equipment vary, from no existing integrated controls at all, to older pneumatic or direct digital control (DDC) systems.” The paragraph goes on to discuss an estimate that participant sites with existing control systems had an estimated 50/50 mix of pneumatic and DDC controls. These findings imply that the program uses the as found condition as baseline, regardless of the existence of controls. This is the only known EMS specific program in the country. No Impact Evaluations of this Program were identified.
- ▶ CA PUC Resolution E-4818, Feb. 9, 2017 published in response to Assembly Bill 802 which addresses energy efficiency savings as follows:

“...the commission <shall authorize> financial incentives, rebates, technical assistance, and support to their customers to increase the energy efficiency of existing buildings based on all estimated energy savings and energy usage reductions, taking into consideration the overall reduction in normalized metered energy consumption as a measure of energy savings. Those programs shall include energy usage reductions resulting from the adoption of a measure or installation of equipment required for modifications to existing buildings to bring them into conformity with, or exceed, the requirements of Title 24 of the California Code of Regulations, as well as operational, behavioral, and retrocommissioning activities reasonably expected to produce multiyear savings. (emphasis added)”

- ▶ The CA PUC published the following table to address baseline determination:

Table 1. Adopted Default Baseline Policy for All Sectors

Alteration Type	Delivery	Savings Determination	Shell & Bldg System and Add-On Equipment	Behavioral, Retro-commissioning, and Operational	Normal replacement	Accelerated replacement and repair eligible
New construction, expansions, added load	Any	Any	Code	N/A	Code	N/A
Existing buildings, including major alterations	Upstream & Midstream	Any	Code	N/A	Code	N/A
	Downstream	Calculated	Existing	Existing	Code	Dual
		Deemed	Existing	Existing	Code	Dual
		NMEC	Existing	Existing	Existing, Program Design	Existing
	RCT/experimental	Existing	Existing	Existing	Existing	
Non-building projects, including industrial and agricultural processes	Any	Any	N/A	Existing	Standard Practice	Dual

This does not specifically address the EMS Baseline issues that we are seeking to address in that the underlying question for projects affecting buildings with existing systems is whether those projects should be characterized as Normal replacement or Accelerated replacement and repair eligible.

- ▶ PNNL-22169 Small- and Medium-Sized Commercial Building Monitoring and Controls Needs: A Scoping Study, October, 2012. This study focuses primarily on controls architecture and the opportunity to improve building automation controls to better serve medium to small buildings. Insights regarding baseline determination include:

- An example EMS upgrade project in which they document the savings as the difference between pre and post energy consumption, indicating an as operating baseline. However, this building did not have a pre-existing EMS.
- Project Scope of Work drafted for EMS upgrade procurement includes the following language which implies support for existing conditions baseline when replacing a BAS:

Scope

Design and install (or upgrade) an existing small commercial building with a new (or upgraded) BAS that is affordable and capable of achieving between 15% and 30% energy reductions with simple paybacks of no more than 5 years.

- No distinction is made in this report regarding savings calculations for buildings with pre-existing networked controls vs those without such systems.
- ▶ PNNL-25985 Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction, May 2017. This study uses modeling of three building efficiency scenarios (low, medium and high

efficiency) to estimate savings potential for a variety of control related HVAC measures nationwide. While it does not directly address the pre-existence or replacement of controls, it appears to use the existing efficiency levels of these buildings as the default baseline.

Several other papers were reviewed but found to have no useful findings regarding EMS Baselines.

EMS IWG MEMBERS

The EMS-IWG is comprised of a group of energy professionals with deep experience in building controls and automation. The bios of the members follow.

Jennifer Chiodo, PE, LEED AP BDC (EEAC consultant, JLC Consulting) – Jen has worked in the building design, construction and energy efficiency sector for 35 years. In operating Cx Associates over the past 15 years, she focused on HVAC system controls commissioning in new and existing buildings and is highly familiar with the controls market.

Shane Heneghen (Liberty) - Shane has more than two decades of experience designing and installing industrial and commercial energy efficiency controls in the public and private sector. Shane currently leads Liberty in Massachusetts developing Commercial and Industrial energy efficiency programs and projects. Prior to Liberty he served as the Senior Project Manager Mechanical C&I for ENGIE, a nationwide energy engineering firm offering over 100 energy efficiency measures. In that capacity he was responsible for delivering energy projects from concept through construction ensuring energy goals were delivered. Some of his licenses and certifications include Environmental Engineering, Journeyman Electrician, Digital Controls, Building Data Analytics, and Building Commissioner.

Adam Jacobs (EEAC Consultant, Optimal Energy) – Adam serves as the C&I lead for the Massachusetts EEAC Consultant Team and has 9 years of energy efficiency experience in both public and private sectors. Adam served as the Energy Manager for the City of Boston where he oversaw and implemented EMS upgrades for dozens of public buildings. Before that, Adam worked for Johnson Controls as an energy analyst providing M&V for efficiency projects in client data centers which largely relied on HVAC controls strategies and EMS upgrades.

Amit Kulkarni (Eversource) - Amit has more than a decade of experience with New England utilities and over 20 years of experience in the energy and engineering industry. One of his current focus areas is technical program design and implementation. He is responsible for leading a team that develops EMS applications and guidelines for utility programs. Prior to his current work, he was responsible for design, commissioning and savings analysis of HVAC controls for C&I buildings and is very familiar with prevailing market conditions.

Zack Lippert, CEM (National Grid) - Zack has been in the energy industry for eight years as a Retrocommissioning Agent, Energy Engineer, Product Manager and now as a Lead Analyst for MA Energy Efficiency Programs. Prior to working for National Grid managed energy audits and retrocommissioning projects for commercial, healthcare and university clients in the New York City region. He also helped to develop a monitoring-based commissioning system for these clients.

Maryette Haggerty Perrault (Eversource) - Maryette has spent her professional career working to reduce the environmental impact of buildings through energy efficiency. Prior to joining Eversource, she worked as the Building Analytics Manager for the Retroficiency Analytics Platform developing rapid engagement tools to prioritize facilities within large portfolios and identify efficiency opportunities within each. At Eversource, she has led the effort to redesign the statewide retro-commissioning offering.

Lisa Zagura (Columbia Gas) - Over the past 13 years, Lisa has served as an analyst, mechanical engineer and manager on both the contractor and owner's representative sides. She specialized in HVAC, control systems and monitoring based commissioning predominantly in the laboratory and pharmaceutical sectors prior to her work at Columbia Gas.