Memo to:
Massachusetts PAs C&I Research Team and Energy Efficiency Advisory Council EM&V Consultants

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P73B – ENERGY MANAGEMENT SYSTEMS BASELINE OPINION MEMO

This memo provides the DNV GL team's opinions on the baseline event type of energy management system installations in Massachusetts supported by the energy efficiency programs. The baseline event types are discussed in detail in the Massachusetts Commercial/Industrial Baseline Framework (Baseline Framework).[1] No primary research was completed for this memo. This opinion is being provided at the request of the PA/EEAC team and is not intended to serve as the basis for the creation of any Industry Standard Practice baseline assumption nor does it attempt to define what industry standard practice is. The opinions provided are based on DNV GL staff's experience evaluating and reviewing proposed or installed energy management system measures. We begin the memo with a review of the current measure definition. We then provide our proposed approach for baseline type categorization, opinions on new market issues for this measure, a brief summary of the known codes and standards with relevant language relevant, and a discussion of the newer features available to customers. Finally, DNV GL presents ideas for future research that the PAs could pursue relative to this measure.

Energy Management System Overview

Energy management systems (EMS) are defined by the programs in the technical reference manual (TRM) and on the measure application. It is DNV GL's understanding that EMS systems can also be installed and supported as a custom measure. The measure definitions and descriptions are provided here to demonstrate the range of applications that could be considered EMS installations.

The program website currently describes the measure as "Energy Management Systems (EMS) that automatically turn off equipment through programmable electronic controls and meet eligibility requirements."[2] The 2016-2018 planning TRM includes the following key measure characteristics.[3] for non-custom installations.[4]

1. **Description:** The measure is the installation of a new building energy management system (EMS) or the expansion of an existing energy management system for control of non-lighting electric and gas end-uses in an existing building on existing equipment.

2. **Baseline Efficiency:** The baseline for this measure assumes the relevant HVAC equipment has no control.

[1] Available at: http://ma-eeac.org/wordpress/wp-content/uploads/MA-Commercial-and-Industrial-Baseline-Framework-1.pdf
[2] Available at: https://www.masssave.com/en/saving/business-rebates/energy-management-systems-and-vending-misers/
[3] Available at: http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf
[4] Available at: http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf

3. **High Efficiency:** The high efficiency case is the installation of a new EMS or the expansion of an existing EMS to control additional non-lighting electric or gas equipment. The EMS must be installed in an existing building on existing equipment.

4. **Measure Life:** For lost-opportunity applications, the measure life is 15 years. For retrofit applications, the measure life is 10 years.[5]

The 2017 measure application provides the most recent measure requirements referenced in the website definition:[6]

1. To qualify for an incentive, the building's new energy management system (EMS) must incorporate all EMS strategies listed if they are appropriate to the facility and equipment. Only EMS points associated with control of non-lighting electric end uses and gas end uses are eligible for incentives (i.e., fuel controls, lighting controls and alarm points are not eligible).

2. Only the installation of a new EMS or expansion of an existing system to control additional equipment is eligible for incentives. EMS must be installed in an existing building on existing equipment. The replacement of an existing EMS or existing control points or a software upgrade is not eligible for incentives. The installation of EMS on new equipment is not eligible for incentives.

3. An EMS shall include a central operator's station including a central processing unit, PC (local or remote), monitor and printer. The operator's station shall be capable of monitoring all sensors and field devices in real time. Communications shall be via modem, communications bus, wireless device or internet connection to other microprocessor-based field services.

There are multiple other terms and acronyms used in the controls market. Each term typically refers to a specific component, system type, or level of information or decision making.[7] **For this memo, DNV GL defines EMS as systems which control and monitor heating, cooling, and any other non-lighting energy consuming systems.[8]**

DNV GL Opinions

The information below represents the opinions of the DNV GL team relevant to the measure type categorization of the installation of new energy management system in commercial buildings. These systems can deliver significant energy savings through the tools and information available, but the complexity of these systems and the current market conditions create risks for energy efficiency program administrators. DNV GL recommends that the PAs consider and manage these risks when designing their programs.

In this memo DNV GL provides staff opinions on how DNV GL would approach determining the measure type classification on a case by case basis, new market conditions that should impact the key distinctions, expected measure type categorization of future installations, what role codes and standards have in measure type categorization, and how the capabilities of new installations can and cannot deliver energy savings. After these opinions, DNV GL provides research ideas for the PAs and EEAC consultants to consider.

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[5] Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1.

[6] Available at: https://www.masssave.com/-/media/Files/PDFs/Business/EMS_ApplicationForm_2017.pdf

[7] Informative overviews: https://www.melbourne.vic.gov.au/SiteCollectionDocuments/bms-the-basics-explained.pdf, https://buildingretuning.pnnl.gov/training/ddc_control_fundamentals/ddc_controls_part_1_pnwd-sa-8834.pdf

[8] ASHRAE uses a different definition, calling these types of systems Building automation (BAS) and Energy management systems are the overlays that draw information from the BAS and other sources to monitor and manage energy use. For the purposes of this memo we have chosen to be consistent with the terminology used by the MA PAs.

Baseline Type

In this section DNV GL provides basic guidance on how EMS installations should be categorized if reviewed on a project by project basis. We use the baseline event types shown in the Baseline Framework.

- The DNV GL team believes that EMS installations should be considered Early replacement (retrofit) projects with a pre-existing baseline condition throughout the measure life when all of the following are true:
  - The existing building controls system is operating and could continue to be operated in the near future (near future is likely around 2 years to prevent classification as ROF). If a site expects to make a major investment within 5 years, the EMS project should still be classified as Early replacement, but with remaining useful life consideration. This condition must be met even when the existing systems are standalone, manual, or no system.
  - A customer upgrades a functional but outdated controls system no longer supported by the controls vendor, or the existing and functional controls at the facility only reports system status.
  - The facility is under no contractual obligation to upgrade their controls system.
  - No change in the facility has resulted in a building or energy code requiring an EMS, set-back schedules, or additional controls.
- It is the opinion of the DNV GL team that under any of the following conditions installations are a clearly lost opportunity and industry standard practice should be the baseline:
  - There is a code requirement to install a building automation system. This would fall under New construction or major renovation.
  - There is a contractual obligation to do something to improve system control, scheduling, or reporting and an upgrade over the minimum required will provide energy savings. The baseline type should be Replace on failure.
  - The existing system can no longer maintain the required control of the building. The baseline type should be Replace on failure.
  - The participant is compelled to upgrade from their current control system. The baseline type should be Replace on failure.
- DNV GL offers the following opinion on categorization of EMS expansions:
  - Current eligibility guidelines state that “expansion of an existing system to control additional [existing] equipment is eligible for incentives”. DNV GL generally agrees that expansion of an existing system to control existing equipment should be classified as an Add-on.
  - If an EMS system is expanded or upgraded at the same time of a major renovation project, it should generally be considered Lost Opportunity, New Construction even if the HVAC equipment is not replaced. However, there may be circumstances specific to each individual case that could make this scenario an Early replacement.
  - If an existing EMS system’s capacities are expanded with new software and firmware this should be classified as Add-on. However, software only changes likely have a shorter measure life due to the likely need for additional upgrades in relatively short time period.

- If a project is completed to consolidate proprietary controls or allow one system to control another system, then the project should be considered an Early replacement. Control companies can reach agreements or acquire another manufacturer and the change allows for expansion of some EMS system capabilities.
- If an existing EMS system's capacities are expanded when new unitary equipment is installed, the measure should be classified as Replace on failure.

Current Market Conditions

In this section, DNV GL presents three market conditions our team has observed through evaluations of energy efficiency programs. DNV GL staff believe each condition exists in the current market and that each condition's prevalence will change over time. None of the three conditions exist across the entire market for EMS systems.

- The DNV GL team believes the reduction in control system costs and increase in labor and maintenance cost are two factors driving the current EMS market. We have observed that some organizations now view centralized EMS systems with remote access to their portfolio or buildings as the least cost method for managing building systems. Even without efficiency programs, organizations find it in their financial interest to upgrade systems. Upgrading to new EMS allows many organizations to manage their facilities with fewer staff hours. While this may positively impact the customers motivation for upgrading the equipment and creates an opportunity for systems to offer value beyond efficiency; it also increases the likelihood that any new system will not result in efficient building operation. This market condition is likely to result in a greater percentage of EMS installations being Replace on Failure due to customers having a compelling reason to install a new system.
- Similarly, DNV GL staff also expect that a lack of support (including institutional knowledge) for existing older EMS systems (such as pneumatic systems) and the inability for some systems to communicate with each other is compelling a portion of the market to upgrade. The cost to upgrade may have been prohibitive for a long time and facilities were generally able to make do with their outdated but for the most part functional systems, ., Based on our teams recent evaluation experience, that is no longer the case across the market. Rather, the benefit-cost assessment has changed for some facilities and they are upgrading as the cost of the new system no longer outweighs the cost to maintain the existing system.[9] As an illustrative example from a similar industry, DNV GL has recently observed buildings upgrading their elevator controls because no one in the local market knew how to service the old system resulting in more expensive and time delayed service. DNV GL learned that the local technical training programs were no longer teaching the systems as the skill set is no longer in demand by enough employers. We believe that a similar transition is currently happening in the EMS market. This market condition likely results in a greater percentage of EMS installations being Replace on Failure due to customers being compelled replace their existing system.
    - Important note: Information showing deferred investment and therefore a customer's inability to make the capital commitment necessary for the installation is evidence of Early replacement. Similarly, information showing recent repair of major equipment or policies regarding repair are

[9] A number of factors may contribute to this calculation including the falling cost to upgrade, diminishing institutional knowledge and/or lack of software upgrades for the old system, lack of manufacturer support for the old system, or the rising cost to maintain the status quo.

evidence of Early replacement. DNV GL believes that potential early replacement projects also still exist within the PAs service territory.

- Most new unitary equipment arrive equipped with the capability to communicate with a new DDC systems or with an independent web based control interface. When old unitary equipment is replaced, the building therefore also achieves an expansion of the EMS system. However, as with many other energy efficiency measures, correct operation of the equipment is required to achieve efficiency. Efficiency programs should not provide incentives or rebates for EMS expansion when the expansion is achieved through the installation of new unitary equipment. DNV GL would categorize the measure type for systems in unitary equipment as Replace on failure (ROF). Rebates or incentives should be provided only when an energy efficient control strategy is also implemented. DNV GL also believes the existence of these systems in new units can lower the incremental equipment measure cost for full building energy management and will make transitioning from local to central control possible for some customers.

Each of the three above conditions suggest to DNV GL that the percent of Replace on failure installations completed each year compared to Early replacement will increase over time. DNV GL believes both measure category types are occurring in the program today and that the future program design will impact the fraction of each that participate. One indicator of the percent of participants compelled to upgrade may be measure freeridership rates. DNV GL believes EMS program participants that were compelled to install a new system for any reason will have a higher freeridership score than true Early replacement participants.

Code and Standards

The following codes and standards have language relevant to energy management systems. Generally, these codes and standards require that some sort of monitoring and control exists that is intended to reduce consumption, but the language does not provide specifics on building operation. When a site is compelled to meet a code or standard, then the systems required by the code should be considered baseline and standard practice should determine the assumed building operation. In cases when a participant's organization has chosen to meet a voluntary standard, then project baseline is uncertain, but the program risks freeridership adjustments when supporting such installations.

- ISO 50001 – Requires the establishment of an analysis and reporting format around the use of energy that reduces business risk and improves productivity and operations. EMS/BMS are tools typically employed and part of the analysis function. There are no standards or requirements set for these systems.
- ANSI/MSE 2000-2008 - Specifies requirements for a management system for energy (MSE) that enables an organization to take a systematic approach to the continual improvement of energy performance. Energy performance may include improved energy intensity, increased use of renewable energy and reduced expenditures for energy. No specific equipment is recommended. EMS/BMS are tools to achieve the required performance but no minimum digital controls are specified.
- 2015 International Energy Conservation Code – Does provide minimum criteria for temperature control, unoccupied temperatures and controls, on/off scheduling and other HVAC components and operations. Levels of control are identified and basic local controls are considered the minimum equipment [time clocks, local programmable thermostats, etc.]. The IECC can provide some minimum criteria for baseline requirements.

- The 2009 International Building Code – Energy efficiency is referred to *International Energy Conservation Code (IECC)* discussed above. This building code essentially states that buildings must compress the IECC. See SECTION 1301, GENERAL
  - *1301.1 Scope. This chapter governs the design and construction of buildings for energy efficiency.*
  - *1301.1.1 Criteria. Buildings shall be designed and constructed in accordance with the International Energy Conservation Code.*
- ASHRAE 90.1 – This standard provides prescriptive and mandatory control requirements that are both cost effective and can improve the energy performance of building systems and overall building. The standard specifies the control requirement along with various setpoints for building spaces, HVAC equipment and systems. However, ASHRAE 90.1 does not mandate the building to have any specific form of control system. Thus, the control requirement for building spaces, equipment and systems can be attained either with an equipment built-in controller for a given building category and size or with a dedicated centralized EMS to control large number of buildings or HAVC systems. Additionally, the standard recommends the commissioning aspect for HVAC control system serving projects larger than 50,000 sq. ft.

Potential for Savings

New EMS systems typically have capabilities that older systems do not and these capabilities can provide savings with proper program intervention; however, savings achievement often requires changes in operator behavior. Commissioning and recommissioning is necessary to ensure that the programmed controls and setpoints work. The capabilities of new systems may include:

- **Remote access** – This can save energy if it results in building operator spending more time reviewing building performance and making efficient adjustments. Does not save energy without operator interaction and change in behavior. The labor cost savings associated with the ability to remotely access the system is typically mentioned when reviewing new system features with participants.
- **Visual information display** – Can save energy if displayed information helps operator understand building better and make decisions that reduce consumption. Some displays show the results of automated fault detection and diagnosis. Does not save energy without operator interaction and change in behavior.
- **Multi-building/site access and control** – Similar to remote access, if the ability to control and observe multiple buildings on one platform increases the attention to any building and operators take new actions, energy savings can be achieved.
- **Automatic controls based on system operation** – Many systems now come with pre-packed algorithms such as floating head pressure control in grocery. These will likely save energy over pre-existing systems as long as the new controls are enabled. However, if the new system's automatic setpoints are relaxed or the same as the pre-existing setpoints, no or negative energy savings will be achieved.
- **Smart learning controls** – Some systems come with learning controls (will likely be referred to artificial intelligence in the future). These systems observe building operation and then begin to

automatically adjust schedules to optimize specific parameters (similar to Nest thermostats). These can save energy, especially if the building did not previously have an active operator.

- **Increase in control points and information monitored that includes analysis, comparison, target setting, and reporting** – These can save energy by providing operators with more information if the increase in information results in actions by the building operator. Building operators have been observed to regularly change set-points based on the feedback received from the new sensors.
- **Demand response modules** – Should not be assumed to impact annual energy consumption.

Despite the promise of savings from these new features, it is also feasible that new EMS installations may not save energy or save less energy than promised. There are a number of factors that could drive this sort of result including:

1. **Tight Pre-Existing Scheduling –** If the pre-existing condition includes occupied and un-occupied schedules that follow building use then a new EMS may not save significant energy (active building operators). DNV GL has found that the installed condition does not typically significantly improve the building scheduling. In some cases, the schedules have been found to be relaxed compared to the pre-existing condition.
2. **Limited Behavior Change –** New systems often enable organizations to do things differently. However, in some cases the new system is only used to identify and respond to issues and alerts faster. This does not result in significant energy savings.
3. **Broken Equipment –** The equipment controlled by the EMS must function correctly for savings to be achieved. For example, new economizer controls will not save energy if the economizer cannot open and close. Any installation of a new EMS at an existing facility should confirm that controlled equipment is operating correctly.

Savings Opportunity

When considering whether there are any savings opportunities for Lost Opportunity projects, the DNV GL team believes that:

- Energy savings exist for lost opportunity projects in how the EMS is used to optimize building performance relative to standard practice using these same controls. The opportunity is therefore in a building's ability to operate compared a standard practice benchmark.
- Additional opportunities for energy savings will exist with increased use of machine learning or artificial intelligence in energy management. The savings potential is still unknown and will require research as the algorithms and technologies become available to the market.

Research Opportunities

DNV GL staff identified the following research activities that could be completed to support the acquisition of energy efficiency savings through improved building control:

1. **Standard Practice Performance** – The evaluation team could utilize the utility meter data, public records, program records, and market characterization studies to estimate standard practice building consumption metrics.
2. **Standard Practice Sequence of Operation** – Evaluation could complete market research focused on identifying key assumptions for the standard practice baseline for lost opportunity installations.
3. **Focused Market Research** – The evaluation team could complete focused market research to provide PAs with suggestions for measure and program design specific to a market segment. This research should focus on sectors with potential for energy savings that the PAs would like to adjust their offering for.