MA ENERGY EFFICIENCY ADVISORY COUNCIL

Potential Innovative Options to Explore

Briefing Documents for October 31 EEAC Commercial & Industrial Planning Workshop

Prepared by DOER, the EEAC Consultant Team (Optimal Energy) and the Massachusetts Program Administrators

October 30, 2017

EEAC Commercial Workshop #2: October 31st—9:00 to 1:15

Potential Innovative Options to Explore

Facilitators: Dr. Jonathan Raab, Raab Associates & Toby Berkman, CBI

Agenda

9:00 **Introduction and Overview**

9:05 **Lighting & Controls**

Short presentation including draft potential strategic recommendations; Q&A; discuss any modifications/additions/alternatives and finalize recommendations

10:00 **HVAC & Controls**

Repeat same process as under Lighting & Controls

10:55 **Break**

11:15 **New Demand Management Opportunities**

Repeat same process as under Lighting & Controls

12:00 **Fuel Switching**

Repeat same process as under Lighting & Controls

12:45 **Wrap Up and Next Steps**

1:00 **Public Comment**

1:15 **Adjourn**

Document Overview

The C&I briefing document content was developed by both the EEAC Consultants and the Program Administrators. Each topic has the following sections:

- → Overview Prepared by Consultants and PAs – This section is intended to be an impartial look at the topic and its context in Massachusetts
- → EEAC Consultant Team Findings – a summary of the Consultant team thoughts on barriers and solutions on the topic
- → EEAC Consultant Team Strategic Recommendation – A single strategic recommendation proposed by the EEAC Consultants proposed as a starting point for discussion at the workshop.
- → Program Administrator Provided Information – A PA prepared section on the topic
- → Appendices contain detailed information on the topic by the Consultant team

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TOPIC #1 – LIGHTING AND CONTROLS

OVERVIEW PREPARED BY CONSULTANTS AND PAS

This brief addresses potential lighting energy efficiency opportunities in the 2019-2021 Massachusetts Energy Efficiency Plan. In 2016, lighting made up 57% of net lifetime commercial and industrial (C&I) electric savings, and was a major component of all electric retrofit initiatives. Lighting savings have remained strong, persisting after advances in technology and the efficiency programs have caused a significant reduction in New England lighting energy consumption, which dropped 50% between 2003 and 2012.[1] Lighting will continue to be an important source of C&I energy savings in 2019-2021. This brief describes the current sources of lighting savings in Massachusetts as well as remaining savings opportunities from LED linear retrofits, controls, and new program delivery models designed to make lighting retrofits more appealing to commercial customers.

Table 1. Quick View of Massachusetts Program Activity2

Topic	Lighting Savings
Contribution to C&I net lifetime 2016 savings	57%
Cost to achieve (incentives only)	$0.02 per lifetime kWh, $0.23 per annual kWh
Current market activity	Strong
Projected market	Good for linear and controls

Status in MA

Lighting is a key component of nearly all electric C&I initiatives. For example, most of the savings from 2016's largest lighting initiative, C&I existing buildings retrofit, came from custom lighting measures. Lighting controls were also most prevalent within this initiative. Upstream lighting was the second largest contributor to lifetime lighting savings in 2016, 81% of which was from screw in LEDs.[3]

Table 2. 2016 Lighting Savings and Contribution Summary by Initiative[4]

Initiative	Net Lifetime Lighting Savings (MWh)	Lighting as % of initiative savings
C&I Existing Building Retrofit	2,247,891	50%
C&I Multifamily Retrofit Core Initiative	56,469	69%
C&I Small Business Core Initiative	1,264,109	94%
C&I Upstream Lighting Core Initiative	1,758,204	100%
C&I NC - Initial Purchase & End of Useful Life	181,964	14%
C&I NC - New Buildings & Major Renovations	320,398	39%
Total - All Initiatives	5,829,035	59%

C&I lighting savings in Massachusetts can be achieved through three different savings calculating tracks, prescriptive, custom, and upstream. Each track is designed to meet specific needs of the lighting market. For large projects with many fixtures, custom allows for increased replacement of whole fixtures (as opposed to upgrading or re-lamping an existing fixture), increased controls, and for the use of advanced lighting design. The prescriptive track provides rebates after the sale is complete, so it allows for the least amount of program influence at the time of sale, but strives to influence the market by including a whole range of measures. Upstream is the most accessible and least cost-to-achieve track, but limits the number of fixtures per customer in order to steer larger projects to the custom initiative where the PAs have the most influence.

[1] https://www.eia.gov/consumption/commercial/
[2] BCR Screening Models, 2016
[3] Ibid.
[4] Ibid.

Savings have shifted from being 76% prescriptive in 2011, the year the upstream initiative was first launched, to being distributed more evenly across all three tracks in 2015. Upstream savings have increased because it is the most accessible path to participation. Custom savings have increased as the PAs have engaged with customers to do large custom projects. As seen in the chart below, upstream lighting was the largest contributor to gross annual lighting savings in 2015. However, the chart below indicates that the share of lifetime upstream lighting savings is lower than the share of annual upstream lighting savings. Upstream savings tend to come from lamp sales, which have shorter measure lives than fixtures. This difference is heightened in 2016 compared to 2015 levels, and is partly due to the upcoming Energy Independence and Security Act (EISA) standard which is shortening the measure life of screw-in lamps by making LEDs the baseline for general service lamps in 2020. Savings from the prescriptive and custom tracks tend to be from fixtures, which have longer measure lives and are not impacted by the EISA regulations.

Table 3. Lighting Savings by Track, 2015 and 2016[5]

Contribution to savings					Cost of savings
Track	**Gross annual 2015**	**Net lifetime 2015**	**Net annual 2016**	**Net lifetime 2016**	**Incentive $/ gross annual kWh (2015)**
Custom	26%	64%	55%	70%	$0.27
Prescriptive	32%				$0.43
Upstream	42%	36%	45%	30%	$0.23

In comparison with the other PAs, Eversource saves proportionally more from the upstream and custom tracks. Other PAs have customers who utilize the prescriptive program more.[6]

A recent draft upstream impact evaluation for 2015 revealed that with the exception of linear T8 LEDs (TLEDs) and G24 lamps, all other upstream lighting products, mainly A-lamps, had realization rates significantly less than 100%. The realization rate for TLEDs was very high at 198%[7], which is fortunate for the program as the lighting market shifts away from screw-in lighting toward linear lighting.

There is also a market shift from high pressure sodium, mercury vapor, and metal halide streetlights and other exterior lighting to LEDs. Most of the customer owned streetlights in the eastern part of Massachusetts have been upgraded at this point, leaving most of the streetlight opportunity in National Grid and Eversource West territories. These are mostly utility owned streetlights.[8] For outside lighting typically mounted on a wall, exterior wall-pak LED lighting is now offered upstream, which may increase uptake of this measure. [9]

[5] http://ma-eeac.org/wordpress/wp-content/uploads/Final-Deep-Dive-Report-Advanced-Lighting.pdf, BCR screening models (2016)

[6] http://ma-eeac.org/wordpress/wp-content/uploads/Final-Deep-Dive-Report-Advanced-Lighting.pdf

[7] Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Program

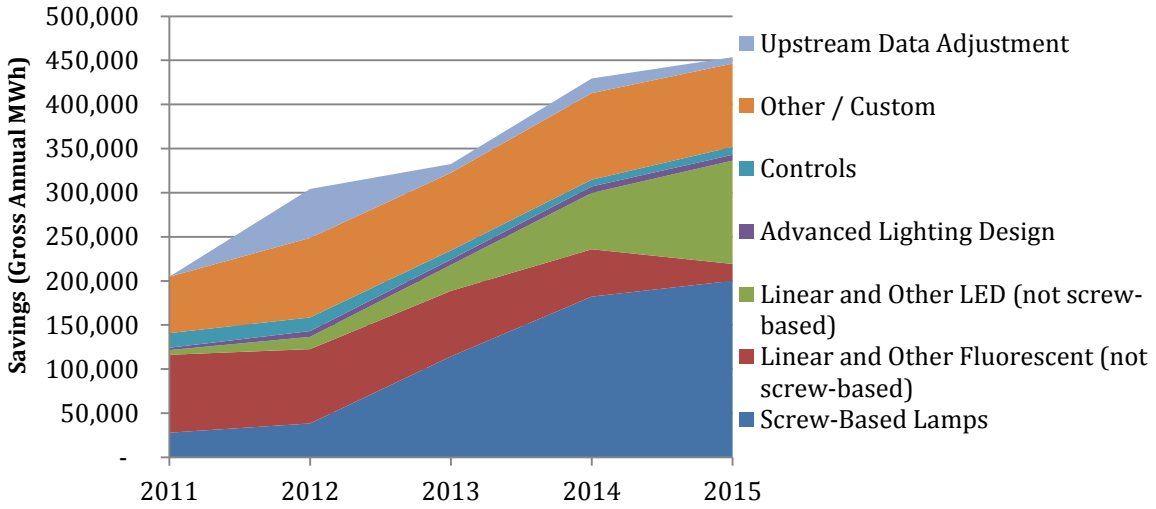
[8] http://ma-eeac.org/wordpress/wp-content/uploads/PA-EEAC-LED-Street-Lighting-Presentation-Final.pdf

[9] When LED troffer fixtures were offered upstream their market share increased from 30% to 70%. https://aceee.org/files/proceedings/2016/data/papers/7_384.pdf

Current Technologies

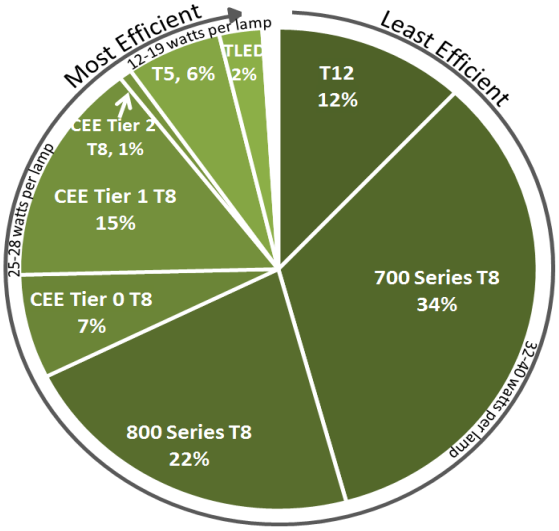
The upstream screw-in savings contribution in Massachusetts has likely peaked and may be on the decline.[10] As seen in Figure 1 below, screw-based lamp savings were flattening as of 2015, fluorescent technology savings were declining, and linear and other LED savings were increasing. Linear LED uptake will need to continue growing at a higher rate, in order to maintain current C&I upstream lighting savings levels.

Figure 1. Historical Savings by Lighting Technology[11]



Baseline linear lighting represents a large portion of the C&I lighting currently installed in Massachusetts. Almost 75% of the C&I interior lighting is linear and 68% of that lighting is baseline efficiency.[12] As seen in the pie chart to the right, less efficient T12 and standard efficiency 700 and 800 seriesT8 lighting still make up the majority of the existing linear lamps in Massachusetts. However, the newest linear lighting technologies use 70% fewer watts per lamp than the oldest technologies (12 watts per lamp compared 40 watts). Therefore, significant savings can be achieved by replacing outdated linear lighting with the latest available LED fixtures and TLEDs.[13]

Figure 2. Efficiency by Linear Lamp Type



In addition, the savings opportunities from linear lighting and controls also have significant savings potential. A case study from the United States General Services Administration projects documented savings potential from properly tuned controls.[14] In two office spaces, LED fixtures with integrated controls reduced lighting energy by 69%, of which controls were responsible for 28% of savings.

[10] The Consultants have seen a declining LED screw in savings trend in other New England states, but have been unable to confirm this trend in Massachusetts due to a lack of current information from the PAs. In addition, poor realization rates will depress screw-in LED savings in the future.

[11] http://ma-eeac.org/wordpress/wp-content/uploads/Final-Deep-Dive-Report-Advanced-Lighting.pdf

[12] http://ma-eeac.org/wordpress/wp-content/uploads/MA-CI-Market-Characterization-Study.pdf

[13] While the Market Characterization Study does not look at hours of operation, the MA TRM provides typical hours of operation in Table 5, page 388 for many C&I customer building types. Most C&I building types operate lighting more than 4000 hours annually. http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf

[14] http://www.gsa.gov/portal/mediaId/240295/fileName/GPG_Findings_024_-_LED_Integrated_with_ALC.action

Installing integrated controls is also beneficial to contractors because they are easier and faster to install and commission than separate controls.

EEAC CONSULTANT TEAM FINDINGS

Innovative Technologies

Changes in lighting technology are creating a dynamic and exciting market that offers new potential for both energy and demand savings in the C&I sector over the next decade.

Figure 3. Philips EasySmart TLED

Rapid innovation in LED lighting products and falling costs are stimulating the lighting market beyond what would be driven by energy efficiency programs alone. This innovation is providing multiple controllable options for customers to upgrade linear lighting systems. For example, in addition to LED fixtures with integrated controls, there are now wirelessly enabled TLEDs that can be controlled by an occupancy sensor, a daylight sensor, or dimmed to tune for light levels.[15] The product specifications estimate a 50% savings from a standard T8 baseline. New technologies, falling costs, significant run hours, and a substantial inventory of existing inefficient lamps all indicate the C&I linear lighting market should be a driver of savings in the 2019-2020 Three Year plan.

Other Considerations

In additional to innovative technologies, new service and delivery models are emerging to provide customers with more efficient lighting. Lighting as a service (LaaS), for example, is a new model for customers to access and pay for lighting, which may be able to address cost barriers and allow for customers to use the latest technology as soon as it becomes cost effective. This model is based on a subscription service, where customers pay for the installation of efficient lighting and electricity consumption on a monthly basis. The model allows customers to make payments to a third party provider based on the savings achieved from the new more efficient lighting. LaaS providers may also provide on-going lighting system maintenance during the contract period and will replace light bulbs upon burnout or when more advanced and efficient technology becomes available.

Barriers and Opportunities

The table below describes the barriers to achieving lighting savings and the opportunities to overcome those barriers and transform MA lighting systems to state of the art digital lighting systems.

BARRIERS	OPPORTUNITIES
Technology is improving faster than evaluation can document savings	Revise savings estimates more frequently alongside advancements. Improve required efficacy of program supported products to increase savings.
Prescriptive program is not as easy to participate in as upstream program, or as impactful as custom	Maximize savings by driving customers to participate through the upstream and custom pathways
The lighting market is ever changing; Vendors and contractors not up to date on controls	Educate vendors on selling, installing and commissioning controls
Lack of knowledge about the capabilities of LEDs: color tuning, dimming, long life	Educate owners – maintenance cost reductions and improved environmental quality two big pluses for LED in addition to building asset value
Cost of fixtures with integrated controls can impede adoption of highest savings measures	Lighting as a service model may be an effective new approach to deliver savings with subscription payments. Work with ESCOs and lighting as a service providers to drive deep retrofits.

[15] HTTP://WWW.USA.LIGHTING.PHILIPS.COM/PRODUCTS/PRODUCT-HIGHLIGHTS/INSTANTFIT/EASYSMART

Lower than anticipated use of controls, and higher than necessary light levels are common issues impeding lighting savings	Incentivize lighting design to promote good design, controls, and moving beyond one-for-one swaps.
Utility owned streetlights need a company-owned LED streetlight tariff to justify upgrading to LEDs	National Grid and Unitil have such tariffs. Eversource has a pending rate case. CLC has already upgraded to LED.

Savings Potential

The consultants believe that the linear market represents the most potential for savings in the 2019-2020 Three Year plan. Controls could provide additional energy and demand savings. There are also a significant number of utility owned streetlights that could be upgraded to LED if there was an appropriate tariff structure.

Fixtures

- → LED fixtures with integrated advanced controls offer the most savings, best light quality, and provide an opportunity to reduce passive demand and potentially manage active demand or respond to an ISO New England emergency event.
- → TLEDs are the lowest first cost and show promise for savings through technology advancements. The new wirelessly controlled TLED address past concerns about lack of control, but are still dependent of the life of existing ballasts.

Controls

- → Tuning, or dimming light levels to be appropriate at time of installation, can drive immediate and long term savings and demand reduction.
- → Addressable fixtures save energy and provide employee satisfaction benefits – but may have maintenance barriers.
- → Networked lighting controls have potential active demand response benefits. In addition, controls have passive demand reductions if coincident with peak.

EEAC CONSULTANT TEAM STRATEGIC RECOMMENDATION

The Council would like to see the PAs maximize C&I lighting savings, with an emphasis the linear lighting market. Methods to consider include:

- → A new offering to increase the penetration of advanced controls
- → A broad-based linear lighting delivery strategy, that also identifies other potential customer energy efficiency opportunities to use as lead generation for the PAs and their vendors
- → Expanding lighting design service support through a lighting design initiative
- → Increase participation in lighting initiatives (including upstream) by increasing marketing, outreach and technical support to customers, contractors, and trade associations

PROGRAM ADMINISTRATOR PROVIDED INFORMATION

The PAs largely concur with the lighting overview and Consultant Findings above. The PAs constantly work to find new approaches to deliver more lighting savings opportunities with a focus on quality for customers and the Commonwealth.

TOPIC #2 – HVAC AND CONTROLS

OVERVIEW PREPARED BY CONSULTANTS AND PAS

This Brief addresses heating, ventilation and air conditioning (HVAC) energy efficiency opportunities in MA commercial, and industrial (C&I) facilities. HVAC systems provide elements of indoor environmental quality necessary to support business operations including comfort and fresh air and consume over half of the total energy and 25% of electricity used in commercial buildings in New England[16] and will therefore be an important consideration for achieving all cost-effective energy efficiency in the market in the 2019-2021 Plan. HVAC systems are typically custom designs, unique for each building and space. They have controls that range from individual thermostats to computer operated building automation systems (BAS). Almost all buildings in the C&I market have HVAC equipment; while systems are highly varied, they typically include electrical loads for cooling and distributing air and water as well as fossil fuel combustion equipment to provide heat. There is a correlation between utilities' HVAC savings and their overall savings achievement (in other words, utilities that garner more HVAC savings have higher savings overall).[17]

Reducing HVAC energy use requires efforts in three areas:

1. **Supply Chain:** When new HVAC equipment, it should be as efficient as possible and correctly sized. Due to long measure lives for HVAC equipment, installing the most efficient equipment that is cost-effective and sizing it to meet loads will maximize benefits over the life of the HVAC system.

2. **Optimized Systems:** HVAC systems are complex and dynamic. System operation and control can be improved to maximize indoor environmental quality (IEQ) to the end users and minimize energy input. Systems that are designed, tuned and operated in this manner (highest benefit; lowest energy input) are considered optimized. System optimization opportunities range from comprehensive energy driven system retrofits to tuning existing systems without major upgrades.

3. **Efficient Operation:** Even when efficient HVAC equipment is installed and optimized, building operators can override controls. System overrides often result in systems that waste energy and/or don't consistently meet IEQ standards. Maintaining and monitoring HVAC systems are critical to ongoing performance.

Addressing these three areas is necessary to reduce electricity and natural gas consumption for C&I HVAC systems.

Table 1 provides a quick overview of the MA program activity in the HVAC end-use.

Table 1 Quick View of Massachusetts Program Activity

Topic	HVAC Savings
Contribution to C&I gross annual 2015 savings	HVAC comprised 3.6% of projects and 10.3 % of electric savings[18] and 31% of gas projects delivering 39% of gas savings[19]
Cost to achieve (incentives only)	$0.027 per lifetime kWh and $0.20 per lifetime therm[20]
Current market activity	Diminishing savings over past 4 years
Projected market w/ increased PA activity	Very good

[16] Regional building average data from Commercial Building Energy Consumption Survey 2012 (CBECS).

[17] 2016 PA Differences Study (published in 2017)

[18] Final 2015 C&I Expedited Customer Profile Report Tables 5-2 with Motor/Drive savings and counts allocated to HVAC from Tables 5-17 and 5-18.

[19] Final 2015 C&I Customer Profile Report Table 6-6.

[20] Calculated from 2015 Benefit-Cost Model.

Status in MA

The HVAC market includes many market actors who can influence the efficiency of HVAC systems. A map of Market Actors is included in Appendix A. The Massachusetts PAs address HVAC efficiency using several strategies to influence efficiency decisions in the market as shown in Table 2. Not all offerings in Table 2 are available or applicable to every Massachusetts C&I customer.

Table 2 MA HVAC Program Offerings

Mass Save Offering	New Buildings/Major Renovations	End of Life Replacement	Equipment or System Retrofit	Electric Contribution[1]	Gas Contribution[1]
Upstream	Efficient equipment	Efficient equipment		~15%	Note[2]
Prescriptive Rebates	Efficient equipment	Efficient equipment	Efficient equipment + thermostats	~11%	~14%
Custom Projects	Efficient equipment + control		Efficient equipment + control	~74%	~86%
Comprehensive Design Assistance	Optimized systems		Optimized systems	Varies[3]	Varies[3]
Pay for performance			Optimized systems	Very Low	Very Low
Retro-commissioning			Optimized systems	Very Low	Very Low
Building Operator Certification			Control	Low	Low

1. Contribution to savings is the share of total C&I savings from 2016 Mass Save Data
2. Data not applicable.
3. Market engagement with programs for large new construction projects is moderate to high; smaller new construction projects are less likely to engage in comprehensive design; comprehensive design assistance participation for existing buildings is very low.

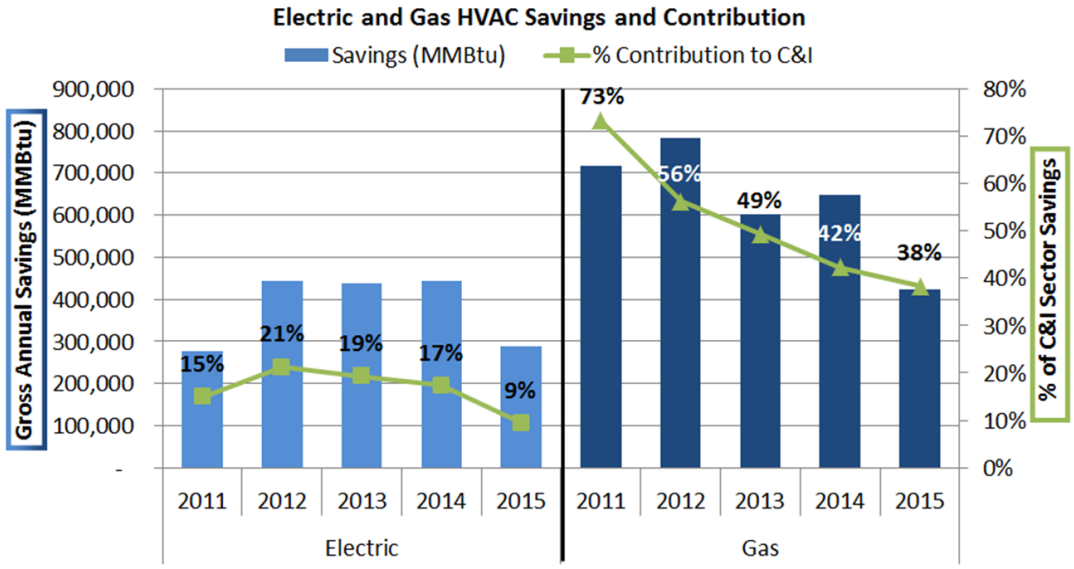
In 2015, gross annual C&I electric portfolio savings were approximately 2% of the C&I customer electric load. This is a form of indexing savings to the load. If the savings from HVAC projects were proportional to HVAC load, then one might expect to see HVAC savings match the overall C&I savings rate of 2% of load. However, electric HVAC load for C&I customers, savings were estimated to be only 1% of HVAC load. This suggests that HVAC as an end use is contributing less than its potential share to total load reduction. There is a correlation between PA HVAC savings and their overall savings achievement (in other words, utilities that garner more HVAC savings have higher savings overall).[21] This means that electric HVAC savings are small relative to the percent of load represented by HVAC.

The gas indexing is more proportional. Gas savings directly attributed to HVAC measures comprised about 0.7% of the C&I Gas savings which is comparable to total C&I gas savings as percent of load.

Savings from HVAC measures have been decreasing both in real energy reductions and percent of savings over the past several years as shown in Figure 1.

Figure 1 HVAC Savings Over Time

[21] http://ma-eeac.org/wordpress/wp-content/uploads/2016-PA-Differences.pdf



However, evaluation results have suggested that there are opportunities for improving current programs to achieve greater HVAC savings. Evaluation results relevant to HVAC are summarized in Appendix C. Themes across evaluations include:

- → The need for increased education and training
- → Opportunities for improved statewide marketing
- → Differences in PA outcomes for HVAC – PAs have an opportunity to expand best practices statewide
- → Significant HVAC opportunities remaining in all PA territories[22]

EEAC CONSULTANT TEAM FINDINGS

Savings Potential

The contribution of HVAC to electric savings had not been proportional to the HVAC load within buildings. The electric HVAC indexing is low. The programs have recently achieved over 50% of savings from lighting that represents only 17% of building loads on average and only 11% from HVAC which represents over 25% of the electric load.[23] To reverse the HVAC savings decline the PAs should seek to achieve 4% reductions of HVAC load across the market (2015 achievement was an estimated 1% in HVAC energy consumption) by developing the market capacity to consistently deliver HVAC projects that reduce customer HVAC electric use by 25% or more.[24] These projects should also target gas reductions of similar or greater magnitude driving gas savings from 0.7% of load to 3-4% of load through increased system optimization coupled with building envelope improvements.

The Massachusetts programs focus on driving a high volume of efficient equipment at time of replacement through the prescriptive and upstream initiatives. Because time-of-replacement purchases only happen every 10 or 20 years for a lot of HVAC equipment, it is really important to capture as much of these naturally occurring opportunities as possible to maximize savings. The Consultants estimate that between 4,000 and 6,000 buildings

[22] The MA C&I Market Characterization Study identified opportunities for efficient equipment replacements and upgrades of building automation systems. This is discussed in more detail in the Appendix.

[23] Total load percent from Commercial Building Energy Consumption Survey Data and PA savings percentages from 2015 Customer Profile Report.

[24] MA EEAC Consultants regularly implement HVAC projects across a variety of C&I customer types that save 25% or more of HVAC energy use. For the largest customers, these reductions are at the system level, not facility level, but in most cases it is cost effective to drive down HVAC energy use through system optimization coupled with strategic equipment retrofits and new controls.

need electric HVAC equipment replacement annually in Massachusetts. Similarly, the Consultants estimate a range of 1,000-1,500 gas fired equipment replacements annually.

The Massachusetts PAs completed 423 electric and 481 gas custom HVAC projects in 2015. While these projects delivered the bulk of HVAC savings, as expected, the total savings averaged 134,000 kWh/project which is only about twice what was achieved through gains in incremental efficiency improvements under prescriptive and upstream programs. In general, incremental efficiency improvements save 1-5% of system HVAC energy use while system optimization should save 5-10 times as much energy.

Comparison Area Information

Three examples from other states or provinces may help illustrate some opportunities for program improvements in Massachusetts.

Upstream Program

Upstream HVAC program approaches have been successfully developed in other states. Massachusetts launched its C&I upstream HVAC initiative and the number of measures available through this initiative has been growing.

Efficiency Vermont implemented a comprehensive planning and engagement strategy for upstream HVAC that made distributors active partners in program development, incentive levels and implementation. [25] Using this strategy, they drove major increases in market share of equipment through the upstream program:

- → High performance circulator pumps went from 1% to 57% market share in two years
- → Heat pump hybrid water heaters (50 gallon) sales increased by 32% in one year
- → Cold climate heat pump sales increased 44% in one year

While these advances are noteworthy, the savings that are derived from new equipment sales, as mentioned earlier, are relatively small due to relatively high baselines. However, it is important for the programs to work to maximize the market share for efficient new equipment. While Massachusetts has also seen dramatic year over year increases in sales for many upstream HVAC measures, we do not have information on market share to fully understand the penetration of efficient equipment in the Massachusetts.

As described below, Program Administrators in other jurisdictions have identified other successful HVAC program methods and strategies that could potentially be implemented in Massachusetts.

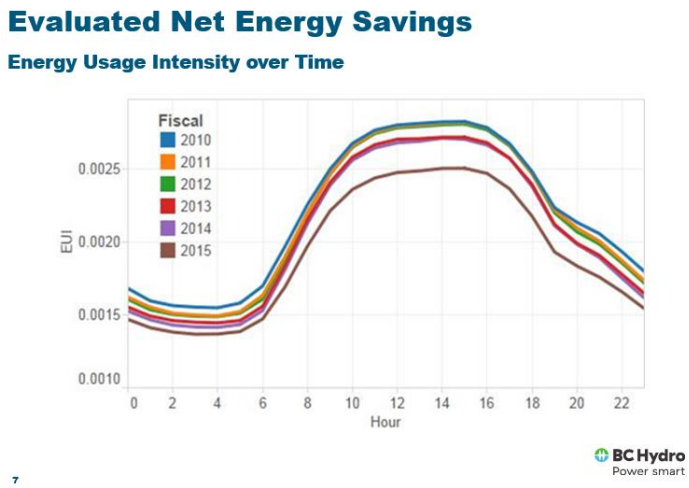
Retro-commissioning Program

British Columbia Hydro (BCH) recently completed an impact evaluation of its integrated retro-commissioning (RCx) and energy management information system program. The study found decreasing energy use over time for the 433 facilities engaged in the program from 2010 through 2015 as shown in **Error! Reference source not found.**.[26] The data presented is the evaluated net reduction in building energy intensity; the study focused only on electric impacts of RCx and did not report a program realization rate.

[25] Driving Upstream Markets through Strategic Partnerships and Excellence in Supply Chain Management, Merson, H., ACEEE. https://aceee.org/files/proceedings/2016/data/papers/7_460.pdf

[26] Commercial Recommissioning Program Evaluation: Accurate and Timely Results by Combining Qualitative Research with Statistical Analysis of Big Data, Yu, M. BC Hydro; IEPEC 2017

Figure 2 - BCH RCx Program Evaluated Savings (annual energy use/sq.ft./year)



Equipment Maintenance

The Southern California Edison Commercial Quality Maintenance Program is a market transformation program seeking to operationalize ASHRAE Standard 180[27], increase demand for quality HVAC maintenance, and increase the market capacity to deliver quality maintenance with the intention of increasing operating energy efficiency for serviced equipment. A recent process evaluation found that the program is impacting the market but needs to improve communication and cooperation with market actors as well as improve baseline and measurement protocols. These programs have been evolving in California since the 1990s. Strategic engagement across the HVAC equipment and service supply chain will most effectively move the market to higher levels of system efficiency over time. Improving the expertise of HVAC service providers will deliver small amounts of savings that will add up over time.

CONSULTANT OBSERVATIONS

The following discussion outlines some of the opportunities that exist for increasing the availability, adoption and maintenance of HVAC system energy efficiency measures in Massachusetts. In addition, there is a section on strategic market engagement.

Supply Chain

As shown in the HVAC Market Map, Appendix A, the HVAC supply chain is complex. Strong relationships with market actors throughout the supply chain will provide a solid foundation to the existing and new program offerings.[28] Program offerings that are developed with input from supply chain actors and that provide clear value to the market actors have been shown to increase engagement and participation. Evaluations cited the need for improved marketing, communications, relationships, training and program protocols (administrative burden and incentive processing) to better establish the value proposition for distributors and increase participation in upstream offerings.

The PAs can build on strong market relationships to advance practices in new ways. For instance, oversizing of HVAC equipment is a known issue that affects first cost and operating costs as well as comfort over the life of the equipment. The PAs could develop innovative new solutions to this issue by engaging with the market to understand what drives oversizing (which include higher profit margin on larger equipment and overuse of safety factors due to fear of under sizing). Understanding these drivers would help the PAs to develop solutions that address the underlying barriers while providing incentives for right sizing. The effort could include working with

[27] American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standard 180, Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems.

[28] Evaluations including the Upstream HVAC Process Evaluation and the Gas Boiler Market Characterization Study cited the need for improved communication with and marketing to supply chain market actors.

industry partners to update rule-of-thumb metrics such as square foot per ton of cooling since some actors rely on these rules to "conservatively" size equipment as well as addressing other sizing protocols that drive oversizing. The PAs already support variable load equipment, but there are more opportunities to move variable load equipment into the mainstream.

Gaps in the availability of efficient equipment are another barrier to achieving higher levels of HVAC savings. Areas of specific need include cold climate heat pump retrofits for packaged-terminal-air conditioning units (PTACs which include electric resistance heat) and high efficiency rooftop air handling units (RTU) furnaces. As National leaders in energy efficiency, the Massachusetts PAs are uniquely positioned to help drive development of and demand for new products. To overcome the availability barrier, the PAs could partner with other energy efficiency program providers as well as larger end use customers who would agree to procure products meeting an agreed upon specification. This approach was used by the U.S. Department of Housing and Urban Development (HUD) to stimulate the development of energy efficient apartment sized refrigerators at an affordable price point.[29] This approach could be coupled with a "cash for clunkers" program to drive wide-spread early replacement when the new equipment becomes available to the market.[30]

Optimized Systems

As shown in the Market Characterization Study[31], Building Automation Systems (BAS) exist in some form in about 50% of the C&I facilities with a prevalence in the largest buildings. About half of the existing systems are eight years old or more. These are computer-based systems; eight-year-old computers can no longer be updated with modern programs and protocols. The expansion of lower cost BAS to smaller customers coupled with replacing and upgrading BAS in existing buildings presents a tremendous opportunity for savings if the work is combined with optimized sequences of operation and rigorous testing. Large projects should incorporate measurement and verification as part of the implementation protocols per the National Energy Efficiency Best Practice Study[32] this will help providers better understand how well their engineering estimates of savings compare to achieved performance, improve savings estimates over time, improve PA realization rates and increase transparency and customer awareness of realized savings.

Promoting new control protocols, such as ASHRAE Guideline 36, will provide the PAs an opportunity to work closely with design engineers, controls contractors and commissioning agents to raise the level of efficient control design and implementation. An important aspect of driving market change is to incorporate feedback loops in the program design. For instance, design engineers rarely learn how the buildings and systems they design actually perform. Controls contractors tend to have longer engagement with buildings because the provide service to the proprietary control systems that they sell, but they have lower understanding of energy efficiency and HVAC system optimization protocols. Commissioning providers range in service levels from simply checking off boxes to actual system optimization. Understanding the barriers that each member of the team faces and developing strategies to overcome them, including training, incentives and post installation testing and feedback through measurement and verification will increase the knowledge and awareness of market actors over time.

Another opportunity to promote system optimization is the use of refrigerant or water based systems for transferring heat and cooling energy within buildings as opposed to using air systems. While these approaches are relatively easily applied at the time of new building design or major renovation, there are also opportunities to incorporate best practices within energy efficiency retrofits. Working with design firms to identify cost-effective retrofit and rehabilitation of out of date designs will increase market engagement in advancing new solutions to reduce energy use of HVAC systems. Such out of date designs include dual duct air handling systems[33], constant

[29] http://aceee.org/files/proceedings/1996/data/papers/SS96_Panel2_Paper19.pdf

[30] Cash for clunkers was a federal program designed to cause the early replacement of cars with poor fuel economy in order to increase the efficiency of cars in the United States and help spur the economy after the economic crash of 2008.

[31] http://ma-eeac.org/wordpress/wp-content/uploads/MA-CI-Market-Characterization-Study.pdf

[32] http://aceee.org/files/proceedings/2004/data/papers/SS04_Panel5_Paper21.pdf

[33] EEAC Consultants received an RFP for an energy performance contract of an existing dual duct mechanical system which retained the dual duct system. We have found that it is cost effective and will deliver higher lifetime savings to convert dual duct systems (the standard for health care occupancies in the 1970's) to variable air volume systems. While the PA involvement in this MA project is unknown, it was clear from review of this proposal that 1. Significant effort had gone into project development and 2. Lost energy efficiency opportunities were designed into the upgrade.

volume air systems, and even pneumatically controlled variable air volume systems. These same design firm alliances can be used to advance understanding of the upgrades necessary to increase the operating hours at which condensing boilers operate in condensing mode.[34].

Advancing the market for retro-commissioning (RCx), monitoring based ongoing commissioning (MBCx) and energy management and information systems (EMIS) will drive the market toward both optimized systems and ongoing operational assessment and improvements.

Efficient Operation

In general, the market actors working in HVAC tend to be more comfortable with business as usual. That is, operators prefer manual controls, designers prefer the way they've always done it and contractors want to follow historic practices. This inertia makes moving the entire HVAC market away from tradition toward high performance challenging, and will require a whole market approach. Opportunities include highlighting the practitioners and customers that are on the leading edge of HVAC system performance through recognition, tours, and trainings based on successful projects. PAs have historically sought to be market actor agnostic. However, when the differences in delivered performance between market actors is significant, it is not in the best interest of the Massachusetts ratepayers to treat all market actors as equal. We recognize that the PAs should not alienate market actors, but they should find ways to advance best practices and enable the practitioners that adopt those practices to gain recognition and increased market share. Recognition and reward for the market leaders, coupled with advanced education and training, will help advance the rest of the market more rapidly.

The EEAC Consulting Team and large customers in the Northeast have been exploring the development of a recognition and awards program for building operators. The intent of this innovative approach would be to incentivize building operators to optimize system efficiency for HVAC systems. This concept includes installing the EMIS necessary to identify operating efficiencies, setting key performance metrics with the input of the building operators and establishing an incentive system and/or incorporation of those metrics into the employee evaluation process. For customers whose goals are aligned with the State's efforts to reduce energy use and drive down carbon emissions, this approach will give them a new tool to advance continuous improvement and consistently efficient operation.

Many Massachusetts customers use service contractors for preventive and emergency maintenance. California has implemented programs to advance the skill and knowledge of service providers to identify and rectify equipment issues that increase energy consumption over time such as failed dampers, reduced refrigerant charge, clogged coils, etc. The idea behind these programs is to advance skill and awareness in the entire market so that equipment across the market is operating closer to peak efficiency on an ongoing basis.

EEAC CONSULTANT TEAM STRATEGIC RECOMMENDATION

The Council would like to see the PAs increase HVAC savings and reverse the trend of diminishing HVAC savings and participation. As lighting and other end use baselines change, it is important for the PAs to build market capacity for future savings growth to reflect the increasing importance of HVAC savings in the C&I portfolio in both the 2019-2021 and 2022-2024 Plans. The PAs should work toward transformation in the HVAC market to make energy efficient HVAC systems the norm and by taking a system optimization approach for existing and new systems. Methods to consider include:

- → Change market practices so that optimally efficient and right sized HVAC equipment become the norm at the time of purchase for retrofit, upstream and new construction applications.
- → Promote building automation systems that are designed for optimal function including retro-commissioning of existing systems and rigorous design review and commissioning of new control systems (for existing and new buildings).
- → Address known market barriers to upfront investment in the engineering services necessary for system optimization through innovative program offerings.

[34] https://buildingenergy.cx-associates.com/2012/04/getting-the-most-out-of-your-commercial-condensing-boiler/

- → Support performance verification and ongoing system tuning so that providers and operators learn what works, identify new opportunities, and improve practices over time as a savings strategy.
- → Build a strong and growing market capacity for high efficiency HVAC system design, installation, operation and management.

PROGRAM ADMINISTRATOR PROVIDED INFORMATION

The PAs use a suite of approaches to delivery of services to customers of all types and sizes. Some are turnkey approaches and others are delivered through distributors at a point-of-sale where customers/trade allies can essentially self-serve. This wide array of approaches allows the PAs to effectively deliver efficient solutions to the thousands of customers annually in the Commonwealth. The PAs consider the complimentary and conflicting aspects of these different delivery models and must weigh benefits and costs of any to customer experience and the portfolio. PAs look at what is working and lessons to take from one delivery path that can be applied to others.

Pathways for Customer Participation

Turnkey, sometimes called direct install (DI), delivery is the traditional form of energy efficiency delivery to small business customers, which comprise the bulk of the PAs customers. The approach consists of a no-cost assessment, customer specific proposal including HVAC control retrofit measures, where applicable, installation, and recycling or post-installation cleanup for customer-selected measures. The Turnkey delivery path offers electric and gas measures and is intended to help customers navigate efficiency options, mostly retrofit type measure, that improve the operations of their existing buildings in a streamlined manner. The vendors working for the PAs conduct many thousands of these projects each year and have during the long history of this delivery pathway. The activity and savings from this pathway are recorded presently in the Small Business Core Initiative line item.

Upstream delivery, involves inserting PA incentives at the wholesale or distributor level in the supply chain for efficient equipment. This broad reaching approach changes stocking patterns of distributors and yields a behind the scenes promotion of efficient equipment across many transactions, many more than PAs have traditionally been a part of using downstream delivery approaches. Upstream also allows for a customer/contractor self-serve model which has been powerful in moving large quantities of efficient equipment. Upstream delivery creates efficient decisions at a narrow point; meaning by reaching a couple hundred distributors PAs are reaching tens of thousands of customers, in the supply chain and as a result drives a large volume of units across many more customers than a Turnkey approach can over the same time. There are tradeoffs and the PAs work to minimize downsides and maximize customer choice. Upstream HVAC and Water Heating activity is reported in the New Construction – New and End of Useful Life Equipment initiative.

Downstream Applications, these are traditionally referred to as Large Commercial applications or prescriptive applications which can be for retrofitting existing buildings or for new or replacing failed equipment. These applications are open to all customers that have the equipment or run hours to meet the minimum requirements for eligibility. Often trade allies' use these applications to create a value add to their business. Businesses of all sizes use these incentive pathways to improve their facilities, replace failed equipment, and make their operations more efficient.

The PAs provide independent technical advisory services through a network of preferred energy engineering vendors. These vendors act as extension of PAs and provide information pertaining to energy and financial metrics to positively influence customer decision. PAs also engage with independent building commissioning agents to ensure optimum operation of building systems and provide training as necessary.

Where HVAC Savings Come From

2016 Electric Savings[35]

HVAC makes up roughly 9% of lifetime electric portfolio savings, 9% of the incentive spend, and 12% of total benefits. Custom HVAC accounts for 74% of HVAC savings. 58% of HVAC savings occur in retrofit project settings leaving 42% falling under new construction or end of useful life project types. The type of projects considered in Custom HVAC are including but not limited equipment replacement, systems retrofits, enhanced control sequences and energy efficient building envelope. PAs strive for comprehensiveness and try to influence implementation of multiple interactive measures, which results in greater cost-benefit and enhanced customer experience.

End Use	Measure	Sum of Quantity	Sum of Net Lifetime Electric Savings (MWh)	Sum of Incentive	Sum of Total Benefits ($)
Lighting		2,636,906	5,836,472	$134,274,975	$876,623,477
Everything Else		172,526	1,663,336	$30,086,141	$233,128,944
CHP		4	1,488,948	$10,949,504	$146,305,967
HVAC Total		*20,161*	*825,131*	*$17,530,683*	*$172,361,632*
HVAC	HVAC - Custom	32	608,138	$12,292,867	$89,793,066
	HVAC Upstream -- Heat Pump Systems	3,786	53,659	$928,744	$7,902,143
	HVAC Upstream -- Unitary Air Conditioners	7,402	46,896	$1,562,380	$29,228,022
	Energy Management System	2,664	37,290	$1,224,910	$9,258,833
	High Efficiency Chiller -- IPLV	2,524	32,723	$299,863	$7,054,589
	High Efficiency Chiller -- FL	636	15,303	$26,046	$2,457,035
	HVAC Upstream -- ECM Fan Motors	2,450	15,215	$818,316	$2,982,865
	HVAC Upstream -- Dual Enthalpy Economizer Controls (DEEC)	401	7,210	$101,100	$22,500,354
	HVAC Custom- Multifamily	1	6,228	$58,880	$804,349
	Programmable Thermostats	28	851	$54,455	$153,483
	Programmable Thermostat, Electric Resistance, No AC	235	256	$15,018	$46,778
Grand Total		2,829,597	9,813,886	$192,841,303	$1,428,420,019

[35] Masssavedata.com

2016 Gas Savings[36]

HVAC makes up roughly 44% of lifetime gas C&I portfolio savings, 47% of the incentive spend, and 44% of total benefits. Custom HVAC accounts for 86% of HVAC gas savings. 49%% of HVAC savings occur in retrofit project types leaving 51% falling under new construction or end of useful life project types. The type of projects considered in Custom HVAC are including but not limited to end use equipment replacement, air-side system retrofits, boiler controls, heat recovery, kitchen exhaust ventilation steam trap repairs and insulation. PAs strive for comprehensiveness and try to influence implementation of multiple interactive measures, which results in greater cost-benefit and enhanced customer experience.

End Use	Measure	Sum of Quantity	Sum of Net Lifetime Therms	Sum of Incentive	Sum of Total Benefits ($)
HVAC Total		*61,728*	*66,058,526*	*$13,113,485*	*$71,833,939*
HVAC	Heating - Custom	57,064	22,135,463	$4,354,843	$22,156,449
	HVAC - Custom	130	21,454,079	$3,144,301	$20,504,947
	Control - Custom	60	8,724,508	$2,019,302	$9,248,165
	Steam Trap - Custom	36	4,480,812	$696,381	$10,267,301
	Condensing Boiler 500-999 mbh (.90 TE)	227	2,274,141	$917,000	$1,977,354
	HVAC - Multifamily High Rise	16	1,304,610	$91,323	$1,228,526
	Condensing Boiler 1000-1700 mbh (.90 TE)	50	891,041	$360,000	$771,218
	Condensing Boiler 1701+ mbh (.90 TE)	26	818,235	$258,500	$704,544
	Condensing Boiler <= 300 mbh (.95 TE)	244	807,410	$367,800	$683,585
	Programmable Thermostat, Gas	2,642	672,332	$235,447	$1,106,975
	Condensing Boiler 301-499 mbh (.90 TE)	115	626,351	$230,000	$543,064
	Combo Condensing Boiler/Water Heater 95%	93	475,809	$148,800	$414,853
	Boiler Reset Control, Gas	80	325,123	$18,000	$707,773
	Condensing Boiler <= 300 mbh (.90 TE)	100	294,481	$127,000	$257,119
	Steam Trap - Prescriptive	488	284,689	$23,700	$652,335
	Condensing Unit Heater <= 300 mbh	29	159,004	$21,750	$142,771
	Wi-Fi Thermostat (controls gas heat only)	143	112,123	$14,289	$244,086
	Infrared Heater	67	108,585	$50,250	$95,764
	Furnace w/ECM 95%	57	43,562	$12,800	$39,121
	Wi-Fi Thermostat (controls elec cooling & gas heat)	29	22,223	$2,900	$48,377
	Combo Condensing Boiler/Water Heater 90%	6	20,733	$7,200	$17,166
	Furnace w/ECM 97%	17	16,476	$8,600	$14,618
	Furnace w/ECM 95% - Muni	7	5,018	$2,100	$5,855
	Furnace w/ECM 97% - Muni	2	1,717	$1,200	$1,972
Everything Else		8,998	56,479,466	$9,423,051	$57,623,876
Hot Water		126,520	27,588,519	$5,440,418	$33,896,710
Grand Total		197,246	150,126,510	$27,976,954	$163,354,525

New Approaches & Demonstrations proposed and tried during 2016-2018

→ Equipment Replacement Initiatives: PAs are exploring new initiatives based on customers' needs and tying it with innovations happening in the market place. PAs are currently working on targeted

[36] Massavedata.com

initiatives such as Ultra Low Temperature Freezer replacement, targeted early replacement of Roof Top Units. These initiatives are in demonstration phase and PAs will review the results to determine the pertinent next steps

- → National Accounts Franchise Strategy: PAs are collaboratively working with different franchises in Massachusetts to streamline the process and turnkey-implement comprehensive energy efficiency measures. The streamlining of process is expected to expedite implementation, result in deeper energy efficiency savings and enhanced customer experience.
- → Custom Express Tools: PAs continue to develop and deploy strategies to streamline and simplify energy savings tools to ensure consistency in the market place. These tools and products include but not limited energy savings spreadsheets for heat recovery and simplified approach to replacing transformers. PAs continue to develop the tools based on the need.

Trainings and Workforce Development

MAEEP HVAC TRAINING[37]

HVAC very well may be the largest energy user in a commercial building. When you add heating, cooling, and ventilating together and treat them as a single system (as they generally are), it is 45 to 70% of the building's energy use. For comparison, lighting is usually just 10-30%. Of course a lot depends on climate, building type, and building usage, but HVAC should be a major retro-fit target for those who are concerned about energy conservation.

CODE TRAININGS[38]

Building energy code compliance training sessions are available for all Massachusetts code officials and building professionals.

BOC TRAININGS[39]

Participants will learn the fundamentals of automatic control systems for building mechanical systems to target possible inefficiencies in their HVAC systems and to evaluate potential problems as part of an enhanced operation and maintenance program. Participants will be introduced to Building Automation Systems (BAS) and the graphic user interface as a cost effective tool to review real time building data, identify problems, and verify proper performance for air handling and central plant systems.

Evaluation/Code/Baseline Considerations

Given Massachusetts' position as a leader in Energy Efficiency, high efficiency market transformation and related Evaluation baseline adjustments are expected to continue pressuring claimable savings during the next planning cycle. This effect will be felt most in the New Construction/Equipment Replacement space, but also more generally, for any measures where the evidence supporting broader market transformation is mounting.

The PAs are currently investigating the implications of dual baseline and industry standard practice considerations and impacts on HVAC savings.

[37] https://www.maeep.org/event-display/414

[38] https://www.masssave.com/en/learn/partners/energy-code-training-and-events/

[39] http://www.theboc.info/courses/boc-1004/

TOPIC #3 – NEW DEMAND MANAGEMENT OPPORTUNITIES

OVERVIEW PREPARED BY CONSULTANTS AND PAS

The purpose of this brief is to present information about electric demand, which drives the need for electric capacity resources such as generation, transmission, and distribution assets, as well as costs to ratepayers, in Massachusetts. The PAs have reduced the demand of customers for years through energy efficiency, otherwise known as passive demand reduction[40], and now are exploring the use of active demand management, including but not limited to traditional demand response, to expand the portfolio of cost-effective customer solutions delivered through the EE programs.

The electric PAs deliver passive demand reductions or savings with most electric projects completed. Through thousands of lighting, HVAC, process, and CHP projects the PAs have reduced 1,134 MW in all sectors, 734 MW in C&I alone, from 2010 through 2016 and have committed to 577 MW of additional demand reductions in the 2016-2018 Plan (327 MW in C&I)[41]. These demand reduction savings exist for the life of the measure so each year of program activity builds on the next and Massachusetts currently stands with 1,077 MW of passive demand reduction, or 7% of the total forecasted peak capacity need of Massachusetts in 2017[42].

Definitions

Active Demand Management: includes all active management of demand including demand response, active demand reduction, load control and load shifting.

Demand Response: reductions in customer demand resulting from a signal sent to the customer requesting that reduction.

Active Demand Reduction: automated control of loads to reduce customer peak demand, flattening loads over time with mixed impacts on total energy use. Demand reduction controls can provide demand-response capability as an additional benefit.

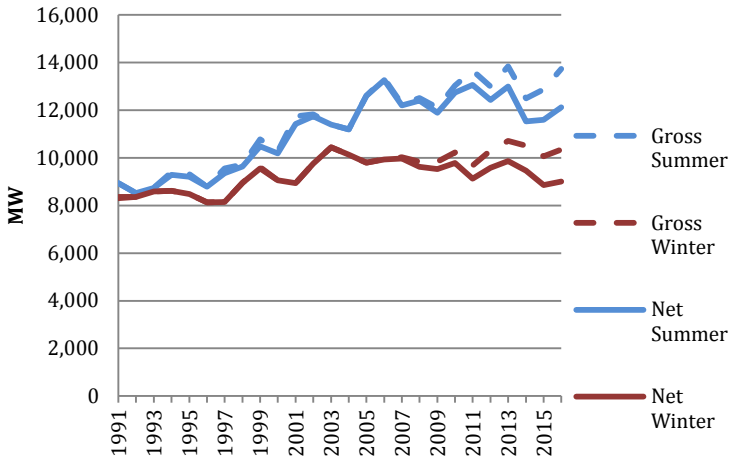
Passive Demand Reduction: energy efficiency, principally designed to save electricity use at many times throughout a year.

The Green Communities Act identifies demand side management programs within the energy efficiency framework, and peak demand reduction as a way to reduce ratepayer costs was one of the priority areas identified in the term sheet for the 2016-2018 Three Year Plan. In alignment with the Department of Public Utilities' Order approving the plans, the electric PAs have been planning and implementing active demand management demonstration offerings with the goal of determining their impact and cost-effectiveness within the framework of the Three Year Plan.

Demand in Massachusetts

Although peak demand has not been growing in the ISO New England (ISO-NE) system or in Massachusetts (see Figure 1), which makes up roughly 45% of the ISO-NE total load, in the past decade,[43] three of the top 10 demand days have occurred since 2011[44]. The system, and Massachusetts, reached a historic peak in 2006. Massachusetts, and the ISO-NE system, is a summer peaking system, driven largely by space cooling needs in homes and businesses[45]. Until 1989, New England was a winter-peaking system. ISO-NE cites two main factors that contributed to the change decades ago from a winter to summer peaking system; in the summer, the growing use of air conditioning has contributed to increase demand and in the winter, a decline in electric heating use has

Figure 3: Massachusetts Demand Over time – Gross & Net



40 https://www.iso-ne.com/markets-operations/markets/demand-resources/about
41 www.Massavedata.com
42 ISO-NE, 2017 CELT Forecast
43 https://www.iso-ne.com/about/key-stats/electricity-use
44 https://www.iso-ne.com/about/key-stats/electricity-use
45 https://www.iso-ne.com/about/key-stats/electricity-use

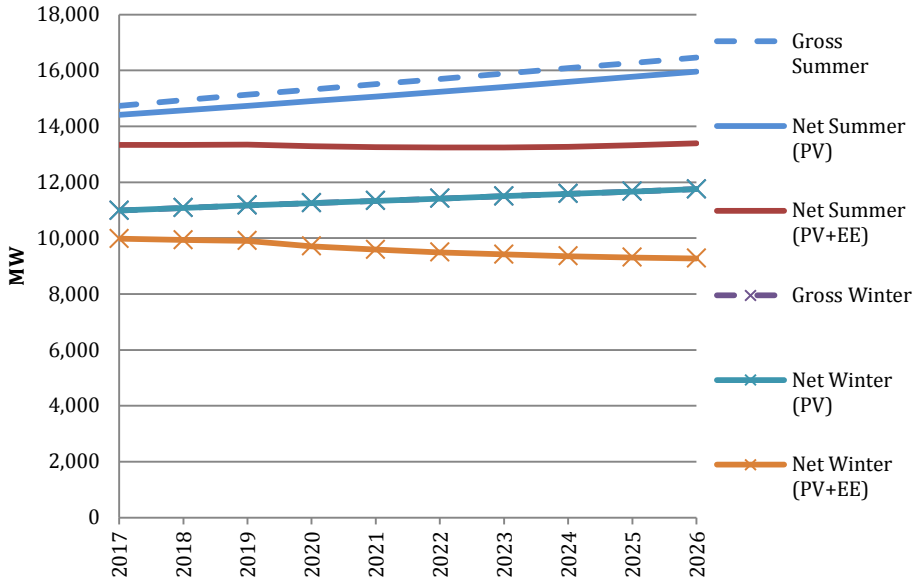
helped push down demand[46].

Even when forecasts of peak demand are flat, peak usage drives costs for ratepayers because the peak hours of use are often the most expensive. This is reflected in a number of ways, including through capacity costs (both the forward required capacity needs and the "ICAP" capacity reconciliation charges), energy costs and planned transmission and distribution expansion costs. Thus reducing peak usage can reduce costs to ratepayers.

System Forecasts

Since 2010, a divergence in gross and net system demand has developed due to the growth of energy efficiency reducing demand of the system for the measure life which, ranges from 7 to 20 years47. Due to the significant demand reductions delivered by energy efficiency measures, the long measure lives of energy efficiency measures, the expectation that more efficient equipment will be installed at the end of the measure lives in the future, and the increased installation of behind the meter (BTM) distributed generation, regional summer demand is not expected to increase in the next ten years, as shown in Figure 2. ISO-NE, in the 2016 and 2017 Capacity, Energy, Loads, and Transmission (CELT) forecast, expects net summer demand to be flat for the next 10 years.

Figure 2: MA Summer & Winter Demand Forecast Gross vs. Net (90/10)

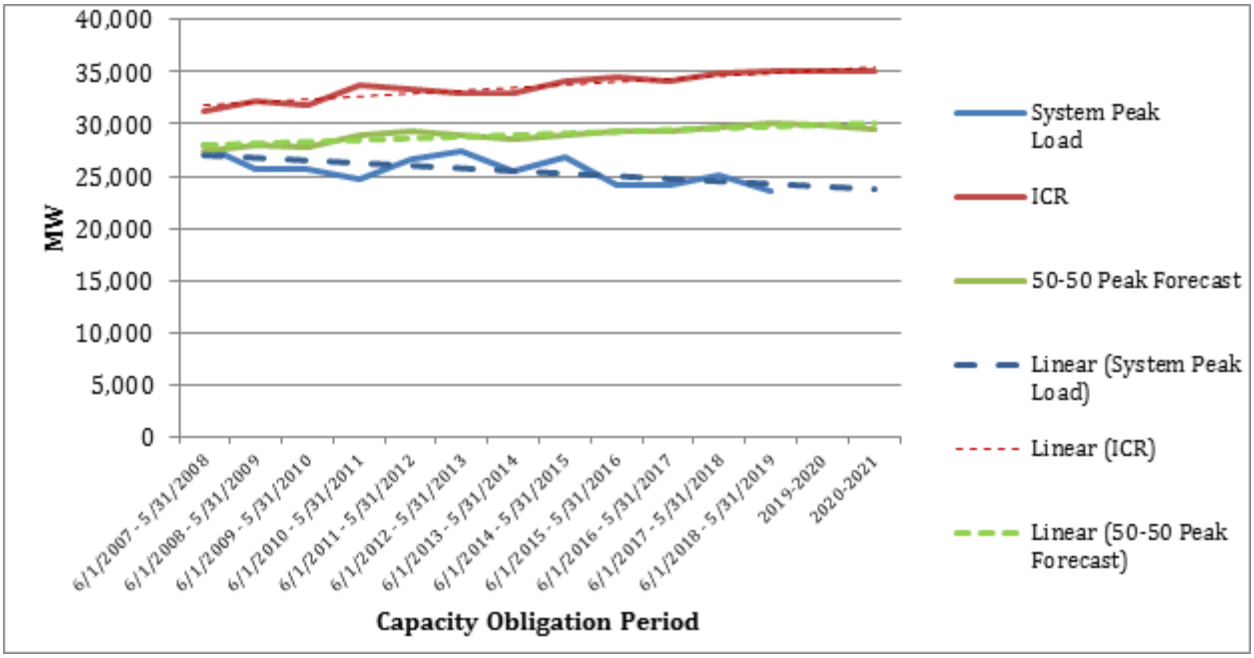


Likewise, and to a greater degree than summer, in the most recent ISO forecast winter demand is forecasted to decline over the next 10 years. Winter does not have the benefit of coincident photovoltaic (PV) BTM generation like summer, due to fewer daylight hours and angle of the sun, so the Gross Winter and Net Winter (PV) forecast lines are nearly identical. Energy efficiency, which provides passive demand reduction, is the direct contributor to a declining winter net peak forecast.

Figure 3 below reflects the total installed capacity requirement (ICR) that ISO-NE is required to buy through the forward capacity market, which is then passed on to all New England customers including Massachusetts customers. Load, otherwise known as customers, in each state of the ISO-NE system pays their share of the ICR. As mentioned earlier, Massachusetts is roughly 45% of ISO-NE system.

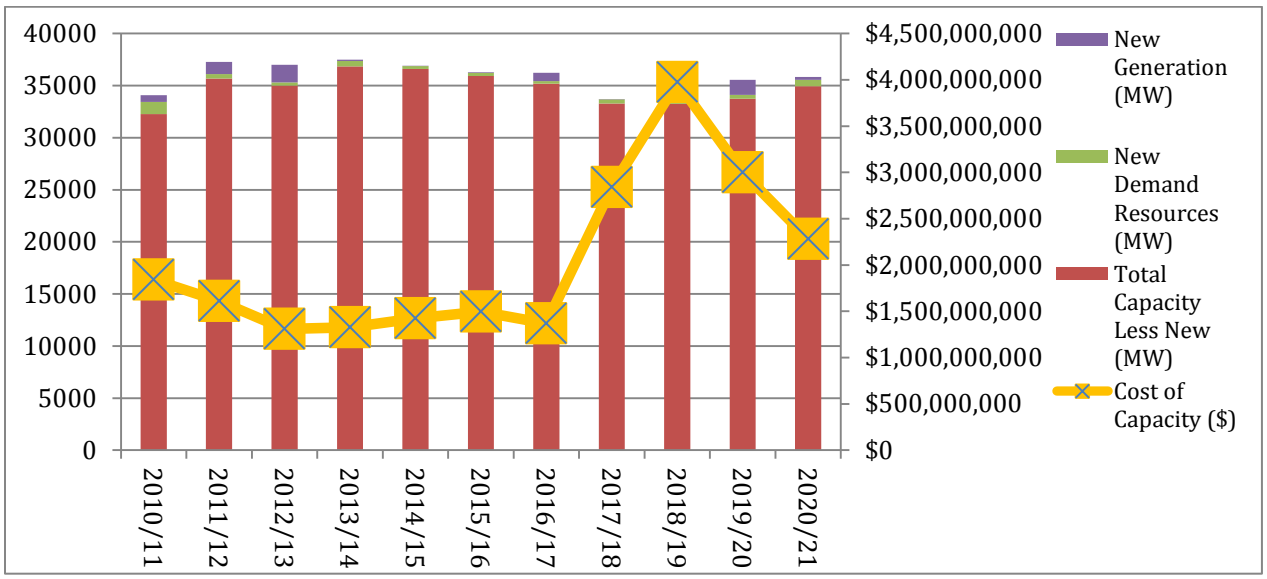
[46] https://www.iso-ne.com/about/key-stats/electricity-use
[47] https://www.iso-ne.com/about/key-stats/electricity-use

Figure 3: ISO-NE System Year over Year Forward Capacity Commitments



Capacity costs remain a significant portion of electricity costs for Massachusetts and vary from year to year due to forward capacity auction (FCA) results and total energy cost. The cost of capacity has been unpredictable in recent years with FCA total costs during the 2018/2019 commitment period more than three times the cost of the FCA during the 2015-2016 commitment period and then dropping in more recent auctions.48 Figure 4 below shows all Forward Capacity Auctions (FCA) to date, including the total capacity procured and the clearing price. The cost of capacity, for FCA 9 for commitment year 2018/2019 is nearly three times than the results of FCA 6 for the 2015-2016 commitment period.49

Figure 4: Forward Capacity Auction Results



[49] https://www.iso-ne.com/about/key-stats/markets#fcaresults

Like summer peak, the cost of winter energy increases, even if demand declines.50 Wholesale electricity prices in the real-time energy market reached their annual peak in January for six out of the past 8 years with sharp increases in winter that were up to four times the price during summer in 2013, 2014, and 2015, indicating that energy costs are more driven by winter conditions while capacity costs are driven by summer conditions.51

Every MW of peak usage and every MWh of peak period energy use that can be reliably reduced will lower costs to Massachusetts ratepayers in real energy costs, annual and future capacity costs and reduced infrastructure costs.

CONSULTANT FINDINGS

The Consultants find that while state and regional peak demand projections are flat, significant drivers remain for increasing PA focus on cost-effective active demand management. The electric grid is increasingly dynamic as local renewable resources are incorporated, technology and automation continue to advance, and growth is concentrated in discrete and in some cases, isolated parts of the state. Grid resiliency in the face of more extreme weather events and potential attacks is bolstered by the ability to manage and reduce demand.. Capacity costs and peak period energy costs remain a significant portion of electricity costs for Massachusetts, and the capacity and energy costs have varied significantly and have spiked in some prior years, and future capacity and energy costs are uncertain and likely will vary. Therefore, even when ISO-NE forecasts of demand are flat, there are economic benefits to MA and its ratepayers when peak demand and peak period energy use are reduced and managed. In addition, future changes in electricity use, the resource mix, and the electrification of transportation and other energy uses make the future uncertain. Thus, it is appropriate and prudent to include active demand management, as well as energy efficiency, as part of the demand side management portfolio.

The PAs have achieved significant passive demand reductions through energy efficiency and MA PAs have bid a portion of energy efficiency program demand impacts into the FCM, offsetting the need to collect program funding through the system benefit charge.

In the PAs' current demonstration offering, only one PA has an approved C&I demand response demonstration operating and three others are seeking DPU approval for C&I demonstrations. We see the following areas of opportunity to advance demand management to manage system costs in the future:

1. Integrate demand management (continuous active customer demand management coupled with capability for demand response) into the energy efficiency programs.

2. LED lighting with integrated controls, an energy efficiency measure, offers an opportunity for the PAs to work with customers to install systems that enable both customer demand management, tuning of light levels to maximize productivity, and provide a resource for demand response. Imagine if the lighting load of MA could be automatically dimmed by 10% to reduce loads when needed.

3. Because of the nature and increasing prevalence of demand response and demand management pilots the Electric Power Research Institute (EPRI) has developed guidance for PAs to use in developing "pilots." Following the EPRI protocols in the demand demonstration study design will help ensure that the study results are useful in assessing actual demand impacts. The guidelines are intended to instruct PAs in the design and development of studies, including sample design, the use of control groups, etc. to ensure that results are statistically valid and can be evaluated. We urge the PAs to review and follow these guidelines developed within their industry to provide best practices in the design and deployment of the demand demonstrations.

Considerations

Continue to develop and expand efforts to reduce and manage customer and system demand. All electric PAs should move beyond demand demonstrations to include active demand management programs, and/or demand management strategies integrated within efficiency programs, in the 2019-2021 Plan, in addition to achieving

50 https://www.iso-ne.com/about/key-stats/markets#fcaresults
51 Id.

passive demand reductions through efficiency.

Continue to develop new approaches to reduce and manage customer and system demand. Ensure that currently planned demonstrations and program integrated offerings are well designed and transparent.

- → Clearly document study designs, objectives and outcomes and make them public. Use published guidelines such as EPRI *Quantifying the Impacts of Time-Based Rates, Enabling Technology, and Other Treatments in Consumer Behavior Studies: Protocols and Guidelines*[52]. The MA Ratepayers are funding these studies and it is important to ensure that they are well designed, documented and that the lessons learned are widely disseminated so that successes can be built upon and issues avoided in future iterations and as demonstrations are expanded to new service territories.
- → Look for opportunities to reduce costs, increase market availability and expand approaches to other customers impacted to demand charges in this plan period.

CONSULTANT TEAM STRATEGIC RECOMMENDATION

The Council would like to see all electric PAs include active demand management programs, and/or demand management strategies integrated within efficiency programs, in the 2019-2021 plan, in addition to achieving passive demand reductions through efficiency.

PROGRAM ADMINISTRATOR PROVIDED INFORMATION

Overview

The Massachusetts PAs have been investigating adding active demand reduction and demand management to the portfolio since the start of the 2016-2018 Three Year Plan. National Grid and Cape Light Compact (CLC) included demand demonstrations in the 2016-2018 plan and have been delivering on the approved demonstrations during the summers of 2016 and 2017. Eversource, Unitil, and CLC have filed demand demonstration proposals to the Department of Public Utilities (DPU) and are still awaiting approval.

Consistent with the Plan, the PAs have assembled and will continue to work with a small group of interested and qualified experts, as part of the Demand Savings Group ("DSG"), to research potential demand reduction and demand management efforts. The Program Administrators appreciate the strong support and interest of the Department of Energy Resources ("DOER"), the Attorney General, the Department of Public Utilities ("Department"), the Energy Efficiency Advisory Council ("Council" or "EEAC"), demand response experts, and other stakeholders.

The PAs and the Council recognize the continued importance of achieving demand reduction and mitigating peak load growth incrementally from the approved energy efficiency plans. Issues related to demand reduction are complex, and it is important to design efforts that take into account both positive attributes of these programs and possible unintended negative consequences, such as increased energy usage or fossil fuel use. This is particularly significant when considering active demand reduction approaches as compared to the typical passive demand reductions that occur through many energy efficiency efforts. Through a highly collaborative and expert driven process, the PAs are exploring approaches to new cost-effective demand reduction initiatives.

Matrix of Approved & Proposed Demonstrations

The Electric PAs have proposed many different types of demand demonstrations targeting active demand management. Due to the DPU Order for the 2016-2018 Three Year Plan, the PAs were unable to propose and run similar or duplicate demonstrations and therefore had to carve out unique demonstration space. Through the DSG and Evaluations the PAs running demonstrations are sharing findings from the field demonstrations.

52 https://www.epri.com/#/pages/product/000000003002000282/

Table 2. Matrix of Approved and Proposed Demonstrations

PA	Residential	C&I		
		Small	Mid	Large
National Grid	Wi-Fi Tstat DLC (Central A/C)	Wi-Fi Tstat DLC	Wi-Fi Tstat DLC	Interruptible load approaches
Eversource		*EMS* *Lighting/HVAC controls* *Wi-Fi Tstat DLC*	*Software & Controls* *Onsite training* *Process audits* *Batteries* *Thermal storage*	*Software & Controls* *Onsite training* *Process audits* *Real time info* *Batteries* *Thermal storage* *Demand response*
CLC	Wi-Fi Tstat DLC (Central A/C) Behavioral DLC on DMSHP, window A/C	*BTM thermal storage*	*BTM thermal storage*	
Unitil	*Battery Storage for existing solar PV systems*			*Operations Changes to Reduce Demand*

Note: *Red Italic Text* indicated proposed but not approved demonstrations

National Grid's Interruptible Demand Reduction Incentive Offer

LARGE C&I CUSTOMERS

The intent of National Grid's C&I active demand reduction demonstration is to determine if a PA can cost-effectively incentivize customers to participate for peak-shaving demand response that compliments the consultative sales approach already used for selling efficiency. This technology-agnostic demonstration, as described below, was offered to Large C&I customers starting in January 2017 for delivery in the summer of 2017.

Eligibility for 2017 Summer:

- → Must be a National Grid Electric Customer
- → Minimum 50 kW Curtailment
- → Customer must be on an interval commercial rate (G-3, G-2 if upgraded)
- → Use one of the Curtailment Service Providers (CSPs)
- → Curtailment caused by natural gas or diesel generators is not eligible
- → Existing FCM participants or those already under contract to participate are not eligible

Dispatch for 2017 Summer:

- → Summer (June, July, August, September)
  - ○ Weekdays Between 11am and 5pm, no Holidays
  - ○ Events will last from 1 to 4 hours
  - ○ Events will be in even hour increments. (for example, from 2 to 4pm , not 1:15 to 2:15pm)
- → We will notify the CSPs the day before we plan to have an event. The CSPs will notify the customers. Typically by email, text, and/or voicemail

Incentives for 2017 Summer:

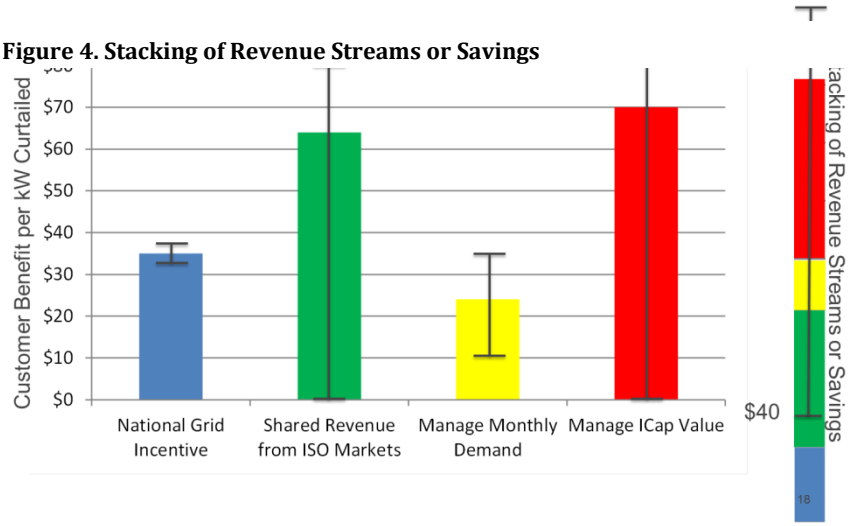
→ Capacity Reserve Incentive = $20/kw-year

→ Performance Incentive = $0.75/kwh during events

Customer Value Proposition

National Grid envisions some customers who sign up just to take advantage of the incentive provided for this demonstration. However, it is more likely that customers must stack values from multiple revenue streams to justify their investment.

Figure 4. Stacking of Revenue Streams or Savings



Using our demonstration offer, customers can leverage approaches to comprehensive demand management to lower energy and demand supply costs and/or participate in wholesale market demand response programs. This stacking of values is a concept frequently presented when discussing the customer value proposition from Distributed Energy Resources (DERs). The CSPs offer this value added service to customers.

Table 3. 2017 Summer Demonstration Results

	Demonstration Target for 2018	Demonstration Target for 2017	Signed Up
MW	40	20	20.6
# Customers			98

→ 4 Events have been called a day-ahead

→ 2 Events were cancelled same day due to updated forecast

→ 2 Actual events so far for this summer

MARKETING/OUTREACH/TRAINING

The PAs conduct the following outreach to promote and guide the New Construction market in Massachusetts:

→ Direct customer & CSP outreach using PA Staff and marketing

EVALUATION/BASELINE CONSIDERATIONS

The National Grid C&I demonstration is being evaluated following the evaluation framework governing energy efficiency. Results will be made public when they are available.

Baseline is a key consideration for active demand reduction approaches. To make it simple for customers and CSPs working in Massachusetts, National Grid adopted the ISO-NE baseline calculation methodology.

TOPIC #4 – FUEL SWITCHING

OVERVIEW PREPARED BY CONSULTANTS AND PAS

The purpose of this brief is to review the concept of full and partial fuel switching for C&I Customers. For the purposes of the PAs' C&I energy efficiency programs, fuel switching can be defined as a customer choosing to increase use of one fuel at a customer's site while reducing the use of another fuel, which can be a viable option for some customers. The nature and degree of energy efficiency program support for fuel switching, and for which forms of fuel switching, will be determined as part of developing the next Three-Year Plan.

The majority of fuel switching opportunities occur under the retrofit program. If there is a new construction opportunity, the customer's decision is more of a fuel choice at the time of design and construction.

The Green Communities Act of 2008 (GCA) calls for energy efficiency program administrators (PAs) to capture all cost-effective gas and electric energy efficiency measures. The only fuel switching components within the GCA that are explicitly named are Combined Heat and Power (CHP) and geothermal heating and cooling systems.

Fuel Use in Massachusetts C&I Market

Massachusetts C&I customers use regulated (electricity and natural gas) and unregulated fuels (such as biomass, propane, or oil) for multiple uses in their buildings. Some use fuels primarily for space and water heating while manufacturers operate a variety of different processes like dryers, process heaters, or absorption chillers.

As shown in Figure 1, the C&I Market Characterization Study53 shows that natural gas is the predominant heating fuel among C&I customers. A low percentage (~<20% of electric accounts) of customers heat their facilities with electricity or unregulated fuels.

Definitions

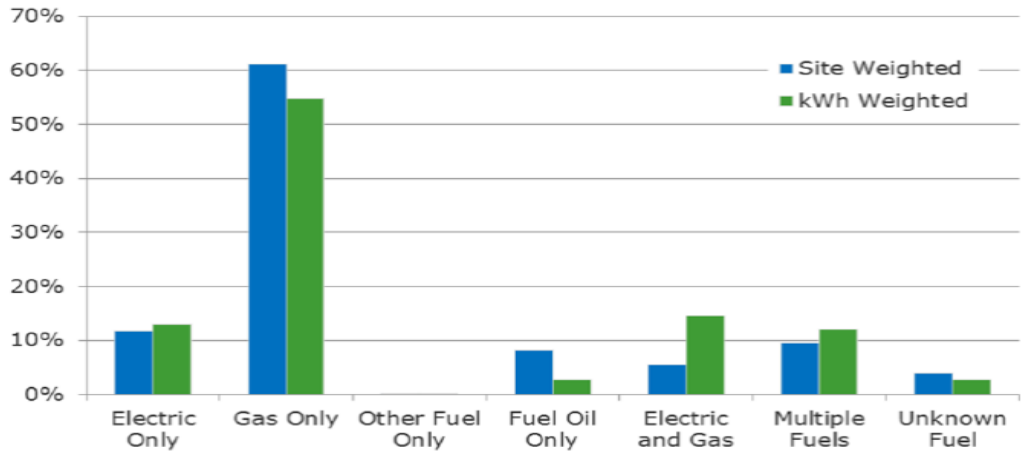
Fuel Switch: A permanent substitution of equipment that uses a different fuel/energy source to provide the same service more efficiently or cost-effectively.

Partial Fuel Switch: A substitution whereby the customer choses the fuel to use if supplemental equipment is added and the original system still remains and is used as needed at the choice of the customer.

Early Retirement Fuel Switch: Replacing working equipment (with remaining useful life) with higher efficient equipment as "early replacement" while at the same time changing the input fuel at the request of a customer.

New Construction: Customer is making a fuel choice when building a new building or adding new equipment or replacing equipment with no remaining life.

Figure 1 Distribution of Standalone Heating Equipment



53 DNVGL, P41 C&I Market Characterization

Types of Equipment Considered for Fuel Switching

- → Heating Equipment (boilers, furnaces, electric strip heating);
- → Domestic Water Heating
- → Cold climate heat pumps (CCHP), variable refrigerant flow (VRF) & gas fired AC & heat pumps;
- → Combined Heat and Power (CHP);
- → Kitchen Equipment;
- → Chillers;
- → Process Equipment.

Customer Considerations

Customers are primarily interested with the amenity produced by the fuels consumed in their facilities. While a subset of customers may include environmental impact and operating costs as a factor in select heating sources, in general customers retain their existing heating source absent significant external drivers. Customer drivers for fuel switching can include availability of new products, such as, though not limited to, cold climate heat pumps that can more efficiently meet cooling needs while also offsetting a significant portion of fossil fuel heating loads, or end of life replacement, such as an oil fired hot water heater being replaced with an electric heat pump hot water heater.

Due to the differences between real-time retail costs of fuels and the values of avoided costs (developed every three years in the avoided energy supply cost studies), projects that may be cost-effective for the PAs may not be economical for a specific customer. For example: switching completely from oil to cold climate heat pumps may lack cost competitiveness, performance, and site suitability for customers.54 Similarly, a customer may want to fuel switch for reasons other than economics, but the fuel switch might not be not cost-effective for the programs to support due to attribution and other factors. However, if a customer chooses to undertake a partial fuel switch, where a customer adds cold climate heat pumps yet still retains the fossil-fuel heating system for the coldest days, the customer may see a compelling business case for the investment.

Complete fuel switch examples of this conflict between customer economics and program cost-effectiveness requirements were prepared by the PAs and are presented below; partial switches may present different economics for customers and PAs while the fossil systems will still be accessible:

PA Perspective

Fuel Swtich	Cost-effective*
Oil to Gas Heating	Generally Yes
Oil to CCHP Heating	Borderline - Case by Case
Propane to CCHP	Borderline - Case by Case
CHP	Borderline - Case by Case
* Subject to avoided cost fluctuations	

Customer Perspective

From/To	Payback* (years)	Payback* (years)	Payback* (years)
	CCHP	Nat. Gas	Wood Pellet Blrs.
Oil	very long	mid	very long
Electric Baseboard	short	short	long
Propane	short	short	mid
Natural Gas	No payback		No payback
Wood Pellet Boiler	very long	mid	
* assumes a 50% of installed cost inc. or Incentives for Wood Pellet Boilers from CEC only.			

54 NEEP, Strategic Electrification Regional Assessment, pg 13

EEAC CONSULTANT TEAM FINDINGS

The Consultants concur that there are cost effective opportunities to achieve energy efficiency gains and greenhouse gas reductions through strategic use of fuel switching and partial switches. There is also the opportunity for PAs to engage with customers who have decided to switch fuels and incentivize the most efficient option at the time of the switch.

EEAC CONSULTANT TEAM STRATEGIC RECOMMENDATION

The Council recommends that the 2019-2021 Plan include support for some forms of fuel switching. The Council would like to see the PAs identify opportunities and support fuel switching where cost-effective, provided that the program impacts are consistent with Global Warming Solutions Act compliance. These include opportunities to strategically electrify energy uses, and to switch from inefficient equipment to more efficient fuel and/or equipment, where cost-effective. A customer should be able to choose energy efficiency services regardless of current or desired fuel, as long as the equipment or upgrade is to efficient equipment and is cost-effective.

PROGRAM ADMINISTRATOR PROVIDED INFORMATION

Overview

The Massachusetts PAs assist C&I customers in switching fuels and equipment when requested by customers and when cost-effective and more efficient. Incentives are only available for energy efficiency measures that save regulated fuels (electricity and natural gas). However, an increase in usage of fuels is currently allowed, if the measure(s) save electricity or natural gas cost-effectively. The PAs view fuel switching measures in two distinct categories:

1. The shift from existing fuel to a new fuel 'baseline' efficient system
2. Incremental improvements in efficiency above the 'baseline' new fuel system

In either category, the PAs require the installation of high efficiency equipment (prevailing code or industry standard practice baseline) in fuel switching projects. The savings above baseline would contribute towards savings goals for respective fuels. The PA with reduced electric or natural gas energy usage will count these savings along with other energy efficiency measure savings toward their program goals.

The PAs work with C&I customers to support all cost-effective (qualifying benefit-to-cost ratio) fuel switching opportunities, such as CHP, consistent with regulatory requirements.

Examples of Fuel Switching Scenarios

The PAs treat C&I fuel switching as a custom project with a customer specific basis, that is implemented at a customer's request, and is subject to technical review and/or assistance and project specific cost/benefit screening. There is often a customer cost-share for any technical review and/or assistance The PAs incentivize the incremental efficiency increase for the equipment installed after the switch takes place.

Fuel Switch- Electric Heating to High Efficiency Natural Gas Heating: An electric heat customer electing to switch to natural gas may be eligible for an incentive from the electric PA for the reduction in electric load. The electric PA would record electric savings and a natural gas increase to baseline efficiency natural gas system. The natural gas PA would provide an incentive based on incremental cost for the high efficiency natural gas fired energy efficient equipment and claim the incremental natural gas efficiency savings, as an energy efficiency measure. There is no natural gas efficiency program incentive available to support the switch to natural gas.

Fuel Switch- Natural Gas to Electric Heating: Natural gas customer who requests to switch completely to electric heating such as cold climate heat pumps or Variable Refrigerant Flow equipment is eligible to receive incentive from electric PA for incremental energy efficiency improvement above a standard efficient CCHP or VRF system. Natural gas PA would record natural gas savings and electric energy increase to baseline electric system.

Fuel Switch- Fuel Oil to Natural Gas Heating: A fuel oil heat customer who requests to switch to a natural gas

system is eligible to get an incentive from the natural gas PA for the incremental energy efficiency improvements that exceed the requirements of current Massachusetts Energy Code and/or industry standard practice.

Fuel Switch- Electric Heating to High Efficiency Fuel Oil Heating: An electric heat customer switching to fuel oil would get an incentive from its electric PA for the reduction in electric load, and the electric PA would record electric savings and fuel oil increase to the baseline for a fuel oil system. However, the customer would not then be able to take advantage of high efficiency incentives that saved only fuel oil because no ratepayer funds are available for efficiency savings of non-regulated fuels in C&I.

Non-Fuel Switching Example: A natural gas customer that has a large process boiler and wishes to install heat recovery equipment and use the recovered heat to operate an absorption chiller, thus reducing electric load would qualify for an incentive as a custom electric application as there is no increase in fuel usage at the expense of another fuel.

Fuel Switching is in the Portfolio Currently

Fuel switching at the request of the customer currently occurs and may be incentivized by the PAs, consistent with regulatory restrictions, in the following places:

At the time of construction or at time of equipment replacement

- Absorption Chillers – uses excess steam available
    - Fewer than 25 incentivized since 2010
- Heat pumps in Upstream HVAC – simply incentivizing new equipment
    - >20,000 incentivized statewide since 2013
- Variable Refrigerant Flow (VRF) – at the time of construction, the customer/builder may decide to use VRF even if gas is available
    - Fewer than 50 incentivized since 2015
- Customers installing High Efficient Gas Equipment when Oil Equipment is at EUL.

In Existing Buildings – Retrofit (early retirement)

- Custom case-by-case typically for Process, HVAC, or Domestic Hot Water end uses
    - Possibly 60-100 since 2010

The PAs do not use EE funds for gas service connections, main extension, and promotion of gas commodity/distribution service. These are distribution company functions and the efficiency funds are not used for these purposes.

Marketing & Education Considerations

Fuel switching is currently a customer driven decision and delivered/evaluated on a case by case basis – may not be scalable.

Fuel switching promotion and education must comply with relevant statutes and regulatory precedent.

Fuel Switching in C&I for 2019-2021

Note that this brief does not reflect potential program designs and is not a proposal for future programs, nor does it account for policy restrictions or changes to policies or programs – such as future proposals that may be included in the 2019-2021 Plan, and would be subject to DPU approval and need to be considered in light of legal and regulatory standards and precedent. The PAs are presenting what occurs currently and continue to follow policy, legal, and regulatory developments that in reviewing any potential future expanded services for customers.

APPENDIX

EEAC CONSULTANT TEAM DETAILED INFORMATION ON LIGHTING & CONTROLS

Potential technology options for retrofitting linear fluorescent installations with LEDs are shown below. This data originally appeared in a lighting memo from September 2016. The efficacy (lumens per watt) data has been updated using mean data from the Department of Energy Commercially Available LED Product Evaluation and Reporting (CALiPER) products list. [55]

Table 4. Common Linear LED Technologies[56]

	LED Linear Lamp, TLED – newer products can be driven directly from an existing fluorescent ballast; older designs require some fixture rewiring. **113 lumens/watt**[1] (GE T8 LED) *Lowest first cost retrofit.*
	Linear Retrofit Kit – installed in existing fluorescent fixture housing replacing fluorescent lamps, ballast and reflector. Some manufacturers provide integrated controls with these kits. **112 lumens/watt** (Cree ZR24-40L 2x4 LED Troffer) *Significant and increasing savings expected*
	Integrated LED Fixture (with controls) (Cree LED Troffer) **102 lumens/watt** *Significant and increasing savings expected*
1. When a TLED is put into troffer type fixtures, the lumen output must be de-rated ~20% to 91 lumens/watt in order to account for fixture losses. This deration is not necessary for a LED fixture or retrofit kit designed for LED use from the start.	

Additional Considerations

There are several points or trends that will have an impact on lighting savings that should be considered for the next three year plan. The information available for lamp counts and types indicates good potential for continued savings in the C&I market. LED technology continues to improve and become more efficient, which actually expands the potential for savings when compared to fluorescent and halogen technologies.

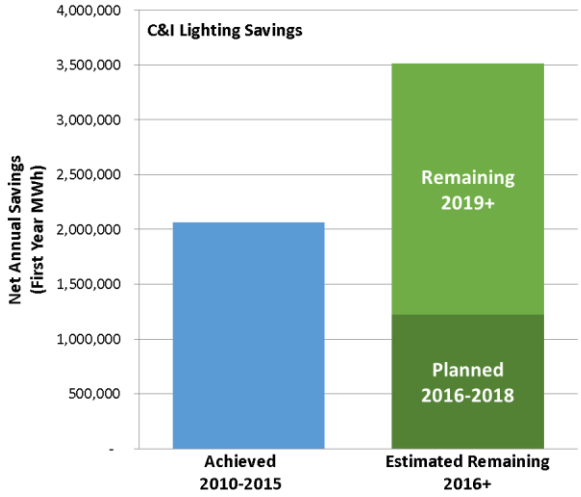
This estimate in the chart below demonstrates that lighting will continue as a strong contributor to C&I sector savings beyond 2018. . Annual lighting savings in 2016 and beyond could be 1.7 times more than savings achieved between 2010-2015. Estimated remaining annual savings are based on counts of existing stock from the DNV GL Onsite report and calculated using Technical Resource Manual (TRM) savings and hours of use for

[55] https://energy.gov/sites/prod/files/2016/12/f34/snapshot2016_troffers.pdf

[56] http://ma-eeac.org/wordpress/wp-content/uploads/EEAC-Lighting-Memo-20160908.pdf

different C&I building types. However, the hours of use included in the TRM represent average values, and it may not be cost-effective to retrofit lighting in C&I buildings that uses less than the TRM values. Another consideration that may effect the longevity and extent of lighting savings claims through energy efficiency programs is the rapidly shifting lighting market. In the next decade or so, as fluorescent technologies reach the end of their life, and LED technologies continue to improve and decline in cost, 100% of lighting is anticipated to ultimately convert to LED technology. PA ability to garner savings from LEDs is dependent on them leading the market and driving conversions before they would happen without incentives.

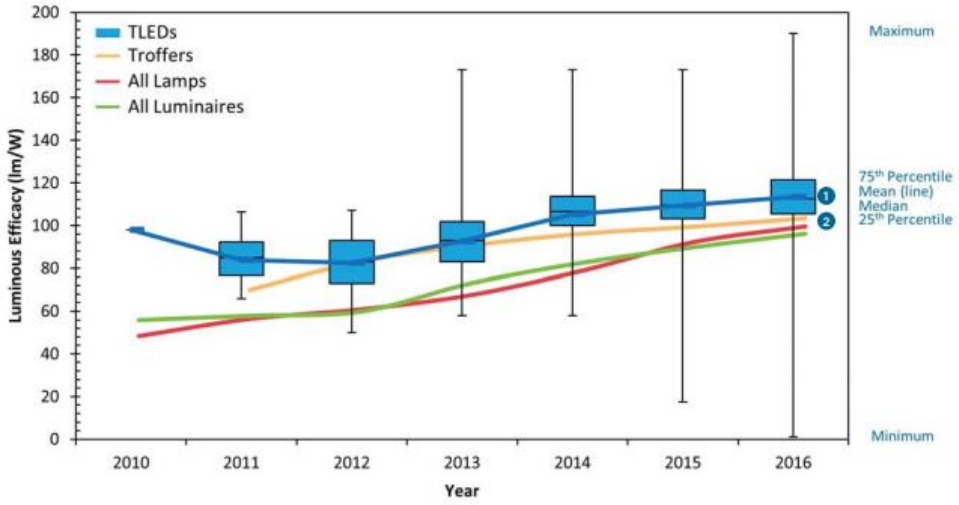
Figure 4. Consultant Estimated Remaining Technical Potential in Massachusetts[57]



All LED technologies show an increasing trend in efficacy, which is the amount of light produced per watt of energy consumed. The mean efficacy of TLEDs has been increasing by about 5 lumens per watt for the past two years, using less energy to produce the same amount or light, or more. In order to claim the correct amount of savings, the PAs need to keep savings assumptions updated in the Technical Resource Manual for prescriptive and upstream initiative measures.

[57] http://ma-eeac.org/wordpress/wp-content/uploads/CI-Savings-Opportunities-Final.pdf

Figure 5. TLED efficacy trends compared to other LED product types[58]



FROM THE DRAFT UPSTREAM IMPACT EVALUATION

The table below illustrates the share of different technologies in the upstream program for 2015, the most recent data the Consultant Team has at the measure level. In 2015 linear fluorescent T8 technology still provided more savings than TLEDs, and LED fixtures were not yet offered upstream. As of October 2017 fluorescent T8 technology is no longer incentivized through the upstream program, and both TLEDs and LED fixtures are available upstream. The Consultants expect that savings that used to come from fluorescent T8 lamps will shift to these linear LED technologies.

Table 5. Summary of 2015 upstream lighting purchases (Jan-Dec)

Product Type	Count of Rows	Quantity of Lamps	Watts Saved per Lamp	kWh Saved per Lamp	Total kW Saved	Total kWh Saved	2012 Evaluation Sample Measure Groups
A-line, 40/60w	**7,459**	**436,156**	**33.53**	**130.82**	**14,626**	**57,057,299**	**LED**
A-line, 75/100w	**821**	**53,652**	**47.11**	**183.77**	**2,527**	**9,859,647**	**LED**
Decoratives	1,169	35,327	21.07	82.18	744	2,903,211	N/A
G24 LED	2,014	371,658	12.83	50.06	4,769	18,604,572	N/A
LED Retrofit kit, <25W	7,929	130,098	40.66	158.61	5,290	20,635,101	N/A
LED Retrofit kit, >25W	59	967	59.95	233.86	58	226,147	N/A
MR16	**1,434**	**33,836**	**23.40**	**91.28**	**792**	**3,088,665**	**LED**
PAR20	**2,227**	**37,971**	**29.80**	**116.25**	**1,132**	**4,414,121**	**LED**
PAR30	**6,929**	**163,845**	**40.40**	**157.60**	**6,619**	**25,822,038**	**LED**
PAR38	**5,220**	**90,824**	**46.80**	**182.57**	**4,251**	**16,581,447**	**LED**
Stairwell Kit, 2ft w/sensor	58	2,276	53.40	467.78	122	1,064,676	N/A
Stairwell Kit, 4ft w/sensor	532	24,986	46.00	402.96	1,149	10,068,359	N/A
T5HO	**299**	**35,651**	**4.00**	**13.64**	**143**	**486,280**	**FLR**
T8	**725**	**65,320**	**3.52**	**12.00**	**230**	**784,049**	**FLR**
T8 - 25	**362**	**44,800**	**6.16**	**21.01**	**276**	**941,051**	**FLR**
T8 - 28	**5,113**	**512,621**	**3.52**	**12.00**	**1,804**	**6,153,092**	**FLR**
TLED, 2ft	102	4,012	4.25	14.49	17	58,144	N/A
TLED, 4ft	1,200	118,476	8.51	29.02	1,008	3,438,067	N/A
U-Bend T8 - 25	**188**	**5,925**	**6.16**	**21.01**	**36**	**124,458**	**FLR**
U-Bend T8 - 28	**334**	**11,077**	**3.52**	**12.00**	**39**	**132,959**	**FLR**
Total	**44,174**	**2,179,478**	**494.59**	**2,392.92**	**45,633**	**182,443,382**	

[58] https://energy.gov/sites/prod/files/2016/07/f33/snapshot2016_tleds.pdf

EEAC CONSULTANT TEAM DETAILED INFORMATION ON HVAC & CONTROLS

SECTION A – HVAC MARKET MAP

Figure 5 Mechanical (HVAC) market map

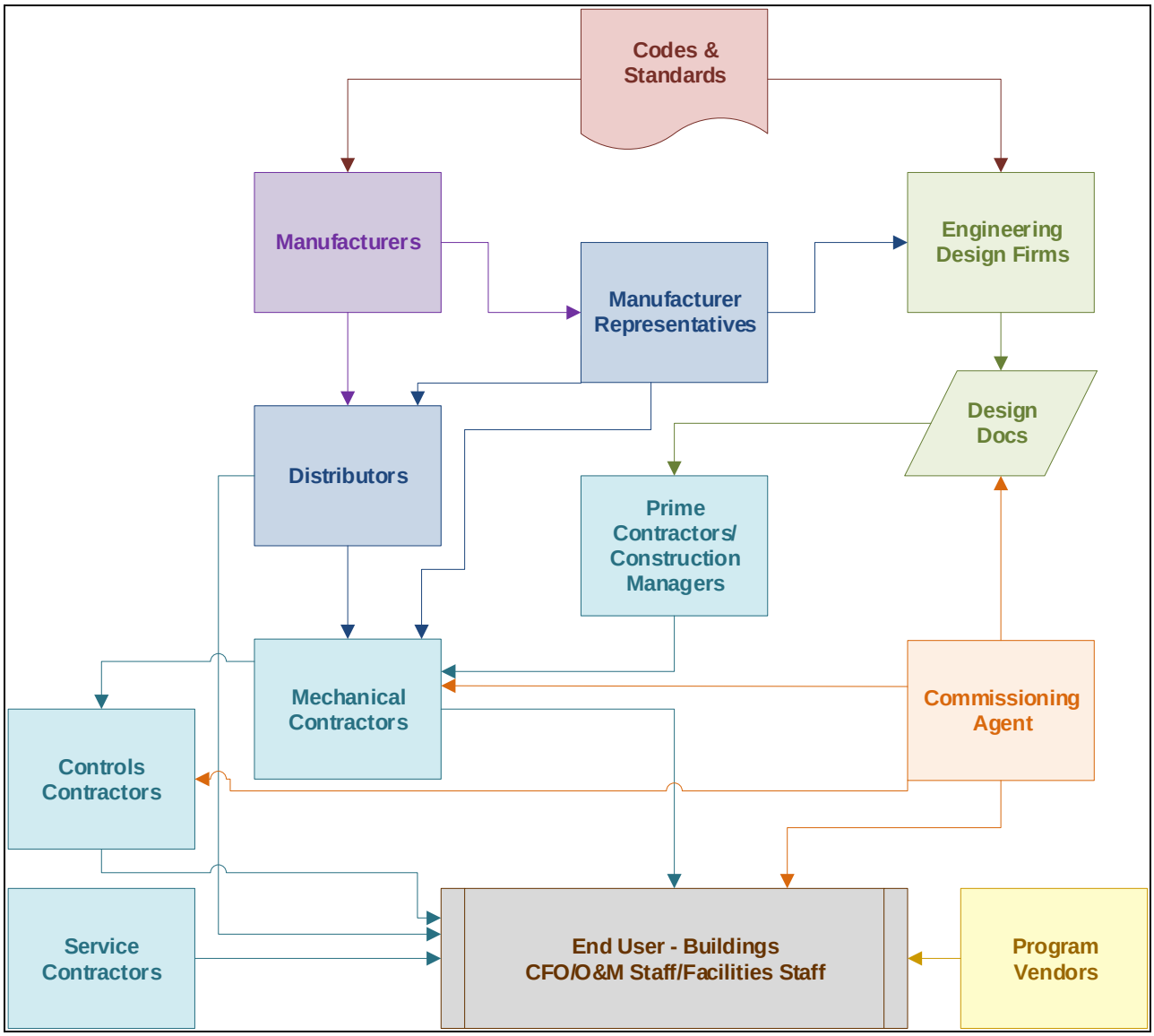


Table 3 Mechanical (HVAC) market matrix – current program intersections

	Upstream	Prescriptive Rebates	Custom Projects	Small Business	Comprehensive Design Assistance (CDA)	Training	Other

	Upstream	Prescriptive Rebates	Custom Projects	Small Business	Comprehensive Design Assistance (CDA)	Training	Other
Codes & Standards	-[1]	-[1]	-[1]	-[1]	-[1]	Limited	Adoption support?
Manufacturers	?					-	Limited strategic alliances[2]
Distributors	Less than expected	Limited					
Manufacturer Representatives							
Mechanical Contractors							
Controls Contractors							
Service Contractors							
Prime Contractors / Construction Managers	-[1]						
Engineering Design Firms	-[1]	-[1]			Varies	Limited	
Commissioning Agent	-[1]	-			Limited		
Program Vendors	Engaged	Limited	Limited	Engaged	-[1]	Engaged	-[1]
End User - Buildings CFO/O&M Staff/Facilities Staff	-[1]	Incentives	Technical Assistance& Incentives	Technical Assistance & Incentives	Technical Assistance & Incentives	Limited[3]	-[1]

[1]No additional utility activity would be applicable
[2]Generally product agnostic
[3]Some Building Operator Training

Table 4 Mechanical (HVAC) market matric – program intersection opportunities

	Upstream	Prescriptive Rebates	Custom Projects	Small Business	Comprehensive Design Assistance (CDA)	Training	Other
Codes & Standards	-[1]	-[1]	-[1]	-[1]	-[1]	Limited	Adoption support?
Manufacturers	?					-	Limited strategic alliances[2]
Distributors	Less than expected	Limited					
Manufacturer Representatives							
Mechanical Contractors							
Controls Contractors							
Service Contractors							
Prime Contractors / Construction Managers	-[1]						
Engineering Design Firms	-[1]	-[1]			Varies	Limited	
Commissioning Agent	-[1]	-			Limited		
Program Vendors	Engaged	Limited	Limited	Engaged	-[1]	Engaged	-[1]
End User - Buildings CFO/O&M Staff/Facilities Staff	-	Incentives	Technical Assistance & Incentives	Technical Assistance & Incentives	Technical Assistance & Incentives	Limited[3]	-[1]

Drive Market Change:

- **Expand/Increase state-wide marketing**
- **Build strategic alliances**
- **Seek input on programs**
- **Increase training and education opportunities**
- **Recognize and promote early adopters, high achievers, and best practice**

Increase operator knowledge and skill in efficient operations and recognize high achievers

[1]No additional utility activity would be applicable
[2]Generally product agnostic
[3]Some Building Operator Training

SECTION B – EEAC CONSULTANT HVAC OPPORTUNITIES TABLE

The following table summarizes barriers to achieving HVAC efficiency and the opportunities to increase adoption of efficient HVAC equipment, optimized HVAC systems and continued efficient operation of those systems. Overall the EEAC sees opportunities to increase engagement with market actors to drive market change from business as usual, which includes some program driven improved efficiency for HVAC systems, to optimal energy efficiency of HVAC systems across the market.

Some opportunities are broad, indicating a need for a market-wide strategy and some are very specific, applying to particular HVAC technologies or specific market actors. Most opportunities exist for both electric and gas HVAC end uses. The overall intent is to convey that there are significant opportunities in this important market segment and that making progress on multiple fronts at the same time will most effectively change business as usual practices.

Table 5 - Opportunities for Energy Savings from HVAC

AREA	BARRIERS	OPPORTUNITIES
Supply Chain	The HVAC market is complex and only a limited number of market actors are knowledgeable about and/or engaged with energy efficient approaches[59].	Develop a strategic market oriented approach that engages market actors in developing solutions that will support widespread adoption of efficient practices. Maintain engagement over time and practice continual improvement of program designs and offers to reflect changing market conditions.
Supply Chain	Efficient Equipment is not as widely promoted as it could be: Distributor engagement in upstream is less than expected.[60]	Improve marketing, communications, relationships and program protocols (administrative burden and incentive processing) to better establish the value proposition for distributors and increase participation.
Supply Chain	New HVAC equipment is often oversized increasing cost and reducing efficiency	Create a market awareness campaign using trade ally partnerships to increase awareness of the benefits associated with right sized hvac Equipment and the correct methods for sizing.
Supply Chain	New HVAC equipment typically runs well below full load, even when right sized.	Move the market to variable load equipment with high turn-down ratios so that equipment is efficient over the full range of operation, not just at full load.
Supply Chain	Efficient solutions are not readily available for some applications.	Seek to develop manufacturer incentives for equipment that is needed but not readily available in the market such as cold-climate heat pump PTACs, condensing furnaces in RTUs, etc.
Optimized Systems	C&I customers do not have the level of control that enables systems to be optimized. Building automation systems (BAS) exist in about half the	Implementation and upgrade of BAS is a prime opportunity to undertake system optimization strategies. Work with market actors to increase understanding of leading edge control sequences that deliver both energy

[59] The EEAC Consultants have direct experience with this in the market. Cx Associates has conducted 00's of new construction design reviews for major new construction projects in the Northeast and has provided direct commissioning on many of these projects. Even on projects pursuing LEED Platinum, there are often opportunities to improve HVAC system efficiency. The consultants have reviewed energy efficiency projects in MA in which the systems and approaches proposed increase efficiency, but do not maximize the cost effective achievement of efficiency (reviews have occurred as part of Impact Evaluation reviews and also of projects being bid by DCAMM.)

[60] Draft Process Evaluation of MA Upstream HVAC Program finding.

	buildings and about half of those systems are nearing or past the end of their useful life. Thermostats are not delivering verifiable savings and provide limited control.	efficient operation and indoor environmental quality.
Optimized Systems	New control sequences may not be optimized due to practitioners preferring “proven” approaches.	Increase engineering firm and control contractor familiarity with optimally efficient sequences of operation such as those documented in ASHRAE Guideline 36. Work to develop and maintain a feedback loop so designers and contractors understand the impacts of the design and installation choices they make on the ongoing system operating costs and benefits.
Optimized Systems	Energy codes are reducing the savings available on new construction projects.	System optimization and selection remain the best mechanisms for obtaining deep savings in new construction. Promote the use of water or refrigerant for the transfer of BTUS for heating or cooling. While ground source heat pumps have high first cost, they have lowest energy intensity and life-cycle costs and should be supported by the programs.
Optimized Systems	High-efficiency condensing boilers don’t operate at optimal efficiency due to lower than expected hours in which equipment is actually condensing.	Improve industry understanding of key control parameters that will enable condensing. Couple boiler installation with thermal envelope assessments and upgrades to decrease the hours during which high temperature heating water (which puts the boilers outside of condensing range) is needed.
Optimized Systems & Efficient Operation	Low market adoption of retro-commissioning.	Expand the current RCx program beyond health care. Improve the pool of providers by offering in depth training and developing standardized tools and measure lists to increase consistency across providers. Work with providers to develop projections and strategies to target the right buildings early and develop skill and confidence in measure identification and savings realization.
Optimized Systems & Efficient Operation	Savings from HVAC measures can be unpredictable and easily changed by building operators.	Provide commissioning that is linked directly to the energy savings measures and includes verification of energy performance. Have independent commissioning providers conduct design reviews and savings calculations reviews on the retrofit projects that they commission to ensure they understand and agree with the basis for the savings claim. This will increase their ability to verify threats to savings in the commissioning process and result in a better performing project due to buy-in of the whole team.
Optimized Systems & Efficient Operation	Savings from HVAC measures can be unpredictable and easily changed by building operators.	Develop improvements and potentially alternatives to the Pay-for-performance model to increase the awareness and adoption of energy management information systems and ongoing commissioning activities.

Efficient Operation	HVAC measures can be easily changed by building operators.	Engage with the market to develop a culture of energy performance among building operators. Consider awards for operators who demonstrate continued operation of systems below a target efficiency threshold (Such as 0.5 kW/ton of cooling for an entire chilled water system). Work with employers to develop incentives for operators and occupants to manage HVAC energy use and provide EMIS so that they can manage their performance.
Efficient Operation	Industry service providers have inconsistent skill and knowledge regarding HVAC opportunities and methods for system optimization.	Educate providers by sponsoring tours of successful HVAC system optimization projects including technical details of pre/post conditions, project costs and savings. Highlight best in field practitioners as such and help aspiring practitioners improve through education and developing a protocol where providers test and verify the performance of their projects rather than walking away after the TA study is complete. Work with targeted market actors to develop strategic training and engagement activities to the mutual benefit of the providers and the PAs.
Efficient Operation	HVAC control tuning measures have a short measure life and therefore deliver less lifetime benefits than other measures.	Provide ongoing commissioning and EMIS to support longer savings claims. Work with evaluation to develop protocols to test and verify measure persistence and increased measure life.
Efficient Operation	Equipment goes out of spec due to poor or lack of maintenance.	Increase market capacity for and interest in quality maintenance such as described in ASHRAE Standard 180.
CRE	Commercial building owners pay the cost of replacing, maintaining and operating HVAC equipment, but the energy costs are normally allocated back to the tenants. This gives the owner no incentive to pay for energy efficiency and the tenants have no power over the system efficiency.	Work to increase adoption of energy aligned leases. Increase building owner awareness of asset value of market draw of high performance buildings and develop pathways for building owners to invest in system upgrades and receive recognition for those improvements.

SECTION C - EVALUATION REVIEW AND OBSERVATIONS

HVAC EVALUATIONS

The following evaluations reported findings related to HVAC systems (both gas and electric). Key study elements are highlighted below and EEAC Consultant Observations are included. Studies include recent draft reports, not yet published, more recent published studies and older studies that have yet to be updated in the study cycle.

Evaluation studies reviewed to inform the HVAC Brief:

- PA Differences Study (2017)
- Upstream HVAC Initiative Process Evaluation (proposed final report 10/2017)
- Deep Dive Report – Exploration of HVAC Trends (Draft report 10/2017)
- Gas Boiler Market Characterization Study Phase II - Final Report (2017)
- MA CI Market Characterization On-site Assessments and Market Share and Sales Trend Study V1 – Main Report (2016)
- Follow-up Interviews with CCSI Commercial Training Attendees (2016)
- Impact Evaluation of Prescriptive Chiller and Compressed Air Installations (2015)
- Impact Evaluation of 2012 Custom HVAC Installations (2015)

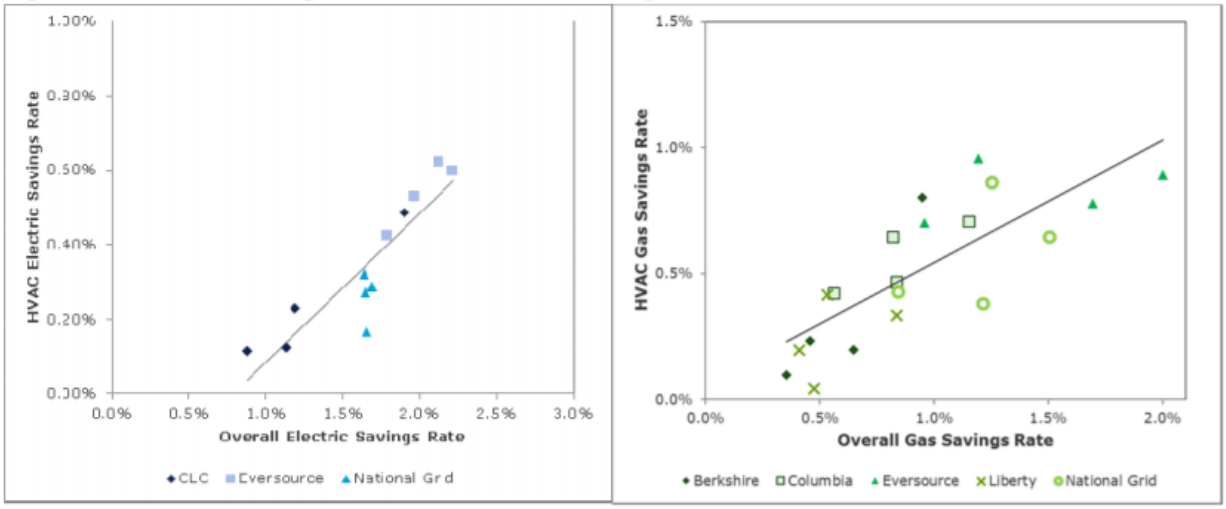
PA DIFFERENCES STUDY

August, 2017, http://ma-eeac.org/wordpress/wp-content/uploads/2016-PA-Differences.pdf

Evaluator Findings

PAs that derive a greater percentage of their savings from HVAC also tend to get higher savings overall; this is a multi-year trend.

Figure 1-1. Electric and gas HVAC and overall savings



For electric customers, Eversource's practices are resulting in greater depth of savings per participant than National Grid's or Cape Light Compact's.

- Eversource allowed program managers greater flexibility to offer customers higher incentives in 2013 and 2014 than the other PAs.
- Eversource may be achieving deeper savings per participant by cross-selling custom HVAC and prescriptive projects.
- Eversource has more repeat electric HVAC participation in 2013 and 2014 than the other PAs.
- There may be differences in engineering or sales practices that lead to identification of additional savings opportunities.

Eversource's and the small gas PAs' practices resulted in greater HVAC participation and greater savings per gas participant than either National Grid or Columbia.

- Eversource allowed program managers greater flexibility to offer customers higher incentives in 2013 and 2014 than the other PAs. This potential source of difference is also identified for electric.
- Eversource is achieving a greater percentage of gas HVAC savings from custom HVAC than National Grid.

EEAC Consultant Observations : This study focused on the quantitative drivers for differences. It found clear differences in performance regarding achievement of HVAC savings, with Eversource being uniquely successful in capturing market share for both electric and gas savings from custom HVAC. Overall the PAs should seek to develop a consistent statewide approach to obtaining deep HVAC savings, sharing best practices between PAs, customers and market actors to continually raise the bar for HVAC systems performance.

UPSTREAM HVAC INITIATIVE PROCESS EVALUATION

Proposed Final Report, October 2017 - Not yet posted on EEAC Website

Key Evaluator Findings:

Non-participation by distributors was attributed to the high administrative burden and low awareness of the program. Note that the PAs have changed the vendor for this program in an attempt to improve in these areas.

The distributor interviews revealed several barriers to greater program activity (e.g., more units of rebated equipment) among participating distributors including lack of demand for the rebated equipment from contractors and end-users, lack of contractor education, incentive levels which are perceived to be too low to adequately cover incremental costs, and perceptions of administrative burden.

Several of the program managers and implementers mentioned that certain HVAC technologies currently in the Initiative that may not be a good fit for the purpose or model of the Initiative, while there are other HVAC technologies that would be a better fit. More specifically, nearly all market actors we spoke to mentioned the need to add Variable Refrigerant Volume (VRF) technology to the technologies incentivized by the Initiative.

The turnaround time for incentives to distributors creates a barrier for promotion of measures through the program as does the perceived low value of incentives relative to incremental costs for higher efficiency units. The incentive structure is allowed to vary by distributor.

The marketing of the Initiative appears to occur infrequently and on an ad-hoc basis. Nearly all market actors noted that the Initiative would benefit from increased awareness and marketing to contractors and end-users. Further, our interviews with Non-Massachusetts program staff provided evidence of marketing success with strategic outreach through presence at conventions, trade shows and local meetings.

Evaluator Recommendations:

1. Update the incentivized technologies to include VRF
2. Address lengthy rebate processing times
3. Develop a focused marketing campaign

EEAC Observation: The PAs should be more proactive at driving technologies rather than responding to market demand. Proactive program design could have identified VRF as a technology with high market potential several years ago and developed a cohesive strategy that incorporated the distributor perspective to accelerate adoption of the technology. While VRF is planned for inclusion in the upstream market, the length of time it takes to move technologies into the program should be shortened and the PAs should develop and clearly communicate strategies for accelerating adoption of emerging technologies on a more proactive basis.

Distributor engagement, strong relationships and understanding the distributor value proposition are key to the success of HVAC upstream programs. The following is an example of the way information can be developed and presented in language that the distributors use to assess their own benefits. MA should adopt these best practices statewide.

Factor	Standard pump	HPCP pump	Variance
Resale from distributor to customer	$65	$165	$100
Distributor cost (estimate)	$52	$120.25	$68.25
Incentives at distributor's point of sale	-	$100	-
Resale value, with $100 incentive to distributor's customer	$65	$65	-
Gross profit per circulator pump	$13	$44.75	$31.75 / **$13**
Gross margin per circulator pump	20%	27%	**244%**
Gross profit generated from 10,000 units / year	$130,000	$447,500	**$317,500**

Distributor Value Proposition: A Strategic Partnership[61]

DEEP DIVE REPORT – EXPLORATION OF HVAC TRENDS

First Draft, 10/6/2017, Not published.

6

7 to National Grid, RI

Findings of interest

For the electric PAs, it appears that HVAC savings are becoming costlier to achieve (in terms of $/kWh saved); this cost/savings trend is not apparent for the gas PAs. There may be an opportunity for increased cross-fuel efforts to ensure that customers engaging in future HVAC programs (especially large customers) are aware of both electric and gas opportunities relevant to their unique circumstances.

EEAC Observation: Upstream for 2015 delivered gross savings at a cost of $0.25/kWh annual. While this is higher than the average cost of upstream savings. Overtime, the cost of upstream savings should be lower than the costs associated with the prescriptive offerings.

Custom HVAC and Retrofit HVAC (which have a high degree of overlap) deliver the largest and most significant HVAC savings. Eversource completed almost twice as many custom HVAC projects as National Grid completed in 2015.

EEAC observation. These two areas have a high degree of overlap in that most custom HVAC projects are retrofit[62]. Custom HVAC projects deliver the most cost effective savings for this end use and can result in significant impacts on participant energy consumption for both gas and electricity. Increasing the market capacity to undertake high quality, rigorously vetted HVAC system optimization projects that result in high efficiency systems delivering improved indoor environmental quality will maximize the benefits of the PAs HVAC efforts by increasing savings and delivering significant non-energy benefits to customers. The PA should also seek to incorporate continuous monitoring and improvement such as Energy Management and Information Systems, Fault Detection and Diagnostics and training/incentives/recognition for building operators who maintain systems at peak performance.

Motors and drives had consistently delivered the highest HVAC savings/participant account and are one of the lowest cost measures. Generic HVAC and Other HVAC deliver savings that are close to those from drives, but the lack of granularity for these categories makes drawing conclusions difficult.

EEAC observation. Drives are the source of this high savings percentage for Motors and Drives as the incremental efficiency of motor upgrades is small. Variable speed drives are a commodity measure that can deliver significant savings. However, savings from drives are often found to be unrealized due to a variety of design, installation and operating practices. Because drives change the dynamics of the water and air systems to which they are applied, drives provide an excellent entry point for moving to a system optimization approach.

Eversource achieved 10 times the savings of any other PA in the upstream program in 2015. Average upstream savings per project for 2015 were: Eversource 26,000 kWh, CLC 10,000 kWh National Grid 3,000kWh.

EEAC observation: For a statewide program, these are surprising finding and suggest that perhaps Eversource may be providing marketing to drive its customers to the upstream program and/or have a more successful distributor engagement strategy. Eversource should help to propagate its successful model statewide.

HVAC participation rates are relatively low with about half of one percent of customers participating in HVAC measures annually. Population savings were 0.36% in 2015, which means that C&I electric consumption overall was reduced by about 1/3 of one percent due to participant HVAC upgrades (gross savings).

GAS BOILER MARKET CHARACTERIZATION STUDY PHASE II - FINAL REPORT

3/1/2017

[62] While some are true new construction, new buildings are a smaller portion of the market overall and the most comprehensive new construction projects roll all measures into a single measure classification from which the HVAC component is not readily visible (this is the industry norm for comprehensive design and we are not seeking any change to that reporting practice as it would force inaccurate allocation of savings to specific end uses.)

http://ma-eeac.org/wordpress/wp-content/uploads/Gas-Boiler-Market-Characterization-Study-Phase-II-Final-Report.pdf

High-efficiency boilers are widely available in the market. The market for gas boilers in Massachusetts is shifting toward high efficiency. System design is a key factor in achieving rated efficiencies for condensing boilers.

Opportunities to improve boiler programs (Rx and likely upstream) include:

1. Incentivize field efficiency testing.
2. Provide contractor education in system design. Continue with the planned contractor education effort.
3. Offer a tiered rebate structure for all program-eligible models.

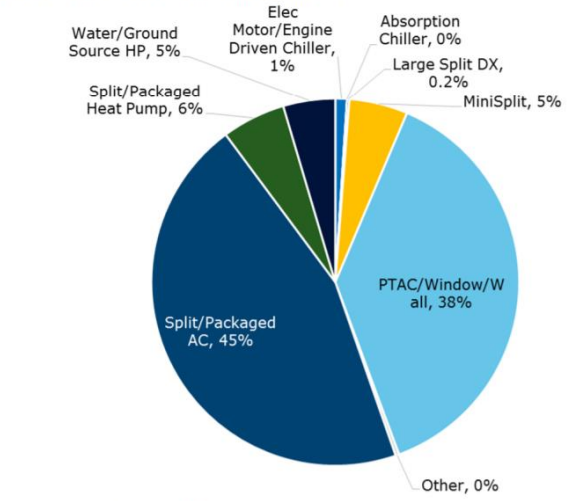
EEAC Observation: Education is another theme that evaluation reports provide. While the PAs report providing significant education, it is unclear that the PAs have a strategic education plan that establishes goals for the changes that the PAs are seeking to effect in the market and targeting educational activities and programs toward those goals. Taking a more strategic approach to developing, delivering and assessing educational efforts could improve benefits and reduce costs associated with education over time.

MA CI MARKET CHARACTERIZATION ON-SITE ASSESSMENTS AND MARKET SHARE AND SALES TREND STUDY V1 – MAIN REPORT

November, 2016 http://ma-eeac.org/wordpress/wp-content/uploads/MA-CI-Market-Characterization-Study.pdf

Split and packaged AC units are associated with businesses that represent 70% of Massachusetts business square footage while chiller are estimated to be found in businesses that represent 20% of business square footage (see Figure 4-10).61 Chillers cool substantially more square footage than their share of cooling units.

Figure 4-1: Distribution of cooling equipment



*The results presented above are weighted using the respondent-level sample weight.

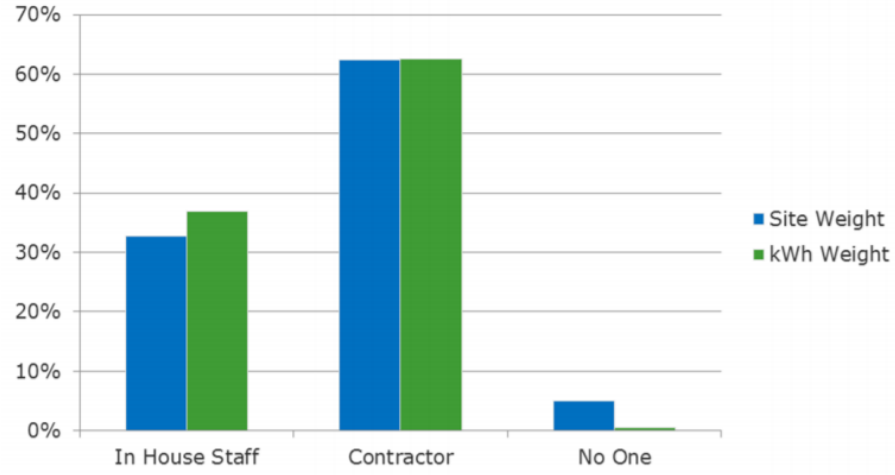
** These data represent 13,654 units.

Figure 4-1 indicates that 15-35% of installed cooling equipment exceeds federal standards (depending on size) and 33% to 75% of new equipment purchases exceed standards.

EEAC Observation: There may be some cost effective equipment retrofit opportunities available and there is room to move the equipment replacement market to higher levels of efficiency adoption. In addition, the PAs do not currently support high efficiency Packaged Terminal Air Conditioning (PTACs) or window ACUs for C&I other than under custom; however these measures could benefit from a more market based approach due to the high volume and prevalence in smaller customer locations. While the EEAC Consultants recognize that PTACs are sub-optimal equipment and applaud PA efforts to change out PTAC systems, we see two additional opportunities. One would be for the MA PAs to join with other energy efficiency program providers in the northeast and offer an incentive for a manufacturer or manufacturers to develop cold climate heat pump PTACs. This technology could then be widely promoted in an effort to change out PTACs across the northeast. Wifi enabled controls could be incorporated into this product as well delivering demand management and response capability along with large electric heat savings. Second best would be to find appropriate non-PTAC replacement options, develop trade ally partnerships and work to transform the market away from PTACs. Both of these solutions require a proactive engagement by the PAs to

move building owners away from existing technology and potentially bringing new technology to the market.

Figure 4-51: HVAC maintenance personnel



*The results presented above are weighted using the kWh-level and site-level sample weight.

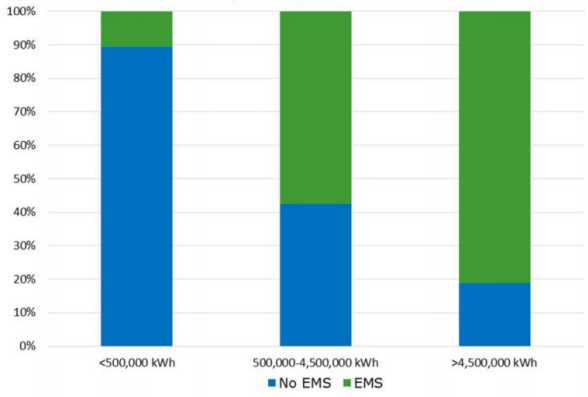
** These data represent 724 sites.

EEAC Observation: Because contractors are involved with a large share of maintenance, both preventive and reactionary, on HVAC systems, increasing understanding of the skills, goals and profit streams for this segment of the market could help identify means for increasing collaboration to improve energy efficiency as a result of HVAC service contracts. Opportunities that could be explored include: working with service companies to develop and market EMIS and FDD based services in which the service company sells the system, provide monitoring and continual service rather than the current low cost, low value service model that is very common in the market.

"Energy Management Systems" –

EEAC Observation - the MA PAs and their evaluators regularly refer to Building Automation Systems as Energy Management Systems. ASHRAE has a published Guideline 13-2015 "Specifying Building Automation Systems". ASHRAE is the internationally recognized organization that develops standards and guidelines affecting building hvac and refrigeration systems. It would improve clarity of the programs if the PAs could adopt industry standard terminology. That way when the PAs begin to support true Energy Management Information Systems, the distinction will be clear within the programs and out in the marketplace.

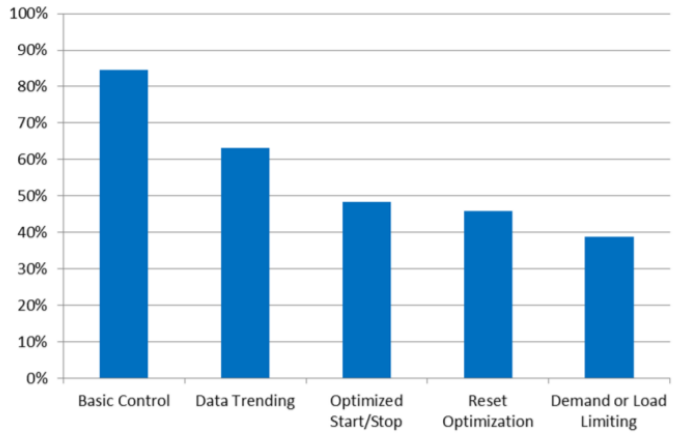
Figure 5-1: Businesses with EMS by kWh usage



*The results presented above are weighted using the kWh-level sample weight.

**These data represent 313 businesses <500,000 kWh, 382 businesses between 500,000 and 4,500,000 kWh, and 105 businesses >4,500,000 kWh for a total of 800 businesses.

Figure 5-11. Businesses with specific EMS control capability



*The results presented above are weighted using the kWh-level sample weight.

**These data represent 277 sites.

EEAC Observation: While building automation systems are more common in larger facilities, there are increasing opportunities to install lower cost systems in medium to small sized buildings. Control algorithms found/reported in the field indicate that within existing BAS there are many opportunities to optimize systems with improved control algorithms. The large amount of older BAS and pneumatic control devices means that there will be significant opportunities for PAs to work with customers to upgrade their control systems and undertake system optimization at the same time. Eliminating pneumatic controls where feasible provides multiple benefits – it improves the ability to develop more sophisticated control sequences, to monitor system performance, to overlay EMIS capabilities on the system and it eliminates or reduces losses and energy use from the air compressors necessary to support pneumatic controls. Control upgrade projects that include system optimization can deliver significant savings (Cx Associates recently worked with a customer to replace the controls for a large air handling system and provided updated sequences of operations to optimize system function. Savings were independently verified by evaluators to be 1.3 GWH annually).

FOLLOW-UP INTERVIEWS WITH CCSI COMMERCIAL TRAINING ATTENDEES

Revised Draft February 8, 2016

http://ma-eeac.org/wordpress/wp-content/uploads/Follow-up-Interviews-with-CCSI-Commercial-Training-Attendees%E2%80%94Revised-Draft.pdf

Table 2-1. Year of Commercial Training Attended

Year of Commercial Training Attended	Number of Attendees Listed
2014	112
2015	109
Total	221

EEAC Consultant Observations – code trainings are only affecting a small portion of the market. The HVAC code is the most complex part of the code and while the table above indicates only the classes attended by the study survey respondents, the PAs should be monitoring and reporting specific training activities that pertain to HVAC including target audience, target attendee levels and achieved audience and attendees. If participation in HVAC trainings is low, the fact that the PAs offer them is of little consequence. Trainings must be designed, marketed and monitored to ensure they are addressing the needs of the target audiences.

IMPACT EVALUATION OF PRESCRIPTIVE CHILLER AND COMPRESSED AIR INSTALLATIONS

October 26, 2015

http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

Overall, the weighted average operating load was found to be 27% of rated capacity for the entire sample. This indicates that, on average, the installed chillers are operating at the lower end of their maximum capacity. In addition, the weighted average maximum monitored load was approximately 66% of rated capacity. Both these findings suggest significant oversizing.

EEAC Consultant observation: equipment oversizing is a known issue in the hvac market. Oversizing increases first cost so it may increase the adoption of lower cost, less efficient technologies to "help control overall project costs", it can result in lower comfort due to chiller inability to turn down to meet load, it shortens equipment life due to cycling and increases the energy use of the systems. The PAs should have specific activities including training, partnerships with ASHRAE and HVAC design firms and others interested in developing a right-sizing movement that will help transform the market to accept right sizing as best practice rather than the traditional view that more is always better.

IMPACT EVALUATION OF 2012 CUSTOM HVAC INSTALLATIONS

Oct 23, 2015

http://ma-eeac.org/wordpress/wp-content/uploads/Impact-Evaluation-of-2012-Custom-HVAC-Installations.pdf

Findings from this study may not reflect current practices due to the age of the study. However, it is unclear whether the study recommendations have been fully implemented across all PAs.

EEAC Consultant Observation: realization rates were highly variable at the PA level. However, smaller PAs did not receive statistically valid samples of their sites. Consider increasing sample sizes for smaller PAs under the new C&I evaluation framework to provide a better picture of small PA performance and enable small PAs to determine whether there are issues and opportunities for improvement within their custom project delivery model. The Council should recognize that while there are similarities between PAs on customer project delivery, the programs are not the same and may vary considerably depending on the sophistication of the customer engagement strategy, personnel and consultants involved.

Recommendations from this study include:

- Improve Baseline or Pre-Retrofit Documentation
- Provide Sufficient Documentation
- Clearly Document Calculations of Peak Demand Savings
- Encourage More Comprehensive Commissioning and Updating of Tracking Estimates with Findings from Commissioning
- Conduct Pre-Installation Metering for More Retrofit Projects
- Improve use of Post Inspection to Verify Measure Operation

EEAC Consultant Observations: The upcoming custom impact evaluations will increase understanding of how the PAs are performing on these recommendations; particularly the first three which are foundational to ensuring that reported savings can be independently verified to ensure the MA ratepayers are receiving the benefits for which they are paying. Recommendations regarding more comprehensive commissioning, metering and performance monitoring speak directly to the potential for a program design that seeks to increase the attention on post-installation performance and continuous measurement and validation of savings.