Memo

MA ENERGY EFFICIENCY ADVISORY COUNCIL

EEAC

→ CONSULTANT TEAM

To: **EEAC**

From: **Jennifer Chiodo, George Lawrence, Rebecca Harcourt - EEAC Consultants**

Date: **September 8, 2016**

Subject: **C&I Lighting Market and Technologies**

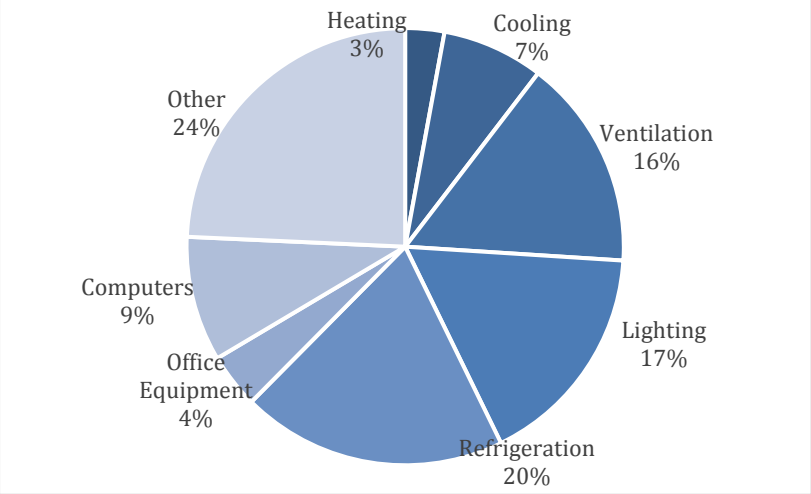
INTRODUCTION

Lighting is an important energy end use in Massachusetts' efficiency portfolio. Nearly 80% of C&I projects in 2014 were lighting-related, representing almost 60% of C&I savings.[1] 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. The purpose of this memo is to provide information regarding the C&I lighting market, LED technologies, lighting baselines, and the resulting program implications.

THE C&I LIGHTING MARKET

The efficiency gains in lighting over the past two decades have substantially decreased the contribution that lighting makes to C&I building loads. The 2012 Commercial Building Energy Consumption Survey (CBECS) found that lighting represents 17% of the electric load for commercial buildings in New England, as shown in **Error! Reference source not found.**.[2] This is a significant change from the comparable 2003 study which found lighting represented 39% of C&I building energy consumption. Between 2003 and 2012, New England lighting consumption dropped 50% while commercial building electric consumption increased by 24%. As lighting energy consumption drops, the total remaining potential for lighting savings also decreases. Energy efficiency programs need to pursue new opportunities to further reduce lighting energy consumption through LEDs and controls while working to improve their capability to drive increased efficiency for other building end uses.

Figure 1: Electric Loads by End Use in Commercial Buildings (New England)



[1] 2014 Customer Profile Report

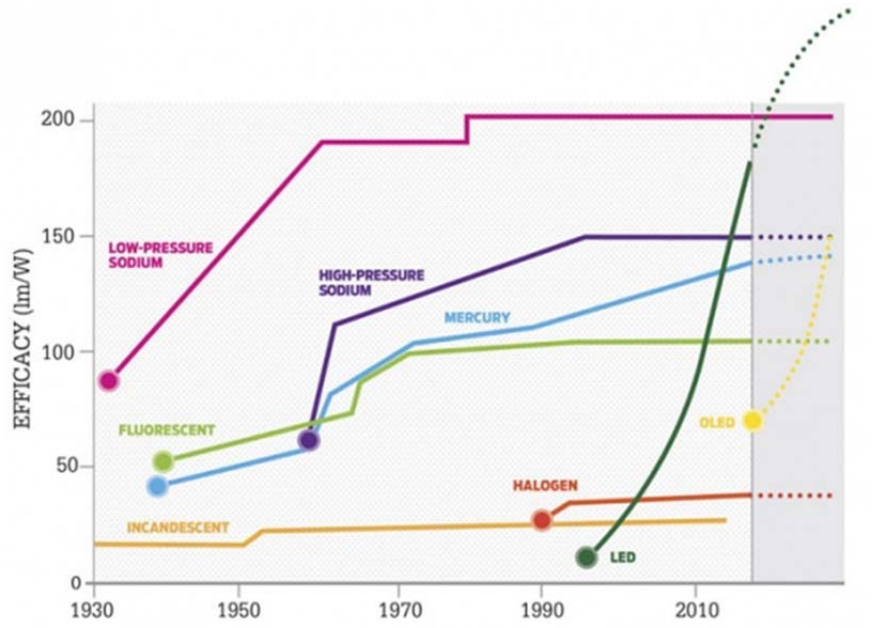
[2] https://www.eia.gov/consumption/commercial/reports/2012/energyusage/ While these data are regional, the distribution of commercial electric loads by end use is expected to be similar in Massachusetts.

Rapid innovation in LED lighting products and aggressive manufacturer promotion are stimulating the lighting market beyond what would be driven by energy efficiency programs alone. The PAs are in the role of providing both additional market stimuli to accelerate the technology adoption curve and guidance to steer the market toward optimally energy efficient solutions when LED retrofits and new designs are undertaken. The market for LED lighting in the C&I sector is projected to expand over the next ten years, creating the potential for continued contributions from lighting savings to C&I energy efficiency goals.[3]

LED TECHNOLOGY OVERVIEW

LED fixtures and lamps continue to improve the efficiency with which they convert input energy (e.g., watts) into light output (e.g., lumens). Figure 2 presents the efficacy of several lighting technologies as measured in lumens per Watt. LED products available on the market today deliver between 75 and 150 lumens-per-watt.[4] Leading manufacturers have prototype products that have reached 200 lumens/watt. The top end of that range is significantly better than the best fluorescent technologies which provide between 50 and 100 lumens/ watt. Care must be taken when comparing the efficacy of different technologies. In particular, the efficacy of individual light sources (i.e., "lamps") should not be compared with the efficacy of complete lighting fixtures[5].

Figure 2: Efficacy of Different Lighting Technologies[6]



The sections below provide an overview of LED technology and examples of three common lighting products types.

- → Replacement lamps for compact fluorescent and incandescent fixtures
- → Linear LED products that replace or supplant linear fluorescent lamps and fixtures
- → Controls

[3] US DOE Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, August 2014. Table 3.2 shows the continued increase in LED lighting efficiency and adoption through 2030 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/energysavingsforecast14.pdf

[4] Sources: Philips, Sylvania, GE and CREE product literature.

[5] The differences between lamp and fixture efficacy are explained in more detail in Appendix A to this memo.

[6] Energy Efficiency of LEDs, USDOE, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_energy_efficiency.pdf

LED Replacements for Compact Fluorescent and Incandescent

Figure 3 provides an overview of common lighting technologies used to replace compact fluorescent lighting (CFL) and incandescent lighting in the C&I market. CFLs represent approximately 11% of the interior lamps found MA businesses.[7]

Figure 3: Common LED Technologies

	**A-lamp LED (**LED Screw in Lamp) – replaces incandescent and screw-in compact fluorescent lamps **76 lumens/watt**[1] (Philips A-lamp LED) *Significant continued savings expected until 2020*
	**G-24 LED –** Pin-based CFL replacement lamp – replaces pin based CFLs and does not require the fixture or ballast to be removed for a hard wired CFL fixture **124 lumens/watt**[1] (Philips G24q bulb) *Lowest first cost retrofit for pin-based CFLs. Likely to have significant market share; savings until 2020.*
	**Downlight Retrofit Kit –** replaces the guts of a downlight using the existing housing to change an incandescent, CFL, or high intensity discharge fixture to an LED fixture **77 lumens/watt**[1] (Lithonia LED Retrofit Kit) *Higher cost and lower efficacy will limit market share*.
1. The efficacy of lamps and retrofit kits are not directly comparable.	

To date, MA C&I LED savings have been predominantly generated by A-lamp LEDs with approximately 490,000 units moving through the upstream program in 2015, generating annual energy savings of 67,000 MWh.[8] Sales of G-24 LED were also significant in 2015, with over 370,000 units generating annual savings of 18,600 MWh[9]. Savings are lower for the G-24 LEDs because the baseline is a CFL lamp, while the baseline for the A-lamp is a higher-wattage mixture of incandescent and CFL lamps.

[7] Draft DNV GL Market Characterization Report
[8] Stage 3 Workplan – Impact Evaluation of MA CI Upstream Program, DNV GL. Savings cited in this plan are gross (prior to evaluation or application of realization rates).
[9] Ibid.

Linear LED Products

Linear lighting technology represents 74% of the lighting in the existing MA C&I building stock. Over 70% of the linear lamps are fluorescent.[10] In 2015, the C&I programs had limited volume of upstream LED linear lamps (TLEDs); most LED fixtures were addressed through downstream programs. Technology options for retrofitting linear fluorescent installations with LEDs are shown in Figure 4.

Figure 4 Common Linear LED Technologies

	**LED Linear Lamp**, TLED – newer products can be driven directly from a fluorescent ballast; older designs require some fixture rewiring. **90-120 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. **90-110 lumens/watt**[1] (Cree ZR24-40L 2x4 LED Troffer) *Significant and increasing savings expected*
	**Integrated LED Fixture (with controls)** (Cree LED Troffer) **90-130 lumens/watt**[1] *Significant and increasing savings expected*
1. Lumens/watt is not directly comparable between the TLED and the fixture based solutions.	

LED Linear Lamp Replacements (good)

Replacing linear fluorescent lamps with TLEDs is a relatively low-cost measure. The savings from these retrofits are improving as TLEDs become increasingly efficient. Linear LED replacement lamp prices have dropped rapidly, from $45/lamp in 2013 to $14/lamp in 2016.[11] On the other hand, linear LED lamps are still about ten times costlier than their fluorescent counterparts. The U.S. Department of Energy (DOE) is seeking to drive innovation in LED lamp technology and is seeking a 50% reduction from the current price by 2020[12].

Some of these products require changes to the existing fixture, such as removing power from the ballast and installing an LED driver or changing the tombstones (sockets) into which the lamps will be mounted. These

[10] Draft DNV GL Market Characterization Report
[11] During the development of this memo lamp prices dropped from $15 to $13/unit.
[12] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/energysavingsforecast14.pdf

changes increase the installation cost. Newer lamps can be installed directly in fluorescent fixtures with the existing ballast in place. Issues that energy efficiency programs should consider when supporting these products include the remaining life of the existing ballast and fixture, compatibility between the LED products and the existing fixture characteristics, safety, lighting quality, and the lack of available integrated controls. TLEDs are popular in the market and supported through the current Massachusetts upstream program. The PAs should continue to support TLEDs while also continuing to drive the market toward more comprehensive fixture retrofits (as described below) where feasible.

LED Fixture Retrofit Packages (better)

LED fixture retrofit packages integrate a new reflector, heat sink, LEDs, and driver into a single package. The existing fixture housing and wiring remain, reducing installation costs. The benefit of fixture retrofits is that the new fixture has a higher total efficacy than fixtures where only the lamps are replaced. Retrofit kits can also offer significant new control capabilities, including dimming, integrated occupancy control, and addressable fixtures which enable fixture control from a smart phone or other device. The costs of LED fixture retrofits are decreasing and the availability of attractive options is increasing, making this an important measure for the energy efficiency programs in the coming years.

Integrated LED Fixtures (best)

Retrofitting existing fluorescent lighting systems with new LED fixtures with integrated controls is the most expensive first cost retrofit option, but typically delivers the largest savings because the lighting system can be redesigned to more closely meet the needs of end users. New LED fixtures are comparable in cost to new fluorescent fixtures, making them increasingly common in new construction projects.[13]. Integrated LED fixtures remain costly enough that comprehensive projects to retrofit fixtures from T-8 to LED typically have a simple payback of over 5 years before incentives.

Comprehensive LED lighting retrofits should be treated as capital improvements that increase the value of the property which increases the return on investment above the return provided by the energy cost savings alone.

Controls

Because LEDs are electronic components, integration of controls into LED drivers can be accomplished at a minimal incremental cost. While many control options already existed in the market, their low cost integration into LED fixtures is a significant change. Controls provide a variety of functions, including dimming, occupancy control, and daylight sensing. In addition, LEDs offer a new feature – addressability.

Unlike fluorescent lamps, LEDs are readily dimmable and LED products already incorporate dimming as a standard feature. In some cases, LED lighting systems are too bright when installed; dimming controls can reduce issues from initial high light output and increase savings. LED's dimming capability lowers the cost and improves performance of daylight dimming. Daylight sensors integrated into the fixtures improve local response to daylight on the individual work surfaces. Lights can dim gradually so that adjustments in response to changing daylight levels are not noticeable to occupants. LED dimming increases the potential for lighting systems to serve as demand resources because 5-10% reductions in light levels (and therefore lighting demand) can be automatically implemented during peak periods without impacting productivity.

LEDs are energized instantly, which reduces the delay that occurs with fluorescent fixtures when rooms become occupied, improving user satisfaction. Occupancy sensors can be integrated into fixtures to reduce the cost of adding controls in a retrofit.

Electronic controls allow LEDs fixtures to be independently controlled (or "addressed") through a digital lighting control system.[14] This addressability is a game changer for lighting control because it enables a level of control that previously was very expensive and therefore not widely adopted. Addressable lighting control systems

[13] Acuity Brands, a major lighting fixture manufacturer reported the LED fixtures made up 55% of sales in its most recent quarter while it comprised 0 of sales in 2010.

[14] Addressability already exists in HVAC building automation systems and in commercial fire alarm systems in which each device is discoverable and potentially controllable from a central computer.

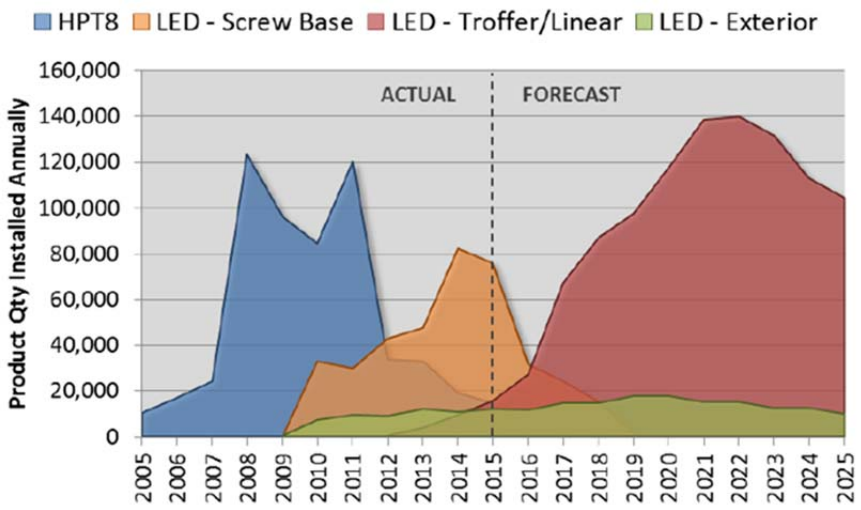
provide control by individual end users from a computer or smart phone while also enabling centralized control of the lighting system. For example, users can have individual control over light levels while the building operator retains the ability to implement a 10% dimming scheme to reduce demand during peak periods. The incremental costs for these lighting controls remains significant but is decreasing. Incorporating addressable controls will expand the range of cost-effective efficiency associated with LED lighting upgrades and enable lighting systems to be used as demand resources in the future.

SAVINGS POTENTIAL

Annual savings from C&I LED retrofits are expected to increase over the next few years. Market transformation[15] to LED lighting technology is anticipated in the mid 2020's. This section discusses anticipated changes to baselines that will affect program offerings and savings, the potential implications of increasing efficiency and decreasing costs of LED technology, and the potential for program savings.

Efficiency Vermont developed an analysis of lighting sales that compares the market potential and timing for LEDs to historic high performance T-8s (HPT8) sales data. **Figure 1**Figure 5 shows Vermont sales of HPT8 products tailing off to zero around 2016 and sales of screw base LEDs peaking in 2013. The Commonwealth has seen increasing sales for screw base LEDs over the past 3 years, with sales expected to peak in 2015 or 2016. Sales for these products will continue after 2020, but energy efficiency programs will cease to claim savings for them at that point due to Federal Standards which will make them the baseline technology. Although Massachusetts will cease to offer incentives on linear fluorescent products this year, the products will continue to be sold to users who have not converted to LED technology. Therefore, fluorescent sales will continue for a few years, but Massachusetts will not realize efficiency savings from these sales. Similar to Vermont, the Massachusetts market is on the cusp of a rapidly accelerting adoption rate for linear LED products, with significant sales potential as lighting systems are converted to LEDs over the next decade.

Figure 5 C&I Lighting Product Adoption Analysis (Vermont)

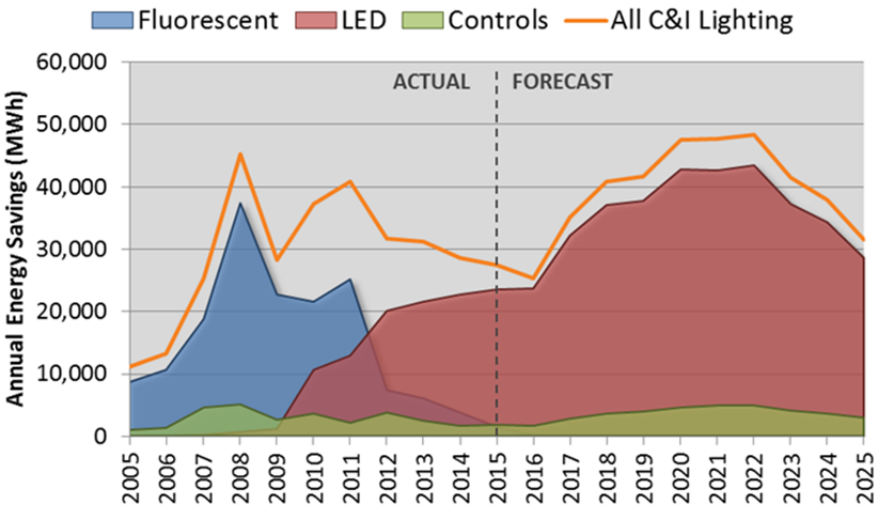


Efficiency Vermont estimates that they have more savings potential available from LED lighting than they obtained from HPT8 products, as shown in

Figure **6**, even without a large contribution from controls. Therefore, Massachusetts has the potential to drive LED savings even higher by making significant efforts in the lighting controls market.

[15] In this context market transformation is a situation where over 90% of the lighting products sold on the market will be LED products.

Figure 6 C&I Lighting Savings (Vermont)



Baseline Considerations

Baselines for calculating savings from efficiency lighting will be affected by changes in building codes and Federal standards, changes in product availability, and advances in standard practice. These topics are addressed at a high level here; more detail is provided in Appendix A.

Increases in minimum efficacy requirements mandated under Federal Standards for screw-in lamps are expected to eliminate savings from these products by 2020. GE has announced that they are ceasing production and distribution of screw-in CFL lamps this year. As a result, there is a limited period over which savings from screw-in LEDs will continue to generate savings for the programs. C&I lighting sockets are being rapidly converted to screw-in LEDs and the programs are obtaining good savings from these measures which are expected to remain viable sources of savings for the next 2 to 3 years. Evaluations are being conducted regularly to assess the impacts of these measures and to verify performance and baseline assumptions.

The lighting requirements in Massachusetts energy codes are failing to keep pace with the level of efficiency readily available in the market. Recent evaluation studies found that standard practice for lighting were better than code even when T8 technology was in use. We do not expect that changes in code will have any impact on C&I lighting savings over the next 3 to 5 years. The requirement that lighting efficiency exceed code by 10% is easily met with fluorescent technology and very easily met with LED technology. Therefore, standard practice is being used to establish baselines for lighting in C&I new construction projects due to the lagging code.

LEDs offer significant benefits over existing lighting technology in characteristics beyond cost and efficiency, which contributes to market adoption. As prices drop and the market transforms to LED technology over the next decade, regular assessment of baselines through evaluation will be necessary to ensure that reported savings are in fact attributable to the programs.

Efficacy Improvements and Costs

This memo has already touched on the increasing efficacy improvements and falling costs for LED technologies. The expectation is that linear LED fixtures will top out at efficacies well over DOE's target of 200 lumens per watt. Indeed, a prototype TLED has already been developed that exceeds this level. We can expect products available in the next few years that are about twice as efficient as current LED products.

As with many products, LED lighting comes in a wide range of quality and cost. Currently, the Massachusetts PAs require promoted products to be certified by Energy Star or the Design Lights Consortium. These certifications provide a floor for equipment performance and a modicum of quality assurance. However, even certified products have significant variation in cost and quality. Screw-in lamps and TLEDs are available from both traditional lamp

manufacturers and a handful of newcomers that offer high quality products. Similarly, traditional luminaire manufactures continue to offer quality products, but face stiff competition from newcomers to the market that offer LED products at very low prices. For example, the cost of a 2'x4' LED fixture to replace an existing 2-lamp T8 fluorescent fixture ranges from $40 for an uncertified product to $300. These large cost discrepancies are unique to the LED market, as many newcomers seek a share of this very large opportunity. The range in cost for products that appear similar pose challenges to program implementers as they try to help customers identify products that will deliver the promised benefits. While more sophisticated building owners and managers will readily grasp the impact that lighting system quality has on the value of their building assets, less knowledgeable owners and managers may be swayed by the lowest first-cost option. Poor quality products may have higher failure rates, flicker, color-shifting, noise, and glare. The programs need to find the right path to achieve the maximum cost effective savings while helping customers understand the full range of benefits that comes with certified products.

Prices on lighting control packages are also dropping. Fixtures with fully integrated controls or that are zone addressable by a central computer are available now and are advancing in terms of both features and cost effectiveness. One approach the PAs could consider would be to design a lighting controls competition in which manufactures strive to deliver the specified features within a price limit. This could stimulate market interest in advancing controls development and provide a showcase for new products.

Available expertise in lighting installation is a key barrier to advanced lighting controls. Despite their role selling and installing lighting upgrades, most electricians are uncomfortable pricing and designing lighting control systems. California has developed the California Advanced Lighting Control Training Program (CALCTP) to educate, train, and certify installers and acceptance technicians to support the proper installation, programming, and maintenance of advanced lighting controls systems.[16] Ensuring that trade allies have the necessary skills to install and program these systems is an important element to advancing lighting controls and ensuring that savings are reliable.

Program Implications

The following summarizes program implications identified throughout this memo:

- → Continue to support and evaluate screw-in LED products until 2020 or until the standard practice baseline shifts to LED, whichever occurs first
- → Continue efforts to advance linear LED products through the upstream program, with a similar eye to evaluation and baselines
- → Continue efforts to advance more comprehensive LED retrofits with integrated controls
- → Identify and advance efforts to address market barriers to advanced controls
- → Use non-energy benefits such as increased building asset value, improved light quality and occupant productivity gains to help sell upgrades
- → Support efforts to advance energy code baselines to more closely reflect standard practice
- → Continue to use independent product certifications to support product quality

The programs are continuing to build capacity and features to effectively advance LED lighting in the C&I market. Attention and action to address market capacity and action to improve the consistency between energy codes and standard practice are the areas where new efforts may be needed.

[16] https://www.calctp.org/ CALCTP is currently undergoing a process evaluation.

APPENDIX A: LIGHTING REGULATION, CODES AND STANDARDS

This appendix provides additional information and references for those who wish to delve into the details of codes, standards and federal regulations that guide the efficiency of lighting sources and installed lighting systems.

Summary of regulations, standards and codes

- Federal lighting product efficiency regulations – mandatory requirements
- Energy Codes – mandatory requirements
- Product standards such as Energy Star and Design Lights Consortium – optional participation

While the lighting memo touches briefly on each of these areas, this appendix provides more details on the content and impact of these regulations, codes and standards.

FEDERAL LIGHTING PRODUCT EFFICIENCY REGULATIONS

The Department of Energy (DOE) released a notice of proposed rulemaking[1] on February 12, 2016 which sets minimum efficacy standards for general service lamps at a level that will exclude both incandescent and omnidirectional CFLs from the market. The new regulations will take effect in 2020. As shown in Table 1, LEDs are the only product that is currently achieving the standard; incandescent and CFL lamps are far below the requirements of the new rules for typical lamps. The result of the rules' implementation will be to make LEDs the baseline product for integrated lamps.

Table 1 – Example of Proposed Energy Conservation Standards for General Service Lamps

	Examples[2]		
	Incandescent A-Lamp	Compact Fluorescent Lamp	LED
Watts	60W	13W	8.5W
Lumens	865 ILU[3]	825 ILU[3]	800 ILU[3]
Efficacy (2016)	14 lumens/watt	63 lumens/watt	94 lumens/watt
Required Efficacy[1] (2020)	95 Lumens/watt	94 lumens/watt	94 lumens/watt

1. The required efficacy is proscribed via a formula. The standards include a variety of lamp types with different efficacy formulae for each type. The uses the lumen output of the lamp as the key variable which explains the slight differences between the requirements in this row.
2. These examples are for integrated lamps which means a lamp that contains all components necessary for the starting and stable operation of the lamp, does not include any replaceable or interchangeable parts and is connected directly to a branch circuit through an ANSI base and corresponding ANSI standard lamp holder socket.
3. ILU – Initial lumen output

[1] Energy Conservation Program: Energy Conservation Standards For General Service Lamps, Notice Of Proposed Rulemaking - http://www.energy.gov/sites/prod/files/2016/02/f29/General%20Service%20Lamp%20NOPR_1.pdf

As discussed in the cover memo, these regulations are expected to have minimal impacts on the MA C&I programs due to the fact that the affected products will have become baseline in the market by 2020.

There are no new proposed standards for non-integrated lamps.

MASSACHUSETTS COMMERCIAL ENERGY CODE

Massachusetts will adopt the 2015 IECC with amendments on January 1, 2017. The Green Communities Act requires Massachusetts to update the energy code to the newest version of the IECC within a year of its release. It may be noticeable that the time between the implementation of the newest 2015 IECC code has been longer than a year. This is due to an extended concurrency period, where both codes are effective, but people have the choice of adhering to the more recent code or the 2012 version during this time. In terms of commercial lighting, some of the key updates to be aware of are outlined below:

- → Most interior lighting power densities have decreased. For the building area method, LPD measures have decreased by an average of 18% from 2012 IECC levels. The space by space method has an average decrease in LPD of 15%. Refer to charts below for a more detailed comparison.
- → Additional more stringent requirements for daylighting, lighting controls and allowed lighting power densities are required in new and existing buildings.
- → Daylight responsive controls are required in spaces greater than or equal to 150 W per zone general lighting.
- → Addition of warehouse occupant sensor requirement of lighting in unoccupied areas to be reduced by less than 50%.
- → Control enhancements have been expanded to incorporate continuous dimming, luminaire grouping controls in daylight zones, and expanded requirements for occupancy sensors.
- → In an attempt to improve effectiveness of controls at turn-over and over the life of the building, the 2015 code requires functional testing of occupant sensor controls and time-switch controls and that lighting contractors provide operations and maintenance manuals for lighting and lighting controls.

The following charts illustrate changes to LPA by building type and space by space methods from the 2012 IECC to the 2015 version specified in section C405: Electrical Power and Lighting Systems. Figure 1 looks at a sample of 12 building area types of the 32 specified in the Interior Lighting Power Allowances: Building Area Method tables of 2012 and 2015 IECC. The family dining area had the largest decrease in LPD of 40%. The LPD specified for warehouses increased in the newest version of the code by 10%.

Figure 1: Interior Lighting Power Allowances: Building Area Method

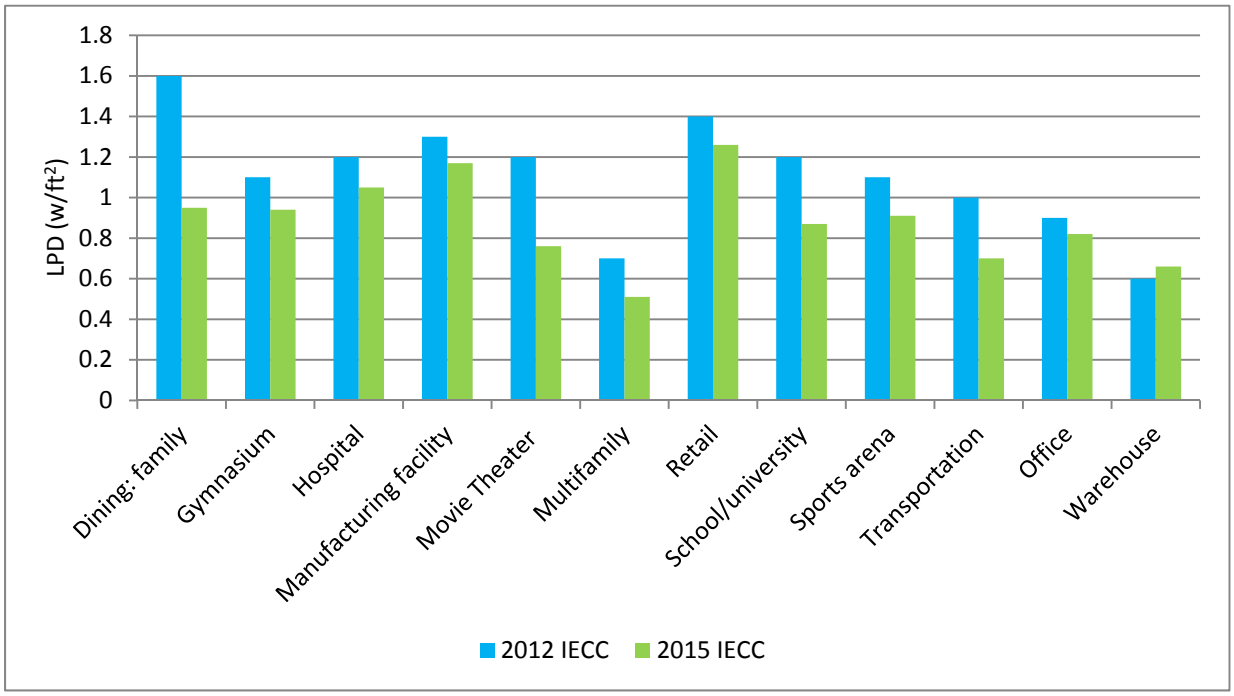
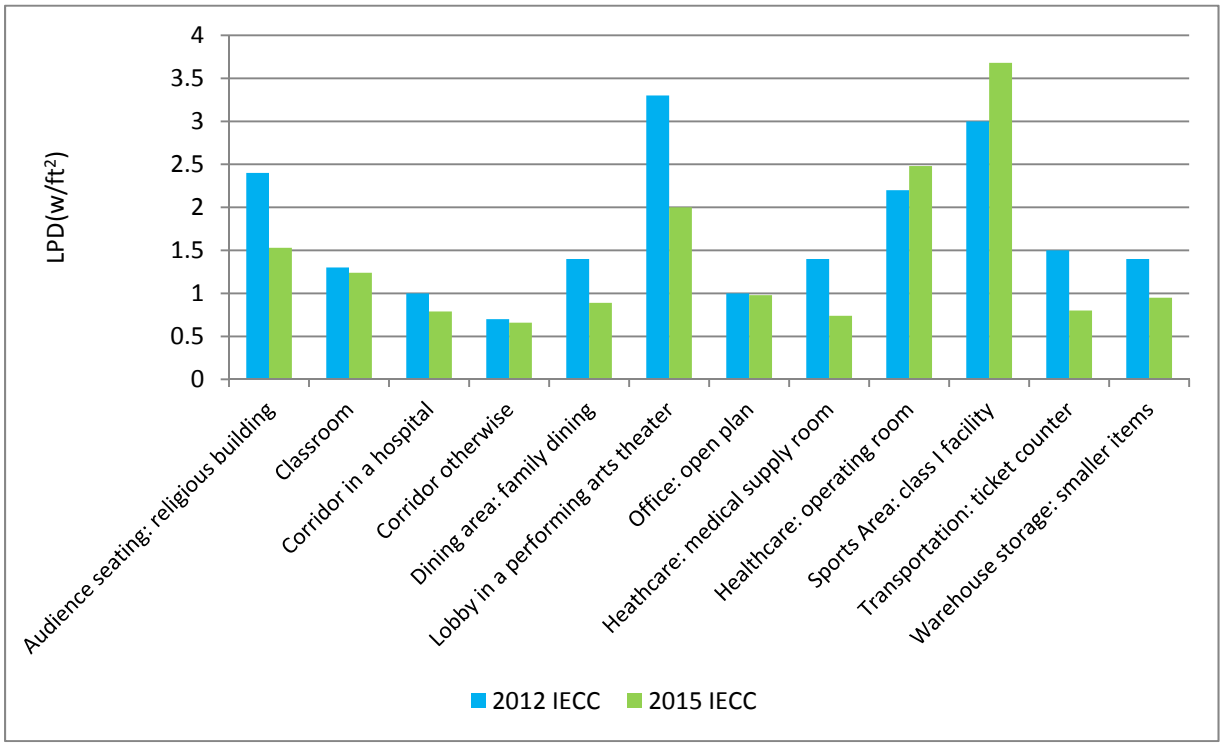


Figure 2 presents a sample of 12 space types out of 93 specified in the 2012 IECC. The 2015 IECC added 10 additional area categories including LPA specifications in spaces for the visually impaired, computer rooms, and elevators. The space by space method is generally considered to be a better method for assessing code compliance and performance that exceeds code in energy efficiency programs. The reason for this is that the code addresses only the installed wattage and control of the lighting system but does not directly address operating hours. Because operating hours typically vary by space type, the expected energy savings from more efficient lighting in new construction can be more accurately estimated using different hours for each space type under the space-by-space method.

In addition, the detailed specifications for areas where a range of lighting levels are essential to meet the needs of each space type provide flexibility when compared to the building area method. For example, the building area method 2015 IECC lists an LPD of 1.05 W/ft^2 for hospitals, while the space by space method offers a range from 0.6 to 2.48 W/ft^2 for spaces commonly found in hospitals. This provides room for customization, where areas that need to be highly lit can be balanced with areas requiring less illumination.

While there are some significant changes in allowances under the space-by-space LPAs, open plan offices, which are a common space type in new commercial construction, can be illuminated using 0.6-0.8 w/sq ft using currently LED technology yet had no reduction in the LPA. The performing arts theater lobby had the greatest decrease in LPD, at a 39% reduction from 2012 levels. The class I facility sports arena increased its LPD by 23% from 2012 levels.

Figure 2: Interior Lighting Power Allowances: Space by Space Method



Additional Efficiency Package Options

In addition to the mandatory lighting requirements of the IECC, Section C406 of the Code requires that buildings comply with at least one of several additional efficiency package options. For Massachusetts, this section has been amended to require buildings to comply with at least two of the efficiency package options.

The Program Administrators, Evaluation Consultants and EEAC Consultants have agreed that the lighting option of exceeding code by 10% will be considered baseline for true new construction projects. This added level of lighting efficiency was determined to already be baseline practice in follow-up analysis of lighting power densities in the recent code compliance study. While this provision will be treated as the lighting baseline by program implementers (no incentives will be provided for lighting that meets the requirement for the 10% more efficient than code requirement), the programs will support and claim savings for lighting efficiency beyond the 10% better than code minimum requirement. It is possible that future evaluations could find that lighting code continues to lag the market and that standard practice is more than 10% better than code in which case program reported savings greater than 10% beyond code would be adjusted downward.

The second required beyond code measure will be eligible for ratepayer funded incentives and savings resulting from supporting the additional required beyond code efficiency measure will be reported by the programs.

In addition to the more aggressive lighting power density reductions option, Section C406 also includes an additional compliance option for enhanced lighting controls. This requires all luminaries to be capable of continuous dimming and specifies that not more than eight luminaires can be controlled together in a daylight zone. This option also provides further specifics on enhanced controls.

As noted above and in the cover memo, LED fixtures are being rapidly adopted into the new construction market. This may result in standard practice for lighting continuing to exceed code and by an increasing

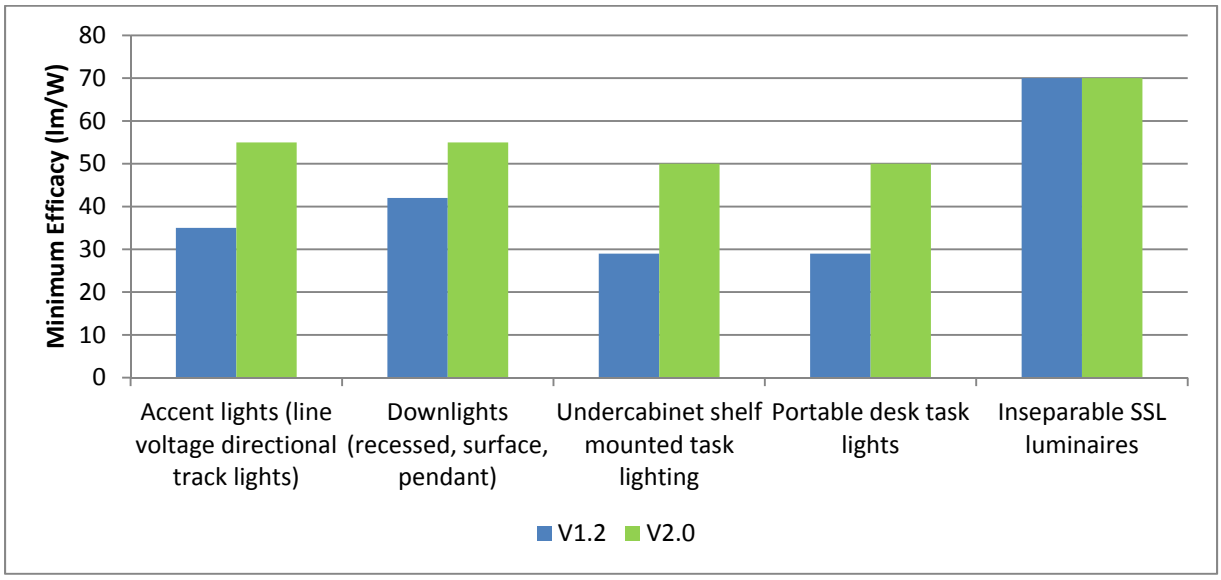
margin. This will put savings from lighting efficiency in new construction projects at risk. Evaluation should continue to focus on providing feedback to the PAs regarding the lighting baseline for the new construction market.

ENERGY STAR AND DESIGN LIGHTS CONSORTIUM STANDARDS

The MA C&I Energy Efficiency Programs rely on Energy Star and Design Lights Consortium (DLS) certifications to help ensure the products they are supporting meet minimum quality standards including efficacy, color temperature, adequate product testing, etc. This section provides an update on the evolving standards from Energy Star and the DLC.

Energy Star is a program established by the Environmental Protection Agency which has minimum requirements for both luminaires (fixtures) and lamps and focuses primarily on products common in the residential market. However, there is significant crossover between the residential and commercial markets. Version 2.0 (V2.0) of the Energy Star luminaire specification took effect on June 1, 2016. Figure 3 documents changes to minimum efficacy requirements for luminaires with commercial crossover listed in the current Energy Star version 1.2 (V1.2). An average increase in efficacy of 37% can be seen across the measures between V1.2 and V2.0.

Figure 3: Energy Star Changes in Luminaires Minimum Efficacy Requirement



In addition to the luminaires V2.0 specification, Energy Star has also released a version 2.0 (V2.0) lamp specifications, which will be effective on January 2, 2017. The current specification in use is version 1.1 (V1.1).

Key changes to be aware of in the new V2.0 specifications include:

- → Omnidirectional and reflector CFLs will no longer be able to meet the new lumens/watt requirements.
- → Reduced rated lifetime from 25,000 to 15,000 hours and relaxed light distribution requirements for omnidirectional LEDs. This is an effort to encourage manufacturers to seek certification for their less expensive LEDs.

The following table demonstrates new efficacy requirements in V2.0.

Table 2: Energy Star Lamps V1.1 compared with V2.0

	Lamps V1.1		Lamps V2.0	
	Lamp Rated Wattage *(watts)*	Minimum Lamp Efficacy *(initial lm/W)*	CRI	Minimum Lamp Efficacy *(initial lm/W)*
Omnidirectional	<15	55	≥90	70
	≥15	65	<90	80
Directional	<20	40	≥90	61
	≥20	50	<90	70
Decorative	<15	45	≥90	65
	15≤W<25	50	<90	65
	≥25	60		

The DLC is a project of the Northeast Energy Efficiency Partnerships (NEEP) that works to encourage widespread adoption of high performing, energy efficient commercial lighting solutions. DLC focuses on commercial LED lighting products. Many energy efficiency programs, both regional and beyond, use the DLC's qualified products list and technical requirements for defining minimum performance standards. The current Version 3.1 of the DLC technical requirements went into effect in November 2015 making it somewhat dated relative to the rapidly advancing LED lighting product market. A new Version 4.0 (V4.0) is currently under review, and the effective date of 4.0 is anticipated for the first quarter of 2017. Figure 4 illustrates the proposed minimum efficacy requirements for a variety of products. The average increase in efficacy is 31%. The new V4.0 requirements propose a minimum efficacy level of 90 lm/w for linear LED products, which will have a significant impact on the qualifying products list; currently 49% of products on the list meet the V4.0 standard. Manufacturers are modifying their products accordingly, with 71% of existing product applications meeting the new V4.0 requirements.

Figure 4: DLC Efficacy Requirements