MA ENERGY EFFICIENCY ADVISORY COUNCIL

→ CONSULTANT TEAM

The Future of C&I Lighting in Massachusetts

A continued major source of savings or in decline?

9/25/19

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INTRODUCTION

Historically, lighting has played a critical role in delivering cost-effective savings for the commercial and industrial sector, and the Mass Save program overall. As seen below (**Figure 1**), about 60% of net lifetime electric savings for C&I from 2016-2018 were from lighting, and this savings accounted for nearly 40% of overall savings across all sectors during the same period.

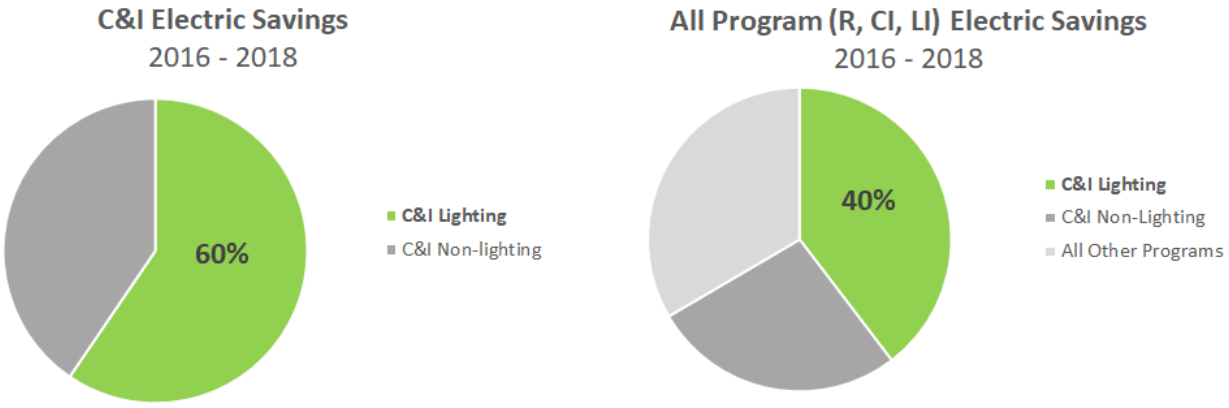

Figure 1. C&I Lighting as a percentage of total C&I electric savings (left) and as a percentage of total program electric savings (right) – all in Net Lifetime MWh

However, both Massachusetts energy efficiency programs and the overall lighting market are at an inflection point where savings and benefits attributable to lighting could continue for several years to come or decline precipitously, depending on program actions. Therefore, the future of C&I lighting should be approached strategically. This paper will examine the potential for Massachusetts C&I programs to continue to leverage savings from lighting as the market transitions rapidly to LED sources. This paper will also make the point that for the Mass Save program to continue delivering benefits to customers over the long-term, serious thought must be put into what technologies we deploy today.

If a customer installs a good solution today, the opportunity to install the best solution - that delivers the most savings – could be lost. Mass Save should prioritize the best solutions and seek to minimize the amount of cost-effective savings left on the table. Tubular LEDs (TLEDs) save customers energy today and are a good solution; however, LED fixtures are a better solution and LED fixtures with integrated controls present the greatest savings and most benefits to customers, even when accounting for higher first costs.

OVERVIEW OF C&I LIGHTING MARKET

Codes and industry standard practices have made LED fixtures the standard for new construction. Initiatives like the Mass Save Performance Lighting program for new construction are pushing customers to go beyond code and industry standard practice, but the available savings from new construction lighting projects is limited.[1] This paper is primarily concerned with lighting in existing buildings, which can be retrofitted through the Large Business Retrofit, Turnkey/Small Business retrofit, and Upstream initiatives.

Efficiency gains in lighting over the past two decades have significantly reduced the percentage of energy consumed by lighting in C&I buildings. The 2012 Commercial Building Energy Consumption Survey (CBECS) found that lighting represented 17% of the electric load for C&I buildings in New England compared to a 2003 study which found lighting represented 39% of C&I building energy consumption.[2] More recent figures from the

[1] https://www.masssave.com/en/saving/business-rebates/new-lighting-and-lighting-controls/
[2] https://www.eia.gov/consumption/commercial/data/2012/index.php?view=consumption

U.S. Energy Information Administration estimate that nationally, lighting accounts for just 10% of commercial sector electricity consumption as of 2018.[3] Lighting *efficacy*, or the efficiency with which lamps convert input power (watts) into the delivered light output (lumens), has increased substantially through LED technology improvements and rising standards from ENERGY STAR and the Design Light Consortium (DLC). The DLC's required efficacy for LED linear lights has increased by 53% from 2012 through 2018 and is expected to increase by another 10% by 2020.[4] The U.S. Department of Energy predicts an additional efficacy improvement of 40% for LED linear fixtures between 2020 and 2035.[5]

Almost three quarters of lamp types used for interior lighting in C&I buildings in Massachusetts are linear (**Figure 2**). Linear lighting largely comes in the form of four-foot linear florescent lamps and are commonly found in office buildings, schools, hospitals, warehouses, and a variety of other applications.

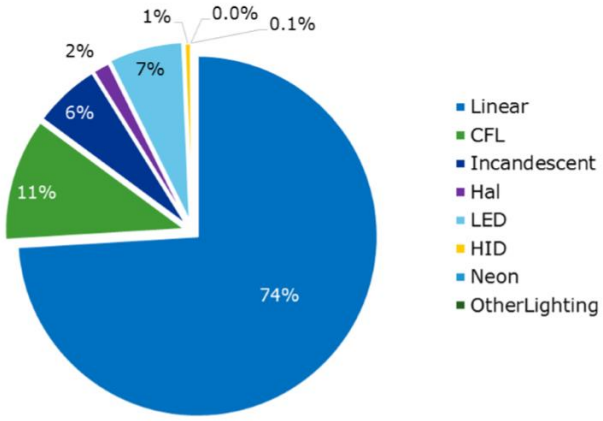

Figure 2. Distribution of lamps by type – interior lighting (MA Commercial Lighting)[6]

Prior to the maturation of LED technology, Mass Save (and efficiency programs elsewhere) promoted efficient fluorescent technology upgrades, such as T5 and High-Performance T8, from less efficient T12 and standard T8. Between the significant increase in LED efficacy coupled with considerable product price reductions, nearly all fluorescent technology can be cost-effectively upgraded to LED with significant energy savings. Fluorescent lighting can be upgraded to LED using three potential solutions: lamp (bulb) replacement, retrofit kits, or whole-fixture replacement. LED replacement lamps, also known as TLEDs (tubular LEDs), represent the easiest method to retrofit fluorescent lamp types and present the lowest first cost for a florescent to LED retrofit. Some TLEDs require changes to the electrical wiring of existing fixtures, while other TLEDs can be directly installed into a fluorescent fixture without rewiring, which allows the work to be completed by facilities or custodial staff (as opposed to a licensed electrician). TLED product prices have dropped rapidly, from $45 per lamp in 2013 to $14 per lamp in 2016 and can now be purchased from online retailers at prices as low as $5-8/lamp.[7]

While TLEDs offer energy savings at a low cost, higher levels of energy savings can be cost-effectively attained by retrofitting or fully replacing the fluorescent fixtures with integrated LED equipment. LED fixture retrofit packages integrate a new reflector, heat sink, LEDs, and driver (electronics) into a single package that is retrofitted into an existing fixture housing. Whole-fixture replacement requires complete removal of an existing fluorescent light fixture and replacement with a new LED fixture in its place. The benefit of fixture retrofits or replacement is that the new fixture has a higher total efficacy than fixtures where only the lamps are replaced since the fixture optics and electronics are specifically designed to take advantage of the LEDs. Furthermore, retrofit kits and replacement fixtures can also offer significant new control capabilities, including initial task tuning, daylight dimming, integrated occupancy control, and addressable fixtures which enable coordinated fixture control

[3] https://www.eia.gov/tools/faqs/faq.php?id=99&t=3
[4] The DLC efficacy requirement for LED fixtures was 65 lumens per watt (lpW) in 2012 and 100 lpW in 2018. The DLC has proposed an efficacy requirement of 110 lpW for LED fixtures in its SSL V5.0 Specification, which would take effect in 2020.
[5] https://www.energy.gov/sites/prod/files/2016/09/f33/energysavingsforecast16_2.pdf, Table D-4
[6] http://ma-eeac.org/wordpress/wp-content/uploads/MA-CI-Market-Characterization-Study.pdf
[7] https://www.1000bulbs.com/category/led-tube-price-break/

from a smart phone or other device.

LIGHTING CONTROL SAVINGS OPPORTUNITIES

Beyond higher efficiencies from the fundamental technology of converting electricity into light, there have also been dramatic improvements in the availability and sophistication of different types of lighting controls systems. Traditional On/Off switches dominate the current commercial lighting market (68% as of 2016); however, some control technologies that have been available for several years are now reaching a point of product maturity. In new construction, driven by building energy codes and utility programs, it is common to find one or more of the lighting control strategies shown in Table 1 employed. Lighting systems are also increasingly being integrated with building energy management systems to be scheduled along with other equipment.

INSTALLED STOCK PENETRATION (%)	COMMERCIAL
None	68%
Dimmer	3%
Daylighting	<1%
Occupancy Sensor	6%
Timer	4%
Energy Management Systems	15%
Multiple Strategies	4%
Connected	<1%

Table 1. US installed stock penetration of lighting controls, 2015 (DOE 2016).[8]

The graph in Figure 3 illustrates the daily potential for energy savings that can be achieved by incorporating lighting controls into an LED retrofit project. It represents an example commercial building that piloted a number of different controls strategies as part of a broader LED retrofit project.

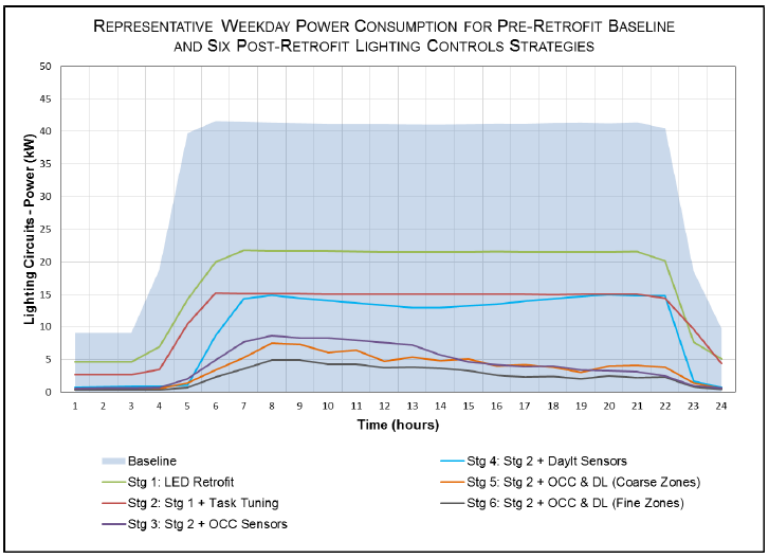

Figure 3. Power Consumption example for various LED retrofit and controls strategies[9]

The vertical axis shows lighting power demand (measured in kilowatts, kW), while the horizontal axis shows a single 24-hour period. The chart shows the non-LED baseline lighting system (blue shaded area) drawing about 40 kW of power during regular business hours. The first line (green) shows a standard LED retrofit's power draw, which yields an impressive ~50% reduction, leaving just 21 kW during peak hours. Each subsequently lower line

[8] https://www.energy.gov/sites/prod/files/2016/09/f33/energysavingsforecast16_2.pdf
[9] https://www.etcc-ca.com/sites/default/files/reports/ET12PGE3361%20LED%20High-Bay%20Lighting%20and%20Controls%20Assessment.pdf

represents an alternative retrofit strategy that also incorporates 1 or more types of lighting controls. The lowest line (black) shows a sophisticated control strategy that incorporates task tuning (initial dimming), occupancy sensors and daylight dimming for each individual fixture, defined here as fine zones. This strategy yields an overall power draw reduction of 87.5%, leaving less than 5 kW of remaining connected lighting load. The initial conversion from metal halide to LEDs delivered most of the savings (50% reduction from base case), but that additional 37.5% of demand savings from the best control strategy represents what the future of lighting savings could be. Beyond the reduction in load from lighting controls such as dimming, daylight sensors and occupancy controls, this example demonstrates the reduction in run-hours that can be achieved through better lighting controls. The standard LED retrofit line (green) closely aligns with the run-hours in the baseline condition (blue shaded region). The lines for nearly all controls strategies shown (light blue, purple, orange, black) start up a full hour later than the baseline system (blue shaded region) and LED only system (green).

The combination of multiple control strategies into a single system, with coordinated operation and individually addressable light fixtures, is often referred to as Networked Lighting Control ("NLC"). Similar to LED products, the DLC provides independent product qualification of NLC systems in support of utility programs. In 2017, the DLC collected energy data from multiple networked lighting control system installations to develop improved estimates of energy savings. Based on this research, they found that NLC systems reduce energy consumption by 47% on average (**Figure 4**), not including the original savings captured through an LED retrofit.[10] The impacts of widespread NLC deployment/adoption would go beyond energy savings. If, for example, half of all linear fixtures in the Commonwealth were dimmed by just 10%, the Mass Save program could deliver 28% more peak demand savings from C&I customers than the Program Administrators filed for 2019.[11]

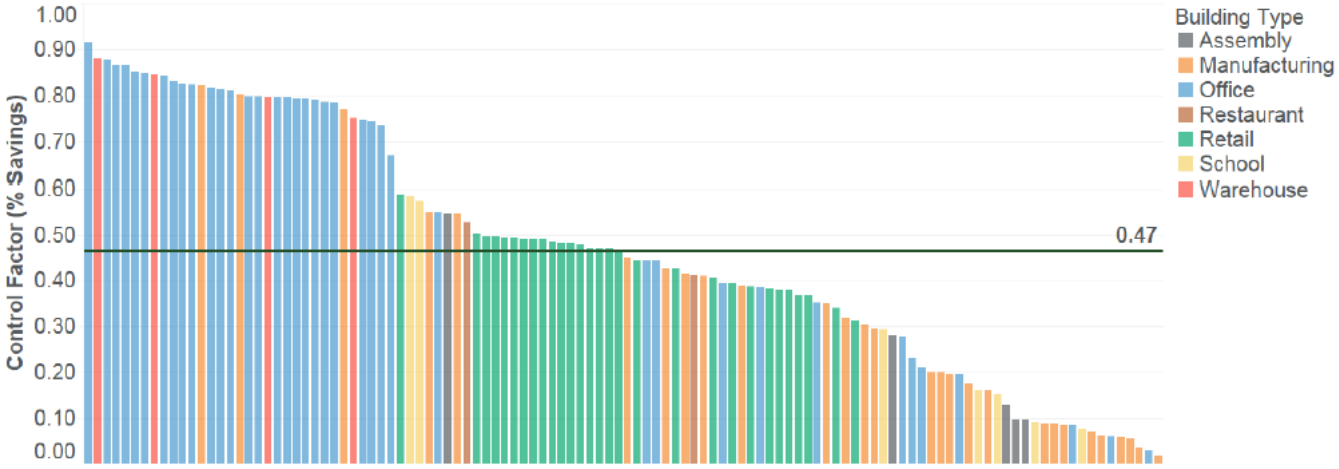

Figure 4. Savings Potential from Networked Lighting Controls (DesignLights Consortium, 2017)

In addition to the improved energy savings of pairing LED fixtures with controls, there are significant non-energy benefits that can be attained through these solutions. Certain LED lighting, when paired with appropriate controls, can adjust the spectrum of lighting from warm to cool white, or even the color. There is strong scientific evidence that points to the important role that light spectrum plays in regulating our body's biological systems.[12] Human-centric lighting can not only improve occupant comfort but can deliver health benefits. In 2016, the U.S. Department of Energy and the Sacramento Municipal Utility District conducted a trial of LED color tuning at a senior care center. The LED solution was able to adjust the color temperature and brightness of the LED fixtures throughout the day to mimic natural sunlight patterns. Staff at the senior care center noted a 41% reduction in target behaviors such as yelling, agitation, and crying. The senior care center Administrator noted that they "will be incorporating many of the lighting solutions piloted in this project as best practices in terms of fall risk, sleep enhancement, and non-pharmacological approaches for behaviors related to dementia".[13]

[10] https://www.designlights.org/lighting-controls/reports-tools-resources/nlc-energy-savings-report/
[11] 2019 C&I ADR filed = 102.4MW; 49 million linear lamps in MA x 50% x 14W x 10% dimming x 0.83 CF (summer) = 28.5 MW
[12] https://www.lrc.rpi.edu/programs/lighthealth/index.asp
[13] https://www.energy.gov/sites/prod/files/2016/09/f33/2016_gateway-acc.pdf

Another promising non-energy benefit achievable using LED fixtures with controls is the potential for an Internet of Things (IoT) asset tracking solution. Utilizing Bluetooth beacons embedded into new LED fixtures, some manufacturers can provide asset tracking capabilities that allow building owners to track the location of their most valuable infrastructure. For example, using lighting controls to create a mesh network, C&I customers such as hospitals can embed transmitters into high value mobile assets like ultrasounds and portable ECG machines can be tracked in real time (**Figure 5**). Tracking asset locations in real-time allows hospitals to deploy services and equipment faster and more efficiently.

Figure 5. OSRAM EINSTONE Track & Trace Solution deployed in a hospital[14]

Asset tracking may not be a necessary use case for all C&I customers, but there are many other benefits customers could gain from intelligent lighting solutions. A lighting control system can integrate with other building systems and provide valuable operational data. A lighting fixture that senses occupancy can be tied into an HVAC system to control temperature setbacks and adjust ventilation rates based on fresh air requirements for the number of people in a given space. Atlas Box, a manufacturer in Sutton, MA, was able to use occupancy data collected from their lighting system to reduce production bottlenecks and increase productivity 20%.[15] Having accurate real-time occupancy data can also be useful for purposes like security monitoring and safety.

CURRENT STATUS OF C&I LIGHTING IN MASSACHUSETTS

As noted in the introduction to this paper, lighting has historically been the largest source of C&I savings (60% from 2016-2018), and C&I lighting savings has been a major contributor to overall program savings (40% from 2016-2018). As show in figure 6, lighting is expected to play a smaller role in C&I savings for the 2019-2021 plan period (49%, mainly due to known large CHP projects) but a larger role in total program savings overall (42%) compared to the prior 3-year plans results.

[14] https://luxreview.com/article/2018/03/breakthrough-for-asset-tracking-using-lights
[15] https://www.digitallumens.com/resources/white-paper/atlas-box-case-in-point/

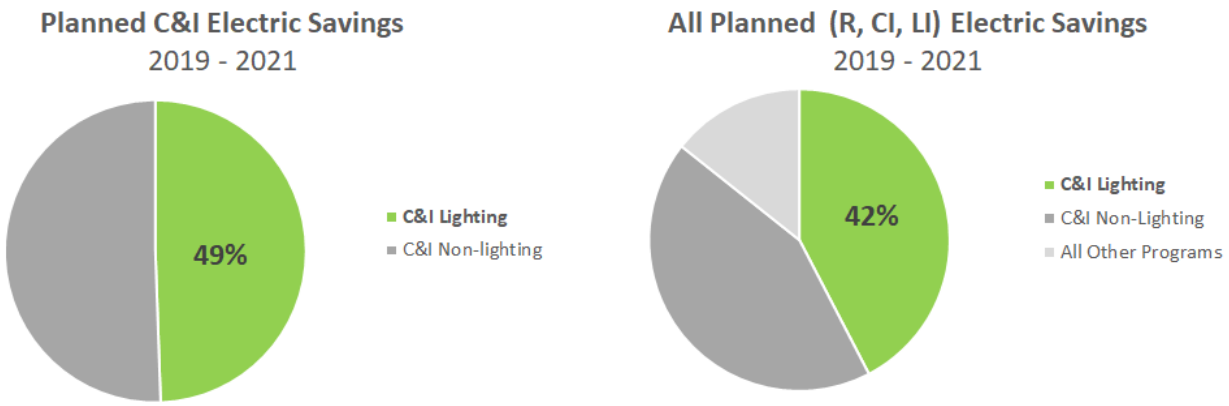

Figure 6. C&I Lighting as a percentage of total C&I electric savings (left), and as a percentage of total program electric savings (right) – all in Net Lifetime MWh

Based on the success from 2016-2018 (**Figure 7**, 2016-2018 plan vs. actual savings), the Program Administrators increased their goals for C&I lighting for the 2019-2021 plan period. While this is an excellent step towards realizing the full potential for C&I lighting savings, it is important to recognize that program decisions made today will impact the market for years to come. If the Program Administrators under-planned again in this cycle, the C&I lighting market transformation will occur faster than anticipated, driving an even greater urgency to capture deeper savings today.

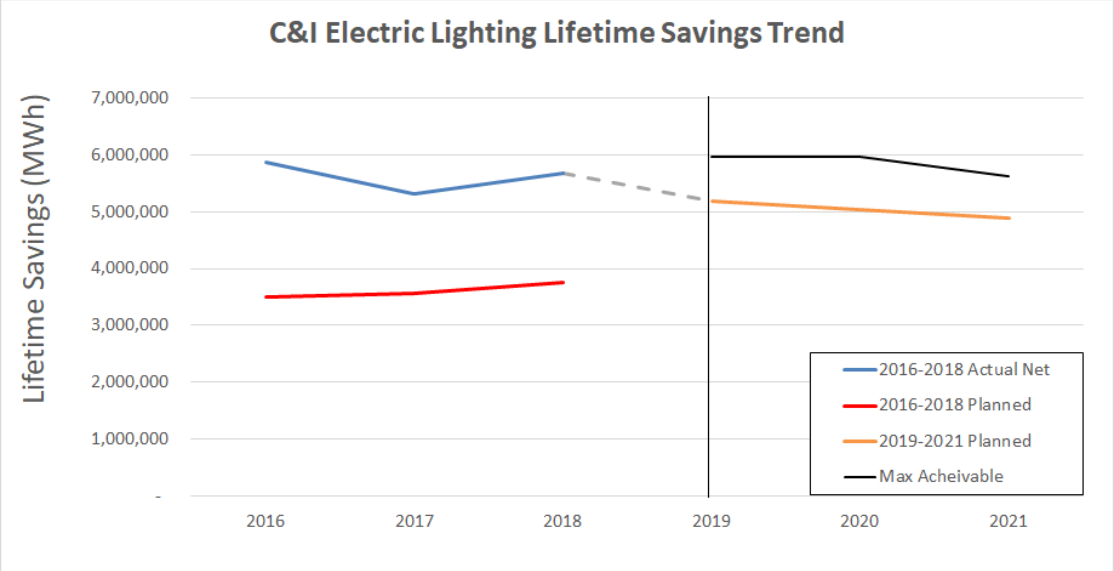

Figure 7. C&I electric lighting lifetime savings from over time

Based on current and projected market adoption of LEDs, the next several years will largely determine how much C&I lighting savings will be achieved by the Mass Save program. According to models developed by Massachusetts evaluation contractor DNV GL on behalf of the Massachusetts Program Administrators (**Figure 8**), an estimated 44% of C&I linear lighting fixtures in the field will be LED by the end of 2019. By the end of the current Three-Year Plan, that figure could climb as high as 69%. These saturation forecasts are data-derived estimates that include a level of uncertainty. That does not change the fact that adoption is occurring rapidly and the window of opportunity for the Massachusetts Program Administrators to influence the market is closing.

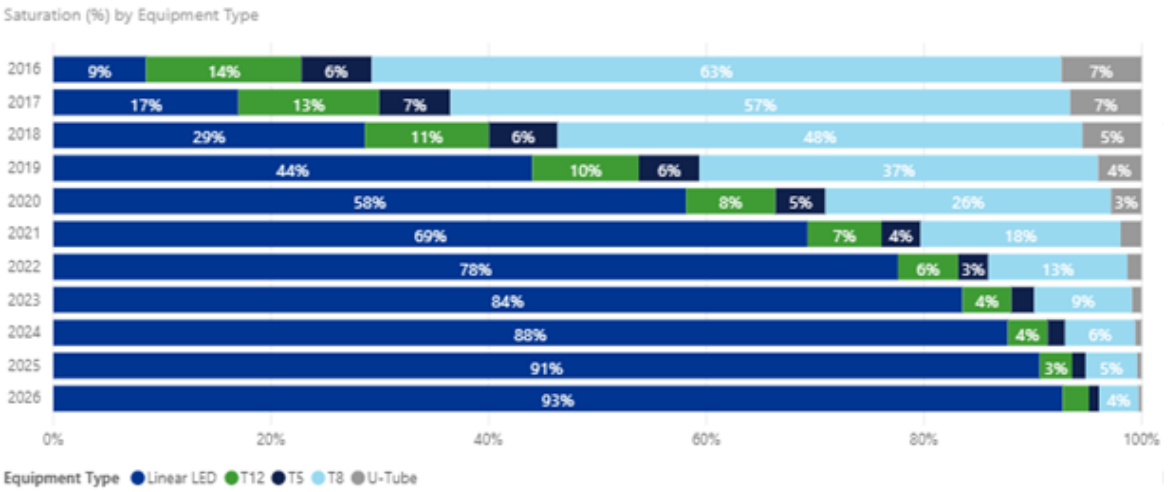

Figure 8. Projected C&I Linear LED inventory market saturation in Massachusetts[16]

In terms of product sales, DNV GL estimates that 70% of linear lights sold in Massachusetts in 2019 will be LEDs. This is extremely encouraging and is a testament to both the rapid advances in LED technologies and the success of the Mass Save program in accelerating market adoption. The longevity of new LED technologies means that once a new LED lamp or fixture is installed, it is unlikely to be replaced for many years. DesignLights Consortium (DLC) qualified TLEDs are required to last at least 50,000 hours.[17] Assuming these lights are "On" approximately half of the time (4,380 hours/year), a new TLED installed today will last until approximately 2030. Since the expected useful life of a TLED measure extends beyond the point when LED lighting is expected to still be claimable (by 2030 the market may be close to 100% LEDs), it is imperative that the Mass Save Program Administrators promote the best lighting technologies today.

If all linear lighting in Massachusetts is primarily replaced with TLEDs, customers will see significant bill savings. However, if more of those customers install LED fixtures with controls, they could see up to 75% more energy savings (**Table 2**) and receive additional non-energy benefits from controllable fixtures. The Green Communities Act requires all cost-effective energy efficiency to be pursued. By relying on TLEDs for most linear lighting retrofits, Massachusetts will be leaving significant cost-effective energy and emissions savings on the table.

	TLED*	LED Fixture	LED Fixtures w/ Controls
Net Annual kWh Savings per Fixture	136	207	238
Incentive	$7.50	$30.24	$75.00
$/Net kWh	$0.06	$0.15	$0.32

Table 2. Linear LED Retrofit Comparison [18]

According to DNV GL, there are nearly 50 million linear lamps in use at C&I facilities across the Commonwealth of Massachusetts.[19] It is estimated that 29% of these lamps have already been retrofitted to LEDs as of 2018. That leaves the remaining C&I LED retrofit opportunity at about 35 million lamps, though this figure will continue to decline as DNV GL also predicts 44% market saturation (27 million lamps remaining) by the end of 2019. Based

[16] The model does not distinguish between TLEDs and LED fixtures, however the linear market is essentially zero-sum
[17] https://www.designlights.org/solid-state-lighting/qualification-requirements/technical-requirements/
[18] *Average 2.5 lamps per fixture used for TLED values, based on MA/RI upstream savings and MassSave C&I Upstream Lighting Incentives
[19] DNV GL Massachusetts C&I Linear Lighting Market Model

on the savings differential between TLEDs, new LED fixtures, and new LED fixtures with integrated controls, the remaining C&I lighting net annual savings in Massachusetts ranges from a low of 1.5 million MWh (all TLEDs) to a high of 3 million MWh (all new LED fixtures with integrated controls). The difference between the low- and high-end savings potential is a massive 1.5 million MWh in savings (**Figure 9**), or roughly the equivalent annual electricity generation of the Kendal Square Station in Cambridge.[20] This potentially forgone 1.5 million MWh in savings is equal to more than one third of the entire 2019-2021 planned savings across all sectors.[21]

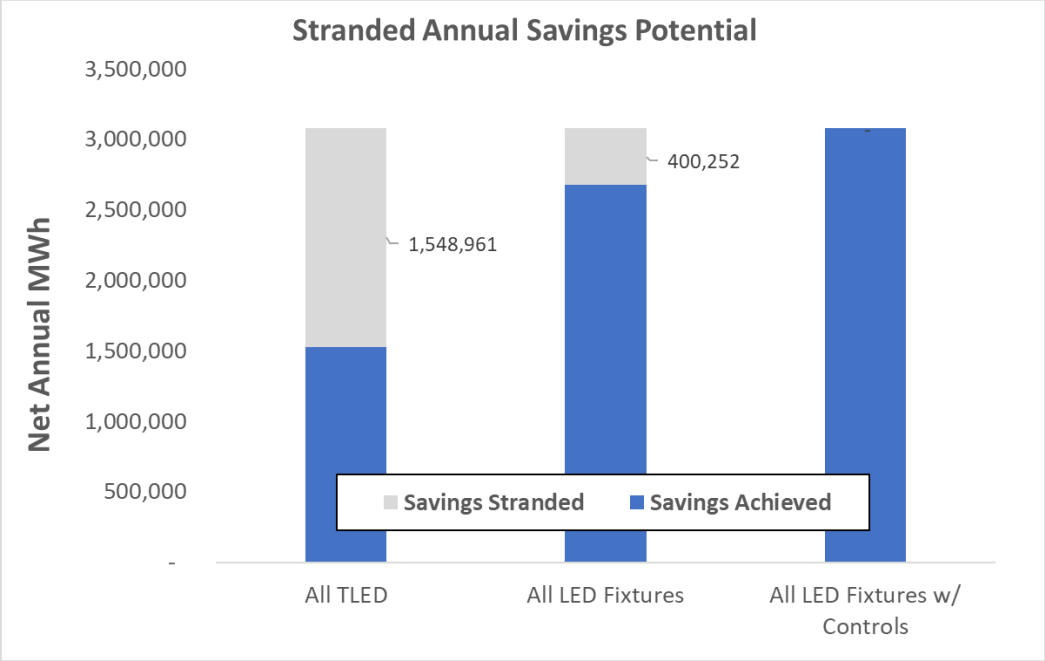

Figure 9. Stranded savings potential from remaining C&I linear lighting market as of 2019

This analysis presents the range of potential outcomes and Mass Save currently delivers a combination of these retrofit solutions. The real-world proportions of these solutions are based on PA actions, market factors and individual customer decisions. Some customers prefer the simplicity and lower first cost of TLEDs, which do not require a licensed electrician for installation. For some customer and applications lighting controls may not be appropriate or practical. Accounting for these situations, industry experts still estimate that roughly 55-65% of the linear LED market could be retrofit to fixtures with controls.[22,23] Massachusetts, a national leader in energy efficiency, is at a crossroads. C&I lighting savings may cease to contribute savings in a significant way to the Mass Save program by the end of the current 3-yr plan, or with aggressive and targeted intervention, could continue to tap into savings and be a major contributor for years to come. If action is postponed until the next planning cycle, it could be too late for C&I lighting.

NEW APPROACHES TO C&I LIGHTING

The DesignLights Consortium (DLC) has conducted extensive research on the potential for C&I lighting savings under various scenarios. DLC predicts that on our current path, lighting savings will begin to decline after 2021; however, significant lighting savings could continue well into the mid-2020s (another 5-years) with aggressive support for network lighting controls (**Figure 10**). The additional savings from network lighting controls could also extend the tail of lighting savings while utilities ramp up cost-effective programs for other end uses (e.g. – ESPO

[20] EIA – Kendal Square Power Station Generation 2018
[21] 2019-2021 Planned Net Annual Savings = 4.3 million MWh
[22] DOE forecasts 55% linear LED would be fixtures with connected controls by 2035; Figure 4.27. Excludes conventional lighting https://www.energy.gov/sites/prod/files/2016/09/f33/energysavingsforecast16_2.pdf
[23] The DLC estimates that 65% of linear LED could include networked lighting controls by 2035. https://www.designlights.org/resources/energy-savings-potential-of-dlc-commercial-lighting-and-networked-lighting-controls/

program targeting HVAC, water heating, etc.).[24] Rather than quickly pursuing linear lighting savings opportunities with TLEDs during the current Three-Year Plan, taking the time to promote a more comprehensive solution of LED fixtures with controls could help deliver more savings and benefits to customers over a longer period of time. This is critical to the sustainability of the Mass Save program over the long-term.

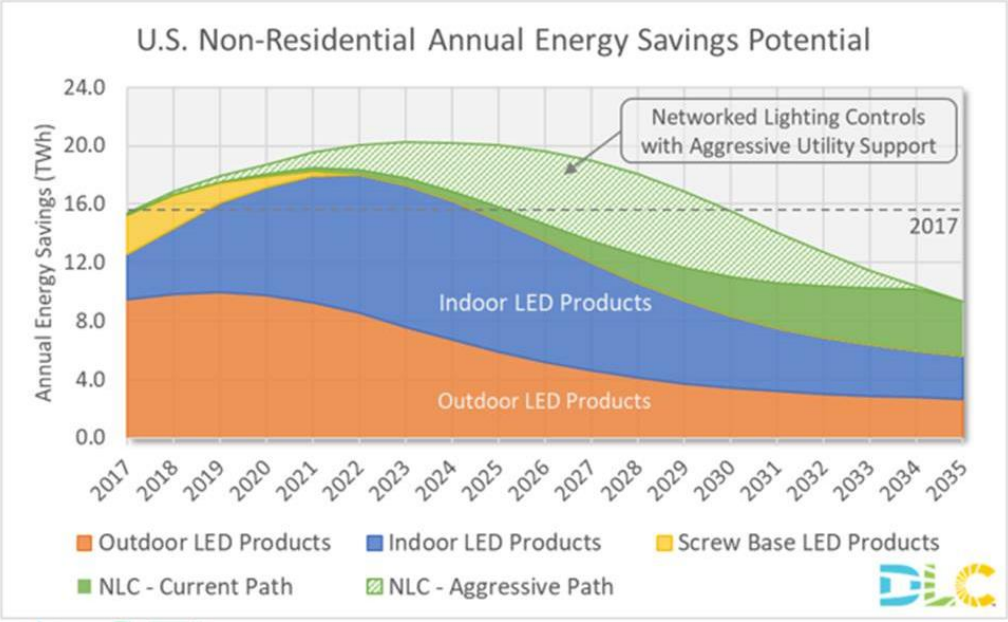

Figure 10. Savings potential for various C&I LED scenarios[25]

The Massachusetts Program Administrators have already started addressing this challenge by offering enhanced incentives for LED fixtures with controls. In order to overcome the higher initial cost of installing LED fixtures with controls (as opposed to a simple lamp replacement) Mass Save offers a $75 per fixture incentive.[26] Mass Save also offers stand-alone incentives for occupancy sensors, daylight dimmers and a handful of other technologies. In addition to changes in incentive amounts to promote better lighting solutions, the Mass Save Program Administrators have also recently increased pre-approval limits for LED fixtures from 25 to 50 and dropped the pre-approval limits for TLEDs from 300 to 250. On the margins, this makes it a little easier to get incentives for LED fixtures and a little more difficult to get incentives for TLEDs. The Program Administrators have also implemented some programmatic efforts to encourage better lighting solutions that are worth noting. For example, the Performance Lighting program is an incentive offering for new construction that promotes “right sizing” and appropriate lighting controls for a given building space and use.[27]

Enhanced incentives and adjustments to pre-approval limits for those incentives are a great start towards driving market adoption of the best solutions, but additional work needs to be done given the urgency of this issue. Massachusetts is not alone in addressing this challenge, and other states have begun to consider ways to capture this potential. Utilities across the U.S. must find solutions that help capture the maximum amount of lighting savings. Looking to some of these examples from Massachusetts peers may provide insights that prove valuable to the Mass Save program.

The Northwest Energy Efficiency Alliance (NEEA) is a member organization of more than 140 Northwest utilities and energy efficiency organizations working on behalf of more than 13 million energy consumers. NEEA has developed Toolkits and marketing materials through their *Better Bricks* initiative, including FAQs and infographics, which member utilities are free to use along with their logo and other marketing materials to help promote lighting controls.[28] These marketing materials promote the enhanced savings potential of integrated controls, but also

[24] https://www.masssave.com/en/learn/business/espo/
[25] https://www.designlights.org/resources/energy-savings-potential-of-dlc-commercial-lighting-and-networked-lighting-controls/
[26] https://www.masssave.com/en/saving/business-rebates/new-lighting-and-lighting-controls/
[27] https://www.masssave.com/-/media/Files/PDFs/Business/2017_Performance_Lighting_MA_New_Construction.pdf
[28] https://betterbricks.com/resources/neea-lllc-toolkit

recognize the range of non-energy benefits eluded to earlier in this paper. Pairing additional energy savings with simple installation, occupant comfort, flexible control and improved light quality combine to a much more compelling business case to customers than energy savings alone.

In Connecticut, the Program Administrators have recently been experimenting with a "Good, Better, Best" approach to C&I LED lighting where the "Good" solution is TLEDs, the "Better" solution is LED fixtures, and the "Best" solution is LED fixtures with integrated controls. Based on initial data from their 2019 Upstream Program, it appears to be having some effect on customer decisions. The portion of savings from fixture retrofits are up, and the portion of savings from TLEDs are down compared to 2018.[29]

CONCLUSIONS AND RECOMMENDATIONS

The most recent C&I Customer Profiles Study found linear LEDs across all delivery pathways can offset a significant portion of the decline in savings from screw-based LED savings.[30] Additionally, the study noted that control measures are showing increased market adoption and represent a way to increase depth of savings from lighting upgrades even as baseline efficiencies rise.

Commercial lighting has been and can continue to be a major source of electric savings for the Mass Save program. LED lighting delivers customer savings, reduces environmental impacts, and improves occupant comfort in our commercial buildings. The important questions are: *how much savings, and for how much longer?* On the first question, it is important to realize that higher levels of energy (and economic) savings come at a cost. A TLED retrofit offers the lowest initial cost on a per-unit basis by a significant margin (**Figure 11**). The cost to the customer, incentive and overall costs are substantially lower than either an LED fixture or LED fixture with integrated controls.

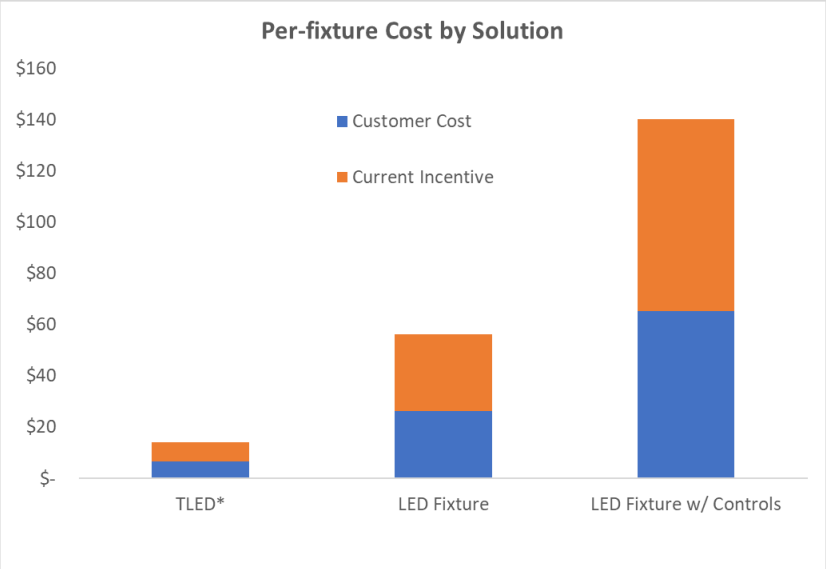

Figure 11. C&I LED First Costs[31]

However, LEDs have an effective useful life of about 15 years. All three solutions (TLEDs, LED fixtures, and LED fixtures with controls) pay for themselves in under 2 years. While first costs and simple paybacks are important metrics, they fail to consider the lifecycle benefits of each solution. Even accounting for the higher first cost of LED fixtures and fixtures with controls, those more comprehensive solutions still offer the greatest benefits to

[29] CT C&I Sub-Committee Meeting 7/9/19
[30] http://ma-eeac.org/wordpress/wp-content/uploads/Final-2017-CCPS-report.pdf
[31] MA 2019-2021 BCR model, *Average 2.5 lamps per fixture used for TLED values

customers, along with significant non-energy benefits TLEDs are unable to deliver (**Figure 12**).

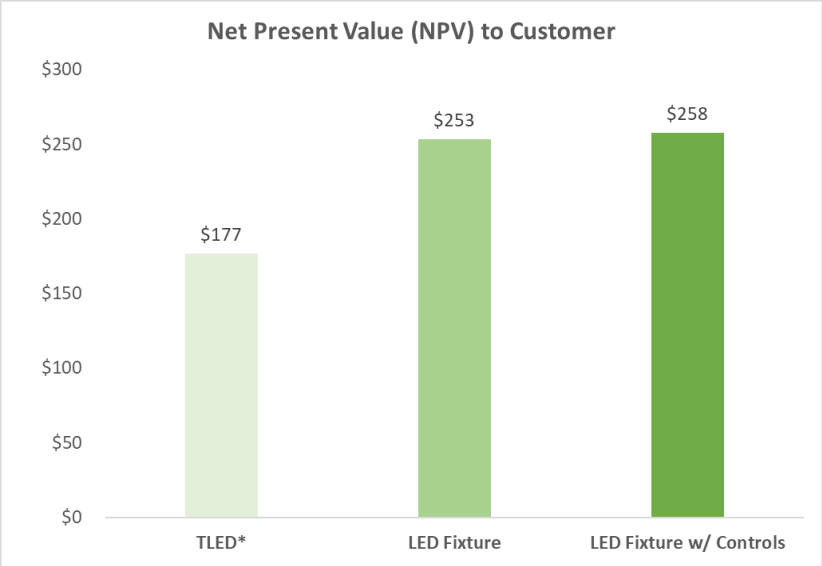

Figure 12. C&I LED Net Present Value[32]

In order to capture these higher levels of energy savings and avoid stranding significant cost-effective savings, the Mass Save Program Administrators should make every effort to drive customers towards the greatest savings solutions. This will require trying new approaches to program delivery, enhancements to existing pathways, and even the consideration of sunsetting incentives for certain less efficient technologies.

New Approaches

Massachusetts should look to other jurisdictions and trends in the overall lighting market to improve the Mass Save program's current approach to C&I lighting. These include:

Reimagine Lighting Incentives. The Mass Save Program Administrators have already taken strides in evolving incentive programs to encourage the adoption of LED fixtures with controls, as previously described. However, more can be done in this area. Example options include additional limitations on TLED quantities, bundling fixture and control rebates, and offering more transparent and flexible networked lighting control rebates such as a $ per square foot methodology employed by Focus on Energy in Wisconsin.[33]

Lighting as a Service (LaaS): "Lighting as a Service" is an emerging approach to third-party installation and management of lighting systems. These services can start with design and installation, continue through maintenance and management of the system, and eventually address recycling and disposal of equipment at the end of its useful life. This approach takes the complexity and uncertainty out of the hands of the customer. LaaS also enables companies to pay for lighting upgrades using "off balance sheet" service fees, which can come out of a maintenance budget instead of a capital budget. Companies like Siemens subsidiary, Enlighted, offer state-of-the-art IoT building technologies. Through their platform, they can integrate energy management (lighting and HVAC controls), security systems, space utilization and asset tracking.[34] Navigant Research forecasts that the LaaS market will grow from $35.2 million in 2016 to as much as $1.6 billion by 2025.[35]

Metered Energy Savings: Traditionally, the Mass Save program has relied on calculated energy savings and hours of use based on either evaluation studies or customer inputs. These data are a snapshot in time, and do not always accurately estimate energy savings for a given customer. While lighting savings are generally easy to

[32] Assumes 6% cost of capital, *Average 2.5 lamps per fixture used for TLED values
[33] https://focusonenergy.com/sites/default/files/Application_PDFs/Networked_Lighting_Controls.pdf
[34] https://www.enlightedinc.com/system-and-solutions/iot-applications/light/
[35] https://info.aee.net/hubfs/PDF/AEN%202017%20Market%20Report.pdf

predict, actual savings can differ from site to site based on a number of factors, especially when controls are included. Some lighting systems include integrated energy measurement that customers can use to monitor their energy usage. The DesignLights Consortium v4.0 Networked Lighting Controls specification requires that systems be capable of energy monitoring.[36] In addition to the standard deemed or calculated savings values, Massachusetts Program Administrators could consider incentivizing lighting projects for the additional incremental metered savings achieved through advanced lighting controls strategies. Energy monitoring through networked lighting controls can also support other programs such as Pay for Performance (recently rebranded as "ESPO").

Emphasize Other Benefits: As noted earlier in this paper, some utilities and Regional Energy Efficiency Organizations (REEOs) are looking at new ways to promote the non-energy benefits of high-efficiency lighting with integrated controls. The Program Administrators have already done some great work by partnering with the DesignLights Consortium and the Massachusetts Energy Efficiency Partnership to deliver vendor trainings on advanced lighting controls systems.[37] These efforts should be expanded with a focus on sales and installation training, and the use of case studies such as National Grid's Atlas Box project presented earlier in this paper.[38] Program Administrators should also focus on training the customer how to properly operate their lighting control systems to ensure savings from projects supported by Mass Save fully realize their savings potential.

Integrate with Demand Response: The 2016 updates to the California's Building Energy Efficiency Standards included a requirement that indoor lighting systems in commercial buildings greater than 10,000 square feet be capable of automatically reducing lighting power in response to demand signals initiated by their utility.[39] Systems are required to lower lighting system wattage by at least 15% upon receiving a demand response signal. There are exemptions for building areas with health or life safety regulations or ordinances that prohibit reduced lighting. While under no requirement to specifically deliver lighting peak demand savings, California's efforts prove that this technology exists and is a viable option for C&I customers today. The recently launched Mass Save Active Demand Response program should look to proactively include lighting control systems.

Recommended Improvements to Current Pathways

There are several different ways for customer to participate in Mass Save lighting incentive programs, and the Program Administrators have various levels of control over each of these pathways. These include:

Turnkey: The Turnkey pathway, sometimes referred to as *direct install*, is targeted for small businesses and commonly includes a no-cost energy assessment of the customers facility. The outcome of this audit is a proposal with recommendations for efficiency measures and the opportunity for direct installation of certain measures and facilitation of professional installation for more complex measures. Given the close relationship between the Program Administrators and their turnkey vendors, the opportunity to build in more lighting control savings could be significant. The turnkey program can also offer financing options that allow customers to pursue deeper savings without necessarily increasing their upfront costs. By presenting lighting solutions that provide the highest value to the customers (LED fixtures with controls), the Program Administrators can capture the greatest amount of savings and maximize customer benefits. The 2019-2021 plan shows low planned savings from lighting controls through the Turnkey Program (Figure 13), however, the most recent Customer Profile Study found that 70% of C&I program participants who installed electric controls measures were small and medium sized customers.[40] The Turnkey pathway presents a strong opportunity for the Program Administrators to grow adoption of lighting controls for smaller customers.

[36] https://www.designlights.org/lighting-controls/qualify-a-system/technical-requirements/
[37] http://ma-eeac.org/wordpress/wp-content/uploads/2019-2021-Three-Year-Energy-Efficiency-Plan-April-2018.pdf
[38] https://www.digitallumens.com/resources/white-paper/atlas-box-case-in-point/
[39] http://pge-adr.com/title-24/
[40] http://ma-eeac.org/wordpress/wp-content/uploads/Final-2017-CCPS-report.pdf

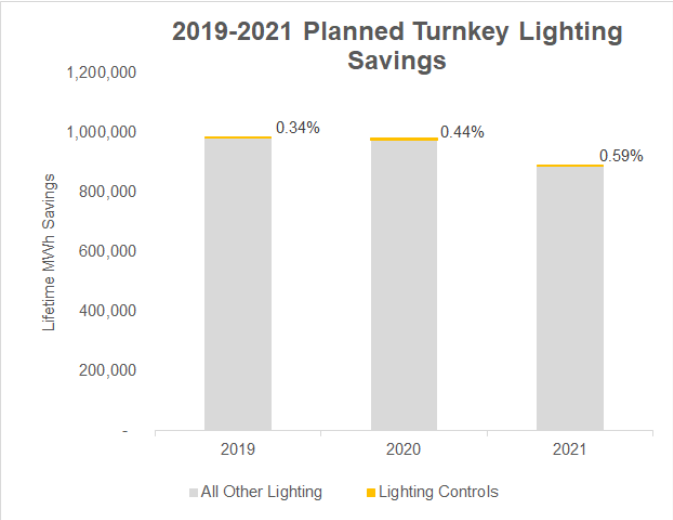

Figure 13. Turnkey lighting controls savings vs. all other lighting savings (2019-2021 planned)[41]

Custom: The Custom pathway offers an opportunity for customers and Program Administrators to develop creative solutions. The Program Administrators have a chance to interact with customers and vendors during the pre-approval process, and present educational materials about the benefits of more sophisticated lighting solutions. When the Program Administrators review proposed designs early in the process, they can identify opportunities to integrate lighting controls and recommend these more comprehensive solutions to their customers. The Custom pathway offers higher incentives for Networked Lighting Control Systems installed in new construction or major renovations projects through the Performance Lighting program and should seek to maximize the number of customers who engage in this approach. Mass Save should consider reducing or eliminating incentives for TLEDs through the Custom pathway all-together since these solutions do not justify the higher transaction costs of custom engineering.

Upstream: The Upstream pathway is convenient for many customer segments. Program incentives are provided directly to the distributors and applied to qualified lighting products, so the customer has already received their incentive at the time of purchase. Since this approach involves no direct touchpoint between the Program Administrators and the customer, it is incredibly important to ensure that products offered through the upstream pathway are as efficient as possible. In many ways, the upstream pathway should be considered the Program Administrators last resort to reach customers who are not interested in participating in more structured paths of the Mass Save program. The current Upstream pathway requires TLEDs be listed by the DesignLights Consortium, with a minimum efficacy of 110 lumens per watt. DLC's proposed update for 2020 increases the minimum efficacy to 120 lumens per watt and will also include an option for manufacturers to designate products as "Networked Replacement Lamps". These lamps must be capable of continuous dimming, wireless communication, high-end trim, and individual addressability.[42] By working directly with distributors, the Program Administrators have already been able to improve stocking patterns of equipment across a variety of technologies. Doubling down on these efforts, conducting distributor trainings and potentially even providing incentives or bonuses to distributors could enhance the effectiveness of driving deeper savings through the Upstream program. Mass Save should consider dramatically reducing incentives and pre-approval limits for standard TLEDs and introduce new, higher rebates for TLEDs designated as "Networked Replacement Lamps".

FINAL THOUGHTS

The Mass Save program is at an inflection point. C&I lighting has played a pivotal role in delivering on program goals – both in terms of overall savings and cost-effectiveness. Given the projected rapid increase in market saturation of C&I lighting products during this Three-Year Plan, the Commonwealth must consider what this will mean going forward. Targeted intervention today will help capture the greatest amount of benefits to customers

[41] http://ma-eeac.org/plans-updates/
[42] https://www.designlights.org/default/assets/File/Workplan/DLC_SSL-Technical-RequirementsV5_0_DRAFT2_9-30-19.pdf

and limit the amount of stranded savings by driving focus away from TLEDs and towards linear LED fixtures.

The Consultants will continue to work with the Program Administrators to share best practices from other jurisdictions and collectively push for the greatest amount of savings from C&I lighting in Massachusetts. While the Program Administrators' KPI #4 (percentage of lighting projects with controls) is a good first step in monitoring progress, this data currently only includes New Construction and Custom projects - leaving out Turnkey and Upstream pathways. This KPI should be updated to reflect C&I lighting savings for all pathways, broken out by pathway to monitor progress across each way C&I customers interact with Mass Save. The EEAC, their Consultants, and the Program Administrators should monitor trends in this KPI closely and do everything possible to drive the percentage of lighting projects with controls towards the potential 55-65% put forward by experts from the U.S. Department of Energy and The DesignLights Consortium (DLC). As previously noted, the Program Administrators have the least interaction with the customer through the Upstream program. This makes monitoring the Upstream pathway even more crucial to understand what customers decisions look like in the absence of direct interaction with the Program Administrators. Regularly providing Upstream lighting data (product counts, savings, etc.) to the Consultant team will enable more frequent updates to the EEAC on the state of the C&I lighting market during this critical period.