Retrofit Lighting Controls Measures Summary of Findings

FINAL REPORT

Massachusetts Energy Efficiency Program Administrators

Massachusetts Energy Efficiency Advisory Council

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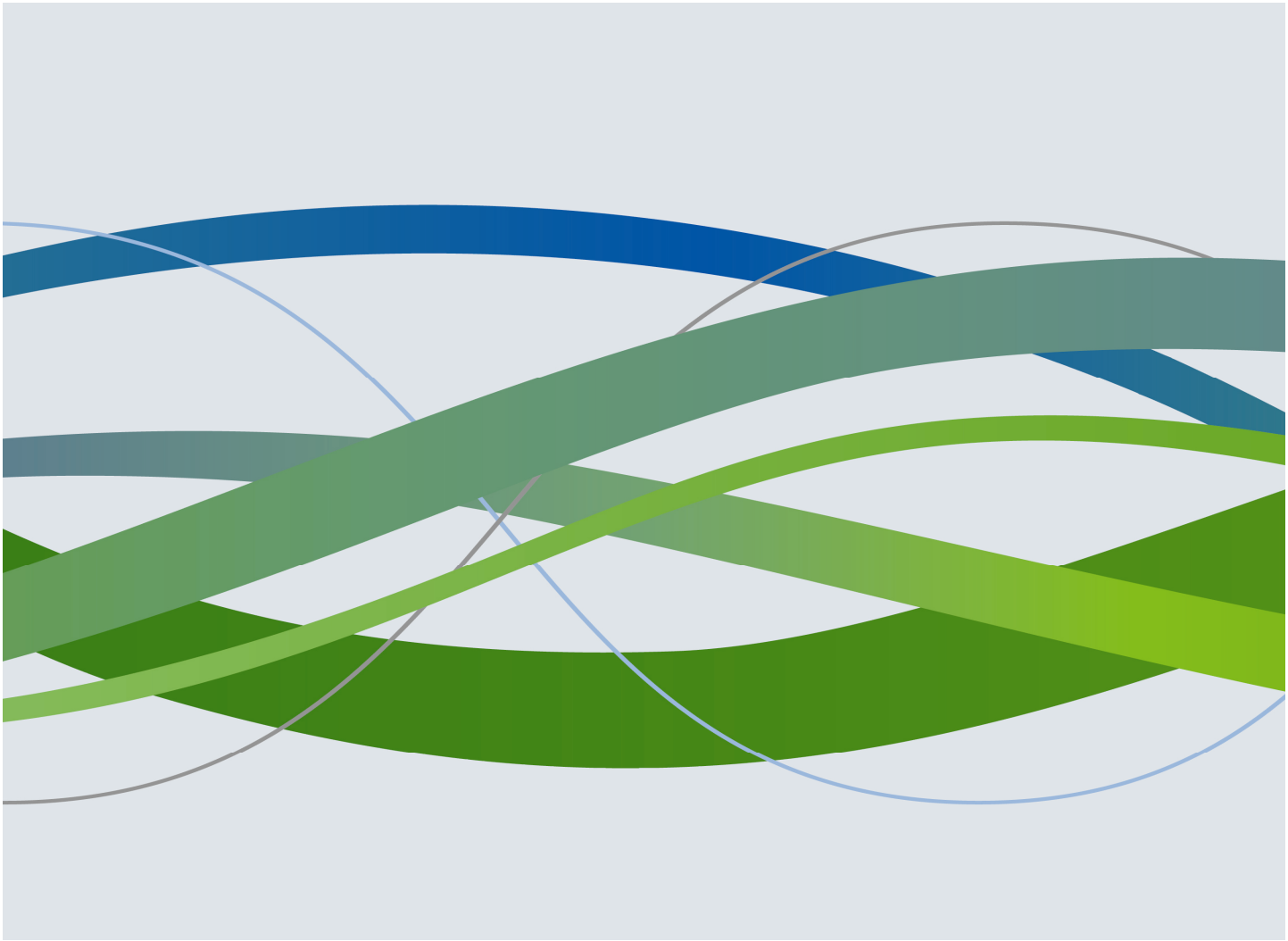

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1. Executive Summary

This document presents the summary of findings of DNV GL's research into the state of the market for C&I Retrofit Lighting Controls Measures in Massachusetts. The goals of this research are to provide the Massachusetts Program Administrators (PAs) with recommendations to improve the lighting controls options through the retrofit program, tracking methods, and to determine how lighting controls measures should be evaluated.

1.1 Evaluation Objectives

The results of this research include the following core objectives:

- Discover why program savings for the retrofit lighting controls market dropped off to about half its size between 2010 and 2011, and whether the program can reverse this decline
- Determine what kind of impact evaluation to conduct for Large C&I Retrofit Lighting Controls installations under MA-Large Commercial and Industrial Evaluation Contract (LCIEC) -study 22. The previous plan of an innovative pre-post metering study may prove either appropriate or overly ambitious, depending on the expected future growth or decline of the measure savings;
- Make recommendations for changes to future lighting controls measures to account for new market conditions, including how to track savings consistently. These recommendations may include new technologies and market segments to target, old technologies and market segments to leave behind, and existing technologies and market segments to reallocate resources to, and;
- Make recommendations for adjustments to savings estimation methods currently in use in the Massachusetts Technical Resource Manual (TRM).

The research addresses retrofit lighting controls installed under all PA C&I programs including Large C&I and Small Business, both Prescriptive and Custom. The focus will be on Large C&I, while data for the Small Business programs was also reviewed for comparison. Measures addressed include occupancy, daylight dimming, photo sensor controls, advanced/network controls and wireless controls. Though prescriptive programs utilize the algorithms from the TRM, hours of use reduction are site specific, not deemed. This is similar for custom lighting controls projects.

DNV GL conducted the following research activities.

- **Task 1**: Savings Estimation Literature Review
- **Task 2**: Market Assessment Literature Review
- **Task 3**: Tracking Data Review
- **Task 4**: Review of Previous MA-LCIEC Studies
- **Task 5**: Program Staff Interviews
- **Task 6**: Lighting Vendor / Distributor Interviews

1.2 Program Description

Commercial and Industrial lighting controls are supported by all electric utility sponsors of this study effort. Specifically, each sponsor administers a program that promotes the installation of lighting controls. These programs include C&I Large Retrofit in both Prescriptive and Custom tracks[1]. In addition to these programs, this review will look at the C&I Small Business programs.

Regardless of the application or setting of the control installation, the savings for prescriptive programs are guided by the calculations in the Massachusetts Technical Reference Manual (TRM). The TRM is a document, updated annually and used by regulatory agencies, customers, and other stakeholders to calculate savings from the installation of efficient equipment. The reference manual provides methods, formulas and default assumptions for estimating energy, peak demand and other resource impacts from efficiency measures. Custom programs receive savings determined on a project-by-project basis.

1.3 Summary of Findings

The following sections provide a high level overview of the key findings of the study.

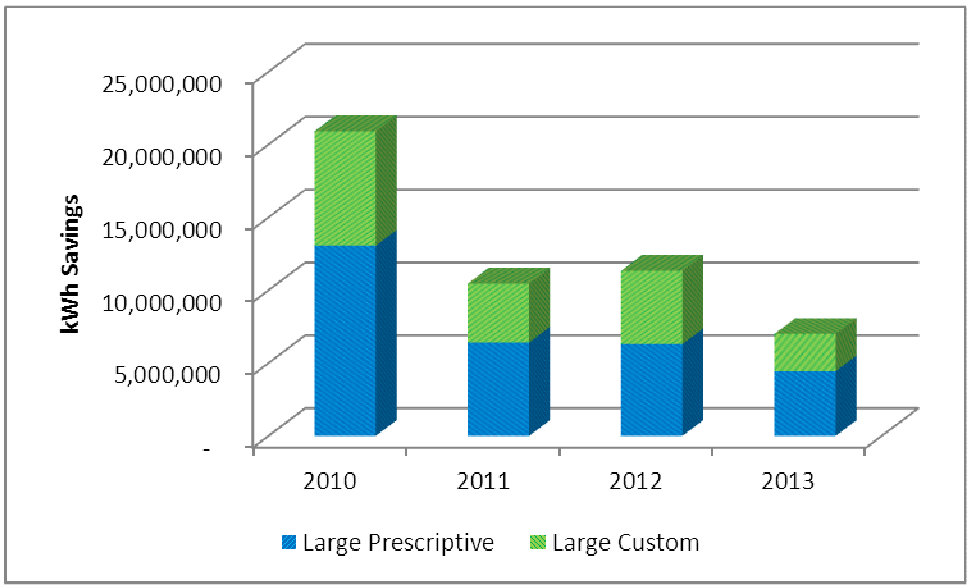
1.3.1 Massachusetts Lighting Controls Market Trends

DNV GL reviewed available tracking data to determine if the trends pointed out by the PAs can be explained by shifts in categorization, such as a shift from prescriptive to custom. It also looked to tease out trends within the data which may suggest whether reductions in the large C&I retrofit lighting controls program are occurring universally, or are confined to specific PAs or measure types. As shown in

[1] The MA PAs provide rebates for Large C&I lighting control retrofits in both their Prescriptive and Custom offerings. Prescriptive retrofits include occupancy sensors and daylight dimming controls in existing facilities that do not have pre-exisiting lighting controls. Custom retrofits generally include more complex control strategies, such as wireless, or whole building/networked controls.

Figure 1, the tracking data revealed a decline in retrofit lighting controls savings in the Large C&I program between 2010 and 2011 of about one half. The 2012 program year saw an increase of approximately 8% over the 2011 program year. However, 2013 saw large C&I lighting controls savings decrease to their lowest levels since 2010.

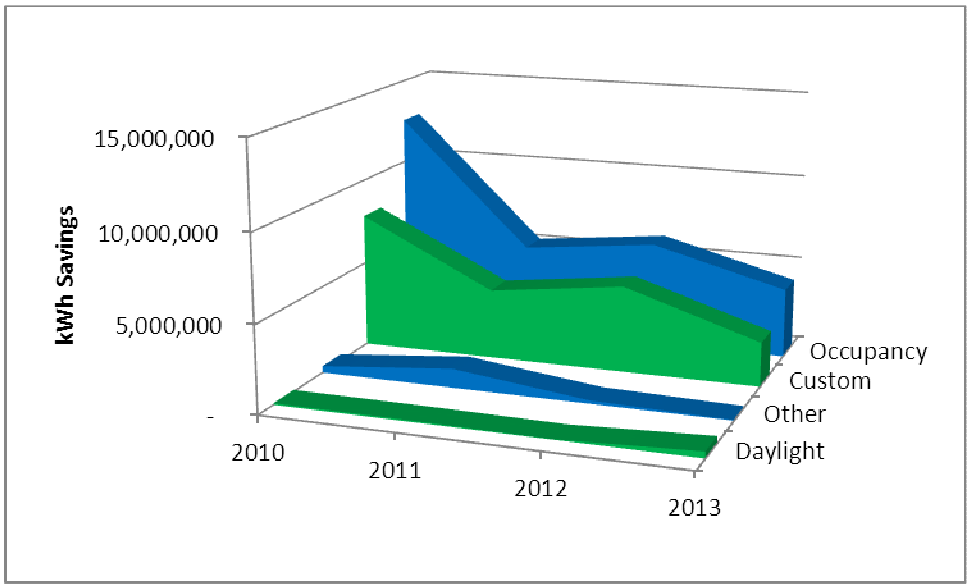
Figure 1: Retrofit Large C&I Lighting Controls Savings by Year



The data analysis showed that the decline occurred in both custom and prescriptive projects. Both custom and prescriptive lighting controls savings dropped more than 60% from 2010 to 2013 despite a small bounce back in 2012. The trend for custom projects is less trustworthy because it is possible that some of these projects include savings from both lighting systems and controls.

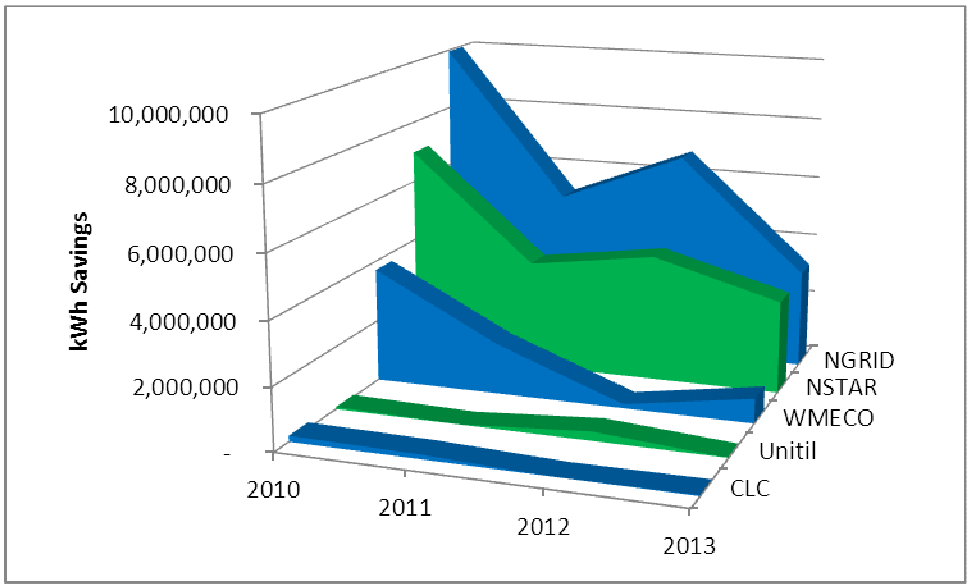
When reviewing the Large C&I savings by lighting control type in Figure 2, it was found that lighting controls savings are dominated by prescriptive occupancy sensors and custom projects. Both categories declined between 2010 and 2011, increased between 2011 and 2012, and declined again in 2013. Over the four year period, occupancy sensors decreased by about 70% while custom controls savings also decreased by about 70%. Daylighting represents a very small percentage of all lighting controls installations, but this technology did increase between 2012 and 2013.

Figure 2: Retrofit Large C&I Savings by Control Type



As shown in Figure 3, savings decreased for both of the large PAs (National Grid and NSTAR) between 2010 and 2013. The decreased savings for the large PAs between 2010 and 2011 bounced back partially in 2012, and dropped again in 2013. In 2013, National Grid Large C&I lighting controls savings decreased by 53% over 2012, and NSTAR decreased by 27% over 2012. These savings values are now 32% and 43% of 2010 savings, respectively. Lighting controls savings for WMECO dropped significantly between 2010 and 2012, but turned in a positive gain in 2013. CLC and Unitil claimed very few lighting control projects during these program years.

Figure 3: Retrofit Large C&I Controls Savings by PA



We do not have a clear answer at this time, based on this data, whether this trend reflects a market shift, a slowdown in the large C&I sector, changes in program planning, or other factors. Based on the research conducted in this study, and summarized in the sections below, we have some hypotheses of what may be driving the decline in savings. Table 1 presents a list of the potential reasons based on our research.

Table 1: Potential Reasons for Decline in Lighting Controls Savings

Potential Reasons for Decline	Evidence from this Study
Cost	MA-LCIEC Project 10[2] identified cost as a barrier to energy efficiency upgrades, while MA-LCIEC Project 1A[3] found that decreased costs and better performance would help boost controls savings in high bay applications. Though costs of controls haven't increased, costs for newer technologies such as wireless controls, remain higher.
Marketing	Interviews conducted with lighting contractors for MA-LCIEC Project 17[4] found that some of the smaller distributors may not be providing controls through the retrofit program, citing more marketing needed.
Rebates	MA-LCIEC Project 10 also noted that rebates for lighting controls do not have a large impact on the installation of controls.
Vendor Technical Awareness	PA interviews highlighted the issue surrounding vendor awareness and the ability for them to calculate energy savings and communicate those effectively to customers.
Saturation	Although most of the literature review and surveys concluded that there are still plenty of opportunities for lighting controls, some vendors did note that their impression is that occupancy sensors have been installed in many traditional commercial building types.

DNV GL also spoke with MA implementation program staff and MA implementation vendors to gather information on the recent trends in lighting controls installations.

Program Administrators were asked about the growth and decline of program sponsored lighting controls measures over the past several years. Respondents were asked to comment on each control type individually. The following bullets summarize the responses provided:

- Occupancy Sensors. This control type produced inconsistent responses. One respondent from a small PA stated that this measure type has produced a positive trend over time due to more customers becoming aware of control technologies. A second response from a large PA indicated that occupancy sensors are not as robust as they once were. This respondent indicated that there

[2] KEMA, Inc. Massachusetts Large Commercial & Industrial Process Evaluation. Prepared for the Massachusetts Energy Efficiency Program Administrators and the Massachusetts Energy Efficiency Advisory Council. July 2012.

[3] KEMA, Inc. HBL Market Effects Study Project 1A New Construction Market Characterization. Prepared for the Massachusetts Energy Efficiency Program Administrators and the Massachusetts Energy Efficiency Advisory Council. June 2011.

[4] KEMA, Inc. Process Evaluation of the Bright Opportunities Program. Prepared for the Massachusetts Energy Efficiency Program Administrators and the Massachusetts Energy Efficiency Advisory Council. June 2013.

are still opportunities, citing parking garages and high bay fluorescent or LED applications, but not as much in typical building applications due to possible saturation.

- Daylight Dimming. This type of control has never been very large due to challenges that are sometimes difficult to overcome. For example, it has been difficult for vendors to provide a strong methodology for how to quantify savings. It is also a more complex type of retrofit due to having to replace the entire lamp/ballast system, and is not attractive for existing buildings. This control type is better suited for new construction situations.

- Advanced/Network Controls. This technology typically includes whole building lighting controls, which are connected to a central control system, and can be programmed for optimal lighting control, including on/off and dimming. This is a newer technology that hasn't been fully integrated by some PAs yet. According to one large PA respondent, there appears to be an upward trend for this type of lighting control. There are some energy service companies (ESCOs) that are beginning to do a higher volume of these installations. However, there are some challenges due to the relatively high cost of this technology.

- Wireless Controls. Similar to advanced/network controls, wireless controls haven't been adopted by customers of some PAs yet. The noted advantage of wireless controls as compared to advanced/network controls is the cost. Wireless controls can communicate with a ballast to perform tasks such as dimming and task lighting, while avoiding having to run as much cable and wiring as needed for advanced/network controls.

Lighting vendors were asked if they noticed any industry trends over the past three years that would affect lighting controls installations within the large C&I retrofit programs. The following bullets provide a summary of the responses provided by vendors:

- Increase in installation of lighting controls for C&I buildings across all sectors.

- Trend of occupancy sensors is going towards more advanced technologies.

- Technology is changing with more converting to LEDs.

- Sensors are becoming more built in and network ready.

- One vendor noted that the cost of lighting controls is decreasing (cost was prohibitive for quite some time).

- Businesses are far more aware of what is available about things they can do to save energy.
- Impact of the building code updates (the utilities are reducing rebates due to code).

All lighting vendors surveyed report noticing changes in customers' level of understanding of the benefits of lighting control technologies over the past three years. Half the vendors indicate customers are asking more about advanced technology controls - especially daylight dimming controls.

1.3.2 Current and Expected Future State of Lighting Controls Market

To better understand whether the recent trends found for Massachusetts Large C&I Retrofit Lighting Control measures are occurring in other jurisdictions or nationally, DNV GL conducted a literature review of existing lighting control market potential studies and evaluations performed outside Massachusetts. DNV GL found that comprehensive research regarding trends seen in the lighting controls market and the expected market potential for occupancy sensors, daylight dimming, and photo sensor controls are rare. However, at a higher level, many of the reviewed studies did suggest that the retrofit lighting control market is not saturated and still offers a large opportunity for energy savings in commercial and industrial settings. A growing interest in wireless lighting controls and integrated systems, technologies currently not part of the prescriptive Massachusetts Large C&I Retrofit program, was also a reoccurring theme in many of the more recently published studies.

Interest in wireless lighting controls and integrated building systems has been growing in recent years. These technologies offer significant potential to address many of the barriers other control systems face, such as high costs and a lack of flexibility. The use of wireless lighting controls can reduce the barriers to adoption that exist for standard lighting control technologies. Wireless controls remove the need to run new wires to connect lighting systems therefore reducing installation time and costs. By being connected on a wireless network, lights can be controlled remotely as well which offers flexibility and additional operating options. As equipment costs decrease, this technology offers greater potential for controls installations.

It is likely that the reduced costs and additional control options would increase the adoption of these products over standard lighting controls in numerous retrofit applications, including existing buildings, street lighting, and parking garages. Current market trends indicate that demand for wireless controls will

increase the size of the lighting control market and sales of these controls will surpass hardwired controls.[5]
Trends also show growing interest in integrated systems. Integrated lighting systems allow additional flexibility: a remote operator can adapt conditions to current lighting needs, detect outages, and adjust lighting conditions

While there is a lack of quantitative information from other jurisdictions and at the national level regarding recent trends seen in retrofit lighting control programs that offer occupancy sensors, daylight dimming, and photo sensor controls, two major findings were uncovered in the literature review:

- Current market saturation for lighting controls is low but has more potential, and
- Substantial interest is growing in the market for wireless and integrated controls.

1.3.3 Recommendations for Program Expansion, Contraction and Future Marketing and Rebate Opportunities

1.3.3.1 High Potential Technologies

Interviews with program implementation staff, and lighting controls vendors highlighted some technologies in which the program may focus on in the future.

- **Advanced/Networked Lighting Controls** – Whole building, advanced/network lighting controls are becoming more prominent and cost effective as ESCOs are starting to implement these more frequently. This type of technology can be as sophisticated as lighting designers and programmers can make it. They can integrate the best of all lighting controls systems including, on/off scheduling, vacancy control, daylight dimming, and individual user controls. Though these types of systems are best suited for new construction types of projects, lighting vendors and designers should be encouraged, through program incentives, to look for opportunities to implement these complex systems in existing facilities where possible.

- **Wireless Controls** - Wireless controls are gaining in popularity as it allows the users to implement lighting controls without having to run the additional electrical wires necessary for traditional lighting controls. Wireless controls should be considered as a lower cost alternative to Advanced/Network controls in some retrofit applications.

[5] Spark Optoelectronics S&T, Global Lighting Controls Market Will Grow to 8 Billion Dollars by 2018, 2012

- **LED Lighting and Controls** – Many PAs and vendors surveyed noted the savings potential combining LEDs and lighting controls. There are many possible controls strategies offered with newer LED technology, including dimming capabilities. New LEDs with integrated controls offer increased lighting systems savings when combined in a package, or connected to an advanced system.

- **Daylight Dimming** – Many vendors suggested that customers are asking about daylight dimming controls more frequently. Vendors theorize that customers are becoming more comfortable with lighting controls systems, and are eager to learn more about how to make daylight dimming work in their facilities. It should be noted that some PA respondents thought that this was a challenging technology to implement due to the difficulties that some vendors have in explaining the savings and benefits for potential daylight dimming projects to their customers.

1.3.3.2 High Potential Sectors

The following represent some of the sectors in which the program may benefit from focusing more in terms of lighting controls opportunities. In addition to the specific sectors listed, spaces that are overilluminated, could benefit from more flexibility in light levels, while spaces with highly variable occupancy, are good candidates for lighting controls.

- **Offices** – There appear to be significant opportunities for lighting controls installations in office facilities. In addition to traditional occupancy/vacancy controls and daylight dimming controls, large offices would be good candidates for the more sophisticated types of controls, since they tend to have dedicated energy managers, and existing building automation systems.

- **Small business (<300 kW)** - There are opportunities for integral controls like common areas in multi-family buildings and hotels/motels. In this sector, one of the biggest advances is the advent of the dimming feature of LEDs.

1.3.3.3 Low Potential Technologies/Sectors

When asked if there were any technologies and/or sectors that the program shouldn't focus on as much, respondents generally stated that incentives should not be terminated or decreased for any technology or sector because there are still opportunities. However, some lighting vendors indicated that schools are difficult to implement effectively since some of them tend to have lower hours of use (i.e. less than 40 hours per week, and no summer operation).

1.3.3.4 Future Program Marketing and Rebate Opportunities

PAs and vendors were asked what they think the incentive programs could do to improve the number of retrofit lighting controls projects. In addition to vendors who unanimously suggested increasing incentives, the list below highlights some additional recommendations from PAs, vendors and DNV GL.

Many business are cautious about lighting system installations (i.e., how will it look, will it have right lumen output and color rendering properties). They suggest being able to try lighting controls for free for 30 days and if business doesn't like the system, have the technology taken out;

- Every lighting application should include an investigation of lighting controls at the site level. This would put more focus on lighting controls, and would require that vendors are better educated on the different technologies.

- Additional opportunities can come from training workshops reinforcing technical standards and savings quantifications. By providing these forums, program staff could be in a better position to assist vendors and future program participants on calculating baseline savings or redirect vendors to other retrofit control technologies to capture similar savings.

- Generate an energy savings calculation and presentation approach to show customers positive implications of installing lighting controls measure(s).

- Should keep all current incentives in place and just figure out way to implement specific incentives for advanced lighting controls. Consider increasing incentives for sites with 5,000 hours or more.

- Need to provide greater financial and technical assistance for more complex efficiency projects

- Need for more outside sales and account managers to contact and visit sites and bring in project expeditors to do implementation. Project expeditors are defined as PA authorized energy efficiency vendors. In buildings that appear to be good candidates for advanced controls, PAs may consider teaming with a lighting controls expert, who specializes in implementing advanced controls systems. Some project expeditors are not comfortable specifying lighting controls because they don't know how well they work;

1.3.4 Recommendations for Impact Evaluation and Savings Estimation Approach

DNV GL looked to gather the best information and methods currently available for calculating prescriptive lighting controls savings. The findings of this section focus mostly on occupancy sensors, since this technology currently dominates the prescriptive lighting controls savings in MA. The body of this report covers other technologies in addition to occupancy sensors.

DNV GL reviewed several sources, including the MA TRM, to be able to identify the best information and methods currently available for calculating prescriptive lighting controls savings. In addition to the MA TRM, the evaluation team reviewed the following studies:

- Focus on Energy Deemed Savings Manual[6]
- LBNL Meta Evaluation[7]
- Massachusetts SBDI Lighting Controls Evaluation[8]
- 2005 National Grid Lighting Controls Evaluation[9]
- Impact Evaluation of 2010 Prescriptive Lighting Installations[10]

1.3.4.1 Current Savings Estimation Approach from MA TRM

The calculation for prescriptive lighting controls savings essentially operates as a custom calculation. It calculates kWh savings using values obtained from the application, using the following formula:

$$\Delta kWh = (\text{Controlled kW})(\text{Hours}_{base} - \text{Hours}_{EE})$$

$$\Delta kW = \text{Controlled kW}$$

Where

[6] KEMA, Inc. *Business Programs: Deemed V1.0*. Prepared for State of Service Wisconsin. March, 2010.

[7] Erik Page & Associates, Inc. *A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings*. Prepared for the Ernest Orlando Lawrence Berkeley National Laboratory. September, 2011.

[8] The Cadmus Group: Small Business Direct Install Program: Pre/Post Lighting Occupancy Sensor Study. Prepared for the Massachusetts Utilities. October, 2012

[9] RLW Analytics. National Grid Lighting Controls Impact Evaluation FINAL REPORT: 2005 Energy Initiative, Design 2000plus and Small Business Services Programs. June, 2007.

[10] KEMA, Inc. Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for the Massachusetts Energy Efficiency Program Administrators and the Massachusetts Energy Efficiency Advisory Council. June 2013.

Controlled kW = Controlled fixture wattage

$Hours_{base}$ = Total annual hours that the connected Watts operated in the pre-retrofit case.

$Hours_{EE}$ = Total annual hours that the connect Watts operate with the lighting controls implemented.

This equation calculates accurate savings estimates to the extent that the parameters entered into it are accurate. However, these parameters are drawn entirely from customer or vendor-reported information on the application, including *Hours of reduction.* and .*Controlled kW*. While *Controlled kW* is relatively easy to accurately estimate from product cut sheets of lamp and ballast configurations, *Hours (reduction)* is notoriously hard to estimate accurately. The program does not require the customer to perform any kind of M&V activities, so empirical data is rarely collected. This issue may compromise the accuracy of tracking savings estimates for retrofit lighting controls.

1.3.4.2 Percent Savings

DNV GL recommends that the program make a change to its current calculation methodology. We recommend that the program adopt the parameter Percent Savings (%Sav) for use in its lighting controls energy savings calculation going forward. This parameter, used by most other programs and research institutions, allows for a more intuitive calculation of savings for all lighting controls measures, including those which do not turn off lights completely such as daylight dimming. Using Percent Savings results in the following formula:

$$\Delta kWh = Controlled\ kW * [Hours]\_base * \%Sav$$

DNV GL compared occupancy sensor savings from each study by space type, as data were available. Percent reduction values were available from all studies but the National Grid study, and may be applicable to the Massachusetts TRM, which has default hours of operation estimates by building type in the appendix of the document, which can be multiplied by percent reduction to get to hours reduced by building type. However, since most MA PAs utilize site specific hours estimates in their savings calculations, an alternative approach would be to apply the percent reduction against evaluated MA site specific hours.

- DNV GL recommends using the weighted average values from the LBNL study, which is weighted by the total number of studies used for calculating percent reduction for each facility type. The percent savings value for occupancy sensors is 24%, and the percent savings value for daylight dimming is 28%. This recommendation should apply for all occupancy sensor and daylight dimming installations until a new large C&I lighting controls study is completed.

1.3.4.3 Coincidence Factors

Table 2 below shows the coincidence factor results from all occupancy sensor sources together. Coincidence factors are multiplied by the Controlled kW to estimate summer or winter peak kW reductions.

Table 2 – Occupancy Sensor CF Source Summary

Coincidence Factor	MA 2010 Prescriptive Lighting	National Grid Occupancy Sensor Large	National Grid Occupancy Sensor Small	SBDI Occupancy Sensor
Summer On-Peak	15.0%	30.4%	34.8%	17.0%
Winter On-Peak	13.3%	19.2%	28.0%	13.0%
Summer Seasonal Peak	14.3%	N/A	N/A	N/A
Winter Seasonal Peak	13.9%	N/A	N/A	N/A

The National Grid and SBDI studies are both less than ideal since the National Grid study was based on a small sample size, and the SBDI study is focused on small C&I, while this evaluation deals with large C&I. Note that the SBDI study was the only study to utilize pre/post metering, while the MA 2010 Prescriptive Lighting, and National Grid studies used post-only metering.

- DNV GL recommends that the program continues to use the CF values from the recent 2010 prescriptive lighting impact evaluation for all occupancy sensor installations until a new large C&I lighting controls study is completed..

1.3.4.4 Future Impact Evaluation

DNV GL reviewed several studies, savings estimation methods, and had detailed conversations with program staff and lighting controls vendors in an effort to understand the lighting controls market in MA. The results of this study show that there is some uncertainty of the future of lighting controls as more new technologies infiltrate the market, and customers are becoming more comfortable with controls strategies.

However, it is clear that lighting controls will continue to be offered as a measure, and there will always be a need for accurate savings estimates. Recommendations for future impact evaluations include:

- DNV GL recommends that the PAs implement the above savings estimation methods and savings values until a new statewide lighting controls impact evaluation can be conducted. When it comes time for a new impact evaluation, DNV GL strongly suggests that the PAs consider a full pre/post metering approach. Pre/Post metering of lighting controls will be difficult to employ, but it offers the most rigorous approach for estimating the key savings parameters; percent savings and the coincidence factors.