

Impact Evaluation of the Massachusetts Upstream Lighting Program FINAL REPORT

Massachusetts Energy Efficiency Program Administrators

Massachusetts Energy Efficiency Advisory Council

Prepared by KEMA, Inc.

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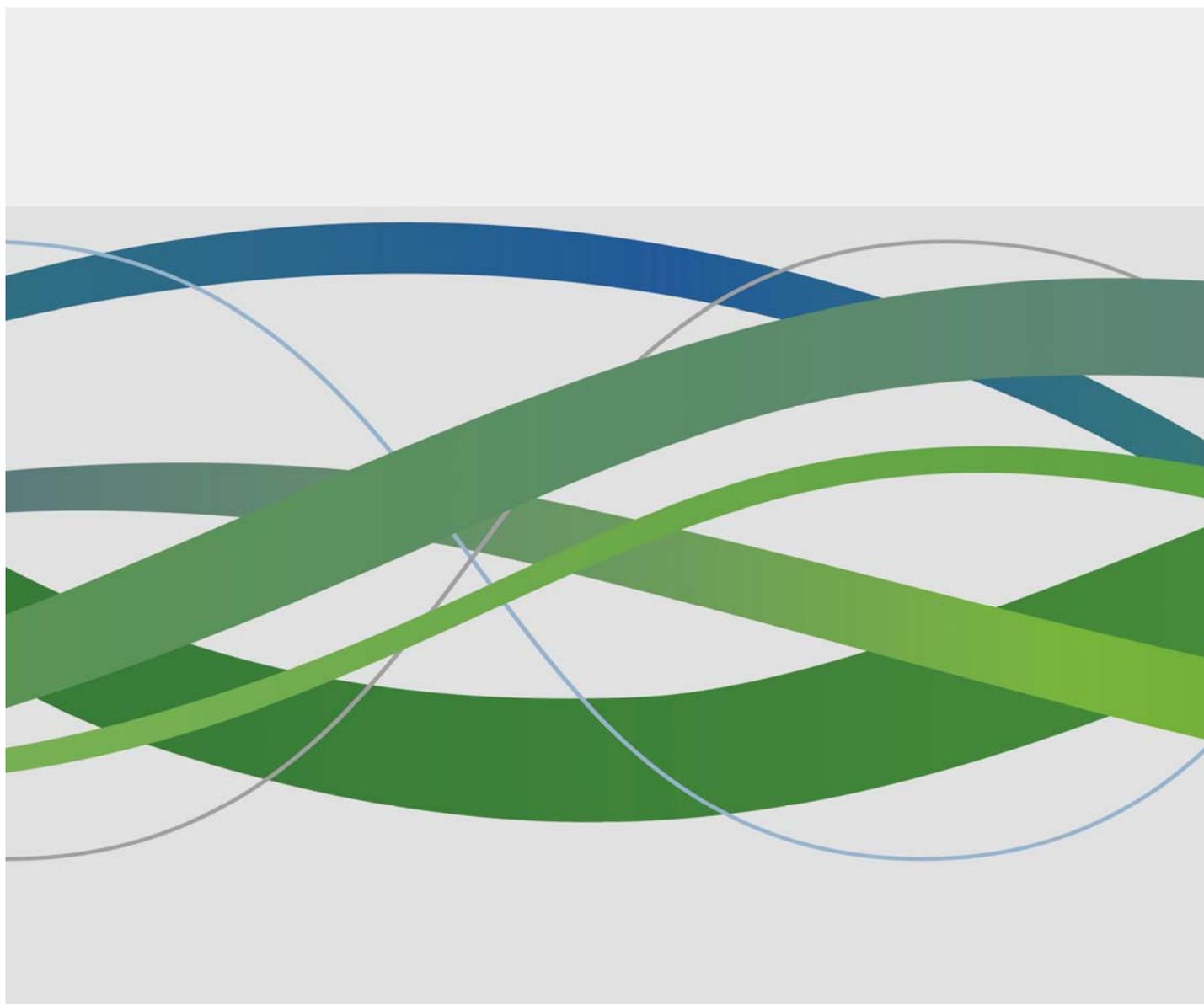


Table of Contents

1.	Executive Summary	1-1
1.1	Introduction	1-1
1.1.1	Program Description.....	1-1
1.1.2	Purpose of Study.....	1-1
1.1.3	Scope	1-3
1.2	Results	1-3
1.2.1	LED Results.....	1-3
1.2.2	Fluorescent Results.....	1-4
1.2.3	Program Observations and Savings Adjustments.....	1-6
1.3	Conclusions and Recommendations	1-8
1.3.1	LED Savings Assumptions.....	1-8
1.3.2	Fluorescent Savings Assumptions	1-9
1.3.3	Program Tracking Documentation	1-10
1.3.4	Future Impact Evaluation	1-10
2.	Introduction.....	2-12
2.1	Program Description.....	2-12
2.2	Purpose of Study.....	2-12
2.3	Scope	2-14
3.	Evaluation Approach.....	3-15
3.1	Preliminary Sampling Strategy for the Impact Evaluation.....	3-15
3.1.1	Determining the Customer Sample Frame	3-15
3.2	Initial Sample Design	3-16
3.3	Customer Recruitment and Sample Re-Design	3-17
3.4	Final Sample	3-19
3.5	Measurement, Verification and Analysis Methodology	3-20
3.5.1	Verification.....	3-20
3.5.2	Monitoring.....	3-21
3.5.3	Site Analysis.....	3-21
3.5.4	HVAC Interactive Effects.....	3-22
4.	Results.....	4-23
4.1	LED Results.....	4-25
4.2	Fluorescent Results.....	4-27
4.3	Combined Results.....	4-30
4.4	Outliers	4-31
4.5	Program Observations and Savings Adjustments.....	4-33
4.5.1	Installation Rate.....	4-33
4.5.2	Delta Watts	4-34

Table of Contents

4.5.3	Hours of Use	4-34
5.	Conclusions and Recommendations	5-34
5.1	LED Savings Assumptions	5-35
5.2	Fluorescent Savings Assumptions	5-36
5.3	Program Tracking Documentation	5-36
5.4	Future Impact Evaluation	5-37
A.	Description of Results and Factors	A-1
A.1	Realization Rates	A-1
A.2	Savings Factors	A-1
B.	Site Level Results	B-4
B.1	LEDB-4	
B.2	Fluorescent	B-10
C.	Site Summaries	C-12
D.	Post-Report Analysis of Lighting Distributor/Contractor Interviews, Final Revised Memorandum	D-36
D.1	Background	D-36
D.2	The Scope of the Post-Analysis	D-36
D.3	Findings	D-37

List of Exhibits

Table 1:	Summary of LED Energy Realization Rate	1-3
Table 2:	Summary of LED Savings Factors	1-4
Table 3:	Summary of Fluorescent Energy Realization Rate	1-5
Table 4:	Summary of Fluorescent Savings Factors	1-6
Table 5:	Building Type	1-7
Table 6:	Per Lamp Savings Assumptions by Product Type	3-16
Table 7:	Distribution of Upstream Lighting Projects by Product Group	3-16
Table 8:	Population for Impact Evaluation	3-17
Table 9:	Proposed Sample Design for Impact Evaluation	3-17
Table 10:	Anticipated Precisions for Impact Evaluation	3-17
Table 11:	Additional Per Lamp Savings Assumptions by Type	3-18
Table 12:	Phase II Population	3-18
Table 13:	Phase II Sample Design	3-19
Table 14:	Combined Population Phase I + Phase II	3-19
Table 15:	Combined Sample Phase I + Phase II	3-19
Table 16:	General Heating and Cooling COP Assumptions	3-22

Table of Contents

Table 17: Summary of LED Energy Realization Rate.....	4-26
Table 18: Summary of LED Savings Factors	4-27
Table 19: Summary of Fluorescent Energy Realization Rate.....	4-28
Table 20: Summary of Fluorescent Savings Factors.....	4-29
Table 21: Summary of Combined Energy Realization Rate.....	4-30
Table 22: Summary of Combined Savings Factors	4-31
Table 23: Building Type	4-33
Table 24: Summary of Results and Factors	A-3
Table 25: LED Tracking and Evaluation Savings Estimates	B-4
Table 26: LED Realization Rates and Reasons for Discrepancies.....	B-7
Table 27: Fluorescent Tracking and Evaluation Savings Estimates	B-10
Table 28: Fluorescent Realization Rates and Reasons for Discrepancies.....	B-11
Table 29: LEDs as Percent of Floodlight Sales by State	D-40
Figure 1: Scatter Plot of Evaluation Results for Systems for Annual MWh Savings.....	4-25
Figure 2: Scatter Plot of Evaluation Results for Fluorescents for Annual MWh Savings	4-28
Figure 3: Standard Deviation and Tolerance Intervals	4-32
Figure 1: LEDs as Percent of Floodlight Sales by State	D-39
Figure 2: Participating Lighting Distributor 2012 LED Sales, Program vs. Non-Program	D-42
Figure 3: Why Participating Lighting Distributors Did Not Sell All LED Bulbs Through Program	D-43
Figure 4: LED Floodlight/Spotlight Market Penetration Over Time.....	D-44
Figure 5: Factors Influencing LED Floodlight/Spotlight Market Penetration Over Time.....	D-45

1. Executive Summary

1.1 Introduction

This report documents DNV KEMA's impact evaluation of the Massachusetts Upstream Lighting Program, which is known as the Bright Opportunities Program. This impact evaluation was performed by DNV KEMA under the Massachusetts Large C&I Evaluation Contract (MA-LCIEC). This report represents the impact component of a broader evaluation effort, which also included a process evaluation completed in June 2013¹. This impact evaluation was completed for the Massachusetts electric Program Administrators (PA) under the guidance of the Massachusetts Energy Efficiency Advisory Council (EEAC).

1.1.1 Program Description

The Massachusetts Bright Opportunities Program is a program which attempts to increase the market penetration of energy-efficient lighting technologies through the use of upstream incentives that are used to buy down the cost of these lighting technologies at the lighting distributor level. All five electric PAs in the state are participating in the program. The program began offering upstream incentives on linear fluorescent lighting technologies in September 2011 and incentives for LED lighting technologies in November 2011. In the case of the LED lighting technologies the upstream incentives take the place of the downstream incentives that the Massachusetts C&I programs previously offered for these technologies.

The lighting distributors who participate in the program are obligated to collect sales data on the type and quantity of lamps they sold, as well as the name, location, and contact information of the customers to whom they sold the discounted lighting products. Every month the distributors submit their sales data to the Massachusetts electric PAs and to a third-party program manager. This third-party program manager combines the sales data from the various participating distributors and then allocates the energy savings and incentives to each participating PA. They then issue invoices to each PA for that particular month. The program also conducts quality control inspections for about 10 percent of the sites to make sure that they can verify on-site the lighting quantities and types claimed in the distributor sales reports.

1.1.2 Purpose of Study

The research objectives of the impact evaluation for the Upstream Lighting Program include updating the following assumptions with Massachusetts-specific research:

¹ Process Evaluation of the 2012 Bright Opportunities Program, Final Report, June 14, 2013, Prepared by DNV KEMA. A post-analysis of the process evaluation was completed in August, 2013 following the finalization of the process evaluation report. This analysis is included in this report in Appendix D.



- Application of purchased lamps by facility and space type;
- Hours of use of purchased lamps;
- Baseline replaced lamps for estimating delta watts;
- Gross savings realization rates to be applied to 2012 results; and
- Estimates of delta watts and hours of use to be applied prospectively.

This report presents the following realization rates at the statewide level using metered data collected from each site:

- **Annual kWh** – This result is the gross annual kWh realization rate including additional savings due to HVAC interactive effects. This realization rate is the evaluation gross annual kWh savings divided by the tracking gross annual kWh savings.
- **Connected kW** – This result is the gross connected kW realization rate, which includes any documentation, quantity, and technology adjustments. This realization rate is the evaluation gross connected kW savings divided by the tracking gross connected kW savings.
- **Connected kWh** – This result is the gross connected kWh realization rate, which includes only the documentation, quantity, and technology adjustments. This realization rate is the evaluation gross connected kWh savings divided by the tracking gross connected kWh savings.
- **Installation Rate** – This represents the percentage of the tracking connected kW savings based on the quantity of installed lamps found during the on-site evaluation. This rate is embedded in the Annual kWh, Connected kW, and Connected kWh realization rates above.
- **Delta Watts** – This result represents the percentage of the tracking connected kW savings based on the difference in the delta watts (pre minus post installation wattage) as found during the on-site evaluation. This rate is embedded in the Annual kWh, Connected kW, and Connected kWh realization rates above.
- **Hours of Use** – This result is the hours of use realization rate, which represents the evaluation estimate of hours of use divided by the tracking estimate of hours of use. This rate is embedded in the Annual kWh realization rate above.

The evaluation sample for this study was designed in consideration of the 90% confidence level for energy (kWh) and on-peak and seasonal demand savings.



1.1.3 Scope

The scope of work of this impact evaluation covered upstream lighting purchases made between November 2011 and April 2012, and also between October 2012 and November 2012. The reason for the two separate periods of upstream lighting purchases was due to the inability to recruit the full sample of sites from the initial sample design. Additional data was requested from the third party program manager to develop a second sample design to meet the original sample targets. The final sample size for this impact evaluation was 81 sites, including 66 LED sites and 15 Fluorescent sites.

1.2 Results

1.2.1 LED Results

Table 1 summarizes the statewide results of this analysis. In the case of annual kWh savings, the realization rate for LEDs was found to be 101.9% with HVAC interactive effects included. The relative precision for this estimate was found to be $\pm 17.5\%$ at the 90% level of confidence. Note that gross tracking savings did not include HVAC interactive effects. The error ratio was found to be 0.90, which was significantly higher than the estimated error ratio of 0.40.

Table 1: Summary of LED Energy Realization Rate

Savings Parameter	Energy - LED	
	kWh	% Gross
Gross Savings (Tracking)	68,715,511	
Documentation Adjustment	1	0%
Technology Adjustment	22,480,524	33%
Quantity Adjustment	-16,255,696	-24%
Operational Adjustment	-9,243,234	-13%
HVAC Interactive Adjustment	4,328,036	6%
Adjusted Gross Savings	70,025,141	102%
Gross Realization Rate	101.91%	
Relative Precision	$\pm 17.5\%$	
Confidence Interval	90%	
Error Ratio	90%	

Table 2 summarizes the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level, including 80% for kW factors. The on-peak summer coincidence factor was 60.9%, with a relative precision of $\pm 12.6\%$. The seasonal summer coincidence factor was 56.6%, with a relative precision of $\pm 13.9\%$. The on-peak winter coincidence factor was 54.7%, with a relative precision of $\pm 13.1\%$. The seasonal winter coincidence factor was 51.5%, with a relative precision of $\pm 13.7\%$. The table also provides savings factors for on-peak and seasonal summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 2: Summary of LED Savings Factors

Savings Factors and Realization Rates	LED		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	82.1%	±8.7%	±6.8%
Delta Watts (Technology Adjustment - kW)	133.2%	±8.5%	±6.6%
Connected kW Realization Rate ²	109.4%	±13.2%	±10.3%
Summer Coincidence Factor			
On Peak Hours	60.9%	±12.6%	±9.8%
Seasonal Hours	56.6%	±13.9%	±10.8%
Winter Coincidence Factor			
On Peak Hours	54.7%	±13.1%	±10.2%
Seasonal Hours	51.5%	±13.7%	±10.7%
Summer kW HVAC Interactive Effect			
On Peak Hours	119.8%	±2.0%	±1.6%
Seasonal Hours	120.2%	±2.1%	±1.6%
Winter kW HVAC Interactive Effect			
On Peak Hours	96.6%	±4.1%	±3.2%
Seasonal Hours	97.0%	±3.3%	±2.6%
KWh Factors (Precisions at 90% confidence)			
Connected kWh Realization Rate	109.1%	±13.3%	
KWh HVAC Interactive Effect	106.6%	±1.8%	
Hours of Use Realization Rate	87.7%	±14.0%	
% On Peak KWh	59.2%	±5.1%	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00112		

1.2.2 Fluorescent Results

Table 3 summarizes the statewide results of this analysis. In the case of annual kWh savings, the realization rate for Fluorescent lamps was found to be 89.1% with HVAC interactive effects included. The relative precision for this estimate was found to be ±26.9% at the 90% level of confidence. The error ratio was found to be 0.62.

² The Connected kW Realization Rate is the product of the Documentation Adjustment, Installation Rate and Delta Watts factors.



Table 3: Summary of Fluorescent Energy Realization Rate

Savings Parameter	Energy - FLR	
	kWh	% Gross
Gross Savings (Tracking)	23,600,503	
Documentation Adjustment	0	0%
Technology Adjustment	6,783	0%
Quantity Adjustment	-4,644,999	-20%
Operational Adjustment	563,107	2%
HVAC Interactive Adjustment	1,494,622	6%
Adjusted Gross Savings	21,020,016	89%
Gross Realization Rate	89.07%	
Relative Precision	±26.9%	
Confidence Interval	90%	
Error Ratio	62%	

Table 4 summarizes the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level, including 80% for kW factors. The on-peak summer coincidence factor was 66.2%, with a relative precision of ±21.0%. The seasonal summer coincidence factor was 59.3%, with a relative precision of ±24.2%. The on-peak winter coincidence factor was 51.4%, with a relative precision of ±22.1%. The seasonal winter coincidence factor was 45.9%, with a relative precision of ±20.9%. The table also provides savings factors for on-peak and seasonal summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.



Table 4: Summary of Fluorescent Savings Factors

Savings Factors and Realization Rates	FLR		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	80.3%	±13.1%	±10.2%
Delta Watts (Technology Adjustment - kW)	100.0%	±0.1%	±0.1%
Connected kW Realization Rate ³	80.3%	±13.1%	±10.2%
Summer Coincidence Factor			
On Peak Hours	66.2%	±21.0%	±16.4%
Seasonal Hours	59.3%	±24.2%	±18.9%
Winter Coincidence Factor			
On Peak Hours	51.4%	±22.1%	±17.2%
Seasonal Hours	45.9%	±20.9%	±16.3%
Summer kW HVAC Interactive Effect			
On Peak Hours	118.9%	±5.0%	±3.9%
Seasonal Hours	119.2%	±5.2%	±4.0%
Winter kW HVAC Interactive Effect			
On Peak Hours	100.0%	±0.0%	±0.0%
Seasonal Hours	100.0%	±0.0%	±0.0%
KWh Factors (Precisions at 90% confidence)			
Connected kWh Realization Rate	80.3%	±13.1%	
KWh HVAC Interactive Effect	107.7%	±2.4%	
Hours of Use Realization Rate	103.0%	±18.5%	
% On Peak KWh	71.0%	±5.8%	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)		-0.00076	

1.2.3 Program Observations and Savings Adjustments

One of the goals of the evaluation was to identify where the upstream lamps were being installed. The PAs and EEAC were interested to find out what types of buildings and space types that the lamps ended up in. Table 5 presents a list of building types where the upstream lighting purchases were installed. The building type with the most installations was School/University. This represented 28% of the entire sample, including 27% of the LED sample and 33% of the Fluorescent sample. In schools, LEDs were primarily installed in common areas such as corridors. The “Other” building type contained a mix of buildings that only had one or two sites in the sample. Additional prominent building types included Retail, Office, Hospital, Hotel, Religious Buildings and Multi-Family.

³ The Connected kW Realization Rate is the product of the Documentation Adjustment, Installation Rate and Delta Watts factors.

Table 5: Building Type

Building Type	Fluorescent	LED	Total
School/University	5	18	23
Other	5	8	13
Retail		11	11
Office	2	8	10
Dining		6	6
Hospital/Healthcare	2	4	6
Hotel		5	5
Religious Building		4	4
Multi-Family	1	2	3
Total	15	66	81

1.2.3.1 Installation Rate

This evaluation found that approximately 82% of all purchased lamps were found to have been installed at the time of the on-site visits. LED and Fluorescent lamps had almost the same installation rates of 82% and 80%, respectively. These numbers represent the percentage of all lamps that were in operation at the time of the evaluation. In many cases, the missing lamps were identified in storage, and expected to be installed as other lamps burned out. In other situations, lamps were said to have been sent to a different location. When this occurred, evaluators attempted to verify these lamps by visiting these separate locations. However, they were not always identified as having been installed. In this evaluation, any lamps that were found in storage or not found at all were counted as zero in the installation rate calculation.

1.2.3.2 Delta Watts

The delta Watts factor was determined to be 123% for the overall impact evaluation. However, this was entirely driven by the LED category, which had a delta Watts factor of 133%. The Fluorescent category had a delta Watts factor of 100%. Delta Watts are defined as the pre-installation, or baseline wattage, minus the post-installation wattage. The factor represents the difference between the tracking delta Watts and the evaluation delta Watts as a percentage. For LED, this factor was mostly driven by the pre-existing or baseline wattages.

Tracking savings were based on an estimated baseline and installed wattage for each lamp type. These baseline wattages were developed by the PAs based on historical information, and manufacturer data. For LEDs, it was assumed that the baseline wattage would have been a mix of CFL and incandescent lamps corresponding to the installed LED lamp. To determine the pre-existing, or baseline wattage as part of this evaluation, engineers asked site personnel to identify what type and wattage bulb was there prior to the installation of the new lamps. In most cases, site personnel were very confident in their answers, were able to identify other sockets or fixtures that still had the “old” lamps installed, or still had some of the

older lamps in storage. The evaluation estimated savings based on these reported baseline wattages. One thing that the evaluation found was that there were very few cases where LEDs were replacing either existing LEDs or CFLs. The majority of the replaced lamps were incandescent/halogen lamps of higher wattage. The site summaries in Appendix C describe the findings at each of the sites.

1.2.3.3 Hours of Use

The overall hours of use realization rate was found to be 91% based on the monitoring of hours of use. The LED hours of use realization rate was 88%, while the Fluorescent hours of use realization rate was 108%. The differences in realization rates could be attributed to the tracking estimates of hours of use. LED hours of use were expected to be higher than Fluorescent hours of use based on the tracking savings estimates. The tracking estimates were based on PA assumptions regarding usage of each different lamp type. The majority of LED lamps were expected to operate 4,500 hours per year, while Fluorescent lamps were expected to operate 3,380 hours per year. The analysis found that the evaluated hours of use for LEDs were approximately 3,979 hours per year, and 3,559 hours of use for Fluorescent

1.3 Conclusions and Recommendations

Overall, the Bright Opportunities program appears to be successfully delivering energy savings, especially with respect to the LED category. LEDs were found to have a realization rate of 102%, which was driven by several adjustments. Fluorescents were found to have a realization rate of 89%, which was primarily driven by the quantity adjustment. Based on the results of this study, it is recommended that realization rates for connected kW and kWh, and adjusted savings estimates for hours of use should be applied at the category level (LED and FLR). This study does not have enough data points to disaggregate results at the building type or LED lamp type level with acceptable estimates of precision.

The following are some conclusions and recommendations for the program, and future evaluations of the program.

1.3.1 LED Savings Assumptions

- **Delta Watts.** This study produced an estimate of delta Watts that was approximately 33% higher than tracking estimates. Almost this entire discrepancy was due to the finding that the baseline bulbs/lamps were of higher wattage than the tracking estimates. The tracking estimates were based on an assumption that there would be a mix of CFL and incandescent in the existing case. However, it was found that the majority of the lamps that were replaced were incandescent, with a very small percentage of CFL/LEDs. Additionally, as market penetration increases, the replacement of CFL/LEDs likely increases, which will result in lower baseline wattages. A follow-up evaluation should consider this shifting baseline as a factor in deciding when the next one should take place. Note that the study connected kW and kWh realization rates include this

adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.

- **Quantity.** This study found that approximately 82% of the purchased LED lamps were installed at the time of the evaluation. It was common to find many of these not yet installed lamps in storage at each of the facilities. Customers expect that they will eventually install each of these bulbs as soon as their existing lamps burn out. It is unclear what the lag time will be for the installation of these remaining lamps, and therefore, a follow-up study should be designed to revisit sites from this study that had a large number of units still in storage or not yet installed. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.
- **Hours of Use.** This study found that the hours of use realization rate was 88% for LEDs. This is a relatively low hours of use realization rate as compared to other lighting impact evaluations. As mentioned above, the assumed hours of use for the majority of LED lamps was 4,500 hours per year. Based on lighting logger data at each of the sites, the average hours of use for LED lamps were found to be 3,979 hours per year. It is recommended that the hours of use be adjusted downward to account for this finding for the near term. *Note that the study connected kW and connected kWh realization rates do not include this adjustment for hours, which means that program savings estimates can be updated with the new hours estimates from this study.*

1.3.2 Fluorescent Savings Assumptions

- **Quantity.** This study found that approximately 80% of the purchased Fluorescent lamps were installed at the time of the evaluation. It was common to find many of these not yet installed lamps in storage at each of the facilities. Customers expect that they will eventually install each of these bulbs as soon as their existing lamps burn out. It is unclear what the lag time will be for the installation of these remaining lamps, and therefore, a follow-up study should be designed to revisit sites from this study that had a large number of units still in storage or not yet installed. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.
- **Hours of Use.** This study found that the hours of use realization rate was 103% for Fluorescent lamps. This is in line with other impact evaluations of Fluorescent lighting systems. As mentioned above, the assumed hours of use for the majority of Fluorescent lamps was 3,380 hours per year. Based on lighting logger data at each of the sites, the average hours of use for Fluorescent lamps were found to be 3,559 hours per year. It is recommended that the hours of use be adjusted downward to account for this finding for the near term. *Note that the study connected kW and connected kWh realization rates do not include this adjustment for hours,*

which means that program savings estimates can be updated with the new hours estimates from this study.

1.3.3 Program Tracking Documentation

- **Consider Efforts to Increase the Customer’s Awareness of the Program.** Many customers were aware that they had received discounted lamps from this program, but not all were aware that the discounts came from the PAs. Many customers were under the impression that their electrical contractors were offering the deep discounts. It is recommended that the PAs consider utilizing a program sticker or label that participating distributors would attach to a customers’ shipping/purchase order. This may help the program gain recognition and will help the end-users recall the Upstream lighting purchases. It should not be overlooked how good the program discounted LED bulbs make the electricians look to their customers. Their customers, in many cases, know the longevity and energy savings of LED bulbs but they can’t come to purchasing them at regular cost. For example, site L2796 is a restaurant that would not have paid full price for the LED bulbs that were installed. The electricians who oversee the building dealt with the program and the credit for the financial discount is lost. In some cases, it’s the electricians who appear as though they are selling or giving the company (restaurant in this case) a great deal. The managers at this site allowed us to conduct our study but at first they didn’t know the program bulbs were offered by the utilities.
- **Consider Additional Supporting Information for Large Purchases.** One of the major discrepancies found during this evaluation was that in some cases, large quantities of lamps were being stored for future use by end users. There are several sites, the most extreme being L1505, in which evaluators identified pallets of program bulbs being stockpiled by customers. In the case of L1505, which was a school district, the large quantity of bulbs was considered so that they wouldn’t have to worry about purchasing replacement lamps for several years. It is recommended that electrical contractors or end users be required to provide more information to support extremely large purchases so that it would be more likely that the program bulbs are installed earlier.

1.3.4 Future Impact Evaluation

- **Consider a Follow-up Impact Evaluation.** This impact evaluation provides important feedback to the PAs for reporting savings, and improving savings estimates. However, due to the relatively large error ratios found in this study, the targeted 90/10 precision was not achieved. Depending on PA needs, a follow-up study may be considered to improve the evaluation results, or to obtain statistically valid factors for some of the building types where a majority of LED and Fluorescent lamps are being installed. The PAs and EEAC may want to consider performing a third phase of impact evaluation, which could be designed in consideration of the error ratios that were found



with this study to try to achieve a combined 90/10 precision at the measure category, or targeted at a measure category and building type. Alternatively, the PAs and EEAC may consider following up on those sites with lower installation rates. Follow-up discussion and long-term planning should take place to determine what the evaluation needs are on an ongoing basis, and also what the target precision levels should be based on the needs of the PAs and EEAC.

2. Introduction

This report documents DNV KEMA's impact evaluation of the Massachusetts Upstream Lighting Program, which is known as the Bright Opportunities Program. This impact evaluation was performed by DNV KEMA under the Massachusetts Large C&I Evaluation Contract (MA-LCIEC). This report represents the impact component of a broader evaluation effort, which also included a process evaluation completed in June 2013⁴. This impact evaluation was completed for the Massachusetts electric Program Administrators (PA) under the guidance of the Massachusetts Energy Efficiency Advisory Council (EEAC).

2.1 Program Description

The Massachusetts Bright Opportunities Program is a program which attempts to increase the market penetration of energy-efficient lighting technologies through the use of upstream incentives that are used to buy down the cost of these lighting technologies at the lighting distributor level. All five electric PAs in the state are participating in the program. The program began offering upstream incentives on linear fluorescent lighting technologies in September 2011 and incentives for LED lighting technologies in November 2011. In the case of the LED lighting technologies the upstream incentives take the place of the downstream incentives that the Massachusetts C&I programs previously offered for these technologies.

The lighting distributors who participate in the program are obligated to collect sales data on the type and quantity of lamps they sold, as well as the name, location, and contact information of the customers to whom they sold the discounted lighting products. Every month the distributors submit their sales data to the Massachusetts electric PAs and to a third-party program manager. This third-party program manager combines the sales data from the various participating distributors and then allocates the energy savings and incentives to each participating PA. They then issue invoices to each PA for that particular month. The program also conducts quality control inspections for about 10 percent of the sites to make sure that they can verify on-site the lighting quantities and types claimed in the distributor sales reports.

2.2 Purpose of Study

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- Application of purchased lamps by facility and space type;

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- Hours of use of purchased lamps;
- Baseline replaced lamps for estimating delta watts;
- Gross savings realization rates to be applied to 2012 results; and
- Estimates of delta watts and hours of use to be applied prospectively.

This report presents the following realization rates at the statewide level using metered data collected from each site:

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- **Connected kW** – This result is the gross connected kW realization rate, which includes any documentation, quantity, and technology adjustments. This realization rate is the evaluation gross connected kW savings divided by the tracking gross connected kW savings.
- **Connected kWh** – This result is the gross connected kWh realization rate, which includes only the documentation, quantity, and technology adjustments. This realization rate is the evaluation gross connected kWh savings divided by the tracking gross connected kWh savings.
- **Installation Rate** – This represents the percentage of the tracking connected kW savings based on the quantity of installed lamps found during the on-site evaluation. This rate is embedded in the Annual kWh, Connected kW, and Connected kWh realization rates above.
- **Delta Watts** – This result represents the percentage of the tracking connected kW savings based on the difference in the delta watts (pre minus post installation wattage) as found during the on-site evaluation. This rate is embedded in the Annual kWh, Connected kW, and Connected kWh realization rates above.
- **Hours of Use** – This result is the hours of use realization rate, which represents the evaluation estimate of hours of use divided by the tracking estimate of hours of use. This rate is embedded in the Annual kWh realization rate above.

This report also provides the following savings factors:

- **Summer Coincidence Factor**
 - **On Peak Hours** – This is the percentage of the connected kW savings coincident with the summer on-peak period, as defined in Section 4.



- **Seasonal Hours** –This is the percentage of the connected kW savings coincident with the summer seasonal peak period, as defined in Section 4.
- **Winter Coincidence Factor**
 - **On Peak Hours** –This is the percentage of the connected kW savings coincident with the winter on-peak period, as defined in Section 4.
 - **Seasonal Hours** –This is the percentage of the connected kW savings coincident with the winter seasonal peak period, as defined in Section 4.
- **Summer kW HVAC Interactive Effect**
 - **On Peak Hours** – This is the percentage of gross connected kW savings that are due to interactive effects during the summer on-peak period.
 - **Seasonal Hours** – This is the percentage of gross connected kW savings that are due to interactive effects during the summer seasonal peak period.
- **Winter kW HVAC Interactive Effect**
 - **On Peak Hours** – This is the percentage of gross connected kW savings that are due to interactive effects during the winter on-peak period.
 - **Seasonal Hours** – This is the percentage of gross connected kW savings that are due to interactive effects during the winter seasonal peak period.
- **KWh HVAC Interactive Effect** – This is the percentage of the gross kWh savings that are due to interactive effects.
- **% On Peak KWh** – This is the percentage of energy savings that occur during on-peak hours.

A listing of all realization rates and savings factors with descriptions and algorithms is presented in [Appendix A](#). The savings factors presented in this report are developed so that they may be applied to future program assumption updates.

The evaluation sample for this study was designed in consideration of the 90% confidence level for energy (kWh) and on-peak and seasonal demand savings.

2.3 Scope

The scope of work of this impact evaluation covered upstream lighting purchases made between November 2011 and April 2012, and also between October 2012 and November 2012. The reason for the

two separate periods of upstream lighting purchases was due to the inability to recruit the full sample of sites from the initial sample design. Additional data was requested from the third party program manager to develop a second sample design to meet the original sample targets. This is further explained in the sampling section below.

3. Evaluation Approach

3.1 Preliminary Sampling Strategy for the Impact Evaluation

The Upstream Lighting Program evaluation included both process and impact evaluations. The on-site sample for the impact evaluation was selected first, and then excluded from the sample frame for the process surveys.

One complication in the sampling strategy that we discovered after the submission of our initial work plan was that many of the companies that were listed in the program tracking database under the “Customer Installation Name” appeared to be lighting contractors rather than end use customers. In these cases we also checked a sample of the entries for “Customer Installation Address” and “Customer Installation City” on the Internet and found out that these street addresses and cities were those of the lighting contractors. While it is possible that these lighting contractors installed the discounted lighting products on their own premises, we think this is unlikely and that a more likely scenario is that they installed these lighting products at an end user address that is not captured by the program tracking database. So our strategy was to remove these lighting contractors from the end user sample frame. We did this by looking for words like “lighting” or “electric” in the company name.

The population frame for the initial impact evaluation was the tracking data provided by a third party data collector. It includes customers who participated in the upstream lighting program between November 2011 and April 2012. For each purchase, some limited data were provided about the customers (whether end users or lighting contractors), distributors, manufacturers, as well as the quantity and type of product installed.

3.1.1 Determining the Customer Sample Frame

In May 2012 we were provided with program tracking data which covered the November 2011 to April 2012 period. We used these data to determine the sample frames discussed in this subsection. The Program data included information about the types and quantities of products installed, customer names and addresses, distributor names and addresses, and equipment manufacturers. The product types identified in the data were LEDs (MR16, PAR20, PAR30 and PAR38) and Fluorescents (T5 and T8). Since no estimates of savings were provided, standard formulas were applied to calculate annual kWh savings by product type and wattage. The per lamp savings estimates for each product type are presented



in Table 6. One of the goals of the impact evaluation was to produce new estimates of delta watts and hours of use.

Table 6: Per Lamp Savings Assumptions by Product Type

Product Type	Baseline Fixture Wattage	Baseline Ballast Factor	Baseline Wattage	Installed Fixture Wattage	Installed Ballast Factor	Installed Wattage	Delta Watts	Annual Hours	kWh Savings
T8	32	0.88	28	28	0.88	25	3.5	3,380	12
T5	54	1.00	54	50	1.00	50	4.0	3,380	14
PAR20	38	1.00	38	8	1.00	8	29.8	4,500	134
PAR30	55	1.00	55	15	1.00	15	40.4	4,500	182
PAR38	61	1.00	61	14	1.00	14	46.8	4,500	211
MR16	31	1.00	31	8	1.00	8	23.4	4,500	105

The sample frame for the impact evaluation was defined as unique rows for each customer location and product type. For purposes of designing and selecting the sample, the level of detail for product types was the two major groups: LEDs and Fluorescents. The tracking data were aggregated by customer name, address and group. The initial 6,343 records produced 3,365 unique combinations. However, we noticed that there were many instances where names and addresses were spelled, abbreviated, or punctuated differently, creating multiple records. Software tools and manual review reduced the number of unique combinations of name, address and product group to 3,077. After eliminating a few records where the sales quantity was less than or equal to zero, the number of records is 3,070. The distribution of savings and quantities installed across the product groups follows in Table 7.

Table 7: Distribution of Upstream Lighting Projects by Product Group

Product Group	Savings (kWh)	% of Savings	Quantity Installed	% of Quantity Installed	Number of Customer Locations	% of Customer Locations
LED	37,478,740	93.21%	219,691	49.04%	2,513	81.86%
Fluorescent	2,728,501	6.79%	228,295	50.96%	557	18.14%
Total	40,207,241	100.00%	447,986	100.00%	3,070	100.00%

3.2 Initial Sample Design

One of the goals of the impact evaluation was to estimate energy and peak demand realization rates and other factors with $\pm 10\%$ relative precision at a 90% confidence interval. In light of the fact that LEDs make up such a large percentage of the program savings, it was most important that these results achieved the precision targets. Since fluorescents made up less than 7% of the total program savings, the 90/10 criteria was relaxed somewhat for that sample to 90/20.

The population for the impact evaluation included only the sites that had previously been identified as end use customers. Summary statistics about the population frame for the impact evaluation are provided in Table 8.



Table 8: Population for Impact Evaluation

Customer Group	Product Group	Sites	Total KWh Savings	Average Savings	Minimum	Maximum	StdDev	CV
End User	LED	2,407	36,430,888	15,135	105	631,688	35,681	2.36
End User	Fluorescent	522	2,591,251	4,964	12	362,924	18,904	3.81
Total		2,929	39,022,139					

In order to estimate the sample sizes required to produce estimates that meet the precision targets described above, we made an assumption about the level of variability in the results (error ratio). Other studies of lighting impact evaluations have found an error ratio of 0.4 to be realistic. The sample design was stratified by size, based on the total savings at each location, using Model-Based Statistical Sampling techniques. The process assigns a higher selection probability to larger installations to maximize the efficiency of the sample. After reviewing alternatives, the evaluation team decided on the sample design described in Table 9.

Table 9: Proposed Sample Design for Impact Evaluation

Product Group	Stratum	Maximum KWh Savings	Sites	Total KWh Savings	Sample	Inclusion Probability
LED	1	7,796	1459	4,756,134	14	0.00960
	2	15,171	493	5,950,855	14	0.02840
	3	34,806	259	6,954,547	13	0.05019
	4	85,497	141	8,120,784	13	0.09220
	5	412,639	55	10,648,569	13	0.23636
Fluorescent	1	2,213	432	505,501	5	0.01157
	2	14,872	65	747,486	5	0.07692
	3	35,693	24	975,339	4	0.16667
	4	362,924	1	362,924	1	1.00000

Based on the information available at the current time regarding the distribution of customer locations by size (total savings) and assumed error ratio, this design was anticipated to produce estimates of realization rates and other factors with the precisions indicated in Table 10.

Table 10: Anticipated Precisions for Impact Evaluation

Product Group	Sites	Total Savings	Assumed Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision
LED	2,407	36,430,888	0.4	90%	67	±8.17%
Fluorescent	522	2,591,251	0.4	90%	15	±18.13%
Total	2,929	39,022,139	0.4	90%	82	±7.71%

3.3 Customer Recruitment and Sample Re-Design

In September 2012, following the decision to move forward on the above sample design of 82 sites from



the initial set of program data (Nov-11 to Apr-12) DNV KEMA began scheduling site visits. Since this is an upstream program, which meant that customers were purchasing lamps directly from their electrical contractor or distributor, there were several recruiting issues. The primary issue with the recruitment was that there was little information available on customer contact person and phone number. Recruiters had to rely on internet searches to identify customer phone numbers, and then conduct cold calls to identify the appropriate person to speak to regarding this study. This resulted in several attempts to contact primary sample points, and when those attempts were exhausted (usually after five or six unreturned voicemails or messages) back-up sites were selected. Ultimately, DNV KEMA was unable to complete site visits for the original 82 site sample using the original set of program data. A total of 35 sites were completed as part of this original sample, designated as Phase I.

In January 2013, DNV KEMA obtained a second set of program data from the third party program manager, which included the months of October and November, 2012. This new set of program data included additional offerings as shown in Table 11. These lamp types were again split into LED and Fluorescent categories for purposes of sampling.

Table 11: Additional Per Lamp Savings Assumptions by Type

Product Type	Baseline Fixture Wattage	Baseline Ballast Factor	Baseline Wattage	Installed Fixture Wattage	Installed Ballast Factor	Installed Wattage	Delta Watts	Annual Hours	kWh Savings
F32T8/25W	28	1.00	28	22	1.00	22	6.2	3,380	21
FB32T8/25W U-Bend	28	1.00	28	22	1.00	22	6.2	3,380	21
FB28T8 U-Bend	28	1.00	28	25	1.00	25	3.5	3,380	12
LED A-Lamp	55	1.00	55	17	1.00	17	38.6	2,800	108
LED Decorative Lamp	27	1.00	27	5	1.00	5	21.1	4,000	84

From this new set of program data, DNV KEMA developed a second sample, which was referred to as Phase II, to complete the data collection. The Phase II population data is presented in Table 12. The evaluation team performed data collection for both phases of the study in a consistent manner.

Table 12: Phase II Population

Customer Group	Product Group	Sites	Total KWh Savings	Average Savings	Minimum	Maximum	StdDev	CV
End User	LED	3,561	32,284,623	9,066	105	1,215,643	29,492	3.25
End User	Fluorescent	1,680	21,009,251	12,506	12	1,570,483	69,427	5.55
Total		5,241	53,293,874					

The Phase II sample, which included 47 sites, is presented in Table 13. We selected 47 sites, which would result in a combined sample size of 82 when added to the Phase I sites.



Table 13: Phase II Sample Design

Product Group	Stratum	Maximum KWh Savings	Sites	Total KWh Savings	Sample	Inclusion Probability
LED	1	6,321	2,431	5,351,977	9	0.00370
	2	16,273	690	6,940,064	10	0.01449
	3	43,828	329	8,333,138	10	0.03030
	4	1,215,643	111	11,659,444	10	0.09009
Fluorescent	1	35,693	1,590	7,066,270	4	0.00252
	2	1,570,483	90	13,942,981	4	0.04444

3.4 Final Sample

Table 14 presents the final combined population, which includes all Phase I and II end users in the impact evaluation sample frame.

Table 14: Combined Population Phase I + Phase II

Customer Group	Product Group	Sites	Total KWh Savings	Average Savings	Minimum	Maximum	StdDev	CV
End User	LED	5,968	68,715,511	11,514	105	1,215,643	32,270	2.80
End User	Fluorescent	2,202	23,600,503	10,718	12	1,570,483	61,420	5.73
Total		8,170	92,316,013					

The final sample resulted in 81 sites according to the breakdown in Table 15. The reason that there were only 81 sites in the final sample as opposed to 82 was that there was one site that was completed, but was unable to be monitored by evaluators due to customer refusal. At the time of this discovery, it was too late to do additional metering at a new site, and the on-site effort was completed.

Table 15: Combined Sample Phase I + Phase II

Product Group	Stratum	Maximum KWh Savings	Sites	Total KWh Savings	Sample	Case Weight
LED	1	6,360	3,751	9,104,188	16	234.44
	2	14,162	1,130	10,879,462	12	94.17
	3	29,852	630	13,011,314	16	39.38
	4	74,359	333	15,341,761	9	37.00
	5	1,215,643	124	20,378,785	13	9.54
Fluorescent	1	30,696	2,079	7,960,567	10	207.90
	2	1,570,484	123	15,639,935	5	24.60

The combined sample case weights were provided in the table above based on the stratified design. However, two of the sample sites were later identified as being outliers based on the results of the statistical analysis. Therefore these two sites were given a weight of one and the stratum from which

these sites were pulled had their weights adjusted accordingly. A more detailed explanation of the outlier detection test, and which sites were involved is provided in Section 4.4.

3.5 Measurement, Verification and Analysis Methodology

A key task in the on-site engineering assessment is the installation of measurement equipment to aid in the development of independent estimates of savings. The type of measure influences the measurement strategy used. Time-of-use (TOU) lighting loggers were utilized to inform the savings calculations with a direct measurement of hours of operation. For this study, most sites included a minimum of three months of data collection, while the remaining sites included at least 4 weeks of data.

In the context of an energy analysis, most efficiency measures can be characterized as either time-dependent or load-dependent. Time-dependent equipment typically runs at constant load according to a time-of-day operating schedule. Mathematically, hour-of-day and day-of-week are usually the most relevant variables in the energy savings analysis of these measures. Lighting is the most prevalent time-dependent measure.

3.5.1 Verification

Each site visit consisted of a verification of installed equipment, a discussion with facility personnel regarding the baseline characteristics of the measure, and the collection and analysis of monitored data. Once on-site, data was collected for calculating savings estimates for all LED and fluorescent lamps that were purchased through the program; including an inventory of the measures installed. If measure(s) have been removed, we attempted to gather the reason(s) for removal. If measures have not yet been installed, we have tried to understand when they are planning on being installed.

Program measure operating characteristics and general building operation characteristics were also gathered; including information on heating and cooling systems to assess interactive effects. Information on the pre-existing or baseline conditions was also collected to increase the accuracy of savings calculations. To gather this, the field auditor tried to identify the person who is most knowledgeable about the lighting at each facility to ask questions such as:

- What type and wattage fixtures were replaced by the program fixtures?
- Do you have any of these old bulbs/fixtures in storage for us to look at?
- Is there a part of your facility that still has similar old bulbs/fixtures in place?

For new installations, the on-site protocol was to explore what the customer would have installed in the absence of the program. There was one such site in the sample, and the customer was not able to say what bulb type would have been installed. Therefore, the evaluation reverted to the tracking savings assumption for baseline lamp type specific to this site and installed bulb.

3.5.2 Monitoring

Time-dependent measures typically call for the installation of (TOU) loggers to measure hours of use. These small devices use specialized sensors – photocells in the case of lighting measures – to sense and record the dates and times that a device turns on and off. This TOU data was used to support the evaluation in two key ways:

1. To develop peak coincidence factors, and
2. To develop annual hours of use.

The measure scope influences the appropriate number of loggers and systems monitored for each site. Factors that drive the number of installed loggers include the number of unique schedules at the site, and the anticipated level of variation among the schedules within a particular space type.

3.5.3 Site Analysis

Data collected from TOU lighting loggers were used to develop time-of-use load profiles and estimate total run-times during the monitoring period. Short-term metered data, like that obtained from the typical three month period performed for this study, pose challenges in accurately expanding the data from the monitored period to a typical year or to specific periods of interest that do not coincide with the monitoring period, e.g., peak demand. In determining lighting schedules from time-of-use data, annual trends such as seasonal effects (e.g., daylight savings), production, and occupancy swings (such as vacations, business cycles, etc.) were accommodated to the extent supported by the data. As a general rule, visual inspection of time-of-use data should reveal explicable patterns that agree with other data sources, such as the information gathered from on-site interviews. Each site included an interview with the site contact to gather information that was used to assist in the expansion of the short-term metered data.

The data gathered from the on-sites were compiled into spreadsheets for analysis. The savings were calculated as line-by-line comparisons of pre- and post-retrofit electrical use. Pre- and post-retrofit energy estimates were developed for each line item within each measure. Interactive cooling and heating effects of the installed measures were also calculated utilizing engineering algorithms where applicable. This component of the savings is described in further detail in the following section.

All analyses were calculated so as to identify discrepancies between the tracked and gross savings according to each adjustment phase, including Documentation, Technology, Quantity, Operation, HVAC Interaction. These adjustments are further defined in [Section 4 Results](#).

In addition to these adjustments, DNV KEMA also provides measure-specific estimates for the following savings input parameters, based on the data collected on-site:

- Installation Rate;



- Delta Watts; and
- Annual Hours of Use.

3.5.4 HVAC Interactive Effects

When lighting equipment converts electrical energy to light, a significant amount of that energy is dissipated in the form of heat. Energy efficient lighting measures convert more electrical energy to light and less to heat. Since installing energy efficient lighting adds less heat to a given space, a complete estimation of energy savings considers the associated impacts on the heating and cooling systems or “interactive effects.”

The interactive effects take into account the effect of the energy efficient lighting measures on their corresponding heating and cooling systems. Energy efficient lighting serves to reduce the heat gain to a given space and accordingly reduces the load on cooling equipment. But this reduced heat gain has the added consequence of increasing the load on the heating system.

As part of the on-site methodology, evaluators interviewed facility personnel to ascertain the cooling and heating fuel, system type, and other information with which to approximate the efficiency of the HVAC equipment serving the space of each lighting installation. The DNV KEMA team expresses HVAC system efficiency in dimensionless units of Coefficient of Performance (COP), which reflects the ratio of work performed by the system to the work input of the system. Table 16 details the COP assumptions for general heating and cooling equipment types encountered in this study. Where site specific information yields improved estimates of system efficiency, these were used in place of the general assumptions below.

Table 16: General Heating and Cooling COP Assumptions

Cooling System Type	COP	Heating System Type	COP
Packaged DX	2.9	Air to Air Heat Pump	1.5
Window DX	2.7	Electric Resistance	1
Chiller <200 Ton	4.7	Water to Air Heat Pump	2.8
Chiller >200 Ton	5.5		
Air to Air Heat Pump	3.9		
Water to Air Heat Pump	4.4		
Refrigerated Area (high temp)	1.4		
Refrigerated Cases (low temp)	1.9		

Interactive effects are calculated at all sites where heating or cooling systems are in use. Leveraging the 8,760 profile of hourly demand impacts, the DNV KEMA team computes electric interactive effects during the hours that lighting and HVAC are assumed to operate in unison.



DNV KEMA utilizes Typical Meteorological Year 3 (TMY3) hourly dry-bulb temperatures for Worcester, Massachusetts as the balance point criteria in this analysis. For each hour in a typical year, DNV KEMA computes HVAC interaction according to the following equations:

$$\text{Cooling kW Effects} = 80\% * \text{Lighting kW Savings} / \text{Cooling System COP}$$

$$\text{Heating kW Effects} = -80\% * \text{Lighting kW Savings} / \text{Heating System COP}$$

The 80% values represent the assumed percentage of the lighting energy that translates to heat which either must be removed from the space by the air conditioning system or added to the space by the heating system during the aforementioned HVAC hours. This assumption is consistent with those established and employed in previous impact evaluations of custom lighting measures. Also, heating factors are negative because heating interaction erodes gross lighting savings, while cooling interactive boosts it.

4. Results

The results presented in the following section include statewide level realization rates (and associated precision levels) for annual kWh savings, percent on-peak kWh savings, and on-peak and seasonal demand (kW) coincidence factors at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

- Coincident Summer On-Peak kW Reduction is the average demand reduction that occurs over all hours between 1 PM and 5 PM on non-holiday weekdays in June, July and August.
- Coincident Winter On-Peak kW Reduction is the average demand reduction that occurs over all hours between 5 PM and 7 PM on non-holiday weekdays in December and January.
- Seasonal Peak: Non-holiday week days when the Real-Time System Hourly Load is equal to or greater than 90% of the most recent “50/50” System Peak Load Forecast for the summer and winter seasons.

The adjusted gross energy savings and connected kW demand reduction are presented with their associated realization rate and relative precision for each lighting measure. These tables present results as adjustments to tracking savings. Each of these adjustments, or discrepancies, is described below:

- **Documentation Adjustment:** The Documentation Adjustment reflects any change in savings due to discrepancies in project documentation. Evaluators recalculated the tracking estimates of savings using all quantities, fixture types/wattages, and hours documented in the project file. All tracking system discrepancies and documentation errors are reflected in this adjustment.



- **Technology Adjustment:** The Technology Adjustment reflects the change in savings due to the identification of a different lighting technology (fixture type and wattage) at the site than represented in the tracking system estimate of savings.
- **Quantity Adjustment:** The Quantity Adjustment reflects the change in savings due to the identification of a different quantity of lighting fixtures at the site than presented in the tracking system estimate of savings.
- **Operational Adjustment:** The Operational Adjustment reflects the change in savings due to the observation or monitoring of different lighting operating hours at the site than represented in the tracking system estimate of savings.
- **HVAC Interactive Adjustment:** The HVAC Interactive Adjustment reflects changes in savings due to interaction between the lighting and HVAC systems among the sampled sites. Generally, these impacts cause a heating penalty and a cooling credit. This adjustment reflects impacts from electric heating and/or cooling, not other fuels.

Also included in the results are savings factors for summer and winter on-peak and seasonal coincidence factors, summer and winter kW HVAC interactive effect factors, kWh HVAC interactive effect factor, percent of energy savings during on-peak periods, and a non-electric heating HVAC Interaction effect, which is presented in MMBTU/kWh saved. Relative precision levels and error bounds are calculated at the 80% and 90% confidence level for demand savings factors and values. For all kWh realization rates, the standard 90% confidence level is used.

A summary of site level results are also presented in [Appendix B](#).

4.1 LED Results

Figure 1 presents a scatter plot of evaluation results for LEDs for annual energy savings using all 66 PA sample points. The dashed line in this graph represents a realization rate of 100%. The slope of the solid line in this graph is an indication of the overall realization rate, and can be seen to be slightly greater than 100%. These sample data vary widely from the trend line, which indicates that the error ratio would be relatively high. Site level realization rates ranged from 0% to 774% in this measure category. The evaluation found that discrepancies were not limited to one particular area, but a mix of quantity, technology, operational and interactive adjustments.

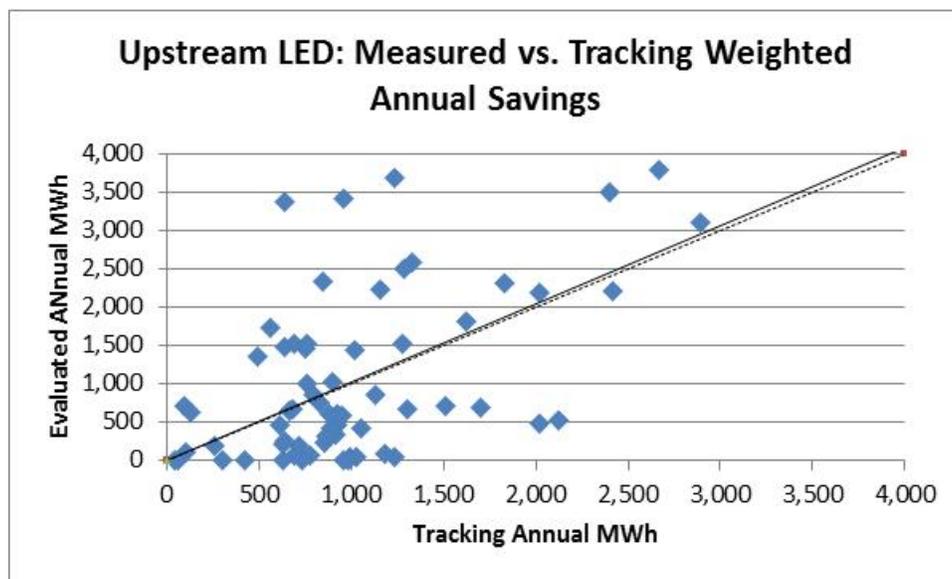


Figure 1: Scatter Plot of Evaluation Results for Systems for Annual MWh Savings



Table 17 summarizes the statewide results of this analysis. In the case of annual kWh savings, the realization rate for LEDs was found to be 101.9% with HVAC interactive effects included. The relative precision for this estimate was found to be ±17.5% at the 90% level of confidence. Note that gross tracking savings did not include HVAC interactive effects. The error ratio was found to be 0.90, which was significantly higher than the estimated error ratio of 0.40.

Table 17: Summary of LED Energy Realization Rate

Savings Parameter	Energy - LED	
	kWh	% Gross
Gross Savings (Tracking)	68,715,511	
Documentation Adjustment	1	0%
Technology Adjustment	22,480,524	33%
Quantity Adjustment	-16,255,696	-24%
Operational Adjustment	-9,243,234	-13%
HVAC Interactive Adjustment	4,328,036	6%
Adjusted Gross Savings	70,025,141	102%
Gross Realization Rate	101.91%	
Relative Precision	±17.5%	
Confidence Interval	90%	
Error Ratio	90%	

Table 18 summarizes the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level, including 80% for kW factors. The on-peak summer coincidence factor was 60.9%, with a relative precision of ±12.6%. The seasonal summer coincidence factor was 56.6%, with a relative precision of ±13.9%. The summer peak coincidence factors from this study are lower than what would be expected from a typical lighting evaluation (75% to 85%). It is unclear exactly why the coincidence factors are lower, but one reason could be due the high number of schools that turned up in the sample as shown below in Section 4.5. The on-peak winter coincidence factor was 54.7%, with a relative precision of ±13.1%. The seasonal winter coincidence factor was 51.5%, with a relative precision of ±13.7%. The values for winter peak coincidence factor are more in line with traditional lighting evaluations. The table also provides savings factors for on-peak and seasonal summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 18: Summary of LED Savings Factors

Savings Factors and Realization Rates	LED		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	82.1%	±8.7%	±6.8%
Delta Watts (Technology Adjustment - kW)	133.2%	±8.5%	±6.6%
Connected kW Realization Rate ⁵	109.4%	±13.2%	±10.3%
Summer Coincidence Factor			
On Peak Hours	60.9%	±12.6%	±9.8%
Seasonal Hours	56.6%	±13.9%	±10.8%
Winter Coincidence Factor			
On Peak Hours	54.7%	±13.1%	±10.2%
Seasonal Hours	51.5%	±13.7%	±10.7%
Summer kW HVAC Interactive Effect			
On Peak Hours	119.8%	±2.0%	±1.6%
Seasonal Hours	120.2%	±2.1%	±1.6%
Winter kW HVAC Interactive Effect			
On Peak Hours	96.6%	±4.1%	±3.2%
Seasonal Hours	97.0%	±3.3%	±2.6%
KWh Factors (Precisions at 90% confidence)			
Connected kWh Realization Rate	109.1%	±13.3%	
KWh HVAC Interactive Effect	106.6%	±1.8%	
Hours of Use Realization Rate	87.7%	±14.0%	
% On Peak KWh	59.2%	±5.1%	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00112		

4.2 Fluorescent Results

Figure 2 presents a scatter plot of evaluation results for Fluorescent lamps for annual energy savings using all 15 PA sample points. The slope of the solid line in this graph is an indication of the overall realization rate, and can be seen to be less than one. These sample data spread from the trend line, which is indicative of a higher error ratio. Site level realization rates ranged from 1% to 247% in this measure category. The evaluation found that majority of the discrepancies between the tracking and evaluated savings estimates were due to quantity differences.

⁵ The Connected kW Realization Rate is the product of the Documentation Adjustment, Installation Rate and Delta Watts factors.

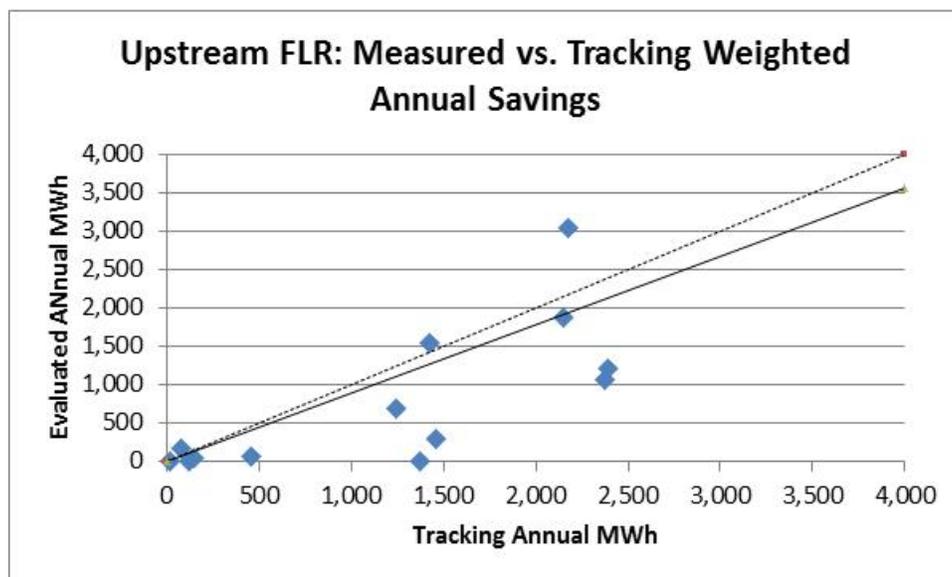


Figure 2: Scatter Plot of Evaluation Results for Fluorests for Annual MWh Savings

Table 19 summarizes the statewide results of this analysis. In the case of annual kWh savings, the realization rate for Fluorescent lamps was found to be 89.1% with HVAC interactive effects included. The relative precision for this estimate was found to be $\pm 26.9\%$ at the 90% level of confidence. The error ratio was found to be 0.62.

Table 19: Summary of Fluorescent Energy Realization Rate

Savings Parameter	Energy - FLR	
	kWh	% Gross
Gross Savings (Tracking)	23,600,503	
Documentation Adjustment	0	0%
Technology Adjustment	6,783	0%
Quantity Adjustment	-4,644,999	-20%
Operational Adjustment	563,107	2%
HVAC Interactive Adjustment	1,494,622	6%
Adjusted Gross Savings	21,020,016	89%
Gross Realization Rate	89.07%	
Relative Precision	$\pm 26.9\%$	
Confidence Interval	90%	
Error Ratio	62%	

Table 20 summarizes the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level, including 80% for kW factors. The on-peak summer coincidence factor was 66.2%, with a relative precision of $\pm 21.0\%$. The seasonal summer coincidence factor was 59.3%, with a relative precision of $\pm 24.2\%$. The summer peak coincidence factors from this study are lower than what would be expected from a typical lighting evaluation (75% to 85%). It is



unclear exactly why the coincidence factors are lower, but one reason could be due the high number of schools that turned up in the sample as shown below in Section 4.5. The on-peak winter coincidence factor was 51.4%, with a relative precision of $\pm 22.1\%$. The seasonal winter coincidence factor was 45.9%, with a relative precision of $\pm 20.9\%$. The values for winter peak coincidence factor are more in line with traditional lighting evaluations. The table also provides savings factors for on-peak and seasonal summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 20: Summary of Fluorescent Savings Factors

Savings Factors and Realization Rates	FLR		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	80.3%	$\pm 13.1\%$	$\pm 10.2\%$
Delta Watts (Technology Adjustment - kW)	100.0%	$\pm 0.1\%$	$\pm 0.1\%$
Connected kW Realization Rate ⁶	80.3%	$\pm 13.1\%$	$\pm 10.2\%$
Summer Coincidence Factor			
On Peak Hours	66.2%	$\pm 21.0\%$	$\pm 16.4\%$
Seasonal Hours	59.3%	$\pm 24.2\%$	$\pm 18.9\%$
Winter Coincidence Factor			
On Peak Hours	51.4%	$\pm 22.1\%$	$\pm 17.2\%$
Seasonal Hours	45.9%	$\pm 20.9\%$	$\pm 16.3\%$
Summer kW HVAC Interactive Effect			
On Peak Hours	118.9%	$\pm 5.0\%$	$\pm 3.9\%$
Seasonal Hours	119.2%	$\pm 5.2\%$	$\pm 4.0\%$
Winter kW HVAC Interactive Effect			
On Peak Hours	100.0%	$\pm 0.0\%$	$\pm 0.0\%$
Seasonal Hours	100.0%	$\pm 0.0\%$	$\pm 0.0\%$
KWh Factors (Precisions at 90% confidence)			
Connected kWh Realization Rate	80.3%	$\pm 13.1\%$	
KWh HVAC Interactive Effect	107.7%	$\pm 2.4\%$	
Hours of Use Realization Rate	103.0%	$\pm 18.5\%$	
% On Peak KWh	71.0%	$\pm 5.8\%$	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00076		

⁶ The Connected kW Realization Rate is the product of the Documentation Adjustment, Installation Rate and Delta Watts factors.



4.3 Combined Results

Table 21 summarizes the statewide results of combined program, including LED and Fluorescent lamps. In the case of annual kWh savings, the realization rate for was found to be 98.5% with HVAC interactive effects included. The relative precision for this estimate was found to be ±14.9% at the 90% level of confidence. The error ratio was found to be 0.86

Table 21: Summary of Combined Energy Realization Rate

Savings Parameter	Energy - Combined	
	kWh	% Gross
Gross Savings (Tracking)	92,316,013	
Documentation Adjustment	1	0%
Technology Adjustment	22,299,484	24%
Quantity Adjustment	-	-23%
Operational Adjustment	-8,589,122	-9%
HVAC Interactive Adjustment	5,822,856	6%
Adjusted Gross Savings	90,971,376	99%
Gross Realization Rate	98.54%	
Relative Precision	±14.6%	
Confidence Interval	90%	
Error Ratio	86%	

Table 22 summarizes the statewide savings factors resulting from this analysis. All relative precisions were calculated at the 90% confidence level, including 80% for kW factors. The on-peak summer coincidence factor was 62.2%, with a relative precision of ±11.0%. The seasonal summer coincidence factor was 57.3%, with a relative precision of ±12.1%. The on-peak winter coincidence factor was 53.9%, with a relative precision of ±11.2%. The seasonal winter coincidence factor was 50.1%, with a relative precision of ±11.5%. The table also provides savings factors for on-peak and seasonal summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh

Table 22: Summary of Combined Savings Factors

Savings Factors and Realization Rates	Combined		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	81.6%	±7.3%	±5.7%
Delta Watts (Technology Adjustment - kW)	122.8%	±7.3%	±5.7%
Connected kW Realization Rate ⁷	100.2%	±10.5%	±8.2%
Summer Coincidence Factor			
On Peak Hours	62.2%	±11.0%	±8.6%
Seasonal Hours	57.3%	±12.1%	±9.5%
Winter Coincidence Factor			
On Peak Hours	53.9%	±11.2%	±8.7%
Seasonal Hours	50.1%	±11.5%	±9.0%
Summer kW HVAC Interactive Effect			
On Peak Hours	119.5%	±2.0%	±1.5%
Seasonal Hours	119.9%	±2.0%	±1.6%
Winter kW HVAC Interactive Effect			
On Peak Hours	97.4%	±3.1%	±2.5%
Seasonal Hours	97.7%	±2.6%	±2.0%
KWh Factors			
Connected kWh Realization Rate	101.5%	±11.0%	
KWh HVAC Interactive Effect	106.8%	±1.5%	
Hours of Use Realization Rate	90.8%	±12.0%	
% On Peak KWh	62.0%	±4.8%	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.001025		

4.4 Outliers

It is important to determine how much influence that one sample point has in the determination of the relationship between the tracking and evaluation savings. The observations should be tested to determine if they are outliers. Since we are examining and expecting a linear relationship between the tracking and evaluation savings, the assumption that the residuals are normally distributed is a valid assumption. Calculating the residuals and then standardizing them (called Studentized Residuals) will determine if any of the sample points are outliers. Studentized residuals will be normally distributed with a mean of zero and a standard deviation of 1. When we standardize them, it is easier to determine what observations are outliers. For example, a studentized residual of 2 means that the residual is 2 standard

⁷ The Connected kW Realization Rate is the product of the Documentation Adjustment, Installation Rate and Delta Watts factors.

deviations away from the mean of zero. Table 2 contains the Studentized Residuals for the relationship between the tracking and evaluated savings for two of the 81 sites.

Table 2: Studentized Residuals

Site	Group	Tracking Savings	Evaluated Savings	Studentized Residual
L1505	FLR	1,370,603.52	11,926.93	-3.04339
I2675	LED	132,631.88	633,790.34	6.49972

The Studentized Residuals represent the number of standard deviations away from the mean (in the case of a residual, the mean is 0). Since they are assumed to be normally distributed any site that contains a Studentized Residual greater than 3 or less than -3 would be considered an outlier.

The reason that -3 and 3 is considered a good cut point is because in a normal distribution, residuals at this level are only 1% likely to occur. The graph below shows this.

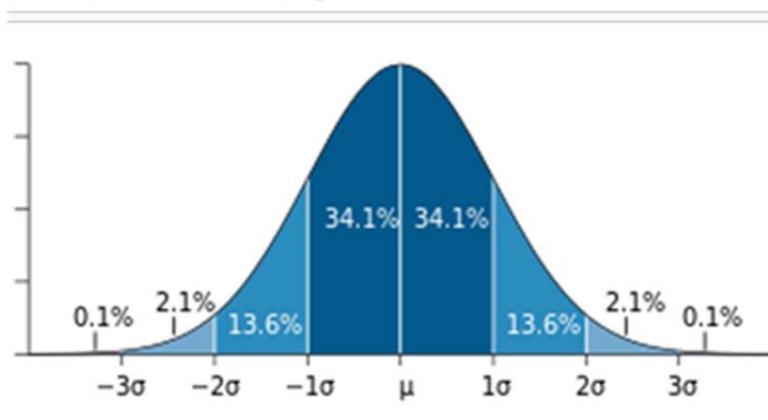


Figure 3: Standard Deviation and Tolerance Intervals

For the residuals, the average, represented by the symbol μ (mu), is zero. Anything within 1 standard deviation is 68.2% to occur. If the value is greater than 1 and less than 2 (or less than -1 and greater than -2) standard deviations from the mean is 27.2% likely to occur. So anything that is greater than 2 standard deviations away from the mean is only 4.4% likely to occur. While this seems like very small percentages, these observations would be considered potential outliers. Any Studentized residuals that are greater than 3 standard deviations away from the mean is only .2% likely to occur. These would be considered extreme outliers and would be very unusual to occur. It is up to the user to determine what the outliers are, but to ensure pulling out the extreme outliers, using a Studentized residual less than -3 or greater than 3 will be the best method.

In this study, both sites above (L1505 and I2675) were identified by this test as likely outliers. Therefore, these two sample points were each given a weight of one, and the rest of the sample was re-stratified. By assigning these a weight of one, the assumption is that these are unique cases that are not representative of the overall population. Rather than removing these observations from the sample, this weighting

approach keeps them in, but doesn't compound the extreme result by multiplying by a case weight that is greater than one. A summary of these two sites is provided, along with the other site summaries, in Appendix C.

4.5 Program Observations and Savings Adjustments

One of the goals of the evaluation was to identify where the upstream lamps were being installed. The PAs and EEAC were interested to find out what types of buildings and space types that the lamps ended up in. Table 23 presents a list of building types where the upstream lighting purchases were installed. The building type with the most installations was School/University. This represented 28% of the entire sample, including 27% of the LED sample and 33% of the Fluorescent sample. In schools, LEDs were primarily installed in common areas such as corridors. The "Other" building type contained a mix of buildings that only had one or two sites in the sample. Additional prominent building types included Retail, Office, Hospital, Hotel, Religious Buildings and Multi-Family.

Table 23: Building Type

Building Type	Fluorescent	LED	Total
School/University	5	18	23
Other	5	8	13
Retail		11	11
Office	2	8	10
Dining		6	6
Hospital/Healthcare	2	4	6
Hotel		5	5
Religious Building		4	4
Multi-Family	1	2	3
Total	15	66	81

4.5.1 Installation Rate

This evaluation found that approximately 82% of all purchased lamps were found to have been installed at the time of the on-site visits. LED and Fluorescent lamps had almost the same installation rates of 82% and 80%, respectively. These numbers represent the percentage of all lamps that were in operation at the time of the evaluation. In many cases, the missing lamps were identified in storage, and expected to be installed as other lamps burned out. In other situations, lamps were said to have been sent to a different location. When this occurred, evaluators attempted to verify these lamps by visiting these separate locations. However, they were not always identified as having been installed.

4.5.2 Delta Watts

The delta Watts factor was determined to be 123% for the overall impact evaluation. However, this was entirely driven by the LED category, which had a delta Watts factor of 133%. The Fluorescent category had a delta Watts factor of 100%. Delta Watts are defined as the pre-installation, or baseline wattage, minus the post-installation wattage. The factor represents the difference between the tracking delta Watts and the evaluation delta Watts as a percentage. For LED, this factor was mostly driven by the pre-existing or baseline wattages.

As shown earlier in Table 6 and Table 11, all tracking savings were based on an estimated baseline and installed wattage for each lamp type. These baseline wattages were developed by the PAs based on historical information, and manufacturer data. For LEDs, it was assumed that the baseline wattage would have been a mix of CFL and incandescent lamps corresponding to the installed LED lamp. To determine the pre-existing, or baseline, baseline wattage as part of this evaluation, engineers asked site personnel to identify what type and wattage bulb was there prior to the installation of the new lamps. In most cases, site personnel were very confident in their answers, were able to identify other sockets or fixtures that still had the “old” lamps installed, or still had some of the older lamps in storage. The evaluation estimated savings based on these reported baseline wattages. One thing that the evaluation found was that there were very few cases where LEDs were replacing either existing LEDs or CFLs. The majority of the replaced lamps were incandescent/halogen lamps of higher wattage. The site summaries in Appendix C describe the findings at each of the sites.

4.5.3 Hours of Use

The overall hours of use realization rate was found to be 91% based on the monitoring of hours of use. The LED hours of use realization rate was 88%, while the Fluorescent hours of use realization rate was 108%. The differences in realization rates could be attributed to the tracking estimates of hours of use. LED hours of use were expected to be higher than Fluorescent hours of use based on the tracking savings estimates. The tracking estimates were based on PA assumptions regarding usage of each different lamp type. The majority of LED lamps were expected to operate 4,500 hours per year, while Fluorescent lamps were expected to operate 3,380 hours per year. The analysis found that the evaluated hours of use for LEDs were approximately 3,979 hours per year, and 3,559 hours of use for Fluorescent

5. Conclusions and Recommendations

Overall, the Bright Opportunities program appears to be successfully delivering energy savings, especially with respect to the LED category. LEDs were found to have a realization rate of 102%, which was driven by several adjustments. Fluorescents were found to have a realization rate of 89%, which was primarily driven by the quantity adjustment. Based on the results of this study, it is recommended that realization rates for connected kW and kWh, and adjusted savings estimates for hours of use should be

applied at the category level (LED and FLR). This study does not have enough data points to disaggregate results at the building type or LED lamp type level with acceptable estimates of precision.

The following are some conclusions and recommendations for the program, and future evaluations of the program.

5.1 LED Savings Assumptions

- **Delta Watts.** This study produced an estimate of delta watts that was approximately 33% higher than tracking estimates. Almost this entire discrepancy was due to the finding that the baseline bulbs/lamps were of higher wattage than the tracking estimates. The tracking estimates were based on an assumption that there would be a mix of CFL and incandescent in the existing case. However, it was found that the majority of the lamps that were replaced were incandescent, with a very small percentage of CFL/LEDs. Additionally, as market penetration increases, the replacement of CFL/LEDs likely increases, which will result in lower baseline wattages. A follow-up evaluation should consider this shifting baseline as a factor in deciding when the next one should take place. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.
- **Quantity.** This study found that approximately 82% of the purchased LED lamps were installed at the time of the evaluation. It was common to find many of these not yet installed lamps in storage at each of the facilities. Customers expect that they will eventually install each of these bulbs as soon as their existing lamps burn out. It is unclear what the lag time will be for the installation of these remaining lamps, and therefore, a follow-up study should be designed to revisit sites from this study that had a large number of units still in storage or not yet installed. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.
- **Hours of Use.** This study found that the hours of use realization rate was 88% for LEDs. This is a relatively low hours of use realization rate as compared to other lighting impact evaluations. As mentioned above, the assumed hours of use for the majority of LED lamps was 4,500 hours per year. Based on lighting logger data at each of the sites, the average hours of use for LED lamps were found to be 3,979 hours per year. It is recommended that the hours of use be adjusted downward to account for this finding for the near term. *Note that the study connected kW and connected kWh realization rates do not include this adjustment for hours*, which means that program savings estimates can be updated with the new hours estimates from this study. In this instance the kWh realization rate would be based on the product of the Connected kWh RR (109.1%) and the kWh HVAC Interactive Effect (106.1%), which results in a factor of 115.8%.

The assumed Hours of Use (4,500) used in the savings algorithms would need to be replaced with the evaluated Hours of Use (3,979). The combination of these two adjustments would result in the evaluated savings.

5.2 Fluorescent Savings Assumptions

- **Quantity.** This study found that approximately 80% of the purchased Fluorescent lamps were installed at the time of the evaluation. It was common to find many of these not yet installed lamps in storage at each of the facilities. Customers expect that they will eventually install each of these bulbs as soon as their existing lamps burn out. It is unclear what the lag time will be for the installation of these remaining lamps, and therefore, a follow-up study should be designed to revisit sites from this study that had a large number of units still in storage or not yet installed. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.
- **Hours of Use.** This study found that the hours of use realization rate was 103% for Fluorescent lamps. This is in line with other impact evaluations of Fluorescent lighting systems. As mentioned above, the assumed hours of use for the majority of Fluorescent lamps was 3,380 hours per year. Based on lighting logger data at each of the sites, the average hours of use for Fluorescent lamps were found to be 3,559 hours per year. It is recommended that the hours of use be adjusted upward to account for this finding for the near term. *Note that the study connected kW and connected kWh realization rates do not include this adjustment for hours, which means that program savings estimates can be updated with the new hours estimates from this study.* In this instance the kWh realization rate would be based on the product of the Connected kWh RR (80.3%) and the kWh HVAC Interactive Effect (107.7%), which results in a factor of 86.5%. The assumed Hours of Use (3,380) used in the savings algorithms would need to be replaced with the evaluated Hours of Use (3,559). The combination of these two adjustments would result in the evaluated savings.

5.3 Program Tracking Documentation

- **Consider Efforts to Increase the Customer's Awareness of the Program.** Many customers were aware that they had received discounted lamps from this program, but not all were aware that the discounts came from the PAs. Many customers were under the impression that their electrical contractors were offering the deep discounts. It is recommended that the PAs consider utilizing a program sticker or label that participating distributors would attach to a customers' shipping/purchase order. This may help the program gain recognition and will help the end-users recall the Upstream lighting purchases. It should not be overlooked how good the program discounted LED bulbs make the electricians look to their customers. Their customers, in many

cases, know the longevity and energy savings of LED bulbs but they can't come to purchasing them at regular cost. For example, site L2796 is a restaurant that would not have paid full price for the LED bulbs that were installed. The electricians who oversee the building dealt with the program and the credit for the financial discount is lost. In some cases, it's the electricians who appear as though they are selling or giving the company (restaurant in this case) a great deal. The managers at this site allowed us to conduct our study but at first they didn't know the program bulbs were offered by the utilities.

- **Consider Additional Supporting Information for Large Purchases.** One of the major discrepancies found during this evaluation was that in some cases, large quantities of lamps were being stored for future use by end users. There are several sites, the most extreme being L1505, in which evaluators identified pallets of program bulbs being stockpiled by customers. In the case of L1505, which was a school district, the large quantity of bulbs was considered so that they wouldn't have to worry about purchasing replacement lamps for several years. It is recommended that electrical contractors or end users be required to provide more information to support extremely large purchases so that it would be more likely that the program bulbs are installed earlier.

5.4 Future Impact Evaluation

- **Consider a Follow-up Impact Evaluation.** This impact evaluation provides important feedback to the PAs for reporting savings, and improving savings estimates. However, due to the relatively large error ratios found in this study, the targeted 90/10 precision was not achieved. Depending on PA needs, a follow-up study may be considered to improve the evaluation results, or to obtain statistically valid factors for some of the building types where a majority of LED and Fluorescent lamps are being installed. The PAs and EEAC may want to consider performing a third phase of impact evaluation, which could be designed in consideration of the error ratios that were found with this study to try to achieve a combined 90/10 precision at the measure category, or targeted at a measure category and building type. Alternatively, the PAs and EEAC may consider following up on those sites with lower installation rates. Follow-up discussion and long-term planning should take place to determine what the evaluation needs are on an ongoing basis, and also what the target precision levels should be based on the needs of the PAs and EEAC.

A. Description of Results and Factors

This section presents a listing of realization rate and savings factors that were produced as part of this study. Each entry contains a description of that savings variable.

A.1 Realization Rates

Annual kWh – This result is the gross annual kWh realization rate including additional savings due to HVAC interactive effects. This realization rate is the evaluation gross annual kWh savings divided by the tracking gross annual kWh savings.

Connected kW – This result is the gross connected kW realization rate, which includes any documentation, quantity, and technology adjustments. This realization rate is the evaluation gross connected kW savings divided by the tracking gross connected kW savings.

Connected kWh – This result is the gross connected kWh realization rate, which includes only the documentation, quantity, and technology adjustments. This realization rate is the evaluation gross connected kWh savings divided by the tracking gross connected kWh savings.

Installation Rate – This represents the percentage of the tracking connected kW savings based on the quantity of installed lamps found during the on-site evaluation. This rate is embedded in the Annual kWh, Connected kW, and Connected kWh realization rates above.

Delta Watts – This result represents the percentage of the tracking connected kW savings based on the difference in the delta watts (pre minus post installation wattage) as found during the on-site evaluation. This rate is embedded in the Annual kWh, Connected kW, and Connected kWh realization rates above.

Hours of Use – This result is the hours of use realization rate, which represents the evaluation estimate of hours of use divided by the tracking estimate of hours of use. This rate is embedded in the Annual kWh realization rate above.

A.2 Savings Factors

Summer Coincidence Factor

On Peak Hours – This is the percentage of the connected kW savings coincident with the summer on-peak period.

Seasonal Hours – This is the percentage of the connected kW savings coincident with the summer seasonal peak period.

Winter Coincidence Factor

On Peak Hours – This is the percentage of the connected kW savings coincident with the winter on-peak period.

Seasonal Hours – This is the percentage of the connected kW savings coincident with the winter seasonal peak period.

Summer kW HVAC Interactive Effect

On Peak Hours – This is the percentage of gross connected kW savings that are due to interactive effects during the summer on-peak period.

Seasonal Hours – This is the percentage of gross connected kW savings that are due to interactive effects during the summer seasonal peak period.

Winter kW HVAC Interactive Effect

On Peak Hours – This is the percentage of gross connected kW savings that are due to interactive effects during the winter on-peak period.

Seasonal Hours – This is the percentage of gross connected kW savings that are due to interactive effects during the winter seasonal peak period.

KWh HVAC Interactive Effect – This is the percentage of the gross kWh savings that are due to interactive effects.

% On Peak KWh – This is the percentage of energy savings that occur during on-peak hours.



Table 24: Summary of Results and Factors

Tracking System Values		Evaluation Values	
(a)	Annual kWh	(j)	Annual kWh
(b)	kWh HVAC Factor	(k)	kWh HVAC Factor
(c)	On-Peak % Annual kWh	(l)	On-Peak % Annual kWh
(d)	Connected kW	(m)	Connected kW
(e)	Summer kW Coincidence Factor	(n)	Summer kW Coincidence Factor
(f)	Summer kW HVAC Factor	(o)	Summer kW HVAC Factor
(g)	Winter kW Coincidence Factor	(p)	Winter kW Coincidence Factor
(h)	Winter kW HVAC Factor	(q)	Winter kW HVAC Factor
(i)	Average Hours of Use	(r)	Average Hours of Use

Realization Rates	
(s)	Annual kWh
(t)	Connected kW
(u)	Connected kWh
(v)	Hours of Use

Savings Algorithms	
Evaluated Annual kWh Savings	(a) x (s) or (a) x (u) x (v) x (k)
Evaluated Connected kW	(d) x (t)
Evaluated Summer Peak kW Reduction	(d) x (t) x (n) x (o)
Evaluated Winter Peak kW Reduction	(d) x (t) x (p) x (q)



B. Site Level Results

B.1 LED

Table 25: LED Tracking and Evaluation Savings Estimates

KEMA ID	Facility Type	Tracking			Evaluation								
		Annual kWh Savings	Connected kW Savings	Average Hours of Use	Annual kWh Savings	kWh HVAC Factor	On-Peak % Annual kWh	Connected kW Savings	Summer kW Coincidence Factor	Summer kW HVAC Factor	Winter kW Coincidence Factor	Winter kW HVAC Factor	Average Hours of Use
I0648	Multi-Family	10,204	2.3	4,500	36,307	1.07	46%	3.9	0.99	1.17	1.00	1.00	8,679
I0682	School/University	23,410	5.2	4,500	11,843	1.00	57%	7.7	0.18	1.00	0.16	1.00	1,548
I0699	Healthcare-Clinic	3,634	0.8	4,500	996	0.81	69%	0.3	1.00	1.27	0.78	0.21	4,632
I0776	Hospital	147,344	32.7	4,500	69,066	1.06	49%	9.5	0.85	1.14	0.85	1.00	6,887
I0786	Office	421	0.1	4,500	445	1.12	98%	0.2	0.85	1.27	0.47	1.00	2,312
I0891	Multi-Family	268	0.1	4,500	0	0.00	0%	0.0	0.00	1.00	0.00	1.00	N/A
I0909	Office	234,052	52.0	4,500	340,964	1.06	68%	71.9	0.93	1.14	0.85	1.00	4,483
I1160	Retail	46,002	10.2	4,500	18,754	1.12	70%	6.7	0.77	1.27	0.77	1.00	2,502
I1216	School/University	92,898	20.6	4,500	57,437	1.08	73%	16.0	0.71	1.17	0.36	1.00	3,332
I1243	School/University	96,562	21.5	4,500	5,726	1.06	46%	1.0	0.55	1.14	0.55	1.00	5,407
I1348	School/University	127,400	28.3	4,500	65,766	1.06	83%	38.2	0.47	1.14	0.12	1.00	1,619
I1418	Other	20,991	4.7	4,500	19,023	1.12	78%	5.6	0.78	1.27	0.73	1.00	3,045
I1419	Other	11,196	2.5	4,500	4,465	1.12	67%	3.0	0.37	1.27	0.12	1.00	1,313
I1428	Office	77,412	17.2	4,500	83,262	1.07	67%	16.4	0.96	1.17	0.69	1.00	4,731
I1476	School/University	54,506	12.1	4,500	59,301	0.84	58%	14.2	0.63	1.00	0.81	0.48	4,979
I1626	School/University	23,150	5.1	4,500	8,878	1.12	94%	4.7	0.64	1.27	0.28	1.00	1,684
I1628	Museum	129,916	28.9	4,500	252,326	1.07	67%	49.7	0.97	1.17	0.45	1.00	4,729
I1629	School/University	2,393	0.5	4,500	7,371	1.11	47%	0.8	1.00	1.27	1.00	1.00	8,633
I1674	Court House	2,725	0.6	4,500	1,078	1.11	85%	0.5	0.47	1.27	0.03	1.00	1,844



KEMA ID	Facility Type	Tracking			Evaluation								
		Annual kWh Savings	Connected kW Savings	Average Hours of Use	Annual kWh Savings	kWh HVAC Factor	On-Peak % Annual kWh	Connected kW Savings	Summer kW Coincidence Factor	Summer kW HVAC Factor	Winter kW Coincidence Factor	Winter kW HVAC Factor	Average Hours of Use
I1679	Retail	8,262	1.8	4,500	650	1.09	88%	0.6	0.26	1.22	0.18	1.00	925
I1843	School/University	392	0.1	4,500	3,039	1.00	34%	1.6	0.13	1.00	0.21	1.00	1,911
I1997	School/University	7,796	1.7	4,500	0	1.00	82%	0.5	0.00	1.00	0.00	1.00	0
I2031	Office	1,809	0.4	4,500	0	1.00	0%	0.0	0.00	1.00	0.00	1.00	N/A
I2033	Retail	18,487	4.1	4,500	1,857	1.12	86%	0.8	0.73	1.27	0.24	1.00	1,971
I2056	Dining: Family	29,360	6.5	4,500	56,568	1.11	56%	9.6	0.80	1.27	0.80	1.00	5,298
I2186	Office	43,893	9.8	4,500	49,049	1.11	68%	8.1	1.00	1.27	0.96	1.00	5,463
I2274	School/University	182	0.0	4,500	0	0.00	0%	0.0	0.00	1.00	0.00	1.00	N/A
I2675	Hotel	132,632	29.5	4,500	633,790	1.11	50%	78.8	0.90	1.27	0.90	1.00	7,264
I2882	Hospital	282,046	62.7	4,500	301,983	1.07	49%	35.1	0.97	1.17	0.97	1.00	8,055
I2958	School/University	57,409	12.8	4,500	14,099	1.01	82%	17.7	0.18	1.01	0.37	1.00	792
I2978	Retail	23,515	5.2	4,500	15,283	1.12	70%	4.1	0.98	1.27	0.72	1.00	3,363
L1866	Dining: Bar Lounge/Leisure	3,815	0.8	4,500	4,419	1.10	33%	0.8	0.00	1.27	0.06	1.00	4,775
L1920	School/University	33,258	7.4	4,500	1,607	1.06	89%	4.3	0.07	1.10	0.08	1.00	354
L2113	Hotel	21,416	7.6	2,800	59,454	1.11	55%	10.9	0.54	1.27	0.72	1.00	4,932
L2142	School/University	19,142	4.4	4,365	37,211	1.06	66%	6.8	0.86	1.14	0.87	1.00	5,186
L2275	Retail	19,196	4.3	4,500	25,696	1.12	74%	7.5	0.75	1.27	0.18	1.00	3,057
L2409	Religious Building	2,596	0.9	2,800	2,005	1.00	71%	1.2	0.41	1.00	0.13	1.00	1,740
L2529	Retail	99,143	22.0	4,500	140,369	1.12	75%	36.9	1.00	1.27	0.72	1.00	3,387
L2658	Religious Building	1,090	0.2	4,500	818	1.13	81%	0.4	0.17	1.30	0.28	1.00	1,917
L2719	Office	26,163	5.8	4,500	1,035	1.07	47%	0.1	1.00	1.19	1.00	1.00	8,760
L2771	Workshop	2,950	0.7	4,500	293	1.00	73%	0.5	0.12	1.00	0.21	1.00	643
L2796	Dining: Bar Lounge/Leisure	13,627	3.0	4,500	26,475	1.11	60%	3.8	1.00	1.27	1.00	1.00	6,347
L2869	Dining: Cafeteria/Fast Food	2,725	0.6	4,500	6,367	1.11	63%	0.9	1.00	1.27	0.98	1.00	6,356



KEMA ID	Facility Type	Tracking			Evaluation								
		Annual kWh Savings	Connected kW Savings	Average Hours of Use	Annual kWh Savings	kWh HVAC Factor	On-Peak % Annual kWh	Connected kW Savings	Summer kW Coincidence Factor	Summer kW HVAC Factor	Winter kW Coincidence Factor	Winter kW HVAC Factor	Average Hours of Use
L3036	Dining: Family	12,049	2.7	4,500	9,159	1.12	68%	3.0	0.55	1.27	0.69	1.00	2,699
L3222	Office	9,400	2.3	4,023	4,600	1.12	78%	1.6	0.53	1.27	0.17	1.00	2,583
L3459	Hotel	16,224	5.8	2,800	85,472	1.11	60%	13.2	0.87	1.27	0.87	1.00	5,824
L3460	Retail	16,922	3.8	4,500	16,738	1.12	78%	5.5	0.97	1.27	0.36	1.00	2,733
L3510	Hotel	72,137	16.0	4,499	102,740	1.11	58%	33.2	0.48	1.27	0.38	1.00	2,793
L3686	School/University	19,175	4.3	4,500	38,680	1.10	85%	15.5	0.21	1.26	0.28	1.00	2,253
L3693	Retail	6,715	1.5	4,500	52	1.12	74%	0.0	0.88	1.27	0.28	1.00	2,575
L3835	Transportation	2,107	0.5	4,500	5,825	1.00	23%	1.3	0.00	1.00	0.40	1.00	4,380
L3918	Exercise Center	1,298	0.5	2,800	0	0.00	0%	0.0	0.00	1.00	0.00	1.00	N/A
L3985	Hospital	7,198	1.6	4,500	7,238	1.06	47%	2.4	0.33	1.14	0.34	1.00	2,889
L4161	Retail	17,447	4.8	3,671	38,593	1.04	38%	6.0	0.46	1.15	1.00	1.00	6,193
L4185	School/University	49,579	11.1	4,453	62,721	1.06	61%	18.0	0.53	1.14	0.46	1.00	3,300
L4274	Parking Garage	13,064	2.9	4,500	39,081	1.00	46%	4.5	1.00	1.00	1.00	1.00	8,755
L4288	School/University	7,631	1.7	4,500	2,036	1.00	20%	0.5	0.00	1.00	0.21	1.00	3,729
L4485	Hotel	96,294	21.4	4,500	702	0.80	49%	0.4	0.19	1.29	0.26	0.22	2,098
L4575	Office	65,390	14.6	4,473	59,730	1.06	60%	16.9	0.60	1.14	0.60	1.00	3,337
L4668	Religious Building	115,255	28.5	4,048	9,063	1.03	27%	6.5	0.03	1.27	0.15	1.00	1,343
L4680	School/University	21,914	4.9	4,500	8,154	1.00	55%	8.7	0.01	1.00	0.16	1.00	939
L4953	School/University	15,982	4.5	3,563	5,721	1.07	62%	3.3	0.23	1.17	0.13	1.00	1,640
L5052	Religious Building	93,623	20.8	4,500	1,752	1.01	64%	3.7	0.08	1.02	0.11	1.00	475
L5233	Dining: Bar Lounge/Leisure	5,451	1.2	4,500	6,542	1.11	62%	1.1	0.86	1.27	0.84	1.00	5,183
L5361	Retail	9,379	2.1	4,500	6,546	0.94	69%	2.4	0.89	1.20	0.43	0.47	2,876
L5586	Retail	54,506	12.1	4,500	13,227	1.12	73%	3.4	0.81	1.27	0.09	1.00	3,453



Table 26: LED Realization Rates and Reasons for Discrepancies

KEMA ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
		Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
I0648	Multi-Family	356%	173%	193%	Hours of use 193% of tracking. Baseline lamps are 50w rather than 38w and 31w. HVAC interaction added. (2) MR16 lamps not installed.
I0682	School/University	51%	147%	34%	Hours of use 34% of tracking. (19) more PAR20 and (9) less PAR30. Baseline lamps were 65w rather than 55w and 38w.
I0699	Healthcare-Clinic	27%	33%	103%	Baseline lamps were 35w rather than 55w. (6) PAR30 not installed. Electric heat HVAC penalty.
I0776	Hospital	47%	29%	153%	Baseline lamps were 2 lamp 11w CFL. Hours of use 153% of tracking.
I0786	Office	106%	184%	51%	Hours of use 51% of tracking. Baseline lamps 100w rather than 61w.
I0891	Multi-Family	0%	0%	N/A	Lamps not installed yet.
I0909	Office	146%	138%	100%	Baseline lamps were 50w and 75w. HVAC interaction added.
I1160	Retail	41%	66%	56%	Hours of use 56% of tracking. (48) PAR30 not installed and (9) PAR38 not installed. Baseline lamps were 50w rather than 55w and 61w.
I1216	School/University	62%	78%	74%	Several baseline lamps were CFLs. Hours of operation 74% of tracking.
I1243	School/University	6%	5%	120%	Baseline lamps were 13w and 18w CFL.
I1348	School/University	52%	135%	36%	Hours of use 36% of tracking. Baseline lamps were 50w rather than 31w and 38w for majority of spaces.
I1418	Other	91%	120%	68%	Baseline lamps were 50w and 75w rather than 38w and 55w. Hours of use were 68% of tracking. (27) PAR20 not installed.
I1419	Other	40%	122%	29%	Hours of use 29% of tracking. Baseline lamps were 50w rather than 38w and 55w. (6) PAR30 and (1) PAR20 not installed.
I1428	Office	108%	96%	105%	Hours of operation 105% of tracking.
I1476	School/University	109%	117%	111%	Baseline lamps were 75w rather than 55w. (60) PAR30 not installed. Electric heat penalty.
I1626	School/University	38%	92%	37%	Hours of use 37% of tracking. Purchased PAR20 rather than PAR30.
I1628	Museum	194%	172%	105%	Baseline lamps were 65w, 75w and 50w rather than 31w, 38w, 55w and 61w. Hours of operation 105% of tracking. HVAC interaction added.
I1629	School/University	308%	145%	192%	Hours of use 193% of tracking. Baseline lamps are 50w rather than 38w and 31w. HVAC interaction added. (2) MR16 lamps not installed.
I1674	Court House	40%	87%	41%	Hours of use 41% of tracking. Baseline lamps were 50w rather than 55w.
I1679	Retail	8%	35%	21%	Hours of use 21% of tracking. (9) PAR30 and (14) PAR38 not installed. Baseline lamps were 50w rather than 55w and 61w.
I1843	School/University	774%	1823%	42%	Evaluators found (15) PAR38 installed rather than (1) PAR30 and (1) PAR38. Baseline lamps were 120w rather than 55w and 61w. Hours of use 42% of tracking.
I1997	School/University	0%	26%	0%	(29) PAR38 not installed. (8) PAR38 have zero hours of use.
I2031	Office	0%	0%	N/A	Lamps not installed.
I2033	Retail	10%	20%	44%	(73) PAR30 and (2) PAR20 not installed. (18) PAR20 not received. Baseline lamps were 75w rather than 55w. Hours of use 44% of tracking.
I2056	Dining: Family	193%	147%	118%	Baseline lamps were 75w rather than 55w and 61w. Hours of use 118% of tracking.
I2186	Office	112%	83%	121%	The evaluated savings were 21% higher than the tracking documentation. The reason for this discrepancy was a increase in annual operation hours based on metered data. Additional savings are due to HVAC interactions and 48 uninstalled LED lamps.
I2274	School/University	0%	0%	N/A	Lamp not installed.
I2675	Hotel	478%	267%	161%	Hours of use 161% of tracking. Baseline lamps were 120w rather than 55w. Installed lamps were 12w rather than 15w.
I2882	Hospital	107%	56%	179%	Increase in annual hours of use and 846 fixtures in storage



KEMA ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
		Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
I2958	School/University	25%	139%	18%	Hours of use 18% of tracking. Baseline lamps were 75w rather than 55w and 61w.
I2978	Retail	65%	78%	75%	Hours of use 75% of tracking. Baseline lamps were 50w rather than 55w. (7) PAR30 not installed.
L1866	Dining: Bar Lounge/Leisure	116%	99%	106%	Increase in annual hours of use and 12W PAR30s onsite not 15W PAR30s as per tracking. (2) lamps burned out and were not replaced.
L1920	School/University	5%	58%	8%	Reduction in annual hours of use. 12 PAR30 and 90 PAR38 in storage
L2113	Hotel	278%	142%	176%	Existing lamps were 90 watt incandescent. Increase in Annual hours of use, (49) A-Lamps in storage, not installed.
L2142	School/University	194%	154%	119%	Higher wattage baseline lamps and lower wattage installed lamps resulted in technology adjustment. Hours of use were 119% of tracking.
L2275	Retail	134%	177%	68%	Higher wattage baseline lamps and lower wattage installed lamps resulted in technology adjustment. Hours of use were 68% of tracking. (4) PAR 30 not yet installed.
L2409	Religious Building	77%	124%	62%	Hours of use 62% of tracking. Baseline lamps were 60 watt incandescent rather than 55 watt.
L2529	Retail	142%	168%	75%	Higher wattage baseline lamps and lower wattage installed lamps resulted in technology adjustment. Hours of use were 75% of tracking.
L2658	Religious Building	75%	156%	43%	Higher wattage baseline lamps and lower wattage installed lamps resulted in technology adjustment. Hours of use were 43% of tracking.
L2719	Office	4%	2%	195%	New LEDs replaced 15 watt CFLs, which resulted in a -98% technology adjustment.
L2771	Workshop	10%	70%	14%	(8) PAR38 not installed yet. Baseline bulbs were 90 watt incandescent. Hours of use were 14% of tracking estimate.
L2796	Dining: Bar Lounge/Leisure	194%	124%	141%	Hours of use 41% greater than tracking estimates. Baseline lamps were 65 watt rather than 55 watt. Additional HVAC savings.
L2869	Dining: Cafeteria/Fast Food	234%	149%	141%	Baseline lamps were 75 watts rather than 55 watts. Hours of use were 41% higher than tracking estimates.
L3036	Dining: Family	76%	113%	60%	Baseline lamps were 75w rather than 55w and 31w. Hours of use 60% of tracking. (18) PAR30 not installed.
L3222	Office	49%	68%	64%	17 of 56 bulbs not installed. Hours of use 64% of tracking estimates. This was a new construction situation, so baseline is assumed tracking wattages.
L3459	Hotel	527%	228%	208%	Baseline lamps were 100 watt rather than 55 watt. Hours of use were more than twice the tracking estimate.
L3460	Retail	99%	145%	61%	Baseline lamps were higher wattage (90 and 50 watts). Hours of use 61% of tracking.
L3510	Hotel	142%	207%	62%	Higher wattage baseline bulbs. Hours of use 62% of tracking.
L3686	School/University	202%	365%	50%	Reduction in Annual hours of use and HVAC included. (48) PAR30s were found onsite rather than (48) PAR38s
L3693	Retail	1%	1%	57%	(30) PAR30 not installed, (4) PAR38 not installed. Pre-retrofit lamps were all 23w LED instead of 55w and 61w. Hours of use were 57% of tracking.
L3835	Transportation	276%	284%	97%	Baseline lamp was a 150 watt halogen rather than 61 watt.
L3918	Exercise Center	0%	0%	N/A	New lamps not installed. Baseline 60 watt incandescent found on-site.
L3985	Hospital	101%	148%	64%	Baseline lamps are higher wattage than tracking estimates. Hours of use 64% of tracking estimates.
L4161	Retail	221%	126%	169%	Annual hours of use doubled from tracking. (29) fixtures ON 24x7. 8W LED A-lamps were found on site rather than 17W LED A-lamps.
L4185	School/University	127%	161%	74%	(8) 12W LED A-lamps were installed onsite instead of 18W LED A-lamps and (176) 18W PAR38s installed onsite instead of 14W PAR38s as per tracking. 41% decrease in average annual hours of use.
L4274	Parking Garage	299%	154%	195%	(62) 18W LED PAR38s were installed rather than (62) 14W LED PAR38s per tracking.
L4288	School/University	27%	32%	83%	Reduction in annual hours of use based on darkness hours by month calculations as the lights operate on photo sensors
L4485	Hotel	1%	2%	47%	391 of 530 lamps not installed. Baseline lamps were 15 watt CFL, which were lower wattage than



KEMA ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
		Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
					tracking estimates (55 watts).
L4575	Office	91%	116%	75%	Reduction in Annual hours of use. (52) PAR30 and (68) PAR38s in storage (113 total)
L4668	Religious Building	8%	23%	33%	Reduction in Annual hours of use. (196) LED A lamps, (16) PAR20, (208) PAR30, (162) PAR38 fixtures not installed (total of 582)
L4680	School/University	37%	178%	21%	Reduction in Annual hours of use, 3 LEDs in Storage
L4953	School/University	36%	72%	46%	Annual hours of use decreased with Cooling interactions.
L5052	Religious Building	2%	18%	11%	Baseline lamps were 25 watt CFL. 156 lamps not installed. Hours of use were 11% of tracking estimates.
L5233	Dining: Bar Lounge/Leisure	120%	94%	115%	Increase in annual hours of use. 12 fixtures in storage
L5361	Retail	70%	116%	64%	20 of 50 bulbs not installed. Baseline lamps were higher wattage incandescent. Hours of use were 64% of tracking estimates.
L5586	Retail	24%	28%	77%	Reduction in Annual hours of use and 57 fixtures were installed out of 300. 149 were in storage and verified but 94 LEDs are MIA.



B.2 Fluorescent

Table 27: Fluorescent Tracking and Evaluation Savings Estimates

KEMA ID	Facility Type	Tracking			Evaluation								
		Annual kWh Savings	Connected kW Savings	Average Hours of Use	Annual kWh Savings	kWh HVAC Factor	On-Peak % Annual kWh	Connected kW Savings	Summer kW Coincidence Factor	Summer kW HVAC Factor	Winter kW Coincidence Factor	Winter kW HVAC Factor	Average Hours of Use
I0025	Other	2,213	0.7	3,380	345	1.03	94%	0.3	0.26	1.06	0.01	1.00	1,002
I0030	Multi-Family	6,853	2.0	3,380	7,392	1.11	51%	2.0	0.41	1.27	0.48	1.00	3,276
I0140	Other	10,351	3.1	3,380	9,073	1.11	67%	2.4	0.74	1.27	0.57	1.00	3,459
I0244	Hospital	14,872	4.4	3,380	24,576	1.04	69%	4.4	0.96	1.09	0.87	1.00	5,379
I0438	Other	23,795	7.0	3,380	27,401	1.11	72%	7.0	0.74	1.25	0.52	1.00	3,512
L0029	Workshop	71	0.0	3,380	22	1.00	94%	0.0	0.25	1.00	0.02	1.00	1,405
L0082	School/University	40,690	12.0	3,380	22,599	1.00	86%	8.6	0.43	1.00	0.46	1.00	2,634
L0114	School/University	571	0.2	3,380	40	1.00	41%	0.0	0.00	1.00	0.26	1.00	2,492
L0135	Healthcare-Clinic	10,470	3.1	3,380	14,678	1.11	75%	3.1	0.94	1.27	0.57	1.00	4,260
L0649	Office	77,810	23.0	3,380	35,086	1.06	69%	11.4	0.60	1.14	0.29	1.00	2,907
L0667	School/University	47,828	14.2	3,380	9,983	1.00	82%	8.7	0.21	1.00	0.15	1.00	1,145
L1191	School/University	78,524	19.7	3,976	39,771	1.00	90%	20.9	0.24	1.00	0.27	1.00	1,900
L1482	Gymnasium	357	0.1	3,380	881	1.11	49%	0.1	1.00	1.27	0.99	1.00	8,403
L1505	School/University	1,370,604	405.5	3,380	11,927	1.00	95%	6.9	0.22	1.01	0.07	1.00	1,729
L1532	Office	714	0.2	3,380	222	1.12	93%	0.1	0.54	1.27	0.02	1.00	1,761



Table 28: Fluorescent Realization Rates and Reasons for Discrepancies

KEMA ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
		Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
I0025	Other	16%	51%	30%	(91) T8 lamps not installed. Hours of use 30% of tracking.
I0030	Multi-Family	108%	100%	97%	HVAC interaction added.
I0140	Other	88%	77%	102%	(200) T8 Lamps not installed. HVAC interactive savings added.
I0244	Hospital	165%	100%	159%	Hours of use 159% of tracking.
I0438	Other	115%	100%	104%	Hours of use 104% of tracking. HVAC interaction added.
L0029	Workshop	32%	76%	42%	Hours of use 42% of tracking estimate. Two of six lamps not installed.
L0082	School/University	56%	71%	78%	(983) T8 Lamps not installed yet. Hours of use 78% of tracking.
L0114	School/University	7%	9%	74%	44 of 48 lamps not yet installed.
L0135	Healthcare-Clinic	140%	100%	126%	Increase in annual hours of use and HVAC interaction savings
L0649	Office	45%	49%	86%	Reduction in Annual hours of use and 3390 out 6543 fixtures not installed
L0667	School/University	21%	62%	34%	(1,571) T8 Lamps not installed. Hours of use 34% of tracking.
L1191	School/University	51%	106%	48%	Reduction in annual hours of use and 653 fixtures in storage
L1482	Gymnasium	247%	90%	249%	Annual hours of use tripled from tracking or ON 24x7
L1505	School/University	1%	2%	51%	113,250 out of 115,200 fixtures in storage, and reduction in annual hours of use for rest of them
L1532	Office	31%	53%	52%	Reduction in annual hours of use.

C. Site Summaries

▪ **Site I0244**

- Facility type: Hospital
- Tracking: (1,250) 28 watt T8 lamps, (50) PAR20 8 watt LED, (12) PAR30 15 watt LED, (62) PAR38 14 watt LED
- Onsite Actual: (1,250) 28 watt T8 lamps, (50) PAR20 8 watt LED, (12) PAR30 15 watt LED, (62) PAR38 14 watt LED
- Baseline bulbs: (1,250) 32 watt T8 lamps, 90W incandescent, and 50W incandescent
- T8 bulbs were mainly installed in the general areas, private offices, hallways, and maintenance areas throughout the facility. LED bulbs were installed in the lobby and gift shop. The assumption for tracking hours of use are (3380) and the logged average hours of use are (5379).

▪ **Site I0648**

- Facility type: Apartment complex
- Tracking: (74) MR16 8 watt LED, (18) PAR20 8 watt LED
- Onsite Actual: (72) MR16 8 watt LED, (18) PAR20 8 watt LED
- Baseline: (74) 50 watt halogen, (18) 50 watt halogen
- Building is a 3-year old apartment complex. The bulbs were installed in common spaces throughout the facility including lobbies, hallways and elevators. Six PAR20 bulbs were installed at three elevators, and MR16 bulbs were installed at ten elevator lobbies and the main entrance lobby space. Two bulbs were not replaced and still had MR16 halogen bulbs installed. The assumption for tracking hours of use are (4500) and the logged average hours of use are (8679).

▪ **Site I1843**

- Facility type: Educational facility
- Tracking: (200) PAR30 15 watt LED, (100) PAR20 8watt LED; (200) PAR38 14 watt LED
- Onsite Actual: (15) PAR30 15 watt LED
- Baseline: (500) 120 watt incandescent
- This is a middle school consisting of typical school spaces. The LED bulbs were installed in the exterior doorways. There are five doorways in total, including two front doorways, two rear doorways and one side doorway. Each doorway has three recessed can fixtures where PAR38 bulbs were



installed. The 500 bulbs are stored at another school within the district. Bulbs are being installed as need throughout all schools that make up the district. As of the evaluation date (9/13/12), the school has installed 16 PAR38, 67 PAR30, and 34 PAR20 bulbs. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1911).

- **Site I0025**

- Facility type: Electrician shop/offices
- Tracking: (186) 28 watt T8 lamps
- Onsite Actual: (186) 28 watt T8 lamps
- Baseline(186) 32 watt T8 lamps
- This is an electrician shop and office complex. The facility consists of both open and private office spaces, electrical shops, and storage areas. The bulbs were installed throughout the entire facility. In addition, the complex had a recently remodeled area that consists of 4' LED fixtures as well as LED recessed fixtures. The assumption for tracking hours of use are (3380) and the logged average hours of use are (1002).

- **Site I1419**

- Facility type: art gallery
- Tracking: (10) PAR30 14 watt LED, 70 PAR20 8 watt LED
- Onsite Actual:
- Baseline: 50W halogen
- This is an art gallery. The facility consist two main gallery areas with a hall that connects both. The bulbs were installed throughout the facility's floor space and above the front windows. The owner had 6 PAR30s and 11 PAR20s in the back stock. In addition, it was discovered that the track above the front counter consisting of 10 PAR20 bulbs operates on a dimmer. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1313).

- **Site I2978**

- Facility type: retail
- Tracking: (6) PAR20 8 watt LED, (125) PAR30 14 watt LED
- Onsite Actual: (3) PAR20 8 watt LED, (110) PAR30 18 watt LED



- Baseline: 50W halogens
- This is a home retail store, consisting of three main sales floor areas. The bulbs are installed in standard tracking fixtures along the store ceiling. 110 PAR30s are installed throughout the sales floor. Three of the six PAR20s are installed over the counter area by the front door. There are 7 PAR30s in back stock. The facility owner also owns a similar store across town, where possibly the other 8 PAR30s were installed. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3363).

- **Site I0140**
- Facility type: publishing
- Tracking: (870) 28 watt T8 lamps
- Onsite Actual: (640) 28 watt T8 lamps
- Baseline: (870) 32W T8 bulbs
- This is a newspaper printing facility, mainly consisting of open and private office spaces. Along with departments of graphics, advertising, printing and accounting. It also has commonly used office areas such as cafeteria, restrooms and break rooms. The entire facility was upgraded according to the head custodian (primary contact). During the on-site visit, the entire facility was inventoried. There were a few spaces, mainly private offices that were locked and not seen. Based on similar types of rooms, the inventory was estimated for each of the locked spaces. Bulbs were counted and totaled. The on-site produced 664 out of 870 Sylvania T8 bulbs through the program. The assumption for tracking hours of use are (3380) and the logged average hours of use are (3459).

- **Site I1160**
- Facility type: retail
- Tracking: (230) PAR30 14 watt LED, (20) PAR38 15 watt LED
- Onsite Actual: (182) PAR30 15 watt LED, (11) PAR38 18 watt LED
- Baseline: A mixture of halogen and CFL bulbs. Halogen bulbs were likely 50 watts and some were still installed. The CFL bulbs were a mixed batch consisting of various types of bulbs that were used to replace burned-out bulbs before the upstream program. (90-95% confident)
- This is a retail facility that consists mainly of sales floor space. The facility also has exterior fixtures that were involved in the program. There are 3 PAR38s installed above the main entrance in recessed can fixtures, and 8 PAR38s installed on single bulb fixtures along the store front. The exterior fixtures are controlled by a timer based on the season of the year. The season schedule is as follows: summer season 7:30pm-12:30am; winter season 4:00pm-12:30am. Inside the facility throughout the sales



space, the bulbs were installed into track lights along the store ceiling. There are 17 individual tracks, containing multiple bulbs in the entire space. There were 182 PAR30s installed, and there was no track of the remaining 48 bulbs. The facility did not have extra LED bulbs in back stock. The facility contact ensured that what was installed is what they received through the program. This is also the case for the remaining 9 PAR38 bulbs that were not found. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2502).

- **Site I0682**

- Facility type: educational
- Tracking: (12) PAR20 8 watt LED, (120) PAR30 14 watt LED
- Onsite Actual: (10) PAR20 8 watt LED, (99) PAR30 12 watt LED
- Baseline: 65W incandescent floods
- This is an educational facility. The bulbs through the program were installed in the auditorium and hall by the front office. The front hall/lobby consisted of 31 PAR20 bulbs that are controlled by a timer. The timer schedule is from 6am to 6pm. The entire space is controlled by one circuit. There are 99 PAR30 bulbs throughout the entire auditorium, 16 of which are powered by the facility's backup generator and are only operational if the facility loses power. There are 19 12W Phillips PAR30 bulbs in back stock along with 2 8W Sylvania PAR20. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1548).

- **Site I0438**

- Facility type: municipalities - fire house, police station, DPW, public library
- Tracking: (2000) 28 watt T8 lamps
- Onsite Actual:
 - 526 bulbs installed in one-lamp, two-lamp, and three-lamp fixtures in the fire house
 - 351 bulbs installed in one-lamp and two-lamp fixtures in the DPW facility
 - 319 bulbs installed in the police station
 - 804 bulbs installed in the library
- Baseline: (2000) 32 watt T8 lamps
- This facility consisted of multiple facility types spreading throughout the town. The primary contact (a city electrician) identified that 2,000 bulbs were installed throughout the town, primarily in the fire house, police station, DPW, and the public library. Inventories were completed in the fire house, police station and DPW. Library was rescheduled due to operating hours. There are possibly more

facilities that received this type of bulbs, but we could not identify the locations of these facilities. The assumption for tracking hours of use are (3380) and the logged average hours of use are (3512).

- Issue: The walk through of the police station was very limited due to security reasons. There might be more bulbs in the facility than observed. Police staffs were very enigmatic on what was actually installed through the program. We were not able to get access to all spaces where bulbs were installed, therefore, there might be fixtures that were not accounted for.

- **Site I1216**
- Facility type: educational – boarding/prep school
- Tracking: (133) MR16 8 watt LED, (22) PAR20 8 watt LED, (222) PAR30 15 watt LED, (169) PAR38 14 watt LED
- Onsite Actual: (133) MR16 6 watt LED, (22) PAR20 8 watt LED, (222) PAR30 15 watt LED, (169) PAR38 14 watt LED
- Baseline: 13W/26W CFLs for main admissions building, 60W/20W halogen for visual arts hall, 20W halogens, 13W CFLs, and 65W incandescent bulbs for survey/dining hall
- This is a boarding school. The LED lights for this program were installed in four separate locations on campus, including the main admissions building, visual arts hall, survey/dining hall, and hockey rink facility. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3332).

- **Site I1629**
- Facility type: Educational
- Tracking: (10) MR16 8 watt LED, (10) PAR20 8 watt LED
- Onsite Actual: (10) MR16 6 watt LED, (10) PAR20 8 watt LED
- Baseline: 50W halogens
- This is an engineering and science building. The 180 T8 bulbs were installed in the building hallways throughout the six floors. The 10 PAR20 bulbs were installed on certain floors above the exterior elevators. Eight of the 10 MR16 bulbs were installed in track lights in the hallway, with four on each of the two tracks. The contact also mentioned that there were two halogen bulbs installed on each track to eliminate the “flickering” of the new MR16s. The assumption for tracking hours of use are (4500) and the logged average hours of use are (8633).

- **Site I1628**
- Facility type: Educational



- Tracking: (200) MR16 8 watt LED, (100) PAR20 8 watt LED, (42) PAR30 15 watt LED, (202) PAR38 14 watt LED
- Onsite Actual: (166) MR16 8 watt LED, (346) PAR20 8 watt LED, (155) PAR30 15 watt LED, (169) PAR38 14 watt LED
- Baseline: 50W halogens, and 75 watt incandescent
- This is a museum. Bulbs were installed throughout the entire museum in track lighting and display cases in all exhibit rooms and gift shop. The museum has classrooms and offices, but no LED bulbs were installed in those spaces, and field staff was not permitted into those spaces due to being locked. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4729).

- **Site I1679**
- Facility type: Manufacturing/retail
- Tracking: (28) PAR38 14 watt LED, (13) PAR30 15 watt LED
- Onsite Actual: (14) PAR38 14 watt LED, (4) PAR30 15 watt LED
- Baseline: 50W halogens
- This is a manufacturing and retail facility. The bulbs were installed in the showroom and the warehouse. Fourteen of the 28 PAR38 bulbs were installed in movable loading dock lights in the warehouse, and into track lights in the showroom. Five of the 13 PAR30 bulbs were installed in the showroom. The site contact informed the field staff that they would wait to replace the burned-out halogen bulbs with the new ones. The assumption for tracking hours of use are (4500) and the logged average hours of use are (925).

- **Site I3036**
- Facility type: Restaurant
- Tracking: (4) MR16 8 watt LED, (64) PAR30 LED 15 watt LED
- Onsite Actual: (4) PAR20 8 watt LED, (64) PAR30 LED 15 watt LED
- Baseline: 75W floods
- This is a restaurant. The facility did not receive the MR16 bulbs, but instead received and installed 4 PAR20 bulbs. The model number for these bulbs was LED8PAR20/DIM/827/FL36. The site did receive the PAR30 bulbs and installed 46 of them at the time of the site visit. All PAR30 bulbs are on dimmable switches. The restaurant has a bar area with 11 recessed can fixtures that currently installed Sylvania 75W flood bulbs that are also on dimmers. The site contact expressed that the bar area did



not change out bulbs because the LED bulbs were too bright even with the dimmers. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2699).

- **Site I1476**

- Facility type: school
- Tracking: (300) PAR38 14 watt LED
- Onsite Actual: (267) installed, see below. (96) in storage
- Baseline: not available
- This is a school. There were 267 SHARP DL-L16P3830A lamps found installed, different from what was expected to be found. There were 96 more of these bulbs in storage. The site contact was the janitor and the purchasing contact. The site contact was 80% certain that the SHARP bulbs are the upstream LEDs. Eight lighting loggers were installed in various space types with the understanding that the bulb make and model was most likely incorrectly recorded or a change was made to the order. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4979).

- **Site I1997**

- Facility type: school
- Tracking: (37) PAR38 14 watt LED
- Onsite Actual: (8) PAR38 18 watt LED
- Baseline: 75 watt halogen
- This is a school. Eight of the 37 PAR38 bulbs were found in the auditorium, and two lighting loggers were installed. The site contact, who is the school janitor, pointed out that the remaining LED bulbs were different from what we have on file. These bulbs are Sylvania LED8PAR20/DIM/830/FL36, and the quantity found was 49. He also said there is a good chance that the other PAR38 bulbs went to different schools. The purchasing contact, who is also the school electrician, was on leave for two months. The assumption for tracking hours of use are (4500) and the logged average hours of use are (0).

- **Site I2031**

- Facility type: Machine engineering
- Tracking: (3) PAR30 15 watt LED, (6) PAR38 14 watt LED



- Onsite Actual: Not installed
- Baseline: not available
- This is a company that designs robotic machinery. Forty-two FO28/841/XV/SS/ECO bulbs were installed in two different buildings, mostly in the office areas. The remaining 168 FO28/841/XV/SS/ECO bulbs are stored for later use. The site contact replaced burned out lamps with the upstream lamps. The LED PAR bulbs have not yet been installed. Four loggers were installed, two in each building. The assumption for tracking hours of use are (4500) and the logged average hours of use are (X).

- **Site I1418**
- Facility type: Retail
- Tracking: (97) PAR20 8 watt LED, (44) PAR30 15 watt LED
- Onsite Actual: (97) PAR20 8 watt LED, (44) PAR30 15 watt LED
- Baseline: 50W halogen spots (100% confidence); 20W halogen spots (80% confidence)
- This is a large hair salon. Seventy PAR20 bulbs were installed on site, 18 bulbs were found in storage, and 9 bulbs were not found. It is not likely that these bulbs burned out and were discarded, and were possibly used elsewhere. The 44 LED15PAR300LN/DIM were installed in the main room. The site contact, who is in charge of the salon lighting, mentioned that most of the program bulbs were installed in the main salon room and a small quantity was installed in the basement therapeutic rooms. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3045).

- **Site I1626**
- Facility type: university
- Tracking: (30) PAR30 15 watt LED, (84) PAR38 14 watts LED
- Onsite Actual: (30) PAR20 8 watt LED, (84) PAR38 15 watts LED
- Baseline: 50 watt halogen, 67 watt halogen
- This is a university. There are 72 PAR38 bulbs installed in the lecture room. The remaining 12 bulbs were most likely spread throughout the campus in various test locations. The site contact said he did not know the exact location of the 12 bulbs. The LED15PAR30LN/DIM/830/FL40 bulbs were not found. The site contact said that he is very confident that these 30 bulbs are the LED8PAR20/DIM/827/FL36 bulbs, of which 24 were installed. He based his rational on the bulb



quantity and the rooms where they could be installed. The remaining 6 bulbs were not found. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1684).

- **Site I0909**

- Facility type: Office/research/design building
- (30) MR16 8 watt LED, (490) PAR20 8 watt LED, (485) PAR30 15 watt LED, (366) PAR38 14 watt LED
- Onsite Actual: (30) MR16 8 watt LED, (490) PAR20 8 watt LED, (485) PAR30 15 watt LED, (366) PAR38 18 watt LED
- Baseline: (520) 50 watt halogen, (851) 75 watt halogen
- The program bulbs are spread throughout various buildings. The contact explained that all the T8s were installed in the corporate office building, and that most of the LED bulbs were installed in the R&D building. The corporate and R&D buildings are located another location. The site contact mentioned that the program bulbs were installed in three additional buildings, but he was confident that most of the bulbs were installed in the corporate and R&D buildings. The site contact also mentioned that this order is small compared to the bulb quantity in all their company buildings, and that they purchased other orders of the same bulbs as well. The site contact was highly knowledgeable of the bulbs listed for this site. He stated an estimate of 200 PAR20 bulbs were installed at a different building in another location and that an estimated of 250 PAR30 bulbs were installed in a building in yet another location. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4483).
 - Corporate office building: this building consists of five floors and the ground floor. The 480 T8 bulbs were installed throughout the six floors. Eighteen lighting loggers were installed in this building.
 - R&D building: this building has the following LED bulbs installed: 30 MR16s, 265 PAR20s and PAR20s (SKU#78803) combined, 166 PAR30s, and 265 PAR38s. Parts of this building were not accessible and might account for the missing bulbs. Twelve lighting loggers were installed in the R&D building.

- **Site I2882**

- Facility type: medical school
- Tracking: (100) PAR20 8 watt LED, (1176) PAR38 14 watt LED, (198) MR16 8 watt LED
- Onsite Actual: (100) PAR20 8 watt LED, (330) PAR38 14 watt LED, (198) MR16 8 watt LED



- Baseline: 75W incandescent, 50W halogens
- This site consists of two different buildings: one building and a library. The building is part of a medical center, and the PAR20 bulbs were installed on tracks throughout the building. The track lighting is primarily located in the lobbies and waiting areas, and there are approximately 200 of them installed within the Lakeside Building. The 198 MR16 bulbs were installed in the lobbies and general open areas throughout the Lakeside building. (846) PAR38 lamps are in storage and will be installed at a later time.
- The Library is comprised of two sections: the main entry and the main library. The main entry has 80 PAR38 fixtures installed that run approximately 8760 hours. Students and staff have access to this area 24/7. There are approximately 250 PAR38 bulbs installed throughout the three levels of the main library. The library also runs approximately 8760 hours. The remaining 846 PAR38 bulbs were installed in the various amphitheaters throughout the campus. The facility personnel did a test trail with the LED bulbs in one of the amphitheaters to determine necessary foot candle output. The assumption for tracking hours of use are (4500) and the logged average hours of use are (8055).
- **Site I1348**
- Facility type: college
- Tracking: (555) MR16 8 watt LED, (100) PAR20 8 watt LED, (300) PAR30 15 watt LED, (5) PAR38 14 watt LED
- Onsite Actual: (555) MR16 8 watt LED, (100) PAR20 8 watt LED, (300) PAR30 15 watt LED, (5) PAR38 14 watt LED
- Baseline: (960) 50 watt halogen
- This site had four buildings retrofitted on campus. The onsite visit counted 555 MR16 bulbs installed, and approximately 35 PAR38 bulbs installed. However, it was difficult to find all 300 PAR30 and 100 PAR20 bulbs. The facility contact was very knowledgeable about the project and mentioned that more buildings might have these bulbs installed because a lot of classrooms had a combination of PAR20 and PAR30 bulbs. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1619).
- **Site I2186**
- Facility type: Office building
- Tracking: (20) PAR20 8 watt LED, (34) PAR30 15 watt LED, (38) PAR38 14 watt LED
- Onsite Actual: (20) PAR20 8 watt LED, (34) PAR30 15 watt LED, (38) PAR38 14 watt LED



- Baseline: (221) 32 watt T8 lamps
- This site was split between two buildings and was a change from T8 lamps to LED lamps: The first building has 78 PAR38 bulbs installed including 48 unused extra ones. The rest 143 bulbs were installed in the second building. The first building runs on a timer (7am to 11 pm) excluding the restrooms on the third floor which will be turned off at 11pm as well by the janitor during the weekdays. The timer for the second building runs from 6am to 10pm. All lights are turned off during the weekends except for the five emergency lamps (PAR38s). The assumption for tracking hours of use are (4500) and the logged average hours of use are (5462).

- **Site I2274**
- Facility type: High school
- Tracking (1) PAR30 15 watt LED
- Onsite Actual: (0)
- Baseline: Not available
- One LED PAR30 bulb was purchased through the program. However, this bulb could not be found installed or in storage. Site contact was not aware of any LED purchases through the listed distributor.

- **Site I0776**
- Facility type: Hospital
- Tracking: (39) MR16 8 watt LED, (28) PAR20 8 watt LED, (414) PAR30 15 watt LED, (305) PAR38 14 watt LED.
- Onsite Actual: (39) MR16 6 watt LED, (28) PAR20 8 watt LED, (414) PAR30 15 watt LED, (305) PAR38 14 watt LED.
- Baseline: (786) 2x11 watt CFL
- The site contact was not familiar with the installation but was in charge of facilitating the purchase of the bulbs. The main building had LED PAR30 bulbs installed in common areas such as lobbies, hallways, and conference rooms. Two lighting loggers were installed in these areas. Some PAR30 bulbs were found on site. The site contact said that there were over 30 buildings on campus that had a fixture upgrades and was not sure of the exact locations. The site electrician verified that there were over 800 LED bulbs purchased through the program. The assumption for tracking hours of use are (4500) and the logged average hours of use are (6887).



- **Site I2958**

- Facility type: high school
- Tracking: (200) PAR30 15 watt LED, (100) PAR38 14 wall LED
- Onsite Actual: (200) PAR30 15 watt LED, (100) PAR38 18 wall LED
- Baseline: (300) 75W halogen
- The site contact verified that approximately 300 bulbs were purchased through the program and they were in storage. He also mentioned that these LED bulbs were not rebated and he had paid full price. The PAR30 bulbs will be distributed through the rest of the school district as needed. However, the site contact was unsure if and where the PAR38 bulbs would be used due to their size. The site was retrofitted with 16 LED PAR30 bulbs in the school's auditorium. The assumption for tracking hours of use are (4500) and the logged average hours of use are (792).

- **Site I0891**

- Facility type: ski resort/condo association
- Tracking: (2) PAR20 8 watt LED
- Onsite Actual: (2) PAR38 LED not installed
- Baseline: Not available
- The two LED bulbs in storage were actually PAR38s, not PAR20s according to tracking. The two bulbs were not installed because they were not compatible with the fixture type on track lighting. Only two bulbs were purchased at this time because the facility was trying them out first. The resort has a plan to replace all 25W CFLs with LED lights. No loggers were installed.

- **Site I1243**

- Facility type: boarding high school
- Tracking: (100) PAR20 8 watt LED, (300) PAR30 15 watt LED, (136) PAR38 14 watt LED
- Onsite Actual: (100) PAR20 8 watt LED, (300) PAR30 15 watt LED, (136) PAR38 14 watt LED
- Baseline: (100) 13 watt CFL, (436) 18 watt CFL
- Multiple buildings on campus were retrofitted with LED. The assumption for tracking hours of use are (4500) and the logged average hours of use are (5407).

**Site I2056**

- Facility type: restaurant
- Tracking: (150) PAR30 15 watt LED, (10) PAR38 14 watt LED
- Onsite Actual: (150) PAR30 15 watt LED, (10) PAR38 18 watt LED
- Baseline: (160) 75 watt halogen
- All bulbs were installed. The assumption for tracking hours of use are (4500) and the logged average hours of use are (5298).

Site I1428

- Facility type: building management
- Tracking: (202) MR16 8 watt LED, (205) PAR30 15 watt LED, (104) PAR30 15 watt LED
- Onsite Actual: (202) MR16 8 watt LED, (205) PAR30 15 watt LED, (104) PAR30 15 watt LED
- Baseline: (202) 2x13 watt CFL, (205) 55 watt halogen, (104) 55 watt halogen
- This site consists of 11 buildings that are occupied by businesses. Most buildings are offices and some are residences. The site contact was only able to show three buildings where lighting loggers was installed (one in each building). The PAR30s were installed in lobbies and hallways where operation hours are usually 24/7. The MR16s were installed in some conference rooms and other random track lightings. The exact number of bulbs purchased and installed could not be verified, nor could the type or wattage of the previous bulbs installed. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4731).

Site I3686

- Facility type: school
- Tracking: (91) PAR38 14 watt LED
- Onsite Actual: (48) PAR30 14 watt LED, (43) PAR38 15 watt LED
- Baseline: (48) 250 watt metal halide, (43) 2x4' T5 28 watt
- According to site contact, they actually bought 43 PAR38s and 48 PAR30s. Among them, 26 PAR38s were installed in C240 LRG GRP INSTRUCTION room, and 17 PAR38s were installed in the library. The 48 PAR30s were installed in auditorium but could not be verified due to limited access. There are two HVAC units on site, and both are rooftop, DX cooling, single zone, and natural gas

fired. Model numbers are respectively SFHFC30E and SFHFC20E. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2253).

- **Site L1482**

- Facility Type: Health Club
- Tracking: 30 – GE 72866 F28T8/XL/SPX41/ECO
- Baseline: T8's and T12's
- Health care facility purchased 30 bulbs through upstream program. Bulbs were installed as needed in different areas of the building. It is unknown for sure where these model bulbs were installed. Found on site were 25W and 32W T8's, no 28W. Facility consists of workout areas, private offices, hallways, class rooms, tennis courts and basketball courts. Unable to confirm bulbs in high ceiling areas (tennis courts, basketball courts). General counts were 72-32W 2L fixtures and 56 – 25W 2L fixtures. The 32W fixtures were in workout areas and the 25W were in lobby hallways. Packaged RTU/NG Heating. Open Monday through Friday 5am – 10pm, Saturday 6:30am – 8pm and Sunday 7am – 6pm. Cleaning services stay later. Closed Christmas, New Years, Fourth of July and reduced holiday hours on other major holidays.

- **Site I2033**

- Facility Type: Retail Store
- Tracking: (87) PAR30 15 watt LED, and (20) PAR20 8 watt LED
- Onsite Actual: (87) PAR30 15 watt LED, and (20) PAR20 8 watt LED
- Baseline: 75 watt Incandescent
- Retail store, program bulbs installed in general sales area. (14) Par 30s installed, (73) Par 30s not installed. (2) Par20s installed and the remaining (18) were never received by the retail store.

- **Site I0786**

- Facility Type: Office
- Tracking: (2) PAR38 14 watt LED
- Onsite Actual: (2) PAR38 14 watt LED
- Baseline: 100 watt Halogen
- Open office area, program bulbs installed in track light fixtures. The site contact purchased more of the same bulbs to replace the rest of the 100 watt halogens in the office. All together (65) were purchased because it is good quality light and impressive to their clients. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2312).

- **Site I0699**

- Facility Type: Healthcare-Clinic
- Tracking: (20) PAR30 15 watt LED
- Onsite Actual: (16) PAR30 16 watt LED, (4) of the baseline bulbs still installed.
- Baseline: 35 watt Halogen

- Healthcare facility, the program bulbs are installed in the activity room. There are (4) program bulbs not installed. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4632).
- **Site I0030**
- Facility Type: Multi Family/Apartment complex
- Tracking: (576) 28 watt T8 bulbs
- Onsite Actual: (576) 28 watt T8 bulbs
- Baseline: (576) 32 watt T8 bulbs
- Apartment complex with (274) units, each unit has (2) program bulbs in the kitchen. The total installed in kitchens is (548). The remaining (28) are installed in the maintenance storage area, kitchen, and bathroom. The assumption for tracking hours of use are (3380) and the logged average hours of use are (3276).
- **Site I1674**
- Facility Type: Court House
- Tracking: (15) PAR30 15 watt LED
- Onsite Actual: (15) PAR30 15 watt LED
- Baseline: (15) Halogen 50 watt
- Court House, the program bulbs are primarily installed in offices, open office areas, and one in a office closet. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1844).
- **Site L3036**
- Facility Type: Dining/Family
- Tracking: (4) MR16 8 watts LEDs, (64) PAR30 15 watt LED
- Onsite Actual: (4) PAR20 5.5 watt LED, (64) PAR30 15 watt LED
- Baseline: (48) 75 watt incandescent.
- Restaurant, the program bulbs are installed primarily in the dining area of the restaurant, and one in the foyer. The MR16s in tracking were not found and the correct quantity of PAR20s replaced the MR16s. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2699).
- **Site L3686**
- Facility Type: School/University
- Tracking: (91) PAR38 14 watt LED
- Onsite Actual: (43) PAR38 14 watt LED, (48) PAR30 15 watt LED
- Baseline: (43) 60 watt incandescent, (48) 250 watt metal halide
- School, the program bulbs are installed in classrooms, the library, and the auditorium. The quantities match up but PAR30 LED bulbs were included with the PAR38 LED bulbs. The PAR38 LED bulbs are installed in the classrooms and library. The PAR30 LED lamps are installed in the auditorium. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2569).
- **Site L3693**
- Facility Type: Retail
- Tracking: (6) PAR38 14 watt LED, (30) PAR30 15 watt LED
- Onsite Actual: (2) PAR38 14 watt LED
- Baseline: (36) 23 watt LED

- Retail store, two of the program PAR38 bulbs are installed in the retail section. The remaining of the program bulbs are not installed. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2575).
- **Site L0029**
- Facility Type: Workshop
- Tracking: (6) 28 watt T8 lamps
- Onsite Actual: (4) 28 watt T8 lamps
- Baseline: (4) 32 watt T8 lamps
- Airport hangar, the site received six 28 watt T8 bulbs and installed four in a hangar. They replaced 32 watt T8 bulbs. The assumption for tracking hours of use are (3380) and the logged average hours of use are (1405).
- **Site L0082**
- Facility Type: School/University
- Tracking: (3420) 28 watt T8 bulbs
- Onsite Actual: (2437) 28 watt T8 bulbs
- Baseline: (3420) 32 watt T8 bulbs
- School, the program bulbs are primarily installed in classrooms. (1648) T8 bulbs are installed in classrooms, (242) in hallways, and the remaining (547) are installed in offices, teacher's lounge, maintenance areas, and the library. (459) are in storage onsite and (524) are stored at a different school. The assumption for tracking hours of use are (3380) and the logged average hours of use are (2634).
- **Site L0114**
- Facility Type: School/University
- Tracking: (48) 28 watt T8 bulbs
- Onsite Actual: (4) 28 watt T8 bulbs
- Baseline: (48) 32 watt T8 bulbs
- School, (4) of the program bulbs are installed in a hallway. The hallway has (48) sockets and the program bulbs are intended for this space. The site contact is using the program bulbs on an as needed basis which explains why (4) have been used. The remaining (44) are in storage and will be used in the future. The assumption for tracking hours of use are (3380) and the logged average hours of use are (2492).
- **Site L0135**
- Facility Type: Healthcare-Clinic
- Tracking: (880) 28 watt T8
- Onsite Actual: (880) 28 watt T8
- Baseline: (880) 32 watt T8
- Healthcare facility, the program bulbs are installed throughout the 4th, 5th, and 6th floor of the building. The assumption for tracking hours of use are (3380) and the logged average hours of use are (4260).
- **Site L0649**
- Facility Type: Office
- Tracking: (6540) 28 watt T8 bulbs
- Onsite Actual: (3235) 28 watt T8 bulbs



- Baseline: (6540) 32 watt T8 bulbs
- Office, (3235) of the tracking (6540) bulbs are installed. The contractor that installed the bulbs claims he only purchased the (3235). There was extensive time spent going through invoices to come to this result. This is an office building, most of the program bulbs are installed in open office areas, private offices, and conference rooms. The remaining bulbs are installed in hallways, kitchens, and mechanical rooms. The assumption for tracking hours of use are (3380) and the logged average hours of use are (2907).

- **Site L1191**
- Facility Type: School/University
- Tracking: (6600) 28 watt T8 lamps
- Onsite Actual: (5947) 28 watt T8 lamps
- Baseline: (6600) 32 watt T8 lamps
- This site is two schools connected. (5947) of the (6600) program bulbs are installed in the schools. The remaining (653) are in storage. The majority (3286) of the installed program bulbs are installed in classrooms. (1215) program bulbs are installed in offices, bathrooms, lobbies, closets, stairwells, and halls. (1226) programs bulbs are installed in libraries, kitchen, teacher's lounges, and cafes. The assumption for tracking hours of use are (3976) and the logged average hours of use are (1900).

- **Site 0667**
- Facility Type: Schools/University
- Tracking: (4020) 28 watt T8 bulbs
- Onsite Actual: (2449) 28 watt T8 bulbs
- Baseline: (4020) 32 watt T8 bulbs
- This school has (1760) of the program bulbs installed in classrooms. (120) of the program bulbs are installed throughout the cafe, teacher's lounge, and kitchen. The library has (68) of the program bulbs installed. The offices in total have (63) of the program bulbs installed. (438) of the program bulbs are installed in maintenance areas, hallways, and bathrooms. (1571) of the program bulbs are not installed. The assumption for tracking hours of use are (3380) and the logged average hours of use are (1145).

- **Site L1505**
- Facility Type: Schools/University
- Tracking: (115200) 28 watt T8 bulbs
- Onsite Actual: (1950) 28 watt T8 bulbs
- Baseline: (115200) 32 watt T8 bulbs
- This school has program bulbs for this site have been divided amongst different buildings and most of the program bulbs are in storage. (1160) program bulbs are installed in classrooms, (736) in halls, and (54) in the main office. There are (1680) stored in the maintenance building, (110,880) stored in the town municipal warehouse, and (736) stored in the high school.

- **Site L1532**
- Facility Type: Office
- Tracking: (60) 28 watt T8 bulbs
- Onsite Actual: (60) 28 watt T8 bulbs
- Baseline: (60) 32 watt T8 bulbs
- Office with open area space and private offices. All (60) of the program bulbs are installed. The assumption for tracking hours of use are (3380) and the logged average hours of use are (1761).

- **Site L1866**
 - Facility Type: Dining/Bar
 - Tracking: (21) PAR30 15 watt LED
 - Onsite Actual: (3) PAR30 15 watt LED, (16) PAR30 12 watt LED
 - Baseline: (21) 60 watt incandescent
 - This site is a bar and the actual onsite program bulbs were found to be 15 watt and 12 watt LED PAR30s. Two of the 15 watt PAR30 lamps burned out before the on-site visit. (3) PAR30 15 watt LED, (16) PAR30 12 watt LED are installed in the bar seating area. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4775).

- **Site L1920**
 - Facility Type: School/University
 - Tracking: (52) PAR30 15 watt LED, (113) PAR38 14 watt LED
 - Onsite Actual: (40) PAR30 15 watt LED, (23) PAR38 18 watt LED
 - Baseline: (52) 75 watt halogen, (113) 100 watt halogen
 - Notes: (12) of the PAR30 LED and (90) of the PAR28 LED program bulbs are in storage. The site contact had issues with using them with dimmers. (40) PAR30 program bulbs are installed in the auditorium and (23) of the PAR38 LED bulbs are installed in the art room, bathroom, and lobby. The assumption for tracking hours of use are (4500) and the logged average hours of use are (354).

- **Site L2113**
 - Facility Type: Hotel
 - Tracking: (198) 17 watt LED A bulbs
 - Onsite Actual: (149) 8 watt LED A bulbs
 - Baseline: (198) 90 watt halogen
 - This hotel has (31) of the program lamps installed in the lobby area and cafe. (118) of the program bulbs are installed in salons and meeting rooms. (49) Program bulbs are not installed. The assumption for tracking hours of use are (2800) and the logged average hours of use are (4932).

- **Site L2142**
 - Facility Type: School/University
 - Tracking: (9) 17 watt LED A bulbs, (100) PAR30 15 watt LED
 - Onsite Actual: (9) 8 watt LED A bulbs, (100) PAR30 12 watt LED
 - Baseline: (9) 60 watt incandescent bulbs, (100) 75 watt halogen
 - The University has the program bulbs spread through the campus. Many buildings were visited to find the program bulbs. The assumption for tracking hours of use are (4365) and the logged average hours of use are (5186).

- **Site L2275**
 - Facility Type: Retail
 - Tracking: (15) MR16 8 watt LED, (90) PAR30 15 watt LED, (6) PAR38 14 watt LED
 - Onsite Actual: (15) MR16 5.6 watt LED, (86) PAR30 15 watt LED, (6) PAR38 20 watt LED
 - Baseline: (15) 50 watt halogen, (96) 90 watt halogen
 - This retail store has the program MR16 bulbs installed in the display windows. The PAR30 are installed throughout the two showrooms. (4) program PAR30s are not installed. The (6) PAR38 bulbs are installed outside on the store sign. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3057).

- **Site L2409**
 - Facility Type: Religious building
 - Tracking: (24) 17 watt LED A bulbs
 - Onsite Actual: (24) 12 watt LED A bulbs
 - Baseline: (24) 60 watt incandescent bulbs
 - This religious building has all (24) 12 watt LED bulbs installed in the main room. The assumption for tracking hours of use are (2800) and the logged average hours of use are (1740).

- **Site L2529**
 - Facility Type: Retail
 - Tracking: (156) PAR30 15 watt LED, (336) PAR38 14 watt LED
 - Onsite Actual: (156) PAR30 15 watt LED, (336) PAR38 18 watt LED
 - Baseline: (156) 75 watt halogen, (336) 100 watt halogen
 - This retail store has all program bulbs installed and they are located in the showroom. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3387).

- **Site L2658**
 - Facility Type: Religious building
 - Tracking: (6) PAR30 15 watt LED
 - Onsite Actual: (6) PAR30 12 watt LED
 - Baseline: (6) 75 watt halogen
 - This building has the program bulbs installed in the office hallway and the kitchen. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1917).

- **Site L2719**
 - Facility Type: Office
 - Tracking: (144) PAR30 15 watt LED
 - Onsite Actual: (110) PAR30 15 watt LED
 - Baseline: (144) 13 watt CFL
 - The program bulbs are installed in the foyer and hallway. They are on all day, seven days a week. The assumption for tracking hours of use are (4500) and the logged average hours of use are (8760).

- **Site L2771**
 - Facility Type: Workshop
 - Tracking: (14) PAR38 14 watt LED
 - Onsite Actual: (6) PAR38 14 watt LED
 - Baseline: (14) 90 watt halogen
 - This workshop has (5) PAR38 14 watt LED installed in outside floodlights, and (1) installed in a hallway. The assumption for tracking hours of use are (4500) and the logged average hours of use are (643).

- **Site L2796**
 - Facility Type: Restaurant
 - Tracking: (75) PAR30 15 watt LED
 - Onsite Actual: (75) PAR30 15 watt LED
 - Baseline: (75) 65 watt incandescent

- This restaurant has the (75) program bulbs installed in the dining and bar area of the restaurant. They have experienced issues with the bulbs flickering when in use with dimmers. The assumption for tracking hours of use are (4500) and the logged average hours of use are (6347).
- **Site L2869**
- Facility Type: Fast food
- Tracking: (15) PAR30 15 watt LED
- Onsite Actual: (15) PAR30 15 watt LED
- Baseline: (15) 75 watt halogen
- This fast food store has the (15) program bulbs installed at the cashier and food line. The assumption for tracking hours of use are (4500) and the logged average hours of use are (6356).
- **Site L3222**
- Facility Type: Office
- Tracking: (6) decorative 5 watt LED, (16) 17 watt LED A lamps, (34) PAR38 14 watt LED
- Onsite Actual: (4) decorative 3 watt LED, (10) 12 watt LED A lamps, (25) PAR38 14 watt LED
- Baseline: New construction.
- This office area is new construction therefor the evaluation assumed the same baseline. (2) of the decorative 5 watt LED, (6) 17 watt LED A lamps, and (9) PAR38 14 watt LED have not been installed. The PAR38 bulbs are located in three different offices and the remaining program bulbs are installed in the hallways/entry way. The assumption for tracking hours of use are (4023) and the logged average hours of use are (2583).
- **Site L3459**
- Facility Type: Hotel
- Tracking: (150) 17 watt LED A lamps
- Onsite Actual: (150) 12 watt LED A lamps
- Baseline: (150) 100 watt incandescent
- The program LED A lamps are all installed. (109) of the program bulbs are installed in the foyer and hallways. The remaining (41) are installed in the banquet room and AV closet. The assumption for tracking hours of use are (2800) and the logged average hours of use are (5824).
- **Site L3460**
- Facility Type: Retail
- Tracking: (109) PAR20 8 watt LED, (11) PAR38 14 watt LED
- Onsite Actual: (109) PAR20 7 watt LED, (11) PAR38 20 watt LED
- Baseline: (109) 50 watt halogen, (11) 90 watt halogen
- This retail store has all program bulb installed. The bulbs are installed in the showroom area. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2733).
- **Site L3510**
- Facility Type: Hotel
- Tracking: (220) PAR30 15 watt LED, (130) PAR20 8 watt LED, (40) MR16 8 watt LED, (50) PAR38 14 watt LED.
- Onsite Actual: (220) PAR30 15 watt LED, (130) PAR20 8 watt LED, (40) MR16 8 watt LED, (50) PAR38 14 watt LED.

- Baseline: (220) 100 watt incandescent, (130) 75 watt halogen, (40) 50 watt metal halide, (50) 90 watt halogen.
- This hotel has all the program bulbs installed. (210) program bulbs are installed in meeting rooms and suites. (230) program bulbs are installed in the lobby area, restaurant, and bathroom. The assumption for tracking hours of use are (4499) and the logged average hours of use are (2793).
- **Site L3835**
- Facility Type: Transportation
- Tracking: (10) PAR38 14 watt LED
- Onsite Actual: (10) PAR38 17 watt LED
- Baseline: (10) 150 watt halogen
- The program bulbs are installed outside. The assumption for tracking hours of use are (4500) and the logged average hours of use are (4380).
- **Site L3918**
- Facility Type: Exercise Center
- Tracking: (12) 12 watt LED A lamps
- Onsite Actual: (0) 12 watt LED A lamps
- Baseline: (12) 60 watt incandescent
- The program bulbs have not been installed. They will replace 60 watt incandescent A-lamps. The assumption for tracking hours of use are (2800) and the logged average hours of use are (0). This site was not logged because the program bulbs have not been installed.
- **Site L3985**
- Facility Type: Hospital
- Tracking: (12) PAR30 15 watt LED, (6) PAR20 8 watt LED, (20) PAR38 14 watt LED
- Onsite Actual: (12) PAR30 15 watt LED, (6) PAR20 8 watt LED, (20) PAR38 14 watt LED
- Baseline: (12) 65 watt incandescent, (6) 50 watt incandescent, (20) 90 watt halogen
- The program bulbs are all installed. The PAR30 LED bulbs are installed in the doctors lounge. The PAR20 LED bulbs are also installed in the doctor's lounge. The PAR38 LED bulbs are installed in the radiology room. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2889).
- **Site 4161**
- Facility Type: Retail
- Tracking: (60) 17 watt LED A lamps, (52) PAR38 14 watt LED
- Onsite Actual: (60) 8 watt LED A lamps, (52) PAR38 19.5 watt LED
- Baseline: (60) 60 watt incandescent, (52) 75 watt halogen
- The (31) A-lamps and (program bulbs are installed outside of this multi retail store establishment. The assumption for tracking hours of use are (3671) and the logged average hours of use are (6193).
- **Site L4185**
- Facility Type: School/University
- Tracking: (176) PAR38 14 watt LED, (64) PAR30 15 watt LED, (6) 17 watt LED A-lamps
- Onsite Actual: (176) PAR38 18 watt LED, (30) PAR30 15 watt LED, (6) 12 watt LED A-lamps
- Baseline: (176) 100 watt incandescent, (64) 75 watt incandescent, (6) 100 watt incandescent
- This university has the PAR38s primarily installed in presentation room, halls, and classrooms. The PAR30 LED lamps are installed in the lobby and hallways. The program bulbs are spread throughout

various buildings on the main campus and a satellite campus. The assumption for tracking hours of use are (4453) and the logged average hours of use are (3300).

- **Site L4274**
- Facility Type: Parking garage
- Tracking: (62) PAR38 14 watt LED
- Onsite Actual: (62) PAR38 18 watt LED
- Baseline: (62) 90 watt halogen
- This parking garage has the program bulbs installed outside but covered by the garage roof. This is where the buses enter and exit and the bulbs are on all the time. The assumption for tracking hours of use are (4450) and the logged average hours of use are (8755).

- **Site L4288**
- Facility Type: School/University
- Tracking: (42) PAR30 15 watt LED
- Onsite Actual: (42) PAR30 15 watt LED
- Baseline: (42) 26 watt CFL
- This university has the program bulbs installed outside around the base of a building. They are embedded into the ground to project up on the walls of the building. Unable to installed loggers due to surrounding environment. Photocell data was used since these program bulbs are controlled by a photocell lighting system. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3729).

- **Site L4485**
- Facility Type: Hotel
- Tracking: (530) PAR30 15 watt LED
- Onsite Actual: (139) PAR30 15 watt LED
- Baseline: (530) 15 watt CFL
- This site consists of three hotels, a bowling alley, and a candy store. The original contact had moved on to a different job before the audit. In one of the hotels the program bulbs were located in bathrooms. (139) program bulbs are installed. The remaining (391) were not found and multiple contacts at the various buildings did not know the location or if they had received the total quantity. The multiple contacts include the business department and the maintenance staff. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2098).

- **Site L4575**
- Facility Type: Office
- Tracking: (216) PAR30 15 watt LED, (121) PAR38 14 watt LED, (6) 17 watt LED A-lamps
- Onsite Actual: (164) PAR30 15 watt LED, (60) PAR38 14 watt LED, (6) 17 watt LED A-lamps
- Baseline: (164) 90 watt halogen, (83) 90 watt halogen, (6) 100 watt incandescent
- This is a large office building. The majority of the program bulbs are installed. (52) Program PAR30 LED bulbs are not installed. (38) program PAR38 LED bulbs are not installed. The non-installed bulbs are in storage for later use. The (6) LED A-lamps are installed in the daycare. (112) PAR30 LED bulbs are installed in showrooms throughout the building. (52) PAR30 LED bulbs are installed in the main (spine) hallway. The assumption for tracking hours of use are (4473) and the logged average hours of use are (3337).

- **Site L4668**

- Facility Type: Religious building
- Tracking: (310) PAR30 15 watt LED, (196) 17 watt LED A-lamps, (16) PAR20 8 watt LED, (162) PAR38 14 watt LED.
- Onsite Actual: (102) PAR30 11 watt LED
- Baseline: New construction being added to existing building.
- The majority of program bulbs were not installed at time of audit. This is a (old) church and a new larger church is being added to the same building. There is a school that is located in the older part of the building. The installed program PAR30 LED bulbs are installed in the old church. (46) are located in the foyer of the old church, (22) in the old church, and (34) outside in ground fixtures that project towards landscape tree and the building. The non-installed program bulbs will be installed in the new church when it is completed. The assumption for tracking hours of use are (4048) and the logged average hours of use are (1343).

- **Site L4680**
- Facility Type: School/University
- Tracking: (104) PAR38 14 watt LED
- Onsite Actual: (101) PAR38 14 watt LED
- Baseline: (104) 100 watt halogen
- The program bulbs are installed in the two church rooms. (3) program bulbs are in storage for later use. The assumption for tracking hours of use are (4500) and the logged average hours of use are (939).

- **Site L4953**
- Facility Type: School/University
- Tracking: (64) 17 watt LED A-lamp, (20) MR16 8 watt LED, (33) PAR38 14 watt LED
- Onsite Actual: (64) 17 watt LED A-lamp, (20) MR16 8 watt LED, (33) PAR38 14 watt LED
- Baseline: (64) 13 watt CFL, (20) 50 watt halogen, (33) 90 watt incandescent
- The (64) LED A-lamps are installed in a music/theatre. The (20) MR16 LED lamps are installed in a gift shop. The (33) PAR38 lamps are installed in a different theatre than the A-lamps. The assumption for tracking hours of use are (3563) and the logged average hours of use are (1641).

- **Site L5052**
- Facility Type: School/University
- Tracking: (303) PAR30 15 watt LED, (136) PAR38 14 watt LED, (74) PAR20 8 watt LED
- Onsite Actual: (265) PAR30 15 watt LED, (92) PAR38 14 watt LED
- Baseline: (303) 23 watt CFL, (136) 23 watt CFL
- This site consists of two large rooms for worship, office areas, small school, and a large ballroom. The program bulbs are installed throughout these areas. The following program bulbs are not installed, (74) PAR20s, (38) PAR30s, and (44) PAR38s. They are stored for later use. The school and the smaller of the two worship areas are used often and the large worship room is used on special holidays. The assumption for tracking hours of use are (4500) and the logged average hours of use are (475).

- **Site L5233**
- Facility Type: Dining/Bar - Manufacturing
- Tracking: (30) PAR30 15 watt LED
- Onsite Actual: (18) PAR30 15 watt LED
- Baseline: (30) 75 watt halogen



- This site proved difficult. The program bulbs were purchased by an electrician and installed at various projects. (15) Program bulbs were installed in a restaurant/bar. (3) Program bulbs were installed at a manufacturing company; they are installed inside of robotic plastic molding machines. (12) Program bulbs were not found at either of the two sites visited. A third site was visited which had the correct quantity of PAR30s but they were not the program bulbs. The assumption for tracking hours of use are (4500) and the logged average hours of use are (5183).

- **Site L5586**
- Facility Type: Retail
- Tracking: (300) PAR30 15 watt LED
- Onsite Actual: (57) PAR30 15 watt LED
- Baseline: (300) 75 watt halogen
- This retail store has two display rooms. There is a mix of LED, halogen, and incandescent bulbs. The bulbs are mixed throughout the two rooms. The idea is that the blend of the three bulb types is better quality than the LEDs alone. (57) are installed, (149) verified in the back room storage area, and the remaining (94) were not found and the manager did not know where they went. The assumption for tracking hours of use are (4500) and the logged average hours of use are (3453).

- **Site 5361**
- Facility Type: Retail
- Tracking: (70) PAR20 8 watt LED
- Onsite Actual: (70) PAR20 7 watt LED – (20 installed but not in use)
- Baseline: (20) 50 watt halogen, (20) 40 watt T12, (16) 60 watt incandescent
- The program bulbs are installed in the first floor of the store. There are (50) program bulbs installed and in use. There are (20) that are installed in a new construction residential area on the second floor which were not in use at the time of the site visit. The program bulbs took the place of 50 watt halogen lamps and 40 watt T12 fluorescent tubes. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2876).

D. Post-Report Analysis of Lighting Distributor/Contractor Interviews, Final Revised Memorandum

D.1 Background

In June 2013 DNV KEMA issued the Final Report for the Process Evaluation of the 2012 Bright Opportunities Program (Process Evaluation).⁸ Key sources of information for this process evaluation included in-depth interviews with both lighting distributors who participated in the Bright Opportunities program and those who did not, as well as participating lighting installation contractors. The evaluators interviewed the participating distributors during the November-December 2012 period, the nonparticipating distributors in December 2012 through February 2013 period, and the participating installation contractors during the February-March 2013 period.

In commenting on the draft process evaluation report, a couple of Energy Efficiency Advisory Council (EEAC) and Program Administrator (PA) representatives expressed interest in learning more about the sales characteristics of the lighting distributors than was available in the Process Evaluation report. Due to the time constraints imposed by the PA's Annual Report deadlines, this additional analysis could not be completed in time for inclusion in the final version of the Process Evaluation report. However, evaluators proposed that this analysis be conducted after the Process Evaluation report and submitted as a separate "post analysis" memorandum. After this post-analysis memorandum had been reviewed and finalized, it would be submitted as an appendix to the Impact Evaluation Report for the Bright Opportunities Program. The EEAC and PA representatives who had requested this additional analysis accepted this proposal.

D.2 The Scope of the Post-Analysis

The EEAC and PA representatives who requested the additional analysis of lighting distributor interview responses posed the following researchable questions:

- Among distributors with sales in multiple states, what sales figures did they report for each state?
- What are the differences between participants and nonparticipants in terms of products sold?
- For distributors who reported selling to other states, what is their MA market share?

DNV KEMA attempts to address these questions below.

⁸ *Process Evaluation of the 2012 Bright Opportunities Program*, Final Report, Massachusetts LCIEC Project 17 Prepared by KEMA, Inc., June 14, 2013

D.3 Findings

This section discusses the key findings from our post-report analysis of the lighting distributor and lighting contractor interview responses.

D.3.1 Summary

Our post-report analysis of the lighting distributor and lighting contractor interview responses was only able to collect limited information to try to answer the questions posed by the EEAC and PA representatives. This was partly due to the fact that many lighting distributors were unable or unwilling to provide estimates of their annual sales revenue. Another factor was that the participating and nonparticipating distributor interview guides were not designed to answer some of the questions that EEAC and PA representatives were curious about. Finally, as indicated in the main report, the small sample of nonparticipating lighting distributor interviews closed off some possible paths of analysis.

Yet in the process of reanalyzing the lighting distributor and lighting contractor interview responses, we were able to collect some additional useful information about the Massachusetts lighting market which we did not cover in the main report. This additional information includes:

- How lighting distributors who reported different levels of LED market penetration of their spotlight/floodlight sales in Massachusetts vs. other states explained these differences;
- What percentage of lighting distributor LED sales in Massachusetts over the past year were through the Bright Opportunities program and what percentage were outside the program;
- Why lighting distributors did not sell all their LED products through the Bright Opportunities Program;
- What factors the lighting distributors thought caused the increase in LED spotlight/floodlight market share over the last couple of years; and
- Whether participation in the Bright Opportunities program influenced the mix of lighting products that lighting contractors were selling.

Most of this new information lends support to the evidence already presented in the main report as to the importance of the Bright Opportunities Program in increasing LED sales in the Massachusetts C&I market.

D.3.2 Among distributors with sales in multiple states, what sales figures did they report for each state?

One of the follow-up researchable questions posed by the EEAC and PA representatives was among distributors with sales in multiple states, what sales figures they reported for each state. While we did ask the lighting distributors to estimate their company's annual sales, we did not ask respondents to directly report sales figures by state. In addition, many respondents were unwilling to provide estimates of annual sales. Of the 25 participating distributors interviewed, only 14 provided estimates of annual sales. Of the eight nonparticipating distributors we interviewed, only two provided estimates of annual sales. The average response was over \$40 million in sales per year for participating distributors, \$915,000 for nonparticipants. We also asked the distributors to estimate what percentage of their annual sales was from lighting. The average estimate was 57 percent for the participating distributors (n=21) and 71 percent for nonparticipating distributors (n=4).

The evaluators also asked nonparticipating distributors if they sold lighting products outside of Massachusetts. Only four of the eight said that they did. When asked in what states, their responses were:

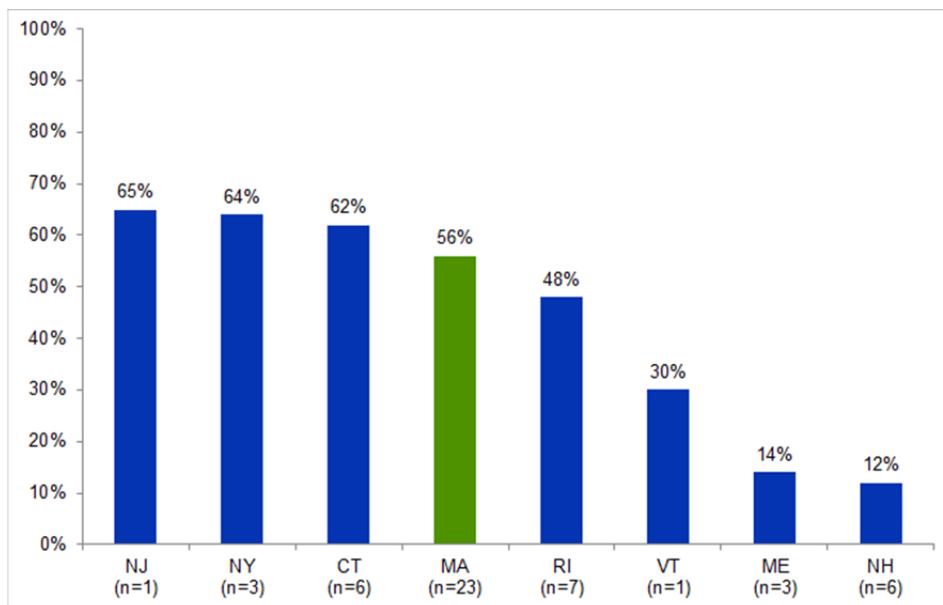
- All of them (two respondents);
- New Hampshire, Rhode Island; and
- All of New England, plus New York, Florida, California and Georgia.

There was also a fifth nonparticipating lighting distributor who indicated that they very occasionally sell lighting products to Rhode Island, but this happened rarely enough that they did not think it qualified them as selling lighting products outside of Massachusetts.

While we did not ask lighting distributors to estimate their annual sales inside Massachusetts vs. other states, we did collect some comparative data on the market penetration of LEDs in the spotlight/floodlight market. We asked the lighting distributors to estimate what percentage of the flood lights/spotlights they sold in Massachusetts were LEDs. We also asked those who sold lighting products outside of Massachusetts to estimate what percentage of the flood lights/spotlights they sold in other states were LEDs.

Figure 1 shows their responses (this figure was listed in the Process Evaluation report as Figure 4-30). Yet due to the small sample sizes, only the difference between the Massachusetts and the New Hampshire estimates was statistically significant.

Figure 1: LEDs as Percent of Floodlight Sales by State



**Only NH is statistically significantly different from Massachusetts at the 90% confidence interval*

If the lighting distributor had provided estimates of LED spotlight/floodlight sales penetration for both Massachusetts and another state and these estimates were different, we asked the follow up question:

You indicated that you are selling a [HIGHER/LOWER] percentage of your flood light/spotlights in Massachusetts compared to these other states. What factors do you think might explain these differences?

Ten respondents were asked this question due to a difference between their Massachusetts estimate and their estimate for another state. All of those respondents indicated that differences were due to rebates or “programs.”

Following an early draft of this memorandum, one commenter requested further clarification on the responses and distribution of individual participating distributors. The main intent of this inquiry was to determine if there were any compositional effects such as a state appearing to have higher LED market penetration simply because the distributors who sell in that state have a higher global market share. Table 29 shows this breakdown. Comparing the average market share with the sales-weighted market share shows that due to the small sample sizes, the impact of a single large distributor with a high LED market share had a larger effect on increasing the LED market share on New Jersey, New York, and Connecticut than it did for Massachusetts. Therefore on a straight average basis, Massachusetts has the larger LED market share of any northeastern state with the exception of New Jersey and its single data point.



Table 29: LEDs as Percent of Floodlight Sales by State

	NJ	NY	CT	MA	RI	VT	ME	NH
A				10%				
B			20%	75%	92%			
C			0%	20%	0%			0%
D				0%				
E					0%			0%
F				65%	65%		20%	20%
G				60%		30%	5%	5%
H				50%				
I								
J				68%				
K		10%	35%	10%	10%			
L								
M				60%				
N	65%	65%	65%	65%				
O				30%			10%	10%
P			5%	25%	40%			
Q				50%				5%
R				30%				
S		10%	10%	50%				
T				50%				
U				40%				
V								
W				90%				
X				15%	15%			
Average	65%	28%	23%	43%	32%	30%	12%	7%
Weighted Average	65%	64%	62%	56%	48%	30%	14%	12%

*Rows are blank where respondents did not know or were not able to respond to the question.

**Weighted average was determined by using sales units in the program as the weighting proxy.

D.3.3 What are the differences between participants and nonparticipants in terms of products sold?

Another one of the follow-up researchable questions posed by the EEAC and PA representatives was what differences existed between the participating and nonparticipating distributors in terms of products sold. Unfortunately the lighting distributor interview guides, both for participating and nonparticipating lighting distributors, did not allow us to fully address this question. We did ask the nonparticipating lighting distributors to estimate what percentage of their total 2012 lighting sales were represented by the kind of lighting products (e.g., LED bulbs, low-wattage linear fluorescents) that were rebated by the



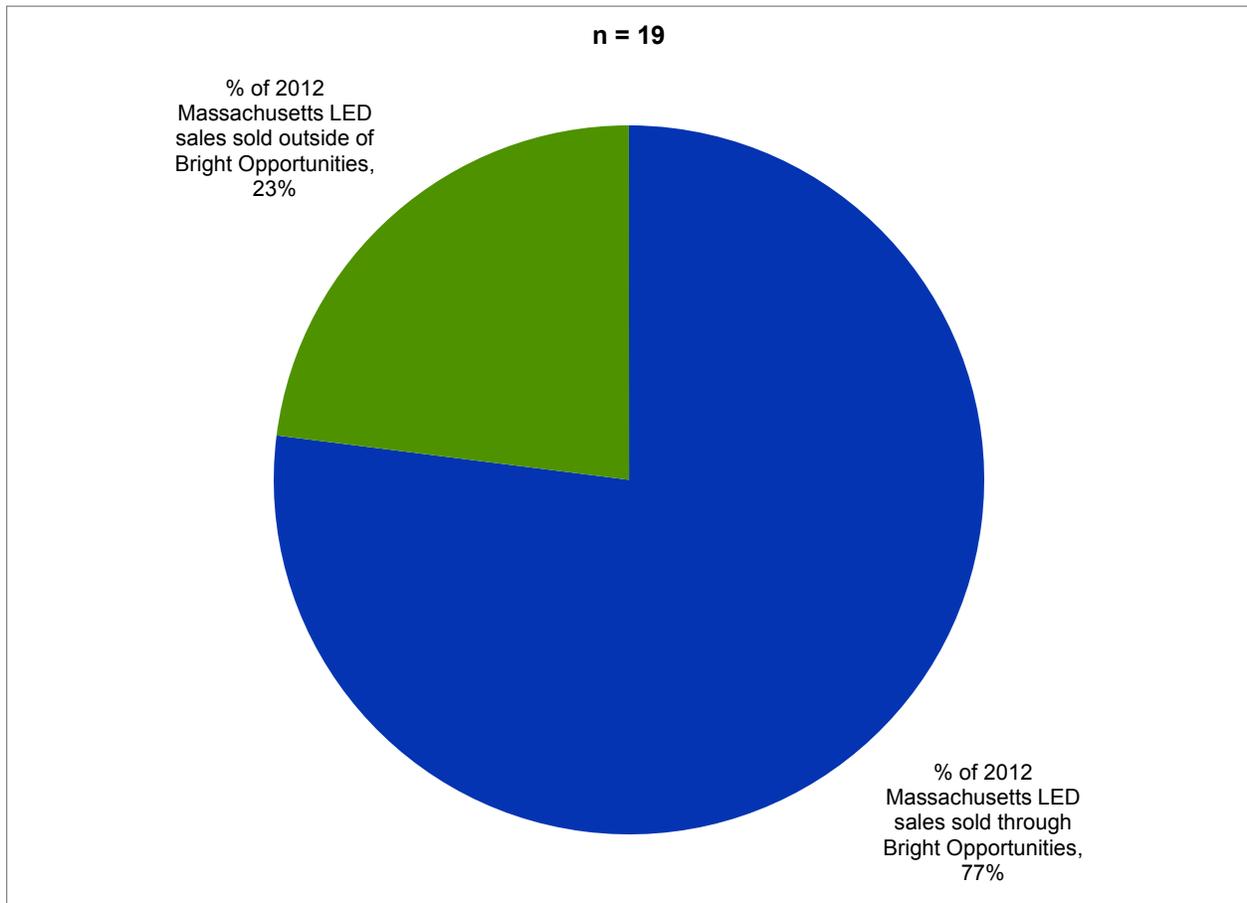
program. Yet we did not ask the same question of participating lighting distributors. We instead asked the participating distributors to verify the quantities of LED bulbs and/or low-wattage linear fluorescents that the tracking data indicated that they sold through the Bright Opportunities program.

However, we did collect some information about the participating distributors' non-program sales including:

1. We asked them to estimate what percentage of their LED sales in Massachusetts over the past year were through the Bright Opportunities program and outside the program; and
2. We asked them what percentage of the spotlights/floodlights they currently sell in Massachusetts, they sold a year ago, and they sold two years ago are/were LED bulbs.

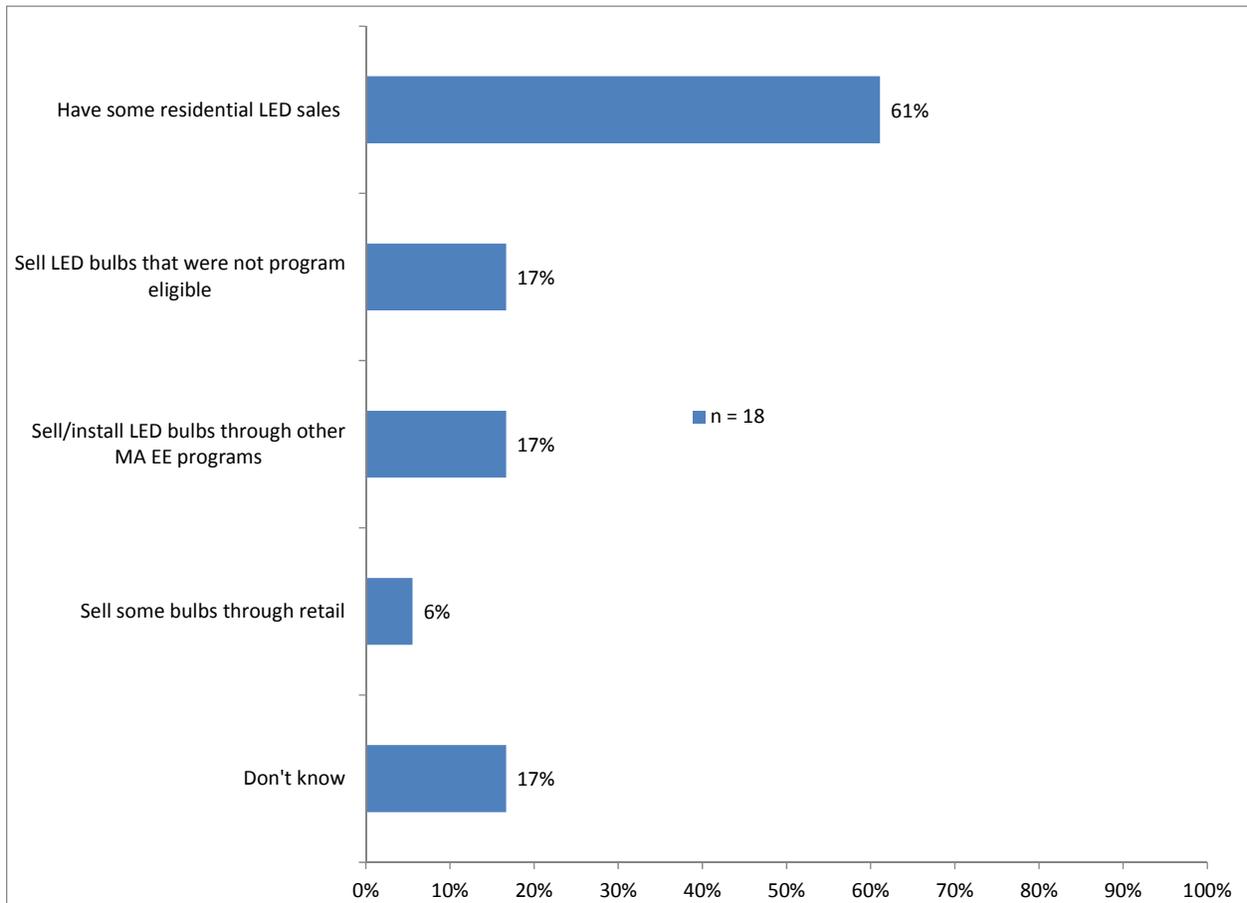
The responses of participating distributors to the first set of questions indicated that the program-discounted LED bulbs have been dominating the Massachusetts LED sales of these participants. Figure 2 shows that participating lighting distributors reported, on average, that over three quarters (77%) of their LED sales were through the program in 2012. Only three of the nineteen respondents said they had more of their Massachusetts LED sales outside the program than through the program.

Figure 2: Participating Lighting Distributor 2012 LED Sales, Program vs. Non-Program



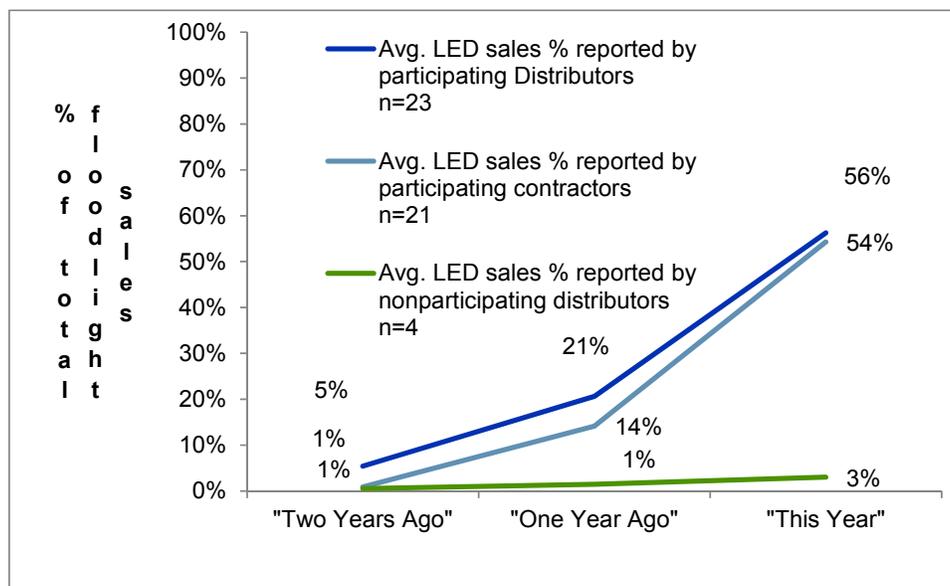
Because the discounts through the Bright Opportunities program were so large, we were curious why these lighting distributors did not sell *all* their LED bulbs through the program. So we asked them this question. Figure 3 shows that the most common response, by far, was that the participating lighting distributors had some sales to residential customers who did not qualify for the Bright Opportunities Program. Other reasons included selling LED products that were not program eligible (e.g., outdoor lighting, wall packs, office space lighting, floodlights in enclosed fixtures), selling or installing LEDs through other Massachusetts energy efficiency programs (e.g. direct install), and selling LEDs through their own retail spaces.

Figure 3: Why Participating Lighting Distributors Did Not Sell All LED Bulbs Through Program



As noted above, we also asked them what percentage of the spotlights/floodlights they currently sell in Massachusetts, they sold a year ago, and they sold two years ago are/were LED bulbs. Since we posed this last group of questions to both participating and nonparticipating distributors, as well as participating contractors, this allowed us to compare the responses of the different groups. Figure 4 compares the average self-reported LED floodlight market penetration of participating distributors and nonparticipating distributors over time. This figure also appeared in the process evaluation report as Figure 1-4.

Figure 4: LED Floodlight/Spotlight Market Penetration Over Time



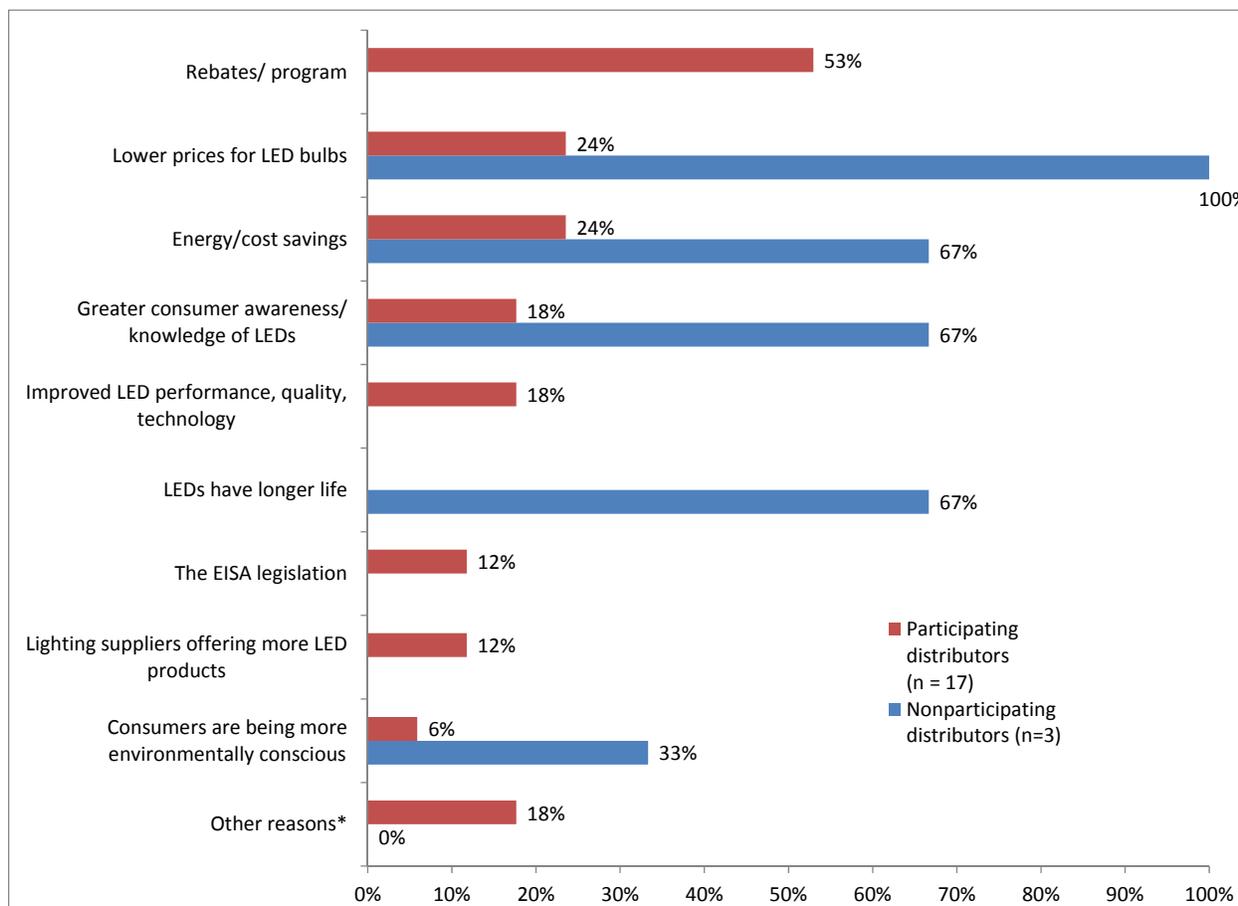
One new finding, which we did not include in the process evaluation report, was how lighting distributors responded to the open-ended follow-up question:

[IF THE PERCENTAGE CHANGED OVER TIME] What factors do you think are influencing these changes in LED market share for these lighting technologies?

We posed this question to the seventeen participating and three nonparticipating lighting distributors who reported some change in their LED floodlight market penetration over time.

Figure 5 shows the factors which lighting distributors cited as influencing changes in their LED market share for floodlight/spotlight sales. Among participating lighting distributors the most-cited factor, by far, was the existence of the program and its rebates with over half of the respondents citing this as a factor. About a quarter of participating distributors also cited lower prices for LED bulbs (which may also be program-related, although nonparticipants also cited this factor) and the desire of customers to save energy/money with the LED bulbs. The participants also cited over a half dozen other reasons, with the EISA legislation’s phase-out of less efficient incandescent bulbs being one of them (12% of responding participants).

Figure 5: Factors Influencing LED Floodlight/Spotlight Market Penetration Over Time



Note: The total percentages exceed 100% because respondents were allowed to identify multiple factors. *Other reasons included

For the very small sample (n=3) of nonparticipating distributors who reported changes in their LED market share for floodlight/spotlight sales, reasons cited by multiple respondents included lower prices for LED bulbs, the opportunity for consumer energy/cost savings, greater consumer awareness/knowledge of LEDs, and the fact that LEDs have longer lives which can reduce maintenance costs.

A related finding which we did not present in the process evaluation report is whether the participating lighting contractors reported being influenced by their participation in the program. We asked the participating contractors: “Has your participation in Bright Opportunities had any impacts on the mix of lighting products that you sell or install?” Exactly half of the responding contractors (n=22) said their participation in the program had influenced their mix of lighting products. Most simply said that the program discounts allowed them to sell more of the LEDs to their customers. However, one contractor did say that since participating in the program, their company has shifted from a focus on fluorescents to a focus on LEDs.



D.3.4 For distributors who reported selling to other states, what is their MA market share?

Another one of the follow-up researchable questions posed by the EEAC and PA representatives concerned the Massachusetts market shares of distributor who reported selling LEDs to other states. There was only limited information we were able to gather to answer this question. Of the 18 participating distributors we interviewed who said they sold lighting products outside of Massachusetts, only 12 of them provided estimates of their annual revenue. Furthermore of the seven participating distributors who did not sell lighting products outside of Massachusetts, only two provided revenue estimates. So based on these small sample of 14 participating lighting distributors who reported their annual revenue, 12 of the 14 (85%) were selling lighting products outside of Massachusetts.

The participating distributors who sold lighting products outside of Massachusetts were on average larger than those who did not. Although they only accounted for 85 percent of those reporting annual revenue, the distributors who sold lighting products outside of Massachusetts accounted for 99 percent of the revenue reported by this group. They also accounted for 99 percent of the employees, which was another indicator of company size that we collected.