DNV·GL

Impact Evaluation of National Grid Rhode Island Commercial and Industrial Upstream Lighting Program

National Grid

Final Report
Date: August 15, 2014

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1 EXECUTIVE SUMMARY

1.1 Introduction

This report documents DNV GL's Impact Evaluation of National Grid Rhode Island's Commercial and Industrial Upstream Lighting Program. This impact evaluation was completed shortly after the impact evaluation of the Massachusetts Commercial and Industrial Upstream Lighting Program performed by DNV GL.[1] This impact evaluation was completed for National Grid and includes combined National Grid Massachusetts and National Grid Rhode Island results.

1.1.1 Program Description

The National Grid Rhode Island Upstream Lighting Program is a new 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. The program offers upstream incentives on linear fluorescent and LED lighting technologies. DNV GL received 2012 data for RI and therefore the evaluation covers that timeframe.

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 a third-party program manager. As part of the program, a third-party contractor performs quality control inspections for 5 percent of the sites to make sure that they can verify onsite the lighting quantities and types claimed in the distributor sales reports. The time of inspection ranges from a couple to several months after the date of purchase.

1.1.2 Purpose of Study

The research objectives of the impact evaluation of National Grid Rhode Island's Commercial and Industrial Upstream Lighting Program include updating the following assumptions:

- 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 2015 tracking estimates;
- Estimates of delta watts and hours of use.

National Grid Rhode Island plans to apply updated realization rates to 2015 planning assumptions.

[1] Impact Evaluation of the Massachusetts Upstream Lighting Program, Final Report, February 19, 2014, Prepared by DNV GL.

This report presents the following realization rates 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 for this study was designed in consideration of the 90% confidence level for energy (kWh) and the 80% confidence level for on-peak summer and winter demand savings.

1.1.3 Scope

The scope of work of this impact evaluation covered upstream lighting purchases made in National Grid service territory in Massachusetts and Rhode Island. In Massachusetts, two separate periods of upstream lighting purchases (November 2011 – April 2012 and May 2012 – November 2012) were used. This was due to the inability to recruit the full sample of sites from the initial Massachusetts sample design. In Rhode Island, data from the third party program manager covered the February 2012 through February 2013 timeframe and therefore the Rhode Island sample covered upstream lighting purchases made during that period. As shown in the table below the final sample size for this impact evaluation was 54 sites, including 42 LED sites and 12 Fluorescent sites; combining each state's results improved overall precisions when compared to completing a RI-only analysis.

Table 1. Final Sample by State and Product Type

State	Fluorescent	LED	Total
MA	7	32	39
RI	5	10	15
Total	12	42	54

1.2 Results

1.2.1 LED Results

Table 2 summarizes the National Grid MA and RI results of this analysis. In the case of annual kWh savings, the realization rate for LEDs was found to be 80.2% with HVAC interactive effects included. The relative precision for this estimate was found to be ±19.5% at the 90% level of confidence. Note that gross tracking savings did not include HVAC interactive effects. The error ratio was found to be 1.02, which was significantly higher than the estimated error ratio of 0.90.

Table 2: Summary of LED Energy Realization Rate

Savings Parameter	Energy - LED	
	kWh	% Gross
Gross Savings (Tracking)	37,217,887	
Documentation Adjustment	5,046	0%
Technology Adjustment	9,041,255	24%
Quantity Adjustment	-10,882,578	-29%
Operational Adjustment	-5,187,619	-14%
HVAC Interactive Adjustment	2,224,041	6%
Adjusted Gross Savings	29,857,843	80%
Gross Realization Rate	80.2%	
Relative Precision	±19.5%	
Confidence Interval	90%	
Error Ratio	102%	

Table 3 summarizes the National Grid MA and RI savings factors resulting from this analysis. All relative precisions were calculated at the 90% and 80% confidence levels. The on-peak summer coincidence factor was 60.6%, with a relative precision of ±11.8% at 80% confidence. The on-peak winter coincidence factor was 58.1%, with a relative precision of ±11.7% at 80% confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 3: Summary of LED Savings Factors

Savings Factors and Realization Rates	LED	
	Value	Precision
KW Factors (Precisions at 80% confidence)		
Installation Rate (Quantity Adjustment - kW)	70.1%	±9.5%
Delta Watts (Technology Adjustment - kW)	124.6%	±7.5%
Connected kW Realization Rate[2]	87.3%	±12.3%
Summer Coincidence Factor	60.6%	±11.8%
Winter Coincidence Factor	58.1%	±11.7%
Summer kW HVAC Interactive Effect	118.8%	±2.0%
Winter kW HVAC Interactive Effect	94.8%	±5.7%
KWh Factors (Precisions at 90% confidence)		
Connected kWh Realization Rate	88.0%	±15.8%
KWh HVAC Interactive Effect	106.0%	±3.1%
Hours of Use Realization Rate	86.1%	±18.0%
% On Peak KWh	60.5%	±5.8%
Non-Electric		
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00090	

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

1.2.2 Fluorescent Results

Table 4 summarizes the National Grid MA and RI results of this analysis. In the case of annual kWh savings, the realization rate for Fluorescent lamps was found to be 109.5% with HVAC interactive effects included. The relative precision for this estimate was found to be ±48.4% at the 90% level of confidence. The error ratio was found to be 0.85.

Table 4: Summary of Fluorescent Energy Realization Rate

Savings Parameter	Energy - FLR	
	kWh	% Gross
Gross Savings (Tracking)	17,702,195	
Documentation Adjustment	16,359	0%
Technology Adjustment	1,813,011	10%
Quantity Adjustment	-2,658,399	-15%
Operational Adjustment	1,599,635	9%
HVAC Interactive	1,251,452	7%
Adjusted Gross Savings	19,379,459	109%
Gross Realization Rate	109.5%	
Relative Precision	±48.4%	
Confidence Interval	90%	
Error Ratio	85%	

Table 5 summarizes the National Grid MA and RI savings factors resulting from this analysis. All relative precisions were calculated at the 90% and 80% confidence levels. The on-peak summer coincidence factor was 57.8%, with a relative precision of ±33.0% at 80% confidence. The on-peak winter coincidence factor was 55.9%, with a relative precision of ±30.2% at 80% confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 5: Summary of Fluorescent Savings Factors

Savings Factors and Realization Rates	FLR	
	Value	Precision
KW Factors (Precisions at 80% confidence)		
Installation Rate (Quantity Adjustment - kW)	85.0%	±11.5%
Delta Watts (Technology Adjustment - kW)	110.2%	±10.5%
Connected kW Realization Rate[3]	93.8%	±20.5%
Summer Coincidence Factor	57.8%	±33.0%
Winter Coincidence Factor	55.9%	±30.2%
Summer kW HVAC Interactive Effect	116.2%	±4.7%
Winter kW HVAC Interactive Effect	100.0%	±0.0%
KWh Factors (Precisions at 90% confidence)		
Connected kWh Realization Rate	93.8%	±26.4%
KWh HVAC Interactive Effect	107.1%	±3.2%
Hours of Use Realization Rate	109.0%	±39.1%
% On Peak KWh	67.4%	±11.4%
Non-Electric		
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00116	

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

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. Table 6 presents a list of building types where the upstream lighting purchases were installed. The building type with the most installations was School/University. In terms of sites, this represented 26% of the entire sample, including 26% of the LED sample and 25% 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 a couple of sites in the sample. Additional prominent building types included Retail, Office, Hospital, Multi-Family, Office and Dining: Bar Lounge/Leisure.

Table 6: Building Type

Building Type	Fluorescent	LED	Total
School/University	3	11	14
Retail	2	6	8
Hospital	2	3	5
Multi-Family	1	1	2
Other	1	1	2
Office	1	4	5
Workshop	1	1	2
Gymnasium	1		1
Healthcare-Clinic		1	1
Dining: Family		2	2
Hotel		2	2
Dining: Bar Lounge/Leisure		6	6
Religious Building		2	2
Dining: Cafeteria/Fast Food		1	1
Exercise Center		1	1
Total	**12**	**42**	**54**

1.2.3.1 Installation Rate

This evaluation found that LEDs had an installation rate of 70% and Fluorescent lamps had an installation rate of 85%. 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. Of the bulbs not installed, considerably more (86 percent) were found in storage and are expected to be installed when compared to those not found or later removed (14 percent). 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 for the LED category was higher (125%) than the Fluorescent category (110%). Delta Watts are defined as the pre-installation, or baseline wattages, minus the post-installation wattage. The factor represents the difference between the tracking delta Watts and the evaluation delta Watts as a percentage. 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 National Grid 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 LED hours of use realization rate was 86%, while the Fluorescent hours of use realization rate was 109%. 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 National Grid 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 3,870 hours per year, and 3,684 hours of use for Fluorescent.

1.3 Conclusions and Recommendations

Overall, the Rhode Island Upstream Lighting program appears to be successfully delivering energy savings. LEDs were found to have a realization rate of 80%, which was driven primarily by technology and quantity adjustments. Fluorescents were found to have a realization rate of 109%, which was driven by several adjustments. 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 25% 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 delta watts adjustment factor, so the delta watts adjustment factor should not be applied if the realization rates are being used as recommended.

- **Quantity.** This study found that approximately 70% 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 quantity adjustment factor, so the quantity 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 86% 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 3,870 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

- **Delta Watts.** This study produced an estimate of delta Watts that was approximately 10% 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.
- **Quantity.** This study found that approximately 85% 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 quantity adjustment factor, so the quantity 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 109% 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 3,684 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 reviewing the Massachusetts Process Evaluation for program improvements.** During this evaluation feedback was received from an implementer. Based on this feedback along with findings in the Massachusetts Process Evaluation it is recommended that distributors better capture the installation address and pass that information onto the third party program manager. An implementer mentioned that while for most of their projects (probably about 80%) bulbs are shipped directly to the customer, for customers where bulbs need to be installed in several buildings such as a campus and/or the customer does not have a shipping/receiving dock and it's hard to get products delivered to the customer location, the implementer has bulbs shipped to their address. This implementer indicated that on every purchase order to the distributor they enter an application ID regardless of whether or not the project is upstream, this could be used to help track installation address and distinguish from shipping address.

2 INTRODUCTION

This report documents DNV GL's Impact Evaluation of National Grid Rhode Island's Commercial and Industrial Upstream Lighting Program. This impact evaluation was completed shortly after the impact evaluation of the Massachusetts Commercial and Industrial Upstream Lighting Program performed by DNV GL.[4] This impact evaluation was completed for National Grid and includes combined National Grid Massachusetts and National Grid Rhode Island results.

2.1 Program Description

The National Grid Rhode Island Upstream Lighting Program is a new 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. The program offers upstream incentives on linear fluorescent and LED lighting technologies. DNV GL received 2012 data for RI and therefore the evaluation will cover that timeframe.

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2.2 Purpose of Study

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- 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 to2015 tracking estimates;
- Estimates of delta watts and hours of use.

National Grid Rhode Island plans to apply updated realization rates to 2015 planning assumptions.

[4] Impact Evaluation of the Massachusetts Upstream Lighting Program, Final Report, February 19, 2014, Prepared by DNV GL.

This report presents the following realization rates 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.

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 1.
- **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 1.
- **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.
- **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.
- **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 for this study was designed in consideration of the 90% confidence level for energy (kWh) and the 80% confidence level for on-peak summer and winter demand savings.

2.3 Scope

The scope of work of this impact evaluation covered upstream lighting purchases made in National Grid service territory in Massachusetts and Rhode Island. In Massachusetts, two separate periods of upstream lighting purchases (November 2011 – April 2012 and May 2012 – November 2012) were used. This was due to the inability to recruit the full sample of sites from the initial Massachusetts sample design. In Rhode Island, data from the third party program manager covered the February 2012 through February 2013 timeframe and therefore the Rhode Island sample covered upstream lighting purchases made during that period. As show in the table below the final sample size for this impact evaluation was 54 sites, including 42 LED sites and 12 Fluorescent sites; combining each state's results improved overall precisions when compared to completing a RI-only analysis.

Table 7. Final Sample by State and Product Type

State	Fluorescent	LED	Total
MA	7	32	39
RI	5	10	15
Total	12	42	54

3 EVALUATION APPROACH

3.1 Preliminary Sampling Strategy for Data Collection Efforts

The National Grid Upstream Lighting Program impact evaluation included on-site measurement and verification (M&V) of participating customers.

In Massachusetts, lighting contractors were removed from the end user sample frame and then combined into a separate lighting contractor sample frame. Part of the rationale for this was that it would be too difficult and costly to determine where lighting contractors installed the bulbs and so that they could be contacted as part of the process evaluation. Lighting contractors that were contacted as part of the LCIEC Project 10 evaluation were removed from the Massachusetts lighting contractor sample frame to avoid respondent fatigue.

The population frame for all studies is the tracking data provided by a third party data collector. Since DNV GL did not plan to interview lighting contractors as part of the National Grid Rhode Island Upstream Lighting Program evaluation and based on experience recruiting on-sites for the Massachusetts Upstream Lighting evaluation, DNV GL included lighting contractors in this study's sample frame.[5] The process for site recruitment was for the recruiter to schedule on-site visits with end-users only. It was planned that if a lighting contractor was reached the recruiter would ask a series of questions to learn quantities and types of bulbs received through the program and if there's a chance the bulbs were installed at a location out of state. After speaking with the lighting contractor the recruiter would proceed with site recruitment by reaching out to the next priority end-user site.

[5] When designing the initial sample, DNV GL found several records with a common address totalling 3,659,078 kWh savings. DNV GL did not think the common address was the installation address and was instead that of an implementer. DNV GL recommended treating this site as a contractor and called to learn about where the bulbs were installed but removed it from the sample frame.

3.1.1 Determining the Customer Sample Frame

In March 2013 DNV GL was provided with program tracking data which covered the February 2012 to February 2013 period. These data were used to determine the sample frames discussed in this subsection. Although some of these customers might have been contacted by an audit team as part of a separate quality control effort during the next few months, they were not excluded from this frame. 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, PAR38, A-Lamps and Decorative lamps) 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 8. The goal of the impact evaluation will be to produce new estimates of delta watts and hours of use.

Table 8: Per Lamp Savings Assumptions by Product Type

Product Type	Baseline Wattage	Installed Wattage	Delta Watts	Annual Hours	kWh Savings
T8	29	25	4	3,380	14
T5	51	47	4	3,380	14
PAR20	38	8	30	4,500	135
PAR30	55	15	40	4,500	180
PAR38	61	14	47	4,500	212
MR16	31	8	23	4,500	104
F32T8/25W	28	24	4	3,380	14
FB32T8/25W U-Bend	28	22	6	3,380	20
FB28T8 U-Bend	28	22	6	3,380	20
LED A-Lamp	56	17	39	2,800	109
LED Decorative Lamp	26	5	21	4,000	84

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 is the two major groups: LEDs and Fluorescents. The tracking data were aggregated by customer name, address and group. The initial 2,923 records produced 1,413 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 1,269. After eliminating three records where the sales quantity was less than or equal to zero and records associated with an implementer which will be called but not included in the sample frame, the number of records is 1,264. The distribution of savings and quantities installed across the product groups follows in Table 9.

Table 9: 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	7,359,134	48.46%	74,049	30.20%	905	71.60%
Fluorescent	7,828,066	51.54%	171,188	69.80%	359	28.40%
Total	**15,187,200**	**100.00%**	**245,237**	**100.00%**	**1,264**	**100.00%**

3.2 Initial Sample Design

The goal of the impact evaluation was to estimate realization rates and other factors with ±10% relative precision at a 90% confidence interval.

The population for the impact evaluation includes sites that have been identified as end use customers, lighting contractors were not split out with the exception of removing one thought to be an implementer (see Section 3.1 above). Summary statistics about the population frame for the impact evaluation are provided in Table 10.

Table 10: Population for Impact Evaluation

Customer Group	Product Group	Sites	Total KWh Savings	Average Savings	Minimum	Maximum	Standard Deviation	CV
End User	LED	905	7,359,134	9,240	109.2	449,010	29,866	3.23
End User	Fluorescent	359	7,828,066	12,589	270.4	48,672	13,424	1.07
Total		**1,264**	**15,187,200**					

In order to estimate the sample sizes required to produce estimates that meet desired precisions, we must make an assumption about the level of variability in the results (error ratio). The error ratio for this RI study was assumed to be exactly equal to the error ratio from the Massachusetts Upstream Lighting study for both LED and Fluorescent product groups. Therefore, for LEDs an error ratio of 0.90 was assumed and for Fluorescents an error ratio of 0.62 was assumed. The sample design is 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. The precisions were calculated for the given sample of 15 on-sites. After reviewing alternatives, the group decided on the sample design described in Table 11.

Table 11: Proposed Sample Design for Impact Evaluation[6]

Product Group	Stratum	Maximum KWh Savings	Sites	Total KWh Savings	Sample	Inclusion Probability
LED	1	9,100	624	1,895,317	3	0.00481
	2	23,685	171	2,464,242	3	0.01754
	3	65,288	81	3,015,039	2	0.02469
	4	444,900	29	3,995,998	2	0.06897
Fluorescent	1	11,064	314	458,396	2	0.00637
	2	35,190	35	679,086	2	0.05714
	3	442,296	10	1,039,626	1	0.10000

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 12.

Table 12: Anticipated Precisions for Impact Evaluation

State	Product Group	Sites	Total kWh Savings	Assumed Error Ratio	Planned Sample Size	Anticipated Relative Precision
RI	LED	905	11,370,596	0.90	10	± 52%
	Fluorescent	359	2,177,108	0.62	5	± 61%
	Total	1,265	13,547,704	0.86	15	± 44%
MA	LED	5,968	68,715,511	0.90	66	± 17%
	Fluorescent	2,202	23,600,503	0.62	15	± 27%
	Total	8,170	92,316,013	0.86	81	± 15%
Overall	Total	9,436	105,863,717	0.86	96	± 14%

[6] During project scoping, DNV GL applied assumptions used in the Massachusetts Upstream Lighting Program Impact Evaluation. Updated assumptions in Table 8 were applied during the analysis phase of this evaluation and therefore results are based on Table 8 assumptions. Tables 11 and 12 come from the proposed sample design and were based on MA assumptions.

3.3 Final Sample

Table 13 presents the final combined population, which includes all NGRID MA and RI end users in the impact evaluation sample frame.

Table 13: Combined Population NGRID MA and RI

Customer Group	Product Group	Sites	Total KWh Savings	Average Savings	Minimum	Maximum	StdDev	CV
End User	LED	3,474	37,217,887	10,715	109	449,010	24,722	2.31
End User	Fluorescent	1,285	17,702,195	13,776	81	1,557,504	46,577	3.38
Total		**4,759**	**54,920,082**					

Table 14 shows the final sample which resulted in 54 sites, 42 LED and 12 Fluorescent.

Table 14: Combined NGRID MA and RI Sample

Product Group	Stratum	Maximum KWh Savings	Sites	Total KWh Savings	Sample	Case weight
LED	1	5,522	2,107	4,642,043	12	175.58
	2	12,240	698	5,809,577	5	139.60
	3	24,984	397	6,689,334	9	44.11
	4	58,779	211	7,818,941	8	26.38
	5	630,000	78	10,577,052	8	9.75
Fluorescent	1	17,441	1,161	3,082,258	6	193.50
	2	88,813	121	4,674,000	5	24.20
	3	1,784,640	21	7,946,231	1	21.00

The combined sample case weights were provided in the table above based on the stratified design. Three sample sites were identified as being outliers based on the results of the statistical analysis. Therefore three of these 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 4.3.

3.4 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 six weeks of data collection, while the remaining sites included at least four 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.

3.4.1 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.

3.4.2 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.

3.4.3 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.

In addition to these adjustments, DNV GL 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.

3.4.4 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 GL 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 15 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 15: General Heating and Cooling COP Assumptions

Cooling System Type	COP
Packaged DX	2.9
Window DX	2.7
Chiller <200 Ton	4.7
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

Heating System Type	COP
Air to Air Heat Pump	1.5
Electric Resistance	1
Water to Air Heat Pump	2.8

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 GL team computes electric interactive effects during the hours that lighting and HVAC are assumed to operate in unison.

DNV GL 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 GL computes HVAC interaction according to the following equations:

Cooling kW Effects = 80% * Lighting kW Savings / Cooling System COP

Heating kW Effects = -80% * Lighting kW Savings / 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 realization rates (and associated precision levels) for annual kWh savings, percent on-peak kWh savings, and on-peak 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.

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 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 C.

4.1 LED Results

Figure 1 presents a scatter plot of evaluation results for LEDs for annual energy savings using all 42 NGRID MA and RI 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 less 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 482% in this measure category. The evaluation found that that discrepancies were not limited to one particular area, but a mix of quantity, technology, operational and interactive adjustments.

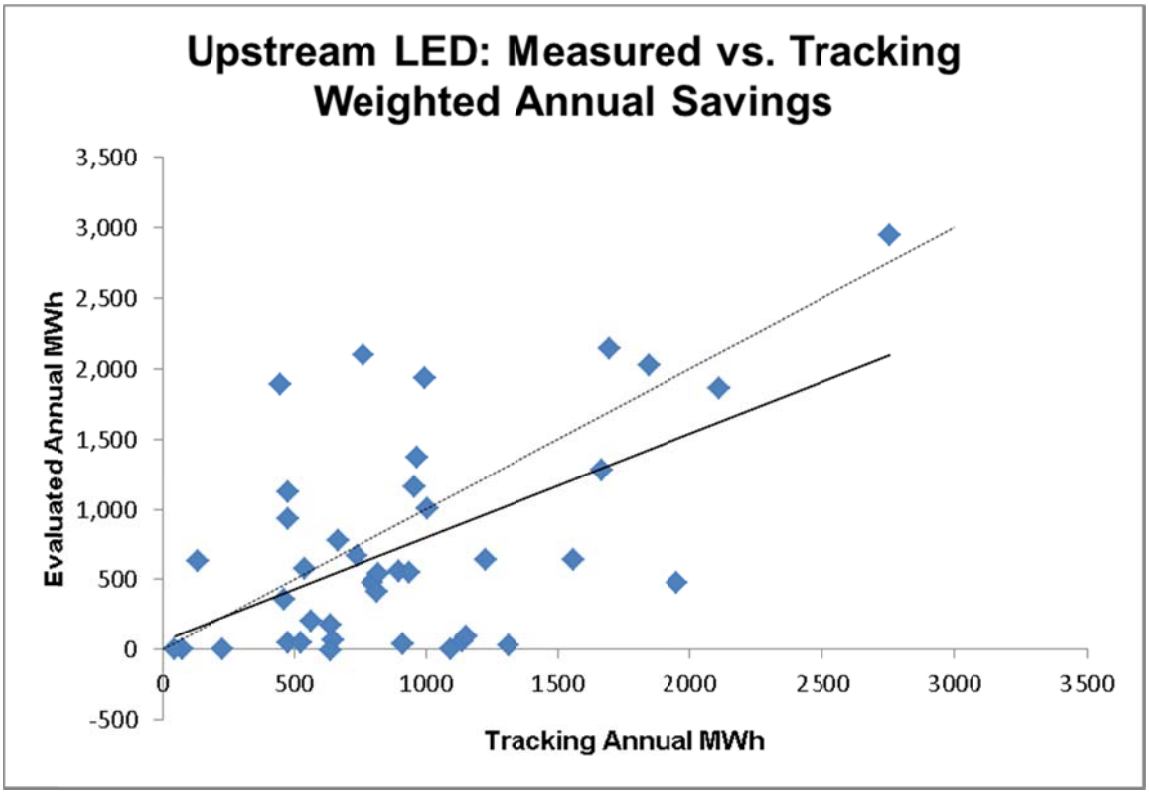

Figure 1: Scatter Plot of Evaluation Results for LEDs for Annual MWh Savings

Table 16 summarizes the National Grid MA and RI results of this analysis. In the case of annual kWh savings, the realization rate for LEDs was found to be 80.2% with HVAC interactive effects included. The relative precision for this estimate was found to be ±19.5% at the 90% level of confidence. Note that gross tracking savings did not include HVAC interactive effects. The error ratio was found to be 1.02, which was significantly higher than the estimated error ratio of 0.90.

Table 16: Summary of LED Energy Realization Rate

Savings Parameter	Energy - LED	
	kWh	% Gross
Gross Savings (Tracking)	37,217,887	
Documentation Adjustment	5,046	0%
Technology Adjustment	9,041,255	24%
Quantity Adjustment	-10,882,578	-29%
Operational Adjustment	-5,187,619	-14%
HVAC Interactive Adjustment	2,224,041	6%
Adjusted Gross Savings	29,857,843	80%
Gross Realization Rate	80.2%	
Relative Precision	±19.5%	
Confidence Interval	90%	
Error Ratio	102%	

Table 17 summarizes the National Grid MA and RI savings factors resulting from this analysis. All relative precisions were calculated at the 90% and 80% confidence levels. The on-peak summer coincidence factor was 60.6%, with a relative precision of ±11.8% at 80% confidence. The on-peak winter coincidence factor was 58.1%, with a relative precision of ±11.7% at 80% confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 17: Summary of LED Savings Factors

Savings Factors and Realization Rates	LED	
	Value	Precision
KW Factors (Precisions at 80% confidence)		
Installation Rate (Quantity Adjustment - kW)	70.1%	±9.5%
Delta Watts (Technology Adjustment - kW)	124.6%	±7.5%
Connected kW Realization Rate[7]	87.3%	±12.3%
Summer Coincidence Factor	60.6%	±11.8%
Winter Coincidence Factor	58.1%	±11.7%
Summer kW HVAC Interactive Effect	118.8%	±2.0%
Winter kW HVAC Interactive Effect	94.8%	±5.7%
KWh Factors (Precisions at 90% confidence)		
Connected kWh Realization Rate	88.0%	±15.8%
KWh HVAC Interactive Effect	106.0%	±3.1%
Hours of Use Realization Rate	86.1%	±18.0%
% On Peak KWh	60.5%	±5.8%
Non-Electric		
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00090	

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

4.2 Fluorescent Results

Figure 2 presents a scatter plot of evaluation results for Fluorescent lamps for annual energy savings using all 12 NGRID MA and RI 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 greater than 100%. These sample data spread from the trend line, which is indicative of a higher error ratio. Site level realization rates ranged from 1% to 477% in this measure category. The evaluation found that the majority of the discrepancies between the tracking and the evaluated savings estimates were due to technology and quantity differences.

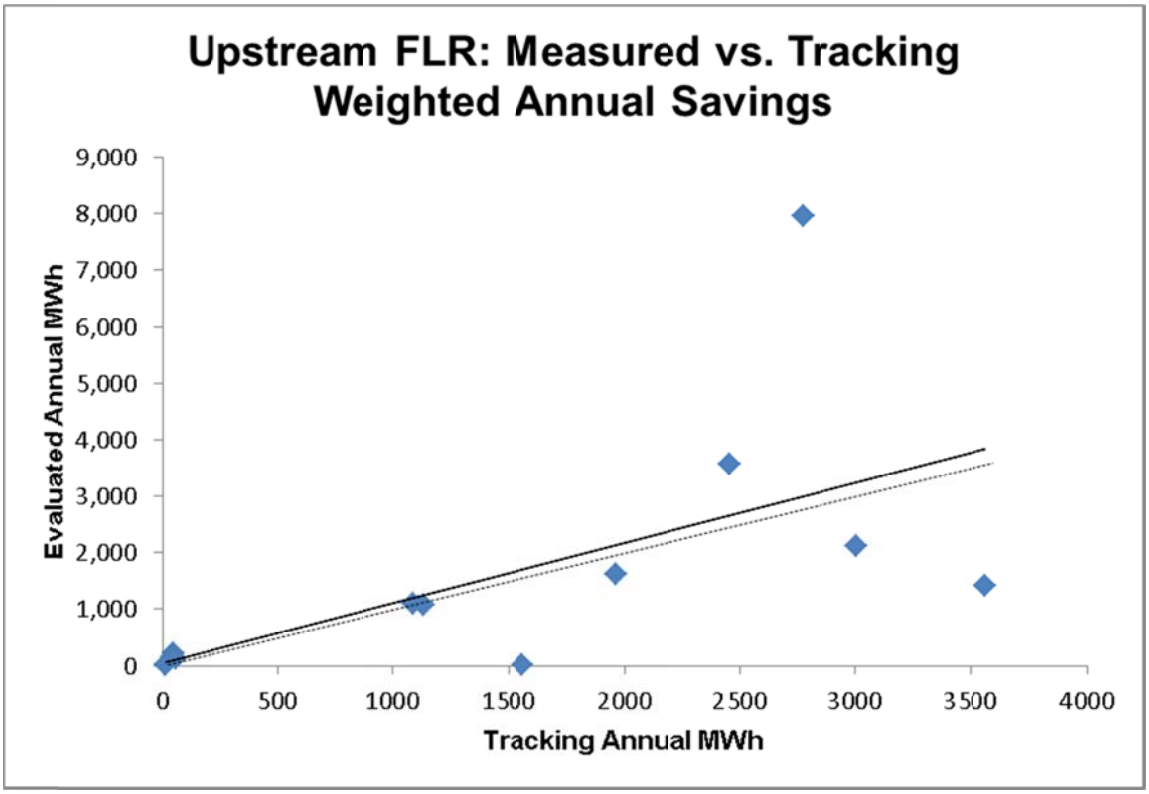

Figure 2: Scatter Plot of Evaluation Results for Fluorescents for Annual MWh Savings

Table 18 summarizes the National Grid MA and RI results of this analysis. In the case of annual kWh savings, the realization rate for Fluorescent lamps was found to be 109.5% with HVAC interactive effects included. The relative precision for this estimate was found to be ±48.4% at the 90% level of confidence. The error ratio was found to be 0.85.

Table 18: Summary of Fluorescent Energy Realization Rate

Savings Parameter	Energy - FLR	
	kWh	% Gross
Gross Savings (Tracking)	17,702,195	
Documentation Adjustment	16,359	0%
Technology Adjustment	1,813,011	10%
Quantity Adjustment	-2,658,399	-15%
Operational Adjustment	1,599,635	9%
HVAC Interactive	1,251,452	7%
Adjusted Gross Savings	19,379,459	109%
Gross Realization Rate	109.5%	
Relative Precision	±48.4%	
Confidence Interval	90%	
Error Ratio	85%	

Table 19 summarizes the National Grid MA and RI savings factors resulting from this analysis. All relative precisions were calculated at the 90% and 80% confidence levels. The on-peak summer coincidence factor was 57.8%, with a relative precision of ±33.0% at 80% confidence. The on-peak winter coincidence factor was 55.9%, with a relative precision of ±30.2% at 80% confidence. The table also provides savings factors for on-peak summer and winter kW HVAC interactive effects, kWh HVAC interactive effect, hours of use realization rate and percent on-peak kWh.

Table 19: Summary of Fluorescent Savings Factors

Savings Factors and Realization Rates	FLR	
	Value	Precision
KW Factors (Precisions at 80% confidence)		
Installation Rate (Quantity Adjustment - kW)	85.0%	±11.5%
Delta Watts (Technology Adjustment - kW)	110.2%	±10.5%
Connected kW Realization Rate[8]	93.8%	±20.5%
Summer Coincidence Factor	57.8%	±33.0%
Winter Coincidence Factor	55.9%	±30.2%
Summer kW HVAC Interactive Effect	116.2%	±4.7%
Winter kW HVAC Interactive Effect	100.0%	±0.0%
KWh Factors (Precisions at 90% confidence)		
Connected kWh Realization Rate	93.8%	±26.4%
KWh HVAC Interactive Effect	107.1%	±3.2%
Hours of Use Realization Rate	109.0%	±39.1%
% On Peak KWh	67.4%	±11.4%
Non-Electric		
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00116	

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

4.3 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 deviations away from the mean of zero. Table 20 contains the Studentized Residuals for the relationship between the tracking and evaluated savings for three of the 54 sites.

Table 20: Studentized Residuals

State	Site	Group	Tracking Savings	Evaluated Savings	Studentized Residual
MA	L1505	FLR	1,557,504.00	11,926.93	-3.064
MA	I2675	LED	131,400.00	633,790.34	6.497
RI	DNV98	LED	449,010	1888201	-6.679

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.

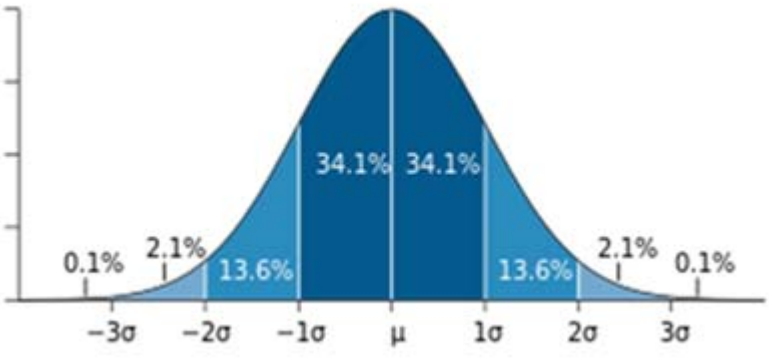

Figure 3: Standard Deviation and Tolerance Intervals

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, the sites above (L1505, I2675 and DNV98) were identified by this test as likely outliers. Therefore, these three 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 three sites is provided, along with the other site summaries, in Appendix C.

4.4 Program Observations and Savings Adjustments

One of the goals of the evaluation was to identify where the upstream lamps were being installed. Table 21 presents a list of building types where the upstream lighting purchases were installed. The building type with the most installations was School/University. In terms of sites, this represented 26% of the entire sample, including 26% of the LED sample and 25% 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 a couple of sites in the sample. Additional prominent building types included Retail, Office, Hospital, Multi-Family, Office and Dining: Bar Lounge/Leisure.

Table 21: Building Type

Building Type	Fluorescent	LED	Total
School/University	3	11	14
Retail	2	6	8
Hospital	2	3	5
Multi-Family	1	1	2
Other	1	1	2
Office	1	4	5
Workshop	1	1	2
Gymnasium	1		1
Healthcare-Clinic		1	1
Dining: Family		2	2
Hotel		2	2
Dining: Bar Lounge/Leisure		6	6
Religious Building		2	2
Dining: Cafeteria/Fast Food		1	1
Exercise Center		1	1
Total	**12**	**42**	**54**

4.4.1 Installation Rate

This evaluation found that LEDs had an installation rate of 70% and Fluorescent lamps had an installation rate of 85%. 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. Of the bulbs not installed, considerably more (86 percent) were found in storage and are expected to be installed when compared to those not found or later removed (14 percent). In this evaluation, any lamps that were found in storage or not found at all were counted as zero in the installation rate calculation.

4.4.2 Delta Watts

The delta Watts factor for the LED category was higher (125%) than the Fluorescent category (110%). Delta Watts are defined as the pre-installation, or baseline wattages, minus the post-installation wattage. The factor represents the difference between the tracking delta Watts and the evaluation delta Watts as a percentage. This factor was mostly driven by the pre-existing or baseline wattages.

As shown earlier in Table 8, all tracking savings were based on an estimated baseline and installed wattage for each lamp type. These baseline wattages were developed by National Grid 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.

4.4.3 Hours of Use

The LED hours of use realization rate was 86%, while the Fluorescent hours of use realization rate was 109%. 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 National Grid 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 3,870 hours per year, and 3,684 hours of use for Fluorescent.

5 CONCLUSIONS AND RECOMMENDATIONS

Overall, the Bright Opportunities program appears to be successfully delivering energy savings. LEDs were found to have a realization rate 80%, which was driven primarily by technology and quantity adjustments. Fluorescents were found to have a realization rate of 109%, which was driven primarily by several adjustments. 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 25% 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 delta watts adjustment factor, so the delta watts adjustment factor should not be applied if the realization rates are being used as recommended.

- **Quantity.** This study found that approximately 70% 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 quantity adjustment factor, so the quantity 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 86% 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 3,870 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.

5.2 Fluorescent Savings Assumptions

- **Delta Watts.** This study produced an estimate of delta Watts that was approximately 10% 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.

- **Quantity.** This study found that approximately 85% 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 quantity adjustment factor, so the quantity 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 109% 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 3,684 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.

5.3 Program Tracking Documentation

- **Consider reviewing the Massachusetts Process Evaluation for program improvements.** During this evaluation feedback was received from an implementer. Based on this feedback along with findings in the Massachusetts Process Evaluation it is recommended that distributors better capture the installation address and pass that information onto the third party program manager. An implementer mentioned that while for most of their projects (probably about 80%) bulbs are shipped directly to the customer, for customers where bulbs need to be installed in several buildings such as a campus and/or the customer does not have a shipping/receiving dock and it's hard to get products delivered to the customer location, the implementer has bulbs shipped to their address. This implementer indicated that on every purchase order to the distributor they enter an application ID regardless of whether or not the project is upstream, this could be used to help track installation address and distinguish from shipping address.

6 APPENDIX 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.

6.1 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.

6.2 Savings Factors

Summer Coincidence Factor

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

Winter Coincidence Factor

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

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.

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 22: 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)

7 APPENDIX B - SITE LEVEL RESULTS

7.1 LED

Table 23: LED Tracking and Evaluation Savings Estimates

			Tracking			Evaluation								
State	Site ID	Facility Type	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
MA	I0682	School/University	23220	5.2	4,500	11843	1	57%	7.7	0.18	1.00	0.16	1	1,548
MA	I0699	Healthcare-Clinic	3600	0.8	4,500	996	1	69%	0.3	1.00	1.27	0.78	0.21	4,632
MA	I0891	Multi-Family	270	0.1	4,500	0	0	0%	0.0	0.00	1.00	0.00	1	N/A
MA	I1160	Retail	45630	10.1	4,500	18754	1	70%	6.7	0.77	1.27	0.77	1	2,502
MA	I1216	School/University	92439	20.5	4,500	57437	1	73%	16.0	0.71	1.17	0.36	1	3,332
MA	I1348	School/University	125483	27.9	4,500	65766	1	83%	38.2	0.47	1.14	0.12	1	1,619
MA	I1418	Other	21015	4.7	4,500	19023	1	78%	5.6	0.78	1.27	0.73	1	3,045
MA	I1476	School/University	54000	12.0	4,500	59301	1	58%	14.2	0.63	1.00	0.81	0.48	4,979
MA	I1679	Retail	8262	1.8	4,500	650	1	88%	0.6	0.26	1.22	0.18	1	925
MA	I1997	School/University	7826	1.7	4,500	0	1	82%	0.5	0.00	1.00	0.00	1	0
MA	I2033	Retail	18360	4.1	4,500	1857	1	86%	0.8	0.73	1.27	0.24	1	1,971
MA	I2056	Dining: Family	29115	6.5	4,500	56568	1	56%	9.6	0.80	1.27	0.80	1	5,298
MA	I2274	School/University	180	0.0	4,500	0	0	0%	0.0	0.00	1.00	0.00	1	N/A
MA	I2675	Hotel	131400	29.2	4,500	633790	1	50%	78.8	0.90	1.27	0.90	1	7,264
MA	I2882	Hospital	282717	62.8	4,500	301983	1	49%	35.1	0.97	1.17	0.97	1	8,055
MA	I2958	School/University	57150	12.7	4,500	14099	1	82%	17.7	0.18	1.01	0.37	1	792
MA	I2978	Retail	23310	5.2	4,500	15283	1	70%	4.1	0.98	1.27	0.72	1	3,363
MA	L3036	Dining: Family	11934	2.7	4,500	9159	1	68%	3.0	0.55	1.27	0.69	1	2,699
MA	L1866	Dining: Bar Lounge/Leisure	3780	0.8	4,500	4419	1	33%	0.8	0.00	1.27	0.06	1	4,775
MA	L1920	School/University	33260	7.4	4,500	1607	1	89%	4.3	0.07	1.10	0.08	1	354

			Tracking			Evaluation								
State	Site ID	Facility Type	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
MA	L2113	Hotel	21622	7.7	2,800	59454	1	55%	10.9	0.54	1.27	0.72	1	4,932
MA	L2409	Religious Building	2621	0.9	2,800	2005	1	71%	1.2	0.41	1.00	0.13	1	1,740
MA	L2529	Retail	99144	22.0	4,500	140369	1	75%	36.9	1.00	1.27	0.72	1	3,387
MA	L2719	Office	25920	5.8	4,500	1035	1	47%	0.1	1.00	1.19	1.00	1	8,760
MA	L2771	Workshop	2961	0.7	4,500	293	1	73%	0.5	0.12	1.00	0.21	1	643
MA	L2796	Dining: Bar Lounge/Leisure	13500	3.0	4,500	26475	1	60%	3.8	1.00	1.27	1.00	1	6,347
MA	L2869	Dining: Cafeteria/Fast Food	2700	0.6	4,500	6367	1	63%	0.9	1.00	1.27	0.98	1	6,356
MA	L3918	Exercise Center	1310	0.5	2,800	0	0	0%	0.0	0.00	1.00	0.00	1	N/A
MA	L3985	Hospital	7200	1.6	4,500	7238	1	47%	2.4	0.33	1.14	0.34	1	2,889
MA	L4185	School/University	49618	11.1	4,453	62721	1	61%	18.0	0.53	1.14	0.46	1	3,300
MA	L4953	School/University	16038	4.5	3,563	5721	1	62%	3.3	0.23	1.17	0.13	1	1,640
MA	L5233	Dining: Bar Lounge/Leisure	5400	1.2	4,500	6542	1	62%	1.1	0.86	1.27	0.84	1	5,183
RI	DNV98	Dining: Bar Lounge/Leisure	449010	149.1	2,945	1888201	1	46%	204.9	1.00	1.12	1.00	1	8,760
RI	DNV118	Hospital	26645	9.5	2,800	15647	1	55%	2.6	0.88	1.14	0.71	1	5,646
RI	DNV319	School/University	109	0.0	2,800	8	1	62%	0.0	0.00	1.00	0.00	1	184
RI	DNV480	Retail	9396	2.1	4,500	234	1	95%	0.1	0.51	1.27	0.00	1	1,680
RI	DNV545	Religious Building	3596	0.8	4,500	-32	1	36%	-0.1	0.13	1.00	0.01	1	465
RI	DNV630	Office	216516	57.6	3,651	190759	1	78%	39.4	1.00	1.14	0.95	1	4,517
RI	DNV747	Dining: Bar Lounge/Leisure	81824	18.2	4,500	49205	1	60%	7.5	0.97	1.10	1.00	1	6,337
RI	DNV850	Office	15389	3.6	4,272	16496	1	57%	4.3	0.52	1.26	0.55	1	3,705
RI	DNV1031	Office	13500	3.0	4,500	1514	1	59%	0.6	0.46	1.14	0.20	1	2,367
RI	DNV1079	Dining: Bar Lounge/Leisure	437	0.2	2,800	0	0	0%	0.0	0.00	1.00	0.00	1	N/A

Table 24: LED Realization Rates and Reasons for Discrepancies

State	Site ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
			Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
MA	I0682	School/University	51%	148%	34%	Hours of use 34% of tracking. (19) more PAR20 and (9) less PAR30. Baseline lamps were 65w rather than 55w and 38w.
MA	I0699	Healthcare-Clinic	28%	33%	103%	Baseline lamps were 35w rather than 55w. (6) PAR30 not installed. Electric heat HVAC penalty.
MA	I0891	Multi-Family	0%	0%	0%	Lamps not installed yet.
MA	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.
MA	I1216	School/University	62%	78%	74%	Several baseline lamps were CFLs. Hours of operation 74% of tracking.
MA	I1348	School/University	52%	137%	36%	Hours of use 36% of tracking. Baseline lamps were 50w rather than 31w and 38w for majority of spaces.
MA	I1418	Other	91%	119%	68%	Baseline lamps were 50w and 75w rather than 38w and 55w. Hours of use were 68% of tracking. (27) PAR20 not installed.
MA	I1476	School/University	110%	118%	111%	Baseline lamps were 75w rather than 55w. (60) PAR30 not installed. Electric heat penalty.
MA	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.
MA	I1997	School/University	0%	26%	0%	(29) PAR38 not installed. (8) PAR38 have zero hours of use.
MA	I2033	Retail	10%	21%	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.
MA	I2056	Dining: Family	194%	149%	118%	Baseline lamps were 75w rather than 55w and 61w. Hours of use 118% of tracking.
MA	I2274	School/University	0%	0%	0%	Lamp not installed.
MA	I2675	Hotel	482%	270%	161%	Hours of use 161% of tracking. Baseline lamps were 120w rather than 55w. Installed lamps were 12w rather than 15w.
MA	I2882	Hospital	107%	56%	179%	Increase in annual hours of use and 846 fixtures in storage
MA	I2958	School/University	25%	139%	18%	Hours of use 18% of tracking. Baseline lamps were 75w rather than 55w and 61w.
MA	I2978	Retail	66%	78%	75%	Hours of use 75% of tracking. Baseline lamps were 50w rather than 55w. (7) PAR30 not installed.
MA	L3036	Dining: Family	77%	115%	60%	Baseline lamps were 75w rather than 55w and 31w. Hours of use 60% of tracking. (18) PAR30 not installed.
MA	L1866	Dining: Bar Lounge/Leisure	117%	100%	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.
MA	L1920	School/University	5%	58%	8%	Reduction in annual hours of use. 12 PAR30 and 90 PAR38 in storage
MA	L2113	Hotel	275%	141%	176%	Existing lamps were 90 watt incandescent. Increase in Annual hours of use, (49) A-Lamps in storage, not installed.
MA	L2409	Religious Building	76%	123%	62%	Hours of use 62% of tracking. Baseline lamps were 60 watt incandescent rather than 55 watt.
MA	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.
MA	L2719	Office	4%	2%	195%	New LEDs replaced 15 watt CFLs, which resulted in a -98% technology adjustment.

State	Site ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
			Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
MA	L2771	Workshop	10%	69%	14%	(8) PAR38 not installed yet. Baseline bulbs were 90 watt incandescent. Hours of use were 14% of tracking estimate.
MA	L2796	Dining: Bar Lounge/Leisure	196%	125%	141%	Hours of use 41% greater than tracking estimates. Baseline lamps were 65 watt rather than 55 watt. Additional HVAC savings.
MA	L2869	Dining: Cafeteria/Fast Food	236%	150%	141%	Baseline lamps were 75 watts rather than 55 watts. Hours of use were 41% higher than tracking estimates.
MA	L3918	Exercise Center	0%	0%	0%	New lamps not installed. Baseline 60 watt incandescent found on-site.
MA	L3985	Hospital	101%	148%	64%	Baseline lamps are higher wattage than tracking estimates. Hours of use 64% of tracking estimates.
MA	L4185	School/University	126%	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.
MA	L4953	School/University	36%	72%	46%	Annual hours of use decreased with Cooling interactions.
MA	L5233	Dining: Bar Lounge/Leisure	121%	95%	115%	Increase in annual hours of use. 12 fixtures in storage
RI	DNV98	Dining: Bar Lounge/Leisure	421%	137%	297%	Actual hours per year are 8,760. Program bulbs replaced incandescent and halogen bulbs.
RI	DNV118	Hospital	59%	28%	202%	The facility manager and house electrician said they did not receive a large portion of the bulbs resulting in reduced savings. The logger data shows the annual usage being twice the amount as the assumed hours per year.
RI	DNV319	School/University	7%	110%	7%	Confirmed light is on a timer; actual hours of operation is less than assumed hours.
RI	DNV480	Retail	2%	6%	37%	This location is more or less open for normal business hours. The assumption hours of use is high when considering the actual usage of this building. The wattage reduction would have been greater if they program bulbs replaced incandescent/halogen bulbs, instead they replaced CFLs thus a less difference in wattage and savings.
RI	DNV545	Religious Building	-1%	-9%	10%	The program LED(18w) bulbs replaced CFLs(14w), there was an increase of wattage by 4 watts per bulb. These bulbs are installed 30-40 ft high in a church, we were able to log them from the balcony. With the height being very high the contact wanted a better quality light and a light that would last longer than the existing CFLs. This is a place of worship and is not used much during the day, it is used mostly on the weekends. Side note: The contact also showed concern for the LED bulbs in that he is worried that the heat sink could separate from the plastic screw base portion of the bulb, thus fall and hit someone. He thinks it's worth mentioning to the manufacturer.
RI	DNV630	Office	88%	68%	124%	A large amount of bulbs are in storage, they were seen and counted. This lowered the savings substantially.
RI	DNV747	Dining: Bar Lounge/Leisure	60%	41%	141%	The customer was not satisfied with the light quality (color) and returned some bulbs (removed from tracking) and replaced some of the LEDs with other LEDs.
RI	DNV850	Office	107%	119%	87%	Some bulbs are in storage and others were returned (returned bulbs were removed from tracking). Also, actual hours of operation were less than assumption hours.
RI	DNV1031	Office	11%	20%	53%	Actual metered hours are lower than assumption hours. CFLs to LEDs don't result in a vast change in wattage compared to Hal/Inc to LED.
RI	DNV1079	Dining: Bar Lounge/Leisure	0%	0%	0%	Zero savings because the program bulbs were removed before the audit, no loggers were installed.

7.2 Fluorescent

Table 25: Fluorescent Tracking and Evaluation Savings Estimates

			Tracking			Evaluation								
State	Site ID	Facility Type	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
MA	I0030	Multi-Family	7788	2.3	3,380	7392	1	51%	2.0	0.41	1.27	0.48	1	3,276
MA	I0244	Hospital	16900	5.0	3,380	24576	1	69%	4.4	0.96	1.09	0.87	1	5,379
MA	I0438	Other	27040	8.0	3,380	27401	1	72%	7.0	0.74	1.25	0.52	1	3,512
MA	L0029	Workshop	81	0.0	3,380	22	1	94%	0.0	0.25	1.00	0.02	1	1,405
MA	L0649	Office	88421	26.2	3,380	35086	1	69%	11.4	0.60	1.14	0.29	1	2,907
MA	L1482	Gymnasium	406	0.1	3,380	881	1	49%	0.1	1.00	1.27	0.99	1	8,403
MA	L1505	School/University	1557504	460.8	3,380	11927	1	95%	6.9	0.22	1.01	0.07	1	1,729
RI	DNV282	Retail	19063	5.6	3,380	54703	1	59%	7.6	0.99	1.25	0.99	1	6,495
RI	DNV310	School/University	20686	6.1	3,380	14601	1	90%	8.2	0.28	1.00	0.34	1	1,780
RI	DNV429	Hospital	324	0.1	3,380	1547	1	46%	0.2	1.00	1.00	1.00	1	8,760
RI	DNV958	Retail	270	0.1	3,380	1046	1	48%	0.1	1.00	1.27	1.00	1	8,760
RI	DNV1126	School/University	48672	14.4	3,380	40075	1	89%	21.8	0.15	1.01	0.25	1	1,834

Table 26: Fluorescent Realization Rates and Reasons for Discrepancies

State	Site ID	Facility Type	Realization Rates			Primary Reasons for Discrepancies
			Annual kWh (Including HVAC)	Connected kW	Average Hours of Use	
MA	I0030	Multi-Family	95%	88%	97%	HVAC interaction added.
MA	I0244	Hospital	145%	88%	159%	Hours of use 159% of tracking.
MA	I0438	Other	101%	88%	104%	Hours of use 104% of tracking. HVAC interaction added.
MA	L0029	Workshop	28%	67%	42%	Hours of use 42% of tracking estimate. Two of six lamps not installed.
MA	L0649	Office	40%	44%	86%	Reduction in Annual hours of use and 3390 out 6543 fixtures not installed
MA	L1482	Gymnasium	217%	79%	249%	Annual hours of use tripled from tracking or ON 24x7
MA	L1505	School/University	1%	1%	51%	113,250 out of 115,200 fixtures in storage, and reduction in annual hours of use for rest of them
RI	DNV282	Retail	287%	134%	192%	This retail building is open for long hours each day, nearly twice the amount of the assumed hours.
RI	DNV310	School/University	71%	134%	53%	Actual hours are less than assumption hours.
RI	DNV429	Hospital	477%	184%	259%	Actual hours of operation is high; usage is 24/7.
RI	DNV958	Retail	387%	134%	259%	The program bulbs are on 24/7.
RI	DNV1126	School/University	82%	151%	54%	Found that 25w T8s were installed rather than 28w T8 which increased the savings. Actual hours of operation was lower than assumed hours.

8 APPENDIX C - SITE SUMMARIES

8.1 RI Sites

- **Site DNV98**
- Facility Type: Dining: Bar Lounge/Leisure
- Tracking: (300) Decorative 3.4 watt LED, (300) PAR38 18 watt LED, (3,300) 12 watt LED A-lamps
- Onsite Actual: (300) Decorative 3.4 watt LED, (300) PAR38 18 watt LED, (3,300) 12 watt LED A-lamps
- Baseline: (300) 40 watt incandescent lamps, (572) 100 watt halogen, (3,028) 60 watt incandescent lamps
- Program bulbs are on 24/7. (280) program bulbs are installed in bathrooms, (18) installed in high limit area wall fixtures, (2) are in 2nd level chandelier, (18) are in south, east and west entrances, (297) are in main room, (1,056) are in hanging signs, (63) in restaurants, (23) in store, (9) in cashier area, (200) second floor main room, (8) elevator, (1,340) in second floor main room and halls and (586) are in storage.

- **Site DNV118**
- Facility Type: Hospital
- Tracking: (244) 12 watt LED A-lamps
- Onsite Actual: (50) 12.5 watt LED A-lamps
- Baseline: (50) 65 incandescent lamps
- The facility manager and house electrician said they did not receive a large portion of the program bulbs. (11) program bulbs were installed in the foyer waiting area, (4) installed in the foyer desk area, (2) in the foyer entrance, (12) in a conference room, (8) in tunnel, (7) in cafeteria, (4) in third floor main office, (2) in restrooms, and (194) not received. The assumption for tracking hours of use are (2800) and the logged average hours of use are (5646).

- **Site DNV319**
- Facility Type: School/University
- Tracking: (1) 17 watt A-lamp
- Onsite Actual: (1) 17 watt LED A-lamp
- Baseline: (1) 60 watt incandescent lamp
- This site is a school with (1) program bulb installed in an outside wall pack. The program bulbs is on a timer. The assumption for tracking hours of use are (2800) and the logged average hours of use are (184).

- **Site DNV480**
- Facility Type: Retail
- Tracking: (24) PAR38 18 watt LED, (24) PAR30 10 watt LED
- Onsite Actual: (24) PAR38 18 watt LED, (24) PAR30 14 watt LED
- Baseline: (16) 23 watt compact fluorescents
- (18) PAR38 LEDs and (14) PAR30 LEDs were found in storage. (6) PAR38 LEDs and 10 PAR30s LEDs were installed. All program bulbs were installed in this retail store's showroom. The assumption for tracking hours of use are (4500) and the logged average hours of use are (1680).

- **Site DNV545**
- Facility Type: Religious Building
- Tracking: (17) PAR38 18 watt LED
- Onsite Actual: (17) PAR38 18 watt LED
- Baseline: (17) 14 watt compact fluorescents
- This church has (17) program bulbs installed in the ceiling (about 30-40 ft from the floor). The evaluation team was able to log the bulbs from a balcony. The site contact stated that he chose to replace the CFLs because he wanted better light quality and something that would last longer than the CFLs. This is a place of worship and is not used much during the day, operation hours are typically weekends. The contact stated he was worried that the heat sink could separate from the plastic screw base portion of the bulb, thus fall and hit someone; he thinks it's worth mentioning to the manufacturer. The assumption for tracking hours of use are (4500) and the logged average hours of use are (465).

- **Site DNV630**
- Facility Type: Office
- Tracking: (355) PAR30 15 watt LED, (350) MR16 6 watt LED, (212) PAR20 9 watt LED, (50) PAR38 18 watt LED, (630) 12 watt LED A-lamps, (100) Decorative 3.4 watt LED
- Onsite Actual: (355) PAR30 15 watt LED, (350) MR16 6 watt LED, (212) PAR20 9 watt LED, (50) PAR38 18 watt LED, (630) 12.5 watt LED A-lamps, (100) Decorative 3.4 watt LED
- Baseline: (50) 90 watt incandescent lamps, (355) 50 watt halogen lamps, (43) 65 watt incandescent lamps, (446) 52 watt incandescent lamps, (9) 60 watt incandescent lamps.
- A large amount of program bulbs were found in storage: (312) PAR30 15 watt LEDs, (184) 12.5 watt LED A-lamps, (91) Decorative 3.4 watt LED, (16) MR16 6 watt LED, (191) PAR20 9 watt LED. Most (713) program bulbs are installed in large cubical work areas on floors 18 and 9, (70) are in the building lobby, (12) are in the floor 18 elevator lobby and all other program bulbs are found in floor 5, 6, 18 foyers and

various locations. The assumption for tracking hours of use are (3651) and the logged average hours of use are (4517).

- **Site DNV747**
- Facility Type: Dining: Bar Lounge/Leisure
- Tracking: (30) PAR30 11 watt LED, (52) BR30 13 watt LED, (248) PAR30 10 watt LED, 20 MR16 10 watt LED, (61) PAR20 7 watt LED, (8) BR40 14 watt LED, (66) MR16 4 watt LED, (17) PAR38 17 watt LED
- Onsite Actual: (52) BR30 13 watt LED, (54) PAR30 11 watt LED, (20) MR16 10 watt LED
- Baseline: (106) 75 watt halogen lamps, (20) 50 watt halogen lamps
- The customer was not satisfied with the light quality (color) and returned some bulbs ((33) PAR20 9 watt LEDs) and initially installed and then removed the following bulbs: (224) PAR30 15 watt LEDs, (17) PAR38 14 watt LEDs, (66) MR16 8 watt LEDs, 8 PAR38 8 watt LEDs, and (28) PAR20 8 watt. The following program bulbs were installed in outside soffits: (33) BR30 13 watt LEDs, (20) MR16 10 watt LEDs, (42) PAR30 11 watt LEDs. (12) BR30 13 watt LEDs were installed above stairs, (7) BR30 13 watt LEDs and (4) PAR30 11 watt LEDs installed in hallways, (8) PAR30 11 watt LEDs installed in bathrooms. The assumption for tracking hours of use are (4500) and the logged average hours of use are (6337).

- **Site DNV850**
- Facility Type: Office
- Tracking: (10) MR16 8 watt LED, (21) PAR38 18 watt LED, (15) PAR30 13 watt LED, (6) 17 watt LED A-lamps, (4) 12 watt LED A-lamps, (4) PAR20 9 watt LED, (31) PAR30 15 watt LED
- Onsite Actual: (10) MR16 8 watt LED, (21) PAR38 18 watt LED, (10) PAR30 13 watt LED, (2) 17 watt LED A-lamps, (4) 12 watt LED A-lamps, (4) PAR20 9 watt LED, (31) PAR30 11 watt LED
- Baseline: (14) 50 watt halogen lamps, (21) 75 watt halogen lamps, (47) 60 watt incandescent lamps
- This site is a dentist office; (28) program bulbs are installed in the waiting area, (26) are installed outside, (5) installed in receptionist area, (4) are in the stairway and the remaining bulbs are in offices or patient rooms. (8) program bulbs were in storage and (5) PAR30 13 watt LED, (18) BR30 14 watt LED and (3) PAR20 9 watt LED were returned. The assumption for tracking hours of use are (4272) and the logged average hours of use are (3705).

- **Site DNV1031**
- Facility Type: Office
- Tracking: (100) PAR20 9 watt LED
- Onsite Actual: (100) PAR20 9 watt LED
- Baseline: (100) 13 watt compact fluorescents
- (15) program bulbs are installed in elevators, (8) are in sales team conference room, (42) are in office work areas, (35) are in other rooms. The assumption for tracking hours of use are (4500) and the logged average hours of use are (2367).

- **Site DNV1079**
- Facility Type: Dining: Bar Lounge/Leisure
- Tracking: (4) 12 watt LED A-lamps
- Onsite Actual: (0) 12 watt LED A-lamps
- Baseline: (4) 60 watt incandescent
- The program bulbs were removed a couple of days prior to the on-site audit. This site was not logged because the program bulbs were removed before the audit.

- **Site DNV282**
- Facility Type: Retail
- Tracking: (1,410) 28 watt T8 bulbs
- Onsite Actual: (1,140) 25 watt T8 bulbs
- Baseline: (1,140) 30 watt T8 bulbs
- This retail building is open for long hours each day; the assumption for tracking hours of use are (3380) and the logged average hours of use are (6495). (484) program bulbs are on a switch for morning prep, (794) are on a switch open to public lights, (89) are in storage area/stock room, (12) are in bathrooms and (31) are in dressing rooms.

- **Site DNV310**
- Facility Type: School/University
- Tracking: (1,530) 28 watt T8 bulbs
- Onsite Actual: (1,530) 25 T8 bulbs
- Baseline: (1,530) 30 watt T8 bulbs

- This elementary school had program bulbs installed mainly in classrooms (1,201). (112) program bulbs are in the library, (54) in the cafeteria, (52) in halls, (12) in locker rooms, (36) in the gym, (2) in closets, (36) in the main office and (25) in admin offices. The assumption for tracking hours of use are (3380) and the logged average hours of use are (1780).

- **Site DNV429**
- Facility Type: Hospital
- Tracking: (24) 28 watt T8 bulbs
- Onsite Actual: (24) 25 watt T8 bulbs
- Baseline: (24) 32 watt T8 bulbs
- (24) program bulbs are installed in the first/bottom level of the hospital parking garage and are on 24/7.

- **Site DNV958**
- Facility Type: Retail
- Tracking: (20) 28 watt T8 bulbs
- Onsite Actual: (20) 25 watt T8 bulbs
- Baseline: (20) 30 watt T8 bulbs
- This site is a grocery store; (20) program bulbs are installed in the check-out area and are on 24/7.

- **Site DNV1126**
- Facility Type: School/University
- Tracking: (3,630) 28 watt T8 bulbs
- Onsite Actual: (3,360) 25 watt T8 bulbs
- Baseline: (3,360) 28 watt T8 bulbs
- This high school required three site visits in order to verify the location of program bulbs. Program bulbs are installed in: classrooms (1,691), bathrooms (72), halls/stairwells (641), offices (238), the cafeteria (164), the gym (144), the wrestling and weight room (168), locker rooms (80), multi-purpose rooms (345) and the guidance department (66). (21) program bulbs are in storage. The assumption for tracking hours of use are (3380) and the logged average hours of use are (1834).

8.2 MA Sites

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 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 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 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 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 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 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 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 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 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 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 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 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 I2675**
- Facility type: Hotel
- Tracking (730) PAR30 15 watt LED
- Onsite Actual: (730) PAR30 12 watt LED
- Baseline: (730) 120 watt halogen lamps
- This site is a hotel with most (650) program bulbs installed in hallways and a common space. (40) program bulbs are installed in a ballroom and the remaining program bulbs are installed in two conference rooms, each conference room has 20 program bulbs. The assumption for tracking hours of use are (4500) and the logged average hours of use are (7264).

- **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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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.

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