DNV·GL

Massachusetts Commercial and Industrial Upstream Lighting Program: "In Storage" Lamps Follow-Up Study

Massachusetts Energy Efficiency Program Administrators
Massachusetts Energy Efficiency Advisory Council

FINAL REPORT
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1 EXECUTIVE SUMMARY

The Massachusetts Bright Opportunities Program uses upstream incentives to buy down the cost of energy efficient lighting technologies at the lighting distributor level. On behalf of the Massachusetts electric Program Administrators (PAs), and under the guidance of the Massachusetts Energy Efficiency Advisory Council (EEAC), DNV GL completed an impact evaluation of this upstream lighting program in February of 2014 (the Year 1 impact evaluation).[1]

As part of the Year 1 evaluation, DNV GL completed 81 on-site visits, which included verification of installed equipment, a discussion with facility personnel regarding the baseline characteristics of the measure, and the collection and analysis of monitored data. One important finding of this effort was that a significant number of program bulbs were actually in storage, as opposed to being installed. In-storage bulbs were counted as "zero" in the installation rate calculation of the Year 1 impact evaluation.

This follow-up study, referred to as the Year 3 impact evaluation, was designed to re-visit sites that were found to have in-storage bulbs to investigate when and whether these bulbs were eventually installed, and to calculate savings from bulbs moved from storage to sockets. This report presents the objectives, approach, and findings of our Year 3 impact evaluation, and offers recommendations based on those findings.

1.1 Evaluation Objectives and Approach

The research objectives of the Year 3 impact evaluation were to:

- Calculate Year 3 installation rates to incorporate in-storage bulbs later installed;[2]
- Calculate savings from bulbs moved from storage to sockets, incorporating observed installation rates and any changes in baseline wattages noted by evaluators;
- Provide a summary of storage lamps to understand the circumstances around the phased approach to lighting installations, and what it might mean for program operations and savings claims; and
- Provide recommendations at the statewide level on how the PAs' savings estimates may be revised based on the findings of this study.

To meet the objectives of this study, DNV GL conducted the following tasks:

1. Examined the Year 1 impact evaluation data, and identified sites that were found to have in-storage bulbs. We found this to be 31 sites.
2. Reached out to the customers who met with DNV GL engineers during the Year 1 impact evaluation in order to recruit sites for re-visits. Based on this effort, we were able to recruit 23 of the 31 sites for participation in this study.
3. Revisited 23 sites and collected comprehensive data in order to support an independent analysis of savings from bulbs moved from storage to sockets, and of Year 3 installation rates.

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

[2] "Year 3 installation rate" is defined as those bulbs installed between years 2 and 3 following purchase. "Year 1 installation rate" is defined as those bulbs installed by the time of the initial on-site visits conducted as part of the February 2014 Impact Evaluation for the Massachusetts Upstream Lighting Program.

4. Calculated savings associated with bulbs moved from storage to sockets, and Year 3 installation rates.

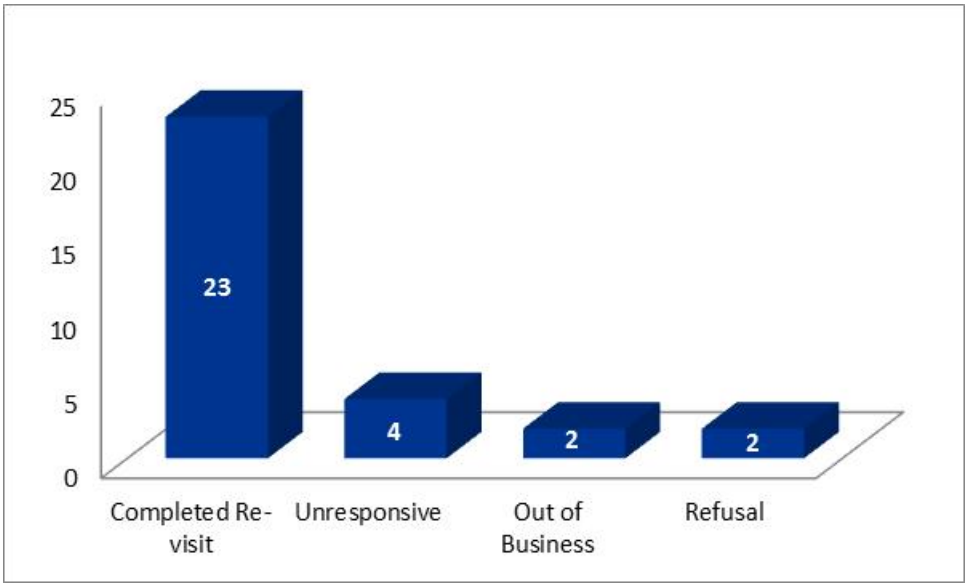
5. Developed a report describing our objectives, approach, and findings. Results are aggregated at the statewide level for LED and fluorescent lighting technologies. PA level results are not presented in this report since the Year 1 impact evaluation was not designed to provide results at this level.

1.2 Key Study Findings

1.2.1 File Review and Recruitment

Our review of data from the Year 1 impact evaluation identified 31 sites (out of 81 total) that had in-storage program lamps. DNV GL targeted all 31 sites for re-visits, in order to collect as much data as possible for the Year 3 impact evaluation study.[3] Figure 1 presents the final results of our recruitment effort. DNV GL successfully recruited 23 sites, including 18 LED and 5 fluorescent.

Figure 1: Final Customer Disposition



As part of this task, DNV GL examined the bulb-quantity data from the Year 1 impact evaluation to determine if there were any key differences between the 18 LED sites that agreed to participate in a second site visit and the 6 LED sites that refused or were unresponsive. This analysis found that:

- LED sites that agreed to a re-visit had fewer bulbs in storage during the Year 1 evaluation, and
- In general, the sites that refused or were unresponsive included larger purchases.

These differences could suggest that the sites that refused or were unresponsive may not have installed bulbs at the same rate as those we re-visited; however, without site visits we cannot verify that theory. We also compared the facility types of sites (both LED and fluorescent) that agreed to a re-visit versus those

[3] While all 31 sites were targeted, it was assumed that the actual number of completed site visits would be less than 31 due to customer unresponsiveness and other factors.

that did not. This cut revealed that schools (8 of 9 targeted) and retail (5 of 6 targeted) were very receptive to follow-up site visits, while office and religious buildings were more difficult to recruit.

1.2.2 LED Savings Results

Table 1 summarizes the statewide LED results for this Year 3 analysis. In the case of annual kWh savings, the realization rate for LEDs was found to be 103.4% with HVAC interactive effects included. The relative precision for this estimate was found to be ±25.7% at the 90% level of confidence. Note that gross tracking savings did not include HVAC interactive effects. The error ratio was found to be 1.17.

Table 1: Summary of LED Energy Realization Rate

Savings Parameter	Energy - LED	
	kWh	% Adjustment
Gross Savings (Tracking)	68,715,511	
Documentation Adjustment	-	0.0%
Technology Adjustment	22,739,749	33.1%
Quantity Adjustment	(14,530,046)	-15.9%
Operational Adjustment	(10,209,438)	-13.3%
HVAC Interactive Adjustment	4,325,517	6.5%
Adjusted Gross Savings	71,041,294	3.4%
Gross Realization Rate	103.4%	
Relative Precision	±25.7%	
Confidence Interval	90%	
Error Ratio	117%	

Section 4.1.1 of this report provides more detail on LED savings results, including a summary table showing the statewide LED savings factors—including summer and winter coincidence factors, HVAC interactive effects, and other factors—resulting from this Year 3 analysis.

1.2.3 Fluorescent Savings Results

Table 2 summarizes the fluorescent statewide results for this Year 3 analysis. In the case of annual kWh savings, the realization rate for fluorescent lamps was found to be 92.4% with HVAC interactive effects included. The relative precision for this estimate was found to be ±24.0% at the 90% level of confidence. The error ratio was found to be 0.53.

Table 2: Summary of Fluorescent Energy Realization Rate

Savings Parameter	Energy - FLR	
	kWh	% Adjustment
Gross Savings (Tracking)	23,600,503	
Documentation Adjustment	-	0.0%
Technology Adjustment	6,891	0.0%
Quantity Adjustment	(3,471,137)	-14.7%
Operational Adjustment	164,352	0.8%
HVAC Interactive Adjustment	1,502,570	7.4%
Adjusted Gross Savings	21,803,180	-7.6%
Gross Realization Rate	92.4%	
Relative Precision	±24.0%	
Confidence Interval	90%	
Error Ratio	53%	

Section 4.1.2 of this report provides more detail on fluorescent savings results, including a summary table showing the statewide fluorescent savings factors—including summer and winter coincidence factors, HVAC interactive effects, and other factors—resulting from this Year 3 analysis.

1.2.4 Summary of Storage and Installation Observations

Figure 2 presents the installation rate by technology type and study year. For LEDs, the Year 1 installation rate was found to be 82%, while the Year 3 installation rate was found to be 85%. This represents an increase of about 3%. For fluorescents, the Year 1 installation rate was found to be 80%, and the Year 3 installation rate was found to be 85%. This represents an increase of about 5%.

Figure 2: Installation Rate by Study Year

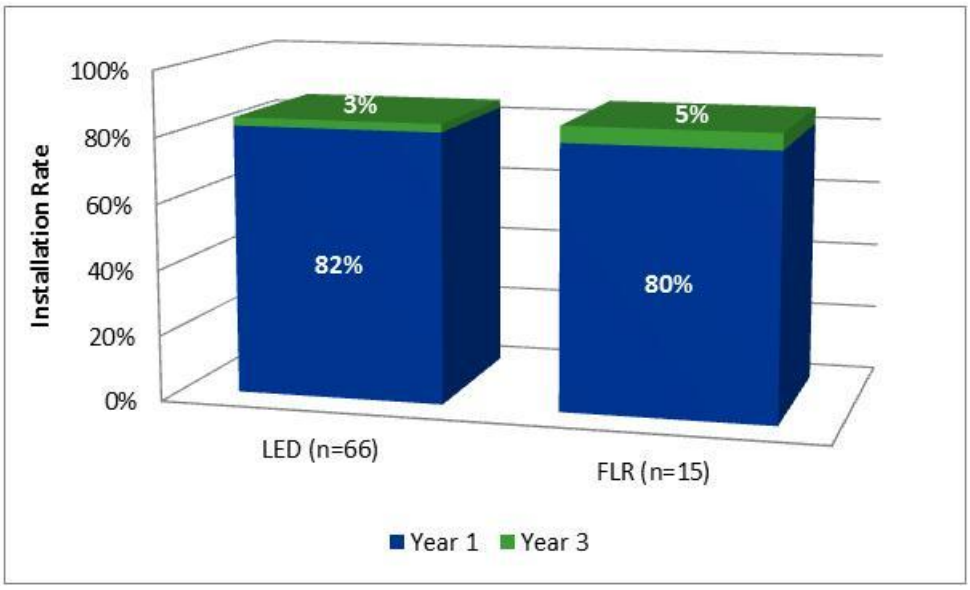


Table 3 presents an overall summary of in-storage bulbs for the Year 1 and Year 3 evaluations. The sites are grouped into five distinct categories. We've excluded a large outlier site, which would dilute the "No Additional Bulbs Installed" row. As shown in the table, 12 of the 22 sites have installed all of the bulbs that were in storage during the Year 1 evaluation. The table shows that there were 919 bulbs in storage across these 12 sites at the time of the Year 1 evaluation, and that there are now zero bulbs in storage.

Table 3: Summary of Bulbs for Re-Visited Sites between Year 1 and Year 3

Year 3 Classification	Number of Sites	Average Number of Days between Purchase and Year 1 Visit	Number of In Storage Bulbs - Year 1	Average Number of Days between Purchase and Year 3 Visit	Number of In Storage Bulbs - Year 3
All Bulbs Installed	12	254	919	917	0
No Additional Bulbs Installed	2	252	14	1,029	14
Program Bulbs Removed	1	358	846	1,057	0
Replaced Program Bulbs	1	212	3	822	0
Some Bulbs Installed	6	353	2,732	935	747
Total	**22**	**284**	**4,514**	**934**	**761**

In the table above, the column labeled “Number of In Storage Bulbs-Year 3” represents the remaining number of bulbs that still have the potential of being installed at some point in the future. Many of these bulbs will remain in storage until current program bulbs burn out, which limits the ability for the program to achieve more savings through an increased installation rate.

1.3 Conclusions and Recommendations

Overall, this Year 3 study resulted in a small increase in program savings as compared to the Year 1 evaluation. The LED kWh realization rate increased from 101.9% to 103.4%, while the fluorescent realization rate increased from 89.0% to 92.4. These increases were the result of installation rate increases in both groups.

Below we summarize key conclusions and recommendations regarding LED and fluorescent savings assumptions, and future impact evaluations of the Bright Opportunities Program. A more comprehensive discussion of conclusions and recommendations can be found in section 0 of this report.

1.3.1 Savings Assumptions

- **Annual Energy (kWh) and Connected kW Realization Rates.** For prospective application of these results—both for LEDs and fluorescents—we recommend that the PAs utilize the Year 3 results (since the potential for additional savings due to increased installations after Year 3 is limited).
- **Quantity**. The LED installation rate increased from 82.1% to 84.6% between Year 1 and Year 3, and the fluorescent installation rate increased from 80.3% to 85.3%. Although many lamps remain in storage at three of the five fluorescent sites, these lamps are not likely to be used until currently installed program lamps burn out. This limits any future increase in savings due to installation of in-storage bulbs. For both LEDs and fluorescents, we recommend that the PAs apply the Year 3 installation rate to savings estimates. Note that the installation rate is embedded into both the Annual kWh and Connected kW Realization Rates, so if these are being applied, the installation rate is not to be used.
- **LED Delta Watts**. The delta watts estimate resulting from this study was not significantly different from the Year 1 study (133.6% vs. 133.2%). As noted in the Year 1 study, almost this entire discrepancy was due to the finding that the baseline bulbs/lamps were of higher wattage than the tracking estimates. Again, the delta watts estimate is embedded into both the Annual kWh and Connected kW Realization Rates, so if these are being applied, the delta watts estimate is not to be used
- **Hours of Use**.
    - The hours of use realization rate was 87% for LEDs. This is a slight decrease from the Year 1 result of 88%. Based on lighting logger data at each of the sites, the average hours of use for LED lamps were found to be approximately 3,901 hours per year.
    - The hours of use realization rate was 101% for fluorescents. This is a slight decrease from the Year 1 result of 103%. Based on lighting logger data at each of the sites, the average hours of use for fluorescent lamps were found to be approximately 3,410 hours per year.

- The hours of use realization rate is also included in the Annual kWh Realization Rate, so it should not be applied if the Annual kWh Realization Rate is being used.

1.3.2 Future Impact Evaluations

This study, as well as the Year 1 study, included a sample of sites from the very early stages of the Bright Opportunities Program (Q4 of 2011 through Q3 of 2012). In addition, an independent QA/QC vendor has been in place since the early stages of the program so that the PAs can receive monthly reports on how the program is performing. Based on feedback from the Year 1 study, as well as the monthly QA/QC reports, it is possible that the program has matured in the three years since the impact evaluation sample was drawn. There could be reason to believe that the growth of the program, and the controls that have been put in place to help limit the stockpiling issue, may have contributed to improved installation rates. The PAs and EEAC may want to consider a follow-up impact evaluation to assess the effectiveness of the efforts that have gone into improving the installation rate.

2 INTRODUCTION

The Massachusetts Bright Opportunities Program uses upstream incentives to buy down the cost of energy efficient lighting technologies at the lighting distributor level. On behalf of the Massachusetts electric Program Administrators (PAs), and under the guidance of the Massachusetts Energy Efficiency Advisory Council (EEAC), DNV GL completed an impact evaluation of this upstream lighting program in February of 2014 (the Year 1 impact evaluation).[4]

As part of the Year 1 evaluation, DNV GL completed 81 on-site visits, which included verification of installed equipment, a discussion with facility personnel regarding the baseline characteristics of the measure, and the collection and analysis of monitored data. One important finding of this effort was that a significant number of program bulbs were actually in storage, as opposed to being installed. In-storage bulbs were counted as "zero" in the installation rate calculation of the Year 1 impact evaluation.

This follow-up study, referred to as the Year 3 impact evaluation, was designed to re-visit sites that were found to have in-storage bulbs to investigate when and whether these bulbs were eventually installed, and to calculate savings from bulbs moved from storage to sockets. This report presents the objectives, approach, and findings of our Year 3 impact evaluation, and offers recommendations based on those findings.

2.1 Program Description

The Massachusetts Bright Opportunities Program seeks to increase the market penetration of energy efficient lighting technologies through the use of upstream incentives. All five electric PAs in the state are participating in the program. The program began offering upstream incentives on linear fluorescent lighting technologies in September 2011, and incentives for LED lighting technologies in November 2011. In the case of LEDs, the upstream incentives replaced the downstream incentives that the Massachusetts C&I programs previously offered for these technologies.

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, address, and contact information of the customers who purchased the discounted lighting products. Every month the distributors submit their sales data to the Massachusetts electric PAs and to a third-party program manager. This third-party program manager combines the sales data from the various participating distributors and then allocates the energy savings and incentives to each participating PA depending on whether the location of installation falls in their territory. They then issue invoices to each PA for that particular month. The program also conducts on-site quality control inspections for about 10% of the sites in order to verify the lighting quantities and types claimed in the distributor sales reports.

2.2 Evaluation Objectives

The research objectives of the Year 3 impact evaluation were to:

- Calculate Year 3 installation rates to incorporate in-storage bulbs later installed;[5]

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

[5] "Year 3 installation rate" is defined as those bulbs installed between years 2 and 3 following purchase. "Year 1 installation rate" is defined as those bulbs installed by the time of the initial on-site visits conducted as part of the February 2014 Impact Evaluation for the Massachusetts Upstream Lighting Program.

- Calculate savings from bulbs moved from storage to sockets, incorporating observed installation rates and any changes in baseline wattages noted by evaluators;
- Provide a summary of storage lamps to understand the circumstances around the phased approach to lighting installations, and what it might mean for program operations and savings claims; and
- Provide recommendations at the statewide level on how the PAs' savings estimates may be revised based on the findings of this study.

2.3 Overview of Approach

To meet the objectives of this study, DNV GL conducted the following tasks:

1. Examined the Year 1 impact evaluation data, and identified sites that were found to have in-storage bulbs. We found this to be 31 sites.
2. Reached out to the customers who met with DNV GL engineers during the Year 1 impact evaluation in order to recruit sites for re-visits. Based on this effort, we were able to recruit 23 of the 31 sites for participation in this study.
3. Revisited 23 sites and collected comprehensive data in order to support an independent analysis of savings from bulbs moved from storage to sockets, and of Year 3 installation rates.
4. Calculated savings associated with bulbs moved from storage to sockets, and Year 3 installation rates.
5. Developed a report describing our objectives, approach, and findings. Results are aggregated at the statewide level for LED and fluorescent lighting technologies. PA level results are not presented in this report since the Year 1 impact evaluation was not designed to provide results at this level.

3 EVALUATION APPROACH

3.1 File Review

The first task of this study was to review the data from the Year 1 impact evaluation to identify sites with program-purchased, in-storage bulbs. The final sample size for the Year 1 impact evaluation was 81 sites, including 66 LED sites and 15 fluorescent sites. Of these, 46 sites (37 LED and 9 fluorescent) had installation rates less than 100%. Table 4 shows that most of these sites were schools/universities, offices, and retail.

Table 4: Original Sample with Low Installation Rates by Building Type

Building Type	Fluorescent	LED	Total
School/University	5	8	13
Office	2	6	8
Retail	0	8	8
Other	2	2	4
Dining: Bar Lounge/Leisure	0	2	2
Hotel	0	2	2
Multi-Family	0	2	2
Religious Building	0	2	2
Dining: Family	0	1	1
Exercise Center	0	1	1
Healthcare-Clinic	0	1	1
Hospital	0	1	1
Workshop	0	1	1
Total	**9**	**37**	**46**

DNV GL examined data for each of these 46 sites to determine if the low installation rate was due to program bulbs being in storage, or some other reason (e.g., lamps were not installed, but also not confirmed to be in storage). This review identified 31 sites that had in-storage program lamps among the Year 1 sample.

DNV GL's approach was to target all 31 sites for re-visits, in order to collect as much data as possible for the Year 3 impact evaluation study.[6] This approach was agreed to by the Massachusetts PAs and EEAC consultants during the project planning phase.

3.2 Recruitment

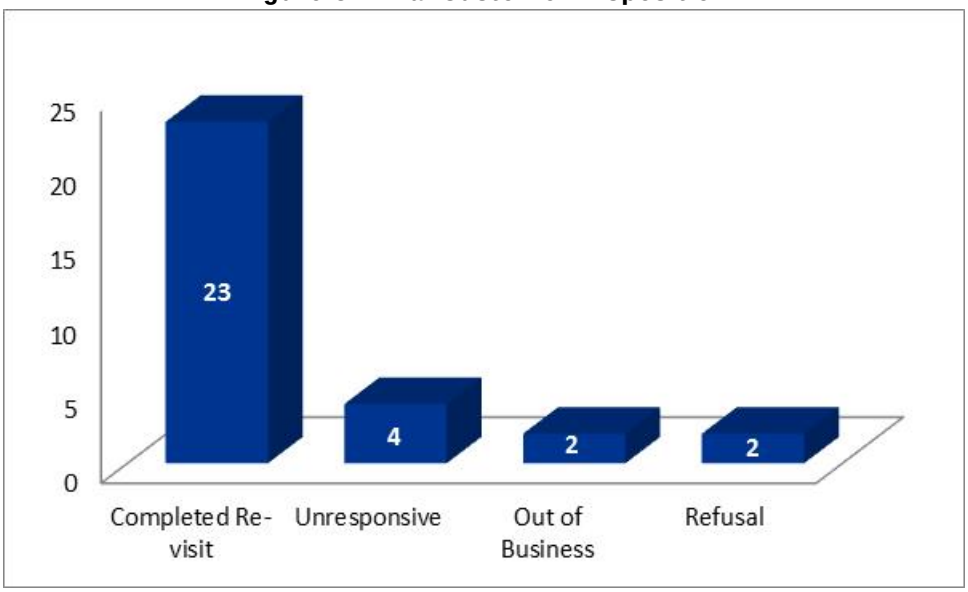
DNV GL attempted to recruit all 31 sites by reaching out to the end-user who met with the DNV GL engineer during the Year 1 impact evaluation. DNV GL offered an incentive of $100 to thank participating customers for the initial site visit(s) and for making the time for another site visit to verify the amount of bulbs still in storage.

[6] While all 31 sites were targeted, it was assumed that the actual number of completed site visits would be less than 31 due to customer unresponsiveness and other factors.

During this initial contact, the site recruiter reminded customers that bulbs were originally found to be in storage during the Year 1 site visit, and that the purpose of the additional site visit was to determine if any of the bulbs in storage were installed since the Year 1 visit.

Figure 3 presents the final results of our recruitment effort. DNV GL successfully recruited 23 sites, including 18 LED and 5 fluorescent. The remaining eight sites, which were all LED sites, were either unresponsive, firm refusals, or out of business, as indicated in the figure below.

Figure 3: Final Customer Disposition



DNV GL examined the bulb-quantity data from the Year 1 impact evaluation to determine if there were any key differences between the 18 LED sites that agreed to participate in a second site visit and the 6 LED sites that refused or were unresponsive.

Table 5 shows that LED sites that agreed to a re-visit had fewer bulbs in storage during the Year 1 evaluation. In general, the sites that refused or were unresponsive included larger purchases. These differences could suggest that the sites that refused or were unresponsive may not have installed bulbs at the same rate as those we re-visited; however, without site visits we cannot verify that theory. If this speculation is true, this suggests the results in this report are biased upward.

Table 5: Average Bulbs per Site Purchased and Year 1 Storage

Customer Disposition	Number of Sites	Average Number of Purchased Bulbs per Site	Average Number of Year 1 In-Storage Quantity per Site	Percent of Bulbs In-Storage in Year 1
Completed Site Re-visit	18	184	70	38%
Refused or Unresponsive	6	297	162	55%
Out of Business	2	88	46	52%

We also compared the facility types of sites (both LED and fluorescent) that agreed to a re-visit versus those that did not. Table 6 shows that schools and retail were very receptive to follow-up site visits, while office and religious buildings were more difficult to recruit.

Table 6: Customer Disposition by Facility Type

Facility Type	Completed Site Re-visit	Refused or Unresponsive	Out of Business
School/University	8	1	
Retail	5		1
Office	3	2	
Other	2		
Religious Building		2	
Dining: Family			1
Exercise Center	1		
Healthcare-Clinic	1		
Hospital	1		
Hotel	1		
Multi-Family	1		
Workshop		1	
Total	23	6	2

3.3 On-Site Data Collection

Between December 2014 and February 2015, DNV GL successfully completed 23 re-visits, including 18 LED and 5 fluorescent. While on site, our project team members:

- Reviewed individual end-user program purchases and quantity of Year 1 in-storage bulbs;
- Performed a field walk-through to provide a current observation of in-storage and installed equipment;
- Conducted interviews with site personnel regarding operating hours and patterns;
- Confirmed previously-collected information regarding holiday, shutdown, and other site schedules;
- Conducted interviews to verify pre-existing or baseline conditions with site personnel;
- Confirmed HVAC equipment for use in interactive savings calculations; and
- Computed Year 3 and accumulated program installation rates and savings based on site-specific information, and hours of use from the Year 1 evaluation.

DNV GL staff developed and used an on-site data collection form for this study to ensure that the data collection needs were met. The form (provided in Appendix A) included questions relating to reasons for having bulbs in storage, timing of installation (if any) of in-storage bulbs, quantities of bulbs moved from storage to installation, locations and pre-existing equipment replaced, reasons for installing/discarding, and customer satisfaction with the program bulbs.

3.4 Site-Level Analysis

DNV GL incorporated data gathered from the on-site visits into a lighting savings spreadsheet we developed for use in the Year 1 impact evaluation.

In the Year 1 evaluation, each site had its own spreadsheet analysis, which calculated lighting savings using line-by-line comparisons of pre- and post-retrofit electrical use. Line items were usually defined as either different lighting types or different uses and schedules.

For the Year 3 impact evaluation, we took the new data from the site re-visits, and updated each of the existing lighting analysis spreadsheets from the Year 1 impact evaluation. In most cases, the only adjustments included updating the number of bulbs installed versus those in storage. We did not look at those fixtures verified in Year 1, meaning that they are all assumed to have persisted into Year 3 in our savings calculation work. The only exception to this would be when we found that the in storage bulbs replaced previously installed program bulbs.

The Year 1 spreadsheets were also updated, where applicable, to include baseline lamp type and wattage for newly installed lamps, based on information evaluators obtained through on-site interviews with facility personnel. “Hours of use” were not logged as part of this Year 3 impact evaluation study, so we used existing logger data from the Year 1 evaluation and/or reported hours from facility personnel if the newly installed lamps were installed in areas that were not previously monitored.

These adjusted key savings parameters culminated in new energy savings estimates for each of the re-visited sites.

3.5 Approach to Identifying and Addressing Outliers

In the Year 1 evaluation, it was important to identify any outliers among the 81 sample points included in this study to assess how much influence one sample point had on the results (i.e., on the determination of the relationship between the tracking and evaluation savings). Outliers in the data can skew the interpretation of results.

To determine if any of the sample points were outliers, we calculated the residuals and then standardized them (called “studentized residuals”). Studentized residuals are distributed normally with a mean of zero and a standard deviation of 1. By standardizing them, it was easier to determine whether any of the observations were outliers.

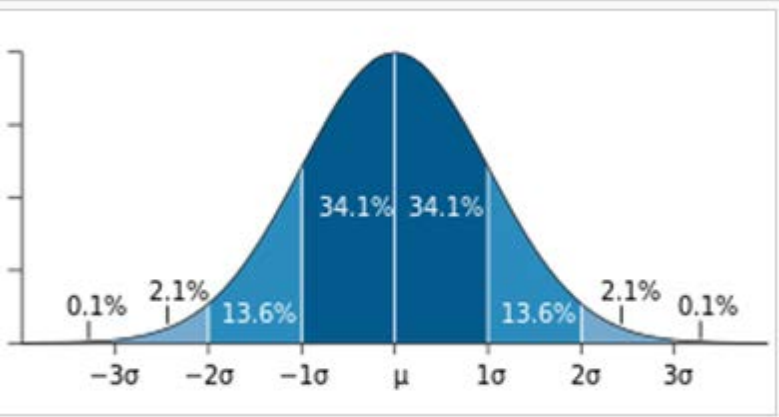
For example, a studentized residual of 2 means that the residual is 2 standard deviations away from the mean of zero. Since we are examining and expecting a linear relationship between the tracking and evaluation savings, the assumption that the residuals are normally distributed is valid. Given that assumption, any site that contained a studentized residual greater than 3 or less than -3 was considered an outlier. Out of the total 81 sites included in this study, two were identified as likely outliers using this approach (see Table 7), with studentized residual values of -3.04 and 6.49.

Table 7: Studentized Residuals for Outliers in the Study

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

These cut-off points (greater than 3 or less than -3) were established because in a normal distribution, residuals at this level are only 0.2% likely to occur, as demonstrated in Figure 4.

Figure 4: Standard Deviation and Tolerance Intervals



For the residuals, the average, represented by the symbol μ (mu), is zero. As shown in Figure 4, anything within 1 standard deviation of μ is 68.2% likely to occur. If the value is greater than 1 and less than 2—or less than -1 and greater than -2—standard deviation from the mean is 27.2% likely to occur. Anything greater than 2 standard deviations away from the mean is only 4.4% likely to occur, and could potentially be considered an outlier.

Any studentized residuals that are greater than 3 standard deviations away from the mean are only 0.2% likely to occur. These are considered extreme outliers and would be very unusual to occur. It is up to the user to determine what the outliers are; however, one would always want to address the extreme outliers, as we have in this study (see the modified savings results below).

In order to produce the results in the next section, the outlier sites identified in Table 7 (L1505 and I2675) were each given a weight of one, and the rest of the sample was re-stratified. By assigning these sites a weight of one, the analysis assumes that these are unique cases that are not representative of the overall population. We used this weighting approach, rather than removing these observations from the sample, in order to: 1) keep all 81 sites in the sample, and 2) avoid compounding the outliers' extreme results by multiplying by a case weight that is greater than one.

3.6 Expansion Analysis

Following the completion of the new site analysis workbooks, the site savings were then expanded up to the original population using a two-step process. First, the eight sites, which were found to have light bulbs in storage but were not available for a re-visit, were excluded from the Year 3 impact sample for the estimation of the quantity adjustment factor. Additionally, their former Year 1 evaluation weights were redistributed to the 23 sites that had been re-visited. This new weighting applied only to the quantity component of the savings analysis. The eight sites were then reinserted for the calculation of the other savings estimates, including delta watts and hours of use. This step resulted in new savings estimates for all 31 in storage sites based on the 23 that participated in a re-visit.

In addition to this modification, the larger 81 site sample from the Year 1 evaluation was also re-stratified to reflect the change in evaluated savings. This slightly altered the site weights, thereby affecting the overall realization rates and standard errors.

4 RESULTS

4.1 Savings from Bulbs Moved from Storage to Sockets

The results presented in this section include the Year 3 statewide-level realization rates (and associated precision levels) for annual kWh savings, percent on-peak kWh savings, and on-peak and seasonal demand (kW) coincidence factors at the times of the winter and summer peaks, as defined by the ISO New England Forward Capacity Market (FCM). All coincident summer and winter peak reductions were calculated using the following FCM definitions:

- **Coincident Summer On-Peak kW Reduction:** 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:** The average demand reduction that occurs over all hours between 5 pm and 7 pm on non-holiday weekdays in December and January.
- **Seasonal Peak:** Non-holiday weekdays when the Real-Time System Hourly Load is equal to or greater than 90% of the most recent "50/50" System Peak Load Forecast for the summer and winter seasons.

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

- **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.
- **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.
- **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.
- **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.
- **The Electric HVAC Interactive Adjustment** reflects changes in electric savings due to interaction between the lighting and HVAC systems among the sampled sites. Generally, these impacts cause a heating penalty and a cooling credit. This adjustment reflects impacts from electric heating and/or cooling, not other fuels.

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

4.1.1 LED Savings Results

Figure 5 presents a scatter plot of annual energy savings results for LEDs using all 66 LED sample points included in the Year 1 impact evaluation, after adjusting for the newly installed lamps. In other words, this is the scatter plot of savings after the accumulated three years of program lighting installations at these sites. The dashed line in this graph represents a realization rate of 100%. The slope of the solid line in this graph is an indication of the overall realization rate, and can be seen to be slightly greater than 100%. The large scatter of the points is a good indication that the error ratio is likely to be poor.

Figure 5: Scatter Plot of Evaluation Results for LEDs for Annual kWh Savings

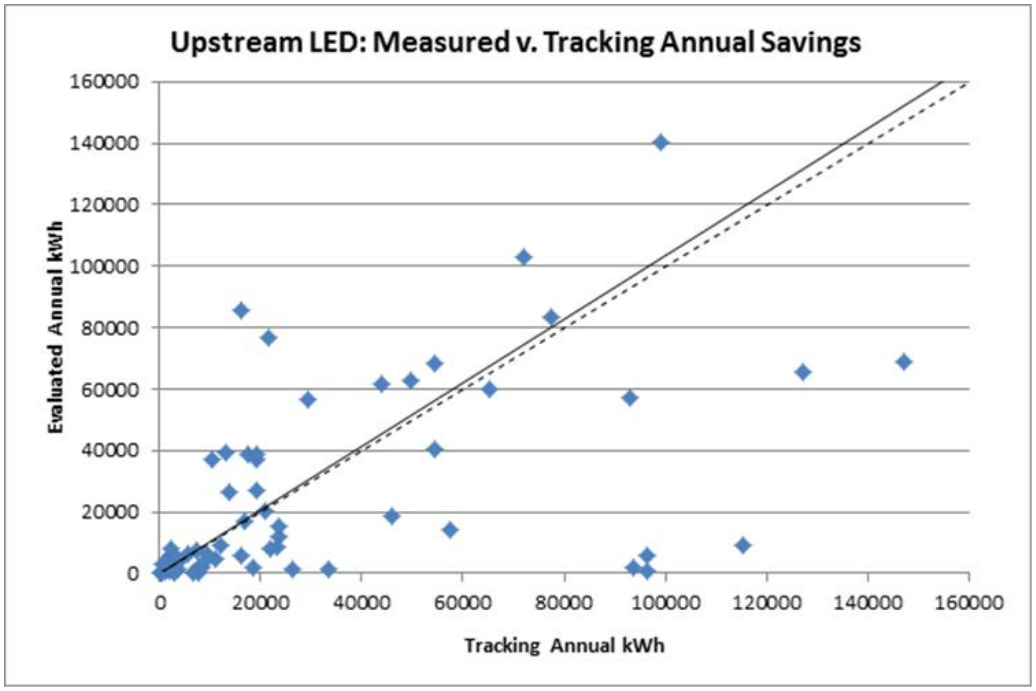


Table 8 summarizes the statewide LED results for this Year 3 analysis. In the case of annual kWh savings, the realization rate for LEDs was found to be 103.4% with HVAC interactive effects included. The relative precision for this estimate was found to be ±25.7% at the 90% level of confidence. Note that gross tracking savings did not include HVAC interactive effects. The error ratio was found to be 1.17.

Table 8: Summary of LED Energy Realization Rate

Savings Parameter	Energy - LED	
	kWh	% Adjustment
Gross Savings (Tracking)	68,715,511	
Documentation Adjustment	-	0.0%
Technology Adjustment	22,739,749	33.1%
Quantity Adjustment	(14,530,046)	-15.9%
Operational Adjustment	(10,209,438)	-13.3%
HVAC Interactive Adjustment	4,325,517	6.5%
Adjusted Gross Savings	71,041,294	3.4%
Gross Realization Rate	103.4%	
Relative Precision	±25.7%	
Confidence Interval	90%	
Error Ratio	117%	

Table 9 summarizes the statewide savings factors resulting from this Year 3 analysis. All relative precisions were calculated at the 90% confidence level; precisions were also calculated at the 80% level for kW factors.

Table 9: Summary of LED Savings Factors

Savings Factors and Realization Rates	LED		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	84.6%	±18.2%	±14.1%
Delta Watts (Technology Adjustment - kW)	133.6%	±8.3%	±6.5%
Connected kW Realization Rate (Doc Adj x Qty Adj x Tech Adj)[7]	113.1%	±20.0%	±15.5%
Summer Coincidence Factor			
On Peak Hours	60.0%	±12.4%	±9.6%
Seasonal Hours	55.4%	±14.2%	±11.0%
Winter Coincidence Factor			
On Peak Hours	54.1%	±13.9%	±10.8%
Seasonal Hours	50.4%	±14.4%	±11.2%
Summer kW HVAC Interactive Effect			
On Peak Hours	120.0%	±2.2%	±1.7%
Seasonal Hours	120.6%	±2.2%	±1.7%
Winter kW HVAC Interactive Effect			
On Peak Hours	97.2%	±3.1%	±2.4%
Seasonal Hours	96.9%	±3.5%	±2.7%
KWh Factors (Precisions at 90% confidence)			
Connected kWh Realization Rate	112.0%	±20.6%	
KWh HVAC Interactive Effect	106.5%	±2.2%	
Hours of Use Realization Rate	86.7%	±13.8%	
% On Peak KWh	63.6%	±6.7%	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00111		

4.1.2 Fluorescent Savings Results

Figure 6 presents a scatter plot of annual energy savings results for fluorescent lamps using all 15 fluorescent sample points included in the Year 1 impact evaluation, after adjusting for newly installed lamps.

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

This plot includes the outlier with a weight of one. Once again, the dashed line in this graph represents a realization rate of 100%. The slope of the solid line in this graph is an indication of the overall realization rate, and can be seen to be slightly lower than 100%.

Figure 6: Scatter Plot of Evaluation Results for Fluorescents for Annual kWh Savings

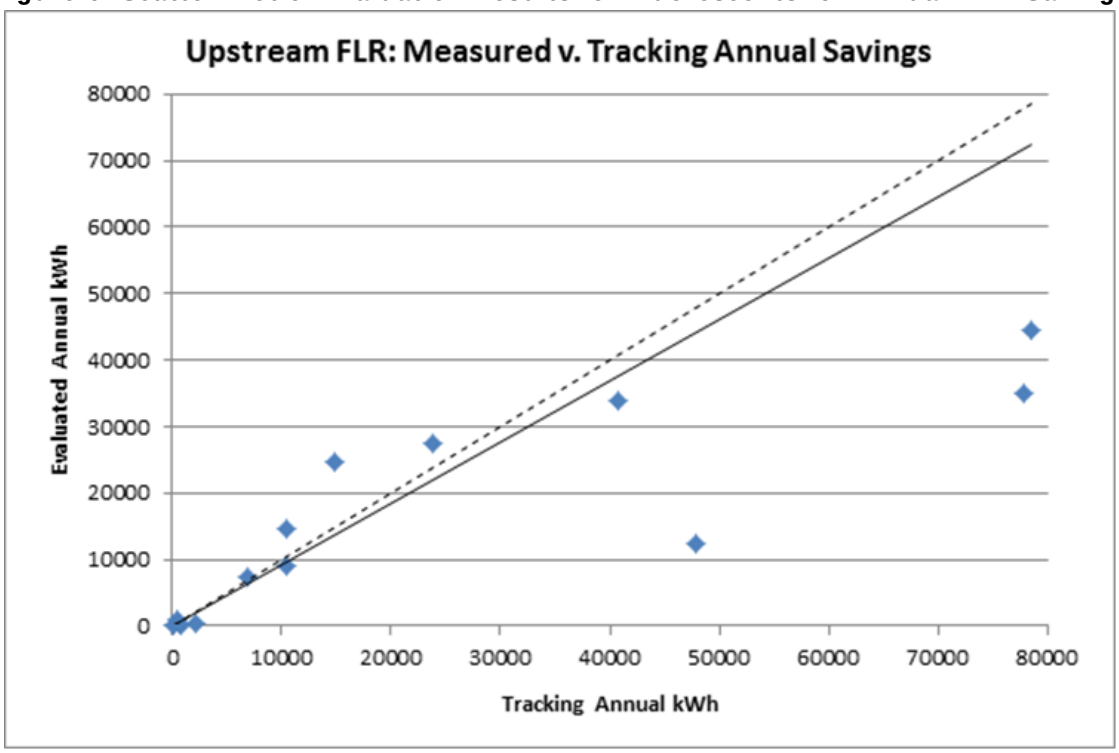


Table 10 summarizes the fluorescent statewide results for this Year 3 analysis. In the case of annual kWh savings, the realization rate for fluorescent lamps was found to be 92.4% with HVAC interactive effects included. The relative precision for this estimate was found to be ±24.0% at the 90% level of confidence. The error ratio was found to be 0.53.

Table 10: Summary of Fluorescent Energy Realization Rate

Savings Parameter	Energy - FLR	
	kWh	% Adjustment
Gross Savings (Tracking)	23,600,503	
Documentation Adjustment	-	0.0%
Technology Adjustment	6,891	0.0%
Quantity Adjustment	(3,471,137)	-14.7%
Operational Adjustment	164,352	0.8%
HVAC Interactive Adjustment	1,502,570	7.4%
Adjusted Gross Savings	21,803,180	-7.6%
Gross Realization Rate	92.4%	
Relative Precision	±24.0%	
Confidence Interval	90%	
Error Ratio	53%	

Table 11 summarizes the fluorescent statewide savings factors resulting from this Year 3 analysis. All relative precisions were calculated at the 90% confidence level; precisions were also calculated at the 80% level for kW factors.

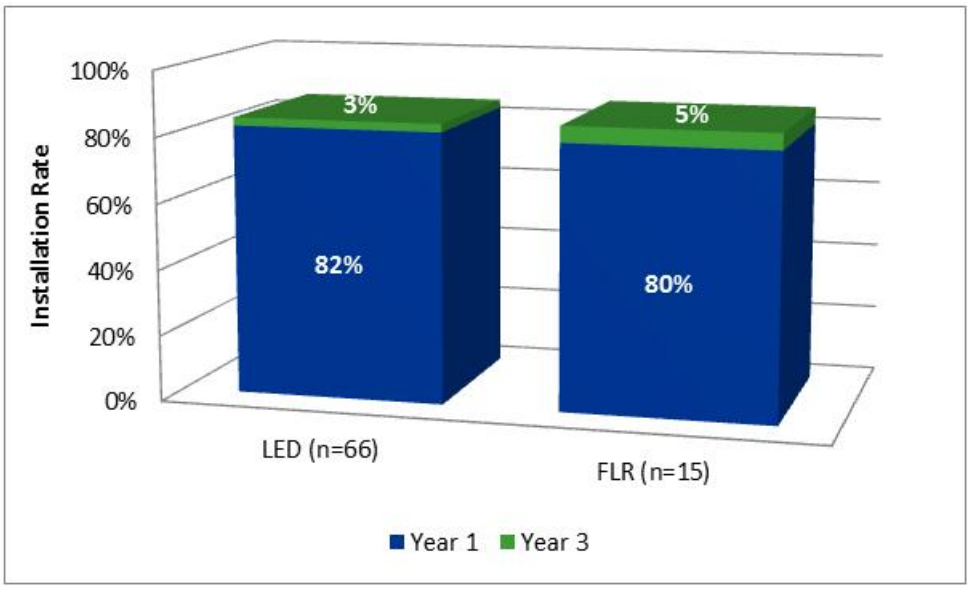
Table 11: Summary of Fluorescent Savings Factors

Savings Factors and Realization Rates	FLR		
	Value	Precision at 90% Confidence	Precision at 80% Confidence
Installation Rate (Quantity Adjustment - kW)	85.3%	±14.6%	±11.2%
Delta Watts (Technology Adjustment - kW)	100.0%	±0.1%	±0.1%
Connected kW Realization Rate(Doc Adj x Qty Adj x Tech Adj)	85.3%	±14.6%	±11.6%
Summer Coincidence Factor			
On Peak Hours	64.3%	±21.4%	±16.3%
Seasonal Hours	57.4%	±25.2%	±19.3%
Winter Coincidence Factor			
On Peak Hours	50.6%	±22.4%	±17.1%
Seasonal Hours	45.4%	±21.1%	±16.1%
Summer kW HVAC Interactive Effect			
On Peak Hours	118.5%	±5.4%	±4.1%
Seasonal Hours	118.8%	±5.7%	±4.3%
Winter kW HVAC Interactive Effect			
On Peak Hours	100.0%	±0.0%	±0.0%
Seasonal Hours	100.0%	±0.0%	±0.0%
KWh Factors (Precisions at 90% confidence)			
Connected kWh Realization Rate	85.3%	±14.6%	
KWh HVAC Interactive Effect	107.4%	±2.5%	
Hours of Use Realization Rate	100.8%	±18.6%	
% On Peak KWh	63.6%	±6.7%	
Non-Electric			
Heating HVAC Interaction Effect (MMBtu/kWh)	-0.00089		

4.2 Comparison of Installation Rates

Figure 7 presents the installation rate by technology type and study year. For LEDs, the Year 1 installation rate was found to be 82%, while the Year 3 installation rate was found to be 85%. This represents an increase of about 3%. For fluorescents, the Year 1 installation rate was found to be 80%, and the Year 3 installation rate was found to be 85%. This represents an increase of about 5%.

Figure 7: Installation Rate by Study Year



4.2.1 Summary of Storage and Installation Observations

Table 12 presents an overall summary of in storage bulbs from the Year 1 evaluation to the Year 3 evaluation. The sites are classified into five distinct categories. We've excluded the large outlier site, which would dilute the "No Additional Bulbs Installed" row. As shown in the table, 12 of the 22 sites have had their remaining in storage bulbs installed since the Year 1 evaluation. The table shows that there were 919 bulbs in storage across these 12 sites at the time of the Year 1 evaluation, and that there are now zero bulbs in storage.

This study found that two of the sites, three if you include the large outlier, had no bulbs installed since the Year 1 evaluation. These two sites included only 14 bulbs total. In one case, the business had moved out, but the space was occupied by a new business, and all of the previously installed bulbs remained. However, the in storage bulbs were no longer on-site. We assume the previous owner took the bulbs with them when they moved out. The second site is a retail store, which has no room to install the remaining bulbs, and has no plans to install them unless they have any burnouts.

There were six sites which had some (73%) of their bulbs installed since the Year 1 evaluation. For five of the six sites in this group, the customers stated that the remaining bulbs were not needed until other bulbs burn out, including either program or non-program bulbs. In one site, a portion of the in storage bulbs were installed, and the remaining bulbs were not found on-site. The customer was not able to provide details on where they ended up.

One site, which was a hospital, not only didn't install any in storage bulbs, but also removed all of the PAR lamps they received due to a strobing issue. They did not replace these bulbs with program bulbs or new LEDs, but went back to their baseline lamp.

In one case, the site used all three of its remaining in storage bulbs to replace program bulbs that had burned out.

Table 12: Summary of Bulbs for Re-Visited Sites between Year 1 and Year 3

Year 3 Classification	Number of Sites	Average Number of Days between Purchase and Year 1 Visit	Number of In Storage Bulbs - Year 1	Average Number of Days between Purchase and Year 3 Visit	Number of In Storage Bulbs - Year 3
All Bulbs Installed	12	254	919	917	0
No Additional Bulbs Installed	2	252	14	1,029	14
Program Bulbs Removed	1	358	846	1,057	0
Replaced Program Bulbs	1	212	3	822	0
Some Bulbs Installed	6	353	2,732	935	747
Total	**22**	**284**	**4,514**	**934**	**761**

In the table above, the column labeled "Number of In Storage Bulbs-Year 3" represents the remaining number of bulbs that still have the potential of being installed at some point in the future. Note that many of these bulbs will remain in storage until current program bulbs burn out, which limits the ability for the program to achieve more savings through an increased installation rate. A more detailed summary of the 23 site visits is also included in Appendix B.

4.2.2 Fluorescent Outlier Site

As identified in Section 3.5 above, site L1505 was found to be an outlier during the Year 1 analysis. This site was a school district, which purchased over 115,000 T8 lamps through the program. However, during the Year 1 evaluation, we found that approximately 2,000 of these lamps had been installed, while the rest remained in a maintenance facility. DNV GL returned to the site for a Year 3 re-visit and found that all of these lamps had remained in storage. Discussions with facility personnel revealed that the school district had not realized how many bulbs they were getting when they signed off on the purchase, since they were getting them for very little cost. With this large stockpile of lamps, they attempted to distribute as many as they could throughout the town to various town buildings. Currently, the school district has no place to use the lamps.

Since this site was part of the earliest phase of this new program, controls have been put into place to try to avoid this situation going forward. One measure put in place was the implementation of an ongoing QA/QC process. An independent QA/QC vendor is currently in place to verify quantities and lamp types, and categorize their inspections as Pass, Fail or Pass with Notes. The process includes inspection of 5% of the locations that purchased lamps through the program with 70% of the inspections targeted at the large sites, and 30% at the small sites. Determination of large versus small sites is based on a quartile analysis of monthly incentive data, and may differ by month. The QA/QC effort also tries to perform visits to locations submitted by each distributor, and at least one site from each PA's service territory.

The QA/QC vendor supplies the PAs with a monthly report that includes the number of sites they visited, what they found and didn't find, and any applicable notes for each site. The PAs review the reports, and look for any large issues or unusual activity. If there are any large issues, the PAs and the program implementation contractor investigate them to ensure that the reports are correct. The PAs look to see if this is a one-time event, or if there is a pattern of unusual activity from a distributor. Ultimately, this information is used to develop programmatic changes to correct the issues.

4.3 Customer Satisfaction

As part of this Year 3 impact evaluation, we asked the 23 customers who agreed to re-visits about their satisfaction with the bulbs or lamps they received through the program, and with the lighting distributors who provided them. These questions were included as part of DNV GL's on-site data collection form, provided in Appendix A, and were taken from the original Upstream Lighting Process Evaluation completed in June of 2013.

For all of the satisfaction questions, we asked customers to use a five-point scale where five equaled "very satisfied" and one equaled "very dissatisfied." In total, we received responses from 16 of the 23 customers in the on-site sample.

Consistent with the June 2013 process evaluation, customer satisfaction with the LED bulbs and linear fluorescent lamps was very high, with 88% of responses in the 4 and 5 rating categories. The average satisfaction rating was 4.2. There was one customer who was not satisfied with their purchase, and we asked the respondent why. The customer indicated that the PAR lamps they received did not work well due to a "strobing" issue. These lamps were ultimately removed. The same customer indicated that the MR16 lamps they received worked well.

We asked the 12 LED customers whether they had used any of their program-discounted bulbs on dimmer switches. A third of the respondents (n=4) said yes. These customers were then asked how satisfied they were with how the bulbs performed with the dimmer switches. All four customers indicated they were satisfied, with an average satisfaction rating of 4.75. One respondent commented that the bulbs would not dim all the way down, but he was otherwise satisfied.

We asked all customers how satisfied they were with the contractor or equipment supplier from whom they purchased the program-discounted bulbs. All customers expressed high satisfaction, with an average rating of 4.75. This is consistent with the responses from the June 2013 process evaluation.

In addition to the questions noted above, we asked some customers if they had made follow-up purchases through the program after their initial purchases. This question was added to the survey after data collection had begun, and was only asked to seven customers. Of the seven, one customer stated that they were so happy with the program bulbs that they purchased new LED bulbs for another facility in their district. All other respondents stated that they had not purchased any additional bulbs through the upstream program.

5 CONCLUSIONS AND RECOMMENDATIONS

Overall, this Year 3 study resulted in a small increase in program savings beyond the Year 1 evaluation savings. The LED kWh realization rate increased from 101.9% to 103.4%, while the fluorescent realization rate increased from 89.0% to 92.4%. These increases were the result of installation rate increases in both groups.

5.1 LED Savings Assumptions

Annual Energy (kWh) and Connected kW Realization Rates. The Year 3 study produced annual kWh (103.4%) and connected kW (113.1%) realization rates that were slightly higher than the Year 1 study. For prospective application of these results, we recommend the PAs adopt the Year 3 results for the entire life of the measure. As shown above in section 4.2.1, the potential for additional savings due to increased installations after Year 3 is limited.

Quantity. The LED installation rate increased from 82.1% to 84.6% between Year 1 and Year 3. This change is the result of bulbs going from storage to sockets between the initial site visits and the re-visit. The evaluation also found that some bulbs that were previously installed had been removed and/or replaced by in storage program bulbs. This finding had a negative impact, which partially offset the gains made from the newly installed bulbs. It is recommended that the PAs apply the Year 3 installation rate for savings estimates going forward. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.

Delta Watts. This delta watts estimate resulting from this study was not significantly different from the Year 1 study (133.6% vs. 133.2%). As noted in the Year 1 study, 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. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.

Hours of Use. This study found that the hours of use realization rate was 87% for LEDs. This is a slight decrease from the Year 1 result of 88%. The change may be due to the newly installed lamps operating slightly fewer hours than the previously installed lamps from Year 1 or due to the re-weighting discussed above in section 3.6. The assumed hours of use for the majority of LED lamps were 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 approximately 3,901 hours per year. Note that the study connected kW and connected kWh realization rates do not include this adjustment for hours, which means that program savings estimates can be updated with the new hours estimates from this study. In this instance the kWh realization rate would be based on the product of the Connected kWh RR (112.0%) and the kWh HVAC Interactive Effect (106.5%), which results in a factor of 119.2%. The assumed Hours of Use (4,500) used in the savings algorithms would need to be replaced with the evaluated Hours of Use (3,901). The combination of these two adjustments would result in the Year 3 evaluated savings.

5.2 Fluorescent Savings Assumptions

Annual Energy (kWh) and Connected kW Realization Rates. The Year 3 study produced annual kWh (92.4%) and connected kW (85.3%) realization rates that were slightly higher than the Year 1 study. For prospective application of these results, we recommend the PAs adopt the Year 3 results for the entire life of the measure. As shown above in section 4.2.1, the potential for additional savings due to increased installations after Year 3 is limited.

Quantity. The fluorescent installation rate increased from 80.3% to 85.3% between Year 1 and Year 3. This change is the result of bulbs going from storage to sockets between the initial site visits and the re-visit. Although many lamps remain in storage at three of the five sites, these lamps are not likely to be used until currently installed program lamps burn out. This limits any future increase in savings due to installation of in storage bulbs. It is recommended that the PAs apply Year 3 installation rate for savings estimates going forward. Note that the study connected kW and kWh realization rates include this adjustment factor, so the adjustment factor should not be applied if the realization rates are being used as recommended.

Hours of Use. This study found that the hours of use realization rate was 101% for fluorescents. This is a slight decrease from the Year 1 result of 103%. The change may be due to the newly installed lamps operating slightly fewer hours than the previously installed lamps from Year 1 or due to the re-weighting discussed above in section 3.6. The assumed hours of use for the majority of LED lamps were 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 approximately 3,410 hours per year. Note that the study connected kW and connected kWh realization rates do not include this adjustment for hours, which means that program savings estimates can be updated with the new hours estimates from this study. In this instance the kWh realization rate would be based on the product of the Connected kWh RR (85.3%) and the kWh HVAC Interactive Effect (107.4%), which results in a factor of 91.6% with the outlier. The assumed Hours of Use (3,380) used in the savings algorithms would need to be replaced with the evaluated Hours of Use (3,410). The combination of these two adjustments would result in the Year 3 evaluated savings.

5.3 Future Impact Evaluation

This study, as well as the Year 1 study, included a sample of sites from the very early stages of the Bright Opportunities Program (Q4 of 2011 through Q3 of 2012). In addition, an independent QA/QC vendor has been in place since the early stages of the program so that the PAs can receive monthly reports on how the program is performing. Based on feedback from the Year 1 study, as well as the monthly QA/QC reports, it is possible that the program has matured in the three years since the impact evaluation sample was drawn. There could be reason to believe that the growth of the program, and the controls that have been put in place to help limit the stockpiling issue, may have contributed to improved installation rates. The PAs and EEAC may consider a follow-up impact evaluation to assess the effectiveness of the efforts that have gone into improving the installation rate.

A suggested approach may be to start with a review of the monthly QA/QC reports to investigate if there have been any trends in verified installations over the past three years. These reports may give an indication of the direction of the installation rate over time, and may provide compelling evidence to conduct a new impact evaluation.

Other reasons to consider a new study would be to investigate the delta watts factor again. It is possible that the delta watts factor may change with time as older incandescent and halogen bulbs become more phased out. A new study may also be designed in consideration of the higher error ratios found in both the Year 1 and Year 3 studies. These higher error ratios resulted in poorer precision estimates than originally planned for. Using the actual error ratios from this study in the planning stage of a new impact evaluation would provide a higher likelihood of achieving the desired precision targets.

APPENDIX A: P49 ON-SITE DATA COLLECTION FORM

Revisits: Upstream Program MA_17/49
Site ID: _____ **Date of Original Visit: _____** **Date of Revisit: _____**
Facility Type: _____ **Overall Facility Operating Hours: _____**

Lamps in Storage at time of First Visit

Type of Lamp (Type/Manuf/Model)	Quantity

For Bulbs Installed since First visit:

Line	Quantity	Lamp Type	Manufacturer	Model Number	Location	Space Type	Customer Description of Type of Lamp Removed	Was the Lamp Removed a Previous Upstream Program Lamp?	Customer Reported Lighting Operating Schedule	When Were Lamps Installed?
example 1	*4*	*25 watt T8*	*GE*	*XX25XX*	*Room 100*	*Conference Room*	*32 watt T8*	*No*	*M-F, 7 am to 6 pm, year round*	*June, 2014*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

For Lamps Still in Storage (Take pictures of in storage lamps if possible)

Line	Quantity	Lamp Type	Manufacturer	Model Number	Location	Why are Lamps in Storage?	When Will Lamps be Installed? If not to be Installed, Why?	If Future Installation Planned, What will they Replace?
example 1	*4*	*25 watt T8*	*GE*	*XX25XX*	*Storage*	*Record customer response verbatim*	*Record customer response verbatim*	*Record customer response verbatim*
1								
2								
3								
4								
5								
6								
7								
8								
9								

Satisfaction

SAT1. On a five point scale where five means very satisfied and one means very dissatisfied, how satisfied or dissatisfied were you with the <TYPE> bulbs you purchased?

01 Very dissatisfied ..... [GOTO SAT2]

02 [GOTO SAT2]

03 [GOTO SAT2]

04 [GOTO SAT3]

05 Very satisfied ..... [GOTO SAT3]

97 (Don't know) ..... [GOTO SAT3]

98 (Refused) [GOTO SAT3]

SAT2. Why do you say that?

DO NOT READ

01 [RECORD VERBATIM]

97 [Don't know]

98 [Refused]

SAT2_os RECORD RESPONSE DIRECTIONAL: PROBE AND CLARIFY FULLY

[IF <TYPE> = "LINEAR FLUORESCENT" GOTO SAT6]

SAT3. Do you have any of the <TYPE> bulbs on dimmer switches?

DO NOT READ

01 [Yes] [GOTO SAT4]

02 [No] [GOTO SAT6]

97 (Don't Know) ..... [GOTO SAT6]

98 (Refused) ..... [GOTO SAT6]

SAT4. On a five point scale where five means very satisfied and one means very dissatisfied, how satisfied or dissatisfied were you with how the <TYPE> bulbs perform in the dimmers?

REPEAT SCALE AS NEEDED

01 Very dissatisfied ..... [GOTO SAT5]

02 [GOTO SAT5]

03 [GOTO SAT5]

04 [GOTO SAT6]

05 Very satisfied ..... [GOTO SAT6]

97 (Don't know) ..... [GOTO SAT6]

98 (Refused) [GOTO SAT6]

SAT5. Why do you say that?

DO NOT READ

01 [RECORD VERBATIM]

97 [Don't know]

98 [Refused]

SAT5_os RECORD RESPONSE directional PROBE AND CLARIFY FULLY

SAT6. On the same five point scale, how satisfied were you with the contractor or equipment supplier from whom you purchased the <TYPE> bulbs?

REPEAT SCALE AS NEEDED

01 Very dissatisfied ..... [GOTO SAT7]

02 [GOTO SAT7]

03 [GOTO SAT7]

04 [GOTO NEXT SECTION]

05 Very satisfied ..... [GOTO NEXT SECTION]

97 (Don't know) ..... [GOTO NEXT SECTION]

98 (Refused) [GOTO NEXT SECTION]

SAT7. Why do you say that?

DO NOT READ

01 [RECORD VERBATIM]

97 [Don't know]

98 [Refused]

SAT7_os RECORD RESPONSE directional PROBE AND CLARIFY FULLY

SAT8. Have you purchased any additional lamps that are the same or similar to the ones originally purchased?

DO NOT READ

01 [Yes] [GOTO SAT9]

02 [No] [END]

97 (Don't Know) ..... [END]

98 (Refused) ..... [END]

2) If so, what influence, if any, did their experience with the original purchase have on the second purchase?

SAT9. What influence, if any, did your experience with the original purchase have on the second purchase?

DO NOT READ

01 [RECORD VERBATIM]

97 [Don't know]

98 [Refused]

APPENDIX B: DETAILED SITE RE-VISIT DATA

Site ID	Group	Facility Type	Days Between Purchase /Year 1 Visit	Number of In Storage Bulbs - Year 1	Year 1 % kWh Savings after QTY Adjustment	Days between Purchase / Year 3 Visit	Number of In Storage Bulbs - Year 3	Year 3 % kWh Savings after QTY Adjustment	% Difference Between Y1 and Y3	Year 3 Class	Site Re-visit Notes
I0648	LED	Multi-Family	204	2	98%	993	0	100%	102%	All Bulbs Installed	All bulbs installed after Y3
I0699	LED	Healthcare-Clinic	297	6	69%	1,151	0	100%	145%	All Bulbs Installed	All bulbs installed after Y3
I1418	LED	Other	294	27	83%	1,135	5	97%	117%	Some Bulbs Installed	22 of 27 in storage bulbs installed. Remaining 5 are not needed yet.
I1419	LED	Other	223	7	92%	999	7	92%	100%	No Additional Bulbs Installed	No increase between Y1 and Y3. This business moved out, but previously installed program bulbs remained installed at this location.
I1476	LED	School/University	293	60	80%	1,136	0	100%	125%	All Bulbs Installed	All bulbs installed after Y3
I1629	LED	School/University	245	2	90%	1,011	0	100%	111%	All Bulbs Installed	All bulbs installed after Y3
I1679	LED	Retail	321	23	44%	1,085	0	83%	189%	Some Bulbs Installed	16 of 23 in storage bulbs installed. Remaining in storage bulbs replaced other program bulbs that burned out.
I2031	LED	Office	242	9	0%	1,026	0	100%	NA	All Bulbs Installed	All bulbs installed after Y3
I2186	LED	Office	324	48	78%	997	0	100%	127%	All Bulbs Installed	All bulbs installed after Y3
I2882	LED	Hospital	358	846	41%	1,057	0	10%	24%	Program Bulbs Removed	All previously installed PAR bulbs have been removed due to strobing issue. MR16 bulbs remain installed.
I2978	LED	Retail	281	7	95%	1,059	7	95%	100%	No Additional Bulbs Installed	No increase between Y1 and Y3. No room in this store, remain in storage, no plan to install.
L0082	FLR	School/University	239	983	71%	769	75	98%	137%	Some Bulbs	908 of 983 in storage lamps installed.

Site ID	Group	Facility Type	Days Between Purchase /Year 1 Visit	Number of In Storage Bulbs - Year 1	Year 1 % kWh Savings after QTY Adjustment	Days between Purchase/ Year 3 Visit	Number of In Storage Bulbs - Year 3	Year 3 % kWh Savings after QTY Adjustment	% Difference Between Y1 and Y3	Year 3 Class	Site Re-visit Notes
										Installed	Remaining 75 lamps are not needed yet.
L0114	FLR	School/University	232	40	9%	785	0	100%	1068%	All Bulbs Installed	All bulbs installed after Y3
L0667	FLR	School/University	208	1,571	61%	769	638	84%	138%	Some Bulbs Installed	933 of 1,571 in storage lamps installed. Remaining 638 not needed yet.
L1191	FLR	School/University	273	653	90%	855	0	100%	111%	All Bulbs Installed	All bulbs installed after Y3
L1505	FLR	School/University	200	113,250	2%	770	113,250	2%	100%	No Additional Bulbs Installed	No increase between Y1 and Y3. School district received significantly more lamps than needed, will not be able to install any more lamps. OUTLIER.
L2113	LED	Hotel	265	49	75%	768	0	100%	133%	All Bulbs Installed	All bulbs installed after Y3
L2275	LED	Retail	219	4	96%	729	0	100%	104%	All Bulbs Installed	All bulbs installed after Y3
L2719	LED	Office	228	34	76%	774	0	100%	131%	All Bulbs Installed	All bulbs installed after Y3
L3693	LED	Retail	614	34	6%	900	29	18%	300%	Some Bulbs Installed	5 of 34 in storage bulbs installed. Remaining 29 will not be installed until existing CFLs burn out.
L3918	LED	Exercise Center	224	12	0%	784	0	100%	NA	All Bulbs Installed	All bulbs installed after Y3
L4680	LED	School/University	212	3	97%	822	0	97%	100%	Replaced Program Bulbs	Storage bulbs replaced other program bulbs that burned out. No additional savings realized.
L5586	LED	Retail	443	94	19%	951	0	58%	305%	Some Bulbs Installed	94 in storage bulbs installed. Remaining 126 not found anywhere on-site.

APPENDIX C: 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.

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.

Savings Factors

Summer Coincidence Factor

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

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

Winter Coincidence Factor

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

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

Summer kW HVAC Interactive Effect

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

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

Winter kW HVAC Interactive Effect

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

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

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

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

Table 13: 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)

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