DNV·GL

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

National Grid

Final Report
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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.