Impact Evaluation of 2011 Rhode Island Custom Lighting Installations

National Grid
Prepared by KEMA, Inc.
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1. Introduction

This document summarizes the work performed by DNV KEMA during 2012 and 2013 to quantify the actual energy and demand savings due to the installation of Custom Lighting measures installed through National Grid's Commercial and Industrial Retrofit and New Construction energy efficiency programs in 2011 in Rhode Island (RI). This report also summarizes the sampling and analysis procedures used for developing the population level results, which are based on the combined results of the Rhode Island sites and a concurrent study of National Grid Custom Lighting projects in Massachusetts.

1.1 Purpose of Study

The objective of this impact evaluation is to provide verification or re-estimation of electric energy and demand savings estimates for a sample of Rhode Island Custom Lighting projects through site-specific inspection, monitoring, and analysis, and to develop new realization rates for the combined Lighting populations in Rhode Island. The results of the project studies are combined with the results from a concurrent study of National Grid Custom Lighting installations in Massachusetts to determine appropriate population level realization rates for the combined Custom Lighting populations in Rhode Island.

This impact study consists of the following four tasks:

1. Develop Sample Design
2. Develop Site Measurement and Evaluation Plans
3. Data Gathering and Site Analysis
4. Report Writing and Follow-up

1.2 Scope

The scope of work of this impact evaluation covered the 2011 Custom Lighting end-uses. This impact evaluation includes only measures which primarily reduce electricity consumption.

2. Description of Sampling Strategy

The primary focus of the sample design task was to examine various precision scenarios for the Custom Lighting programs in Rhode Island. The sample design process included several preliminary designs and options that targeted various sample sizes and precisions. The final sample design had four Rhode Island sites, providing an anticipated Custom Lighting precision around the RI kWh savings results of ±28.4%. In addition to estimating realization rates for RI, the RI sample was also designed to be combined with the MA results to determine a combined realization rate. The combined RI and MA (16 sites) Custom Lighting Samples, the anticipated precision for Custom Lighting kWh results was estimated to be ±11.47%. Results from National Grid's Massachusetts Custom Lighting evaluation as part of the larger PA study were developed previously and are described in a final report available on the MA EAC website[1].

The project populations for National Grid, based on projects MA completed in 2010 and RI sites competed in 2011, are summarized in Table 1.

Table 1: RI & MA Population Statistics – Custom Lighting

State	Projects	Total Savings	Average Savings	Minimum	Maximum	StdDev	CV
Massachusetts	84	9,109,224	108,443	3,174	2,418,500	275,964	2.54
Rhode Island	45	4,706,437	104,587	8,353	971,068	182,764	1.75
Total	129	13,815,661					

The initial design approach was to support the estimation of annual kWh savings realization rates for National Grid's programs in Rhode Island. While annual kWh savings was the primary variable of interest, National Grid is also interested in achieving accurate results for coincident summer peak demand (kW), in order to meet the ISO-NE guidelines for ±10% precision with 80% confidence for their overall portfolio of programs.

The sample design and anticipated precision for annual kWh and summer kW is presented in the following section. The evaluation sample for this study was designed in consideration of the requirements for a 90% confidence level for energy (annual kWh) and an 80% confidence level for coincident peak summer demand (kW).

1 http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2012/2012%20Non-Residential/MA-LCIEC-12%20Custom%20Lighting%20Final%20Report.pdf

2.1 Annual kWh Sample Designs

The parameters considered in the kWh sample design are the number of sample observations planned and the anticipated error ratio of the dimension being estimated which, in this case, is the realization rate for evaluated savings. The error ratio is a measure of the strength of the relationship between the known characteristic (i.e., tracking system savings) and the unknown population characteristic (i.e., evaluated savings). For this study, an error ratio of 0.4 was assumed for energy savings. Preliminary sample designs of two, four, six and eight sites were considered. The final annual kWh design, which served as the basis for the RI sample size of four sites, is shown in Table 2.

Table 2: RI Custom Lighting Sample Design

Stratum	Total Projects	Total Annual MWh	Projects in Sample	Case Weight
1	39	1,736,529	2	19.50
2	6	2,969,908	2	3.00
All	45	4,706,437	4	N/A

Since the individual results for Custom Lighting in Rhode Island were not expected to produce estimates with great precision, plans were made for the likely possibility that they may be combined with Massachusetts results for determining an overall realization rate for these measures for use in Rhode Island. Combining Rhode Island results with Massachusetts results from similar studies was considered due to the high cost of conducting Rhode Island specific evaluations with large enough samples to produce statistically representative results and the fact that the National Grid's program design and delivery infrastructure is similar in both state's subsidiaries. Anticipated precisions for the RI, MA and combined results are shown in Table 3 . The actual precisions achieved in these studies are provided in the results section of this report.

Table 3: Custom Lighting Anticipated Precisions for Annual KWh

State	Projects	Total KWh Savings	Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision	Error Bound
MA	84	9,109,224	0.4	90%	14	±9.34%	850,802
RI	45	4,706,437	0.4	90%	4	±28.42%	1,337,569
Total	129	13,815,661	0.4	90%	20	±11.47%	1,584,656

2.2 Coincident Summer Peak Demand (kW) Sample Designs

Before deciding on a final sample design, we examined the estimated summer kW precision that could be achieved with a sample of this approximate size. The error ratio for summer kW savings from previous custom electric measure studies were higher than that for annual kWh, so a value of 0.5 was assumed for this calculation. Table 4 reports the anticipated precision for summer kW savings, based on a confidence

level of 80%. Overall, the anticipated relative precision around the summer peak demand estimate is anticipated to be ±11.6%.

Table 4: **Anticipated Precision for Summer KW**

State	Projects	Total Summer KW Savings	Error Ratio	Confidence Level	Planned Sample Size	Anticipated Relative Precision	Error Bound
MA	84	1,886	0.5	80%	14	±12.24%	231
RI	45	273	0.5	80%	4	±35.53%	97
Total	129	2,159	0.5	80%	19	±11.60%	250

2.3 Final Samples

Based on these stratified designs, random samples of projects were selected from the tracking system data. Table 5Table 5presents the list of four projects selected as the final sample for RI Custom Lighting projects, including their strata number, and tracking savings (annual kWh, summer kW and winter kW). The final Massachusetts Custom Light sample consisted of 14 sites.

Table 5: RI Final Sample Selection

Stratum	Project ID	Tracking Estimated Savings			
			On-Peak %	Coincident Peak	
		kWh/yr		Summer kW	Winter kW
1	NGRID953974	9,272	61%	1.1	1.1
1	NGRID830353	27,791	61%	5.2	5.2
2	NGRID780584	430,370	61%	0.0	49.0
2	NGRID830596	323,310	90%	39.3	39.4

3. Description of Methodology

3.1 Measurement and Evaluation Plans

Following the final sample selection of 2011 Custom Lighting applications and prior to beginning any site visits, KEMA developed detailed measurement and evaluation plans for each of the 4 applications. The plans outlined on-site methods, strategies, monitoring equipment placement, calibration and analysis issues. National Grid provided comments and edits to clarify and improve the plans prior to them being finalized.

The site evaluation plan played an important role in establishing approved field methods and ensuring that the ultimate objectives of the study were met. Each site visit culminated in an independent engineering assessment of the actual (e.g. as observed and monitored) annual energy, on-peak energy, summer on-peak and seasonal demand, and winter on-peak and seasonal demand savings associated with each project.

3.2 Site Level Data Gathering, Analysis, and Reporting

Data collection at each on-site included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and long-term metering of usage. At each site, DNV KEMA performed a facility walk-through that focused on verifying the installed conditions of each energy conservation measure (ECM). Power meters and/or Time-Of-Use (TOU) loggers were installed to monitor the usage of the installed lighting equipment.

Collected data was analyzed to verify implementation of each lighting project, and savings analyses were performed to estimate hourly energy use and diversified coincident peak demand. Each site report details the specific analysis methods used for each project including algorithms, assumptions and calibration methods where applicable.

KEMA submitted draft site reports to National Grid upon completion of each site evaluation, which after review and comment resulted in the final reports found in Appendix A. This executive summary provides a concise overview of the evaluation methods and findings.

While the metering and analysis of custom lighting performed utilized standard approaches, there are two items of particular note we would like to address here. The first is regarding the determination of the specific metering equipment used at the sites visited and the second is that of how interactive heating and cooling effects were quantified.

Monitoring Equipment

Time-dependent measures typically call for the installation of time-of-use (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.

Clamp-on time-of-use, current, or power loggers were also used in selective situations such as high-bay lighting, or exterior fixtures where traditional time-of-use lighting loggers were impractical due to installation height or accessibility.

Interactive HVAC Methods

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

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

As part of the on-site methodology, evaluators interviewed facility personnel to ascertain the cooling and heating fuel, system type, and other information with which to approximate the efficiency of the HVAC equipment serving the space of each lighting installation. The DNV KEMA team expresses HVAC system efficiency in dimensionless units of Coefficient of Performance (COP), which reflects the ratio of work performed by the system to the work input of the system. Table 6 details the COP assumptions for general heating and cooling equipment types encountered in this study. Where site specific information yielded improved estimates of system efficiency, these were used in place of the general assumptions below.

Table 6: General Heating and Cooling COP Assumptions

Cooling System Type	COP
Packaged Rooftop	2.9
Window Unit	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

Electric interactive effects are calculated only at sites where heating and/or cooling systems are in use at the same time the lighting project provides savings. Leveraging the 8,760 profile of hourly demand impacts, the DNV KEMA team computes electric interactive effects during the hours that lighting and HVAC are assumed to operate in unison.

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

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. The HVAC hours account for when the heating or cooling system is on, and when an outdoor air temperature set point is reached. This assumption is consistent with those established and employed in previous impact evaluations of custom lighting measures. Heating factors are negative because heating interaction erodes gross lighting savings, while cooling interactive boosts it.

3.3 Program Level Analysis Procedures

In order to aggregate the individual site results from the RI Custom Lighting samples, KEMA applied the model-assisted stratified ratio estimation methodology.[2,3] The key parameter of interest is the population

[2]The California Evaluation Framework, prepared for Southern California Edison Company and the California Public Utility Commission, by the TecMarket Works Framework Team, June 2005, Chapters 12-13.

realization rate, i.e., the ratio of the evaluated savings for all population projects divided by the tracking estimates of savings for all population projects. This rate is estimated for the Rhode Island populations only, as well as for National Grid's combined populations of Rhode Island and Massachusetts. Of course, the true population realization rate is unknown, but it can be estimated by evaluating the savings in a sample of projects. The sample realization rate is the ratio between the weighted sum of the evaluated savings for the sample projects divided by the weighted sum of the tracking estimates of savings for the same projects. Statistical precisions and error ratios accompany each level of result provided.

The results presented in the following section include realization rates (and associated precision levels) for annual kWh, % kWh on-peak, and demand (kW) savings during winter and summer on-peak periods, as defined by the ISO-NE 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.

Relative precision levels and error bounds are calculated at the 80% confidence level for demand values, since that is the requirement for portfolios participating in the ISO-NE Forward Capacity Market. For all kWh realization rates, the standard 90% confidence level is used.

[3]Model Assisted Survey Sampling, C. E. Sarndal, B. Swensson, and J. Wretman, Springer, 1992.

4. Custom Lighting Results

Evaluated savings data for the Rhode Island sample points were analyzed to develop Rhode Island realization rates, and then combined with National Grid Massachusetts results (previously reported as discussed above) to represent overall results that can be considered for use in Rhode Island.

In preparation for analyzing the evaluation results collected for the RI sample points, the original 2011 population distribution was used to calculate case weights for each observation in the Rhode Island sample. These weights reflect the number of projects that each sample point represents and allow for the aggregation of results across strata. The case weights for this study are shown in the last column in Table 7Table 7. This table also shows the tracked and evaluated savings for each of the energy and demand impacts of interest to the study. More information on the cause of the discrepancies noted between the tracking and evaluated estimates are provided later in this section.

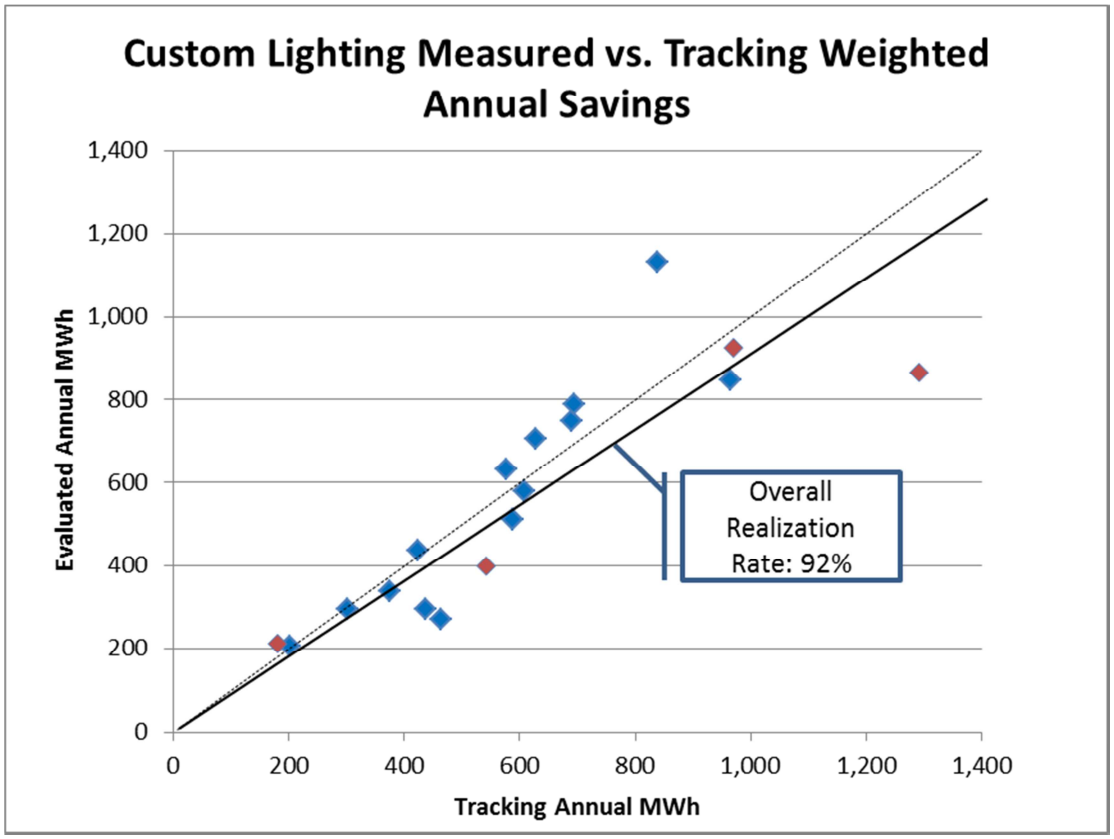
Table 7: RI Custom Lighting Site Results and Case Weights

		Tracking Estimated Savings				Evaluation Savings				
				Coincident Peak				Coincident Peak		
Stratum	Project ID	kWh/yr	On-Peak %	Summer kW	Winter kW	kWh/yr	On-Peak %	Summer kW	Winter kW	Case Weight
1	NGRID953974	9,272	61%	1.1	1.1	10,891	47%	1.4	1.1	19.5
1	NGRID830353	27,791	61%	5.2	5.2	20,503	24%	0.1	0.4	19.5
2	NGRID780584	430,370	61%	0.0	49.0	288,862	27%	2.6	22.8	3.0
2	NGRID830596	323,310	90%	39.3	39.4	308,676	56%	49.1	38.8	3.0

4.1 Major Findings and Observable Trends

Figure 1 presents a scatter plot of evaluation savings for the four Rhode Island sample points (with red markers), combined with the Massachusetts sample points (with blue markers). Each point has been weighted by the number of population projects that it represents. The dashed line represents a realization rate of one. The slope of the solid line in this graph illustrates the realization rate based upon overall weighted results. The realization rate for energy savings is calculated to be 92%. The four Rhode Island sample points have evaluated savings that range from being within 5% of their tracked value to 33% (the third and fourth rightmost red markers, respectively.)

Figure 1: Scatter Plot of RI and MA Evaluation Results for Annual KWh Savings



4.2 Presentation of Results

Table 8: RI Custom Lighting Primary Site Discrepancies summarizes the savings realization rates and primary reasons for discrepancies between the tracking and evaluation estimates of annual energy savings for the four RI sites. Three site discrepancies were driven primarily by operating hours while the fourth was driven by an installation quantity adjustment. Note that for one site, the summer kW realization rate

is listed as "n/a." This is due to the tracking summer kW savings for this site as being 0 kW, which assumed that all lighting would operate in the off-peak hours. This was a reasonable assumption, as these lights were exterior fixtures, which were not expected to operate during the summer peak period.

Table 8: RI Custom Lighting Primary Site Discrepancies

Project ID	Tracking kWh Savings	Realization Rates				Reasons for Discrepancies
		kWh/yr	On-Peak %	Summer KW	Winter KW	
830353	27,791	74%	39%	2%	9%	Evaluation hours of operation 74% of tracking assumptions.
780584	430,370	67%	45%	n/a	46%	Installed quantity is 138 fewer than proposed (32% reduction in savings).
830596	323,310	95%	62%	125%	99%	Evaluation hours of operation 87% of tracking assumptions.
953974	9,272	117%	77%	133%	105%	Positive HVAC and operating hour adjustments

The site-level evaluation results for Massachusetts and Rhode Island were analyzed using stratified ratio estimation both independently and combined. The overall National Grid combined realization rate is the ratio of the total evaluated savings to the total tracking savings, each of which is calculated by summing across the two states. Table 9 and Table 10 respectively summarize the RI and MA Custom Lighting results. Table 11 provides a summary of the aggregated National Grid results. Since the design criteria for the demand realization rates were different than those for the annual kWh (80% vs. 90% confidence levels), the precisions are reported only in the appropriate rows in these tables. A gray cell indicates that the confidence level shown is not applicable.

Table 9: Summary of RI Custom Lighting Results

Rhode Island	Annual KWh	On-Peak KWh	% On-Peak KWh	On-Peak Summer kW	On-Peak Winter kW
Custom Lighting					
Total Tracking Savings	4,706,437	2,126,749	45.2%	273	826
Total Measured Savings	3,771,940	957,066	25.4%	205	524
Realization Rate	80.1%	45.0%	56.2%	75.1%	63.5%
Relative Precision at 90% Confidence	±14.1%	±27.6%	-		
Error Bound at 90% Confidence	532,937	263,872	-		
Relative Precision at 80% Confidence			-	±62.1%	±33.8%
Error Bound at 80% Confidence			-	127	177
Error Ratio	0.20	0.38	-	1.04	0.56

Table 10: Summary of MA Custom Lighting Results

Massachusetts	Annual KWh	On-Peak KWh	% On-Peak KWh	On-Peak Summer kW	On-Peak Winter kW
Custom Lighting					
Total Tracking Savings	9,109,224	4,036,009	44.3%	1,886	2,250
Total Measured Savings	8,921,763	4,273,138	47.9%	2,185	1,913
Realization Rate	97.9%	105.9%	108.1%	115.9%	85.0%
Relative Precision at 90% Confidence	5.9%	13.9%	-		
Error Bound at 90% Confidence	528,587	595,106	-		
Relative Precision at 80% Confidence	4.6%	10.9%	-	7.4%	9.2%
Error Bound at 80% Confidence	411,945	463,785	-	207	225
Error Ratio	0.16	0.33	-	0.25	0.33

Table 11: Summary of Overall MA & RI Combined National Grid Custom Lighting Results

Rhode Island and Massachusetts	Annual KWh	On-Peak KWh	% On-Peak KWh	On-Peak Summer kW	On-Peak Winter kW
Custom Lighting					
Total Tracking Savings	13,815,661	6,162,757	44.6%	2,159	3,076
Total Measured Savings	12,693,702	5,230,204	41.2%	2,390	2,437
Realization Rate	91.9%	84.9%	92.4%	110.7%	79.2%
Relative Precision at 90% Confidence	±5.9%	±12.4%	-		
Error Bound at 90% Confidence	750,618	650,984	-		
Relative Precision at 80% Confidence			-	±10.2%	±11.7%
Error Bound at 80% Confidence			-	243	286
Error Ratio	0.15	0.32		0.34	0.39

From the state-level results, we can observe that the Rhode Island realization rates are moderately lower than those estimated for Massachusetts for energy and significantly lower for the % On-peak kWh and on peak demand estimates. Although we note that the Rhode Island estimates are driven by a small sample size. These lower results were driven by an overestimation of hours of use, and one site which did not install as many fixtures as proposed. At ±5.9%, the overall precision of the combined Massachusetts and

Rhode Island results on the Annual KWh estimate is very good and the overall summer peak precision of ±10.2%, nearly meets the ISO-NE desired threshold of ±10% at the 80% confidence interval for the overall portfolio. With the exception of the Rhode Island on-peak summer precision, the final precisions were better than anticipated in the sample designs.

4.3 Implications for Future Studies

Table 12 below shows the assumed error ratios in the sample design versus those experienced in the studies. From a sampling perspective, it is clear that in future designs targeting energy savings, National Grid can confidently assume a lower error ratio than the 0.4 assumed in the MA and RI studies. The error ratios around the peak estimates were also better than assumed in the sample designs in Massachusetts, but not in Rhode Island. This suggests that future studies might bear some risk in assuming error ratios that are lower than those assumed in the peak demand sample work.

Table 12: Assumed and Actual Error Ratios

Parameter	Assumed e.r.	Actual e.r.
Massachusetts		
Energy	0.40	0.16
Peak Summer	0.50	0.25
Peak Winter	0.65	0.33
Rhode Island		
Energy	0.40	0.20
Peak Summer	0.50	1.04
Peak Winter	0.65	0.56

4.4 Conclusions and Recommendations

Despite the near unity in tracked versus evaluated energy savings results in the Massachusetts sites alone, the Custom Lighting savings are lower than expected when combined with Rhode Island which showed a lower realization rate than the Massachusetts sites. Below are the DNV KEMA evaluation team findings and recommendations, which refer only to National Grid's Rhode Island sites. Additional recommendations, based on National Grid's Massachusetts sites, are available in the concurrent Massachusetts Custom Lighting impact evaluation referenced previously.

Verify installed quantities as part of the post-installation inspection process. At site 780584, evaluated savings were 33% lower than tracking estimates. This was due to a quantity discrepancy found during the on-site visit. Evaluators found 138 fewer fixtures than proposed. Discussions with the implementation vendor confirmed the reduction in quantity. A significant change in quantity such as this

should be captured as part of a post-installation inspection, if not before. It is recommended that National Grid consider program processes that might mitigate such events in the future, such as increased post-installation inspections.

Continue to improve the tracking estimates of hours of use. Overall, National Grid is doing a good job in estimating hours of operation for custom lighting measures in Rhode Island. Over the past 10 – 15 years, National Grid has seen steady improvements in this estimate, which had traditionally been difficult to predict. It is recommended that implementation staff and vendors continue to focus on the hours of use estimate, and to use all of the tools at their disposal. One suggestion would be to try to use more than one hours of use estimate based on the different usage areas involved in the lighting project (i.e., breaking out areas by function and hours of use to the lowest granularity reasonable). Implementation vendors can also take advantage of existing controls such as time clocks and photo sensors when estimating hours of use.

Consider including HVAC interactive effects on a case by case basis. Two sites in this sample (830596, 953974) saw significant savings increases due to the evaluations' inclusion of HVAC interactive effects. In both cases, the new lighting was installed in areas that were mechanically cooled. Since these are custom sites, we recommend that inclusion of interactive effects is considered when it is believed to be a significant contributor to savings. As discussed in an earlier section, the reduction in heat associated with the lower wattage lighting results in reduced space cooling loads. This will result in two positive benefits to the program; increased and more accurately tracked program savings and better precisions resulting from evaluation.

5. Appendix A – Rhode Island Site Reports

Application ID: 830353

Facility Type: Manufacturing Facility

Summary

The exterior lighting at this industrial facility was retrofitted to improve energy efficiency. The project consisted of replacing (13) 175 watt metal halide fixtures with (13) 80-Watt induction lighting fixtures and (20) 250 watt metal halide fixtures with (11) 125-Watt induction lighting fixtures. The new fixtures were installed across three separate areas. Two 80-Watt fixtures were installed on the perimeter of the office building. Three 80-Watt wall packs were installed at the production building. The remaining eight 80-Watt wall packs and the eleven 125-Watt pole fixtures were installed across the street in the processing building and truck parking area. Three existing time clocks, manually programmed, in each of those areas are used to control the installed fixtures.

Table 1 presents the summary of the tracking and on-site savings results.

Table 1: Summary of Tracking and Evaluated Savings Results

Savings Quantity	Tracking Savings	Evaluated Savings	Evaluated/Tracking
Annual Energy (kWh)	27,791	20,503	74%
% Energy Savings On-Peak	61%	24%	39%
Summer On-Peak kW	5.22	0.11	2%
Winter On-Peak kW	5.22	0.44	9%

The overall on-site energy savings estimate is 26% lower than predicted in the tracking estimate. The evaluated estimate of the percent on-peak kWh reduction was 61% less than the tracking value. The summer and winter on-peak kW demand savings were 98% and 91% less than anticipated. The following factors influenced the difference between the tracking and evaluated estimates of energy and demand savings:

- These fixtures are controlled by the three existing time clocks. Tracking savings are based upon 4,380 annual hours of operation. The office time clock controlling the two office fixtures operates 4,278 hours. The production time clock schedule is 4,329 hours for three fixtures installed in the production area. The time clock across the street controls eight 80-Watt fixtures and the eleven 125-Watt fixtures. This time clock has annual operation of 3,098 hours which is 30% less than the tracking estimate.

- Time-of-use loggers were installed on each of the three time clock circuits to capture their unique operation. Monitoring occurred for 107-days from August 21st to December 12th. This span covers summer operation through late fall and data shows the seasonal changes in time clock settings. This is consistent with comments by facility personnel, which stated that lighting is required for security from late evening to early morning and the time clock settings are adjusted accordingly. Production and warehouse settings are typically between 7 pm and 7 am, and office settings are typically between 6 pm and 5 am.
- The variance in peak demand savings is due to the average start/stop times of the lighting. Most of the lighting operation falls outside the seasonal peak demand hours.

Project Description

Table 2 presents a summary of the existing system as outlined in the customer application.

Table 2: Existing Lighting System

Existing Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Pole Lighting	250W Metal Halide	295	20	4,380
Office Wall Packs	175W Metal Halide	220	2	4,380
Production Wall Packs	175W Metal Halide	220	3	4,380
Process Wall Packs	175W Metal Halide	220	8	4,380
	Total	8,760	33	4,380

Table 3 presents the installed fixtures and quantities as proposed in the customer application.

Table 3: Proposed Lighting System

Installed Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Pole Lighting	150W Induction	125	11	4,380
Office Wall Packs	80W Induction	80	2	4,380
Production Wall Packs	80W Induction	80	3	4,380
Process Wall Packs	80W Induction	80	8	4,380
	Total	2,415	24	4,380

Tracking Estimates

The tracking estimates of energy use were calculated based on the full load of the existing and proposed fixtures. The energy savings were calculated as the difference in the pre and post installation energy use based on annual operating hours.

Evaluation Methodology

Evaluation Approach

The evaluation included a verification of installed fixtures, on-site monitoring and interviews of facility staff. The existing time clocks were identified and settings reviewed.

The base case used in the evaluation of the lighting savings was developed from information contained in the customer application. The pre-existing fixture types were confirmed while on-site with the facility contact. An evaluator visited the facility to verify the installed fixtures and install monitoring equipment to quantify the hours of use throughout the retail space. The evaluator surveyed facility personnel to obtain information on the lighting usage throughout the year. This is an exterior lighting project and there is no HVAC interaction.

To determine the hours of use for the new fixtures, the field engineer installed three time-of-use loggers in the lighting electrical panels. Each logger recorded the on/off of the lighting fixtures monitored. Table 4 presents the fixtures monitored by the evaluation engineer.

Table 4: Spaces Monitored

Logger #	Equipment Monitored	Parameter Measured	Test Equip. Make & Model	Measurement Type	Installation Method	Frequency of Observations	Monitoring Duration
CT08010010	Production Wall Packs	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	08/21/12 – 12/12/12
CT08010015	Warehouse & Pole	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	08/21/12 – 12/12/12
CT08010027	Office Wall Packs	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	08/21/12 – 12/12/12

Verification of Equipment and Operating Parameters

The project consisted of replacing (13) metal halide fixtures with (13) 80-Watt induction lighting fixtures and (20) metal halide fixtures with (11) 125-Watt induction lighting fixtures. A fixture count taken during the site visit confirmed that all 24 fixtures were installed at the site and were fully operational.

This is an exterior lighting project. There are no interactive HVAC savings or penalties.

Lighting operation data was downloaded from each logger. The data was then analyzed using computer software, which develops time-of-use load profiles and estimates of percentage on-times during the monitoring period. Evaluators used lighting logger data from the monitoring period, and extrapolated out to 12 months to produce 8,760 hourly operating profiles. The data was annualized using an algorithm that averages the data by day of week (1 through 7), and hour of day (1 through 24). Evaluators observed a one hour shift in operation, which occurred at the end of September. This shifted the lighting ahead one hour, but the total on-time remained the same. Therefore, the logger data were averaged to represent the entire year as stated above.

Table 5 presents the values obtained from the monitored data including annual operation, summer and winter diversity factors, and on-peak hours of use. These values were used for both the pre and post installation calculations because the operation of the lighting remained fixed.

Table 5: Annual Hours of Use and Diversity Factors of Monitored Data

Schedule ID	Logger #	Description	Annual Hours	Summer Diversity	Winter Diversity	On-Peak Hours
1	CT08010010	Production Wall Packs	4,329	0%	41%	1,011
2	CT08010015	Warehouse & Pole	3,098	1%	1%	719
3	CT08010027	Office Wall Packs	4,278	12%	71%	1,258

To estimate annual energy and demand savings, a spreadsheet method was employed. The summary of this spreadsheet is presented in Table 6. Annual hours and diversity factors from Table 5 are used with wattages from Table 6 to calculate energy and demand savings. The final on-site savings estimates are presented in Table 6.

The average daily lighting profiles for the monitored spaces are presented in Figure 1 through Figure 3. This includes the average weekday and weekend day. The x-axis represents one full day and the y-axis is the percentage that the lights are on for each hour.

An hourly summary of the site kW savings for an average summer (June through August), non-holiday, weekday is presented in Figure 4. This summary is provided so that the summer diversified peak kW can be estimated across any range of hours in the event that the FCM definition for summer peak changes in the future. The same summary was also provided for the average winter (December and January), non-holiday, weekday in Figure 5.

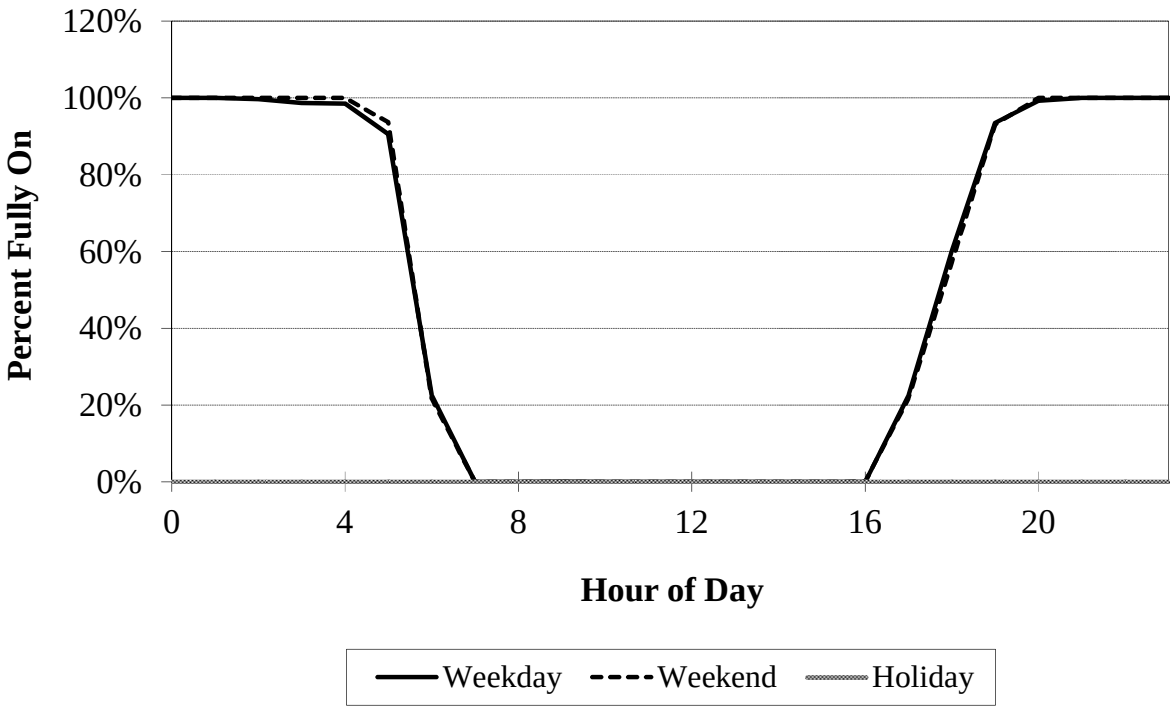


Figure 1: Average Daily Lighting Profile for Production Wall Packs from 08/21/12 to 12/12/12

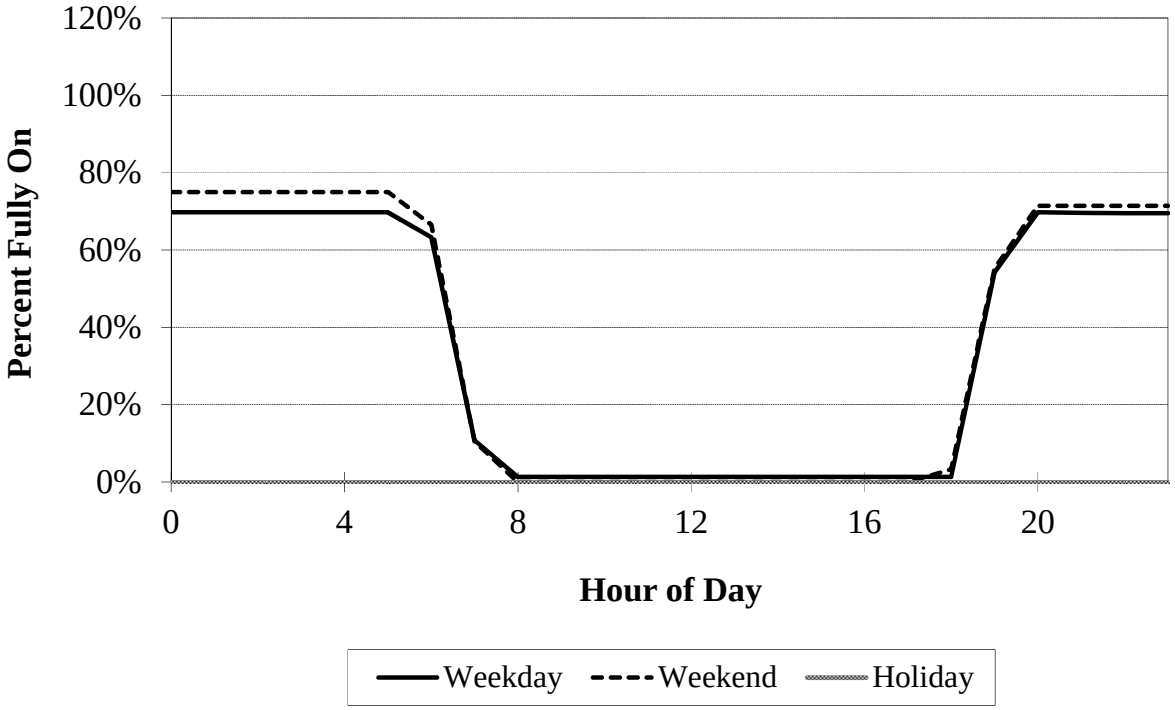


Figure 2: Average Daily Lighting Profile for Warehouse and Pole from 08/21/12 to 12/12/12

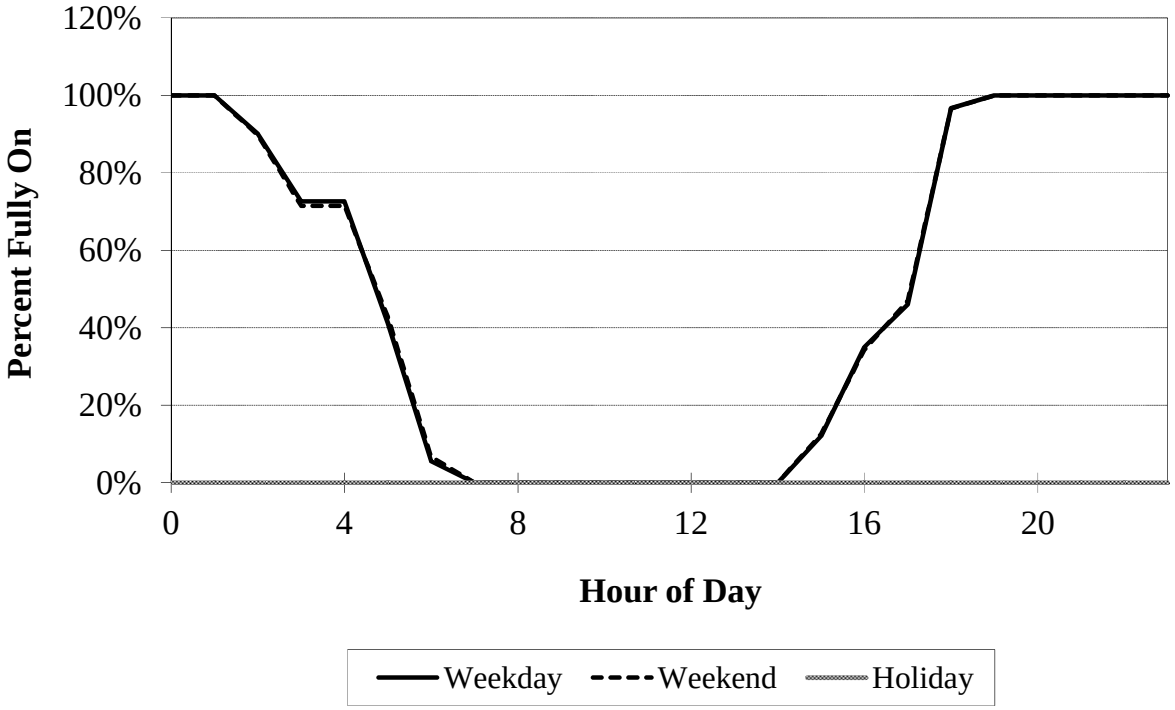


Figure 3: Average Daily Lighting Profile for Office Wall Packs from 08/21/12 to 12/12/12

Table 6: Summary of Evaluated Energy and Demand Savings

Facility Type:	Manufacturing Facility
KEMA ID:	105
Application Number/s:	830353
Project Type:	Systems

	Systems	Controls
Tracking Annual kWh:	27,791	0
Tracking Connected kW:	0.00	0
Tracking % On-Peak kWh:	0%	0%

Fixture Information

		Pre-retrofit Lighting						Post-retrofit Lighting					
Fixture ID	Space Type	Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Diversity Factor Summer	Diversity Factor Winter	Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Peak Diversity Factor Summer	Peak Diversity Factor Winter
1	0	250W METAL HALIDE	20	295	3,098	1%	1%	150W Induction	11	125	3,098	1%	1%
		Totals	33	8,760				Totals	24	2,415			

Pre-Retrofit Demand and Energy Consumption

	Lighting Demand and Energy Consumption				Interactive Hours		Interactive Energy Consumption			
Fixture ID	Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Cooling Hours	Heating Hours	Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	5.90	0.08	0.07	18,278	1,098	1,237	0	0	0.00	0.00
Totals	8.76	0.16	0.68	28,469			0	0	0.00	0.00

Post-Retrofit Demand and Energy Consumption

	Lighting Demand and Energy Consumption				Interactive Hours		Interactive Energy Consumption			
Fixture ID	Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Cooling Hours	Heating Hours	Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	1.38	0.02	0.02	4,260	1,098	1,237	0	0	0.00	0.00
Totals	2.42	0.05	0.24	7,966			0	0	0.00	0.00

Total Savings Summary

	Energy kWh	Summer kW	Winter kW	Connected kW
Annual Lighting Only	20,503	0.11	0.44	6.35
Annual Interactive	0	0.00	0.00	N/A
Annual Lighting and Interactive	20,503	0.11	0.44	6.35

	MMBTU
Annual Non-Electric Heating Savings	#N/A

Savings Adjustment Factors Lighting Systems

Parameter	Annual KWH	Difference %	Summer kW	Difference %	Winter kW	Difference %
Gross (TRACKING) kWh/Connected kW Savings	27,791	N/A	0.00	N/A	0.00	N/A
Adjustment - Documentation Change	0	0%	6.35	0%	6.35	0%
Adjustment - Technology Change	0	0%	0.00	0%	0.00	0%
Adjustment - Quantity Change	0	0%	0.00	0%	0.00	0%
Adjustment - Operation Change	-7,288	-26%	N/A	N/A	N/A	N/A
Adjustment - Coincident Change	N/A	N/A	-6.23	0%	-5.90	0%
Adjustment - Cooling Interaction	0	0%	0.00	0%	0.00	0%
Adjustment - TOTAL	-7,288	-26%	0.11	0%	0.44	0%
Adjusted Gross (ONSITE) Savings	20,503	74%	0.11	0%	0.44	0%

Facility Type:	Manufacturing Facility
KEMA ID:	105
Application Number/s:	830353
Project Type:	Systems

	Systems	Controls
Tracking Annual kWh:	27,791	0
Tracking Connected kW:	0.00	0
Tracking % On-Peak kWh:	0%	0%

Fixture Information

Fixture ID	Space Type	Pre-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Diversity Factor Summer	Diversity Factor Winter	Post-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Peak Diversity Factor Summer	Peak Diversity Factor Winter
1	0	250W METAL HALIDE	20	295	3,098	1%	1%	150W Induction	11	125	3,098	1%	1%
		Totals	33	8,760				Totals	24	2,415			

Pre-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	5.90	0.08	0.07	18,278	1,098	1,237	0	0	0.00	0.00
Totals	8.76	0.16	0.68	28,469			0	0	0.00	0.00

Post-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	1.38	0.02	0.02	4,260	1,098	1,237	0	0	0.00	0.00
Totals	2.42	0.05	0.24	7,966			0	0	0.00	0.00

Total Savings Summary

	Energy kWh	Summer kW	Winter kW	Connected kW
Annual Lighting Only	20,503	0.11	0.44	6.35
Annual Interactive	0	0.00	0.00	N/A
Annual Lighting and Interactive	20,503	0.11	0.44	6.35

	MMBTU
Annual Non-Electric Heating Savings	#N/A

Savings Adjustment Factors Lighting Systems

Parameter	Annual KWH	Difference %	Summer kW	Difference %	Winter kW	Difference %
Gross (TRACKING) kWh/Connected kW Savings	27,791	N/A	0.00	N/A	0.00	N/A
Adjustment - Documentation Change	0	0%	6.35	0%	6.35	0%
Adjustment - Technology Change	0	0%	0.00	0%	0.00	0%
Adjustment - Quantity Change	0	0%	0.00	0%	0.00	0%
Adjustment - Operation Change	-7,288	-26%	N/A	N/A	N/A	N/A
Adjustment - Coincident Change	N/A	N/A	-6.23	0%	-5.90	0%
Adjustment - Cooling Interaction	0	0%	0.00	0%	0.00	0%
Adjustment - TOTAL	-7,288	-26%	0.11	0%	0.44	0%
Adjusted Gross (ONSITE) Savings	20,503	74%	0.11	0%	0.44	0%

Hour Ending	Average kW Reduction
1	4.6
2	4.6
3	4.6
4	4.5
5	4.5
6	4.4
7	3.7
8	0.6
9	0.1
10	0.1
11	0.1
12	0.1
13	0.1
14	0.1
15	0.1
16	0.1
17	0.2
18	0.3
19	0.6
20	3.7
21	4.6
22	4.6
23	4.6
24	4.6

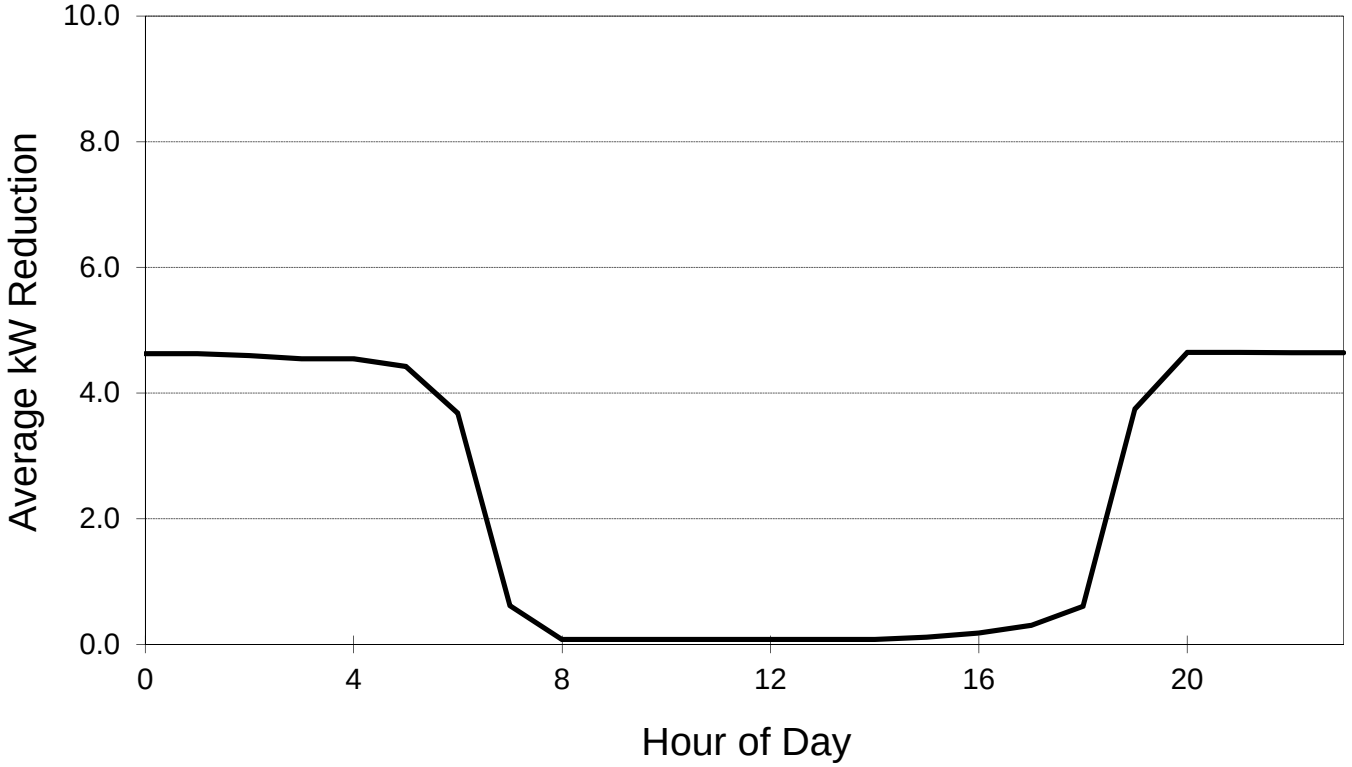


Figure 4: Average Summer Weekday kW Reduction

Hour Ending	Average kW Reduction
1	4.7
2	4.7
3	4.6
4	4.6
5	4.6
6	4.5
7	3.7
8	0.6
9	0.1
10	0.1
11	0.1
12	0.1
13	0.1
14	0.1
15	0.1
16	0.1
17	0.2
18	0.3
19	0.6
20	3.8
21	4.7
22	4.7
23	4.7
24	4.7

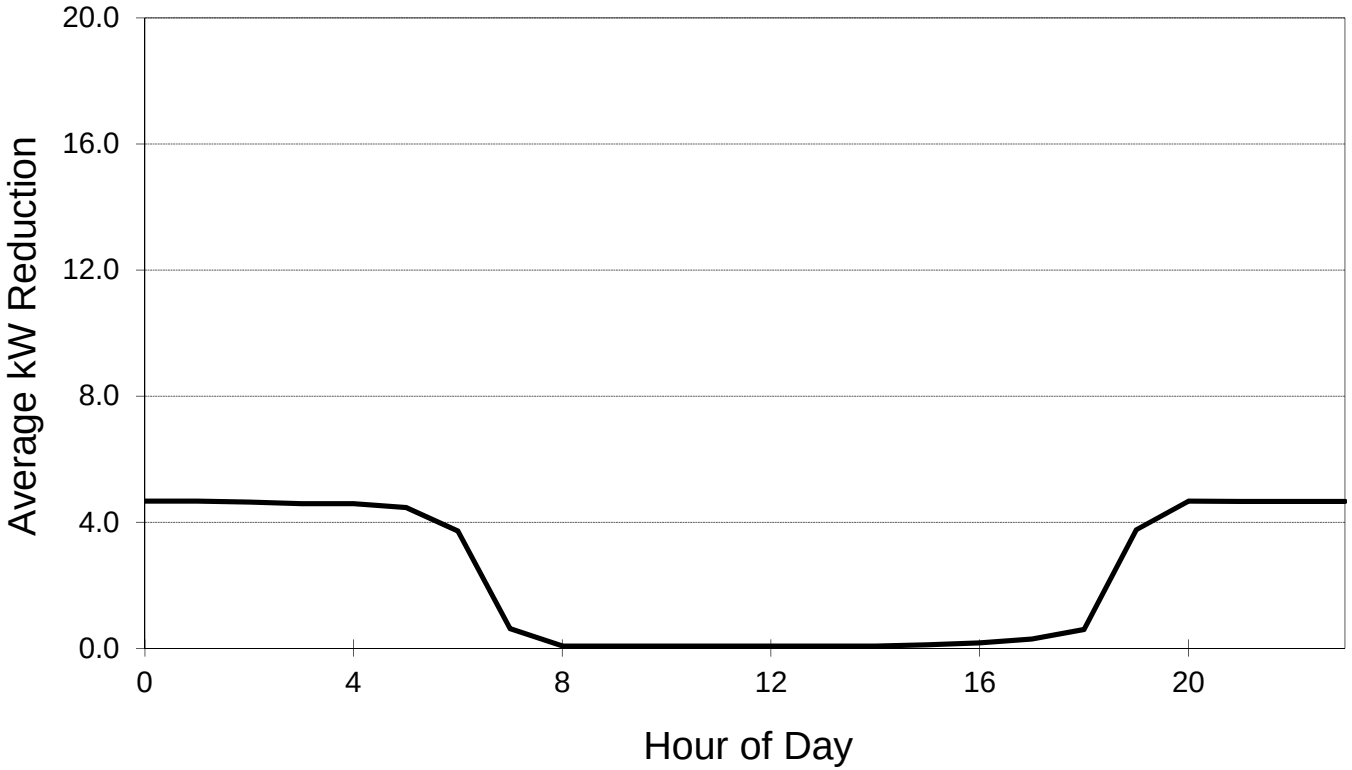


Figure 5: Average Winter Weekday kW Reduction

Application ID: 780584

Facility Type: Hotel

Summary

The exterior lighting at this hotel was retrofitted to improve energy efficiency. A summary of the baseline and installed lighting systems includes:

- 380 Incandescent to compact fluorescent fixtures
- 60 Incandescent to LED fixtures
- 96 T12 fluorescent to T8 fluorescent fixtures
- 18 High pressure sodium to 23 induction fixtures
- 68 Metal halide to compact fluorescent fixtures
- 205 Metal Halide to induction fixtures
- 40 Metal halide to LED fixtures

The locations and wattages of the lighting equipment are presented in Table 2 and Table 3 below.

Lighting is controlled by existing time clocks. Photocells operate with parking lot pole lighting. Photocells were not installed as part of the program.

Table 1 presents the summary of the tracking and on-site savings results.

Table 1: Summary of Tracking and Evaluated Savings Results

Savings Quantity	Tracking Savings	Evaluated Savings	Evaluated/Tracking
Annual Energy (kWh)	430,370	284,365	66%
% Energy Savings On-Peak	61%	26.8%	44%
Summer On-Peak kW	0	1.2	N/A
Winter On-Peak kW	49.0	33.11	68%

The overall on-site savings estimate is 34% lower than predicted in the tracking estimate. The evaluated estimate of on-peak kW reduction was 56% less than the tracking value. No summer on-peak demand savings were claimed in the tracking estimate. The evaluation calculates a 1.2 kW savings for that period. The evaluation winter on-peak savings of 33.1 kW is 32% less than

the tracking estimate. The following factors influenced the difference between the tracking and evaluated estimates of energy and demand savings:

- The quantity of parking lot fixtures was over stated. Tracking savings call for 191 fixtures. The site evaluation identified 63 fixtures. This is a 128 fixture reduction. And represents a 27.1 kW reduction in connected savings load. The grounds were canvased several times looking for the potential fixtures. This included the long entrance drive leading to the facility. There are municipal roads off the perimeter of the lots leading to adjacent properties. No evidence was uncovered of areas where these fixtures could have been located and since removed.
- There are 21 fewer bowtie compact fluorescent fixtures in the evaluation than identified in the tracking documentation. These are hour glass shaped wall washers that provide both up and down lighting. These are located on the exterior walls between window sets. The building perimeter was reviewed several times. There are no signs that other fixtures were removed. This represents a 1.5 kW reduction in the savings load.
- The evaluation identified 11 more recessed cans than stated in the tracking. All the cans were equipped with the 14-Watt LED lamps. This is an increase in the savings load of 0.88 kW.
- Tracking annual operating hours were listed as 4,368 hours for all fixtures. The weighted tracking annual operation is 4,271 hours. This is a 1.5% reduction in operation.

Project Description

Table 2 presents a summary of the existing system as outlined in the customer application.

Table 2: Existing Lighting System

Existing Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Roof Exterior	250-Watt High Pressure Sodium	295	5	4,368
Front Entrance	65-Watt Incandescent	65	204	4,368
Front Entrance	2L8' HO/EE/STD	227	96	4,368
Outside Entrance	65-Watt Incandescent	65	32	4,368
Perimeter Recessed Cans	90-Watt Halogen	90	60	4,368
Perimeter Recessed Cans	70-Watt Metal Halide	95	40	4,368
Side Entrance	65-Watt Incandescent	65	144	4,368
Receiving Dock	250-Watt High Pressure Sodium	295	1	4,368
Receiving Dock	250-Watt High Pressure Sodium	295	7	4,368
Up-light Building	1000-Watt High Pressure Sodium	1085	5	4,368
Perimeter	100-Watt Metal Halide	120	5	4,368
Bowtie Light Fixtures	70-Watt Metal Halide	95	68	4,368
Parking Lot	400-Watt Metal Halide	455	191	4,368
Pole Lights	400-Watt Metal Halide	455	9	4,368
	Total	163,012	867	4,368

Table 3 presents the installed fixtures and quantities as proposed in the customer application.

Table 3: Proposed Lighting System

Installed Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Roof Exterior	80-Watt Induction	84	5	4,368
Front Entrance	15-Watt Compact Fluorescent	15	204	4,368
Front Entrance	4L4' T8EE/ELEE	107	96	4,368
Outside Entrance	15-Watt Compact Fluorescent	15	32	4,368
Perimeter Recessed Cans	18-Watt LED	18	60	4,368
Perimeter Recessed Cans	14-Watt LED Recessed Can	15	40	4,368
Side Entrance	15-Watt Compact Fluorescent	15	144	4,368
Receiving Dock	80-Watt Induction	84	1	4,368
Receiving Dock	40-Watt Induction	44	7	4,368
Up light Building	200-Watt Induction	210	10	4,368
Perimeter	40-Watt Induction	44	5	4,368
Bowtie Light Fixtures	23-Watt CF	25	68	4,368
Parking Lot	200-Watt Induction	210	191	4,368
Pole Lights	200-Watt Induction	210	9	4,368
	Total	64,484	872	4,368

Tracking Estimates

The tracking estimates of energy use were calculated based on the full load of the existing and proposed fixtures. The energy savings were calculated as the difference in the pre and post installation energy use based on annual operating hours.

Evaluation Methodology

Evaluation Approach

The evaluation included a verification of installed fixtures, on-site monitoring and interviews of facility staff. The existing time clocks were identified. The clocks were set for the proper day and time.

The base case used in the evaluation of the lighting savings was developed from information contained in the customer application. The pre-existing fixture types were confirmed while on-site with the facility contact. An evaluator visited the facility to verify the installed fixtures and install monitoring equipment to quantify the hours of use throughout the retail space. The evaluator surveyed facility personnel to obtain information on the lighting usage throughout the year. This is an exterior lighting project and there is no HVAC interaction.

To determine the hours of use for the new fixtures, the field engineer installed three time-of-use [TOU] loggers in the lighting electrical panels. The TOU loggers provide the hour-of-day the lights are turned on and off for each day of the week. One Elite power logger was also installed. It monitored for lighting circuits including the pole lighting which operates with photocells as well as the time-clocks. The Elite logger monitors the volts, amps, and kW of the lighting circuits and identifies the on/off operating schedule according to time-of-day and day-of-week. The Elite logger was set to record average power every 5 minutes throughout the monitoring period. That logger ran out of storage memory on 11/17/2102 resulting in the shorter monitoring period but still provided 78 days of monitored data. Table 4 presents the fixtures monitored by the evaluation engineer.

Table 4: Spaces Monitored

Logger #	Equipment Monitored	Parameter Measured	Test Equip. Make & Model	Measurement Type	Installation Method	Frequency of Observations	Monitoring Duration
CT07120016	Loading Dock	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	08/21/12 – 12/6/12

CT08010041	Tower Roof	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	08/21/12 – 12/6/12
CT08010052	Bow Tie Wall Wash	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	08/21/12 – 12/6/12
EA712 CH 1	Parking lot P Cell	On/Off and Power	Elite Pro	Power and Schedule	Lighting Circuits	15-minute Average	08/21/12 – 11/17/12
EA712 CH 2	Ground Perimeter	On/Off and Power	Elite Pro	Power and Schedule	Lighting Circuits	15-minute Average	08/21/12 – 11/17/12
EA712 CH 3	Soffit	On/Off and Power	Elite Pro	Power and Schedule	Lighting Circuits	15-minute Average	08/21/12 – 11/17/12
EA712 CH 4	Pole Lights	On/Off and Power	Elite Pro	Power and Schedule	Lighting Circuits	15-minute Average	08/21/12 – 11/17/12

Verification of Equipment and Operating Parameters

The exterior lighting at this hotel was retrofitted to improve energy efficiency. The project consisted of replacing (5) high pressure sodium fixtures with (5) 80-Watt induction fixtures, (204) incandescent bulbs with (204) LED A19 bulbs, (96) 2-lamp 8' T12HO fixtures with (96) 4-lamp 4' T8 fixtures, (32) incandescent bulbs with (32) LED A19 bulbs, (60) halogen flood blubs with (60) LED PAR38 bulbs, (40) metal halide lighting fixtures with LED recessed can fixtures, (144) incandescent bulbs with (144) LED A19 bulbs, (1) high pressure sodium fixture with (1) 80-Watt induction fixture, (7) metal halide with (7) 40-Watt induction fixtures, (5) high pressure sodium fixtures with (10) 200-Watt induction fixtures, (5) metal halide fixtures with (5) 40-Watt induction fixtures, (68) metal halide fixtures with (68) 23-Watt self-ballasted screw-in bulbs, (200) metal halide fixtures with (200) 200-Watt induction fixtures. A fixture count taken during the site visit found that 128 fewer parking light fixtures were installed [455-Watt baseline and 210-Watt installed]. Twenty one fewer bowtie fixtures were installed [95-Watt baseline and 25-Watt installed]. Eleven more recessed cans were identified [95-Watt baseline and 15-Watt installed]

This is an exterior lighting project. There are no interactive HVAC savings or penalties.

Lighting operation data was downloaded from each logger. The data was then analyzed using computer software, which develops time-of-use load profiles and estimates of percentage on-times during the monitoring period. Evaluators used lighting logger data from the monitoring period, and extrapolated out to 12 months to produce 8,760 hourly operating profiles. The data was annualized using an algorithm that averages the data by day of week (1 through 7), and hour of day (1 through 24).

Table 5 presents the values obtained from the monitored data including annual operation, summer and winter diversity factors, and on-peak hours of use. These values were used for both the pre and post installation calculations because the operation of the lighting remained fixed. For schedule 4, which were the parking lot fixtures on photocell, evaluators utilized metered data as well as sunrise/sunset data to produce an annual operating profile. Based on the metered data, these lights came on consistently at sunset, and went off approximately one hour after sunrise each morning. Using these observations, schedule 4 was developed by applying this offset to each month of the year.

Table 5: Annual Hours of Use and Diversity Factors of Monitored Data

Schedule ID	Logger #	Description	Annual Hours	Summer Diversity	Winter Diversity	On-Peak Hours
1	CT07120016	Loading Dock	4,451	4%	43%	1,097

2	CT08010041	Tower Roof	4,674	4%	47%	1,233
3	CT08010052	Bow Tie Wall Wash	3,830	3%	48%	1,385
4	EA712 CH 1	Parking Pot P Cell	4,520	0%	100%	1,136
5	EA712 CH 2	Ground Perimeter	1,058	0%	11%	356
6	EA712 CH 3	Soffit	4,680	2%	36%	1,246
7	EA712 CH 4	Pole Lights	1,017	0%	9%	328

To estimate annual energy and demand savings, a spreadsheet method was employed. The summary of this spreadsheet is presented in Table 6. Annual hours and diversity factors from Table 5 are used with wattages from Table 6 to calculate energy and demand savings. The final on-site savings estimates are presented in Table 6.

The average daily lighting profiles for the monitored spaces are presented in Figure 1 through Figure 7. This includes the average weekday and, weekend and holiday day. The x-axis represents one full day and the y-axis is the percentage that the lights are on for each hour.

An hourly summary of the site kW savings for an average summer (June through August), non-holiday, weekday is presented in Figure 8. This summary is provided so that the summer diversified peak kW can be estimated across any range of hours in the event that the FCM definition for summer peak changes in the future. The same summary was also provided for the average winter (December and January), non-holiday, weekday in Figure 9.

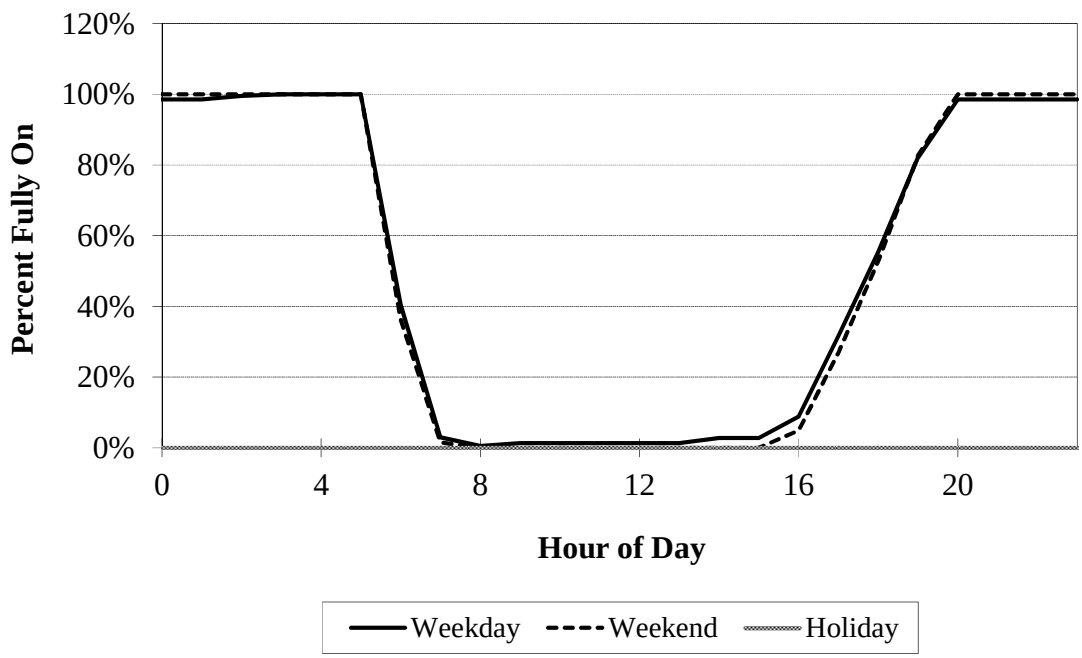


Figure 1: Average Daily Lighting Profile for the Loading Dock 08/21/12 to 12/6/12

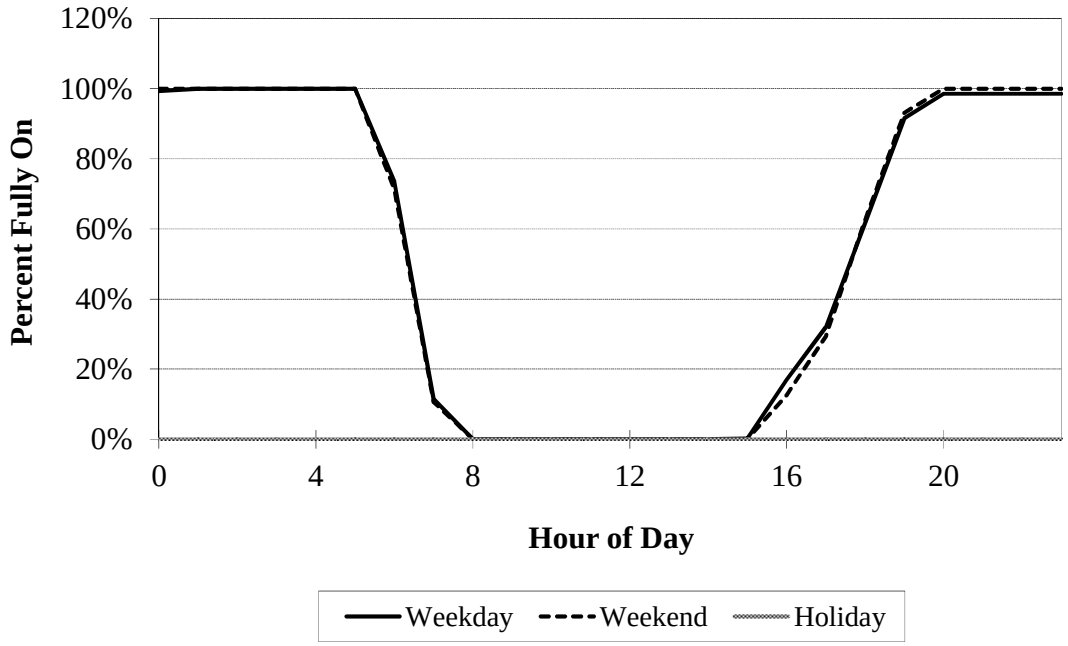


Figure 2: Average Daily Lighting Profile for the Roof Tower from 08/21/12 to 12/6/12

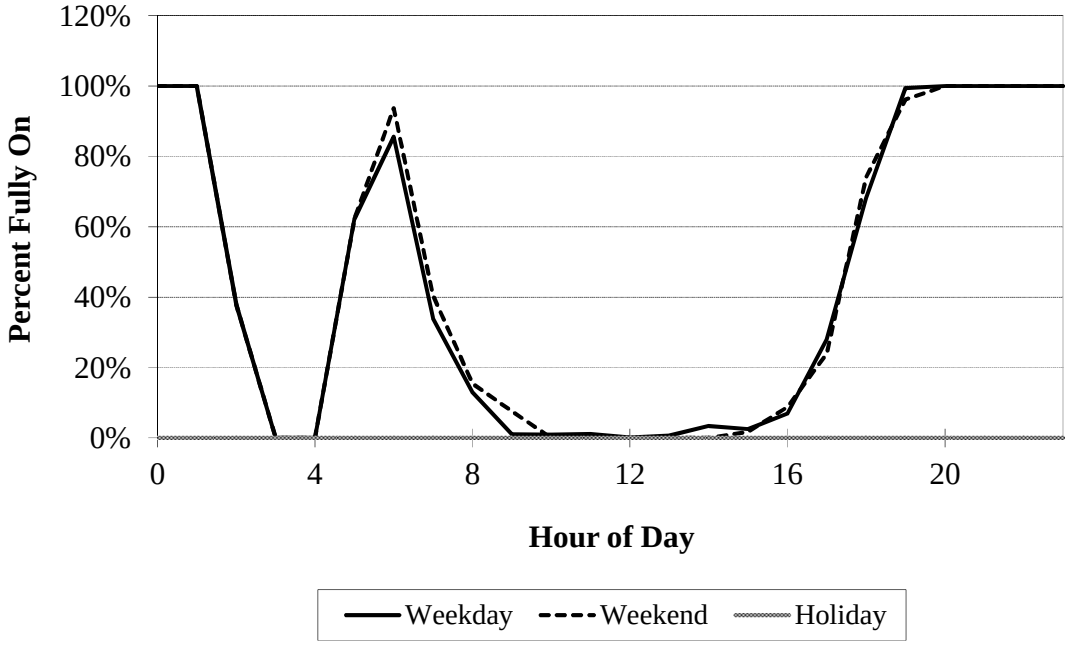


Figure 3: Average Daily Lighting Profile for Bow Tie Wall Washers from 08/21/12 to 12/6/12

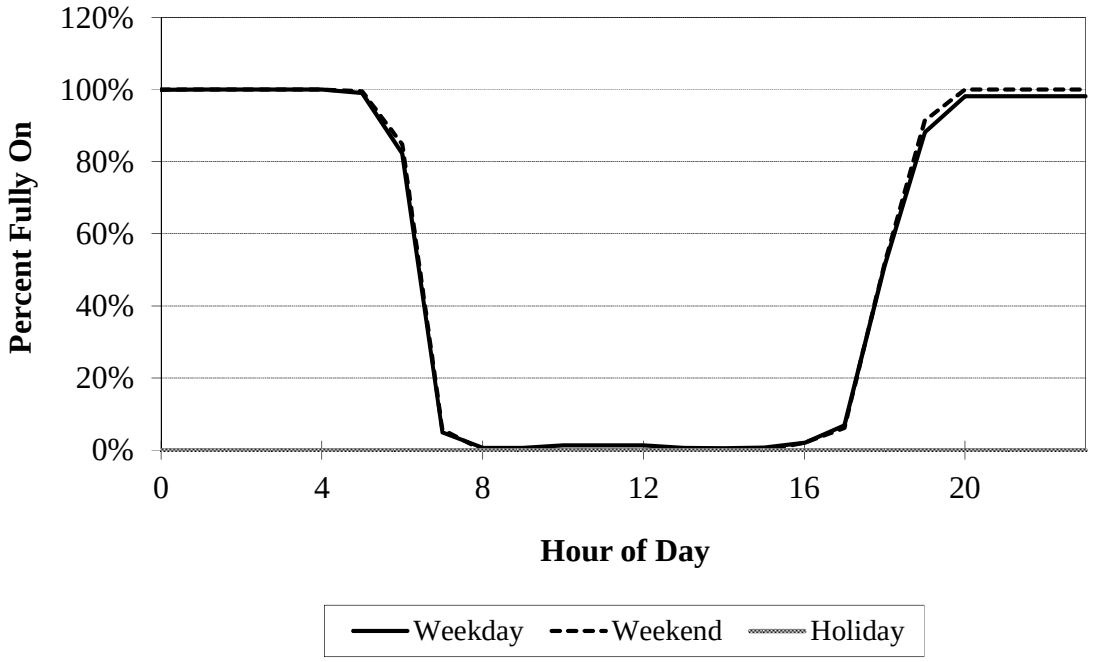


Figure 4: Average Daily Lighting Profile for the Parking Lot from 08/21/12 to 11/17/12

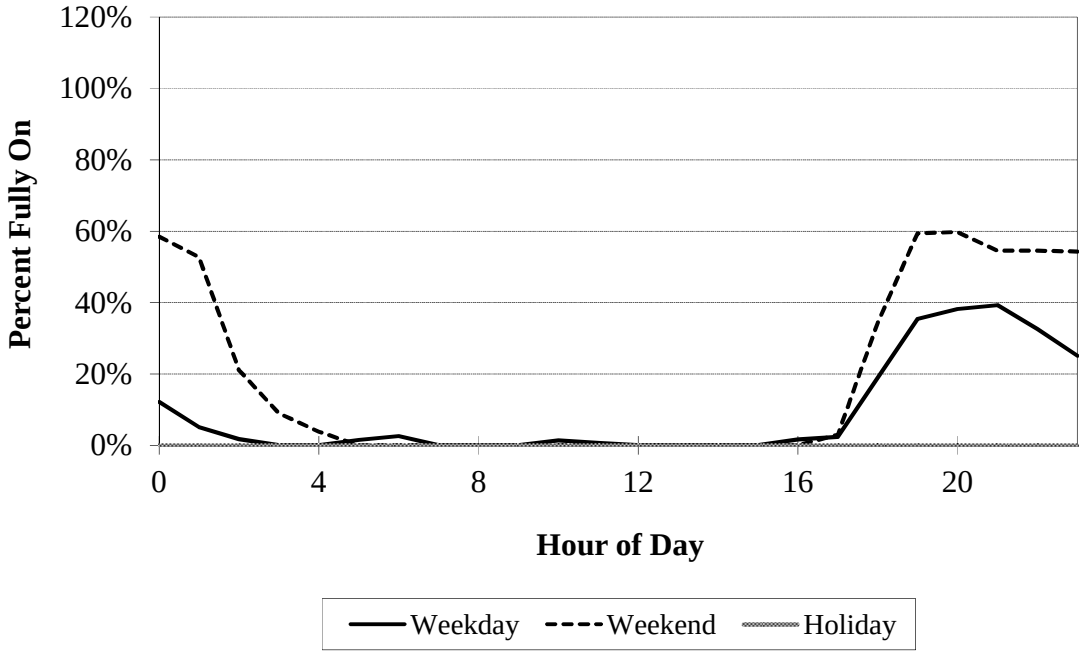


Figure 5: Average Daily Lighting Profile for the Ground Perimeter from 08/21/12 to 11/17/12

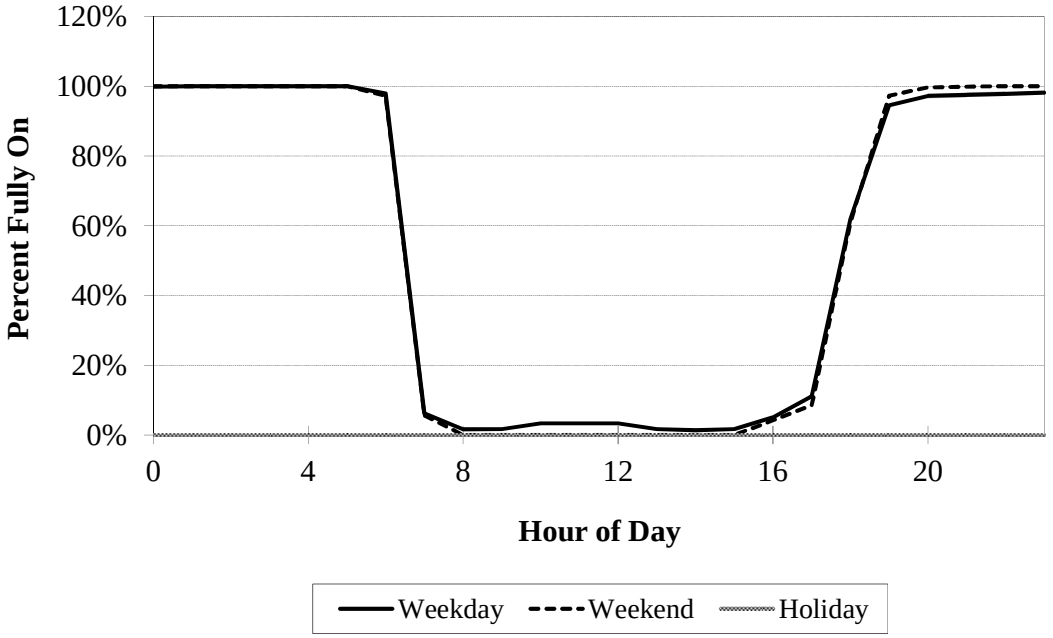


Figure 6: Average Daily Lighting Profile for the Soffit from 08/21/12 to 11/17/12

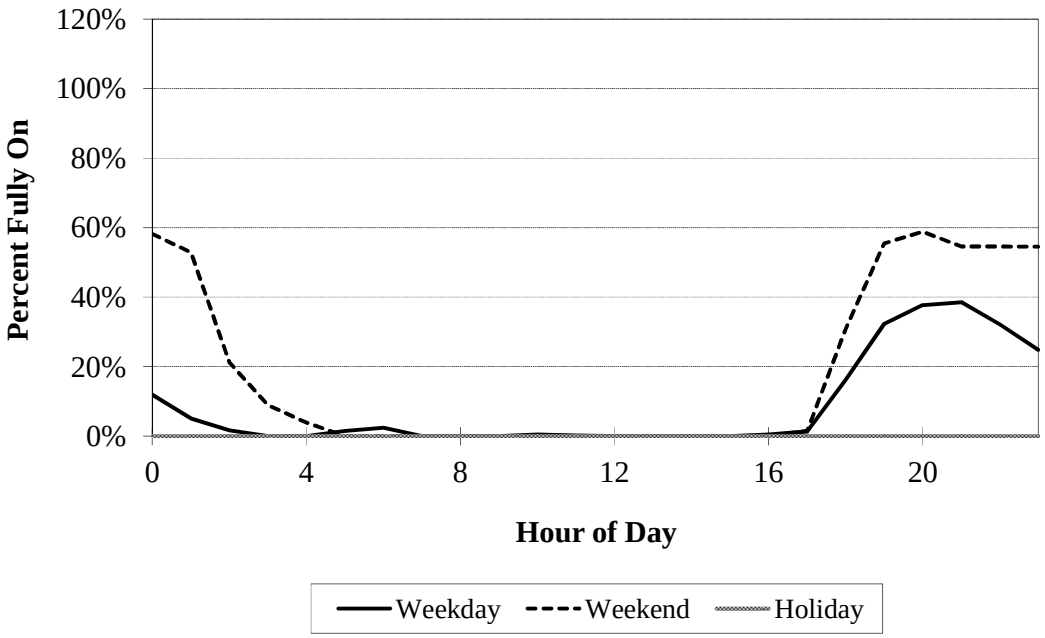


Figure 7: Average Daily Lighting Profile for the Pole Lights from 08/21/12 to 11/17/12

Table 6: Summary of Evaluated Energy and Demand Savings

Facility Type:	Hotel
KEMA ID:	126
Application Number/s:	780584
Project Type:	Systems

	Systems	Controls
Tracking Annual kWh:	430,370	0
Tracking Connected kW:	98.53	0
Tracking % On-Peak kWh:	0%	0%

Fixture Information

Fixture ID	Space Type	Pre-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Diversity Factor Summer	Diversity Factor Winter	Post-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Peak Diversity Factor Summer	Peak Diversity Factor Winter
1	roof exterior	250W HPS	5	295	4,674	4%	47%	80-Watt Induction	5	84	4,674	4%	47%
2	front entrance	65W INC	204	65	4,680	2%	36%	15-Watt Compact Fluorescent	204	15	4,680	2%	36%
3	front entrance	2L8' HO/EE/STD	96	227	4,680	2%	36%	4L4' T8EE/ELEE	96	107	4,680	2%	36%
4	outside entran	65W INC	32	65	4,680	2%	36%	15-Watt Compact Fluorescent	32	15	4,680	2%	36%
5	perimeter rece	90W HALOGEN LAMP	60	90	4,680	2%	36%	18 Watt LED	60	18	4,680	2%	36%
6	perimeter rece	70W METAL HALIDE	51	95	4,680	2%	36%	14-Watt LED Recessed Can	51	15	4,680	2%	36%
7	side entrance	65W INC	144	65	4,680	2%	36%	15-Watt Compact Fluorescent	144	15	4,680	2%	36%
8	receiving dock	250W HPS	1	295	4,451	4%	43%	80-Watt Induction	1	84	4,451	4%	43%
9	receiving dock	250W HPS	7	295	4,451	4%	43%	40-Watt Induction	7	44	4,451	4%	43%
10	uplight building	1000W HPS	5	1085	1,058	0%	11%	200-Watt Induction	10	210	1,058	0%	11%
11	perimeter	100W METAL HALIDE	5	120	1,058	0%	11%	40-Watt Induction	5	44	1,058	0%	11%
12	bow tie light fix	70W METAL HALIDE	47	95	3,830	3%	48%	23 Watt CF	47	25	3,830	3%	48%
13	parking lot	400W METAL HALIDE	63	455	4,520	0%	100%	200-Watt Induction	63	210	4,520	0%	100%
14	pole lights	400W METAL HALIDE	9	455	1,017	0%	9%	200-Watt Induction	9	210	1,017	0%	9%
		Totals	729	103,822				Totals	734	37,244			

Pre-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	1.48	0.06	0.69	6,895	1,698	1,869	0	0	0.00	0.00
2	13.26	0.33	4.82	62,057	1,693	1,872	0	0	0.00	0.00
3	21.79	0.54	7.93	101,987	1,693	1,872	0	0	0.00	0.00
4	2.08	0.05	0.76	9,734	1,693	1,872	0	0	0.00	0.00
5	5.40	0.13	1.96	25,272	1,693	1,872	0	0	0.00	0.00
6	4.85	0.12	1.76	22,675	1,693	1,872	0	0	0.00	0.00
7	9.36	0.23	3.41	43,805	1,693	1,872	0	0	0.00	0.00
8	0.30	0.01	0.13	1,313	1,610	1,779	0	0	0.00	0.00
9	2.07	0.08	0.90	9,190	1,610	1,779	0	0	0.00	0.00
10	5.43	0.02	0.58	5,739	415	427	0	0	0.00	0.00
11	0.60	0.00	0.06	635	415	427	0	0	0.00	0.00
12	4.47	0.15	2.14	17,100	1,449	1,535	0	0	0.00	0.00
13	28.67	0.00	28.67	129,569	1,337	2,155	0	0	0.00	0.00
14	4.10	0.01	0.36	4,165	398	411	0	0	0.00	0.00
Totals	103.82	1.74	54.17	440,134			0	0	0.00	0.00

Post-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	0.42	0.02	0.20	1,963	1,698	1,869	0	0	0.00	0.00
2	3.06	0.08	1.11	14,321	1,693	1,872	0	0	0.00	0.00
3	10.27	0.25	3.74	48,073	1,693	1,872	0	0	0.00	0.00
4	0.48	0.01	0.17	2,246	1,693	1,872	0	0	0.00	0.00
5	1.08	0.03	0.39	5,054	1,693	1,872	0	0	0.00	0.00
6	0.77	0.02	0.28	3,580	1,693	1,872	0	0	0.00	0.00
7	2.16	0.05	0.79	10,109	1,693	1,872	0	0	0.00	0.00
8	0.08	0.00	0.04	374	1,610	1,779	0	0	0.00	0.00
9	0.31	0.01	0.13	1,371	1,610	1,779	0	0	0.00	0.00
10	2.10	0.01	0.22	2,222	415	427	0	0	0.00	0.00
11	0.22	0.00	0.02	233	415	427	0	0	0.00	0.00
12	1.18	0.04	0.56	4,500	1,449	1,535	0	0	0.00	0.00
13	13.23	0.00	13.23	59,801	1,337	2,155	0	0	0.00	0.00
14	1.89	0.00	0.17	1,922	398	411	0	0	0.00	0.00
Totals	37.24	0.52	21.06	155,769			0	0	0.00	0.00

Total Savings Summary

	Energy kWh	Summer kW	Winter kW	Connected kW
Annual Lighting Only	284,365	1.21	33.11	66.58
Annual Interactive	0	0.00	0.00	N/A
Annual Lighting and Interactive	284,365	1.21	33.11	66.58

	MMBTU
Annual Non-Electric Heating Savings	

Savings Adjustment Factors Lighting Systems

Parameter	Annual kWH	Difference %	Summer kW	Difference %	Winter kW	Difference %
Gross (TRACKING) kWh/Connected kW Savings	430,370	N/A	98.53	N/A	98.53	N/A
Adjustment - Documentation Change	0	0%	0.00	0%	0.00	0%
Adjustment - Technology Change	0	0%	0.00	0%	0.00	0%
Adjustment - Quantity Change	-139,558	-32%	-31.95	-32%	-31.95	-32%
Adjustment - Operation Change	-6,447	-1%	N/A	N/A	N/A	N/A
Adjustment - Coincident Change	N/A	N/A	-65.36	-66%	-33.47	-34%
Adjustment - Cooling Interaction	0	0%	0.00	0%	0.00	0%
Adjustment - TOTAL	-146,005	-34%	-97.32	-99%	-65.42	-66%
Adjusted Gross (ONSITE) Savings	284,365	66%	1.21	1%	33.11	34%

Hour Ending	Average kW Reduction
1	61.3
2	60.9
3	58.7
4	57.4
5	57.4
6	55.1
7	44.5
8	3.7
9	1.1
10	0.7
11	1.4
12	1.4
13	1.3
14	0.7
15	0.7
16	0.8
17	2.6
18	6.3
19	29.1
20	47.4
21	58.7
22	62.0
23	61.7
24	61.5

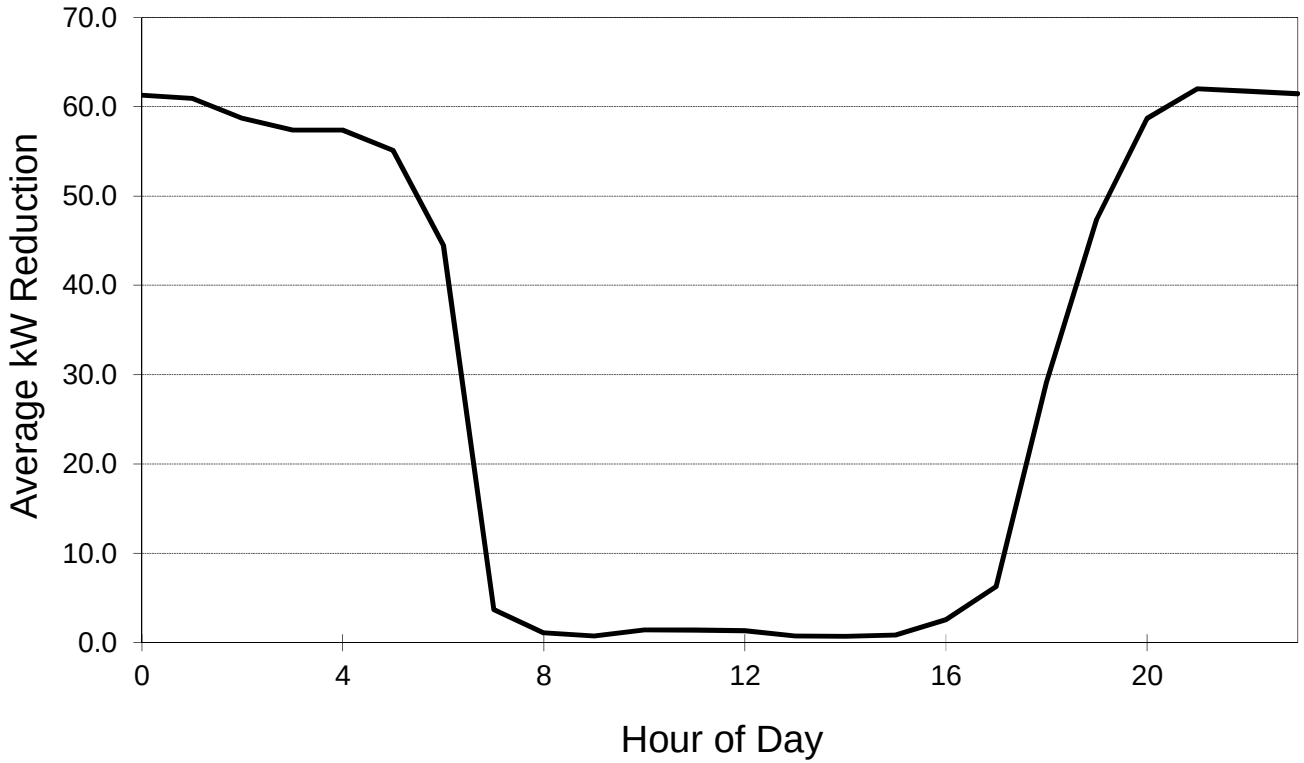


Figure 8: Average Summer Weekday kW Reduction

Hour Ending	Average kW Reduction
1	61.3
2	60.9
3	58.7
4	57.4
5	57.4
6	59.5
7	58.0
8	19.1
9	4.1
10	0.8
11	1.4
12	1.3
13	1.3
14	0.8
15	0.7
16	0.8
17	10.2
18	21.7
19	44.5
20	60.1
21	61.8
22	62.0
23	61.7
24	61.5

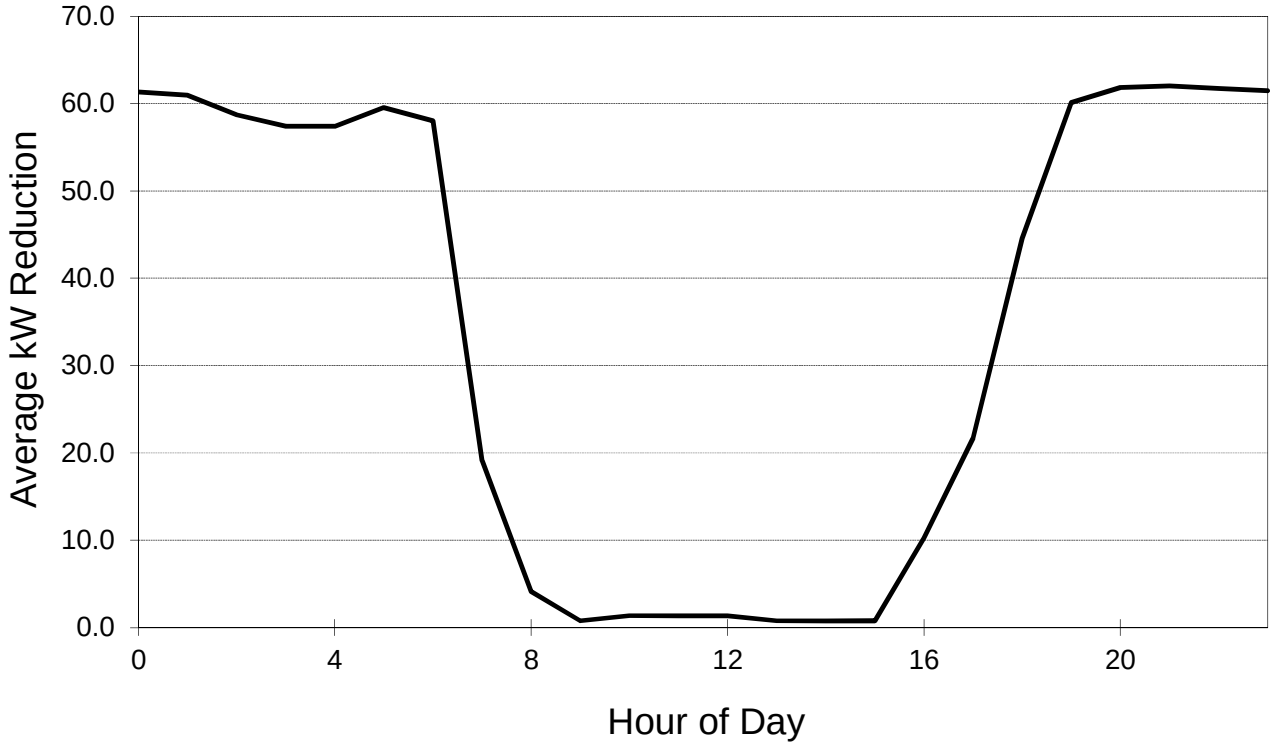


Figure 9: Average Winter Weekday kW Reduction

Application ID: 830596

Facility Type: Retail

Summary

The lighting at a retail facility was retrofitted to improve energy efficiency. According to the application, the project consisted of replacing (100) metal halide lighting fixtures with (100) 165 watt induction lighting fixtures, (37) metal halide lighting fixtures with (37) 80 watt induction lighting fixtures, (30) 100 watt quartz bulbs with (50) 23 watt LED track head bulbs and (20) incandescent bulbs with (20) LED A19 bulbs throughout the retail space.

Table 1 presents the summary of the tracking and on-site savings results.

Table 1: Summary of Tracking and Evaluated Savings Results

Savings Quantity	Tracking Savings	Evaluated Savings	Evaluated/ Tracking
Annual Energy (kWh)	323,310	308,676	95%
% Energy Savings On-Peak	90%	56%	62%
Summer On-Peak kW	39.4	49.1	125%
Winter On-Peak kW	39.4	38.8	99%

The overall on-site savings estimate is 5% lower than predicted in the tracking estimate. The evaluated estimate of summer on-peak kW reduction was 25% higher than the tracking value. The evaluated estimate of winter on-peak kW reduction was in line with the tracking value. The following factors influenced the difference between the tracking and evaluated estimates of energy and demand savings:

- The difference in annual energy savings was the result of two significant factors. The primary reason was that the lights were found to operate 7,112 hours per year which is less than the 8,217 hours per year predicted in the tracking estimates. The evaluation found that half of the 165 watt induction lights are on 8,760 hours, while the other half operates 5,840 hours per year. The tracking savings assumed all of the 165 watt induction fixtures operate 8,760 hours per year. The negative savings difference introduced by the operating difference is 44,520 kWh, or 14% of the tracking savings.
- Despite the negative impact of the operation change, there was a positive difference due to the estimated interactive cooling savings. Since the entire space is mechanically cooled, the reduction in heat associated with the new lighting results in reduced space

cooling requirements. Evaluators estimated interactive cooling savings of 32,798 kWh per year, while the tracking savings did not account for this at all.

- The summer on-peak kW reduction was 49.1 kW or 25% higher than predicted in the tracking estimate using the summer on-peak kW definition. The increase is due to the cooling bonus which adds a 10.27 kW reduction. Again, cooling interaction was not included in the tracking estimates. The winter on-peak kW reduction was 38.8 kW, which is in line with the tracking estimate.

Project Description

Table 2 presents a summary of the existing system as outlined in the customer application.

Table 2: Existing Lighting System

Existing Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Retail – Main Sales Area	400 W Metal Halide	458	100	8,760
Retail – Checkouts	175 W Metal Halide	215	15	5,200
Retail – Specialty Aisle	175 W Metal Halide	215	8	8,760
Retail – Produce Track	150 W Ceramic Metal Halide	150	30	8,760
Retail – Bakery, Deli	40 W Incandescent	40	20	5,200
Retail – Café	250 W Metal Halide	295	14	5,200
	Total	60,175	187	8,310

Table 3 presents the installed fixtures and quantities as proposed in the customer application.

Table 3: Proposed Lighting System

Installed Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Retail – Main Sales Area	165 W Induction LED	165	100	8,760
Retail – Checkouts	80 W Induction LED	85	15	5,200
Retail – Specialty Aisle	80 W Induction LED	85	8	8,760
Retail – Produce Track	23 W LED Track	30	50	8,760
Retail – Bakery, Deli	12 W LED	12	20	5,200
Retail – Café	80 W Induction LED	165	14	5,200
	Total	21,385	207	8,310

Tracking Estimates

The tracking estimates of energy use were calculated based on the full load of the existing and proposed fixtures. The energy savings were calculated as the difference in the pre and post installation energy use based on annual operating hours.

Evaluation Methodology

Evaluation Approach

The evaluation included a verification of installed fixtures, on-site monitoring and interviews of facility staff. There were no occupancy or daylight sensors installed.

The base case used in the evaluation of the lighting savings was developed from information contained in the customer application. The pre-existing fixture types were confirmed while on-site with the facility contact. An evaluator visited the facility to verify the installed fixtures and install monitoring equipment to quantify the hours of use throughout the retail space. The evaluator surveyed facility personnel to obtain information on the lighting usage throughout the year, and inquired about any HVAC equipment serving the space.

To determine the hours of use for the new fixtures, the field engineer installed four time-of-use lighting loggers. Each logger recorded the on/off of the lighting fixtures monitored. Table 4 presents the fixtures monitored by the evaluation engineer. Four lighting loggers were sufficient for this facility because there were only three unique schedules throughout the retail space.

Table 4: Spaces Monitored

Logger #	Equipment Monitored	Parameter Measured	Test Equip. Make & Model	Measurement Type	Installation Method	Frequency of Observations	Monitoring Duration
LL11010332	Retail (165 Watt LED)	On/Off Operation	DENT TOU Lighting Logger	Event Logger	Proximity	Based on Schedule	9/28/12 – 11/21/12
LL11010124	Retail (165 Watt LED)	On/Off Operation	DENT TOU Lighting Logger	Event Logger	Proximity	Based on Schedule	9/28/12 – 11/21/12
LL11030135	Retail (80 Watt LED)	On/Off Operation	DENT TOU Lighting Logger	Event Logger	Proximity	Based on Schedule	9/28/12 – 11/21/12
LL08040773	Retail (12 Watt LED)	On/Off Operation	DENT TOU Lighting Logger	Event Logger	Proximity	Based on Schedule	9/28/12 – 11/21/12

Verification of Equipment and Operating Parameters

The project consisted of replacing (100) metal halide lighting fixtures with (100) 165 watt induction lighting fixtures, (37) metal halide lighting fixtures with (37) 80 watt induction lighting fixtures, (30) 100 watt quartz bulbs with (50) 23 watt LED track head bulbs and (20) incandescent bulbs with (20) LED A19 bulbs throughout the retail space. A fixture count taken during the site visit confirmed that all 207 fixtures were installed at the site. Note that the tracking savings incorrectly doubled the quantity of the (20) LED A19 bulbs. Evaluators confirmed the baseline and installed quantity of 20 fixtures rather than 40 fixtures. This resulted in a 1% reduction in savings taken as a documentation adjustment.

Evaluators found that the entire building is heated and cooled which was taken into account for interactive savings and penalties. Cooling is provided by electric rooftop packaged DX units. Evaluators used an assumed efficiency of 1.2 kW/ton, which is a standard efficiency for this type of cooling system. Heating is provided by natural gas. For both heating and cooling, the evaluation assumes 80% of the heat from the lighting goes into the space.

This facility operates seven days a week between 5 am and midnight. The facility does not close for any holidays, and is open 365 days per year according to site personnel. Facility staff indicated that half of the main sales lighting (165 W LEDs) stay on 24/7, while the remaining main sales area lighting operates between 5 am and midnight.

Lighting operation data was downloaded from each logger. The data was then analyzed using computer software, which develops time-of-use load profiles and estimates of percentage on-times during the monitoring period. Evaluators used lighting logger data from the monitoring period, and extrapolated out to 12 months to produce 8,760 hourly operating profiles. The data was annualized using an algorithm that averages the data by day of week (1 through 7), and hour of day (1 through 24).

Table 5 presents the values obtained from the monitored data including annual operation, summer and winter diversity factors, and on-peak hours of use. These values were used for both the pre and post installation calculations because the operation of the lighting remained fixed.

Table 5: Annual Hours of Use and Diversity Factors of Monitored Data

Schedule ID	Logger #	Description	Annual Hours	Summer Diversity	Winter Diversity	On-Peak Hours
1	LL11010332	Retail (165 Watt LED)	5,840	100%	100%	3,944

2	LL11010124	Retail (165 Watt LED)	8,760	100%	100%	4,064
3	LL11030135	Retail (80 Watt LED)	8,760	100%	100%	4,064
4	LL08040773	Retail (12 Watt LED)	5,475	100%	100%	3,673

To estimate annual energy and demand savings, a spreadsheet method was employed. The summary of this spreadsheet is presented in Table 6. Annual hours and diversity factors from Table 5 are used with wattages from Table 6 to calculate energy and demand savings. The final on-site savings estimates are presented in Table 6. Evaluators found that the average lighting hours throughout the store were 7,112 hours per year compared to 8,217 hours per year in the tracking estimates. The differences are due to the number of fixtures expected to operate 8,760 hours per year in the tracking and on-site estimates. Specifically, the tracking savings assumed that all (100) 165 watt induction lighting fixtures operated 8,760 hours, but the evaluation found that only half of these fixtures operate 24/7. The other half operate approximately 5,840 hours per year. This represents 96% of the operation adjustment.

The average daily lighting profiles for the monitored spaces are presented in Figure 1 through Figure 4. This includes the average weekday and weekend day. The x-axis represents one full day and the y-axis is the percentage that the lights are on for each hour.

An hourly summary of the site kW savings for an average summer (June through August), non-holiday, weekday is presented in Figure 5. This summary is provided so that the summer diversified peak kW can be estimated across any range of hours in the event that the FCM definition for summer peak changes in the future. The same summary was also provided for the average winter (December and January), non-holiday, weekday in Figure 6.

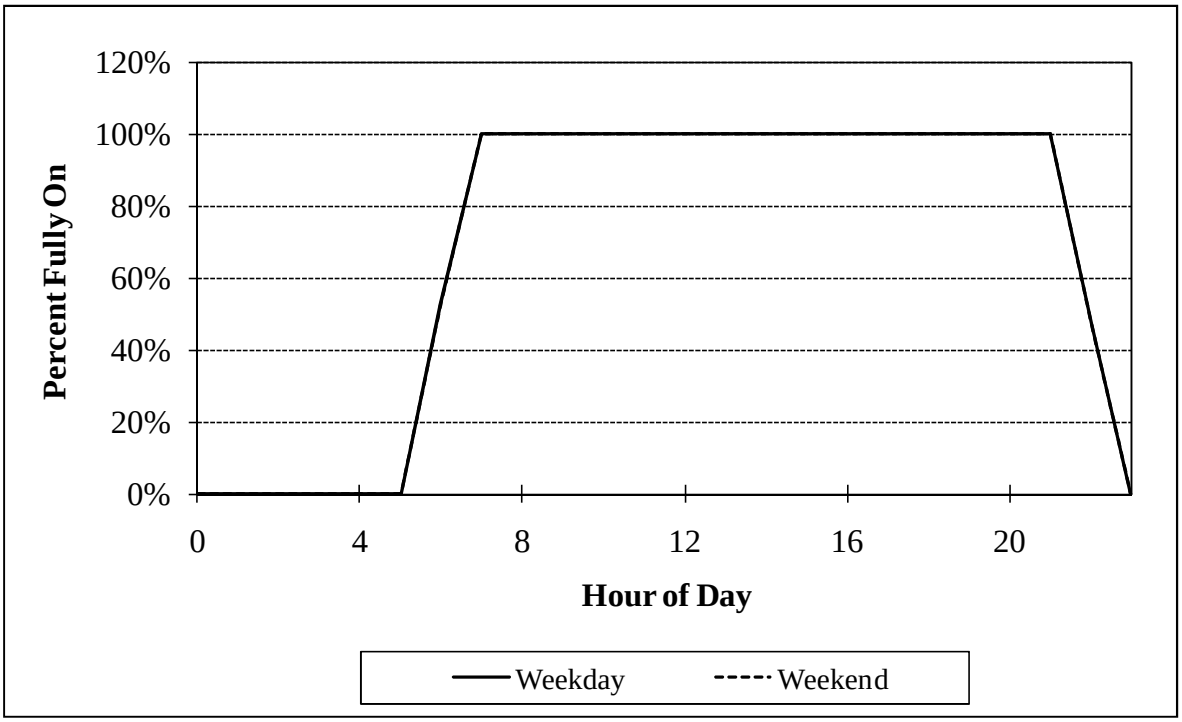


Figure 1: Average Daily Lighting Profile for Main Sales Area from 9/28/12 to 11/21/12

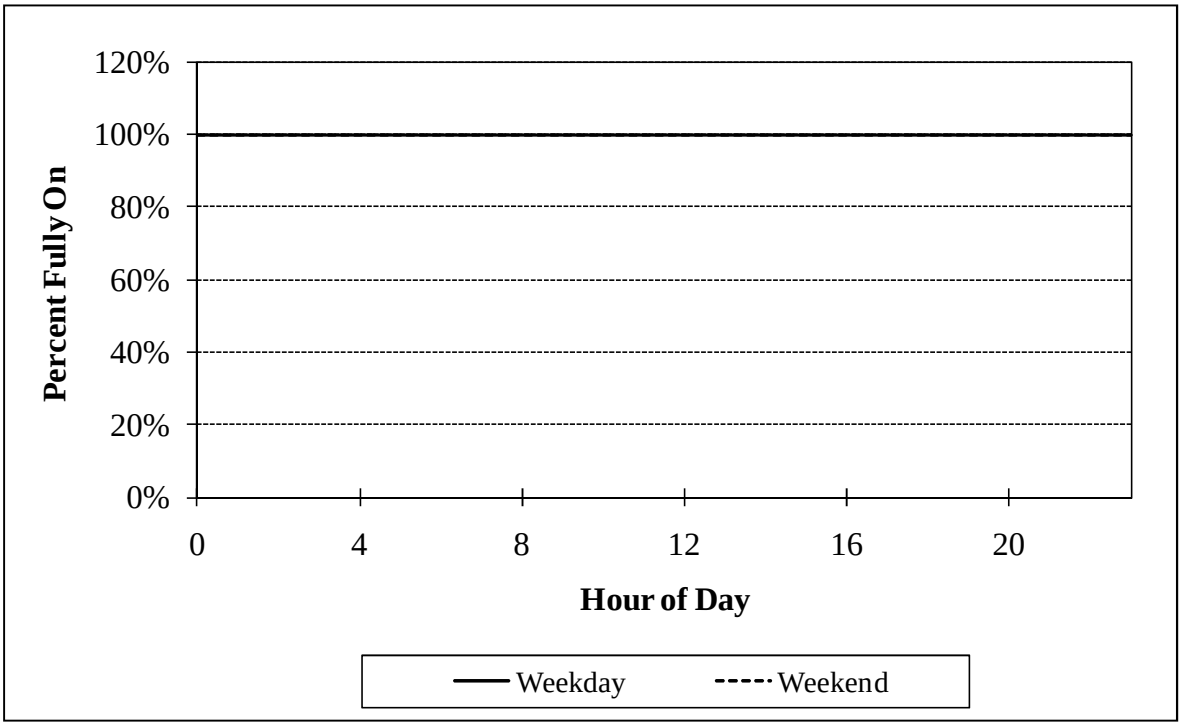


Figure 2: Average Daily Lighting Profile for Main Sales Area from 9/28/12 to 11/21/12

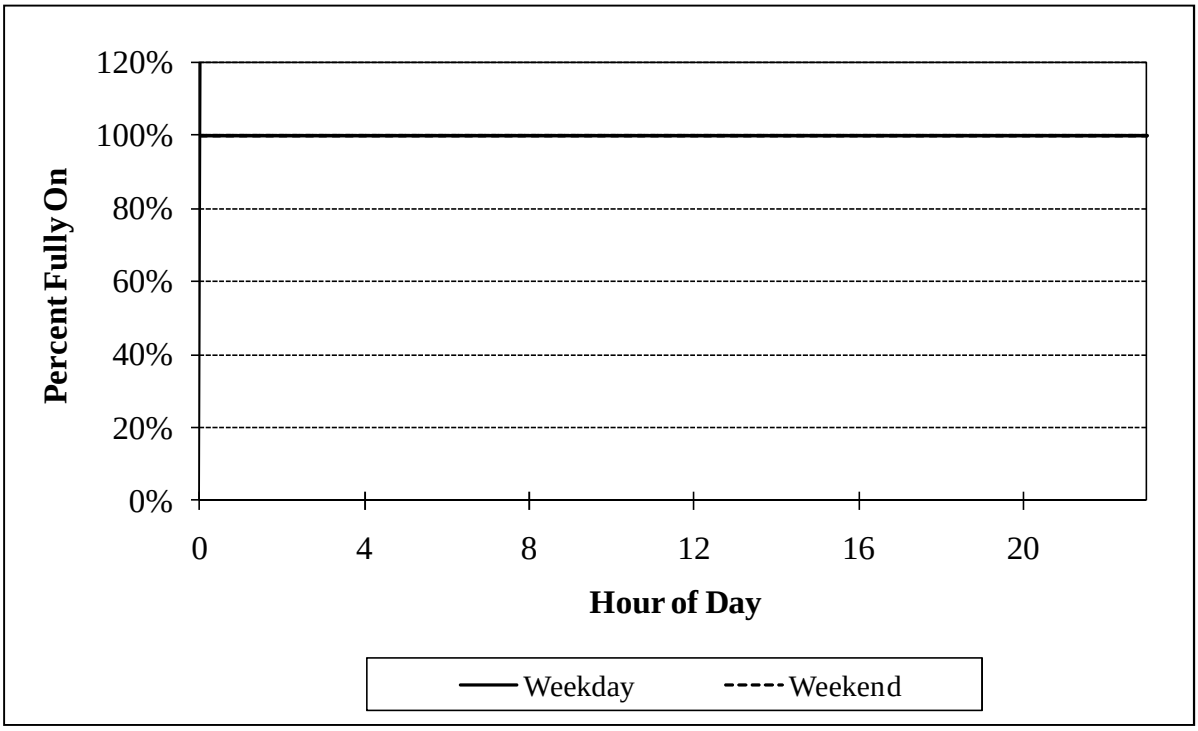


Figure 3: Average Daily Lighting Profile for Cashier Area from 9/28/12 to 11/21/12

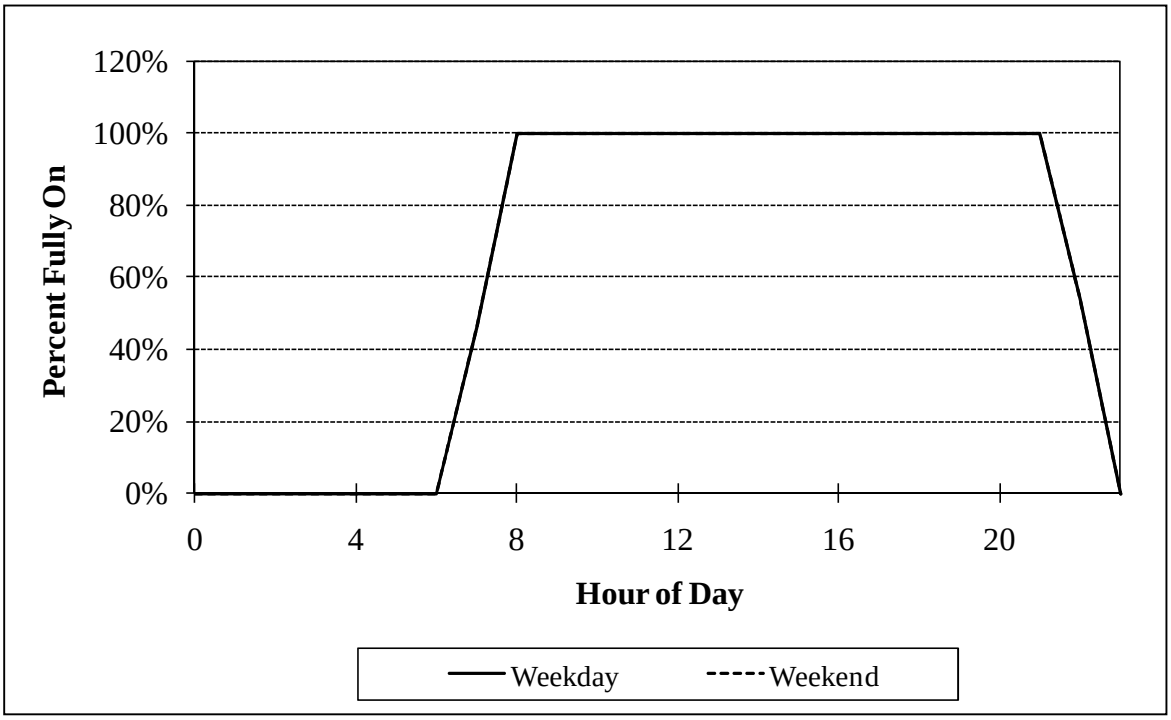


Figure 4: Average Daily Lighting Profile for Produce Section from 9/28/12 to 11/21/12

Table 6: Summary of Evaluated Energy and Demand Savings

Facility Type:	Retail
KEMA ID:	125
Application Number/s:	830596
Project Type:	Systems

	Systems	Controls
Tracking Annual kWh:	323,310	
Tracking Connected kW:	39.35	
Tracking % On-Peak kWh:	0%	0%

Fixture Information

Fixture ID	Space Type	Pre-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Diversity Factor Summer	Diversity Factor Winter	Post-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Peak Diversity Factor Summer	Peak Diversity Factor Winter
1	Whole store hi	400W METAL HALIDE	50	458	5,840	100%	100%	165W Induction	50	165	5,840	100%	100%
2	Cashier check	175W METAL HALIDE	15	215	8,760	100%	100%	80W Induction	15	85	8,760	100%	100%
3	Supplement he	175W METAL HALIDE	8	215	8,760	100%	100%	80W Induction	8	85	8,760	100%	100%
4	Café	250W METAL HALIDE	14	295	5,475	100%	100%	80W Induction	14	85	5,475	100%	100%
5	Produce Track	150W ceramic metal halide	30	150	5,475	100%	100%	23 WATT LED	50	30	5,475	100%	100%
6	Bakery/Deli	40W INC	16	40	5,840	100%	100%	12 WATT LED	16	12	5,840	100%	100%
7	Bakery/Deli	40W INC	4	40	5,840	100%	100%	12 WATT LED	4	12	5,840	100%	100%
8	Whole store hi	400W METAL HALIDE	50	458	8,760	100%	100%	165W Induction	50	165	8,760	100%	100%
		Totals	187	60,175				Totals	207	21,385			

Pre-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	22.90	22.90	22.90	133,741	2,668	2,178	16,683	0	6.06	0.00
2	3.23	3.22	3.23	28,251	3,659	3,349	3,222	0	0.85	0.00
3	1.72	1.72	1.72	15,067	3,659	3,349	1,718	0	0.46	0.00
4	4.13	4.13	4.13	22,613	2,524	2,031	2,846	0	1.09	0.00
5	4.50	4.50	4.50	24,638	2,524	2,031	3,101	0	1.19	0.00
6	0.64	0.64	0.64	3,738	2,668	2,178	466	0	0.17	0.00
7	0.16	0.16	0.16	934	2,668	2,178	117	0	0.04	0.00
8	22.90	22.90	22.90	200,604	3,659	3,349	22,878	0	6.06	0.00
Totals	60.18	60.17	60.17	429,586			51,032	0	15.92	0.00

Post-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	8.25	8.25	8.25	48,182	2,668	2,178	6,010	0	2.18	0.00
2	1.28	1.28	1.28	11,169	3,659	3,349	1,274	0	0.34	0.00
3	0.68	0.68	0.68	5,957	3,659	3,349	679	0	0.18	0.00
4	1.19	1.19	1.19	6,515	2,524	2,031	820	0	0.31	0.00
5	1.50	1.50	1.50	8,213	2,524	2,031	1,034	0	0.40	0.00
6	0.19	0.19	0.19	1,121	2,668	2,178	140	0	0.05	0.00
7	0.05	0.05	0.05	280	2,668	2,178	35	0	0.01	0.00
8	8.25	8.25	8.25	72,270	3,659	3,349	8,242	0	2.18	0.00
Totals	21.39	21.38	21.39	153,708			18,234	0	5.66	0.00

Total Savings Summary

	Energy kWh	Summer kW	Winter kW	Connected kW
Annual Lighting Only	275,879	38.79	38.79	38.79
Annual Interactive	32,798	10.27	0.00	N/A
Annual Lighting and Interactive	308,676	49.06	38.79	38.79

	MMBTU
Annual Non-Electric Heating Savings	(385)

Savings Adjustment Factors Lighting Systems

Parameter	Annual KWH	Difference %	Summer kW	Difference %	Winter kW	Difference %
Gross (TRACKING) kWh/Connected kW Savings	323,310	N/A	39.35	N/A	39.35	N/A
Adjustment - Documentation Change	-2,912	-1%	-0.56	-1%	-0.56	-1%
Adjustment - Technology Change	0	0%	0.00	0%	0.00	0%
Adjustment - Quantity Change	0	0%	0.00	0%	0.00	0%
Adjustment - Operation Change	-44,520	-14%	N/A	N/A	N/A	N/A
Adjustment - Coincident Change	N/A	N/A	0.00	0%	0.00	0%
Adjustment - Cooling Interaction	32,798	10%	10.27	26%	0.00	0%
Adjustment - TOTAL	-14,634	-5%	9.71	25%	-0.56	-1%
Adjusted Gross (ONSITE) Savings	308,676	95%	49.06	125%	38.79	99%

Hour Ending	Average kW Reduction
1	22.2
2	22.2
3	22.0
4	22.0
5	21.9
6	22.2
7	32.3
8	44.7
9	49.1
10	49.2
11	49.2
12	49.4
13	49.4
14	49.1
15	49.1
16	49.1
17	49.1
18	49.1
19	49.1
20	49.1
21	49.1
22	49.1
23	35.5
24	22.2

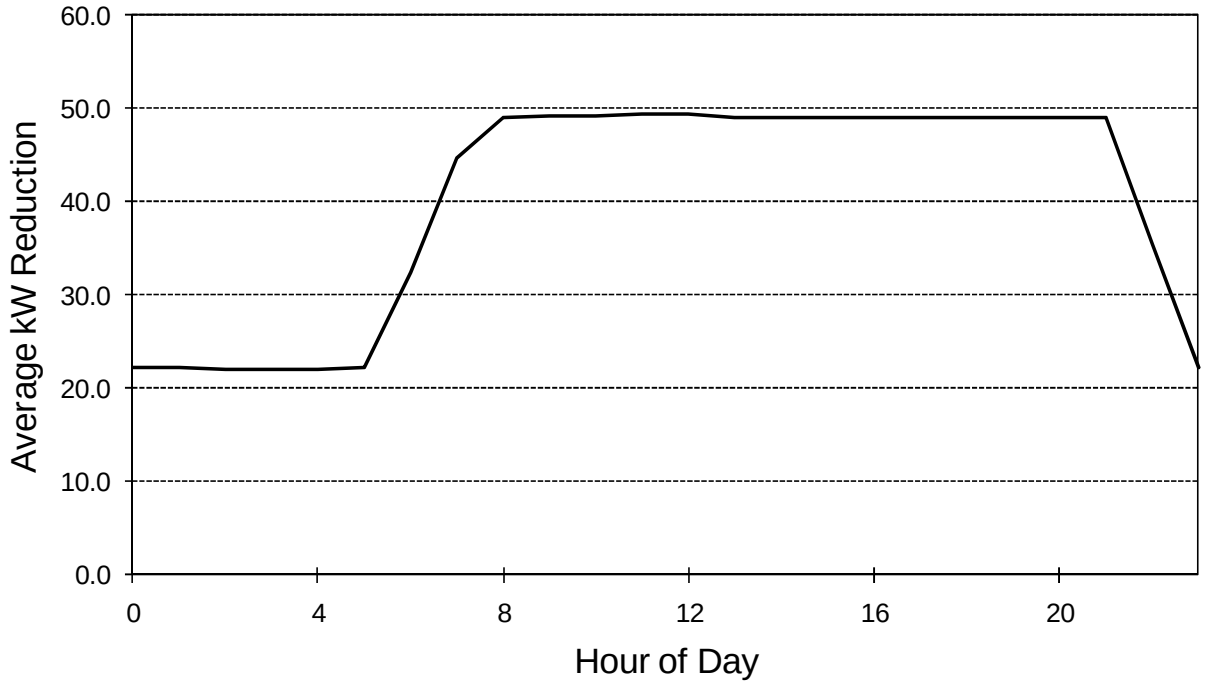


Figure 5: Average Summer Weekday kW Reduction

Hour Ending	Average kW Reduction
1	17.6
2	17.6
3	17.6
4	17.6
5	17.6
6	17.6
7	25.6
8	35.6
9	38.8
10	38.8
11	38.8
12	38.8
13	38.8
14	38.8
15	38.8
16	38.8
17	38.8
18	38.8
19	38.8
20	38.8
21	38.8
22	38.8
23	28.1
24	17.6

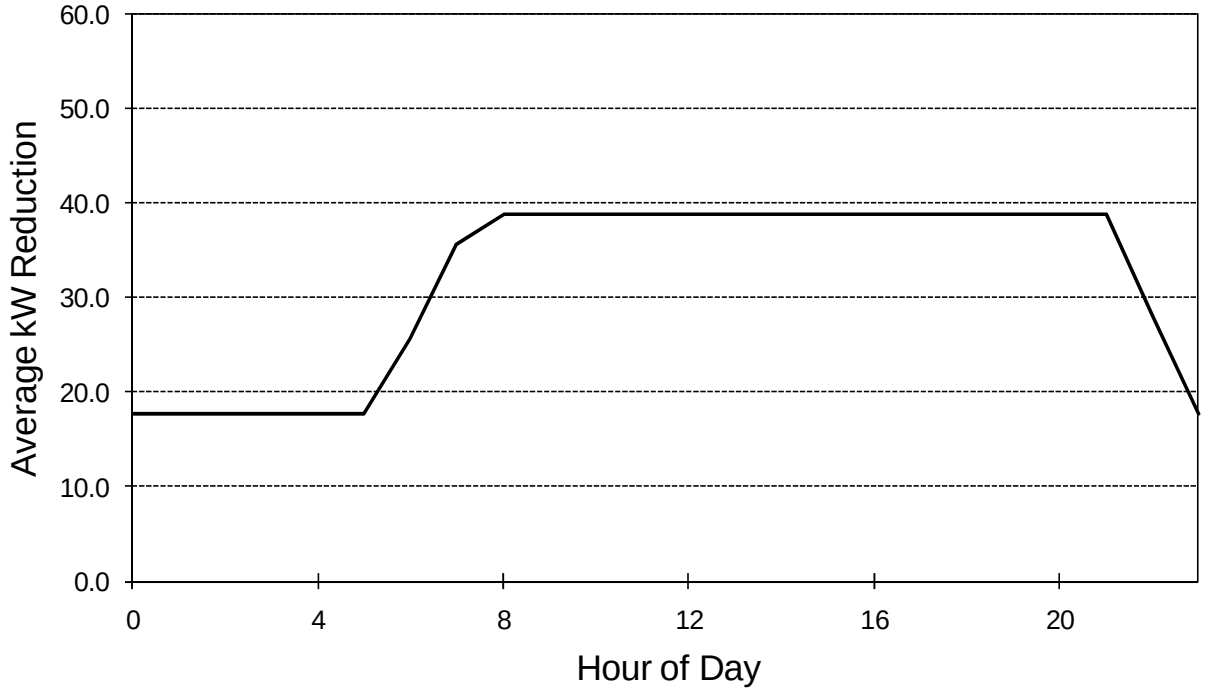


Figure 6: Average Winter Weekday kW Reduction

Application ID: 953974

Facility Type: Retail

Summary

This retrofit project replaces (49) eight-foot T8 strip fixtures and (15) four-foot T8 strip fixtures with (33) 2'x2' 64-Watt LED fixtures on the sales floor of this 24 hour convenience store.

Table 1presents the summary of the tracking and on-site savings results.

Table 1: Summary of Tracking and Evaluated Savings Results

Savings Quantity	Tracking Savings	Evaluated Savings	Evaluated/Tracking
Annual Energy (kWh)	9,272	10,891	117%
% Energy Savings On-Peak	61%	46.7%	77%
Summer On-Peak kW	1.06	1.41	133%
Winter On-Peak kW	1.06	1.12	112%

The overall on-site savings estimate is 17% greater than predicted in the tracking estimate. The evaluated estimate of on-peak energy savings is 23%less than the tracking value. The summer and winter on-peak kW demand savings were 12% and 30% greater than anticipated. The following factors influenced the difference between the tracking and evaluated estimates of energy and demand savings:

- The increase in energy savings is due primarily to the inclusion of the interactive HVAC savings. The reduced load on the cooling units was not incorporated into the tracking savings. This resulted in added savings of 1,115 kWh per year, or 12 % of the tracking savings. This also impacted the summer peak kW savings, which were 28% higher due to the addition of interactive HVAC savings.
- There was also a 6% increase due to a quantity adjustment. The tracking savings were calculated using 32.9 installed fixtures. The site inventory identified 32 fixtures illuminating the sales floor. This reduction in the installed fixture quantity resulted in additional savings of 561 kWh per year.
- The baseline and installed fixture wattages remain unchanged from the tracking documentation. The continuous 8,760 hour annual operation was confirmed by the monitoring. The only savings impacts are the addition of interactive AC affects and fixture count changes.

Project Description

Table 2 presents a summary of the existing system as outlined in the customer application.

Table 2: Existing Lighting System

Existing Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Sales Floor	2L 4' T8	56	49	8,760
Sales Floor	1L 4' T8	28	15	8,760
	Total	3,164	64	8,760

Table 3 presents the installed fixtures and quantities as proposed in the customer application.

Table 3: Proposed Lighting System

Installed Case				
Space	**Fixture Type**	**Wattage**	**Quantity**	**Annual Hours**
Sales Floor	2x2 64-Watt LED	64	23	8,760
Sales Floor	2x2 64-Watt LED	64	10	8,760
	Total	2,112	33	8,760

Tracking Estimates

The tracking estimates of energy use were calculated based on the full load of the existing and proposed fixtures. The energy savings were calculated as the difference in the pre and post installation energy use based on annual operating hours.

Evaluation Methodology

Evaluation Approach

The evaluation included a verification of installed fixtures, on-site monitoring and interviews of facility staff. No day lighting or occupancy sensor controls were found at the site. The continuous lighting operation corresponds with the store operating schedule, which is open 24 hours a day, seven days a week.

The base case used in the evaluation of the lighting savings was developed from information contained in the customer application. The pre-existing fixture types were confirmed while on-site with the facility contact. An evaluator visited the facility to verify the installed fixtures and install monitoring equipment to quantify the hours of use throughout the retail space. The evaluator surveyed facility personnel to obtain information on the lighting usage throughout the year. These fixtures illuminate the store sales floor. This is a heated and cooled space. Heating is provided by natural gas. Cooling is provided through DX equipment in rooftop units. HVAC interaction and savings were not included in tracking calculations, but were generated in the evaluation savings.

To determine the hours of use for the new fixtures, the field engineer installed four time-of-use lighting loggers in selected fixtures. Each logger recorded the on/off of the lighting fixtures monitored. Table 4 presents the fixtures monitored by the evaluation engineer.

Table 4: Spaces Monitored

Logger #	Equipment Monitored	Parameter Measured	Test Equip. Make & Model	Measurement Type	Installation Method	Frequency of Observations	Monitoring Duration
LL08040177	ATM Area	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	062/9/12 – 09/06/12
LL08040508	Store Rear	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	06/29/12 – 09/06/12

LL08050303	Over Soda Machine	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	06/29/12 – 09/06/12
LL08100748	Store Left	On/Off Operation	DENT TOU Logger	Event Logger	Proximity	Based on Schedule	06/29/12 – 09/06/12

Verification of Equipment and Operating Parameters

The project consisted of replacing (49) eight-foot T8 strip fixtures and (15) four-foot T8 strip fixtures with (33) 2'x2' 64-Watt LED fixtures.A fixture count taken during the site visit found one less replacement fixture than the tracking estimate. All fixtures were fully functioning.

Space cooling is provided through DX equipment in rooftop units. HVAC interaction and savings were not included in tracking calculations, but were generated in the evaluation savings.

Lighting operation data was downloaded from each logger. The data was then analyzed using computer software, which develops time-of-use load profiles and estimates of percentage on-times during the monitoring period. Evaluators used lighting logger data from the monitoring period, and extrapolated out to 12 months to produce 8,760 hourly operating profiles. The data was annualized using an algorithm that averages the data by day of week (1 through 7), and hour of day (1 through 24).

Table 5 presents the values obtained from the monitored data including annual operation, summer and winter diversity factors, and on-peak hours of use. These values were used for both the pre and post installation calculations because the operation of the lighting remained fixed.

Table 5: Annual Hours of Use and Diversity Factors of Monitored Data

Schedule ID	Logger #	Description	Annual Hours	Summer Diversity	Winter Diversity	On-Peak Hours
1	LL08040177	ATM Area	8,760	100%	100%	4,064
2	LL08040508	Store Rear	8,760	100%	100%	4,064
3	LL08050303	Over Soda Machine	8,760	100%	100%	4,064
4	LL08100748	Store Left	8,760	100%	100%	4,064

To estimate annual energy and demand savings, a spreadsheet method was employed. The summary of this spreadsheet is presented in Table 6. Annual hours and diversity factors from Table 5 are used with wattages from Table 6 to calculate energy and demand savings. The final on-site savings estimates are presented in Table 6.

The average daily lighting profiles for the monitored spaces are presented in Figure 1 through Figure 4. These include the average weekday and weekend day. The x-axis represents one full day and the y-axis is the percentage that the lights are on for each hour. These graphs confirm the store operating hours, which are 24 hours a day, seven days a week.

An hourly summary of the site kW savings for an average summer (June through August), non-holiday, weekday is presented in Figure 5. This summary is provided so that the summer diversified peak kW can be estimated across any range of hours in the event that the FCM definition for summer peak changes in the future. The same summary was also provided for the average winter (December and January), non-holiday, weekday in Figure 6.

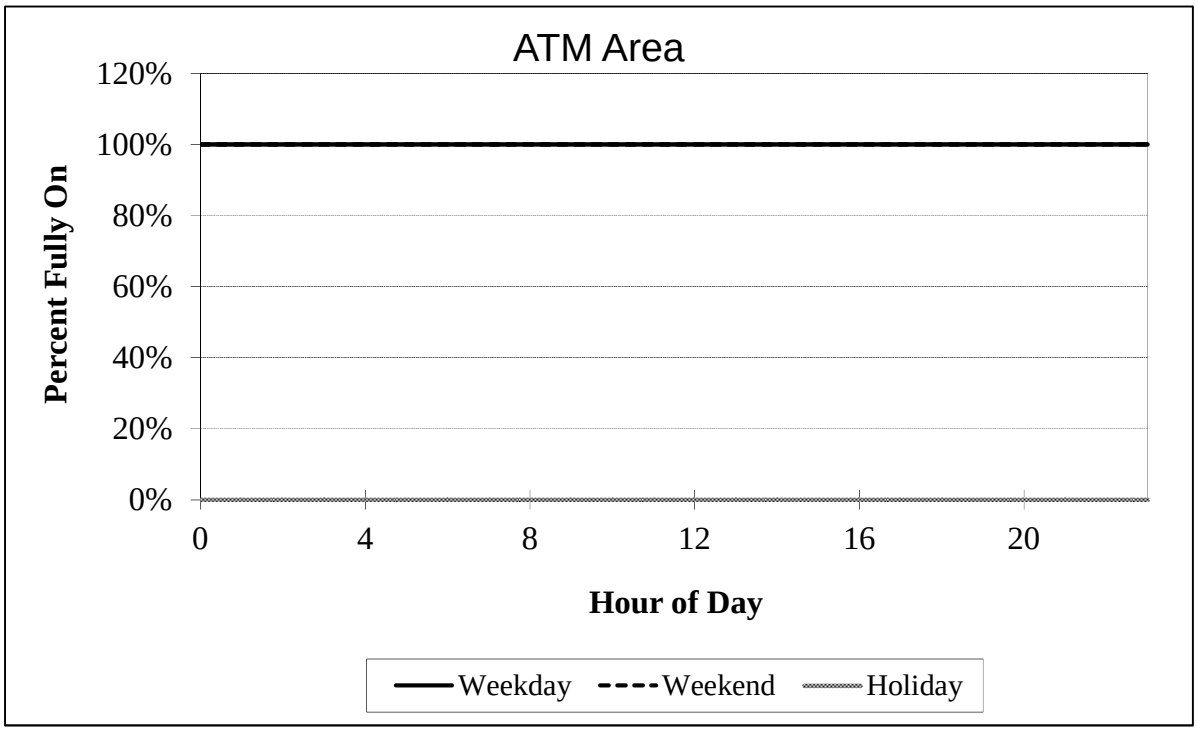


Figure 1: Average Daily Lighting Profile for ATM Area from 06/29/12 to 09/06/12

Figure 2: Average Daily Lighting Profile for Store Rear from 06/29/12 to 09/06/12

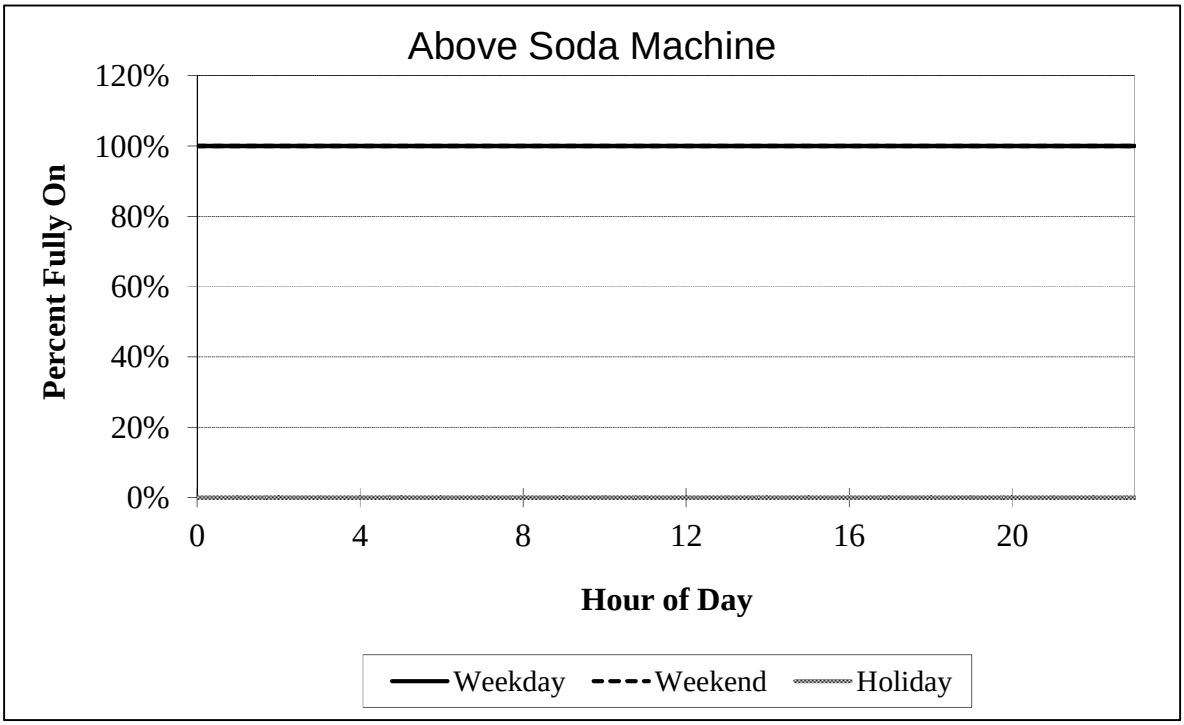


Figure 3: Average Daily Lighting Profile Above Soda Machine from 06/29/12 to 09/06/12

Figure 4: Average Daily Lighting Profile for Store Left from 06/29/12 to 09/06/12

Table 6: Summary of Evaluated Energy and Demand Savings

Facility Type:	Retail
KEMA ID:	91
Application Number/s:	953974
Project Type:	Systems

	Systems	Controls
Tracking Annual kWh:	9,272	0
Tracking Connected kW:	1.06	0
Tracking % On-Peak kWh:	0%	0%

Fixture Information

Fixture ID	Space Type	Pre-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Diversity Factor Summer	Diversity Factor Winter	Post-retrofit Lighting: Fixture Type	Fixture Quantity	Fixture Wattage	Hours of Use Annual	Peak Diversity Factor Summer	Peak Diversity Factor Winter
1	Store	8ftStrip	49	56	8,760	100%	100%	2'x2' LED Fixture	22	64	8,760	100%	100%
2	Store	4ftstrip	15	28	8,760	100%	100%	2'x2' LED Fixture	10	64	8,760	100%	100%
		Totals	64	3,164				Totals	32	2,048			

Pre-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	2.74	2.74	2.74	24,037	3,659	3,349	2,741	0	0.73	0.00
2	0.42	0.42	0.42	3,679	3,659	3,349	420	0	0.11	0.00
Totals	3.16	3.16	3.16	27,717			3,161	0	0.84	0.00

Post-Retrofit Demand and Energy Consumption

Fixture ID	Lighting Demand and Energy Consumption: Connected kW	Peak Diversified kW Summer	Peak Diversified kW Winter	Annual kWh	Interactive Hours: Cooling Hours	Heating Hours	Interactive Energy Consumption: Cooling kWh	Heating kWh	Peak Diversified kW Summer	Peak Diversified kW Winter
1	1.41	1.41	1.41	12,334	3,659	3,349	1,407	0	0.37	0.00
2	0.64	0.64	0.64	5,606	3,659	3,349	639	0	0.17	0.00
Totals	2.05	2.05	2.05	17,940			2,046	0	0.54	0.00

Total Savings Summary

	Energy kWh	Summer kW	Winter kW	Connected kW
Annual Lighting Only	9,776	1.12	1.12	1.12
Annual Interactive	1,115	0.30	0.00	N/A
Annual Lighting and Interactive	10,891	1.41	1.12	1.12

	MMBTU
Annual Non-Electric Heating Savings	(14)

Savings Adjustment Factors Lighting Systems

Parameter	Annual KWH	Difference %	Summer kW	Difference %	Winter kW	Difference %
Gross (TRACKING) kWh/Connected kW Savings	9,272	N/A	1.06	N/A	1.06	N/A
Adjustment - Documentation Change	-56	-1%	-0.01	-1%	-0.01	-1%
Adjustment - Technology Change	0	0%	0.00	0%	0.00	0%
Adjustment - Quantity Change	561	6%	0.06	6%	0.06	6%
Adjustment - Operation Change	0	0%	N/A	N/A	N/A	N/A
Adjustment - Coincident Change	N/A	N/A	0.00	0%	0.00	0%
Adjustment - Cooling Interaction	1,115	12%	0.30	28%	0.00	0%
Adjustment - TOTAL	1,619	17%	0.35	33%	0.06	5%
Adjusted Gross (ONSITE) Savings	10,891	117%	1.41	133%	1.12	105%

Hour Ending	Average kW Reduction
1	1.4
2	1.4
3	1.4
4	1.4
5	1.4
6	1.4
7	1.4
8	1.4
9	1.4
10	1.4
11	1.4
12	1.4
13	1.4
14	1.4
15	1.4
16	1.4
17	1.4
18	1.4
19	1.4
20	1.4
21	1.4
22	1.4
23	1.4
24	1.4

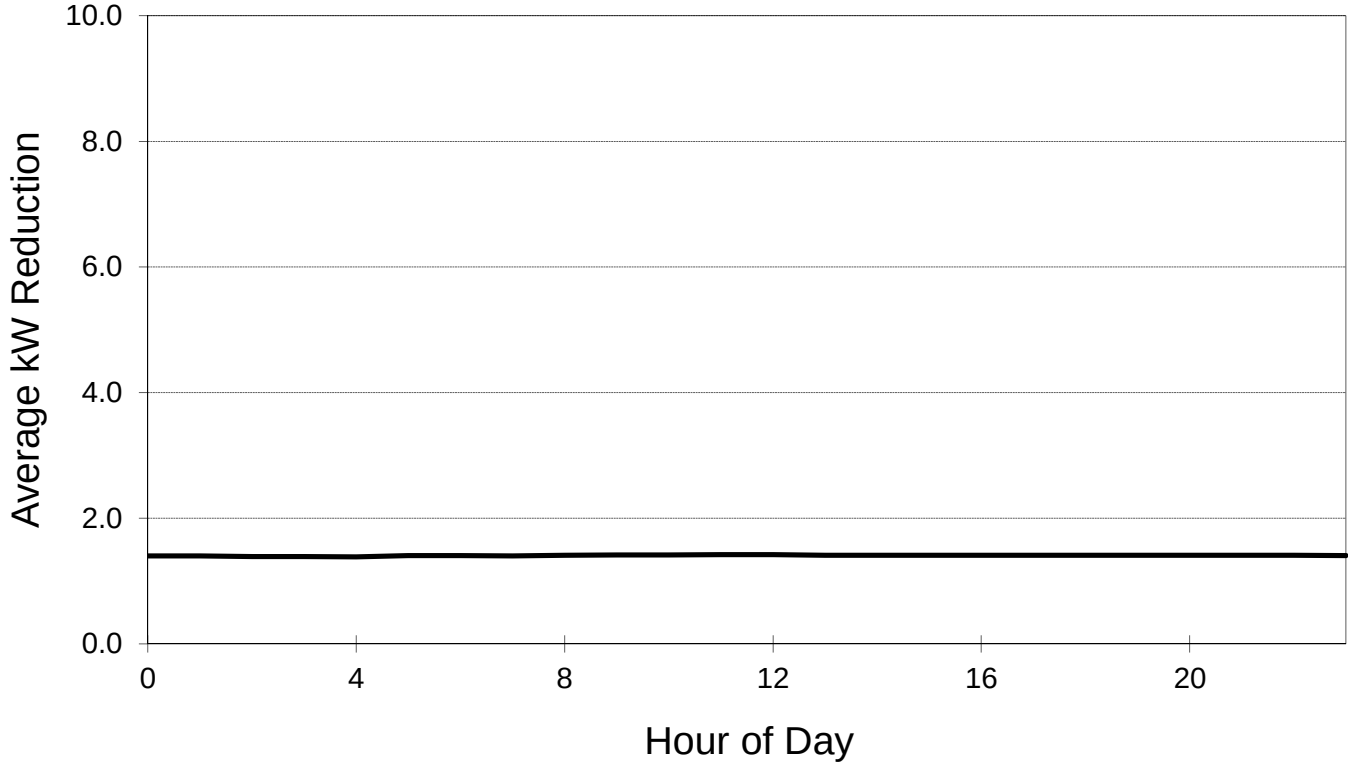


Figure 5: Average Summer Weekday kW Reduction

Hour Ending	Average kW Reduction
1	1.1
2	1.1
3	1.1
4	1.1
5	1.1
6	1.1
7	1.1
8	1.1
9	1.1
10	1.1
11	1.1
12	1.1
13	1.1
14	1.1
15	1.1
16	1.1
17	1.1
18	1.1
19	1.1
20	1.1
21	1.1
22	1.1
23	1.1
24	1.1

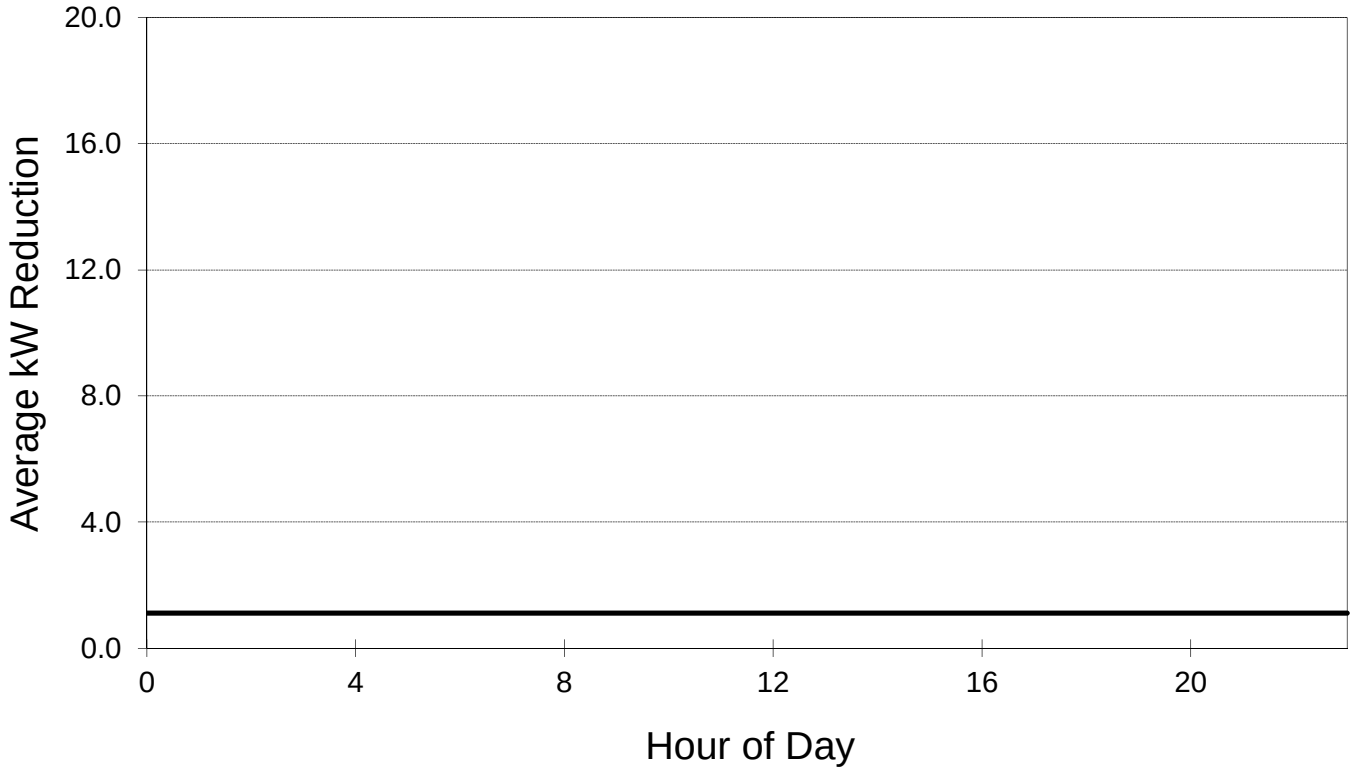


Figure 6: Average Winter Weekday kW Reduction