FINAL REPORT

Impact Evaluation of 2016 New Hampshire Commercial & Industrial Small Business and Municipal Lighting

New Hampshire Electric Program Administrators

Date: June 21, 2018

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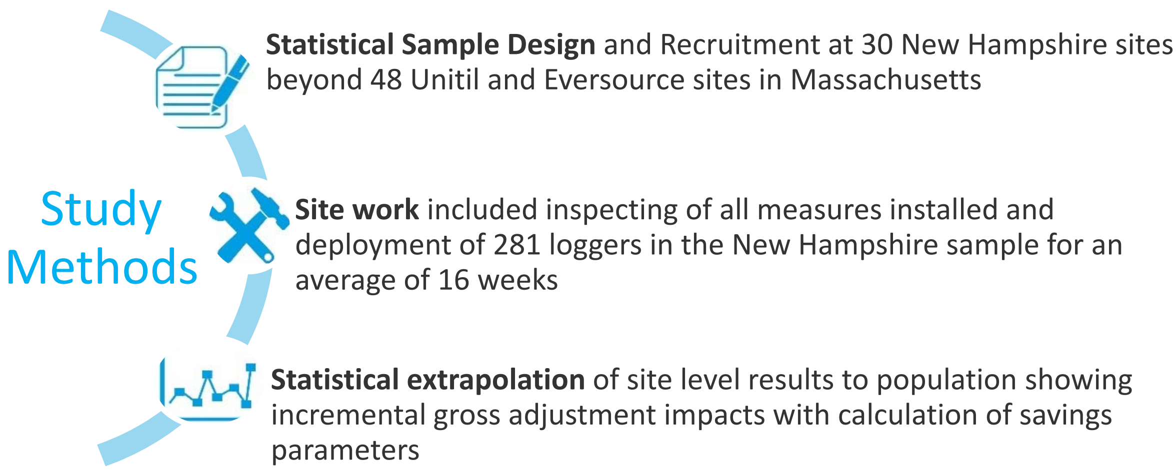
1 EXECUTIVE SUMMARY

DNV GL (KEMA, Inc.) conducted an impact evaluation of the 2016 Commercial & Industrial (C&I) Small Business (SB) and Municipal Program lighting installations offered by the New Hampshire Electric Program Administrators (PAs[1]). This evaluation also included a sample selected for a similar effort undertaken by DNV GL that was performed concurrently in Massachusetts, where Eversource and Unitil also operate. Key data gathered in this study included time of use metering of the lighting installations occurred over the winter of 2017—18.

The overall objective of this evaluation was to quantify the electric energy and peak demand savings and the on-peak coincident factors (as defined by ISO-NE) associated with high efficiency lighting measures through site-specific inspection, monitoring, and analysis. Impacts and realization rates (RRs) were determined overall (Massachusetts and New Hampshire) and for New Hampshire only. Information from the study also provides savings inputs for the New Hampshire PAs to improve future tracking savings estimates, in addition to realization rates presented at various increments of gross savings adjustments. The overall evaluation sample for this study, including that from Massachusetts, was designed to target ±10% precision at the 90% confidence level for energy (kWh) with a high likelihood to also produce coincident factors at a precision of ±10% precision at the 80% confidence level.



Study Results

ES-Table 1 presents the energy savings results from this study. Key drivers of the 92.6% overall realization rate were documentation adjustments (-3.6%) and changes in hours of operation (-3.0%) primarily experienced among the Eversource and Unitil Massachusetts sample. The high realization rate in the New Hampshire results was driven by higher hours of use (+4.8%) and a positive 3.9% interactive adjustment.

[1]Eversource, Unitil, Liberty Utilities, and the New Hampshire Electric Cooperative (NHEC).

ES-Table 1: Summary of Energy Savings and Realization Rates

Savings Parameter	Overall	NH	MA (Eversource and Unitil)
Tracking (kWh)	73,919,272	13,375,212	60,544,060
Evaluated (kWh)	68,427,714	14,262,456	52,215,692
Gross Realization Rate and Precision at 90% Confidence	92.6% at ±4.9%	106.6% at ±8.9%	86.2% at ±5.2%

ES-Table 2 summarizes the summer peak demand results overall, for the Massachusetts sample and for New Hampshire. Upon examination, we made the following observations:

- The Massachusetts (Eversource and Unitil) coincident factor of 64% is substantially higher than that in New Hampshire (40.5%). Most sites in the New Hampshire sample had coincident factors below that assumed in the tracking estimate, including 10 sample points with a coincident factor of 30% or less.
- In New Hampshire, the summer coincidence factor between municipal and small business participants were not substantially different at 36% and 42%, respectively.
- We did find that the New Hampshire interior lighting only summer coincident factor was 50.4%, with a precision of ±11.2%, which is substantially higher than the aggregate New Hampshire estimate of 40.5%.

ES-Table 2: Summary of Summer Peak Savings and Realization Rates

Savings Parameter	Overall	NH	MA (Eversource and Unitil)
Tracking	13,907	2,957	10,950
Evaluated	12,283	2,038	10,756
Gross Realization Rate and Precision at 80% Confidence	88.3% at ±6.7%	68.9% at ±11.7%	98.2% at ±7.3%
Coincidence Factor and Precision at 80% Confidence	55.6% at ±6.8%	40.5% at ±13.8%	64.0% at ±6.7%

ES-Table 3 summarizes the winter peak demand results overall, for the Massachusetts sample, and for New Hampshire. The coincident factors are nearly the same at ~54% and each realization rate is above 100%. When we remove exterior lighting from the winter coincident factor, the interior only lighting factor becomes 38.9% with a precision of ±18.7% at the 80% confidence interval.

ES-Table 3: Summary of Winter Peak Savings and Realization Rates

Savings Parameter	Overall	NH	MA (Eversource and Unitil)
Tracking	8,498	1,921	6,576
Evaluated	9,455	1,974	7,686
Gross Realization Rate and Precision at 80% Confidence	111.3% at ±8.6%	102.8% at ±12.7%	116.9% at ±11.3%
Coincidence Factor and Precision at 80% Confidence	54.0% at ±8.9%	54.0% at ±14.4%	53.9% at ±11.4%

Conclusions and Recommendations

The lighting measures installed in the small business and municipal programs are producing substantial savings and the tracking systems used to capture those savings is reasonably accurate for energy and winter peak savings but overestimate summer peak savings. When we look at the results based on the full sample we estimate gross savings of 68,428 MWh based on a 92.6% realization rate with a precision of ±4.9% at the 90% confidence interval. The New Hampshire sample on its own produces a gross savings estimate of 14,262 MWh (106.6% realization rate) with a precision of better than ±9% at the 90% confidence interval. Although this study was designed to improve precision by combining a sample of Unitil's and Eversource's Massachusetts small businesses with that of a sample for all New Hampshire electric utilities, the precision and error ratio from the NH sample provides a statistically sound estimate of impacts that exceeds the customary desired precision of better than ±10%.

Below we provide conclusions and recommendations regarding the use of savings parameters from this study. It will be important for the PAs and PUC to execute the updating of the savings factors used to estimate tracking system savings and the application of a realization rate carefully to ensure that they complement, and not amplify, one another.

Conclusion and Recommendation #1

Conclusion: At the overall level, we calculated an energy savings realization rate of 92.6% with a precision of ±4.9% at 90% confidence interval. In New Hampshire alone we calculated a realization rate of 106.6% with a precision of ±8.9% at 90% confidence interval.

Recommendation: Although there are advantages and disadvantages to using the overall energy realization rate versus the New Hampshire results from this study that are discussed in this report, we recommend that the PAs use the New Hampshire realization rate of 106.6% for reported energy savings.

Conclusion and Recommendation #2

Conclusion: Overall, the summer peak kW realization rate is 88.3% with a precision of ±6.7% at the 80% confidence interval. The New Hampshire summer peak realization rate is 68.9% with a precision of ±11.7% at the 80% confidence interval. The summer on-peak coincident factors associated with these results are 55.6% overall (±6.8% at the 80% confidence interval) and 40.5% for New Hampshire (±13.8% at the 80% confidence interval). The cause of the lower coincident factor for New Hampshire appears to be due in part to the effect of exterior lighting in the sample but also due to generally lower lighting operation during peak periods among most of the sample. When isolated to only interior lighting, the summer coincident factor is 50.4% with a precision of ±11.2%.

Recommendation: We recommend the New Hampshire utilities have clearly designated interior and exterior summer coincident factors. Currently, New Hampshire has a C&I parking lot lighting category that uses exterior coincidence factors and a C&I lighting category coincident factor assumption that is understood to represent a blend of interior and exterior lighting. We recommend that the summer coincident factor for interior lighting be 50.4%, with a precision of ±11.2%. We recommend that the summer coincident factor for exterior lighting be 0%, which is the same as that currently assumed for parking lot lights and consistent with findings from the 2015 Large C&I study.

Conclusion and Recommendation #3

Conclusion: Overall, the winter peak kW realization rate is 111.3% with a precision of ±8.6% at the 80% confidence interval. The New Hampshire winter peak realization rate is 102.8% with a precision of ±12.7% at the 80% confidence interval. The winter on-peak coincident factors associated with these results are the same at 54.0% with precisions of ±8.9% around the overall coincident factor and ±14.4% for the New Hampshire estimate. When we isolate the interior lighting results, the winter coincident factor becomes 38.9% with a precision of ±18.2% at the 80% confidence interval.

Recommendation: We recommend the New Hampshire utilities have clearly designated interior and exterior winter coincident factors. As stated in the previous recommendation, New Hampshire currently has a C&I parking lot lighting category that uses exterior coincidence factors and a C&I lighting category coincident factor assumption that is understood to represent a blend of interior and exterior lighting. We recommend that the winter coincident factor for interior lighting be 38.9%, with a precision of ±18.7%. We recommend that the winter coincident factor for exterior lighting be 100%, which is consistent with exterior lighting operating on photocell hours and consistent with findings from the 2015 Large C&I study.

Conclusion and Recommendation #4

Conclusion: New Hampshire will soon be developing a TRM to guide the calculation of tracking savings from C&I lighting (and other measures) statewide. This study has produced several lighting factors that can be incorporated into the TRM when developed. The typical TRM energy and peak demand savings calculations are presented below and show how the various factors are combined.

$$\text{kWh Savings} = \left[\sum_{b=1}^{n}\left(\frac{QTY_b \times Watts_b}{1{,}000}\right)_{Base} - \sum_{i=1}^{n}\left(\frac{QTY_i \times Watts_i}{1{,}000}\right)_{Installed}\right] X\ Hours\ X\ Interactive\ Factor$$

$$\text{SkW Savings} = \left[\sum_{b=1}^{n}\left(\frac{QTY_b \times Watts_b}{1{,}000}\right)_{Base} - \sum_{i=1}^{n}\left(\frac{QTY_i \times Watts_i}{1{,}000}\right)_{Installed}\right] X\ Summer\ Coincident\ Factor \times Interactive\ Factor$$

$$\text{WkW Savings} = \left[\sum_{b=1}^{n}\left(\frac{QTY_b \times Watts_b}{1{,}000}\right)_{Base} - \sum_{i=1}^{n}\left(\frac{QTY_i \times Watts_i}{1{,}000}\right)_{Installed}\right] X\ Winter\ Coincident\ Factor \times Interactive\ Factor$$

Recommendation: If New Hampshire decides to include an interactive factor in their calculation of energy or peak savings, we recommend using those provided in this report. Specifically, we recommend using a factor of 103.9% for energy interactive and 113.5% for summer peak interactive. We do not recommend the use of a winter peak interactive due to its marginal presence.

2 INTRODUCTION

DNV GL (KEMA, Inc.) conducted an impact evaluation of the 2016 Commercial & Industrial (C&I) Small Business (SB) and Municipal Program lighting installations offered by the New Hampshire Electric Program Administrators (PAs[2]). For reasons discussed later, this study did not include Municipal Program parking lot lighting projects. Both the SB and Municipal programs offer non-lighting measures, which are the focus of a separate impact and process study planned for 2018. As an independent evaluator, DNV GL began this study with a work plan drafted in September, 2017. This evaluation included the sample selected for a similar effort undertaken by DNV GL that was performed concurrently in Massachusetts, where Eversource and Unitil also operate. Lighting time of use metering occurred over the winter of 2017—18.

2.1 Evaluation Purposes and Objectives

The overall objective of this evaluation was to quantify the electric energy and peak demand savings and the on-peak coincident factors (as defined by ISO-NE) associated with high efficiency lighting measures through site-specific inspection, monitoring, and analysis. The New Hampshire sample selected for this evaluation was analyzed on its own as well as in combination with the sample selected for Eversource and Unitil in the concurrent Massachusetts lighting evaluation.

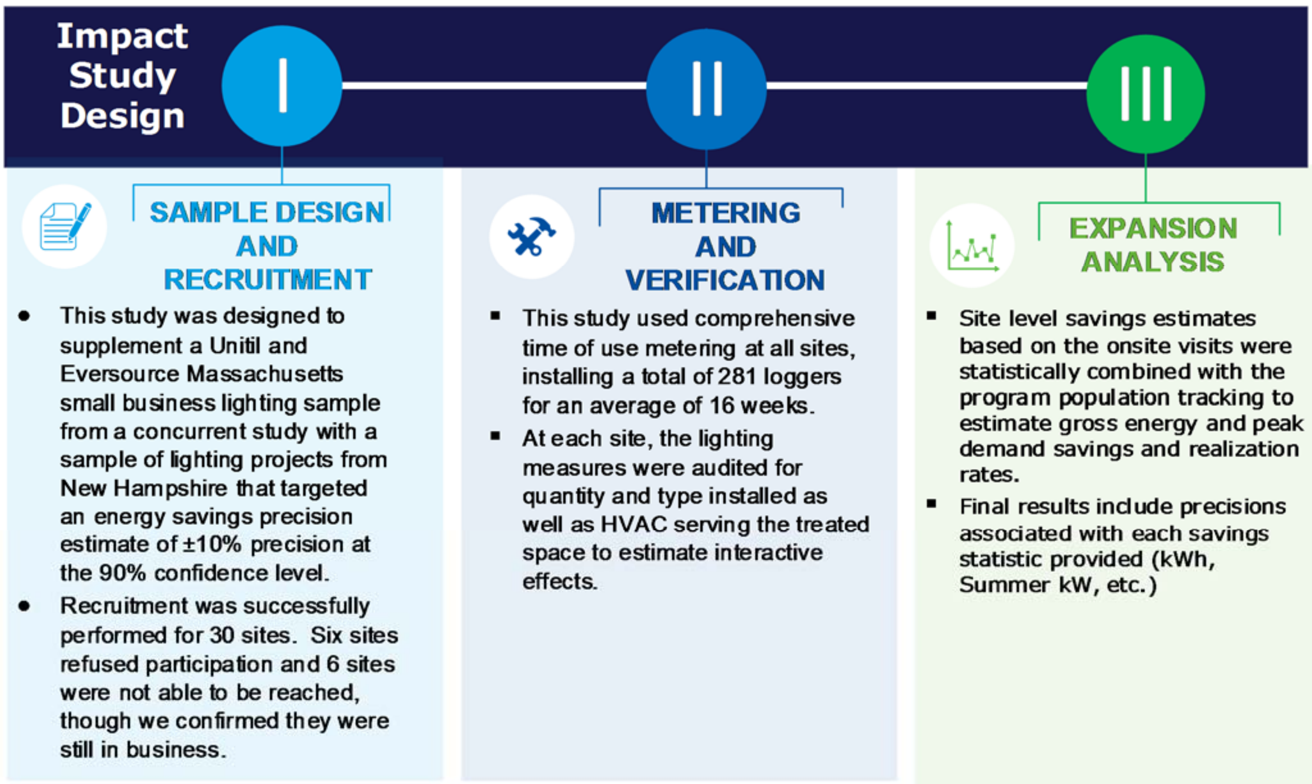
The results of this study were used to determine realization rates for Small Business and Municipal (exclusive of municipal external lighting projects) energy efficiency lighting measures, both custom and prescriptive, installed in 2016. Realization rates (RRs) were determined overall and for New Hampshire. Information from the study also provides savings inputs for the New Hampshire PAs to improve future tracking savings estimates, in addition to realization rates presented at various increments of gross savings adjustments. The overall evaluation sample for this study, including that from Massachusetts, was designed to target ±10% precision at the 90% confidence level for energy (kWh). Given the importance of precision around peak savings estimates we performed the sample design from this perspective and concluded that it was also likely to produce coincident factors at a precision of ±10% precision at the 80% confidence level, based on examining other studies of a similar nature.

[2] Eversource, Unitil, Liberty Utilities, and the New Hampshire Electric Cooperative (NHEC).

3 EVALUATION APPROACH & METHODOLOGY

This section discusses the activities performed to meet the evaluation objectives. Figure 1 presents an overview of the three primary activities undertaken in this study. It is followed by sections that detail each task.

Figure 1: The Three Core Impact Activities Performed



The SBS program in each state uses vendors to provide turnkey audit and lighting installation services comprehensively in participating businesses. Lighting technologies installed between the states are similar as are the methods used to estimate energy savings, both of which are dependent on self-reported hours/operation from contacts at each site and standardized assumed watts based on fixture type. Differences in the programs and samples in this study include a higher consumption threshold for participation in Massachusetts than New Hampshire (average electric demand of less than 300 kW for MA and 200 kW for New Hampshire) and the inclusion of municipal activity in the New Hampshire sample. We also note that Massachusetts has a Technical Reference Manual from which savings calculations are based, though New Hampshire does not have one.

3.1 Sample Design and Selection

When designing the sample for this study, it was decided to not include Municipal Program parking lot lighting projects in the population (i.e., sample frame) since they typically have very different patterns of use when compared to other SB and Municipal Program lighting installations. The NH C&I programs currently assume a 0% summer peak coincidence factor (CF) and a 80% winter peak CF for parking lot lights since they typically operate on photocells. The most recent C&I study performed in NH confirmed these assumptions[3]. There were, however, four small business light installations that were exclusively exterior and nine with at least some exterior lighting. There were also three schools in the New Hampshire small business sample.

From utility-provided tracking data, DNV GL identified 477 unique customers who received lighting measures in the NH Small Business and Municipal Programs in 2016. To develop the sample frame, these customers were combined with 1,970 Eversource and Unitil customers who participated in the Small Business Program in Massachusetts in 2016. Table 1 summarizes this population. Given the relative size of their service territories (in both states) most customers served (91%) and most energy savings (93%) were attributable to Eversource program installations. Unitil is responsible for approximately 6% of customers served and 4% of energy savings with the remainder attributable to Liberty Utilities and NHEC customers.

Table 1: 2016 NH and MA Small Business and Municipal Lighting Installations

Program Administrator	New Hampshire		Massachusetts		Total	
	Customers Served	Energy Savings (kWh)	Customers Served	Energy Savings (kWh)	Customers Served	Energy Savings (kWh)
Eversource						
Municipal	58	2,298,053	-	-	**58**	**2,298,053**
Small Business	289	7,730,818	1,886	59,066,309	**2,175**	**66,797,127**
Total	347	10,028,871	1,886	59,066,309	**2,233**	**69,095,180**
Liberty Utilities						
Municipal	4	360,367	-	-	**4**	**360,367**
Small Business	14	609,091	-	-	**14**	**609,091**
Total	18	969,458	0	0	**18**	**969,458**
New Hampshire Electric Cooperative						
Municipal	7	93,283	-	-	**7**	**93,283**
Small Business	44	710,919	-	-	**44**	**710,919**
Total	51	804,202	0	0	**51**	**804,202**
Unitil						
Municipal	6	156,182	2	7,820	**8**	**164,002**
Small Business	55	1,416,501	82	1,469,929	**137**	**2,886,430**
Total	61	1,572,683	84	1,477,749	**145**	**3,050,432**
Total						
Municipal	75	2,907,885	2	7,820	**77**	**2,915,705**
Small Business	402	10,467,329	1,968	60,536,238	**2,370**	**71,003,567**
Total	477	13,375,214	1,970	60,544,058	**2,447**	**73,919,272**

To develop the NH sample, we considered the entire New Hampshire SB and Municipal 2016 program population and savings as well as the Unitil and Eversource Massachusetts population and sample. We used

[3] http://www.puc.state.nh.us/electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf, Page 68, Table 34.

the two populations as sectors in a stratified sample design that targeted energy results at ±10% at the 90% confidence interval overall with an assumed error ratio of 0.5, which is in line with the error ratio observed in the previous NH small business lighting study and a little lower than that assumed in the MA study (0.6). As Table 2 shows, 30 NH sites were selected in addition to the 48 Eversource and Unitil sites that were in the MA study sample. Note that in Table 3, the final sample of Eversource and Unitil sites was 46 due to backup sample points used that were not from either utility.

Table 2: Designed On-Site Sample Design

State	Customer Sites	Total Energy Savings (kWh)	Sample Size	Expected Relative Precision at 90% Confidence Interval
Massachusetts (Eversource & Unitil Only)	1,970	60,544,058	48	±11.0%
New Hampshire	477	13,375,214	30	±14.6%
Total	2,447	73,919,272	78	±10.2%

Table 3 shows the original and final on-site sample design by strata overall and for each state. The table shows the maximum savings allowed for inclusion, number of sites, total savings, and planned and achieved sample points for each stratum. Designing the strata to have roughly the same amount of energy savings, then targeting an equal number of sample points from each produces a scheme that samples a larger portion of the program savings than random sampling. This design also provides a higher precision around the final savings estimates than random sampling.

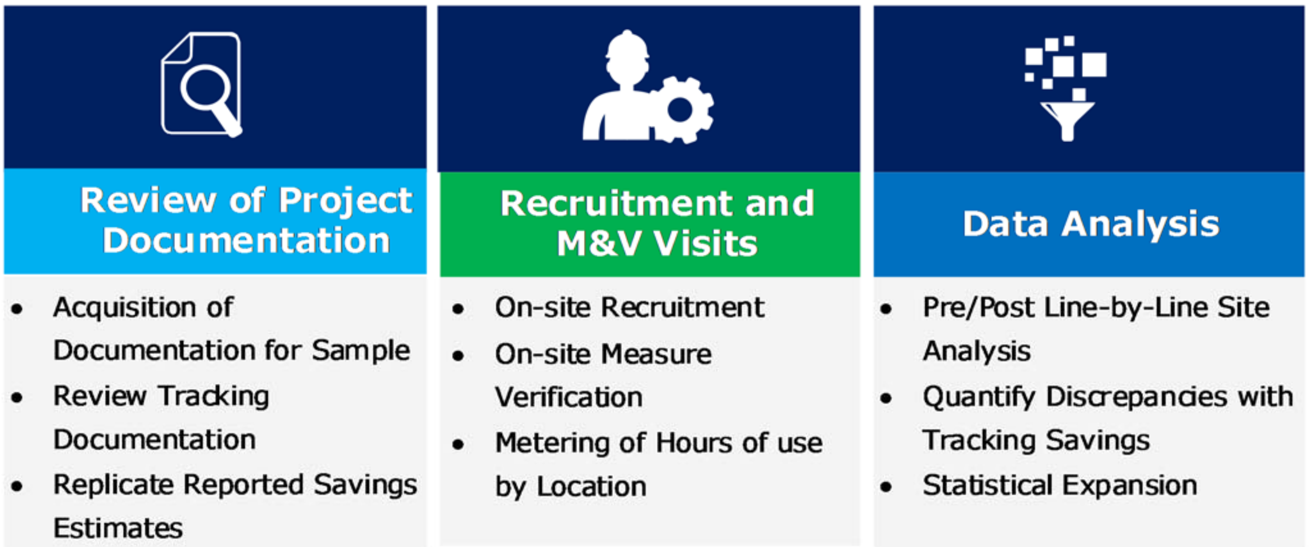
At the outset of the sample design process, we determined that 78 sites were needed to achieve ±10.2% precision overall. At that time, Eversource and Unitil had 48 sites in the MA sample, which meant that the remaining 30 should be selected from the NH population. We extrapolated the sampled savings to the population using the combined sample case weights (rightmost column). The original final sample size was 78 sites overall (30 from New Hampshire) though the final sample is 76 sites due to the use of Massachusetts backup sites from territories outside of Eversource and Unitil.

Table 3: On-Site Sample Design Strata and Sample Sizes

Stratum	Maximum Energy Savings (kWh)	Customer Sites	Total Energy Savings (kWh)	Sample Size	Final Sample Size	Final Case Weights
Massachusetts (Eversource & Unitil Only)						
1	16,163	1,110	8,239,614	11	10	N/A
2	35,559	428	10,140,789	8	10	
3	73,181	232	11,856,872	11	9	
4	136,675	137	13,434,188	11	10	
5	876,619	63	16,872,595	7	7	
Massachusetts Total		1,970	60,544,058	48	46	
New Hampshire						
1	16,495	247	1,953,028	6	6	N/A
2	33,466	101	2,372,619	6	6	
3	56,952	61	2,708,811	6	6	
4	89,817	42	2,928,221	6	6	
5	248,943	26	3,412,535	6	6	
New Hampshire Total		477	13,375,214	30	30	
Overall Massachusetts (Eversource & Unitil Only) & New Hampshire						
1	16,495	1,357	10,192,642	17	16	84.8
2	35,559	529	12,513,405	14	16	33.1
3	73,181	293	14,565,682	17	15	19.5
4	136,675	179	16,362,410	17	16	11.2
5	876,619	89	20,285,133	13	13	6.8
Overall Total		**2,447**	**73,919,272**	**78**	**76**	**N/A**

3.2 Data Collection

After selection of the sample of sites to receive on-site measurement, there were three activities undertaken. These included a review of project documentation for the sampled sites, recruitment and M&V visits to the selected sample sites, and a savings analysis of each site followed by extrapolation of those results to the population. The figure below provides a high-level summary of these activities and is followed by a detailed description of each.



Primary Sample Documentation Review

DNV GL performed a documentation review for all sites in the on-site sample. The purpose of the documentation review is two-fold. The first purpose is to replicate the tracking savings to ensure its proper calculation. In this stage, any differences between the file review and the program tracking estimates of savings were captured as a documentation adjustment in the realization rate of the final savings work. The second purpose is to understand what program measure types and quantities were installed and where they are located within the facility. This information serves as the backbone of the site audit and metering activities as it provides important information needed to verify measure installation and guides the number of loggers installed and the schedules that need to be captured. Put another way, the treated space types identified during the documentation review provide guidance on how many different schedules are likely to be encountered during the site visit. Since we attempt to install at least one logger on every unique schedule that program fixtures operate on, this information also provides guidance on how many loggers will be needed for each site.

Recruitment and M&V Visits

All efforts were made to cluster site visits by day and location to minimize travel time and maximize efficiency. A minimum of seven attempts were made to contact appropriate personnel for each sample point to maximize the response rate. If after seven attempts no contact was made and the customer did not return our messages, the site was replaced with one from the backup sample. Each scheduled participant was called within 48 hours prior to the scheduled on-site visit to confirm the appointment.

Table 4 presents the final disposition of the New Hampshire recruitment calls based on the disposition codes provided in The American Association for Public Opinion Research's (AAPOR) Standard Definitions.[4] Based on the AAPOR algorithms, DNV GL calculated a 71% response rate and a 14% refusal rate for the on-site recruitment calls. These rates are consistent with the rates experienced in the Massachusetts Small Business Lighting sample, which were 78% and 12%, respectively. We routinely examine recruitment disposition rates as they can be an indicator of potential bias associated with sample-specific estimates of population parameters. We cite this as a bias indicator since an assessment of the extent of bias due to

[4] http://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf.

non-response really rests upon any differences there might be between those customers that allowed the visit and those that we were unsuccessfully able to schedule. In Small Business studies, we often expect the greatest risk of bias being non-contacts due to business closings, which if not properly accounted for can result in an upward bias in the expanded M&V results. To address this possible bias, as part of recruitment, we confirmed that the 6 sites not reached were still in business by either noting active voicemail systems or performing an internet search of the business.

Table 4: Final Onsite Visit Recruitment Disposition

Disposition Code	Disposition Description	Total
1.1	Complete	30
2.1	Refusal	6
2.2	No Response, confirmed in business	6
	Total Customers Called	**42**
	Response Rate	**71%**
	Refusal Rate	**14%**

On-site Visit Activities

During each site visit, DNV GL took inventory to verify the product types and operating characteristics (where possible) of program-installed measures and compared their specifications to those reported in the program documentation/data. Other data gathered onsite included:

- Interviews with site personnel regarding holidays, operating hours, seasonal variations in schedules, business cycles, and/or functional area use patterns that might help annualize the short-term lighting logger data.
- When possible, verification of pre-installation baseline conditions with site personnel to help with the accuracy of the savings calculations (e.g., type and wattage of fixtures replaced by the program fixtures, areas of the facility that still have similar old bulbs/fixtures in place)
- Documentation of HVAC equipment for use in interactive savings calculations
- Installation and retrieval of lighting loggers to determine operating characteristics.

DNV GL used DENT SMARTlogger™ Time of Use Lighting Loggers in this study. The electric utilities' participation in the FCM market is governed by evaluation standards contained in ISO M-MVDR §10. There are three relevant requirements in these standards relating to time-of-use loggers such as the Dent Instruments SMART*logger* TOU product used in this study. These are Requirement #1 (General Safety), Requirement #11 (Time Accuracy), and Requirement #13 (Maintenance). The SMARTloggers used are certified to conform to with health, safety, and environmental protection standards that meet requirement #1. They also have a Real-Time Clock Quartz Crystal that provides time drift of no more than 1 minute per month, which meets the threshold of ±2 minutes per month stipulated in Requirement #11. Note that another key element of

Figure 2: Lighting Logger

Requirement #11 is that loggers must be synchronized in time with the National Institute of Standards and Technology (NIST). DNV GL synchronized all loggers prior to deployment and checked (and replaced as necessary) all batteries to be sure they had at least 3 volts of battery capacity prior to deployment. Finally, DNV GL conforms to industry standards in maintaining our SMARTlogger inventory (Requirement 13). Each logger used in this study has documentation noting the date in which each had the battery check and synchronization performed as well as when, where, and for what duration each was installed as part of this study.

DNV GL performed three basic steps to install the SMARTlogger equipment used in this evaluation:

1. *Selection:* During the selection stage, we determined the appropriate number of loggers needed to capture the operating schedules of each site as well as any need for redundant logging on particularly important schedules (e.g., installing two or more loggers to ensure gathering of schedules critical to the site analysis).
2. *Placement:* Proper placement of monitoring equipment ensures sufficient coverage of each uniquely controlled set of program-incented lighting. DNV GL's standard placement protocol ensures measurements are representative of unique schedules with a focus on those with the most uncertainty as well as those that represent substantial parts of the installation. In this study, placement was based on space types and discrete schedules as observed onsite.
3. *Calibration:* Each lighting logger is synched up to computers prior to deployment and calibrated at the time of installation to ensure the reliability of the data recorded. Lighting loggers are relatively simple to calibrate: on/off transitions for lighting loggers can be confirmed at the time of installation by either adjusting a sensitivity screw or by visually inspecting the status LCD on the unit. Calibration is not needed for power loggers.

Operating hours are often the most uncertain part of lighting savings calculations in a direct installation delivery model, as is used by the NH Small Business and Municipal Programs. In addition, operation hours during system peak periods drive the coincidence factors that are key to the ISO NE forward capacity market. To inform these key inputs, DNV GL installed time-of-use loggers on as many program installed lighting fixtures as possible. In this study, 281 loggers were installed among the 30 businesses in the New Hampshire sample, for an average of 9.4 loggers per site. Loggers were installed for an average of 112 days, or approximately 3.7 months per site. As Figure 3 shows, the logging period began in October 2017 and concluded in March 2018. Most of the loggers were installed over the winter peak period as defined by ISO NE (December and January), which was ideal for the determination of coincident winter peak use but required annualization based on customer reported seasonal schedule or shutdown periods to assess summer coincidence and annual HOU. This is discussed further below.

The recently updated Uniform Method for evaluating C&I lighting[5] provides guidance on the duration of monitoring for studies of this nature. In summary, it recommends a 4-week metering period of typical activity for facilities with constant schedules (e.g., offices, grocery stores, retail) and additional time for facilities with irregular schedules. Facilities with seasonal schedules, such as schools, should include monitoring during active periods and additional monitoring during the inactive periods or (if activity is expected to be small), the inactive periods can be estimated as a percent of active period hours.

[5] Chapter 2: Commercial and Industrial Lighting Evaluation Protocol. The Uniform Methods Project: Methods for Energy Efficiency Savings for Specific Measures, October, 2017.

Figure 3: Logger Installations during the Evaluation Period

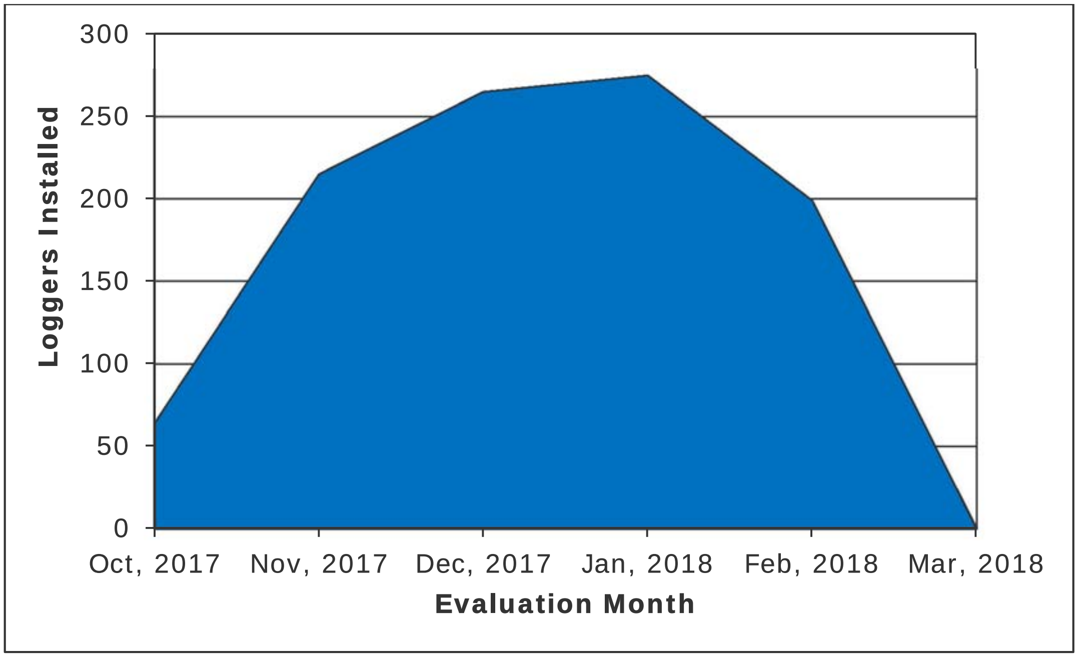


Table 5 presents the business types in the final sample overall and by state. There are five business types (e.g., assembly, automotive, etc.) that only appear in the sample of just one of the two states, although the number of such points is small and represents no more than 9% of the total sample in either state. There are two instances that show large differences in the business types between the states. The first is in offices, which represents nearly a third of the Massachusetts sample but only 13% of that in New Hampshire. The second is retail, which represents 40% of the New Hampshire sample but only 22% of that in Massachusetts. The influence of including municipal program activity in the New Hampshire sample is evident in this summary, where two of the three assembly and two of the three education sample points in New Hampshire were from the Municipal Program.

Lighting operation can be expected to vary by business type. As such the business type distribution within a population can influence the aggregate savings parameters calculated; including hours of use and coincident factors. Because of this, we present results for NH and MA for some of these key study outputs separately. In the overall analysis, each site is case weighted based on its strata, not building type. We also note that the presence of exterior lighting can skew results, particularly the estimation of coincident factors. In the results section of this report we provide interior-only lighting coincident factor results to isolate this influence.

Table 5: Sample by Business Type and State

Business Type	Overall		MA		NH	
	n	%	n	%	n	%
Assembly	3	3.9%	-	-	3	10.0%
Automotive Facility	4	5.3%	4	8.7%		-
Dining: Bar Lounge/Leisure	2	2.6%	2	4.3%		-
Education-College/Secondary	4	5.3%	1	2.2%	3	10.0%
Exercise Center	2	2.6%	2	4.3%		-
Healthcare-Clinic	3	3.9%	3	6.5%		-
Manufacturing	5	6.6%	3	6.5%	2	6.7%
Office	19	25.0%	15	32.6%	4	13.3%
Other	12	15.8%	6	13.0%	6	20.0%
Retail	22	28.9%	10	21.7%	12	40.0%
Grand Total	76	100.0%	46	100.0%	30	100.0%

A Note on Annualizing Short Term Data

The need to annualize short term time-of-use data is typical in lighting impact studies due to the cost and time needed to perform long term metering. To annualize the short term metered data, we average the 24-hour schedule for each day of the week and holidays. These values then provide the basis for representing usage for all other similar days during the year outside of the monitoring period. We adjust these logger data for non-metered periods based on gathered building seasonal schedules or other information provided by the site contact at the time of the on-site. DNV GL staff have performed annualization of short term lighting logger data for many years and drafted a paper on the accuracy of this process for IEPEC in 2013[6] and was expanded on as part of the C&I lighting UMP cited earlier.

In general, it was found that the three-month study did a good job of estimating hours of use and coincident factors for lighting systems and produced overall estimates that were within 3% and 4% of the long-term results for hours of use and coincident factors, respectively. It further found that when logger data from the three-month period of November through January is used to estimate annual hours the ensuing energy savings is within 3% of that calculated from a full year of metered data.

When examined among business types, the paper notes that “There were cases such as schools and offices in which it proved to be more difficult to estimate summer usage using only three months of winter data.” The NH study had one municipal school in it that had interior lighting and 4 offices. We handled the summer schedule for this school manually based on information provided by the facility contact. The offices in the sample did not report any different schedule or hours during summer use.

Data Analysis

We compiled the data gathered from the on-site visits into a lighting savings spreadsheet and conducted line-by-line comparisons of pre- and post-retrofit electricity use based on location and schedule. Interactive cooling and heating effects on the installed measures were also calculated using engineering algorithms

[6] 2013 International Energy Program Evaluation Conference, Chicago, “Going Long: Assessing the Value of 12 Month Monitoring of Lighting Systems”. Telarico, Ledyard, Blake and Piper. https://www.iepec.org/wp-content/uploads/2018/02/059-1.pdf

where applicable. The on-site savings calculations included all relevant information gathered during the on-site visit (e.g., observed installed quantities, technologies, lighting logger results, etc.). Analyses were conducted such that DNV GL could identify discrepancies between the reported and evaluated savings by each gross savings adjustment phase. Gross savings adjustments include documentation, technology, quantity, operational, and interactive HVAC. The adjustments are described in Table 6. Note that the adjustments are applied in the order they are listed. These are the adjustments used to illustrate the key savings drivers in the results section of this report.

Table 6: Gross and Net Savings Adjustments

Gross Savings Adjustments: Changes in Savings	
Documentation	Changes due to discrepancies in project documentation. Evaluators recalculated tracking estimates using all quantities, fixture types/wattages, and hours documented in the project file. All tracking system discrepancies and documentation errors are reflected in this adjustment.
Technology	Changes due to the identification of a different lighting technology (fixture type and wattage) at the site than in the program data system; provided that this technology was rebated by the program.
Quantity	Changes due to the identification of a different quantity of lighting fixtures installed at the site than in the program data system.
Operational	Changes due to the observation or monitoring of different lighting operating hours at the site than in the program tracking system.
Interactive	Changes due to interaction between lighting fixtures and other systems in the building. Typically interaction is between lighting fixtures and electric HVAC systems.

DNV GL combined the savings estimates based on the on-site visits with the program tracking data provided by the PAs to estimate gross savings and realization rates for annual kWh, connected kW, summer peak, and winter peak kW. Results were calculated separately for each site in the sample and then combined to provide state-level savings. To perform the extrapolation from the sample to the population, case weights for the overall population were used based on the sample design. All metrics reported were sample weighted to be statistically representative of the population. The results include precisions associated with each savings value.

4 RESULTS

The evaluation results are comprised of gross annual kWh savings, connected kW savings, summer peak kW savings, and winter peak kW savings.

4.1 Gross Annual kWh Savings Results

Figure 4 presents a scatter plot of evaluation gross annual kWh savings vs. reported or tracked annual kWh savings for the 76 participant sites that were contacted as part of this evaluation. We have colored Massachusetts sample sites green and New Hampshire sites blue. A one-to-one reference line is plotted as a dashed line running diagonally across the graph. All sample points would fall along this line if the evaluated gross kWh savings were identical to the reported savings (i.e., a 100% realization rate).

Due to differences in consumption threshold for program participation being higher in Massachusetts, it has the four largest sites in the sample. The scatter in the field along the one-to-one reference line is very tight overall with no significant outliers. The final error ratio of 0.27 reflects this pattern, and is substantially better than the 0.5 assumed in the sample design. Note that the New Hampshire sample generally performed better than Massachusetts (Eversource and Unitil) when compared to their tracking estimates. The overall combined gross annual kWh realization rate is 92.6%.

Figure 4: Scatter Plot of Gross Annual kWh Savings

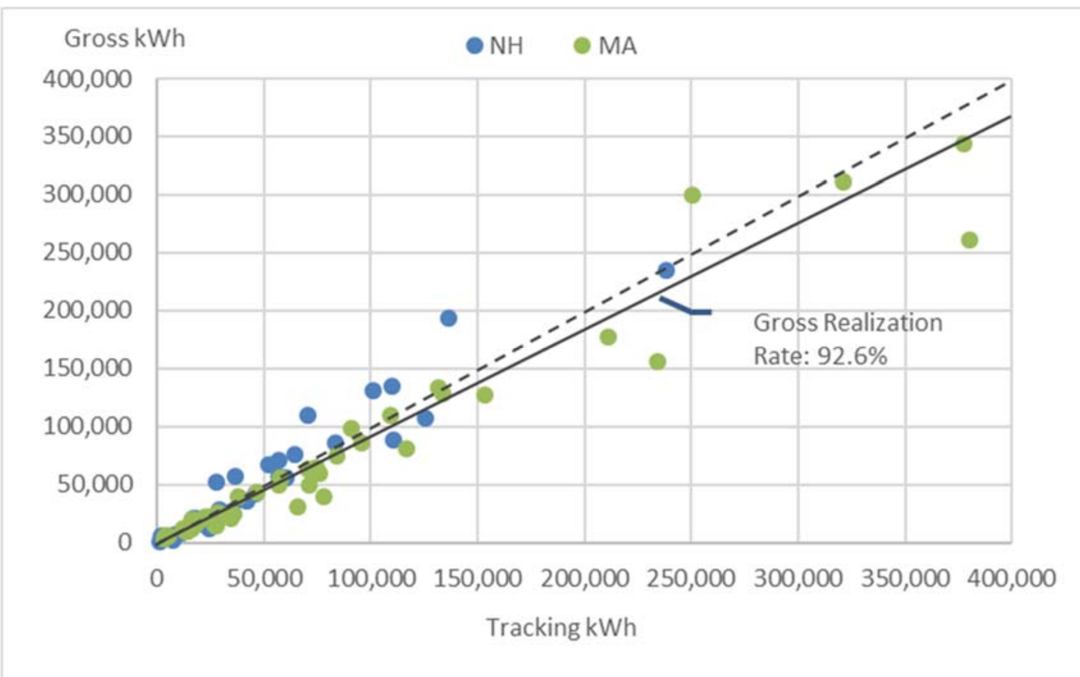


Table 7 shows the effect that each of the gross savings discrepancies discussed earlier had on the overall gross kWh realization rate presented in Figure 4. We also show these results for NH and MA separately to illustrate the influence sample points from Eversource and Unitil in Massachusetts had on the overall results. The documentation adjustment caused a 3.6% reduction in overall impacts while the discrepancy between logged onsite annual HOU and assumed tracking system annual HOU was responsible for a 3% decrease in savings. The overall gross annual kWh realization rate of 92.6% achieved ±4.9% precision at the 90%

confidence interval.

The NH results on their own provide a realization rate of 106.6% with an approximate ±9% precision at the 90% confidence interval. This precision is much better than was anticipated in the sample design and presents an opportunity to consider using the results from the NH sample for evaluation purposes. Overall, the NH sample is under reporting its energy savings. The largest difference between the MA and NH results are in the operational adjustment where the New Hampshire sample had a 4.8% positive adjustment versus a negative 6.5% adjustment among the Massachusetts sample. The second largest difference was in the documentation adjustment (where only marginal adjustments were needed for the NH sample) despite a negative 5.2% adjustment in the MA sample. Note that New Hampshire does not have a formal TRM to guide savings estimates, which largely negates the need for a documentation adjustment among that sample.

Table 7: Gross Annual kWh Savings Adjustments Overall and by State

Savings Parameter	Overall Energy		MA		NH	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Gross savings (Tracking)	73,919,272	N/A	60,544,060	N/A	13,375,212	N/A
Documentation Adjustment	-2,647,026	-3.6%	-3,142,906	-5.2%	-278	0.0%
Technology Adjustment	-399,326	-0.5%	-442,615	-0.7%	-15,519	-0.1%
Quantity Adjustment	-1,012,629	-1.4%	-686,915	-1.1%	-253,194	-1.9%
Operational Adjustment	-2,234,104	-3.0%	-3,958,282	-6.5%	640,890	4.8%
HVAC Interactive Adjustment	801,526	1.1%	-97,649	-0.2%	515,344	3.9%
Adjusted Gross savings	68,427,714	92.6%	52,215,692	86.2%	14,262,456	106.6%
Gross Realization Rate	92.6%	N/A	86.2%	N/A	106.6%	N/A
Relative Precision at 90% CI	N/A	±4.9%	N/A	±5.2%	N/A	±8.9%
Error Ratio	N/A	0.27	N/A	0.22	N/A	0.30

Table 8 compares the current overall study results to the current NH only results and the 2012 New Hampshire Small Business study results[7]. Recall, the magnitude of overall savings in the current study is due to the inclusion of savings from Unitil and Eversource program activity in their Massachusetts territories. Overall, the accuracy of the lighting tracking savings continues to provide a very good estimate of impacts with a 92.6% overall rate, a 106.6% NH only realization rate, and a 96.9% realization rate in 2012. Although there was a more modest documentation adjustment in this study, a greater negative discrepancy in operating hours (notably in the MA sites) and a lower positive HVAC interactive impact resulted in the lower realization rate when both MA and NH are considered together. The final error ratio of the current study (0.27) compares favorably to that of the last study (0.43).

[7] Final Report, New Hampshire Small Business Energy Solutions Program Impact and Process, KEMA, Inc. June 27, 2012

Table 8: Gross Annual Savings Adjustment Comparison to 2012 Results

Savings Parameter	Overall Energy		Current NH Only		2012 (Lighting)	
	kWh	% Gross	kWh	% Gross	kWh	% Gross
Tracking Savings	73,919,272	N/A	13,375,212	N/A	7,984,270	N/A
Documentation Adjustment	-2,647,026	-3.6%	-278	0.0%	-423,670	-5.3%
Technology Adjustment	-399,326	-0.5%	-15,519	-0.1%	-20,207	-0.3%
Quantity Adjustment	-1,012,629	-1.4%	-253,194	-1.9%	-5,702	-0.1%
Operational Adjustment	-2,234,104	-3.0%	640,890	4.8%	-118,580	-1.5%
HVAC Interactive Adjustment	801,526	1.1%	515,344	3.9%	321,521	4.0%
Evaluated Gross Savings	68,427,714	92.6%	14,262,456	106.6%	7,737,632	96.9%
Gross Realization Rate	92.6%	N/A	106.6%	N/A	96.9%	N/A
Relative Precision at 90% Confidence Interval	N/A	±4.9%	N/A	±8.9%	N/A	±11.7%
Error Ratio	N/A	0.27	N/A	0.30	N/A	0.43

4.2 Gross Summer Peak kW Savings Results

Figure 5 presents a scatter plot of evaluated gross summer peak kW savings vs. tracking gross summer peak kW savings. Although several of the sample points from the largest projects (rightmost) had much higher evaluated summer peak savings than claimed, the lower than claimed savings from smaller projects (points below the one-to-one dashed reference line) resulted in a realization rate of 88.3% ±6.8% at the 80% confidence interval. Figure 6 presents the same scatterplot for New Hampshire only at a larger scale. Many of the New Hampshire sites experienced lower evaluated gross savings than was estimated in tracking.

Figure 5: Overall Scatter Plot of Gross Summer Peak kW Savings

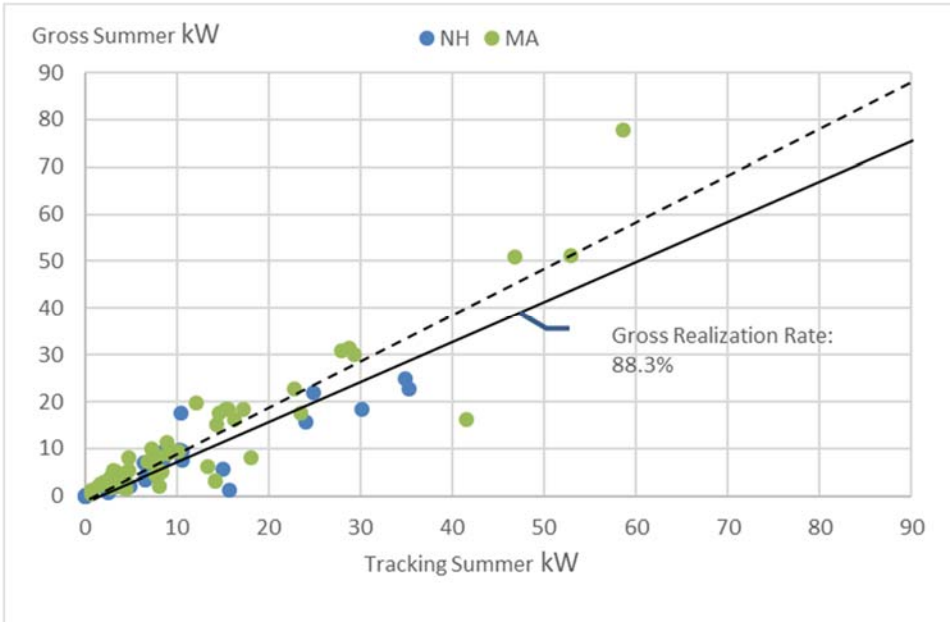


Figure 6: NH Scatter Plot of Gross Summer Peak kW Savings

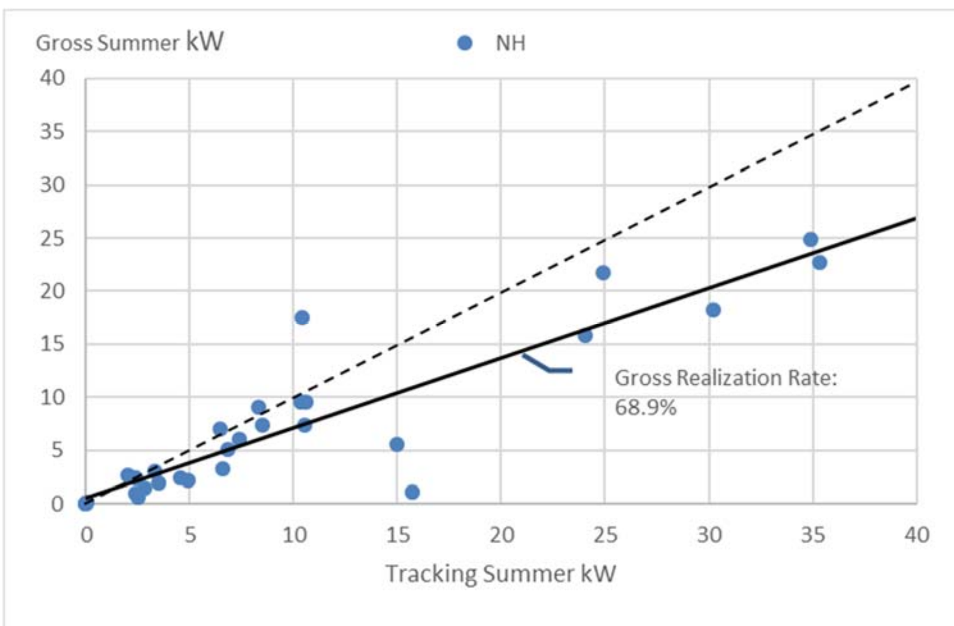


Table 9 presents results related to summer peak impacts overall and by state. Overall, the summer kW realization rate is 88.3% with a precision of ±6.7% at the 80% confidence interval, though the state level rates are substantially different from one another at 98% for MA and 69% for NH. The NH realization rate is lower due to the evaluated coincident factor of 40.5% being lower than the assumed value of 84.8% in the tracking system savings estimate. Note that in the previous small business study performed in 2012[8] the

[8] Ibid, p6

small business lighting coincident factor was determined to be 63.2% (±8.6% at the 90%) or roughly half way between the evaluated NH number and that assumed in the tracking estimates. In the New Hampshire Large C&I study completed in 2015, the lighting summer coincident factor was observed to be 60.2%[9].

The HVAC interactive factor reflects changes in savings due to interaction between the lighting and HVAC systems among the sampled lighting sites. Overall, this study experienced an increase of 12.9% in peak demand savings due to interaction with the cooling system.

Table 9: Summer Peak Results

Savings Parameter	Overall		MA		NH	
	Value	Precision at 80% Confidence	Value	Precision at 80% Confidence	Value	Precision at 80% Confidence
Tracking Savings	13,907	N/A	10,950	N/A	2,957	N/A
Peak kW Realization Rate	88.3%	±6.7%	98.2%	±7.3%	68.9%	±11.7%
Evaluated Savings	12,283	±6.7%	10,756	±7.3%	2,038	±11.7%
Coincident Factor	55.6%	±6.8%	64.0%	±6.7%	40.5%	±13.8%
HVAC Interactive Factor	112.9%	±2.1%	112.6%	±2.6%	113.5%	±3.1%

One possible driver of the low observed coincident factor for New Hampshire (40.5%) is the presence of municipal sites among the sample. To examine this issue, we separated the New Hampshire sample by municipal versus small business participants. The summer coincident factor between them was not substantially different at 36% and 42% for municipal and small business, respectively.

Another possible driver could be the presence of exterior lighting in the New Hampshire sample. To explore this possibility, we removed the exterior fixtures from the New Hampshire analysis and calculated the coincident factor of only the interior fixtures. Unfortunately, we are unable to do this analysis for the full sample as we do not have this information for the MA sample. The coincident factor of New Hampshire only interior lighting is 50.4%, with a precision of ±11.2%. This value is substantially higher than the aggregate New Hampshire estimate of 40.5%.

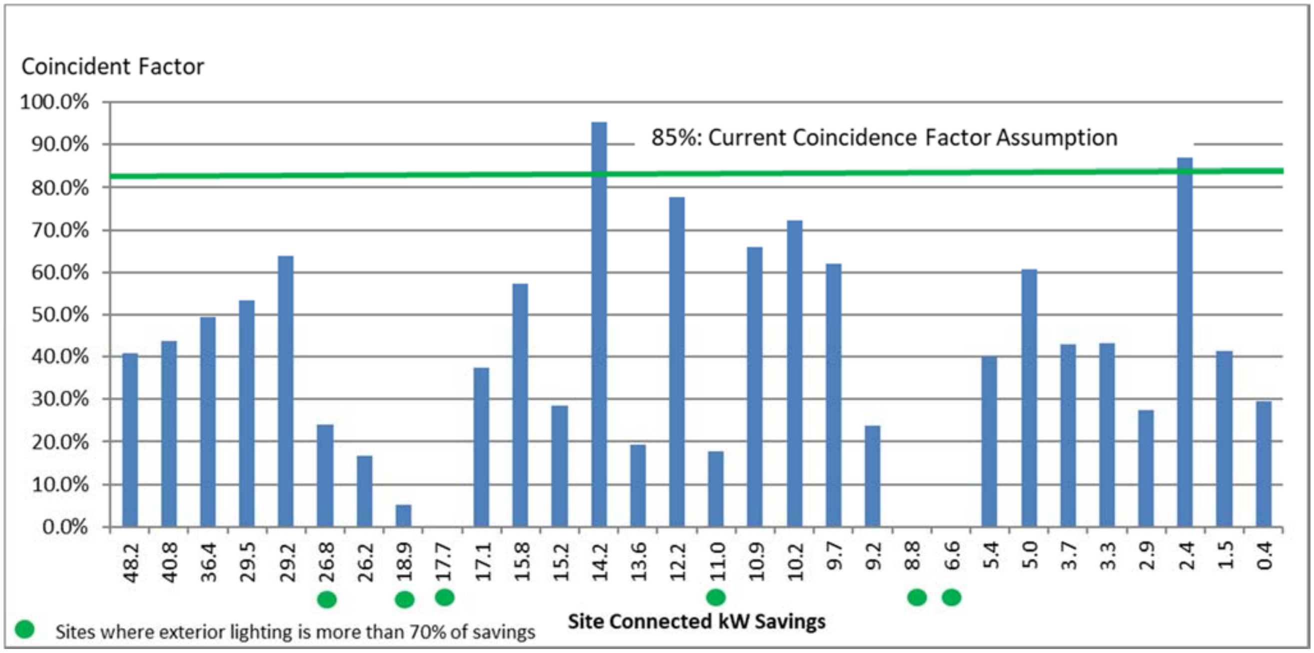
In the absence of municipal sites driving a low coincidence factor and understanding the influence of exterior lighting, we graphed the site level coincident factors for the full New Hampshire sample to see if there was a pattern that might present further context around this result. Figure 7 presents the connected kW savings for each site in the NH sample and their summer coincident factor. The current assumed summer coincident factor for New Hampshire is shown as the green horizontal line (84.8%). Connected demand savings for each site are on the X-axis moving from largest (leftmost) to smallest (rightmost). The Y-axis shows the coincident factor for each site.

Sites where at least 70% of their savings are from exterior lights are flagged with green circles. Not including these predominately exterior sites, 10 of the 30 New Hampshire sample points have a coincident factor of 30% or less and among the ten sites with the largest connected demand savings, only two exceed

[9] http://www.puc.state.nh.us/electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

50%. These ten largest sites include a high school, two transportation businesses, two assembly buildings, three small retail establishments, and a small office.

Figure 7: Summer Coincident Factor versus Connected kW – NH Sites



4.3 Gross Winter Peak kW Savings Results

Figure 8 presents a scatter plot of evaluation gross winter peak kW savings vs. tracking gross winter peak kW savings. It is apparent that many of the sample points fall above the one-to-one reference line, including several medium and large sites. This increase in savings observed in the sample drives a realization rate of 111.3% with precision of ±8.6% at the 80% confidence interval. The precision around the winter results are slightly poorer than its summer counterpart due to more variability between the tracked and evaluated savings among the sample.

Figure 8: Scatter Plot of Gross Winter Peak kW Savings

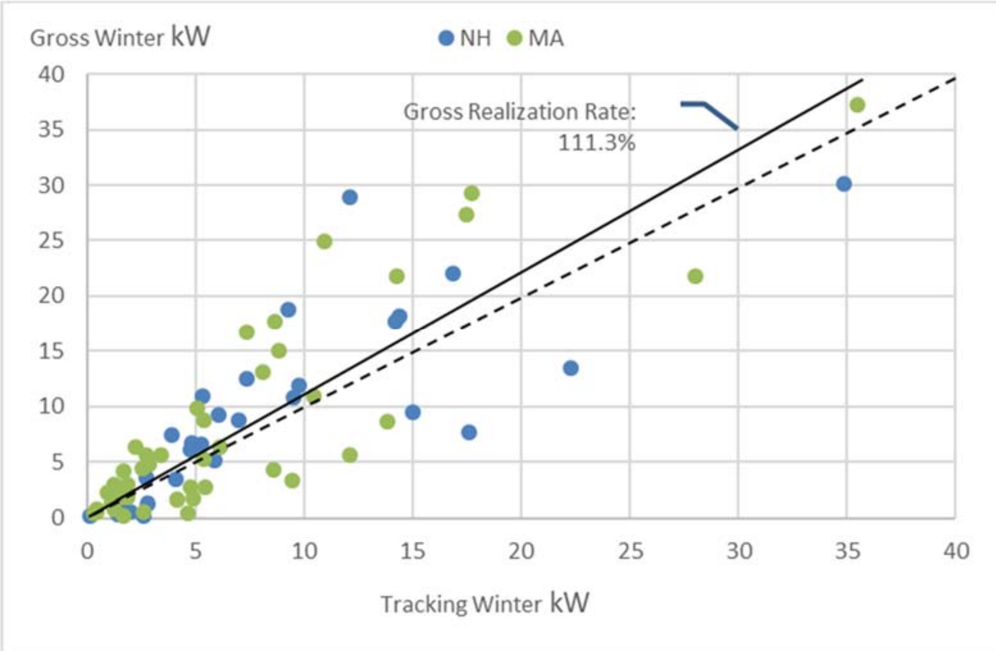


Table 10 presents results related to winter peak impacts overall and by state. Overall, the winter kW realization rate is 111.3% with a precision of ±8.6% at the 80% confidence interval, with state level results that are around 100% for New Hampshire and 117% for Massachusetts. The NH winter kW realization rate is near 100% due to the evaluated coincident factor of 54.0% being slightly higher than the 48.4% assumed in the tracking system savings estimate. When we remove exterior lighting from the coincident factor, the interior only lighting factor becomes 38.9% with a precision of ±18.7% at the 80% confidence interval. Note that in the previous small business study[10] performed in 2012 the small business lighting coincident factor was determined to be 46.7% (±10.5% at the 90%). The current Massachusetts TRM winter coincidence factor assumption is 44% (which appears to include exterior lighting). There is no HVAC interactive factor for the winter peak due to the absence of electric heating in treated spaces.

Table 10: Winter Peak Results

Savings Parameter	Overall		MA		NH	
	Value	Precision at 80% Confidence	Value	Precision at 80% Confidence	Value	Precision at 80% Confidence
Tracking Savings	8,498	N/A	6,576	N/A	1,921	N/A
Peak kW Realization Rate	111.3%	±8.6%	116.9%	±11.3%	102.8%	±12.7%
Evaluated Savings	9,455	±8.6%	7,686	±11.3%	1,974	±12.7%
Coincidence Factor	54.0%	±8.9%	53.9%	±11.4%	54.0%	±14.4%
HVAC Interactive Factor	98.0%	±2.3%	96.9%	±3.5%	100.0%	±0.0%

10 Ibid, p6

5 CONCLUSIONS AND RECOMMENDATIONS

Below we provide conclusions and recommendations from this study. It is clear that small business and municipal program installed lighting measures are producing substantial savings and that the tracking system used to capture those savings is reasonably accurate for energy and winter peak savings but overestimate summer peak savings. When we look at the results based on the full sample we estimate gross savings of 68,428 MWh based on a 92.6% realization rate with a precision of ±4.9% at the 90% confidence interval. The New Hampshire sample on its own produces a gross savings estimate of 14,262 MWh (106.6% realization rate) with a precision of better than ±9% at the 90% confidence interval. Although this study was designed to improve precision by combining a sample of Unitil's and Eversource's Massachusetts small businesses with that of a sample for all New Hampshire electric utilities, the precision and error ratio from the NH sample provides a statistically sound estimate of impacts that exceeds the customary desired precision of better than ±10%.

Below we provide conclusions and recommendations regarding the use of savings parameters from this study. Our understanding is that the New Hampshire PAs apply realization rates to tracking savings prospectively as a way to revise savings estimates that are based upon dated parameters. Accompanying that approach is a desire among the PAs to incorporate more current savings parameters into the tracking savings calculation to better reflect actual savings going forward. It is important to execute the updating of savings factors and the application of a realization rate carefully to ensure that they complement, and not amplify, one another. For example, if the PAs decide to incorporate interactive factors into their energy savings estimates, they would want to remove this impact from any prospectively applied realization rate. Ideally, the development of the planned TRM savings lifecycle marginalizes the need for the application of prospective realization rates over time.

Conclusion and Recommendation #1

Conclusion: At the overall level, we calculated an energy savings realization rate of 92.6% with a precision of ±4.9% at 90% confidence interval. In New Hampshire alone we calculated a realization rate of 106.6% with a precision of ±8.9% at 90% confidence interval.

Recommendation: There are advantages and disadvantages to using the overall energy realization rate versus the New Hampshire results from this study. The overall realization rate has very good precision at ±4.9% but includes a documentation adjustment from the Massachusetts sample that reflects revisions made to adhere to TRM assumptions (New Hampshire does not have a TRM to guide savings calculations). The overall realization rate also includes interactive impacts from the Massachusetts sample where it is taken as part of the tracking estimate whereas the New Hampshire tracking estimate did not include interactive effects. These differences lead us to recommend that the PAs use the New Hampshire realization rate of 106.6% for reported energy savings.

Conclusion and Recommendation #2

Conclusion: Overall, the summer peak kW realization rate is 88.3% with a precision of ±6.7% at the 80% confidence interval. The New Hampshire summer peak realization rate is 68.9% with a precision of ±11.7% at the 80% confidence interval. The summer on-peak coincident factors associated with these results are 55.6% overall (±6.8% at the 80% confidence interval) and 40.5% for New Hampshire (±13.8% at the 80% confidence interval). The cause of the lower coincident factor for New Hampshire appears to be due in part to the effect of exterior lighting in the sample but also due to generally lower lighting operation during peak periods among most of the sample. When we remove exterior lighting and isolate interior lighting in the New Hampshire sample, the summer coincident factor is 50.4% with a precision of ±11.2%. The current assumed summer coincident factor for NH C&I lighting is 84.80%.

<u>Recommendation:</u> We recommend the New Hampshire utilities have clearly designated interior and exterior summer coincident factors. Currently, New Hampshire has a C&I parking lot lighting category that uses exterior coincidence factors and a C&I lighting category coincident factor assumption that is understood to represent a blend of interior and exterior lighting. We recommend that the summer coincident factor for interior lighting be 50.4%, with a precision of ±11.2%. We recommend that the summer coincident factor for exterior lighting be 0%, which is the same as that currently assumed for parking lot lights and consistent with findings from the 2015 Large C&I study.

Conclusion and Recommendation #3

<u>Conclusion:</u> Overall, the winter peak kW realization rate is 111.3% with a precision of ±8.6% at the 80% confidence interval. The New Hampshire winter peak realization rate is 102.8% with a precision of ±12.7% at the 80% confidence interval. The winter on-peak coincident factors associated with these results are the same at 54.0% with precisions of ±8.9% around the overall coincident factor and ±14.4% for the New Hampshire estimate. When we remove exterior lighting from the winter coincident factor, the interior lighting only factor becomes 38.9% with a precision of ±18.2% at the 80% confidence interval. The current assumed winter coincident factor for NH C&I lighting is 48.4%.

<u>Recommendation:</u> We recommend the New Hampshire utilities have clearly designated interior and exterior winter coincident factors. As stated in the previous recommendation, New Hampshire currently has a C&I parking lot lighting category that uses exterior coincidence factors and a C&I lighting category coincident factor assumption that is understood to represent a blend of interior and exterior lighting. We recommend that the winter coincident factor for interior lighting be 38.9%, with a precision of ±18.7%. We recommend that the winter coincident factor for exterior lighting be 100%, which is consistent with exterior lighting operating on photocell hours and consistent with findings from the 2015 Large C&I study.

Conclusion and Recommendation #4

<u>Conclusion:</u> New Hampshire will soon be developing a TRM to guide the calculation of tracking savings from C&I lighting (and other measures) statewide. This study has produced several lighting factors that can be incorporated into the TRM when developed. The typical TRM energy and peak demand savings calculations are presented below and show how the various factors are combined.

$$\text{kWh Savings} = \left[\sum_{b=1}^{n}\left(\frac{QTY_b \times Watts_b}{1{,}000}\right)_{Base} - \sum_{i=1}^{n}\left(\frac{QTY_i \times Watts_i}{1{,}000}\right)_{Installed}\right] X\ Hours\ X\ Interactive\ Factor$$

$$\text{SkW Savings} = \left[\sum_{b=1}^{n}\left(\frac{QTY_b \times Watts_b}{1{,}000}\right)_{Base} - \sum_{i=1}^{n}\left(\frac{QTY_i \times Watts_i}{1{,}000}\right)_{Installed}\right] X\ Summer\ Coincident\ Factor \times Interactive\ Factor$$

$$\text{WkW Savings} = \left[\sum_{b=1}^{n}\left(\frac{QTY_b \times Watts_b}{1{,}000}\right)_{Base} - \sum_{i=1}^{n}\left(\frac{QTY_i \times Watts_i}{1{,}000}\right)_{Installed}\right] X\ Winter\ Coincident\ Factor \times Interactive\ Factor$$

<u>Recommendation:</u> If New Hampshire decides to include an interactive factor in their calculation of energy or peak savings, we recommend using those provided in this report. Specifically, we recommend using a factor of 103.9% for energy interactive and 113.5% for summer peak interactive. We do not recommend the use of a winter peak interactive due to its marginal presence.

APPENDIX A: SITE LEVEL DISCEPANCIES AND RESULTS

Facility Type	Annual kWh						Discrepancy
	TRACKING kWh	Adjustment - Documentation Change	Adjustment - Technology Change	Adjustment - Quantity Change	Adjustment - Operation Change	Adjustment - Cooling Interaction	
Education-College/Second	38,373	38,373	38,373	38,373	37,843	37,843	Evaluation Hours of use are 1% lower than assumed in the tracking system.
Manufacturing-Light Indus	73,741	73,741	73,741	73,741	62,876	63,766	Fixture evaluation hours are 5% lower than in tracking Interactive effects increased savings by 1%. Reduction in operating hours from controls is 74% lower than assumed in the tracking system.
Retail-Small	28,859	28,855	28,855	28,855	28,539	28,539	Evaluation Hours of use are 1% lower than assumed in the tracking system.
Retail-Small	17,077	17,061	17,061	17,061	18,784	20,724	Evaluation hours are 10% higher than in tracking. Interactive effects increased savings by 11%.
Assembly	57,054	57,054	57,054	57,648	67,578	71,121	One more 60W LED was found than reported in tracking. Evaluation hours are 17% higher than in tracking Interactive effects increased savings by an additional 6%.
Manufacturing-Light Indus	8,745	8,745	8,745	8,745	7,925	7,925	Evaluation hours are 9% lower than in tracking.
Office-Small	18,818	18,818	18,818	18,818	16,282	16,282	Evaluation hours are 13% lower than in tracking.
Office-Small	8,037	8,040	7,640	7,172	5,306	5,908	Changes in installed technlogy caused a 5% decrease in savings. Two fewer fixtures than in tracking system. Interactive effects increased savings by 7%.
Other	1,126	1,126	1,126	1,126	1,171	1,171	Fixture Hours 1% lower than in tracking. Reduction in control hours is 11% greater than in tracking.
Office-Small	2,078	2,066	2,066	2,066	5,155	5,664	The project file savings are 1% higher than reported in the tracking system. Evaluation hours more than double the tracking system assumption. Interactive effects increase savings by 24%.
Office-Small	70,670	70,670	70,670	70,670	106,882	109,924	Fixture evaluation hours are 37% higher than assumed in the tracking system. Fixture interactive effects increase savings by an addditional 4%. Evaluation reduction in hours from controls more than doubles the reduction in hours assumed in the tracking system. Interactive effects from controls increased savings by an additional 6%.
Retail-Small	51,935	51,936	51,936	51,936	59,440	66,909	Evaluation hours 14% higher than in tracking. Interactive effects increase savings by 14%.
Other	101,368	101,343	101,343	101,343	129,596	131,317	Fixture evaluation hours are 24% higher than assumed in the tracking system. Interactive effects increase savings by an additional 2%. Reduction in operating hours from controls are nearly twice as high as assumed in the tracking system.
Assembly	125,702	125,702	125,702	125,702	96,721	107,834	Evaluation hours are 23% lower than in tracking. Interactive effects increased savings by 9%.
Retail-Small	7,353	7,353	7,353	3,726	2,503	2,542	Eighteen fewer 9-watt LED fixtures were installed in the garage area than in tracking. Additionally, twelve fewer fixtures were found. This resulted in a 49% decrease in savings. Evaluation hours 17% lower than in tracking. Interactive effects increased savings by 1%.

Facility Type	Annual kWh						Discrepancy
	TRACKING kWh	Adjustment - Documentation Change	Adjustment - Technology Change	Adjustment - Quantity Change	Adjustment - Operation Change	Adjustment - Cooling Interaction	
Education-College/Second	238,087	238,086	238,086	238,086	218,537	235,365	Evaluation hours 8% lower than in tracking. Interactive effects increased savings by 7%.
Education-College/Second	36,570	36,601	36,601	36,601	51,244	56,773	Fixture evaluation hours are 49% higher than assumed in the tracking system. Interactive effects increase savings by an additional 16%. Reduction in hours from controls is 93% lower than assumed in the tracking system. Interactive effects for controls increase savings by 3%.
Retail-Single-Story, Large	60,043	60,043	60,043	57,065	54,458	55,741	Four fewer fixtures were found in the hallways than was reported in the tracking system; resulting in a 5% reduction in savings. Evaluation hours are 4% less than assumed in the tracking system. Interactive effects increase savings by 2%.
Other	45,956	45,956	45,956	45,956	42,556	42,556	Evaluation hours are 7% lower than assumed in the tracking system.
Other	136,095	136,095	136,095	129,425	193,269	193,269	Seven fixtures reported as installed in the bay and storage areas were not installed; resulting in a 5% decrease in savings. Evaluation hours are 47% higher than assumed in the tracking system.
Assembly	18,188	18,188	17,810	17,539	19,315	20,844	Eight fixtures not replaced caused 4% decrease in savings. Evaluation hours 9% higher than in tracking. Interactive effects increased savings by an additional 8%. Occupancy sensor-controlled wattage discrepancy caused a 4% decrease in savings. Evaluation reduction in hours from controls is 21% higher than assumed in tracking. Interactive effects increased savings by 11%.
Retail-Single-Story, Large	41,798	41,798	41,798	41,798	35,817	36,059	Evaluation hours 14% lower than tracking system. Interactive effects increase savings by 1%.
Retail-Small	110,164	110,164	110,164	110,091	127,300	135,133	Evaluation hours 16% higher than assumed in tracking. Interactive effects increased savings by 7%.
Retail-Small	83,701	83,681	83,681	83,681	85,558	86,126	Evaluation hours are 2% higher than tracking. Interactive increased savings by an additional 1%.
Retail-Small	11,240	11,247	11,247	11,247	8,440	8,833	Evaluation hours 25% lower than in tracking. Interactive effects increased savings by 3%.
Retail-Small	24,639	24,639	24,639	24,639	12,249	12,249	Fixture evaluation hours 50% lower than tracking. Reduction in controlled hours 50% lower than tracking.
Other	27,657	27,657	28,245	28,245	51,779	51,779	The wattages of the baseline fixtures was different than assumed in the tracking system; causing a 2% increase in savings. Evaluation hours are 85% higher than assumed in the tracking system.
Retail-Single-Story, Large	56,952	56,952	56,952	56,381	56,484	57,940	Eleven 18-watt LED fixtures were not found installed as was reported in the tracking system, which results in a 1% decrease in savings. Interactive effects increase savings by 3%.
Retail-Small	64,545	64,559	64,559	64,559	76,613	76,613	Evaluation Hours of use are 19% higher than assumed in the tracking system.
Other	110,350	110,351	110,351	110,351	88,424	88,792	Fixture evaluation hours 22% lower than tracking. Reduction in controlled hours 60% higher than tracking.

APPENDIX B: ON-SITE DATA COLLECTION INSTRUMENT

Site ID: ______________________________ Logger Install Date: ______________________________

Auditor: ______________________________ Logger Removal: Date: ______________________________

Area ID	Space Description	Detailed Space Description	Controls (Occupancy Sensors, Dimmers, etc)	Baseline Lighting Fixtures				Program Lighting Fixtures					Logger Installed		
				Qty	Product Type	Watts	Description (Length, lamps, ballast, etc)	Qty	Product Type	Model No.	Watts	Description (Length, lamps, ballast, etc)	Code	Logger ID	Notes
A1	*Office*	*Bldg 1, Flr 2, Office #732*	*OS*	*4*	*T8*		*2L 4' T8/EB HIGH LMN*		*T8-28*	*2F32SH*			*Log1*	*38655*	

(1) FUNCTIONAL AREAS

Major functional spaces with distinct schedules or HVAC systems.

Area ID	Space Description	% of Facility[11]	Lighting Schedule ID(s)	Cooling System ID	Heating System ID
A1		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A2		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A3		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A4		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A5		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A6		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A7		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A8		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A9		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A10		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A11		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4
A12		%	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 V H	0 1 2 3 4	0 1 2 3 4

Notes: ____

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[11] Estimated fraction of the total square footage of the facility

(2) OPERATING SCHEDULES

SCH ID	Days[12]	Operating Hours		Operating Season[13]		% Lit[14]
		Start Time	End Time	Start Date	End Date	
L1	ALWAYS ON	0:00	24:00	Jan 1	Dec 31	100%
L2		:	:			%
L3		:	:			%
L4		:	:			%
L5		:	:			%
L6		:	:			%
L7		:	:			%
L8		:	:			%
L9		:	:			%
L10		:	:			%
L11		:	:			%
L12		:	:			%
L13		:	:			%
L14		:	:			%
L15		:	:			%
L16		:	:			%
LV	Vacation/Shutdown	N/A	N/A			%
LH	Holidays	N/A	N/A	Days/year:		%

☐ *New Year's Day*
☐ *MLK Day*
☐ *Washington's Birthday*
☐ *Good Friday*
☐ *Memorial Day*
☐ *Independence Day*
☐ *Labor Day*
☐ *Columbus Day*
☐ *Veterans Day*
☐ *Thanksgiving Day*
☐ *Thanksgiving Friday*
☐ *Christmas*
☐ *Other*___________________
☐ *Other*___________________
☐ *Other*___________________

Notes: ____

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(3) IMPORTANT QUESTIONS

Schedule changes since installation?____

____

Seasonal variation in schedules?____

____

Occupancy/production/business variations? ____

____

Monitored month(s) typical? ____

____

[12] Categorize operation as appropriate for this business, e.g. Mon–Fri, Mon–Wed, Sat–Sun, holidays, etc.
[13] For use when schedules are different by season, month, or other time period
[14] Estimated diversity fraction of occupied space that is lit under this schedule

(4) INTERACTIVE COOLING SYSTEMS

ID	Description	Type	Fuel	Efficiency	Qty	Size (tons)	Age (yrs)
C1		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ _______________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ __________	_____kW/ton _____EER _____SEER			
Notes:							
C2		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ _______________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ __________	_____kW/ton _____EER _____SEER			
Notes:							
C3		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ _______________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ __________	_____kW/ton _____EER _____SEER			
Notes:							
C4		☐ Direct expansion ☐ Chilled water ☐ Heat pump – air / wtr / gnd ☐ _______________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ __________	_____kW/ton _____EER _____SEER			
Notes:							

Notes: ____

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(5) INTERACTIVE HEATING SYSTEMS

ID	Description	Type	Fuel	Efficiency	Qty	Size (Btuh)	Age (yrs)
H1		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / fnd ☐ ________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____% _____COP			
Notes:							
H2		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / gnd ☐ ________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____% _____COP			
Notes:							
H3		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / gnd ☐ ________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____% _____COP			
Notes:							
H4		☐ Hydronic ☐ Steam ☐ Direct fired ☐ Heat pump – air / wtr / gnd ☐ ________________________	☐ Electricity ☐ Natural gas ☐ LP gas ☐ #2 / #4 / #6 ☐ __________	_____% _____COP			
Notes:							

Notes:____

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.