Evaluating the Underserved Small C&I Market: Building a Bridge to Implementation

Thomas Ledyard, RLW Analytics, Inc, Middletown, CT
Susan Haselhorst, NSTAR Electric and Gas Corporation, Boston, MA

ABSTRACT

The Massachusetts electric utility distribution companies have been leaders in the delivery of successful energy-efficiency programs for many years. A recent decision to continue energy-efficiency charges beyond 2002 in Massachusetts has refocused efforts on providing efficiency services to Small Commercial and Industrial (Small C&I) customers. Coupled with recent characterizations of the Small C&I market in Massachusetts as not being profitable enough for competitive retail suppliers to provide the electricity commodity much less efficiency services, traditional programs are challenged with providing adequate opportunity and means of reducing energy usage to this overlooked market segment.

It has been hypothesized that the largest source of uncertainty in lighting retrofit measures is in hours of operation. Typically, estimates depend upon customer reported hours of operation. The primary purpose of the study was to determine the realization rate of the reported hours of operation for energy efficient lighting measures and to investigate the factors that influenced that realization rate. These results were used to provide evidence of program performance in filings with the Massachusetts Department of Telecommunications and Energy. In addition, the provision of lighting load shapes and analysis of customer reported hours compared to actual hours were undertaken to inform such implementation issues as diversity calculations, cost effectiveness, and accuracy of customer reported inputs to savings assessments.

This study examines how well lighting hours can be established using customer reported hours and whether that correlation is affected by building or space type. The study also compares two techniques for collecting hours: a holistic, top-down building approach compared with a detailed room-by-room, bottom-up approach.

Introduction

A recent decision to continue energy-efficiency charges beyond 2002 in the Commonwealth of Massachusetts has refocused efforts on providing efficiency services to Small C&I customers. Coupled with recent characterizations of the Small C&I Market in Massachusetts as not being profitable enough for competitive retail suppliers to provide the electricity commodity much less efficiency services, traditional programs are challenged with providing adequate opportunity and means of reducing energy usage to this overlooked market segment. As part of its overall Small C&I evaluation strategy, NSTAR has charged evaluators with providing defensible estimates of program savings and realization rates for state filing purposes in addition to providing information to assist implementers in generating better estimates of program energy savings as part of its tracking system. This paper focuses on the evaluation of this Small C&I Program; with the target market, data analysis and use of results making this study a unique example of bridging the gap between evaluation and implementation.

The Small Commercial & Industrial Retrofit Program (Small C&I Program) has been offered by NSTAR since mid-1999. This program targets discretionary retrofit opportunities among existing customers with an average peak demand of 100 kW a month or less. Lighting measures represent over 80% of the program's installed measures, with refrigerator measures representing most of the balance of

program savings. Typical lighting measures in the program include T8 lights with electronic or low power ballasts, compact fluorescent lamps, and LED exit signs. The program is designed to provide a turnkey installation of measures, i.e., it provides all aspects of the lighting installation for the customer; from the initial marketing and ensuing audit process through the final equipment installation. The Small C&I Retrofit Program provides financial incentives between 80% and 100% of the installed costs associated with any cost-effective efficiency opportunities identified. This program is administered through five primary contractors. In 2000 and 2001, the program served 2,722 customers and saved approximately 43,898 MWh of electrical energy.

The primary purpose of the study was to determine the realization rate of the reported hours of operation recorded in the tracking database for lighting energy efficient measures and to investigate the factors which influenced that realization rate, including technology changes and quantity changes. In addition, the provision of lighting load shapes and analysis of customer reported hours compared to actual hours were undertaken as part of this study.

Background. This paper summarizes the results of activities completed by RLW Analytics, Inc. between March and September 2002 to determine the hours of use for lighting measures installed in 2000 and 2001 as part of the NSTAR Small C&I Retrofit Program. This study rested upon the performance of such analytical techniques as the Engineered Calibration Approach (ECA), statistical sample selection, ratio estimation and expansion of results, a correlation analysis of reported, observed and tracked hours of operation, and an aggregate load shape analysis of lighting operating hours by building type. A total of 60 on-sites were performed to support this study, with 355 loggers installed and analyzed.

The primary goal of this study was to determine the realization rate of the hours of operation recorded in the tracking database for lighting energy efficient measures and to investigate the factors which influenced that realization rate. Other site derived estimates were computed, including measure persistence, lighting summer and winter diversity factors, program level net and gross savings, and measures of customer satisfaction. Other analysis performed on the data included the provision of lighting load shapes. In addition, an analysis of customer reported hours compared to actual hours were undertaken to inform such implementation issues as diversity calculations, cost effectiveness, how well lighting hours can be established using customer reported hours, and whether that correlation is affected by building or space type.

Scope. The key research questions sought by NSTAR as part of this study included the following: What is the short-term persistence associated with lighting installed in Small C&I facilities, including specific attrition rates for technology changes, quantity changes, and hour changes? How capable are Small C&I customers to estimate the operating use of their lighting and how does this influence the implementation of the program?

These results are being used to inform such implementation issues as diversity calculations, cost effectiveness, and accuracy of customer reported inputs to savings assessments. Contractors for the program estimate savings and determine measure cost effectiveness through the use of customer provided operating hours and other equipment use factors. Due to contractor dependence on these estimates of operating hours, making an assessment of the accuracy of customer reported hours was of particular importance to program implementers. The study results also included the profiling of lighting operation to inform summer and winter diversity as well as weekend and weekday operations.

Methodology

The primary data collection activities for all tasks included on-site monitoring and surveys with program participants. These activities are further discussed below.

- **Sampling** was performed on a program population of 2,065 participating accounts with lighting installed in the Small C&I Program in 2000 or 2001. The statistically selected sample was designed in consideration of historical error ratios of similar program studies, and was optimized through the designation of five strata with completion quotas in each. The five strata were based on the kWh savings of each account, and were designed to maximize the target precision for the sixty sample points. The final sample design was comprised of 60 sample points, which targeted a precision of ±10% at a 90% level of confidence.

- **On-site monitoring** was performed at 60 sites with representation from 2000 and 2001 program participants as well as each service territory of NSTAR. Where possible, a minimum of five lighting loggers were installed at each site for a four week monitoring period to gather information on the operating hours of the lighting energy conservation measures (ECMs) installed through the program. A total of 355 loggers were installed as part of this evaluation.

- **Participant surveys** were performed with the decision-maker at 57 of the sites that were visited to further inform the determination of hours of operation and to assess levels of measure persistence that may affect the overall program impact. Other information on the program was also gathered, including satisfaction, business demographics, and reasons for participation.

As discussed above, there were two primary data collection activities that were completed for the Small C&I Retrofit Program study. They were on-site monitoring and the participant decision-maker surveys. The following figure presents a flow chart of the elements and lag times associated with the on-site work, although it is by no means exhaustive of all components performed on-site. Following this figure, additional information on the logger protocols incorporated in the study and the analysis of the data is presented.

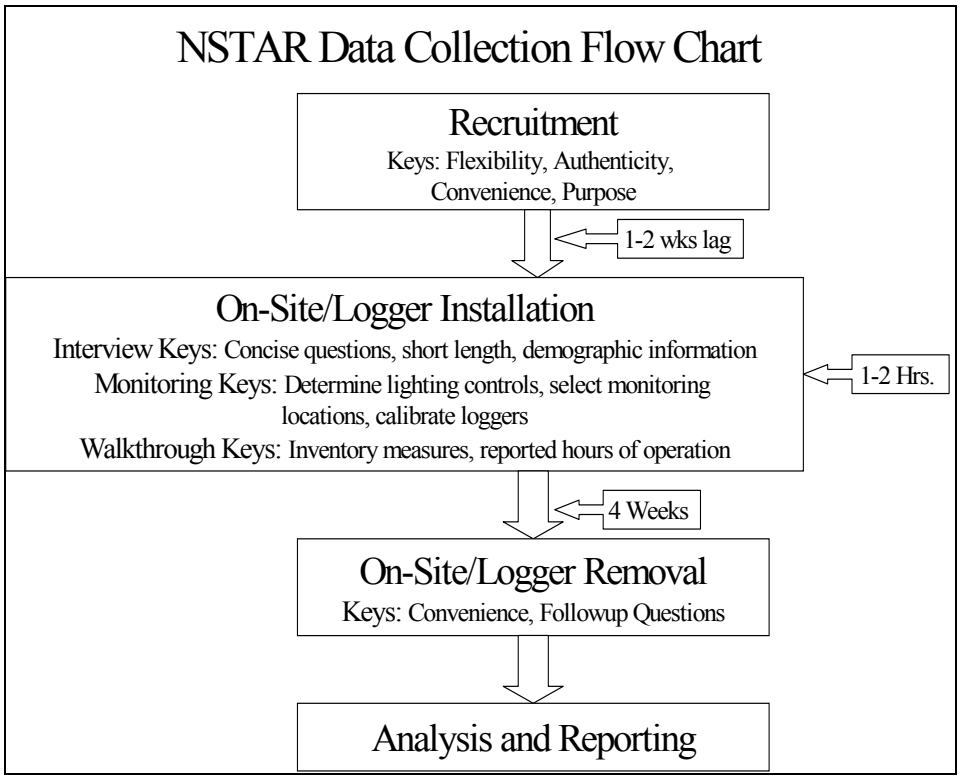

Figure 1. Data Collection Flow Chart

One of the key elements of the on-site activities was to determine lighting logger placement. To do this, an RLW on-site auditor began by interviewing the appropriate facility representatives on typical hours of use for room type. The interviewing process allowed the auditor to form an informal baseline of operating hours. While there were no steadfast rules governed this process, the auditor considered several things when determining logger placement. Considerations in the placement of loggers included, but were not limited to:

- How the fixtures were controlled. For instance, if the lighting was all on one circuit that was controlled by a breaker, placement of the monitoring device was not as crucial as compared to when the lighting was spread out and had many control configurations.
- Where the greatest amount of lighting energy was used. For instance, if the auditor determined that 60% of the lighting energy at a site is located in open office areas, this area would receive logger priority.
- Where the lighting was located. For instance, if there were 50 private offices that had been retrofit, the auditor would ensure that 2-3 loggers were installed to capture representative hours for the private offices at the site.
- The knowledge of the site contact. For instance, if the site contact reported that the Gym lights in a school were controlled by a special key only the janitor had and the janitor turned them on first thing in the morning at 7am and shut them off at 10pm after basketball practice, then this location was typically not logged in lieu of a location with less predictable hours of operation.

Excel was used for data entry and analysis of all information gathered during the evaluation. The spreadsheet tool was comprehensive and complex in its calculation of all of the information required for the analysis. It should be noted that the lighting logger data were collected in spring and summer

months (May through August), which sometimes resulted in seasonal adjustments for the development of the required variables; in particular for those lights identified as daylight sensitive. Where the lights were determined to be daylight sensitive, the analysis assumed that seasonal daylighting effects required adjustments to lighting profiles for lights used in the morning and evening hours.

There were three factors that were calculated from the primary analysis of the on-site data. They were persistence due to quantity changes since installation, persistence due to any noted changes in installed technology from the original installed technology, and hours of use. The engineering estimation of persistence was calculated on a line-by-line basis by using the original project savings estimates and assumptions as compared to the on-site observed quantities, technologies, and hours. The analysis utilized NSTAR's Rated Lighting System Wattages. Coincident demand savings was calculated by weighting the logger reported diversity for each location by the demand savings. Other analyses performed included the aggregation of all lighting loggers to determine a single logger profile of hours of operation, a correlation analysis to determine the reliability of self reported operating hours as compared to actual monitored hours, in addition to correlation analysis to determine for which building and space types self reported hours tend to be most accurate. A meeting between the evaluation team and NSTAR implementation staff was held at the conclusion of the project to relate and discuss results of the analysis and how they could be used to improve the performance of program implementation.

Results

The figure below presents a scatter plot of the on-site sample gross savings estimates after adjusting for all impacts to the tracking system estimates. A one-to-one reference line is the plotted line on the diagonal, which would represent the line on which all points would fall if the tracking system savings estimates were correct. There is a reasonable correlation between the tracking system and gross savings estimates, but not a strong one. Overall, 20 of the sample points were determined to have gross savings greater than their tracking system counterparts.

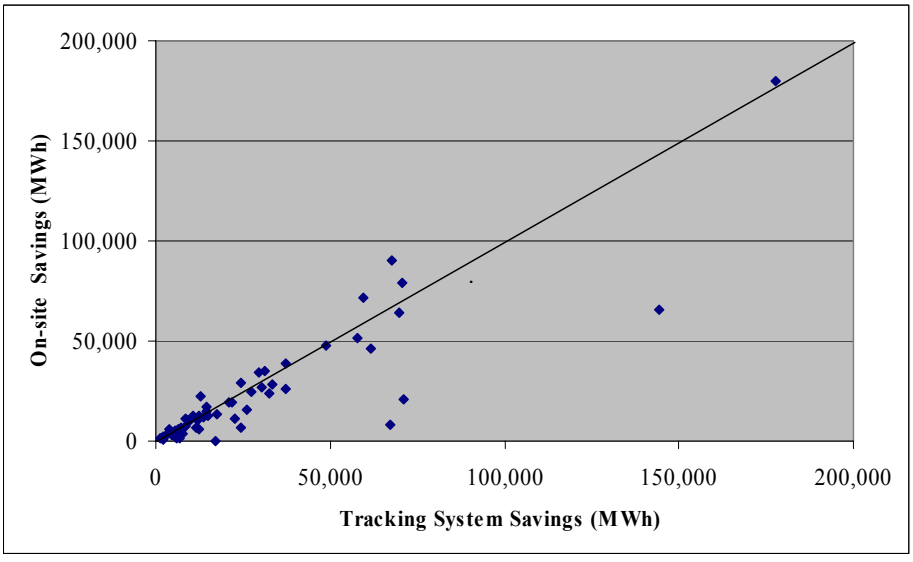

Figure 2. Observed On-site Savings Versus Contractor Estimated Savings

The on-site savings illustrated above resulted in an NSTAR level gross realization rate of 83%, with a precision estimate of ±10.2%. The gross realization rate was driven primarily by changes in

operating hours and measure removal, which caused decreases in savings of 4.2% and 12.4%, respectively. The final net realization rate was determined to be 76.8%, driven primarily by a free ridership rate of 8.6%. The total calculated gross savings associated with the program across years was 29.4 MWh. The net savings was determined to be 27.1 MWh. It is interesting to note the drop in gross realization rates between years from 92% in 2000 to 77% in 2001. In looking over the five sites with the largest drop among the 2001 sample, it was noted that all five fell into the two largest strata. In reviewing the analysis of these five sites, two were directly impacted by vacancies in treated spaces, and three had overestimates of hours in the tracking system. In fact, one site that had a tracking system estimate of 5,000 hours for the entire facility and was ultimately found to have a weighted hour average of 305 hours when informed by the installation of 9 loggers.

Table 1. NSTAR System Small C&I Lighting Savings

	Total MWh	Precision of Total	Year		Precision of Year 00/01	Notes
			2000	2001		
Engineering Estimated MWh	35,338	N/A	17,647	17,691	N/A	From Tracking System
Technology Realization Rate	99.9%	± 2.1	99.8%	101.4%	±2.3% / 3.8%	
Quantity Realization Rate	95.7%	± 3.5	90.1%	99.8%	±6.0% / 3.7%	
Hours of Use Realization Rate	83.3%	± 10.2	91.7%	77.1%	± 9.1% / 17.9%	
Gross MWh Savings	29,423		16,183	13,643		
Spillover Net to Gross Ratio.	0.8%	± 0.6%	0.8%	0.8%	± 0.6%	2001 study @ 90% Conf.
Free rider Net to Gross Ratio	8.6%	± 2.5%	8.6%	8.6%	± 2.5%	2001 study @ 90% Conf.
Net MWh Savings	27,134		14,924	12,582		

As part of the analysis of gross savings, we calculated the demand savings associated with the lighting measures in the sample. In addition, we calculated summer (10:30 AM – 4:30 PM) and winter (4:30 PM – 7:30 PM) coincident savings associated with the visited sites. Unfortunately, neither demand savings nor coincident savings were available for the full population, so RLW estimated these savings for the program through ratio estimation with the kWh savings. Through this process, we estimated the total program kW savings across years to be approximately 8,653 kW. The precision associated with this estimate was ±7%. The summer and winter diversity savings were calculated to be approximately 5,976 kW and 3,660 kW, respectively. The diversity factors from these estimates were calculated to be 69% for summer and 42% for winter.

The table below presents an unweighted average of the logger results. In other words, we averaged the tracking system reported hours and the actual logged hours for all of the fixtures monitored in the on-site sample. In this analysis, the assumed operating hours for the lighting was overstated by 16%. However, it is important to note that simply reviewing averages can be misleading. To further review the data, we calculated the correlation coefficient between the tracking hours and logged hours. The correlation coefficient measures the strength of linear association between two variables. The correlation between the estimated hours and the actual hours was determined to be 0.37.

In interpreting a correlation coefficient, it is important to note that a perfect linear association occurs when the points on a scatter plot form a straight line (i.e., when the estimated tracking system hours and the measure hours are identical). This correlation is calculated be a '1'. In reflecting upon the poor correlation, the on-site monitoring process may have biased the results. Specifically, the logger protocol encouraged the logging of areas that represented the most savings, but secondarily sought to log areas with unpredictable hours. These locations include rest rooms, closets, storage areas, and maintenance areas. These areas tended to have hours overstated in the tracking system, which is not unusual. It is also important to note that early in the program, some contractors had a propensity to group fixtures in the analysis of tracking savings with a single set of hours despite their diverse locations at the participants site. This also will cause large variations in estimated to actual hours when those

diverse locations are logged and are determined to have different operating patterns and hours than the assumed hours.

Table 2. Tracking Versus Logger Operating Hour Comparison

Total Loggers	# of Sites	Avg Trkg Hours	Avg. Log Hours	Percent Difference	Correlation
358	59	3,411	2,850	-16%	0.37

The results presented above show an approximate 16% difference in operating hours between the original tracking reported estimates and the logged hours. However, there are many factors that may be impacting these changes, particularly changes in the use of the fixtures over time. To assess the ability of the contractor to accurately estimate the hours of operation at the time of installation, RLW asked the site contact about the current operating hours of lighting locations that were logged. A comparison of these results illustrates the ability of the site contact to accurately report the current hours of operation of the lighting installed in their facility.

For 236 of the loggers installed, RLW was able to gather current site contact reported hours of operation from which the two can be compared. Those loggers without current reported hours were typically due to site contacts that were not available to provide them for all logger locations. In an analysis of the average current reported hours and logged hours, the current reported hours were 8% less than the actual logged hours, with a correlation factor of 0.9. This suggests that approximately 8% (the difference between 16% and 8%) of the change in operating hours between the tracking system and the actual logged hours was a function of hour changes that occurred after the installation of the lighting. Anecdotally, it was reported that several sites were commercial buildings where one or more tenants that had treated spaces were no longer in business. This impact from the economy may be causing at least some of this observed change in operating hours.

Table 3. Reported Versus Logger Operating Hour Comparison

Total Loggers	Avg. Reported Hours	Avg. Log Hours	Percent Difference	Correlation
236	3,100	2,850	-8.1%	0.9

The next table shows the accuracy of current reported hours by location. We have only presented those locations with at least 7 loggers of data, although all space types with logger data were provided as part of an appendix to the final report. Overall, the areas noted in the table were accurately reported. The three areas with the poorest correlations between the customer reported hours of operation and the logger hours of operation are been placed in bold lettering at the bottom of the table. In reviewing these three areas they appear to be locations that would be most prone to individual lighting behaviors, making them hard to predict. Areas in which current reported hours appear to be accurate predictors of actual hours include open offices, hallways, and sales floors.

Table 4. Hours by Space Type

Lighting Location	Total Loggers	Avg Rptd Hours	Avg. Log Hours	Percent Difference	Correlation
Hallway	10	4,899	4,270	-12.8%	0.99
Storage Room	8	1,093	1,202	10.0%	0.98
Sales Floor	18	3,371	3,428	1.7%	0.97
Kitchen	9	2,485	2,725	9.7%	0.91
Work Room	7	3,476	3,238	-6.9%	0.91
Open Office	27	3,189	3,178	-0.4%	0.89
Product Storage	19	3,079	3,107	0.9%	0.87
Showroom	10	2,416	2,557	5.8%	0.87
Individual Office	**26**	**2,388**	**2,213**	**-7.3%**	**0.78**
Classroom	**9**	**2,143**	**1,586**	**-26.0%**	**0.61**
Restroom	**13**	**2,498**	**2,452**	**-1.8%**	**0.59**

Table 5 shows analogous results for business type. Those business types that appear most difficult to predict hours for include schools, apartment buildings, and municipal buildings.

Table 5. Hours by Building Type

Business Type	Total Loggers	Avg Rptd Hours	Avg. Log Hours	Percent Difference	Correlation
Hardware Store	12	2,582	2,633	2.0%	1.00
Manufacturing/Retail	25	3,095	3,008	-2.8%	0.99
Public Library	12	1,834	2,075	13.2%	0.97
Post Office	13	3,885	3,739	-3.8%	0.96
Retail Store	20	3,706	3,553	-4.1%	0.94
Furniture/Appliance Store	10	2,257	2,091	-7.4%	0.92
Wholesale/Distribution	22	2,653	2,352	-11.3%	0.89
Restaurant	10	3,336	3,614	8.4%	0.89
Office Building	28	4,096	3,652	-10.8%	0.79
Apartment Building	**10**	**6,344**	**5,447**	**-14.1%**	**0.77**
Dept Of Public Works	**6**	**2,106**	**2,936**	**39.4%**	**0.74**
Tire Store	**6**	**2,730**	**2,012**	**-26.3%**	**0.60**
School	**14**	**2,467**	**2,144**	**-13.1%**	**0.43**

In exploring the data further, RLW categorized the sites in the sample by those that over-generalized hour estimates in the tracking and those that provided detailed estimates by location. In other words, if a contractor installed 100 fixtures and provided a single operating hour estimate for all fixtures, we considered that site to have hours that were overgeneralized. If another contractor installed 100 lights, but broke the lights down into locations with specific hour estimates, we considered that site to have hours that were detailed. Table 6 below provides an analysis of the difference between reported and logged hours for these two groups of sites. As is clear, for sites that had overgeneralized lighting hours of operation, the estimates between the tracking hours and the logged hours were 14% off, as compared to sites with detailed hours of operation which were only 6% off. The correlation was also noted to be much better for those sites with detailed hours than sites with hours that were overgeneralized. A similar analysis was performed by contractor and by NSTAR service territory to assess the correlation between these variables and the accuracy of estimated hours, which provided vendor specific targets for implementation improvements.

Table 6. Detailed versus Overgeneralized Hour Estimates

Hour Estimates Category	Total Loggers	Avg Rptd Hours	Avg. Log Hours	Percent Difference	Correlation
Overgeneralized hour estimates	64	2,768	2,380	-14.0%	0.09
Detailed hour estimates	172	3,224	3,023	-6.2%	0.50

To support the determination of system summer and winter diversity factors for the Small C&I Retrofit Program, all loggers deployed as part of the study were aggregated to generate a single program level profile. Figure 3 presents this profile. In addition to this program level profile, business type profiles were generated to assist implementers in understanding the lighting use at different facility types.

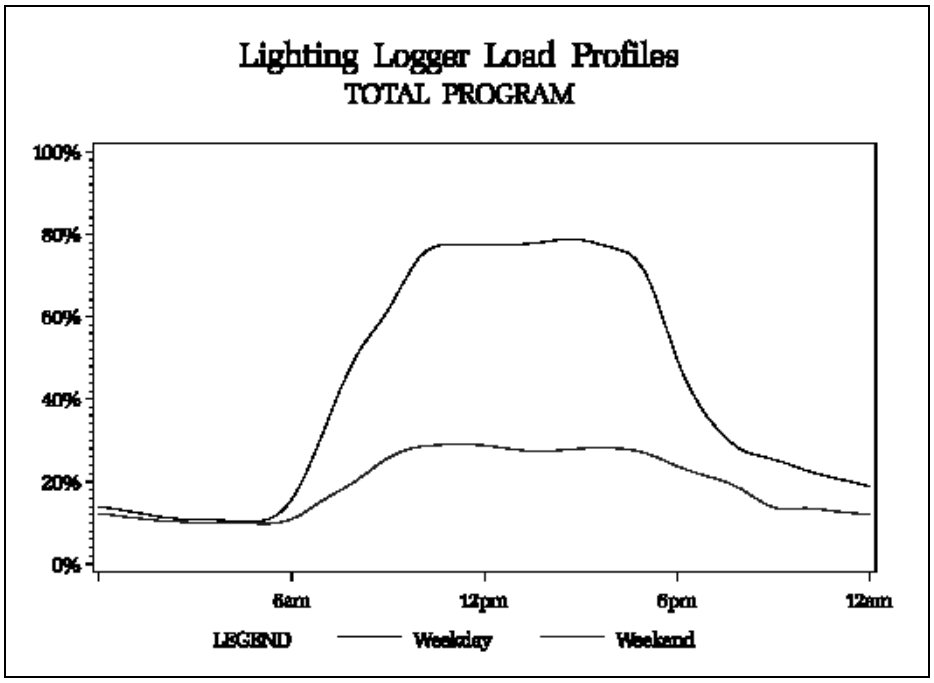

Figure 3. Program Level Lighting Profile

Conclusions

This evaluation was concurrent with ongoing program implementation and refinement; therefore, these recommendations may have already been underway or completed by NSTAR before this study's publication. Overall, the Small C&I program appeared to offer a value-added service to customers while also meeting state mandates and NSTAR energy conservation initiatives. To further refine the program, RLW offered the following conclusions and recommendations for consideration by program implementers:

The cause of the 83% lighting measure gross realization rate was primarily due to changes in operating hours and secondarily to measure removal. In fact, 12% of the decrease in savings was due to changes in operating hours and 5% was due to the removal of lighting since installation. While the noted change in operating hours represents only a relatively moderate decrease, the implication of this finding is that to improve estimated program savings, the target of improvements should be in the estimation of operating hours. The provision of logger informed hours of operation by building and

space type was provided to NSTAR as an appendix to the report as a means of improving the estimate of savings in implementation. While caution would need to be used in the application of hours informed by few loggers (the number of loggers used for each estimate were included in the table), it was anticipated that this data would be useful for contractors as estimates in lieu of more reliable sources, and can be expected to help the estimate of energy savings.

It was noted in performing the file reviews for this evaluation that some contractors tended to utilize a single set of hours for all installed lighting at a site in the tracking system savings estimate (overgeneralized hours). This practice did not allow for the calculation of tracking savings from unique hours estimated for each lighting location within a site. In a comparison of the actual operating hours to estimated hours for over generalized versus detailed estimates, it was noted that the estimates between the tracking hours and the logged hours at sites with overgeneralized hours were 14% off, as compared to sites with detailed hours of operation which were only 6% off. The correlation was also noted to be much better for those sites with detailed hours than sites with hours that were overgeneralized. To improve implementation, contractors should establish operating hours for each unique room type at each site visited, as this will result in a more accurate estimate of energy savings.

As the most difficult areas for customers to estimate hours for appear to be spaces most prone to individual usage patterns, these areas should be focused on in implementation. Spaces noted in this study to be particularly difficult to estimate include private offices and classrooms. When installation of lighting occurs in a facility with areas controlled by individuals, the collection of hours of operation should include the input of as many users as possible. Similarly, schools, apartment buildings, and municipal buildings were noted to be facility types most prone to mis-estimation of operating hours, suggesting that close attention should be given to collecting hours of operation at these facilities.

Customers generally tend to provide hours of operation that are higher than the actual hours. Indeed, customer estimates of hours of operation average over 8% more than the actual hours of operation. The implication of this finding is that implementation staff should use lower estimates of hours when customers provide a range of hours.

Figure 4 provides an overall summary of the ‘bridge’ of information between the evaluation of the Small C&I Retrofit Program and the implementation of the program.

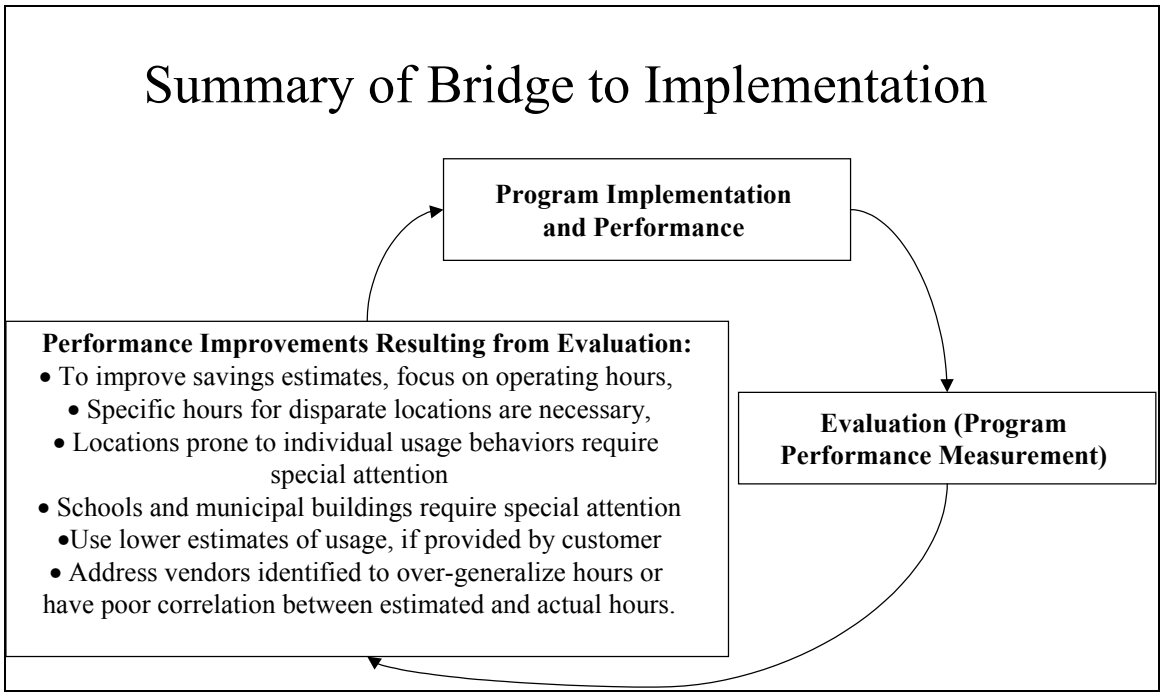

Figure 4. Summary of Bridge to Implementation

Acknowledgements

The authors wish to thank all of the people at NSTAR Electric and the Massachusetts Collaborative who took the time to support and help with this study. Regrettably, we cannot thank everyone individually, but we do want to acknowledge the contributions made by Lisa Shea, Ed McGlynn, Augustine Pimentel and Ralph Prahl. The data, insight, and support provided by these individuals helped to establish the foundation for the original study and subsequently this IEPEC submission.