THE CADMUS GROUP, INC.

Connecticut Small Business Energy Advantage Impact Evaluation Report Program Year 2007

Prepared for:
Connecticut Energy Conservation Management Board
The Connecticut Light & Power Company
The United Illuminating Company

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Prepared by:
M. Sami Khawaja
Lauren Mattison
The Cadmus Group, Inc.

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Executive Summary

This document presents the results of the 2007 impact evaluation of the Connecticut Small Business Energy Advantage Program (SBEA). The evaluation was conducted by The Cadmus Group, Inc. between August 2008 and June 2009.

SBEA Program Overview

SBEA is one of the Conservation & Load Management (C&LM) programs funded by The Connecticut Energy Efficiency Fund and offered by The Connecticut Light & Power Company (CL&P) and The United Illuminating Company (UI) to promote cost-effective energy efficiency retrofits. The direct install program is administered through several prime contractors who act as the single point of contact for customers. The Connecticut Energy Conservation Management Board (ECMB), which comprises representatives from the utilities, environmental organizations and the state attorney general's office, oversees C&LM programs and evaluations.

In 2007, 1,752 SBEA projects were completed, as detailed in Table ES.1. Installed measures included lighting upgrades, lighting controls, refrigeration upgrades, and one air compressor upgrade.[1]

	Number of Projects	Gross Energy Savings (MWh)	Gross Demand Savings (kW)	Incentive
CL&P	1,397	34,871	10,144	$8,597,071
UI	355	7,644	2,439	$1,021,674
Total	1,752	42,515	12,583	$9,618,745

Table ES.1. SBEA 2007 Program Summary

Evaluation Objectives and Methodology

Evaluations of the CL&M programs are conducted periodically to provide information on the attainment of C&LM objectives, to provide feedback to improve the programs, and to support the needs of regulatory authorities. The primary objectives of this evaluation are to determine adjusted gross energy and demand realization rates based on several adjustment factors.

Cadmus conducted verification and data collection visits to a statistically selected sample of 121 SBEA participants from the 2007 program year. The 121 sites represented 126 projects,[2] including 20 of the 40 projects with the highest annual energy savings. Of the 126 projects, 94 were for CL&P

[1] Due to the sample size of one, the air compressor evaluation results are not statistically significant but could be helpful in refining the procedure for analysis of future compressed air measures.

[2] Some customer sites had multiple SBEA projects completed in 2007.

customers and 32 for UI. The distribution of sites in the sample among the utilities is close to the proportion of the state represented by each utility: 78 percent CL&P and 22 percent UI.[3]

Field staff verified installed equipment and measured quantities, installed lighting loggers to measure operating hours, and other meters to measure runtime and energy use for refrigeration equipment and the air compressor. An average of three meters was used for each facility.

Using the data collected during site visits, Cadmus conducted engineering analyses, calculated kWh and kW savings, and compared them to the savings values reported by SBEA contractors to determine savings adjustment factors and realization rates. The results were then extrapolated to all projects to determine the total savings realized by SBEA projects in 2007.

Overview of Results

Connecticut Light & Power

The CL&P results for each major measure type are summarized in Tables ES.2 and ES.3.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects	4,335 MWh	202 MWh	88.2 MWh	38.2 MWh
Total Adjustment[4]	*+18.1%*	*-1.54%*	*+6.82%*	*-85.0%*
Adjusted Annual Savings for Sampled Projects	5,119 MWh	199 MWh	94.2 MWh	5.70 MWh
Number of Measures in Sample	2,040	313	31	1
2007 Total Annual Estimated Savings	31,023 MWh	1,565 MWh	2,172 MWh	38.2 MWh
2007 Total Adjusted Annual Savings	36,628 MWh	1,541 MWh	2,321 MWh	5.70 MWh

Table ES.2. Connecticut Light & Power SBEA Energy Savings

[3] Due to this distribution, the final results are statistically valid at 80 percent confidence with CL&P precision of 5.80 percent for energy savings and 7.35 percent for demand and UI precision of 12.35 percent for energy savings and 18.34 percent for demand.

[4] Total adjustment to revised lighting estimate excluding heating and cooling: -2.27%.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects				
- Winter	940 kW	0.505 kW	7.31 kW	8.6 kW
- Summer	1,142 kW	0.614 kW	8.88 kW	
Total Adjustment				
- Winter	*-24.5%*	*0%*	*-79.1%*	*-4.65%*
- Summer	*+11.1%*		*-82.8%*	
Adjusted Demand Savings for Sampled Projects[5]				
- Winter	710 kW	0.505 kW	1.53 kW	8.2 kW
- Summer	1,268 kW	0.614 kW		
Number of Measures in Sample	2,040	313	31	1
2007 Total Estimated Demand Savings				
- Winter	6,875 kW	4.92 kW	187 kW	8.6 kW
- Summer	8,349 kW	5.98 kW	228 kW	
2007 Total Adjusted Demand Savings				
- Winter	5,193 kW	4.92 kW	39.2 kW	8.2 kW
- Summer	9,272 kW	5.98 kW		

Table ES.3. Connecticut Light & Power SBEA Demand Savings

United Illuminating

The UI results for each major measure type are summarized in Tables ES.4 and ES.5.

	Lighting Equipment	Lighting Controls	Refrigeration
Tracking Estimate for Sampled Projects	1,241 MWh	155 MWh	135 MWh
Total Adjustment[6]	*+24.8%*	*-0.797%*	*+5.13%*
Adjusted Annual Savings for Sampled Projects	1,550 MWh	153 MWh	142 MWh
Number of Measures in Sample	556	423	22
2007 Total Annual Estimated Savings	5,975 MWh	744 MWh	839 MWh
2007 Total Adjusted Annual Savings	7,460 MWh	738 MWh	882 MWh

Table ES.4. United Illuminating SBEA Energy Savings

[5] Total adjustment to revised summer lighting estimate excluding heating and cooling: -19.0%.

[6] Total adjustment to revised lighting estimate excluding heating and cooling: +3.97%.

	Lighting Equipment	Lighting Controls	Refrigeration
Tracking Estimate for Sampled Projects	377 kW	62.2 kW	26.4 kW
Total Adjustment[7]			
- Winter	*-54.5%*	*-1.03%*	*-93.9%*
- Summer	*-3.54%*		
Adjusted Demand Savings for Sampled Projects			
- Winter	171 kW	61.6 kW	1.6 kW
- Summer	364 kW		
Number of Measures in Sample	556	423	22
2007 Total Estimated Demand Savings	1,972 kW	326 kW	131 kW
2007 Total Adjusted Demand Savings			
- Winter	897 kW	322 kW	7.99 kW
- Summer	1,902 kW		

Table ES.5. United Illuminating SBEA Demand Savings

Statewide Results

The combined CL&P and UI results for each major measure type are summarized in Tables ES.6 and ES.7.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects	5,577 MWh	356 MWh	223 MWh	38.2 MWh
Total Adjustment[8]	*+19.6%*	*-1.10%*	*+5.80%*	*-85.0%*
Adjusted Annual Savings for Sampled Projects	6,668 MWh	352 MWh	236 MWh	5.70 MWh
Number of Measures in Sample	2,596	736	53	1
2007 Total Annual Estimated Savings	37,114 MWh	2,194 MWh	3,012 MWh	38.2 MWh
2007 Total Adjusted Annual Savings	44,225 MWh	2,166 MWh	3,203 MWh	5.70 MWh

Table ES.6. Summary of SBEA 2007 Energy Savings

[7] Total adjustment to revised summer lighting estimate excluding heating and cooling: -34.0%.

[8] Total adjustment to revised lighting estimate excluding heating and cooling: -0.882%.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects				
- Winter	1,317 kW	62.7 kW	33.7 kW	8.6 kW
- Summer	1,518 kW	62.9 kW	35.3 kW	
Total Adjustment[9]				
- Winter	*-33.1%*	*-1.03%*	*-90.7%*	*-4.65%*
- Summer	*+7.44%*	*-1.02%*	*-91.1%*	
Adjusted Demand Savings for Sampled Projects				
- Winter	881 kW	62.1 kW	3.14 kW	8.2 kW
- Summer	1,631 kW	62.2 kW		
Number of Measures in Sample	2,596	736	53	1
2007 Total Estimated Demand Savings				
- Winter	8,847 kW	331 kW	319 kW	8.6 kW
- Summer	10,321 kW	332 kW	359 kW	
2007 Total Adjusted Demand Savings				
- Winter	6,090 kW	327 kW	47.2 kW	8.2 kW
- Summer	11,175 kW	328 kW		

Table ES.7. Summary of SBEA 2007 Demand Savings

Confidence and Precision

Table ES.8 displays our achieved precision levels at the 80-percent level of confidence. The table displays the average savings, standard error (SE) and precision for each utility and overall.

	CL&P		UI		Overall	
	Energy	Demand	Energy	Demand	Energy	Demand
Average	49,959	15	48,137	12	52,447	13
Adjusted SE	2,260	0.84	4,637	1.8	4,170	1.0
Precision	5.80%	7.39%	12.35%	18.34%	10.80%	9.00%

Table ES.8. Project Savings with Precision and Confidence Levels

[9] Total adjustment to revised summer lighting estimate excluding heating and cooling: -22.7%. No heating and cooling adjustment for winter.

Environmental Impact

The estimated emissions reductions from the program are shown in Table ES.9.

	Carbon Dioxide (CO_2) reduction (tons)	Nitrogen Oxide (NO_x) reduction (tons)	Sulfur Dioxide (SO_2) reduction (tons)
CL&P	18,800	17.5	47.8
UI	4,200	3.92	10.7
Total	23,000	21.4	58.5

Table ES.9. Annual Emissions Reduction Benefits of 2007 SBEA Program

Recommendations

In the evaluation process, Cadmus identified six areas in which the SBEA program could improve program procedures to better estimate savings:

- CL&P and UI have separate data management systems, which do not collect all of the same data. We recommend that each utility collect the same data.
- The program savings document (PSD) did not include several measures implemented in 2007, though most of these measure types were added to the PSD for 2008. We recommend continuing efforts to keep the PSD updated as the program evolves and new measure types are added.
- We recommend that savings calculations be made according to the formulas provided in the PSD, especially for new measures such as refrigeration upgrades. For example, the PSD states that there are no demand savings for central controls on vending machines, but for most instances of this measure demand savings were claimed in the project data.
- Door heaters typically need to operate more frequently in colder temperatures, but the 2007 PSD provides the same formula for freezers and coolers alike. We recommend that different default values for coolers and freezers be added to the PSD to improve the accuracy of savings calculations.
- Operational factors such as the demand profile for compressed air can be difficult to determine but are essential in calculating energy savings. We recommend metering selected measures, particularly air compressors, before project implementation to improve the accuracy of energy savings predictions.
- In addition to the inspections that are currently conducted after installation, we recommend additional education and follow-up for refrigeration measures to help ensure that equipment is operating properly in the longer term.

1. Introduction

1.1 Program Overview

The Small Business Energy Advantage Program (SBEA) is offered by The Connecticut Light & Power Company (CL&P) and The United Illuminating Company (UI) to promote cost-effective energy efficiency retrofits. Eligible measures include lighting upgrades and controls, air conditioning equipment tune-ups and automated controls for refrigeration equipment.

The SBEA is a direct install program, administered through several prime contractors who act as the single point of contact for customers. Contractor responsibilities include marketing, collecting information on existing equipment, identifying efficiency opportunities, analyzing energy savings potential, making recommendations to customers, obtaining customer agreement to proceed with installations, preparing and submitting completed customer rebate applications, installing eligible measures and disposing of removed equipment.

SBEA is one of the Conservation & Load Management (C&LM) programs funded by a conservation charge on Connecticut customers' electric bills. The goals of the C&LM programs are to advance the efficient use of energy, reduce air pollution and negative environmental impacts, and promote economic development and energy security in Connecticut. The Connecticut Energy Conservation Management Board (ECMB), which comprises representatives from the utilities, environmental organizations and the state attorney general's office, oversees C&LM programs and evaluations.

United Illuminating serves 17 towns and 314,000 customers in the greater New Haven and Bridgeport areas. Connecticut Light & Power serves more than 1.1 million customers throughout the state.

The SBEA program completed 1,752 projects in 2007, as detailed in Table 1.1. The majority of the installed measures were lighting upgrades; most of the other measures were lighting controls, refrigeration upgrades and one air compressor upgrade.

	Number of Projects	Gross Energy Savings (MWh)	Demand Savings (kW)	Incentive
CL&P	1,397	34,871	10,144	$8,597,071
UI	355	7,644	2,439	$1,021,674
Total	1,752	42,515	12,583	$9,618,745

Table 1.1. 2007 Program Summary

1.2 Objectives and Scope of Work

Evaluations of the CL&M programs are conducted periodically to provide information on the attainment of C&LM objectives, to provide feedback to improve the programs and to support the needs of regulatory authorities. UI, CL&P and the ECMB (referred to in this report as the sponsors) contracted with The Cadmus Group, Inc. to conduct an impact evaluation of the SBEA program for the year 2007.

The primary objectives of this evaluation are to determine adjusted gross energy and demand realization rates, derived from gross savings for major end-use categories based on the following adjustment factors:

- Controls adjustment.
- Documentation adjustment.
- Technology adjustment.
- Quantity adjustment.
- Operation adjustment.
- Heating and cooling adjustment.

2. Methodology

2.1 Evaluation Process

CL&P and UI provided Cadmus with spreadsheets containing project numbers, energy savings, and town. Using these data, Cadmus selected a statistically valid sample of SBEA participants. CL&P and UI reviewed the samples to ensure that the selected projects would appropriately represent each utility and the key measure types installed through the program. After reaching agreement on the sample selection, Cadmus obtained the full project data for each selected facility, including customer name, location, contact information, project completion date, measures installed, gross savings estimates, measure costs and incentives paid.

Cadmus worked with CL&P and UI to develop letters of introduction explaining the impact evaluation and site visits. Letters were mailed to the selected customers, followed by calls to schedule site visits.

Site visits were conducted from November 2008 to February 2009. On site visits, Cadmus staff members verified the type and quantity of equipment installed and deployed meters to verify operating hours or energy consumption of the new equipment. Metering equipment included HOBO U-12 light loggers, a laptop and data-transfer cable to download data logs from CoolTrol refrigeration controllers, and a Dent power meter for the air compressor. Meters were retrieved from each facility after approximately three weeks, noting any change in location from initial placement that might invalidate the meter data. The field staff members noted additional retrofit opportunities they observed and customer feedback on the equipment, contractors or program. Confidential customer-specific information will be provided in a separate memorandum to each utility.

Cadmus used these data to calculate energy and demand savings for selected projects. The results were compared to the savings reported by SBEA contractors to determine the adjustment factors and realization rates.

2.2 Statistical Sampling

Cadmus proposed a sample of 120 sites. Participants were sorted by the expected amount of savings impact. Of the 40 largest projects, 30 were randomly selected into the sample. The objective was to include a majority of the total savings from the program in our sample. The remaining sites were selected randomly. The RFP's original goal was to achieve 80 percent confidence and ±10 percent precision at the utility level.

The initial list had 155 projects, including backups. The final sample of 121 sites visited represented 126 projects (94 CL&P and 32 UI) because some customers had multiple projects. Twenty of the 40 largest projects completed in 2007, in terms of claimed energy savings, were included in the final sample. As agreed at the evaluation kickoff meeting, the distribution of sites

among the utilities was based on the proportion of the state represented by each utility: 78 percent CL&P and 22 percent UI. Each utility reviewed the composition of the sample for its service area.

As shown in Table 2.1 and Figure 2.1, the distribution of savings by measure type and utility is similar for the sample and the full program population.

		Number of Measures			Gross Energy Savings (MWh)		
		Lighting	Refrig.	Other	Lighting	Refrig.	Other
CL&P	Program Total	25,407	476	13	32,588	2,172	111
	Sample (% of program total)	2,353 (9.3%)	31 (6.5%)	7 (54%)	4,537 (14%)	88.2 (4%)	70.6 (64%)
UI	Program Total	6,355	177	5	6,719	839	86
	Sample (% of program total)	979 (15%)	22 (12%)	0	1,396 (21%)	135 (16%)	0
Total	Program Total	31,762	653	18	39,307	3,011	197
	Sample (% of program total)	3,332 (10%)	53 (8.1%)	7 (39%)	5,933 (15%)	223 (7%)	71 (36%)

Table 2.1. Comparison of Program Totals to Evaluation Sample

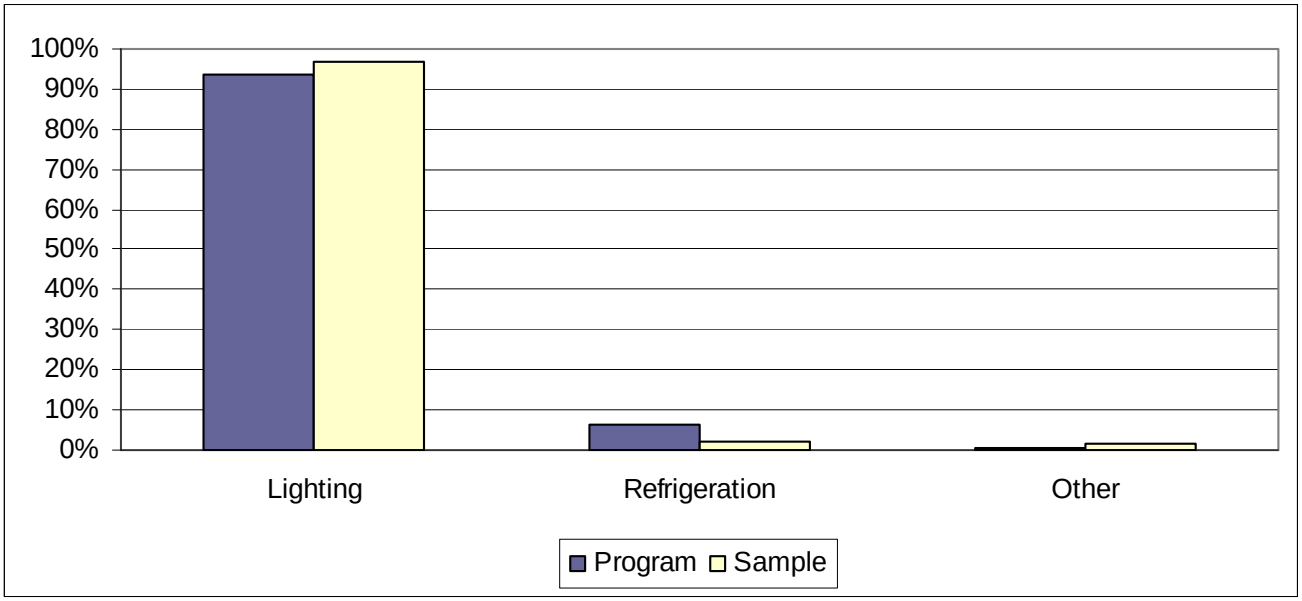

Figure 2.1. Comparison of Total Energy Savings to Sample by Measure Type

2.3 Adjustment Factors

The primary objectives of the evaluation were to determine adjusted gross energy and demand realization rates, derived from gross savings for major end use categories. The adjustment factors are

detailed in Table 2.2, as defined by the sponsors. Each factor was calculated independently and the adjusted gross estimates equal the sum of gross tracking estimates plus or minus each adjustment factor.

Adjustment	Definition
Controls Adjustment	The controls adjustment reflects the savings present in the gross tracking system estimate due to these controls. A subsequent revised tracking estimate excludes the controls from the gross tracking estimate.
Documentation Adjustment	The documentation adjustment reflects any change in savings due to discrepancies in project documentation. Evaluators should recalculate the tracking estimates of savings using all quantities, fixture types/wattages and hours documented in the project file. All tracking system discrepancies and documentation errors are reflected in this adjustment.
Technology Adjustment	The technology adjustment reflects the change in savings due to the identification of a different lighting technology (fixture type and wattage) at the site than represented in the tracking system estimate of savings.
Quantity Adjustment	The quantity adjustment reflects the change in savings due to the identification of a different quantity of lighting fixtures at the site than presented in the tracking system estimate of savings.
Operation Adjustment	The operation adjustment reflects the change in savings due to the observation or monitoring of different lighting operating hours lighting at the site than represented in the tracking system estimate of savings.
Heating and Cooling Adjustment	The heating adjustment and cooling adjustment reflect changes in savings due to interaction between the lighting and HVAC systems among the sampled sites. Generally, these impacts cause a heating penalty and a cooling credit. This adjustment reflects impacts from electric heating or cooling, not other fuels.

Table 2.2. Adjustment Factors

2.4 Measure Types and Savings Analysis Methodology

Energy and demand savings analyses were based on *UI and CL&P Program Savings Documentation for 2007 Program Year* (PSD). The measures are summarized below and detailed in Appendix 1.

- **Standard Lighting:** Replace inefficient lighting with efficient lighting. Wattages and operating hours are determined case by case or by using default hours in program documentation.
- **Evaporator Fans:** Add a control system to shut off evaporator fans in walk-in coolers and freezers when the cooler's thermostat is not calling for cooling. The baseline is continuous operation of the fans.
- **Door Heaters:** Add a control system to shut off electric door heaters in coolers and freezers when the facility's humidity is too low to allow condensation to occur on the doors. The baseline is continuous door heater operation.

- **Vending Machine Central Controls:** Install a central controller for vending machines. The baseline is usually continuous vending machine operation. There are no demand savings for this measure.
- **Custom:** Small business installations not covered by another specific measure. Energy and demand savings are calculated for each installation.

A measure also included in the program was air conditioning tune-up. Few HVAC measures were implemented in 2007, however, so air-conditioning tune-up was not included in this evaluation.

Below are new measures that were added to *UI and CL&P Program Savings Documentation for 2008 Program Year*, but were implemented several times in 2007. These measures were evaluated for this report based on the formulas provided in the 2008 program document.

- **Refrigerator LED:** Replace fluorescent lighting in commercial display refrigerators, coolers and freezers with LED systems.
- **Cooler Night Covers:** Install retractable covers in open refrigerated display cases to deploy when store is closed.
- **Evaporator Fan Motor Replacement:** Replace evaporator fan motors in walk-in or reach-in coolers and freezer with high-efficiency electrically commutated (EC) motors. Evaporator fans normally operate continuously.

The methodology for calculating energy savings for lighting upgrades was updated in 2008 to include the electricity savings from the reduced cooling load that comes with more efficient lighting, as detailed in Appendix 1. Because the heating and cooling adjustment is based on electric impact and electric heating is uncommon in commercial facilities in this region, Cadmus considered the heating impact negligible relative to cooling. The heating and cooling adjustments calculated in this evaluation are therefore based on the 2008 formulas for cooling savings.

2.5 Meter Data

Information was gathered from HOBO U-12 data loggers placed in over 300 locations. The meters provided time-series data of light intensity (in foot-candles) over time (in 10-minute intervals) during a 3-to-10-week period depending on the facility. A level above or equal to 1.8 foot-candles was used as a marker for the lights being on, with lower levels attributed to light from other sources such as hallway lighting. As expected, the time-series data revealed clearly defined on and off periods through distinct step function behavior as the loggers toggled between a very low light intensity when off (as low as 0.4 foot-candles) to very high light intensity when on (as high as almost 3,000 foot-candles). "On" light intensity levels varied depending on the placement and orientation of the logger. For each site, Cadmus determined the percentage of time on for weekdays, weekends and peak periods. For each measure, the percentage of time lights were on during weekdays and weekends was combined to determine the average operating hours per year, which was then used to determine the operation adjustment.

2.6 Demand Coincidence Factors

Coincidence factors for lighting measures were determined for the following peak demand savings periods:

- On-peak, as defined in the 2007 PSD, consists of the entire summer or winter peak period. On-peak hours are non-holiday weekday summer afternoons from 1 p.m. through 5 p.m. in June, July and August, and winter evenings from 5 p.m. through 7 p.m. in December, January and February.
- Seasonal peak, as defined in the 2008 PSD, consists of the highest demand hours in either summer or winter. Seasonal peak hours are those in which the hourly load is equal to or greater than 90 percent of the ISO New England (ISO-NE) 50/50 system peak forecast for the applicable season. The summer season is defined as non-holiday weekdays during the months of June, July and August. The winter season is defined as non-holiday weekdays during December and January. There are typically 25 to 75 such hours in a year.

On-Peak

Cadmus calculated the on-peak coincidence factors from the average percentage of time all metered lights were on from 1 p.m. to 5 p.m. for summer and 5 p.m. to 7 p.m. for winter. The evaluation site visits were conducted between November and February, so actual operation may vary throughout the year.

The 2007 PSD includes two types of coincidence factors for lighting demand savings, as detailed in Appendix 1 of this report. The factors referenced directly from the SBEA lighting section of the PSD are the C&I peak coincidence factors of 0.85 for summer and 0.70 for winter, which are based for summer on energy saved from 3 p.m. to 5 p.m. in June through August. In this evaluation, however, the sponsors directed Cadmus to base summer demand savings on the period of 1p.m. to 5 p.m. in June through August, which is defined in the PSD as the C&I ISO-NE coincidence factor. These coincidence factors are defined in the PSD as 0.68 for summer and 0.47 for winter. For both these types of demand, the winter peak period is defined as 5 p.m. to 7 p.m. from December through February.

Seasonal Peak

Cadmus calculated the seasonal peak coincidence factors based on meter data and the ISO-NE load data for 2007. According to ISO-NE, their 50/50 system peak forecasts for 2007 were 23,089 MW for winter and 27,378 MW for summer.[1] The 2007 hourly load data obtained from ISO-NE is

[1] ISO New England "2007-2016 Forecast Report of Capacity, Energy, Loads, and Transmission" Tables 1.1 and 1.2, http://www.iso-ne.com/trans/celt/report/2007/2007-celt_report.pdf

shown in Figure 2.2.[2] The pink lines indicate 90% of the seasonal 50/50 system peak forecast levels: 20,780 MW for winter and 24,640 MW for summer.

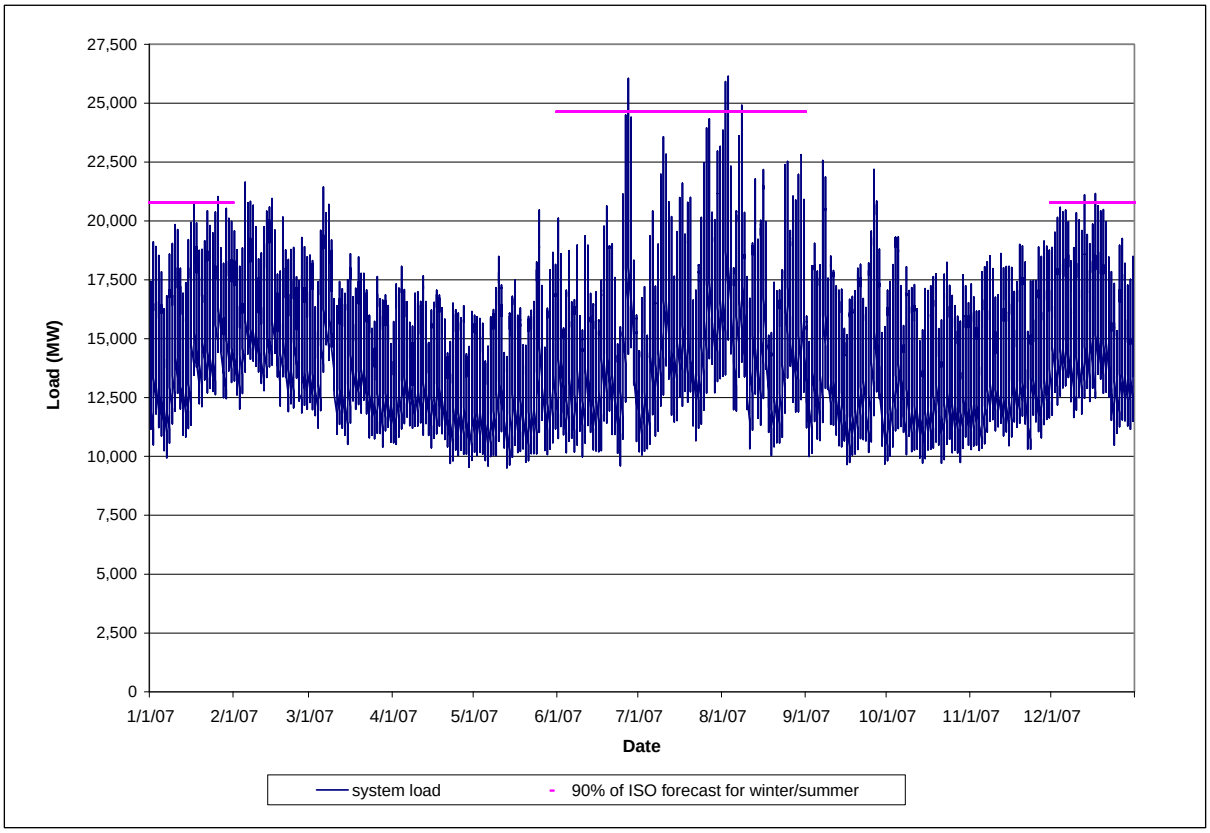

Figure 2.2. ISO New England System Load, 2007

As detailed in Tables 2.3 and 2.4, there were 5 hours during December and January and 23 hours between June and August when the load exceeded 90 percent of the forecast levels.

Date	Hour Ending	System Load (MW)
1/26/07	18:00	21,027
1/26/07	19:00	21,034
12/13/07	18:00	21,109
12/17/07	18:00	21,164
12/17/07	19:00	21,136

Table 2.3. ISO New England Winter Peak Occurrences in 2007

[2] ISO New England Historical Data http://www.iso-ne.com/markets/hstdata/znl_info/hourly/2007_smd_hourly.xls

Date	Hour Ending	System Load (MW)
6/27/07	12:00	24,845
6/27/07	13:00	25,432
6/27/07	14:00	25,854
6/27/07	15:00	26,055
6/27/07	16:00	25,947
6/27/07	17:00	25,634
6/27/07	18:00	25,082
8/2/07	14:00	25,252
8/2/07	15:00	25,664
8/2/07	16:00	25,882
8/2/07	17:00	25,914
8/2/07	18:00	25,685
8/2/07	19:00	24,961
8/3/07	12:00	24,887
8/3/07	13:00	25,480
8/3/07	14:00	25,960
8/3/07	15:00	26,145
8/3/07	16:00	26,102
8/3/07	17:00	25,927
8/3/07	18:00	25,366
8/8/07	16:00	24,673
8/8/07	17:00	24,910
8/8/07	18:00	24,809

Table 2.4. ISO New England Summer Peak Occurrences in 2007

This data was used to determine a frequency distribution for the time of day when demand met or exceeded 90 percent of the 50/50 system peak, as shown in Figure 2.3.

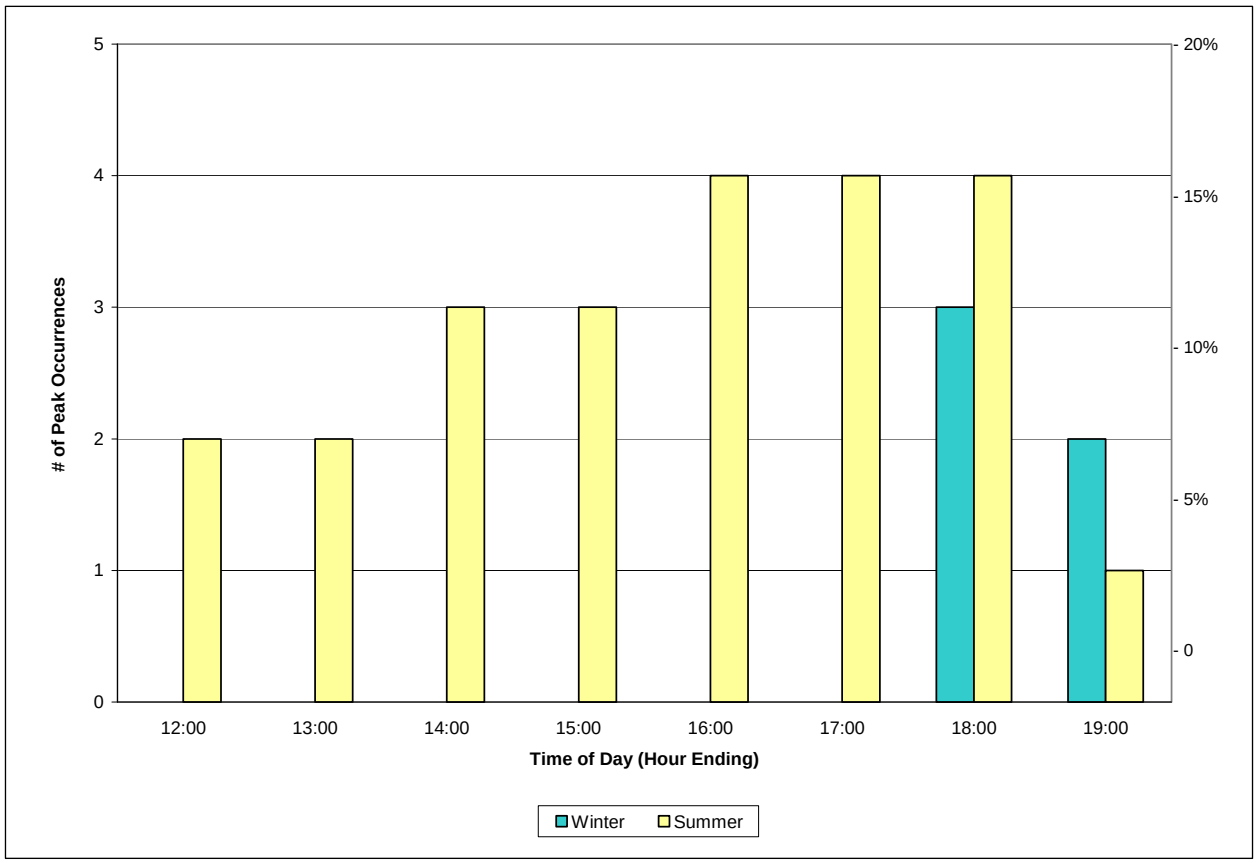

Figure 2.3. Time Distribution of System Peak Occurrences, 2007

From meter data, Cadmus determined the average percentage of lights on during each hour of the day in which any 2007 seasonal peak occurred. The seasonal peak coincidence factors were calculated from a weighted percentage of this meter data and the frequency of seasonal peak occurrence during each hour. These calculations are shown in Tables 2.5 and 2.6, and the results are further discussed in Section 3.1.

Hour Ending	Percentage Of Metered Lights On During Hour	Weighting Based On 2007 ISO Peak Data	Winter Seasonal Peak Coincidence Factor
18:00	40%	60%	36%
19:00	30%	40%	

Table 2.5. Calculation of Lighting Coincidence Factor for Winter Seasonal Peak

Hour Ending	Percentage Of Metered Lights On During Hour	Weighting Based On 2007 ISO Peak Data	Summer Seasonal Peak Coincidence Factor
12:00	82%	9%	65%
13:00	81%	9%	
14:00	80%	13%	
15:00	77%	13%	
16:00	71%	17%	
17:00	59%	17%	
18:00	40%	17%	
19:00	30%	4%	

Table 2.6. Calculation of Lighting Coincidence Factor for Summer Seasonal Peak

3. Results

3.1 Lighting Upgrades

New lighting equipment installed through the program included upgraded overhead and exterior lighting, LED lighting installed in cooler display cases to replace fluorescent lighting and upgrades to LED exit signs. The gross tracking savings estimate for lighting measures included in the evaluation site visits is 5,933 MWh.

Excluding lighting controls, the total revised tracking savings estimate for lighting equipment upgrades is 5,577 MWh. Figures 3.1 and 3.2 break down the revised tracking estimate by utility and lighting application.

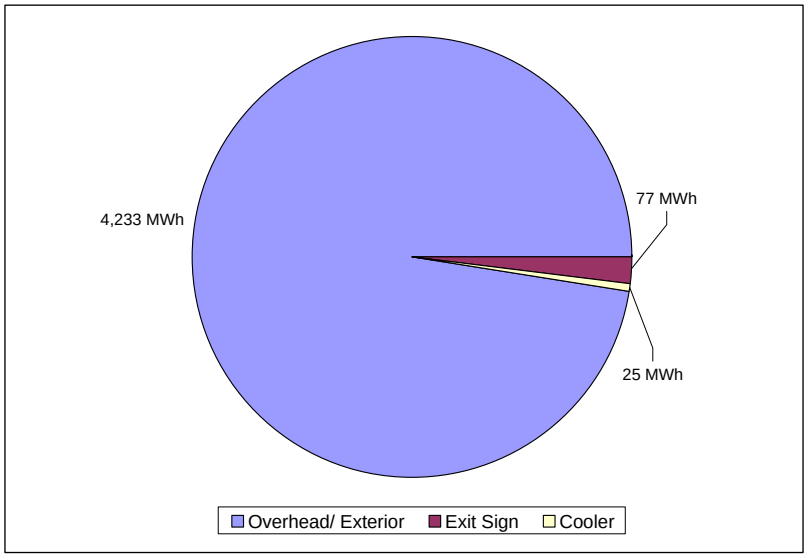

Figure 3.1. CL&P Lighting Tracking Savings for Sampled Projects by Application

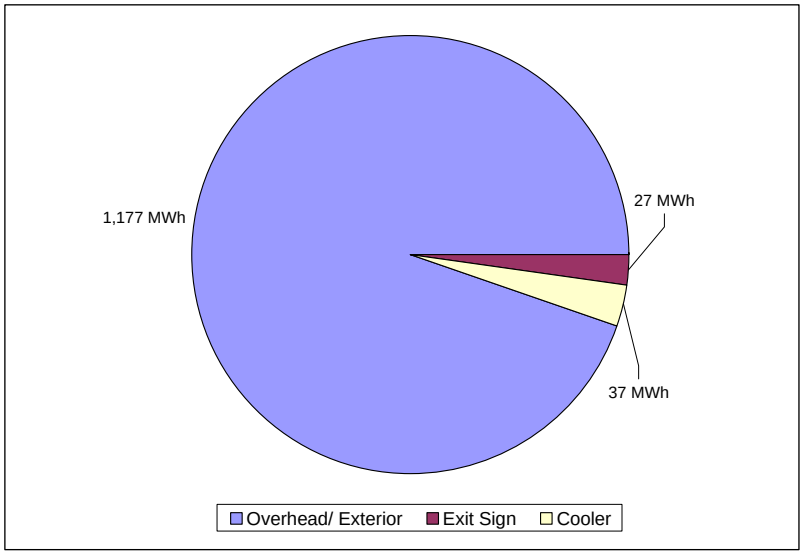

Figure 3.2. UI Lighting Tracking Savings for Sampled Projects by Application

The realization rate for lighting equipment energy savings is 120 percent, bringing the adjusted annual savings to 6,668 MWh. The utilities report that the cooling adjustment has already been addressed for future years because they began to apply cooling savings to SBEA lighting projects in 2008. Therefore we also calculated a realization rate based on all adjustments except heating and cooling, which equals 99.1 percent, and we calculated total adjustments excluding heating and cooling, which are given in table footnotes and summarized in Appendix 3. Table 3.1 details the energy savings for sampled projects and adjustment factors.

	CL&P	UI	Total
Gross Tracking Estimate	4,537 MWh	1,396 MWh	5,933 MWh
Controls Adjustment	*-4.45%*	*-11.1%*	*-6.01%*
Revised Tracking Estimate	4,335 MWh	1,241 MWh	5,577 MWh
Documentation Adjustment	*-0.264%*	*+0.199%*	*-0.161%*
Technology Adjustment	*0%*	*0%*	*0%*
Quantity Adjustment	*+0.301%*	*-0.132%*	*+0.204%*
Operation Adjustment	*-2.31%*	*3.91%*	*-0.926%*
Heating and Cooling Adjustment	*+20.3%*	*+20.9%*	*+20.5%*
Total Adjustment to Revised Estimate[3]	*+18.1%*	*+24.8%*	*+19.6%*
Adjusted Annual Energy Savings	5,119 MWh	1,550 MWh	6,668 MWh
Number of Measures in Sample	2,040	556	2,596

Table 3.1. Annual Lighting Energy Savings for Sampled Projects

[3] Total adjustment to revised estimate excluding heating and cooling: CL&P -2.27%, UI +3.97%, Total -0.882%

The gross tracking demand savings estimate for lighting measures included in the evaluation is 1,770 kW. The revised tracking demand savings estimate excluding lighting controls is 1,379 kW for winter and 1,581 kW for summer. With an overall realization rate of 66.9 percent for winter and 107 percent for summer, the total adjusted demand savings for sampled projects is 880 kW for winter and 1,631 kW for summer. Demand savings and adjustments are detailed in Table 3.2.

	CL&P	UI	Total
Gross Tracking Estimate			
- Winter	940 kW	439 kW	1,379 kW
- Summer	1,142 kW		1,581 kW
Controls Adjustment			
- Winter	*-0.0537%*	*-14.2%*	*-4.55%*
- Summer			*-3.98%*
Revised Tracking Estimate			
- Winter	940 kW	377 kW	1,317 kW
- Summer	1,141 kW		1,518 kW
Documentation Adjustment			
- Winter	*-24.3%*	*-52.1%*	*-32.3%*
- Summer	*-18.8%*	*-31.5%*	*-22.0%*
Technology Adjustment	*0%*	*0%*	*0%*
Quantity Adjustment			
- Winter	*-0.249%*	*-2.45%*	*-0.879%*
- Summer			*-0.795%*
Heating and Cooling Adjustment			
- Winter	*0%*	*0%*	*0%*
- Summer	*+30.1%*	*+30.4%*	*+30.2%*
Total Adjustment to Revised Estimate[4]			
- Winter	*-24.5%*	*-54.5%*	*-33.1%*
- Summer	*+11.1%*	*-3.54%*	*+7.44%*
Adjusted Demand Savings			
- Winter	710 kW	171 kW	881 kW
- Summer	1,268 kW	364 kW	1,631 kW
Number of Measures in Sample	2,040	556	2,596

Table 3.2. Lighting Demand Savings for Sampled Projects

[4] Total adjustment to revised summer estimate excluding heating and cooling: CL&P -19.0%, UI -34.0%, Total -22.7%. No heating and cooling adjustment for winter.

Controls Adjustment

The controls adjustment, as defined by the sponsors, indicates the portion of all lighting-related measures that are lighting controls. First, we combined all lighting-related measures into the gross tracking estimates, then we separated the lighting equipment and controls measures. The revised tracking estimates represent only lighting equipment measures, and lighting controls are addressed in detail in the following section of this report.

Documentation Adjustment

Documentation adjustments were minor for energy savings, but significant for demand.

Energy Savings

The documentation adjustment for UI was determined by comparing the reported energy savings for all lighting measures with the savings Cadmus calculated independently using the raw data reported for before and after quantity, wattage and operating hours.

Operating hours for CL&P projects were recorded on the full project reports, but are not in the files from which data were exported for the evaluation. We therefore calculated the documentation adjustment based on full reports that CL&P provided for 4 projects with 132 lighting equipment measures. Based on these data, the adjustment for lighting energy savings was found to be -0.264 percent, which could likely be attributed to rounding errors and is comparable to the adjustment of +0.199 percent calculated for all UI lighting measures.

Demand

The PSD states that lighting demand savings should be calculated for each winter and summer using the peak coincidence factors for each season, as explained in the lighting demand savings formula in Appendix 1. Some of the project data provided for the evaluation did not appear to properly use these factors. The documentation adjustments were determined by comparing the reported demand savings to savings Cadmus calculated independently using the raw data and the factors provided in the PSD. The resulting adjustments of -33.1 percent for winter and +7.44 percent for summer show the impact of the coincidence factors and the cooling adjustment on demand savings. The utilities report that these issues have already been addressed for future years by automatically applying coincidence factors based on business type and including cooling savings.

Coincidence Factor for Lighting Demand Savings

Table 3.3 compares the demand coincidence factors provided in the PSD with the factors calculated based on metering, as described in Section 2.6 of this report. These are un-weighted averages for all facility types, but coincidence factors will vary significantly based on the business. The PSD for 2008 contains a table of coincidence factors for several types of businesses, in place of the averages provided for the 2007 program year, which is expected to improve the accuracy of future demand calculations.

	Coincidence Factor from PSD[5]	Coincidence Factor Calculated from Evaluation Meter Data
Summer - 1 to 5 p.m.	0.68	0.71
Winter - 5 to 7 p.m.	0.47	0.35
Summer Seasonal Peak Hours (90% of 50/50 Peak)	0.70	0.65
Winter Seasonal Peak Hours (90% of 50/50 Peak)	0.55	0.36

Table 3.3. Lighting Demand Coincidence Factors, Average for All Facility Types

Technology Adjustment

No discrepancies were found between the reported and installed lighting technologies.

Quantity Adjustment

Quantity adjustments for lighting were minor, with the exception of exit sign measures. The field staff found that 7 percent of the LED exit signs reported had not been installed (8 percent CL&P, 5 percent UI), reducing annual program savings by 7 MWh. In some cases, customers explained they had considered upgrading exit signs but ultimately decided against it. Incentives were provided for these measures, however, according to the program data.

Operation Adjustment

Meter data showed operating hours at the time of the evaluation to vary slightly from contractor estimates. In this analysis, operating hours for lighting without occupancy sensors were assumed to be consistent before and after the equipment upgrade. A reduction in operating hours based on meter data therefore reduces the calculated energy savings for the equipment upgrade.

Heating and Cooling Adjustment

Adjustment for the impact on cooling load, which was not included in the savings analysis in program year 2007, significantly increased the energy savings. The cooling savings is due to less heat being generated by more efficient lighting. The methodology for calculating cooling savings was added to the PSD in 2008 and is detailed in Section 2.4 and Appendix 1 of this report.

[5] Seasonal peak was not included in the 2007 PSD, so values displayed here (0.70 for summer and 0.55 for winter) are from the 2008 PSD.

3.2 Lighting Controls

Adjustment factors were calculated for the lighting control measures after they were separated from lighting equipment upgrades. The total savings reported for lighting controls measures was 356 MWh, and the realization rate was 98.9 percent. Table 3.4 details the energy savings and adjustments for lighting controls measures.

	CL&P	UI	Total
Tracking Estimate	202 MWh	155 MWh	356 MWh
Documentation Adjustment	*N/A*	*-0.259%*	*N/A*
Technology Adjustment	*0%*	*0%*	*0%*
Quantity Adjustment	*-1.54%*	*-0.538%*	*-1.10%*
Total Adjustment	*-1.54%*	*-0.797%*	*-1.10%*
Adjusted Annual Energy Savings	199 MWh	153 MWh	352 MWh
Number of Measures in Sample	313	423	736

Table 3.4. Annual Lighting Controls Energy Savings for Sampled Projects

Total demand savings reported for lighting controls was 62.7 kW for winter and 62.9 kW for summer, with a realization rate of 99.0 percent, as shown in Table 3.5.

	CL&P	UI	Total
Tracking Estimate			
- Winter	0.505 kW	62.2 kW	62.7 kW
- Summer	0.614 kW		62.9 kW
Documentation Adjustment	*N/A*	*N/A*	*N/A*
Technology Adjustment	*0%*	*0%*	*0%*
Quantity Adjustment	*0%*	*-1.03%*	
- Winter			*-1.03%*
- Summer			*-1.02%*
Total Adjustment	*0%*	*-1.03%*	
- Winter			*-1.03%*
- Summer			*-1.02%*
Adjusted Demand Savings			
- Winter	0.505 kW	61.6 kW	62.1 kW
- Summer	0.614 kW		62.2 kW
Number of Measures in Sample	313	423	736

Table 3.5. Lighting Controls Demand Savings for Sampled Projects

Documentation Adjustment

Energy Savings

The documentation adjustment for UI was determined by comparing the reported energy savings for all control measures with the savings calculated independently using the raw "before and after" data reported for quantity, wattage and operating hours.

Evaluation of the documentation adjustment was limited for CL&P control measures. As explained in the previous section, the documentation adjustment for CL&P was based on the full project reports provided for four projects because operating hours were not included in the data files exported for the evaluation. These projects did not include a statistically relevant number of control measures, but in a qualitative review the reported hours looked reasonable and consistent with the claimed savings. All of the CL&P control measures were also reviewed by back-calculating the operating hours reductions from the wattage and energy savings information, and inspecting the data for gross errors such as hours reduction exceeding the total number of hours in a year. No such errors were found and no documentation adjustment was made based on the available data.

Demand

A documentation adjustment was not made for demand savings because the 2007 PSD for the SBEA does not address demand savings for lighting controls. The project data provided by the utilities show that demand was calculated differently for each utility. Demand savings were claimed for many of the UI control measures, but for few CL&P control measures. In most facilities, a substantial portion of the energy saved with lighting controls is saved during the off-peak periods on evenings and weekends, so demand savings are relatively low compared to the energy savings. Assuming no demand savings is a conservative approach. In the 2008 PSD, detailed in Appendix 1, a diversity factor of 0.34 was added to account for the demand effect of lighting controls. Meter data collected in this evaluation were used to calculate a diversity factor for comparison, as described below.

Diversity Factor for Lighting Controls Demand Savings

Using the meter data collected on lighting equipped with occupancy sensors, Cadmus calculated the approximate diversity factors shown in Table 3.6. Meter data showed 61 percent of lights with controls to be on between 1 p.m. and 5 p.m. and 30 percent on between 5 p.m. and 7 p.m. By comparison, lights that were not equipped with controls were on 71 percent and 35 percent of those time periods, respectively. We estimated the controls savings to be the difference in lights without and with controls that are on during a given time period.

	Diversity Factor Calculated from Evaluation Meter Data
Summer - 1 to 5 p.m.	0.10
Winter - 5 to 7 p.m.	0.05

Table 3.6. Estimated Demand Diversity Factors for Lighting Controls Measures, Average for All Facility Types

These calculations are significantly lower than the diversity factor of 0.34 in the 2008 PSD, but are based on data from just 45 meters on lighting with controls. Furthermore, these are un-weighted averages for all facility types, while actual diversity factors will vary significantly based on the business. The PSD for 2008 contains coincidence factors for several types of businesses, with separate tables for lighting with and without occupancy sensors. Use of these more specific factors is expected to improve the accuracy of future demand calculations.

Technology Adjustment

No technology adjustment was required for lighting controls.

Quantity Adjustment

Small quantity adjustments were made for occupancy sensors that were not found during site visits.

Operation Adjustment

Calculating energy savings from the installation of lighting controls requires information on the reduction in lighting operating hours, which is obtained by subtracting the operating hours after controls were installed from the hours before. Some lighting fixtures with controls were metered as explained above, but in this evaluation it was not possible to verify operating hours before installation, so there are not sufficient data to calculate operation adjustments for controls.

3.3 Refrigeration Upgrades and Controls

Refrigeration measures included installing evaporator fan controls in walk-in coolers and freezers, controls for heaters on cooler and freezer doors, vending machine controls (central controllers, vending misers or timers), night covers for open coolers and upgrades of evaporator fan motors to EC motors.

The total savings reported for refrigeration measures was 223 MWh, and the realization rate was 106 percent. Refrigeration energy savings and adjustments are detailed in Table 3.7.

	CL&P	UI	Total
Tracking Estimate	88.2 MWh	135 MWh	223 MWh
Documentation Adjustment	*+3.74%*	*+7.76%*	*+6.17%*
Technology Adjustment	*0*	*0*	*0*
Quantity Adjustment	*0*	*0*	*0*
Operation Adjustment	*+3.08%*	*-2.63%*	*-0.375%*
Total Adjustment	*+6.82%*	*+5.13%*	*+5.80%*
Adjusted Annual Energy Savings	94.2 MWh	142 MWh	236 MWh
Number of Measures in Sample	31	22	53

Table 3.7. Annual Refrigeration Energy Savings for Sampled Projects

Total demand savings reported for refrigeration measures was 37 kW, detailed in Table 3.8. The realization rate on refrigeration demand savings is 9.32 percent for winter and 8.90 percent for summer due to large documentation adjustments, which are explained below.

	CL&P	UI	Total
Tracking Estimate - Winter - Summer	 7.31 kW 8.88 kW	26.4 kW	 33.7 kW 35.3 kW
Documentation Adjustment *- Winter* *- Summer*	 *-79.1%* *-82.8%*	*-93.9%*	 *-90.7%* *-91.1%*
Technology Adjustment	*0*	*0*	*0*
Quantity Adjustment	*0*	*0*	*0*
Total Adjustment *- Winter* *- Summer*	 *-79.1%* *-82.8%*	*-93.9%*	 *-90.7%* *-91.1%*
Adjusted Demand Savings - Winter - Summer	 1.53 kW	1.61 kW	 3.14 kW
Number of Measures in Sample	31	22	53

Table 3.8. Refrigeration Demand Savings for Sampled Projects

Documentation Adjustment

The refrigeration documentation adjustments were determined by comparing the reported savings to the values calculated independently using formulas in the PSD and raw measurement

data. The PSD does not specify a difference between winter and summer demand savings for refrigeration measures.

The documentation adjustment makes a significant reduction to demand savings because savings were reported for measures that typically do not have a demand savings during peak hours. Most of the novelty cooler controls observed on site visits were simple timers or central timer controls; because they are used to turn coolers off at night, they don't reduce demand. The energy savings for coolers equipped with night covers also occurs during off-peak hours.

Technology Adjustment

No technology adjustments were required for refrigeration measures that were not found during site visits.

Quantity Adjustment

No quantity adjustments were required for refrigeration measures that were not found during site visits.

Operation Adjustment

Minor refrigeration operation adjustments were made based on data logs downloaded from installed controllers, as detailed in Appendix 2, and other meter data.

Most customers were satisfied with their refrigeration controls, and the collected data confirmed that most controls were operating as expected and delivering substantial energy savings. Refrigeration controls were not operating as expected at four of the sites visited:

- An evaporator fan controller was not operating because it was switched to maintenance bypass mode. The customer reported that its contractor had said the controller was set correctly.
- A customer has had problems with the evaporator fan controller going into bypass mode.
- A customer reported that a novelty cooler control was no longer working and the cooler was operating continuously.
- A plug-in timer was installed for a novelty cooler, but the cooler had since been unplugged from the timer and plugged into another outlet.

These situations could likely be remedied through expanded education and support for participating customers and contractors.

Door Heater Controls

The PSD formula for door heater control energy savings, detailed in Appendix 1, assumes that the controls will turn heaters off for 6,500 hours per year, for annual savings of 74 percent. The baseline heater operation without controls is continuous operation, or 8,760 hours per year. As

shown in Appendix 2, Cadmus downloaded data from six controllers and found that on average the heaters were off 65 percent of the time (5,680 hours) in 2008, which would reduce energy savings by 9 percent relative to the estimate from the PSD. With the sample size of just six, due to the relatively low number of door heater controls installed through the SBEA in 2007, a 9 percent difference is not considered significant, but we recommend further consideration of this factor in the future as more operational data becomes available.

On site visits, typical temperature settings were found to be -5°F for freezers and 38°F for coolers. According to the manufacturer of the controllers, door heaters are expected to operate more frequently at lower temperatures, but the 2007 PSD formula provides the same value for freezers and coolers alike. Assuming different operating hours for coolers and freezers would likely improve the accuracy of savings calculations. UI reports that vendors typically do custom calculations using appropriate values depending on the case temperature. Adding different default values for coolers and freezers to the PSD would be another step to ensure accurate savings calculations.

3.4 Air Compressor Upgrade

While the SBEA focuses primarily on lighting and other prescriptive measures, custom measures may also be included. In 2007, the program supported one customer in upgrading to a new, high-efficiency air compressor in an auto shop. For this evaluation, the new air compressor was metered and analyzed, then compared to the analysis provided by the SBEA contractor. With a sample size of one for this measure type, the evaluation results are not statistically significant but could be helpful in developing a procedure for analyzing future compressed air measures.

According to the project records, the air compressor was sized 30 hp and, at approximately 15 years old, was near the end of its expected life. The contractor provided quotes for two replacement options, both 30-hp Kaesar models: model AS30, the baseline option with 91-percent motor efficiency, and model SFC22 with 91.7-percent efficiency and a variable speed drive.

The contractor-submitted analysis comparing the two options is summarized in Tables 3.9 and 3.10.

Air Demand (cubic feet per minute)	Hours per Year at Demand Level
70	312
50	1,560
40	1,248

Table 3.9. Auto Shop Compressed Air Demand, Contractor Analysis

Compressor Model	Annual Energy Consumption (kWh)	Demand (kW)
Baseline option - AS30	63,054	20.9
High efficiency option - SFC22	24,854	12.3
Savings	38,200	8.6

Table 3.10. Auto Shop Compressor Energy, Contractor Analysis

At the given rate of $0.195/kWh, the annual electric cost saving provided by the variable speed compressor would be $7,450. The incremental cost for purchasing the variable speed compressor was $28,369, which brought the simple payback period for the investment to 3.8 years.

The customer selected the SFC22 compressor with variable speed drive. The power draw by the new air compressor was metered from January 11 to 31, 2009, as shown in Figure 3.3.

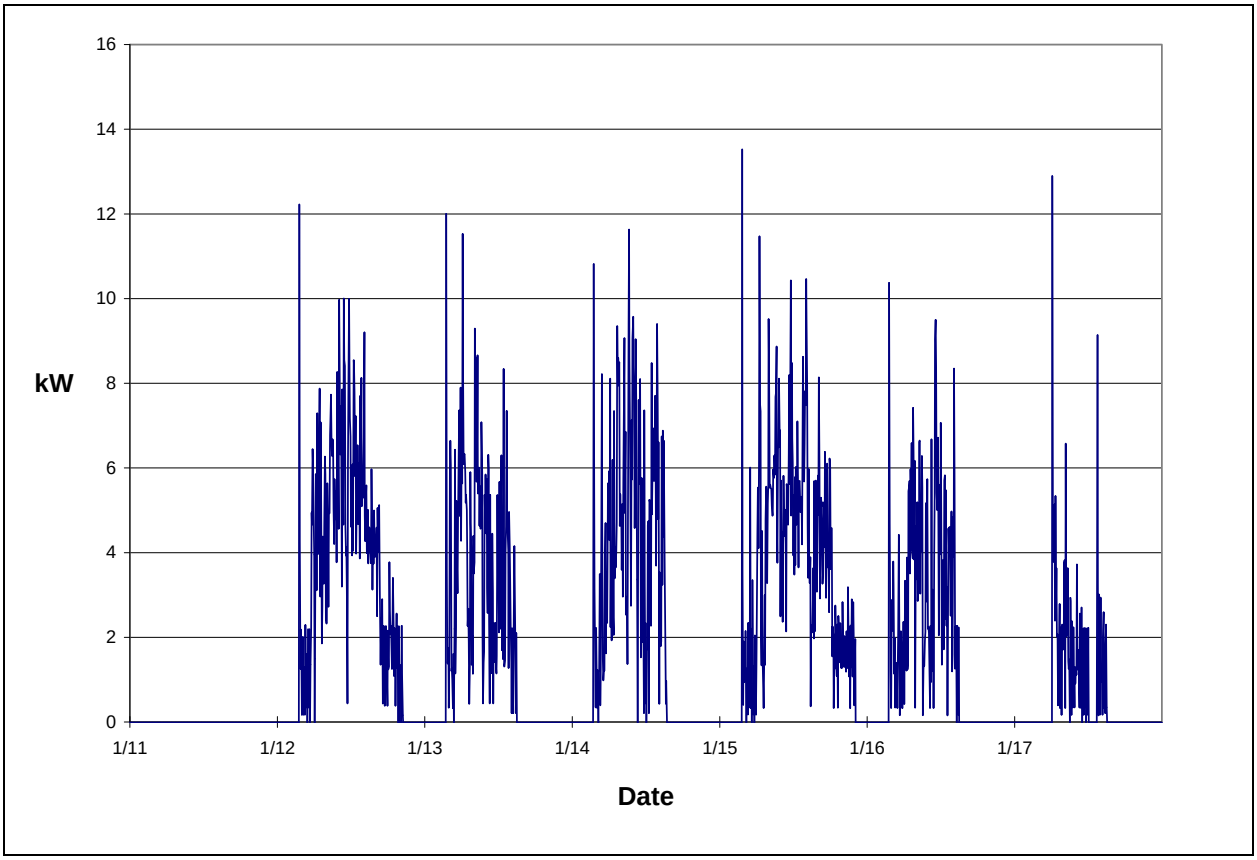

Figure 3.3. Auto Shop Compressed Air Meter Data

Total energy consumption measured was 905 kWh, which translates to average annual energy consumption of approximately 15,700 kWh, assuming this period to be typical of year-round operation. The average compressor power during business hours on Monday through Saturday was

3.68 kW. Using the meter data, the approximate demand for compressed air was calculated, with results shown in Table 3.11. A flow meter could have been used to measure air flow directly.

Air Demand (cubic feet per minute)	Hours per Year at Demand Level
50	20
40	40
30	300
20	400
10	1,600

Table 3.11. Auto Shop Compressed Air Demand, Calculated Based on Meter Data

The compressed air demand and energy consumption found with the meter data are significantly lower than the estimates provided by the contractor. Compressed air demand is difficult to determine without using metering equipment, and this level of discrepancy is not atypical. Overestimates for air demand when metering is not performed are a common cause of inaccuracies in analyses of compressed air systems. Table 3.12 shows the approximate compressor energy calculations based on the meter data.

Compressor Model	Annual Energy Consumption (kWh)	Demand (kW)
Baseline option - AS30	21,400	20.0
High efficiency option - SFC22	15,700	11.8
Savings	5,700	8.2

Table 3.12. Auto Shop Compressor Energy, Calculated Based on Meter Data

This change translates to annual cost savings of $1,110. The simple payback period is 26 years before the incentive and 2 years after the incentive.

One way to make this project more cost effective might have been downsizing the air compressor. The previous compressor was 30 hp, but the meter data showed the maximum demand for compressed air over a 15-minute period to be approximately 42 cubic feet per minute (cfm), which can be satisfied by a 15- or 20-hp compressor. The vendor reported that the business was planning to expand, but unless the metering was conducted when demand was significantly lower than usual, a smaller compressor may have been sufficient to meet the facility's demand and still allow some room for growth. If purchasing a smaller compressor were feasible, the cost of the new compressor could have been reduced and the payback may have improved for the model with the variable speed drive.

3.5 Connecticut Light & Power Summary

Tables 3.13 and 3.14 summarize the CL&P results for each of the major measure types.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects	4,335 MWh	202 MWh	88.2 MWh	38.2 MWh
Total Adjustment[6]	*+18.1%*	*-1.54%*	*+6.82%*	*-85.0%*
Adjusted Annual Savings for Sampled Projects	5,119 MWh	199 MWh	94.2 MWh	5.70 MWh
Number of Measures in Sample	2,040	313	31	1
2007 Total Annual Estimated Savings	31,023 MWh	1,565 MWh	2,172 MWh	38.2 MWh
2007 Total Adjusted Annual Savings	36,628 MWh	1,541 MWh	2,321 MWh	5.70 MWh

Table 3.13. Connecticut Light & Power SBEA 2007 Energy Savings

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects				
- Winter	940 kW	0.505 kW	7.31 kW	8.6 kW
- Summer	1,142 kW	0.614 kW	8.88 kW	
Total Adjustment[7]				
- Winter	*-24.5%*	*0%*	*-79.1%*	*-4.65%*
- Summer	*+11.1%*		*-82.8%*	
Adjusted Demand Savings for Sampled Projects				
- Winter	710 kW	0.505 kW	1.53 kW	8.2 kW
- Summer	1,268 kW	0.614 kW		
Number of Measures in Sample	2,040	313	31	1
2007 Total Estimated Demand Savings				
- Winter	6,875 kW	4.92 kW	187 kW	8.6 kW
- Summer	8,349 kW	5.98 kW	228 kW	
2007 Total Adjusted Demand Savings				
- Winter	5,193 kW	4.92 kW	39.2 kW	8.2 kW
- Summer	9,272 kW	5.98 kW		

Table 3.14. Connecticut Light & Power SBEA 2007 Demand Savings

[6] Total adjustment to revised lighting estimate excluding heating and cooling: -2.27%.

[7] Total adjustment to revised summer lighting estimate excluding heating and cooling: -19.0%.

3.6 United Illuminating Summary

Tables 3.16 and 3.17 summarize the UI results for each of the major measure types.

	Lighting Equipment	Lighting Controls	Refrigeration
Tracking Estimate for Sampled Projects	1,241 MWh	155 MWh	135 MWh
Total Adjustment[8]	*+24.8%*	*-0.797%*	*+5.13%*
Adjusted Annual Savings for Sampled Projects	1,550 MWh	153 MWh	142 MWh
Number of Measures in Sample	556	423	22
2007 Total Annual Estimated Savings	5,975 MWh	744 MWh	839 MWh
2007 Total Adjusted Annual Savings	7,460 MWh	738 MWh	882 MWh

Table 3.15. Summary of United Illuminating SBEA 2007 Energy Savings

	Lighting Equipment	Lighting Controls	Refrigeration
Tracking Estimate for Sampled Projects	377 kW	62.2 kW	26.4 kW
Total Adjustment[9]			
- Winter	*-54.5%*	*-1.03%*	*-93.9%*
- Summer	*-3.54%*		
Adjusted Demand Savings for Sampled Projects			
- Winter	171 kW	61.6 kW	1.6 kW
- Summer	364 kW		
Number of Measures in Sample	556	423	22
2007 Total Estimated Demand Savings	1,972 kW	326 kW	131 kW
2007 Total Adjusted Demand Savings			
- Winter	897 kW	322 kW	7.99 kW
- Summer	1,902 kW		

Table 3.16. Summary of United Illuminating SBEA 2007 Demand Savings

3.7 Confidence and Precision

Cadmus proposed a sample of 120 sites. Participants were sorted by the expected amount of impact. The original sample of customers contacted for site visits represented 155 projects, including 30 projects randomly selected from the 40 with the greatest energy savings. The objective was to

[8] Total adjustment to revised lighting estimate excluding heating and cooling: +3.97%.

[9] Total adjustment to revised summer lighting estimate excluding heating and cooling: -34.0%.

include a majority of the total impacts of the program in our sample. The other sites were randomly selected for the sample. The RFP's original goal was to achieve 80 percent confidence and ±10 percent precision at the utility level.

Table 3.17 shows the precision levels we achieved at the 80-percent level of confidence. The table displays the average savings and standard error (energy and demand) for each utility and overall.

Survey sampling typically deals with a finite population of size N. When the sample constitutes a significant portion of the N, then a correction may be applied to the "variability" of the data called the finite population correction factor (FPCF). Specifically, a sample of size n is taken without replacement from a population of size N, and the sample mean and its standard error (SE) are calculated. Then the standard error of the sample average is computed as:

$$Adjusted\ SE_{\bar{x}} = \frac{1}{\sqrt{n}}\sqrt{1-\frac{n}{N}}\sigma$$

where σ is simply the standard deviation of the estimated kWh and kW in the samples. Finally, the precision values were estimated as:

$$precision = \frac{1.282 * Adjusted\ SE}{x}$$

where the denominator of the equation is either average kWh or average kW for the utility or overall.

As the table shows, we are able to exceed the precision goal for CL&P and nearly meet the overall goal. We missed the desired precision goal for UI. In conducting evaluations of any kind, the precision and confidence levels are merely goals. Once the data are collected, the variability may exceed what was assumed in computing the sample sizes and, as a result, the precision levels are not achieved. As mentioned above, our sample was stratified according to the expected impacts by utility. This is almost always the optimal approach for the program overall, but often the increase in sample accuracy may happen at the expense of the smaller strata. In this case, we exceeded the desired levels for CL&P and fell a little short on the UI components of the program.[10]

[10] Given the observed variability, 10 percent precision could have been reached for UI with the same number of projects if the sample had included more large projects in terms of both energy and demand savings. The actual coefficient of variation was 1.29 for CL&P and 1.21 for UI. These coefficients were significantly higher than the 0.5 we had assumed originally; however, by using the population correction factor coupled with oversampling of large projects we were still able to meet the confidence and precision goals for CL&P and almost meet the overall goals.

	CL&P		UI		Overall	
	Energy	Demand	Energy	Demand	Energy	Demand
Average	49,959	15	48,137	12	52,447	13
FPCF	0.93	0.93	0.89	0.90	0.92	0.92
Adjusted SE	2,260	0.84	4,637	1.8	4,170	1.0
Precision	5.80%	7.39%	12.35%	18.34%	10.80%	9.00%

Table 3.17. Project Savings with Precision and Confidence Levels

3.8 Environmental Impact

The estimated emission reductions from the program are shown in Table 3.18. The reductions were calculated based on total realized savings and the emission factors for electricity generation in New England (eGRID2007 Version 1.1, U.S. Environmental Protection Agency, December 2008, http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html).

	Carbon Dioxide (CO_2) reduction (tons)	Nitrogen Oxide (NO_x) reduction (tons)	Sulfur Dioxide (SO_2) reduction (tons)
CL&P	18,800	17.5	47.8
UI	4,200	3.92	10.7
Total	23,000	21.4	58.5

Table 3.18. Annual Emission Reduction Benefits of 2007 SBEA Program

4. Conclusion

4.1 Summary of Findings

The impact evaluation found that the SBEA program saved participating customers more than 49,500 MWh in total annual energy savings. Most new equipment was found as reported and was operating correctly. Most customers were satisfied with their new equipment and with the SBEA contractors. The largest adjustments to savings were:

- An additional 21 percent in claimed lighting energy savings and additional 30 percent in demand savings to account for the reduced cooling loads in areas with more efficient lighting.
- Decreases of 31 percent to 53 percent in seasonal lighting demand savings due to savings calculations that do not appear to follow the formula provided in the PSD.
- A 90-percent decrease in refrigeration demand savings due to calculations that do not appear to follow the PSD.
- An 85-percent decrease in the energy savings for the one air compressor included in the program due to overestimating the compressed air demand and compressor operating hours.

The energy and demand savings are summarized in Tables 4.1 and 4.2.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects	5,577 MWh	356 MWh	223 MWh	38.2 MWh
Total Adjustment[11]	*+19.6%*	*-1.10%*	*+5.80%*	*-85.0%*
Adjusted Annual Savings for Sampled Projects	6,668 MWh	352 MWh	236 MWh	5.70 MWh
Number of Measures in Sample	2,596	736	53	1
2007 Total Annual Estimated Savings	37,114 MWh	2,194 MWh	3,012 MWh	38.2 MWh
2007 Total Adjusted Annual Savings	44,225 MWh	2,166 MWh	3,203 MWh	5.70 MWh

Table 4.1. Summary of SBEA 2007 Energy Savings

[11] Total adjustment to revised lighting estimate excluding heating and cooling: -0.882%.

	Lighting Equipment	Lighting Controls	Refrigeration	Compressed Air
Tracking Estimate for Sampled Projects				
- Winter	1,317 kW	62.7 kW	33.7 kW	8.6 kW
- Summer	1,518 kW	62.9 kW	35.3 kW	
Total Adjustment[12]				
- Winter	*-33.1%*	*-1.03%*	*-90.7%*	*-4.65%*
- Summer	*+7.44%*	*-1.02%*	*-91.1%*	
Adjusted Demand Savings for Sampled Projects				
- Winter	881 kW	62.1 kW	3.14 kW	8.2 kW
- Summer	1,631 kW	62.2 kW		
Number of Measures in Sample	2,596	736	53	1
2007 Total Estimated Demand Savings				
- Winter	8,847 kW	331 kW	319 kW	8.6 kW
- Summer	10,321 kW	332 kW	359 kW	
2007 Total Adjusted Demand Savings				
- Winter	6,090 kW	327 kW	47.2 kW	8.2 kW
- Summer	11,175 kW	328 kW		

Table 4.2. Summary of SBEA 2007 Demand Savings

4.2 Recommendations

Cadmus found six areas, detailed below, in which the SBEA program could be improved in the future: data collection, program documentation, savings calculations, determination of operating hours, and customer support.

Enhance data collection and tracking with more consistency between the two utilities. CL&P and UI have separate data management systems and do not capture all of the same data for SBEA projects. Data quality would improve if each utility collected the same data in the same format, particularly because there are several contractors who implement SBEA projects for both CL&P and UI. The more consistent the process between the two utilities, the easier it will be to train contractors on the data they need to collect and enter. CL&P and UI should consider establishing a joint DSM tracking system to be used across all programs.

We recommend that these fields be collected for each measure, in additional to general project information such as customer name and contact information, facility type and vendor name:

[12] Total adjustment to revised summer lighting estimate excluding heating and cooling: -22.7%. No heating and cooling adjustment for winter.

- General measure type (lighting, lighting controls, refrigeration, etc.).
- Measure description – prescriptive measure descriptions selected from a list, if possible.
- Measure location (with vendors instructed to exclude other notes from this field so data can later be sorted by location for inspection and evaluation purposes).
- Quantity before and after.
- Unit wattage before and after.
- Operating hours before and after measure implementation, broken down between winter and summer seasons.
- Manufacturer and model number of existing and new equipment, including both lamp and ballast for lighting and control measures.
- Number of lamps per fixture for lighting and control measures.
- Number of light fixtures controlled and number of sensors installed for lighting control measures.
- Cooler/freezer temperature set-point for refrigeration measures such as lighting upgrades and night covers.
- Consistent identifier for measures without energy savings, such as lift rental or disposal of old equipment, so they can be easily removed from the data for evaluation purposes.
- Calculated annual energy consumption before and after.
- Calculated annual energy savings.
- Calculated demand savings for both winter and summer.
- Expected measure lifetime.
- Unit cost for materials.
- Unit cost for labor.
- Total measure cost.
- Incentive amount for measure.
- Installation date.

Ensure that the program savings document is updated as the program evolves and new measure types are added. The PSD did not include several of the measures implemented in 2007. Most of these measures—as well as the cooling benefit from lighting upgrades and the diversity factor for demand savings from lighting controls—were added to the updated documentation for the 2008 program year.

There are different ways of calculating demand savings, as explained in Sections 2.6 and 3.1, depending on whether the focus is on the customer's billed demand or the system-wide peak

demand. The 2007 PSD could have been improved to be clearer on which types of demand should be calculated using which coincidence factors and how each type of demand value should be used.

As the program evolves, it is important to keep this document detailed and up to date. Having the current approved methodology for savings calculations clearly documented and easily accessible to the utilities and participating contractors will improve consistency of savings calculations.

Ensure that savings calculations are made according to the formulas provided in the program documentation. Consistent data can be difficult to collect when a number of contractors are responsible for the analysis and data entry, but the accuracy of program records would improve with additional enforcement of the approved analysis methodology. For example, one of the largest adjustments made in this evaluation is a reduction in demand savings for refrigeration measures. The PSD states that there are no demand savings for central controls on vending machines, but the project data showed that demand savings were claimed for most instances of this measure.

Enhance PSD assumptions for door heater control operating hours. Door heaters typically need to operate more frequently in colder temperatures, but the 2007 PSD provides one formula for freezers and coolers alike. We recommend that different default values for operating hours in coolers and freezers be added to the PSD to improve the accuracy of savings calculations.

Meter selected measures before project implementation to improve accuracy of energy savings predictions. Operational factors such as hours for lighting and demand profile for compressed air can be difficult to determine but are also essential in calculating energy savings. The operation adjustment for compressed air is one of the largest adjustments made in this evaluation. As explained in Section 3.4, metering to determine a facility's actual demand for compressed air can assist in the selection of a properly sized compressor and significantly improve the accuracy of energy savings analysis. While it would be impractical to meter for every lighting measure, metering a sampling of the largest measures could help ensure the accuracy of savings claims.

Enhance support after project implementation to ensure that issues with equipment operation or contractor performance are addressed. The great majority of customers visited for the evaluation were satisfied with their equipment and contractors, but several had difficulties with their new equipment or concerns about their experience with the contractor. Technical issues were primarily for refrigeration measures, as described in Section 3.3. Many of these customers were not sure who to contact with these concerns, and in a few cases contractors were unresponsive after project completion. We recommend that all customers participating in the SBEA program be notified of the appropriate utility contacts for any installation issues and that additional education and follow-up be provided for refrigeration or custom measures to ensure that equipment is operating properly in the longer term.

Appendices

1. Savings Formulas

The following are the formulas provided in the *UI and CL&P Program Savings Documentation for 2007 Program Year*.

Standard Lighting: Replace inefficient lighting with efficient lighting.

Annual energy savings = $(kW_B – kW_A)$ H

kW_B = total power usage of the lighting fixtures that are being replaced, kW
kW_A = total power usage of the new lighting fixtures that are being installed, kW
H = number of hours during which the lighting is used, hours/year

Demand savings = D $(kW_B – kW_A)$

D = peak factor:
C&I peak coincidence factors:
Summer (based on energy saved during 3-5 p.m. in June-August) = 0.85
Winter (based on energy saved during 5-7 p.m. in December-February) = 0.70
C&I ISO-NE coincidence factors:
Summer (based on energy saved during 1-5 p.m. in June-August) = 0.68
Winter (based on energy saved during 5-7 p.m. in December-February) = 0.47

Evaporator Fans: Add a control system to shut off evaporator fans in walk-in coolers and freezers when the cooler's thermostat is not calling for cooling.

Annual energy savings = N*P*H*factors

N = number of fans
P = fan power, kW
H = hours per year the fans are shut off (baseline is 24-hour operation)
Factors = other variables to take into account motor efficiency, number of phases, compressor efficiency

Summer peak demand savings = C*P

C = diversity factor, 10%
P = fan power, kW

Door Heaters: Add a control system to shut off electric door heaters in coolers and freezers when the facility's humidity is too low to allow condensation to occur on the doors.

Annual energy savings = P*6,500

P = door heater power, kW
6,500 = hours per year the heaters are shut off (baseline is 24-hour operation)

Demand savings = D*P

D = estimated diversity factor, 10%
P = door heater power, kW

Vending Machine Central Controls: Install a central controller for vending machines.

Annual energy savings = $kW*(H_B - H_A)$

kW = total power usage of the vending machines being controlled, kW
H_B = number of hours during which vending machines were on before, usually 8,760
H_A = number of hours during which vending machines are on after controls are installed

There are no demand savings for this measure.

Custom: Small business installations not covered by another specific measure. Energy and demand savings are calculated on a custom basis.

Following are several formulas provided in the *UI and CL&P Program Savings Documentation for 2008 Program Year* that were also used in this evaluation.

The methodology for calculating energy savings for lighting upgrades was updated in the 2008 program year to include the electricity savings from the reduced cooling load with more efficient lighting. In this evaluation, cooling savings for lighting measures were calculated based on the cooling factor in the following formula from the 2008 program document.

Standard Lighting: Replace inefficient lighting with efficient lighting.

Annual energy savings = $S_R + S_C$

S_R = savings from reduced lamp wattage = $(kW_B - kW_A)\ H$
S_C = savings from reduced cooling = $S_R * F / COP$
kW_B = total power usage of the lighting fixtures that are being replaced, kW
kW_A = total power usage of the new lighting fixtures that are being installed, kW
H = number of hours during which the lighting is used, hours/year
F = fraction of annual kWh savings that must be removed by the cooling system, 0.5 is characteristic of most small business facilities
COP = cooling system coefficient of performance, 2.4

Demand savings = $D\ (S_P + 0.34\ S_O)(1 + G/COP)/H$

D = peak factor
90% of 50/50 peak forecast factors – without occupancy sensors:
Summer = 0.70
Winter = 0.55

90% of 50/50 peak forecast factors – with occupancy sensors:

Summer = 0.15

Winter = 0.13

C&I ISO-NE coincidence factors – without occupancy sensors:

Summer (based on energy saved during 1-5 p.m. in June-August) = 0.75

Winter (based on energy saved during 5-7 p.m. in December-February) = 0.54

C&I ISO-NE coincidence factors – with occupancy sensors:

Summer (based on energy saved during 1-5 p.m. in June-August) = 0.15

Winter (based on energy saved during 5-7 p.m. in December-February) = 0.14

G = estimated lighting energy heat to space, 0.73

0.34 = diversity factor to estimate the demand effect due to occupancy sensors

Refrigerator LED, cooler night covers and evaporator fan motor replacements were added to the program document in 2008, as follows.

Refrigerator LED: Replace fluorescent lighting with LED systems in commercial display refrigerators, coolers and freezers.

Demand savings = KW = (kW_B – kW_A)*Compressor factor

KW = total kW savings of the refrigeration package, including kW reductions due to lighting and reduced cooling load

kW_B = power usage of the lighting fixtures being replaced, kW

kW_A = power use of the new lighting fixtures being installed, kW

Compressor factor = 1.51 for coolers, 1.65 for freezers

Annual energy savings = kW*H

H = number of hours during which the lighting is used, hours/year

Cooler Night Covers: Install retractable covers in open refrigerated display cases to deploy when store is closed.

Annual energy savings = W*H*F

W = width of the opening that the cover protects, feet

H = number of hours that the covers are in use, hours/year

F = savings factor based on the temperature of the case:

Low temperature (-35 F to -5 F) F = 0.1 kW/ft

Medium temperature (0 F to 30 F) F = 0.06 kW/ft

High temperature (35 F to 55 F) F = 0.04 kW/ft

There are no demand savings for this measure.

Evaporator Fan Motor Replacement: Replace evaporator fan motors in walk-in or reach-in coolers and freezer with high-efficiency electrically commutated motors. Evaporator fans normally operate continuously.

Annual energy savings = N*P*H*F

N = number of fans

P = original fan power, kW

H = hours per year, 8,760

Factors = other variables to take into account motor efficiency improvement and compressor efficiency, 0.65 for walk-in coolers

Demand savings from summer peak = 0.6*P

0.6 = reduced power required by EC motors

2. Refrigeration Data

Table A2.1 shows the runtime data downloaded from central refrigeration controllers for 19 coolers at nine customer sites. The time in bypass mode and the operating time for evaporator fans and door heater are given as a percentage of time during 2008. If the refrigeration system and controls are operating properly, the time in bypass mode will be close to zero. Further detail on the two sites with the highest portion of time in bypass mode is provided in Section 3.3.

Customer	Cooler Setpoint (º F)	Evaporator Fan Operating Time	Door Heater Operating Time	Time in Bypass Mode
Convenience Store	38	40%	29%	0
	-5	74%	N/A	0
	-5	84%	58%	44%
	-5	90%	N/A	52%
Grocery Store	38	80%	50%	0
	38	63%	N/A	0
	0	77%	N/A	0
Private Club	38	21%	N/A	90%
	38	24%	N/A	90%
	-5	79%	N/A	90%
Convenience Store / Restaurant	38	45%	34%	0
	38	34%	N/A	0
Liquor Store	38	36%	N/A	0
	38	55%	21%	0
Liquor Store	39	41%	N/A	0
	38	45%	N/A	0
Liquor Store	37	48%	N/A	0
Liquor Store	38	64%	19%	0
Convenience Store	38	51%	N/A	25%
Average		55%	35%	21%

Table A2.1. 2008 Runtime Data Downloaded from Refrigeration Controllers

3. Total Lighting Adjustments Excluding Heating and Cooling

As explained in Section 3.1, the utilities began to apply cooling savings to SBEA lighting projects in 2008, so the heating and cooling adjustment has already been addressed for future program years. Where applicable, we calculated a total of all adjustments except heating and cooling, and those are summarized in Table A3.1.

	CL&P	UI	Total
Energy Adjustment	-2.27%	+3.97%	-0.882%
Demand Adjustment			
- Winter	-24.5%	-54.5%	-33.1%
- Summer	-19.0%	-34.0%	-22.7%

Table A3.1. Total Lighting Adjustments Excluding Heating & Cooling Adjustment