2012 EM&V Report for the Energy Efficiency for Business Program

Prepared for:
Duke Energy Progress

Navigant Consulting, Inc.
1375 Walnut Street
Suite 200
Boulder, CO 80302

303.728.2500
www.navigant.com

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NAVIGANT

Prepared for
Duke Energy Progress
Raleigh, North Carolina

Presented by
Stuart Schare
Tim Guiterman
Chris Wassmer
Marca Hagenstad

Navigant Consulting, Inc.
1375 Walnut Street
Suite 200
Boulder, CO 80302
phone 303.728.2500
fax 303.728.2501

www.navigant.com

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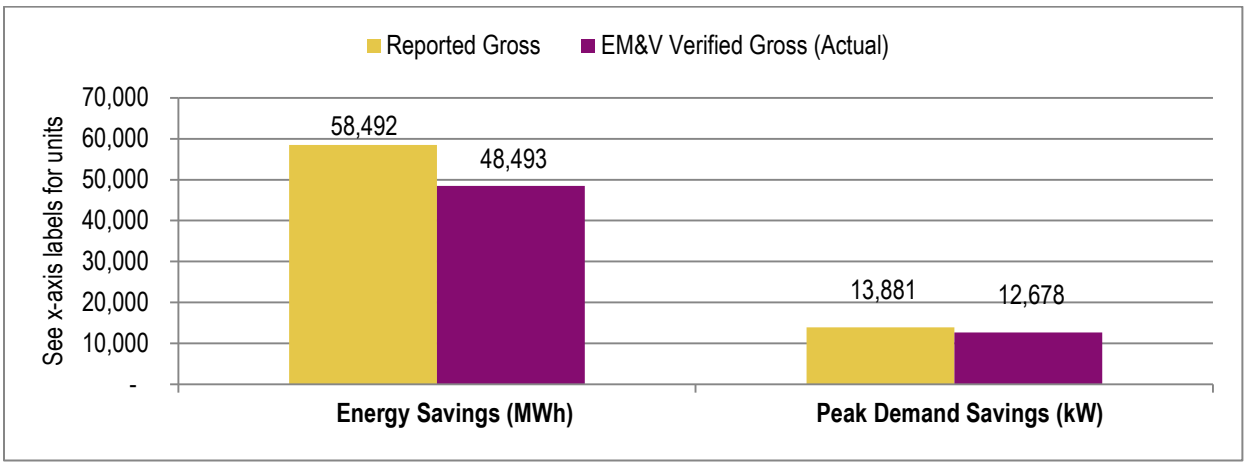
Executive Summary

The Energy Efficiency for Business (EEB) Program is part of the portfolio of energy efficiency programs initiated by Duke Energy Progress (DEP), formerly Progress Energy Carolinas (PEC), beginning in late 2008. The EEB Program is available to all DEP business customers, including commercial, industrial, and governmental customers. This program offers cash incentives for prescriptive energy efficiency measures, as well as custom measures. DEP offers a performance-based incentive for new buildings and major renovations that pursue energy efficiency on an integrated, whole-building basis.

This report covers evaluation, measurement, and verification (EM&V) activities for EEB for Program Year 2012 (PY 2012) projects, defined as those receiving incentives during the 2012 calendar year. The primary purpose of the evaluation assessment is to estimate **net annual energy and peak demand impacts** associated with 2012 EEB activity.

The EM&V team verified 83 percent of reported gross energy savings and 91 percent of gross peak demand reductions. Figure ES-1 shows the reported and verified gross savings for the PY 2012 EEB Program.

Figure ES-1: Comparison of PY 2012 Reported and Verified Gross Savings



Source: EEB Program database and Navigant analysis

Program Summary

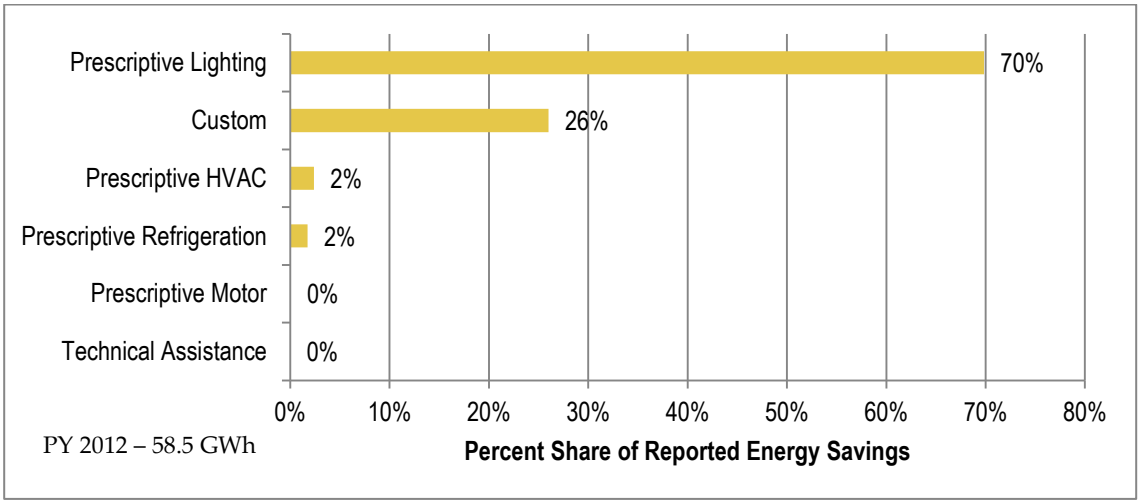
EEB generates energy and peak demand reductions by offering rebates for commercial projects that fall into either the retrofit or new construction category. Within each category, the program offers prescriptive, custom, and technical assistance incentives. Prescriptive incentives provide a fixed dollar amount for a specified unit of measurement (e.g., lamp, ton, or watt reduced). Prescriptive retrofit incentives include lighting, heating, ventilating, and air conditioning (HVAC), custom, and motor measures, while prescriptive new construction incentives are only available for lighting measures. Custom incentives provide a fixed dollar amount per kilowatt-hour (kWh) saved and may include

lighting, HVAC, or other measures that do not meet the program's stated criteria for prescriptive rebates.[1]

DEP maintains a program tracking database that identifies key characteristics of each project, including participant data, measures installed, and estimated energy and peak demand reductions[2] based on assumed ("deemed") savings values. The EEB Program reported 58.5 gigawatt-hours (GWh) of energy savings in 2012.

Prescriptive lighting was the highest contributor to EEB Program energy savings (70 percent), followed by custom measures (26 percent). Prescriptive categories of HVAC, refrigeration, and motors contributed less than 4 percent (combined) to total program energy savings. The EEB Program does not report savings for the technical assistance measure category. Figure ES-2 shows the reported gross savings by measure category.

Figure ES-2: Reported Energy Savings by Measure Category



Source: EEB Program database

Evaluation Methodology

The EM&V assessment of 2012 program activity included impact and process evaluations. The *impact evaluation* focused on lighting and custom measures and included on-site verification of measure quantity and short-term metering of equipment operation.

The *sample* for the PY 2012 evaluation consisted of all paid projects in calendar year 2012. The large share of energy savings (96 percent of the sample) for the prescriptive lighting and custom measure categories is the main driver behind the sampling approach for the PY 2012 evaluation. The EM&V team selected the most cost effective approach and elected to perform engineering reviews (and no on-site visits), for

[1] DEP provided rebates for custom incentives at $0.08/kWh for PY 2012.

[2] "Peak demand reductions" are defined as the reduction in peak power demand that is coincident with the utility system peak.

the non-lighting prescriptive measures ("prescriptive other"), which make up 4 percent of total program savings.

Table ES-1shows the population size, energy savings and target sample size for each measure category. In order to achieve a 10 percent relative precision at a 90 percent confidence interval, the evaluation team targeted 35 lighting sites and 14 custom sites for on-site verification and 10 prescriptive other projects for engineering review.

Table ES-1: Sampling Strata for PY 2012 Evaluation

Strata	Sample Population (# of Sites)	Total Energy Savings for Sample Population (MWh)	Contribution to Total Reported Program Savings for Sample Period	Target Sample Size (# of Sites)[a]
Prescriptive Lighting - Subtotal	796	40,848	70%	35
Custom - Subtotal	226	15,208	26%	14
Prescriptive Other	127	2,436	4%	10
Total	**1,149**	**58,492**	**100%**	**59**

a. Target relative precision is 10% at the 90% confidence interval

Source: Navigant analysis of EEB Program database

The evaluation team also conducted a telephone survey with 155 participants across all measure categories to determine free ridership and spillover in order to calculate a net-to-gross (NTG) ratio. For the *process evaluation,* the evaluation team conducted in-depth interviews (IDIs) with EEB Program staff, implementation contractor (IC) staff, and trade allies.

Program Impact Findings

The program impacts include gross and net verified savings, which are presented in the following sections.

Verified Gross Energy and Peak Demand Savings

Table ES-2 shows the **verified gross savings** and the **reported gross savings** for PY 2012. The relationship between these two values is the "**gross realization rate**," shown here to be 83 percent for energy savings and 91 percent for peak demand reductions.

Table ES-2: PY 2012 Annual Gross Energy and Demand Reductions

	Annual Energy Savings (MWh)	Coincident Peak Demand Savings (MW)
Reported Gross Savings	58,492	13.9
Verified Gross Savings	48,493	12.7
Gross Realization Rate	83%	91%

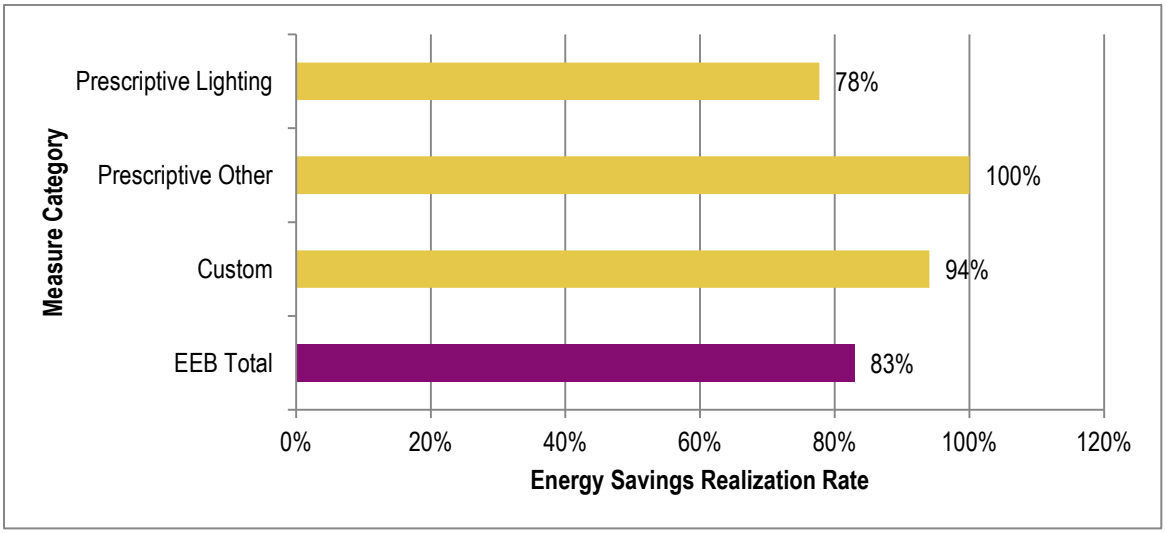
a. The relative precision for verified gross energy savings and peak demand reductions are 9%% and 10%, respectively, at a 90% level of confidence. See Appendix D for discussion of confidence and precision.
b. The EM&V team calculates verified gross savings; these are the final third-party-verified gross savings for the program.
c. Gross realization rate is the ratio of verified gross savings to reported gross savings.

Source: Navigant analysis

For reporting purposes, the evaluation team grouped the EEB Program into three measure categories including prescriptive lighting, custom, and prescriptive other.[3]

Figure ES-3 shows the gross energy savings realization rates for each measure category and the total realization rate for the program year. The prescriptive lighting measure category achieved the lowest realization rate of 78 percent, while the realization rate for the custom measure category was higher at 94 percent. Navigant's engineering review of the prescriptive other projects resulted in a 100 percent realization rate for PY 2012.

Figure ES-3: Gross Energy Savings Realization Rates by Measure Category



Source: Navigant analysis

[3] "Prescriptive other" includes prescriptive HVAC, prescriptive refrigeration, and prescriptive motor categories. The EEB program does not claim savings for technical assistance incentives.

Verified Net Savings

Net savings incorporate the influence of free ridership (savings that would have occurred even in the absence of the program) and spillover (additional savings influenced by the program but not captured in program records) and are commonly expressed as an NTG ratio applied to the verified gross savings values.

The evaluation team estimates free ridership for the EEB Program (i.e., across all measures) at 23 percent of program-reported savings and overall program spillover to be 18 percent of program-reported savings. The resulting NTG ratio is 0.95. The estimated NTG ratio of 0.95 implies that for every 100 MWh of realized savings, 95 MWh are attributable to the program.

Table ES-3 shows the verified net impacts for PY 2012. Table ES-4 compares reported net impacts (using the assumed NTG ratio of 0.85) and verified net impacts for PY 2012.

Table ES-3: PY 2012 Verified Net Impacts

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)
Verified Gross Savings	48,493	12.7
Net-to-Gross Ratio	0.95	0.95
Verified Net Savings	46,067	12.0

Source: Navigant analysis

Table ES-4: Reported and Verified Net Savings

	Reported	Verified
NTG Ratio	0.85	0.95
Net Energy Savings (MWh)	49,718	46,067
Net Summer Coincident Demand Savings (MW)	11.8	12.0

Source: EEB Program database and Navigant analysis

Recommendations

The evaluation team recommends eight discrete actions for improving the EEB Program, based on insights gained through the comprehensive evaluation effort for PY 2012. These recommendations provide DEP with a roadmap to fine-tune the EEB Program for continued success and include the following four broad objectives:

1. Increasing program participation
2. Enhancing marketing/outreach efforts
3. Improving custom measure realization rates
4. Enhancing program evaluation efforts

Table ES-5 summarizes these program recommendations.

Table ES-5: Summary of Recommendations

Increasing Program Participation	
1. Recruit trade allies in rural areas, as well as metropolitan areas	Expand the trade ally network into rural areas in order to capture new participants
2. Use a business segment-targeted approach to marketing	a. Tailor marketing efforts toward specific building types (retail, healthcare, hospitality, etc.) b. Distribute case studies to end users that are specific to their building segment (e.g., gas stations, offices, etc.)
3. Offer prescriptive lighting incentives for LED measures	
4. Consider increasing the incentive amount for prescriptive HVAC measures	
Enhancing Marketing/Outreach Efforts	
5. Implement low-cost marketing strategies for the EEB web site	Periodically include a clickable banner on the utility home page for businesses to "jump to" the EEB page.
Improving Custom Measure Realization Rates	
6. Collect pre-retrofit metering data on projects that retrofit refrigerated cases with doors	There is uncertainty over the projected energy savings for retrofitting existing refrigeration cases with glass doors. DEP can improve realization rates by collecting more information about the energy use of existing cases prior to retrofits.
Enhancing Program Evaluation Efforts	
7. Provide more supporting files with calculations for new construction lighting projects	Customers receive new construction prescriptive lighting incentives based on reductions in lighting power density (W/SF) below code. DEP should include supporting files from software such as COM*check*™ (or similar spreadsheets) with the application.
8. Include more detail in project files on certain prescriptive HVAC and refrigeration measures in project	a. Specify whether the customer installed a variable frequency drive (VFD) on a fan or a pump b. Specify whether the refrigerated case is a low- or medium-temperature case for both Electrically Commutated Motors (ECM) measures and anti-sweat heater control measures

Source: Navigant analysis

1. Introduction

The Energy Efficiency for Business (EEB) Program is part of the portfolio of energy efficiency programs initiated by Duke Energy Progress (DEP), formerly Progress Energy Carolinas (PEC), beginning in late 2008. The EEB Program is available to all DEP business customers, including commercial, industrial, and governmental customers. This program offers cash incentives for prescriptive energy efficiency measures, as well as custom measures in existing buildings. The program offers a performance-based incentive for new construction projects and major renovations that pursue energy efficiency on an integrated, whole-building basis. In addition, technical assistance incentives are available to offset design and engineering costs and for retro-commissioning efforts. This report covers evaluation, measurement, and verification (EM&V) activities for EEB for Program Year 2012 (PY 2012), defined as those receiving rebates during the 2012 calendar year. PY 2012 is the fourth year of the program.

EM&V is a term adopted by DEP and refers generally to the assessment and quantification of the energy and peak demand impacts of an energy efficiency program. EM&V uses a variety of analytic approaches, including on-site verification of installed measures and application of engineering models. EM&V also encompasses an evaluation of program processes and customer feedback, typically conducted through participant surveys.

1.1 Evaluation Objectives

The primary purpose of the impact evaluation is to estimate net annual energy and peak demand impacts associated with 2012 EEB activity. Secondary objectives include the following:

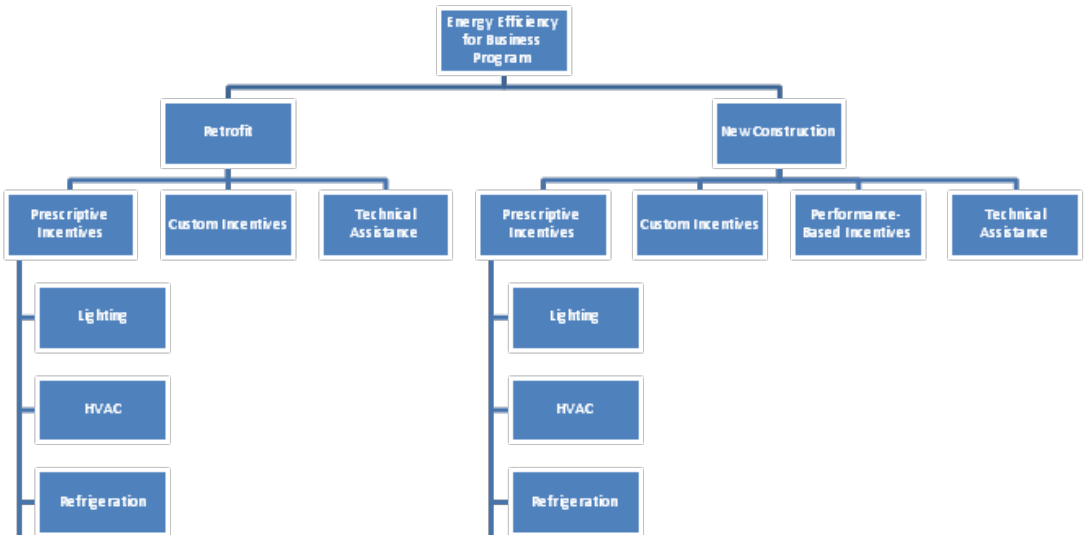
1. Provide gross annual energy and demand impacts of the EEB Program for PY 2012
2. Provide insight into impacts of the program by measure and building type
3. Evaluate the strengths and weaknesses of current program processes through feedback from program staff, implementation contractor staff, and trade allies
4. Recommend improvements to program processes

Ultimately, DEP can use these results for reporting impacts to the North Carolina Utilities Commission (NCUC) and the Public Service Commission of South Carolina and as an input to system planning.

1.2 *Reported Program Participation and Savings*

EEB generates energy and peak demand reductions by offering rebates for commercial projects that fall into either the retrofit or new construction category. Within each category, the program offers prescriptive, custom, and technical assistance incentives. Prescriptive incentives provide a fixed dollar amount for a specified unit of measurement (e.g., lamp, ton, or watt reduced). Prescriptive retrofit and new construction incentives include lighting, heating, ventilating, and air conditioning (HVAC) and refrigeration measures. Custom incentives provide a fixed dollar amount per kilowatt-hour (kWh) saved and may include lighting, HVAC, or other measures that do not meet the program's stated criteria for prescriptive rebates.[4] Figure 1-1 shows the available incentive offerings for retrofit and new construction projects.

Figure 1-1: EEB Incentive Offerings



Source: Navigant

[4] PY 2012 incentives for custom measures are $0.08/kWh.

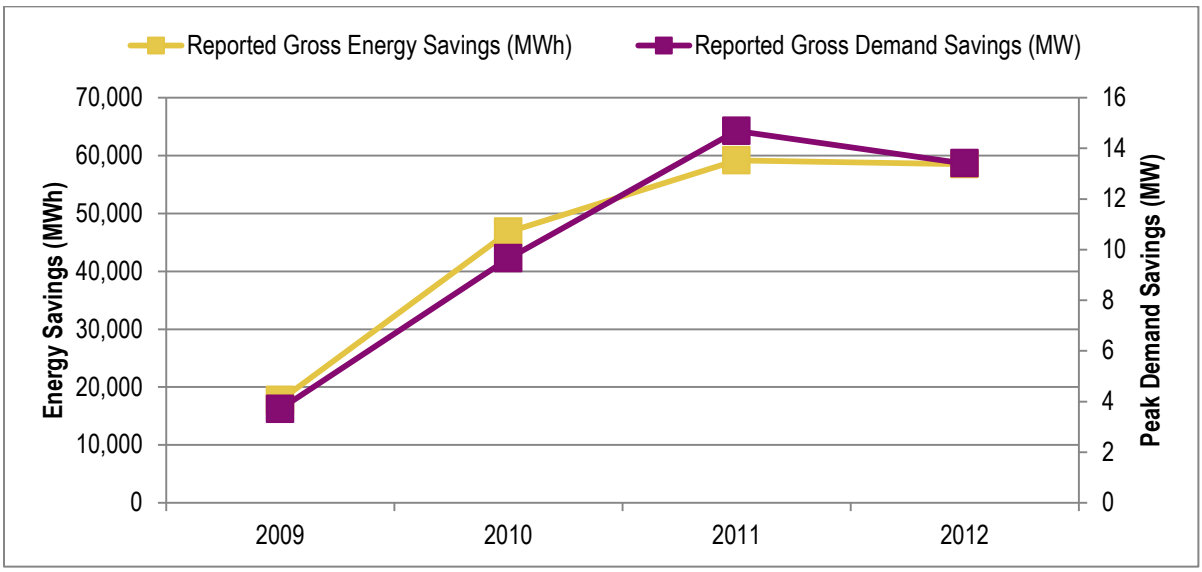
DEP maintains a program tracking database that identifies key characteristics of each project, including participant data, measures installed, and estimated energy and peak demand reductions[5] based on assumed ("deemed") savings values. Table 1-1 provides a summary of gross reported energy and demand savings, as well as participation, for PY 2012. Figure 1-2 charts the energy and demand savings from 2009 (Year 1) through 2012.[6] The program reported approximately 17.7 gigawatt-hours (GWh) in its first year and is reporting approximately 58.5 GWh of energy savings in PY 2012 (fourth year). The following sections of this report provide brief overviews of program activity for PY 2012.

Table 1-1: Reported Participation and Gross Savings Summary

Reported Metrics	PY 2012
Gross Annual Energy Savings (GWh)	58.5
Gross Demand Savings – Summer (MW)	13.9
Participants	1,149
Measures Installed	3,159

Source: EEB Program database

Figure 1-2: Reported Gross Energy and Demand Savings (2009–2012)



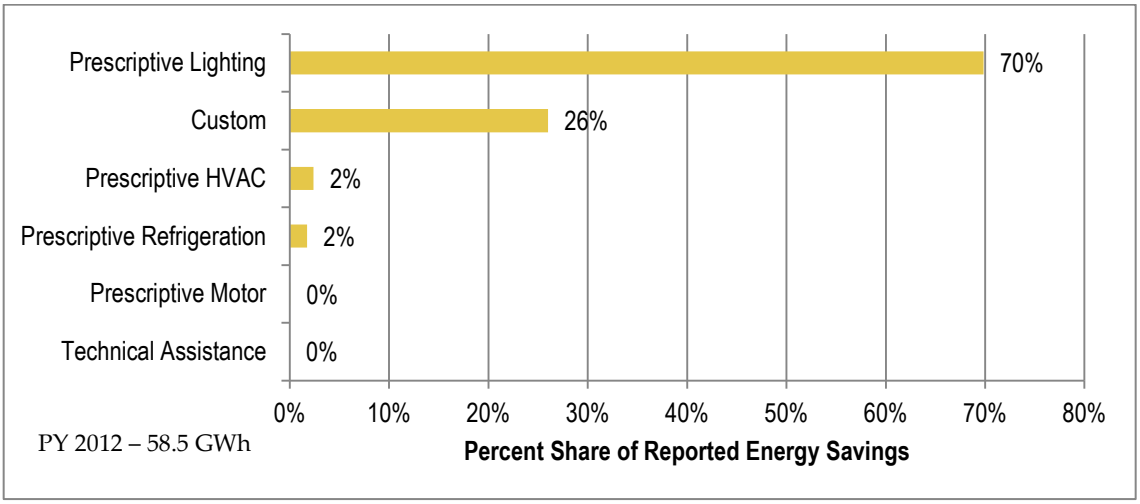
* The chart provides PY 2009 – PY 2011 for comparison only.
Source: EEB Program database

[5] "Peak demand reductions" are defined as the reduction in peak power demand that is coincident with the utility system peak.
[6] This evaluation report only concerns PY 2012. Savings for PY 2009-2011 are shown here to illustrate program trajectory.

1.2.1 PY 2012 Program Summary

Prescriptive lighting was the highest contributor to EEB Program energy savings (70 percent), followed by custom measures (26 percent). Prescriptive categories of HVAC, refrigeration, and motors contributed less than 4 percent (combined) to total program energy savings. Figure 1-3 shows the reported gross savings by measure category. The EEB Program does not report savings for the technical assistance measure category.

Figure 1-3: Reported Gross Energy Savings by Measure Category

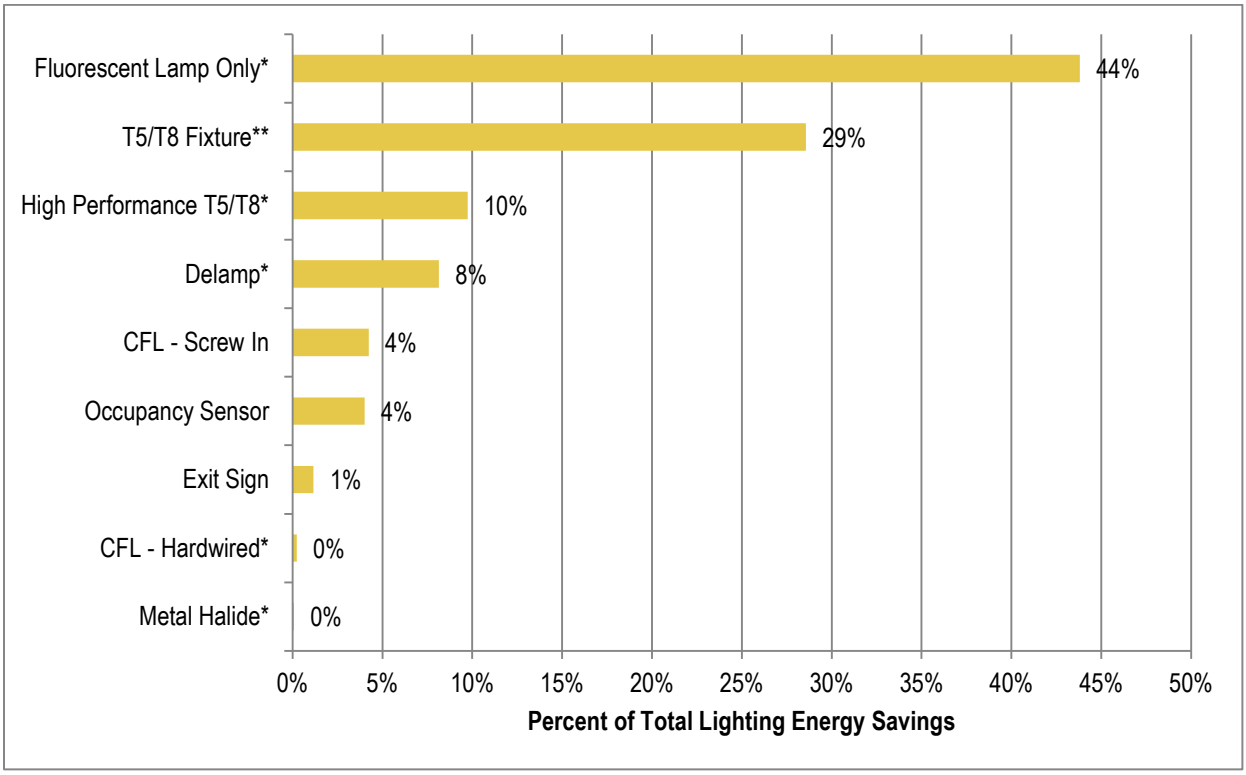


Source: EEB Program database

The major change for PY2012 was the shift to a watts-reduced incentive structure for most lighting measures (except compact fluorescent lamp [CFL] – Screw In, Occupancy Sensor, and Exit Signs). Figure 1-4 shows the reported gross energy savings for prescriptive lighting measures, and denotes the measures eligible for a watts reduced incentive.[7] The fluorescent lamp measure represented the largest share (44 percent) of reported energy savings, with the T5/T8 fixture measure accounting for 29 percent. CFL – Screw Ins make up 4 percent of savings, consistent with the PY 2011 share of 3 percent.

[7] In order to ease the transition for customers that may have already started the application process, customers could apply for incentives for certain measures on either the pre-2012, per-unit incentive or the new, watts-reduced rebate.

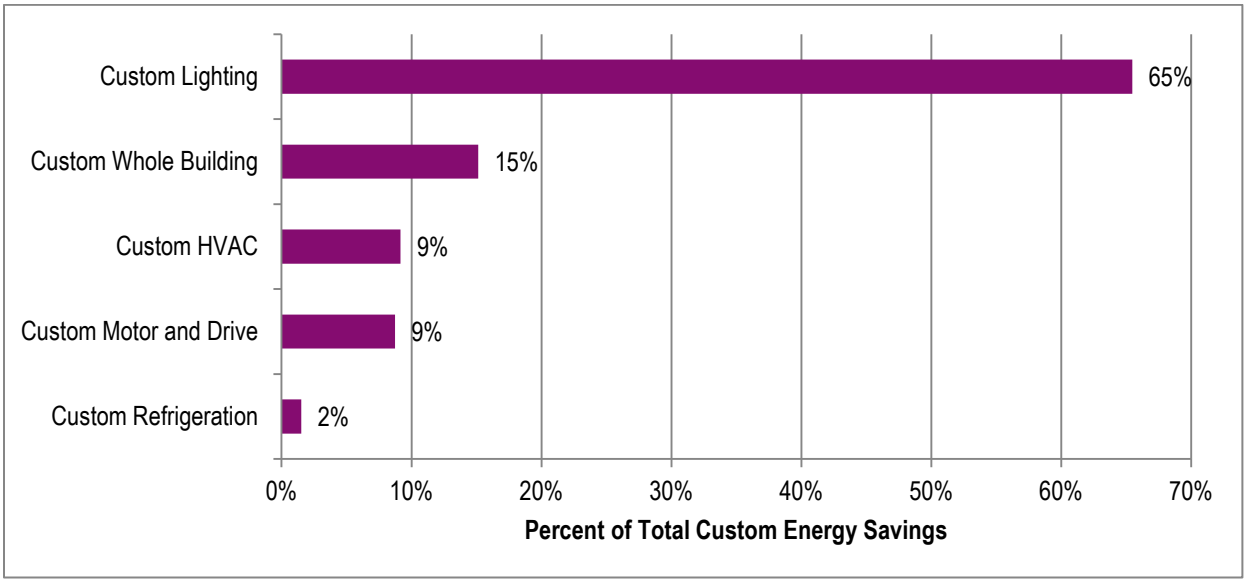
Figure 1-4: 2012 Reported Gross Energy Savings by Lighting Measure Sub-category



**Measures marked with an asterisk were eligible for both the pre-2012 incentive (rebated on a per-unit basis) and the new watts-reduced incentive (rebate is paid per watt reduced). DEP continues to rebate all other measures on a per-unit basis (CFL – Screw In, Occupancy Sensor and Exit Signs).*
***DEP has always rebated the T5/T8Fixture measure per watt reduced.*
Source: EEB Program database

Custom lighting measures accounted for 65 percent of total custom savings in PY 2012, as shown in Figure 1-5. Custom whole-building measures accounted for the next largest share (15 percent), and HVAC and motor/drive measures each accounted for 9 percent of custom savings. Custom refrigeration continues to be a smaller component of the custom projects, contributing only 2 percent to custom savings in 2012.

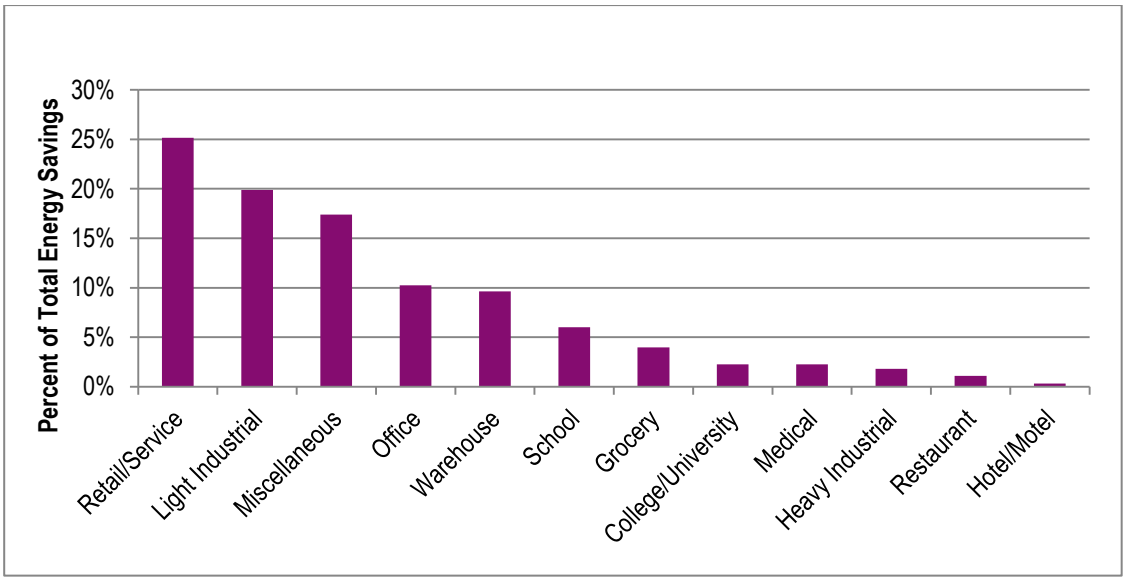
Figure 1-5: Reported Gross Energy Savings by Custom Measure Sub-category



Source: EEB Program database

The EEB Program categorizes participant businesses into one of 12 possible building type designations, and Figure 1-6 shows the distribution for PY 2012.[8] Retail/Service contributed the highest amount of energy savings in 2012, followed by Light Industrial and Miscellaneous buildings.

Figure 1-6: Reported Gross Energy Savings by Building Type



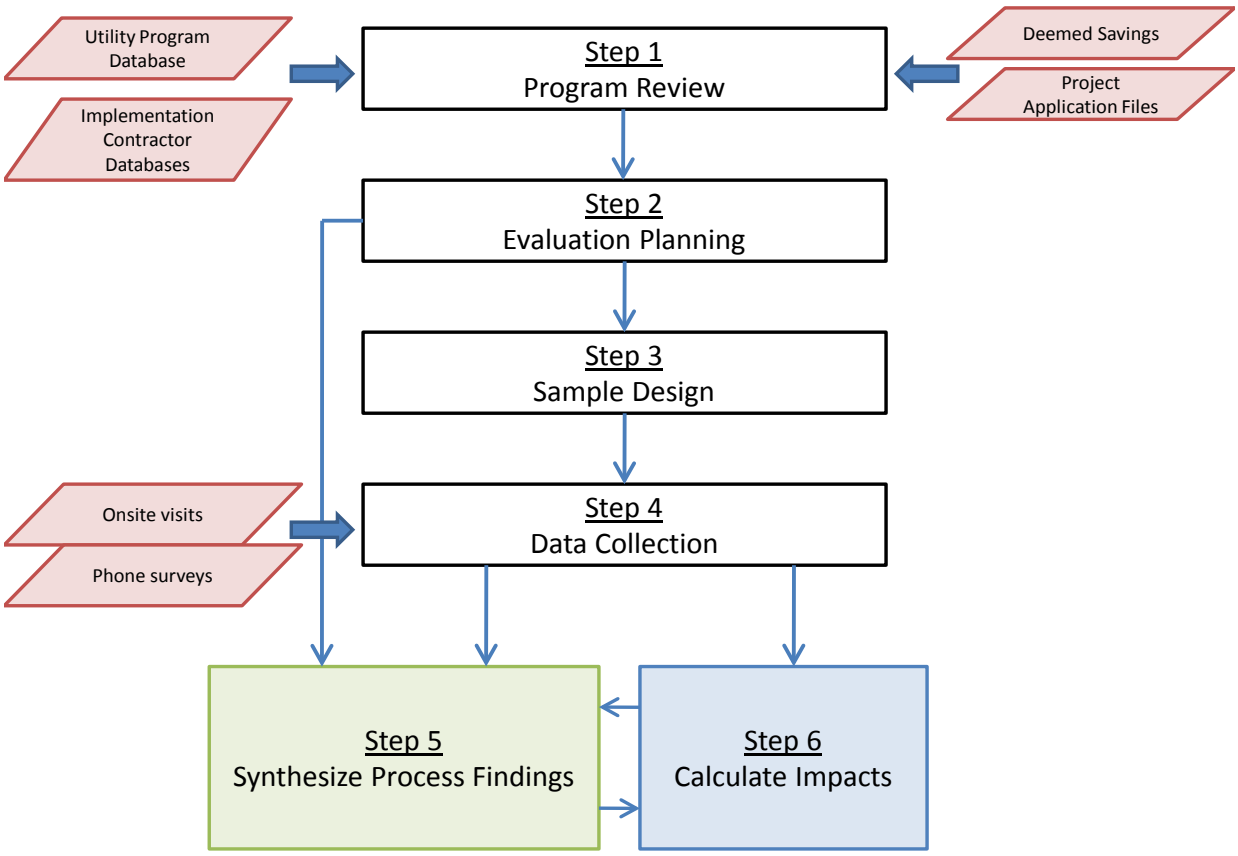
Source: EEB Program database

[8] Buildings can have multiple building type designations, and separate rebates at the same customer site may fall into different categories.

2. Evaluation Methods

Figure 2-1 explains the general process used for evaluating the EEB Program. The following sections provide further detail for each of the individual steps.

Figure 2-1: Evaluation Process Flow Diagram



Source: Navigant analysis

2.1 *Step 1: Review Program Changes*

Navigant Consulting, Inc. ("Navigant") performed the PY 2009 and PY 2010-2011 EM&V efforts and utilized the team's familiarity with the EEB Program to review any changes to operations and procedures for PY 2012. The following is a summary of the review findings:

» As discussed in the preceding Section 1.2.1, DEP now calculates the majority of the prescriptive lighting retrofits based on watts reduced and pays an incentive of $0.35/per watt reduced

    - To ease the transition for customers that may have already started the application process, customers could apply for incentives for certain measures on either the pre-2012, per-unit incentive or the new, watts-reduced rebate

» DEP modified the interaction factor used to calculate prescriptive lighting deemed savings, based on 2010-2011 Navigant recommendations

» DEP adjusted deemed demand savings for prescriptive lighting projects with building type-specific coincidence factors, based on 2010-2011 Navigant recommendations

» Cooling & Heating (HVAC) retrofit prescriptive incentives now qualify for both integrated energy efficiency ratio (IEER) and energy efficiency ratio (EER) ratings to reflect changes in industry ratings and energy code specifications

» New applications under the prescriptive motor incentive are no longer allowed (this category has been eliminated)

Navigant concluded that there were no significant changes to program structure or operations warranting dedicated attention during the PY 2012 evaluation. The evaluation team proceeded to plan the evaluation approach and strategy accordingly, as detailed in the following section.

2.2 Step 2: Evaluation Planning

Evaluation planning consisted of three major steps, which are described below.

» **Analyze Program Tracking Data** – Navigant examined the PY2012 data to determine the measure categories (e.g., Lighting, Custom) on which to focus during the evaluation. The evaluation team also observed trends in the data to detect anomalies or issues that demanded attention during the evaluation.

» **Select Sampling Approaches** – Similar to previous EM&V efforts for the EEB Program, the evaluation team utilized a stratified random sample with ratio estimation. The team grouped projects into nine strata according to measure category and size (kWh savings) and then randomly selected for the sample. The unit of analysis was the estimated ratio of verified savings to reported savings for each sampled project. The evaluation team targeted 35 customer sites for on-site verification of prescriptive lighting measures and 14 sites for on-site verification of custom measures. The team selected ten projects from the prescriptive HVAC and prescriptive refrigeration categories (combined into "prescriptive other"). The team also targeted 185 participants for the net-to-gross (NTG) evaluation via telephone survey (see Section 2.4).

» **Develop Measure Analysis Approach** – Prescriptive lighting and custom measures combined contributed 96 percent of reported energy savings in PY 2012 and were the primary focus of the impact evaluation. The evaluation team utilized engineering review and on-site measurement and verification (M&V) for both lighting and custom measures. The team performed engineering reviews for all "prescriptive other" projects.

2.3 Step 3: Sample Design

The *sample* for the PY 2012 evaluation consisted of all paid projects included in calendar year 2012. The large share of energy savings (96 percent of the sample) for the prescriptive lighting and custom measure categories is the main driver behind the sampling approach for the PY 2012 evaluation. The EM&V team selected the most cost-effective approach and elected to perform engineering reviews (and no on-site visits) for the non-lighting prescriptive measures ("prescriptive other"), which make up 4 percent of total program savings.

Table 2-1 shows the population size, energy savings, and target sample size for each sampling stratum (Table 2-2 provides subtotals for each measure category). In order to achieve a 10 percent relative precision at a 90 percent confidence interval, the evaluation team targeted 35 lighting sites and 14 custom sites for on-site verification and 10 prescriptive other projects for engineering review.

Table 2-1 Sampling Strata for PY 2012 Evaluation

Strata	Sample Population (# of Sites)	Total Energy Savings (MWh)	Contribution to Total Reported Program Savings for Sample Period	Target Sample Size (# of Sites)[a]
Prescriptive Lighting-High Savings	14	11,353	19%	8
Prescriptive Lighting-Medium Savings	88	15,133	26%	13
Prescriptive Lighting-Low Savings	694	14,362	25%	14
Custom-High Savings	12	8,536	15%	6
Custom-Medium Savings	21	3,546	6%	4
Custom-Low Savings	193	3,125	5%	4
Prescriptive Other	127	2,436	4%	10
Total	**1,149**	**58,492**	**100%**	**59**

a. Target relative precision is 10% at the 90% confidence interval.

Source: Navigant analysis of EEB Program database

Table 2-2: Sampling Summary by Measure Category

Strata	Sample Population (# of Sites)	Total Energy Savings for Sample Population (MWh)	Contribution to Total Reported Program Savings for Sample Period	Target Sample Size (# of Sites)[a]
Prescriptive Lighting - Subtotal	796	40,848	70%	35
Custom - Subtotal	226	15,208	26%	14
Prescriptive Other	127	2,436	4%	10
Total	**1,149**	**58,492**	**100%**	**59**

a. Target relative precision is 10% at the 90% confidence interval.

Source: Navigant analysis of EEB Program database

2.3.1 Final Sample Characteristics

The EM&V team conducted on-site verification at a total of 35 prescriptive lighting participant sites, representing 25 percent of the reported energy savings for the prescriptive lighting sample, as shown in Table 2-3.

Table 2-3: Sample Characteristics by Prescriptive Lighting Stratum

Stratum	Sample		Contribution of Stratum Population to Total Reported Energy Savings[a]	On-Site Sample		Contribution of On-Site Sample to Total Reported Energy Savings[a]
	# of Participants	Reported Energy Savings (MWh)		# of Participants	Reported Energy Savings (MWh)	
Lighting – High Savings	14	11,353	28%	8	7,801	19%
Lighting – Medium Savings	88	15,133	37%	13	2,223	5%
Lighting – Low Savings	694	14,362	35%	14	300	1%
Total	**796**	**40,848**	**100%**	**35**	**10,323**	**25%**

a. Total savings of the 2012 sample for all prescriptive lighting measures

Source: Navigant analysis and EEB Program database

Table 2-4 shows the sample characteristics for the custom strata.

Table 2-4: Sample Characteristics by Custom Measure Stratum

Stratum	Sample		Contribution of Stratum Population to Total Reported Energy Savings[a]	On-Site Sample		Contribution of On-Site Sample to Total Reported Energy Savings[a]
	# of Participants	Reported Energy Savings (MWh)		# of Participants	Reported Energy Savings (MWh)	
Custom-High Savings	12	8,536	56%	6	3,452	23%
Custom-Medium Savings	21	3,546	23%	4	602	4%
Custom-Low Savings	193	3,125	21%	4	65	<1%
Total	**226**	**15,208**	**100%**	**14**	**4,118**	**27%**

a. Total savings of the 2012 sample for all custom measures

Source: Navigant analysis and EEB Program database

Table 2-5 provides the stratum, building type, and measure sub-category for each of the 14 sites selected for custom M&V activities. The sample covered nine of the 12 possible building types.

Table 2-5: Custom Sites Included in On-Site Sample

Site ID	Sampling Stratum	Building Type	Custom Lighting	Custom HVAC	Custom Motor and Drive	Custom Refrigeration
13470	High Savings	Light Industrial	X			
13470	High Savings	Light Industrial			X	
105440	High Savings	Office	X			
15520	High Savings	Grocery	X			X
107860	High Savings	School		X		
12100	High Savings	Light Industrial		X		
24720	Medium Savings	Light Industrial		X		
207830	Medium Savings	Miscellaneous	X			
24460	Medium Savings	College/University		X		
23570	Medium Savings	Miscellaneous	X			
30680	Low Savings	Warehouse	X			
31010	Low Savings	Retail/Service	X			
300130	Low Savings	Retail/Service	X			
30000	Low Savings	Retail/Service	X			

Source: EEB tracking data and Navigant analysis

2.4 *Step 4: Data Collection*

The data collection process consisted of three major steps, described in detail in the following sections:

1. **Step 4a: Site visits to randomly selected participant premises.** For both prescriptive lighting and custom sites, evaluation team members conducted visual inspection to verify the quantity and continuing operation of installed measures. For lighting sites, the field technicians then set up data loggers to record lighting hours of usage. For custom sites, the field team developed a site-specific analysis strategy based on a comprehensive review of project files and interviews with EEB Program staff and/or customers. The team then deployed metering equipment to record data specific to the equipment or system included in the rebate. Appendix C contains individual site reports for custom projects, including details on the engineering review, analysis, and on-site metering.

2. **Step 4b: Engineering reviews of randomly selected prescriptive HVAC and Refrigeration projects.** The evaluation team pulled all related project files from the implementer's database and conducted a due diligence review of the files and the tracking database. The main goals of the engineering review were to determine if the deemed savings were applied correctly, to re-calculate incentives and savings to ensure correct tabulation, and to verify equipment quantity and specifications through cut-sheets, invoices, and related project documents.

3. **Step 4c: Telephone surveys of EEB participants**. These surveys focused solely on establishing a NTG ratio. The EM&V team stratified the telephone survey participants in the same manner as the on-site sample and used random selection (except for strata where the team targeted all sites in the stratum, referred to as a *census*).

2.4.1 Step 4a: Customer Site Visits

Navigant performed 49 total site visits, 35 site visits for prescriptive lighting measures and 14 sites for custom measures. The following sections provide an overview of the field data collection. Details on the impact analysis are included in Appendix D.

2.4.1.1 Field Data Collection

Navigant worked with a team of field technicians to complete the on-site portion of the data collection activities. Throughout the fieldwork period, Navigant met with the field teams on a weekly basis to discuss timelines, challenges, and solutions to ensure a consistent level of quality in the field data.

The field technicians grouped customers by location in order to minimize travel time and expense when performing site visits. Site visits typically lasted from a half-day to a full day to complete the verification work at one customer site, depending on the size of the facility. The field technicians followed strict protocols in order to gather the necessary data in a consistent, repeatable, and safe manner across all sites.

The lighting evaluation team performed the following EM&V activities for each site in the sample:

- Performed a comprehensive review of project application files and supporting documents to verify savings calculations and expected quantities of rebated measures
- Performed on-site verification of installation rates
- Metered the time-of-use for a representative number of retrofit lighting fixtures
- Collected fixture details
- Performed on-site customer interviews to collect data on baseline lamp type and wattage, building operation details, and seasonal and holiday schedules
- Recorded data on a standardized set of forms and manually entered into online FACT[9] system for data storage and quality control

[9] Navigant's proprietary Field Activities and Communications Tracker (FACT) system

Figure 2-2 and Figure 2-3 provide examples of the on-site data collection techniques used by the lighting evaluation team.

Figure 2-2: Example of Time-of-Use Lighting Loggers

Collecting Time-of-Use Lighting Data

Gross savings from lighting measures were determined from a few key parameters, including hours of use and coincidence factors. State loggers, which detect a state change via transition through a predefined light or current threshold, were used on-site to collect this information. These devices provide time-of-use data for the metered fixtures by creating a time stamp for every state change.

Source: Navigant

Figure 2-3: Example of On-Site Lighting Verification

On-site Verification of Installed Equipment

During the site visits, field technicians opened accessible retrofit fixtures to record and evaluate fixture details. This included lamp and ballast types, counts, manufacturer name and model number. The team also counted removed or burnt-out lamps.

Source: Navigant

The custom evaluation team performed an in-depth review of project files and then developed site-specific analysis and metering plans to capture the data specific to each customer site (see Appendix C for individual site reports).

2.4.2 Step 4b: Prescriptive HVAC and Refrigeration Engineering Review

The evaluation team randomly selected ten projects for engineering review from the prescriptive HVAC and refrigeration measure categories, distributed across High, Medium and Low Savings strata, as shown in Table 2-6.

Table 2-6: Prescriptive Other Sample

Site ID	Sampling Stratum	Building Type	Prescriptive HVAC	Prescriptive Refrigeration
75080	High Savings	Grocery		X
74780	High Savings	Grocery		X
74900	High Savings	Light Industrial	X	
82500	Medium Savings	Retail/Service	X	
81260	Medium Savings	Retail/Service	X	
80040	Medium Savings	Grocery		X
90000	Low Savings	Retail/Service	X	
90040	Low Savings	School	X	
900460	Low Savings	Office	X	
900100	Low Savings	Retail/Service		X

Source: EEB tracking data and Navigant analysis

The EM&V team performed the following steps for each sampled project:

- Review application and all associated files
  - Ensure measure is consistent between application and tracking data
  - Ensure the measure sub-category and threshold are correct (e.g., correct EER level, etc.)
  - Verify measure quantity in tracking data matches application files
  - Verify measure specifications (e.g., efficiency, capacity, etc.) match supporting files (e.g., invoices, etc.)
- Re-calculate the deemed energy and demand savings and ensure the result matches tracking data
- Re-calculate the deemed incentive level and ensure the result matches tracking data
- Review per-unit deemed savings value for each measure and ensure the baseline is applicable and meets current energy code

The EM&V team assigned a 100 percent realization rate to a project that meets all the above criteria. If a project fails to meet a certain criteria, then the team would re-calculate the savings using the corrected inputs and determine a verified realization rate greater or less than 100 percent.

2.4.3 Step 4c: Telephone Surveys

The evaluation team contacted a sample of customers and conducted a survey lasting approximately 15 minutes. The focus of the survey was to determine free ridership and spillover among EEB customers in order to calculate a NTG ratio. The results of the NTG survey are included in Section 3.5.

The telephone surveys targeted program participants across seven strata covering all measure categories, as shown in Table 2-7. The EM&V team utilized the same strata developed for the on-site sample and added one strata to cover prescriptive measures other than lighting (i.e., HVAC, refrigeration, and motors). The survey effort targeted 185 participants and successfully completed surveys with 155 customers.

Table 2-7: Telephone Survey Sample Disposition

Stratum	Population (Number of Sites)	Target Completes	Completed Surveys
Prescriptive Lighting—High Savings	14	14	7
Prescriptive Lighting—Medium Savings	88	30	30
Prescriptive Lighting—Low Savings	694	40	44
Prescriptive—Other[a]	126	44	24
Custom—High Savings	12	12	7
Custom—Medium Savings	21	15	11
Custom—Low Savings	193	30	32
Total	**1,148**	**185**	**155**

a. Prescriptive—Other category includes prescriptive HVAC, refrigeration, and motor measure categories.

Source: Navigant analysis

2.5 *Step 5: Process Analysis*

For PY 2012, the evaluation team conducted in-depth interviews (IDIs) with EEB Program staff, implementation contractor (IC) staff, and trade allies. The interviews with program and IC staff included a review of the recommendations from previous EM&V reports and the actions taken, as well as qualitative and quantitative questions on customer satisfaction, participation, marketing, and outreach. The trade ally interviews included obtaining feedback on the following items: the impact of the EEB Program on their business, trainings, marketing and outreach, customer decision-making, the IC, satisfaction, recommendations, and impact of the Duke-Progress Energy merger on the EEB Program. The evaluation team delivered the results of these process evaluations to the DEP staff, EEB Program staff, and the IC staff during the evaluation period. Section 4 includes the results of the process evaluation.

2.6 *Step 6: Impact Analysis*

The objective for the impact evaluation was to verify the reported annual energy and peak demand savings and to provide net annual energy and demand impacts of the EEB Program for PY 2012.

2.6.1 Step 6a: Gross Impact Analysis

Navigant utilized the stratified ratio estimation method to determine program-level savings from a selected sample of projects. Results from the sample within each of the sampling stratum were extrapolated to the population of the appropriate stratum, and these extrapolated results were added together to estimate program savings. Appendix D includes additional details on the impact analysis methodology.

Upon completion of the site visits, the EM&V team took the following steps to complete the impact analysis:

- **Review Field Data** — The evaluation team reviewed field data collection forms and online data entry as part of the quality control process**.**
- **Conduct Engineering Review** – The team examined all relevant project documents, including project applications, DEP inspection forms, supporting calculation worksheets, and communications (e.g., customer to implementation contractor) to extract data necessary to verify savings.
- **Review Logger Data** – The evaluation team collected Logger Data, representing hours of lighting operation, at each site for approximately 1-2 months between March 2013 and May 2013. The evaluation team reviewed all logger files, discarded unusable data, cleaned usable data, and visually inspected each file for reasonableness.
- **Extrapolate Logger Data** – The evaluation team generated annual lighting operating hours for each site by extrapolating the data recorded over the metering period to a full year.
- **Calculate Site-Level Savings** – The EM&V team applied the data collected from the field and the engineering review to calculate energy and demand savings at each site. The analysis utilized a standard set of algorithms for lighting measures and a measure-specific approach for custom projects.
- **Calculate Program-Level Savings** – The evaluation team extrapolated site-level savings for the sampled group within each of the strata to the appropriate stratum, and added the results together to determine the total verified program savings. The team then calculated a realization rate, calculated as the ratio of the total verified savings to the total reported savings.

2.6.2 Step 6b: Net Impact Analysis

Navigant used results of the participant survey to estimate a NTG ratio for the program by combining free ridership and spillover estimates. Program participants indicated whether, in the absence of the program, they would have wanted to install the same high-efficiency measures, even if they had not participated in the program or been influenced by the program in any way. Survey participants also indicated whether the program had influenced them to install additional energy- efficient measures. Appendix E provides a description of the methodology for estimating NTG ratios.

The overall NTG ratio accounts for both the net savings at participating projects and spillover savings that result from the program but are not included in the program's accounting of energy savings. When the EM&V team multiplies the NTG ratio by the estimated gross program savings, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program). The basic equation appears in Equation 2-1.

Equation 2-1: Calculation of Net-to-Gross Factor

$$NTG = 1 - free\ ridership + spillover$$

The underlying concept inherent in the application of the NTG formula is that *only* savings caused by the program should be included in the final net program savings estimate but that this estimate should include *all* savings caused by the program.

3. Program Impacts

DEP's program tracking database provided savings values for energy and peak demand ("**reported gross savings**") based on program participation data and assumed unit savings, or **"deemed savings"**, values. As discussed in Section 2, the EM&V team verified the accuracy of these reported savings values for each measure category using comprehensive review of project files and on-site data collection to conduct field verification of measure installations. The result is a set of **verified gross savings** by measure and for the program as a whole.

The term **"gross savings"** refers to reductions in energy consumption and peak demand based on engineering estimates for known quantities and types of measure installations. Gross savings do not account for whether the measures were installed as a result of the program.[10]

The glossary in Appendix A provides brief definitions of commonly used EM&V terms.

Table 3-1 compares the **verified gross savings** to the **reported gross savings** for PY 2012. The relationship between these two values is the "gross realization rate," shown here to be 83 percent for energy savings and 91 percent for peak demand reductions.

These gross realization rates resulted in verified gross savings of 48.5 GWh and 12.7 MW in PY 2012. The EM&V team also estimated a NTG ratio of 0.95, which resulted in verified net energy savings of 46.1 GWh and verified net demand savings of 12.0 MW for PY 2012 (see Section 3.5).

Table 3-1: 2012 Annual Gross Energy and Demand Reductions

	Annual Energy Savings (MWh)	Coincident Peak Demand Savings (MW)
Reported Gross Savings	58,492	13.9
Verified Gross Savings	48,493	12.7
Gross Realization Rate	83%	91%

a. The relative precision for verified gross energy savings and peak demand reductions are 9% and 10%, respectively, at a 90% level of confidence. See Appendix D for discussion of confidence and precision.

Source: Navigant analysis

[10] Savings attributable to the program can be adjusted for free ridership and spillover/market effects. Section 3.5 addresses free ridership and spillover.

The remainder of this chapter presents the detailed impact findings broken down into the following parts:

1. **Verified gross savings by measure category:** The verified savings across the four major measure categories
2. **Prescriptive lighting verification results:** The summary of findings from field verification of prescriptive lighting measures; Appendix B contains detailed findings for lighting measures
3. **Custom measure verification results:** The summary of findings from field verification of custom measures; Appendix C contains detailed reports from each custom site in the sample
4. **Prescriptive HVAC/Refrigeration verification results:** The summary of findings from engineering review of measures in the "prescriptive other" sampling stratum
5. **Net savings analysis:** The results of the free ridership and spillover assessment of the EEB Program

3.1 Verified Gross Savings by Measure Category

For reporting purposes, the evaluation team grouped the EEB Program into the following three measure categories:

- **Prescriptive Lighting** – Includes all prescriptive lighting measures
- **Custom** – Includes custom HVAC, custom motor and drive, custom lighting, and custom refrigeration
- **Prescriptive Other** – Includes prescriptive HVAC, prescriptive refrigeration, and prescriptive motor categories

Table 3-2 shows PY 2012 reported and verified energy savings for each measure category.[11] The prescriptive lighting measure category achieved the lowest realization rate of 78 percent, while the realization rate for the custom measure category was significantly higher at 94 percent. Navigant's engineering review of the prescriptive other projects resulted in a 100 percent realization rate for PY 2012.

Prescriptive lighting and custom measures were included in the field verification sample, and Section 3.2 and Section 3.3, respectively, provide detailed findings.

Table 3-2: 2012 Annual Gross Energy Savings by Measure Category

Measure Category	Reported Gross Energy Savings (MWh)	Realization Rate	Verified Gross Energy Savings (MWh)
Prescriptive Lighting	40,848	78%	31,752
Custom	15,208	94%	14,305
Prescriptive Other[a]	2,436	100%	2,436
Total	**58,492**	**83%**	**48,493**

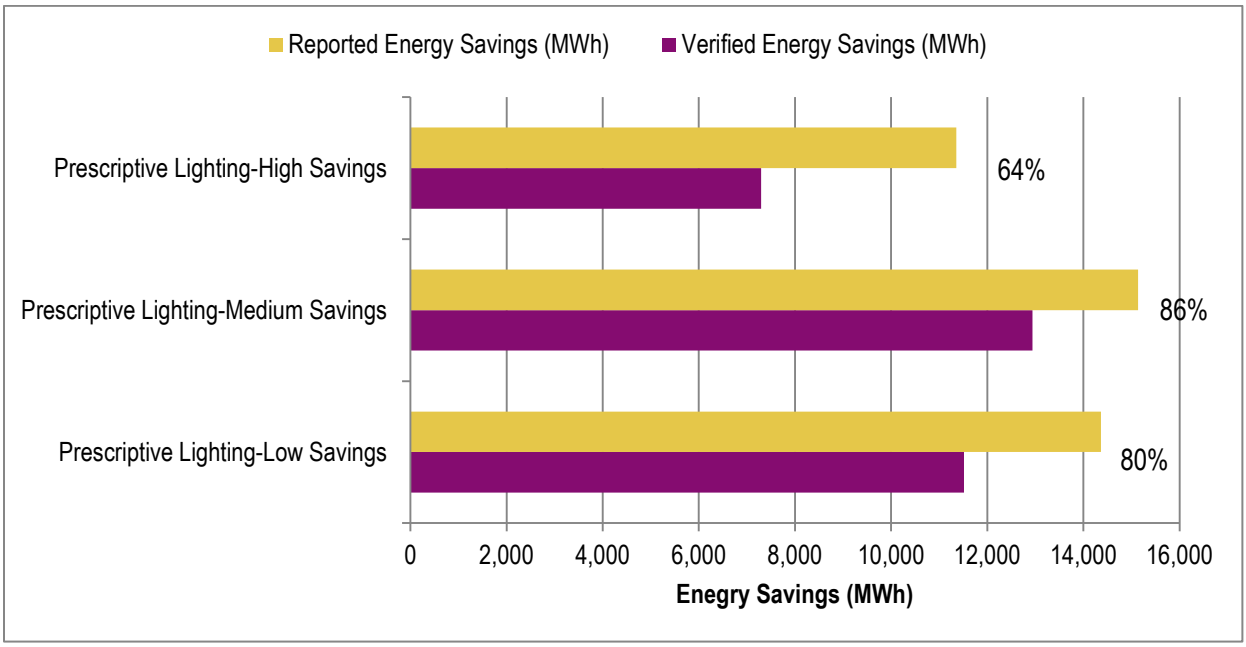
Source: Navigant analysis

[11] Appendix B contains the results for verified peak demand savings by measure category.

3.2 *Prescriptive Lighting Verification Results*

Figure 3-1 shows the verified energy savings results for the prescriptive lighting strata. As shown in the preceding section, the gross realization rate for all prescriptive lighting projects was 78 percent. The High Savings stratum achieved a 64 percent realization rate, primarily due to several large projects with low metered operating hours. The Medium and Low Savings strata achieved, respectively, 86 percent and 80 percent realization rates. Appendix B provides detailed results for all sampled sites within each stratum.

Figure 3-1: Reported and Verified Gross Savings by Prescriptive Lighting Stratum[a]



a. Percentage values represent gross realization rates for each stratum.
Source: EEB Program database and Navigant analysis

3.2.1 Prescriptive Lighting Field Verification Rates

This section examines findings from the evaluation of lighting measures in order to identify the main drivers of the final verified savings values. The following is a summary of the key findings. Appendix B provides detailed findings for the prescriptive lighting field verification rates.

The EM&V team uses the **field verification rate** (FVR) to describe the overall verified savings relative to the reported savings for each measure. FVRs reflect differences between the quantity of equipment installed on-site and the quantity reported in the program tracking database, as well as differences between operating characteristics verified in the field and assumed operating characteristics in the program deemed savings estimates. The EM&V team calculates the field verification rate as the product of the In-Service Rate and the Measure Characteristic Verification Rate, described as follows:

1. **In-Service Rate**[12] **(ISR)** is the ratio of the verified (i.e., installed) quantity to the reported quantity. For lighting measures, the ISR reflects disparities in quantity of installed lamps, fixtures, or *Watts Reduced* (for T5/T8 Fixture and Fluorescent Lamp Only) between the program database and actual, on-site conditions verified by the EM&V team. Section 3.2.1.1 summarizes the measure-level ISRs.

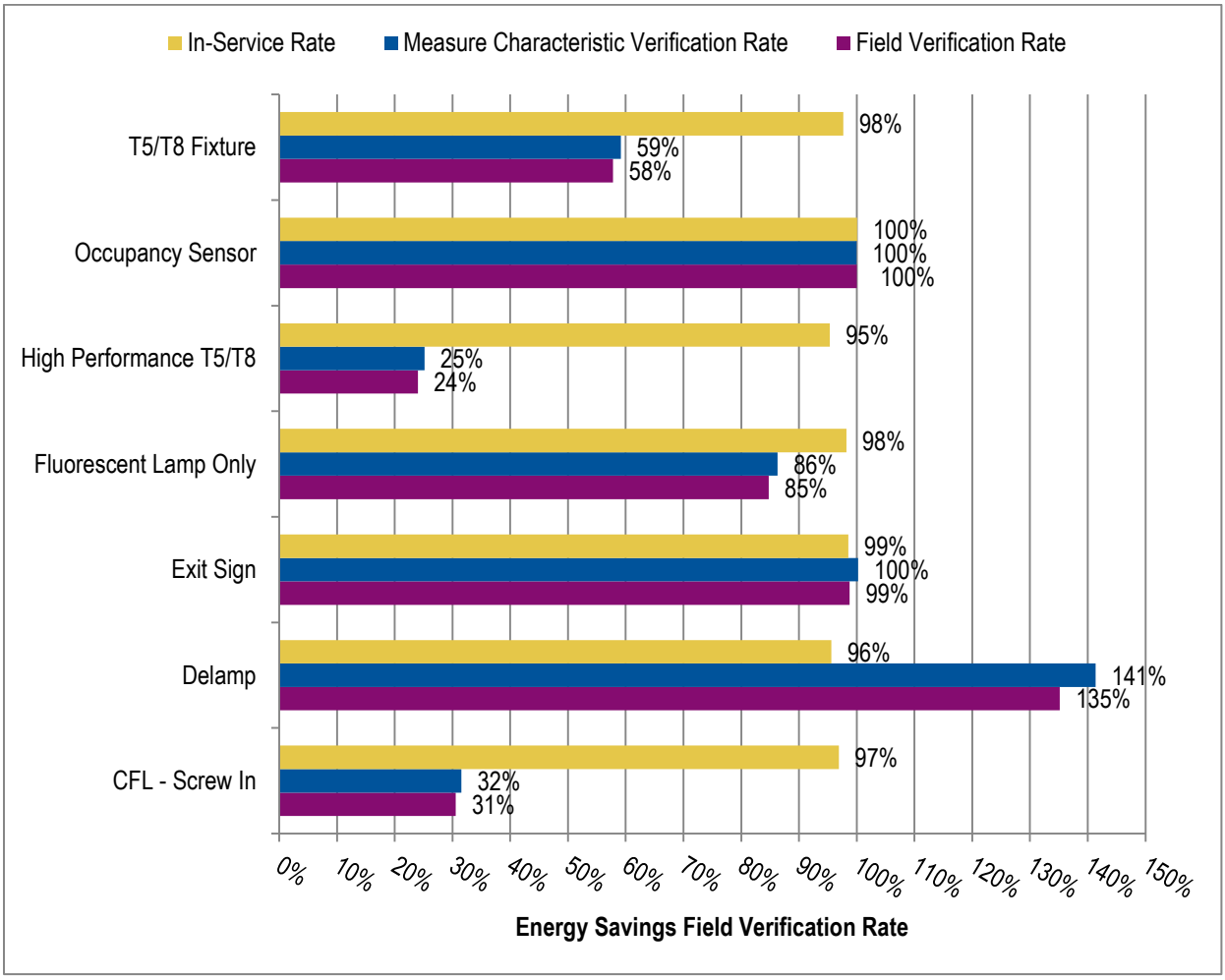
2. **Measure characteristic verification rate (MCVR)** reflects discrepancies between reported and verified *characteristics related to the operating conditions* (e.g., operating hours, coincidence factors). A measure can have different rates for energy savings or peak demand reductions. Appendix B provides the MCVR findings.

The EEB Program rebated nine unique types of lighting measures in 2012, yet two measures, Fluorescent Lamp Only and T5/T8 Fixture, accounted for nearly 75 percent of total savings for the lighting category (see Section 1.2.1). The field verification rate for the T5/T8 Fixture measure is 58 percent, while the FVR for the Fluorescent Lamp Only measure is 85 percent, as shown in Figure 3-2. The FVRs for these two measures are primarily driven by low verified operating hours and differences between the lamp wattages verified on-site and those in the deemed savings values (see Appendix B for discussion of verified operating hours and measure characteristics).

The MCVR is effectively 125 percent for the permanent lamp removal (delamp). This is due to a small sample size and high verified hours at those sites. The field verification rate for occupancy sensors and exit sign measures is nearly 100 percent. The evaluation team verified a 97 percent ISR for the CFL – Screw In measure but an MCVR of 31 percent, due to low operating hours at primarily one site (ID-48640). This site accounted for over 96 percent of the total CFL bulbs rebated among the sampled sites. The evaluation team verified an MCVR of 24 percent for the High Performance T5/T8, primarily due to low operating hours and lower watts reduced between the verified retrofitted fixture and their baseline fixture.

[12] In-Service Rate is an industry-standard term that describes verified quantities of installed equipment relative to reported quantities.

Figure 3-2: Gross Energy Savings Field Verification Rates



Source: Navigant analysis

The remainder of this section discusses the prescriptive lighting ISRs. Appendix B contains a detailed discussion of the measure characteristic verification rates for energy and demand savings.

3.2.1.1 In-Service Rates

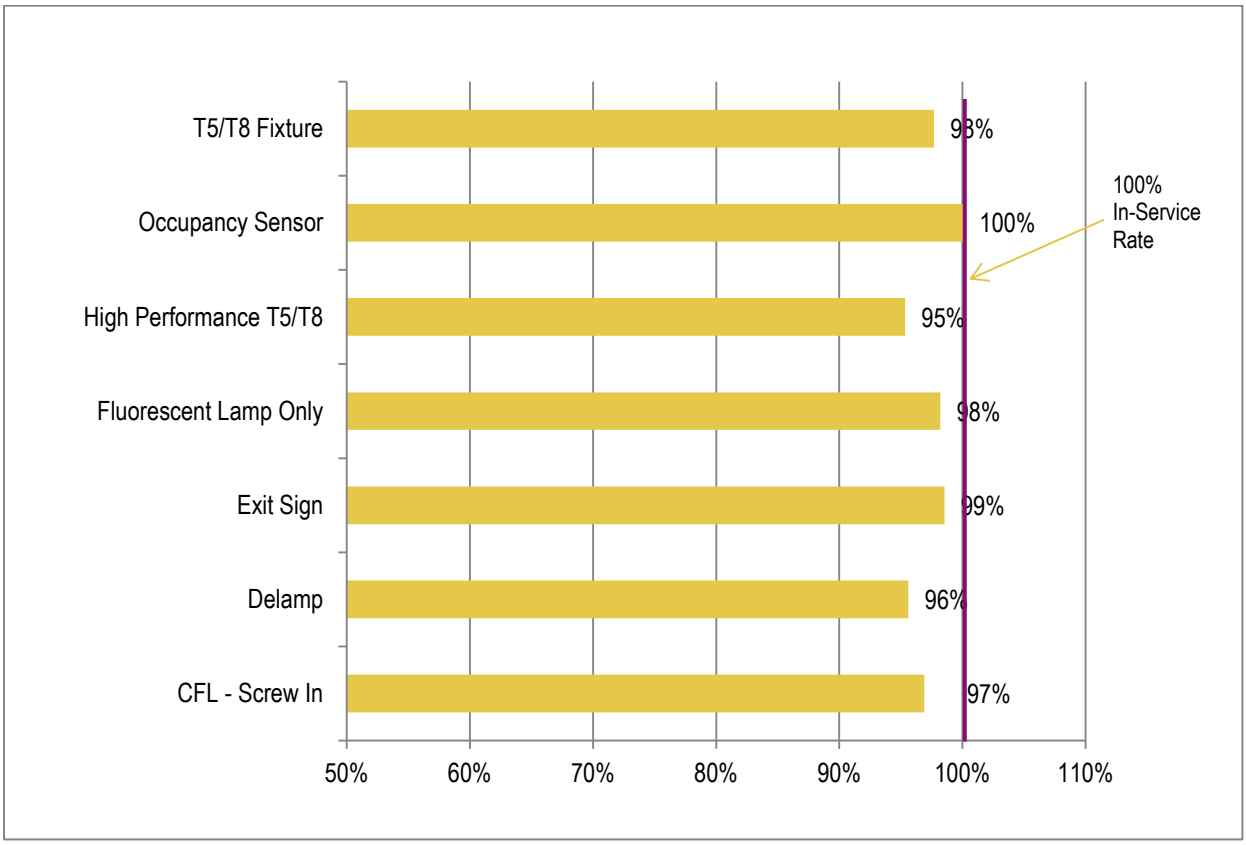
One of the primary functions of evaluation, particularly for lighting, is to verify the quantity of the installed equipment relative to the reported quantity. The resulting ratio is the ISR.[13]

Figure 3-3 shows the verified ISRs for sampled lighting measures.[14] All measures have ISRs at or above 95 percent. The evaluation team did not encounter any individual sites having significant issues with

[13] Measure-level ISRs are used to provide feedback to the EEB program and are not currently applied to past or future program years as measure-level "adjustment factors".

fixtures or lamps missing. In a few cases, the building operator indicated that a very small number of the lamps were never installed that were part of the rebate. At some of the more complex sites, the application paperwork was missing location information, making it difficult for evaluators to locate every retrofitted measure on-site. The EM&V team verified 100 percent of the reported occupancy sensors at all sites.

Figure 3-3: Prescriptive Lighting In-Service Rates



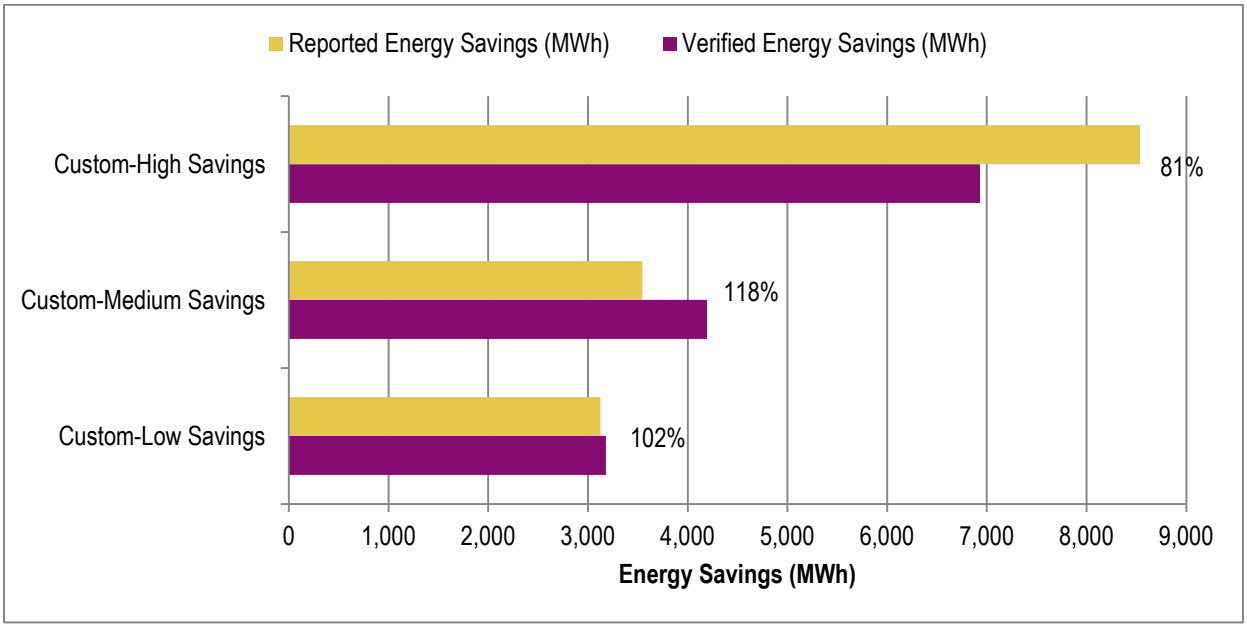
Source: Navigant analysis

3.3 *Custom Measure Verification Results*

The evaluation team calculated an overall gross realization rate of 94 percent of reported energy savings for custom measures (see Section 5). The driving factors for this result are an 81 percent realization rate for the High Savings stratum and realization rates of 118 percent and 102 percent, respectively, for the Medium and Low Savings strata. Figure 3-4 shows the verified energy savings and realization rates for the three custom strata.

[14] This chart shows seven of the nine measures rebated during the sample period. The two not shown are Metal Halide and CFL-Hardwired measures. The random sample did not include any sites with the CFL-Hardwired measure or Metal Halide measure.

Figure 3-4: Reported and Verified Savings by Custom Stratum



Source: Navigant analysis

The overall energy savings realization rate for the custom measure category significantly improved over the 2010-2011 program years (71 percent). One of the key drivers is that the EEB team implemented key recommendations from the past evaluation cycle, including performing more post-installation "auditing" of project performance data (utility bills, trend logging, etc.), prior to finalizing reported savings figures.

The High Savings stratum experienced the lowest realization rate, primarily due to a large refrigeration project that (a) overestimated the savings from retrofitting existing cases with glass doors, (b) overestimated the savings from anti-sweat heater controls, and (c) failed to realize projected savings from motion-sensing controls on case lighting. Another key project in this stratum was a commercial lighting project that involved retrofitting T12 lights with LED tube-lights (LEDs are not a prescriptive measure). The baseline calculations assumed 100 percent of fixtures were operating during occupied hours, and post-retrofit investigation and metering verified that substantially fewer lights operated during occupied hours.

The Medium and Low Savings strata both have realization rates greater than 100 percent, with one project in the Medium stratum realizing twice the reported energy savings, due to a significant underestimating of fan energy savings in an HVAC controls project.

Appendix C includes a summary of the results for each stratum, as well as the individual site reports for all custom projects in the sample.[15]

[15] Appendix B provides the demand savings for custom projects.

3.4 Prescriptive HVAC/Refrigeration Verification

The evaluation team performed the verification steps outlined in the preceding Section 2.4.2 for each sampled project in the "prescriptive other" category (which includes HVAC and refrigeration projects). Navigant determined that all projects met the evaluation criteria and assigned each sampled project a realization rate of 100 percent.

The evaluation team observed the following items that warrant attention in PY 2013:

- Prescriptive variable frequency drive (VFD) projects do not always specify whether the customer installed a VFD on a fan or a pump. This information is necessary if the evaluation team performs on-site verification in future program years.
- Projects involving Electrically Commutated Motors (ECMs) in existing refrigerated cases need to specify whether the case is a low- or medium-temperature case. This information is necessary in order to calculate project-specific savings in future evaluation cycles.
- Projects involving anti-sweat heater controls in existing refrigerated cases need to specify whether the case is a low- or medium-temperature case. This information is necessary in order to calculate project-specific savings in future evaluation cycles.

DEP should note that, in mid-2012, the state of North Carolina adopted a new commercial energy code, the *2012 North Carolina Energy Conservation Code*, which is based primarily on the 2009 International Energy Conservation Code (IECC) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 90.1-2007.[16] The evaluation team reviewed the deemed savings for prescriptive HVAC measures and determined that the current deemed savings are already based on ASHRAE 90.1-2007 baselines. However, Navigant will review the new energy code in greater detail for the PY 2013 evaluation and cross-check all prescriptive HVAC measures to ensure DEP is using the proper baseline efficiency levels.

3.5 Net Savings

The impact analysis described in the preceding sections addresses *gross program savings*, based on program records and modified by an engineering review and field verification of measure installations. *Net savings* incorporate the influence of free ridership (savings that would have occurred even in the absence of the program) and spillover (additional savings influenced by the program but not captured in program records) and are commonly expressed as a NTG ratio applied to the verified gross savings values.

This section displays the high-level results of the NTG analysis, and Appendix E provides definitions, methods, and further detail on the analysis and findings.

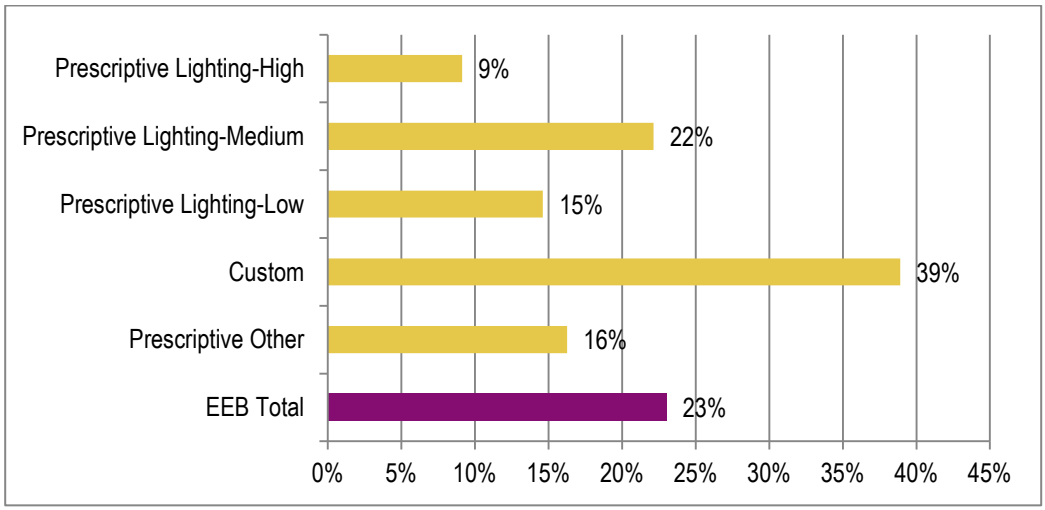
[16] Due to the mid-year adoption, Navigant determined that the previous energy code is the correct application for PY 2012 projects. The code is available for viewing here: http://ecodes.biz/ecodes_support/free_resources/2012NorthCarolina/Energy/12NC_Energy.html

3.5.1 Free Ridership

The evaluation team asked a series of questions to participants regarding the likelihood, scope, and timing of the investments in energy efficiency if the respondent had not participated in the program. The purpose of the surveys was to elicit explicit estimates of free ridership and perspectives on the influence of the program. Figure 3-5 shows the free ridership estimates for each measure category. The free ridership scores range from 9 percent for the Lighting-High Savings stratum to a high of 39 percent for the Custom stratum. The Prescriptive Other measures averaged 16 percent free ridership.

The evaluation team estimates free ridership for the EEB Program (i.e., across all measures) at 23 percent of program reported savings, weighting the measure-specific free ridership values according to each category's share of total savings. The weighted free ridership for the prescriptive lighting measure category is 16 percent, and lighting represents 70 percent of all program savings. Thus, these low free ridership values for prescriptive projects drive program-wide free ridership more than the higher free ridership value (39 percent) for custom projects.

Figure 3-5: Free Ridership by Measure Category



Source: Navigant analysis

3.5.2 Spillover

The EEB Program influenced approximately 21 percent of participants to install additional energy efficiency measures on-site and influenced 14 percent to install additional measures at other locations. On average, respondents reported spillover savings to be approximately 54 percent of the savings from the program-incented project. The EM&V team discounted the reported impact of spillover by 50 percent to account for uncertainty in the self-reported energy savings. Based on the survey findings, the EM&V team estimates the overall program spillover to be 18 percent of program reported savings.

3.5.3 Net-to-Gross Ratio

Equation 3-1 defines the NTG ratio, which represents the ratio of net savings to gross savings:

Equation 3-1: Calculation of Net-to-Gross Factor

$$NTG = 1 - free\ ridership + spillover$$

Using the overall free ridership value of 23 percent and the overall spillover value of 18 percent, the NTG ratio is 1 – 0.23 + 0.18 = 0.95. The estimated NTG ratio of 0.95 implies that, for every 100 MWh of realized savings recorded in EEB records, 95 MWh is attributable to the program.

Table 3-3 displays the free ridership, spillover, and NTG scores by stratum and for the program as a whole.

Table 3-3: EEB Free Ridership, Spillover, and NTG Ratio

Measure Category	Free Ridership	Spillover	NTG Ratio
Prescriptive Lighting-High	9%	18%	1.09
Prescriptive Lighting-Medium	22%		0.96
Prescriptive Lighting-Low	15%		1.03
Custom[a]	39%		0.79
Prescriptive Other	16%		1.02
EEB Total [b]	**23%**		**0.95**

a. Custom strata of high, medium, and low energy savings are combined into one measure category for the net savings analysis, due to smaller sample sizes.
b. EEB Total values for free ridership, spillover, and NTG are weighted values, calculated based on each category's share of total energy savings. The results by category represent the simple average of free ridership values for respondents within each category.

Source: Navigant analysis

3.5.4 Verified Net Savings

The EM&V team applied the resulting NTG ratios to each measure category and to the program as a whole. Table 3-4 shows the verified net savings by measure category for PY 2012. Total verified net energy savings are 46,067 MWh for PY 2012.

Table 3-4: PY 2012 Verified Net Savings by Measure Category

Measure Category	Verified Gross Energy Savings (MWh) [A]	Net-to-Gross Ratio [B]	Verified Net Energy Savings (MWh)[a] [C = A x B]
Prescriptive Lighting[b]	31,752	1.02	32,441
Custom	14,305	0.79	11,323
Prescriptive Other	2,436	1.02	2,479
Total	48,493	0.95	46,067

a. The sum of the verified net energy savings across all measure categories does not equal total net verified savings shown, due to rounding.
b. The NTG ratio for the prescriptive lighting category is the weighted average of the NTG ratios for all lighting strata.

Source: EEB Program database and Navigant analysis

Table 3-5 shows the program-level verified net impacts for energy and demand savings for PY 2012.

Table 3-5: PY 2012 Verified Net Impacts

	Annual Energy Savings (MWh)	Summer Coincident Demand Savings (MW)
Verified Gross Savings	48,493	12.7
Net-to-Gross Ratio	0.95	0.95
Verified Net Savings	46,067	12.0

Source: Navigant analysis

Table 3-6 compares reported net impacts (using the assumed NTG ratio of 0.85) and verified net impacts for PY 2012.

Table 3-6 Reported and Verified Net Savings

	PY 2012
Reported NTG Ratio	0.85
Reported Net Energy Savings (MWh)	49,718
Reported Net Summer Coincident Demand Savings (MW)	11.8
Verified NTG Ratio	0.95
Verified Net Energy Savings (MWh)	46,067
Verified Net Summer Coincident Demand Savings (MW)	12.0

Source: EEB Program database and Navigant analysis

4. Process Findings

The evaluation team conducted IDIs with EEB Program staff, IC staff, and trade allies. The following sections provide the results of these IDIs, including selected quotes from interviewees.

4.1 Program Staff and Implementation Contractor Feedback

The evaluation team interviewed five program staff and seven IC staff members (collectively referred to as the "EEB team") to capture real-time feedback on key aspects of the program, outlined in the following subsections.

4.1.1 Customer Satisfaction

Consistent with the previous years' customer surveys, interviewees believe that the EEB customers are "highly satisfied." On a scale of one to five (where five is very satisfied), program staff indicated customer satisfaction was a five, and the average score for the IC staff was 4.9. The EEB team states that customer feedback includes a high degree of satisfaction with the responsiveness of program staff, as well as the incentives toward energy efficiency improvements and savings on their energy bills. In addition, some of the customers highly value the public relations opportunity of receiving "a big cardboard check." Some of the customers are repeat customers who have used the program in several of the facilities they own. Feedback regarding customer satisfaction appears below:

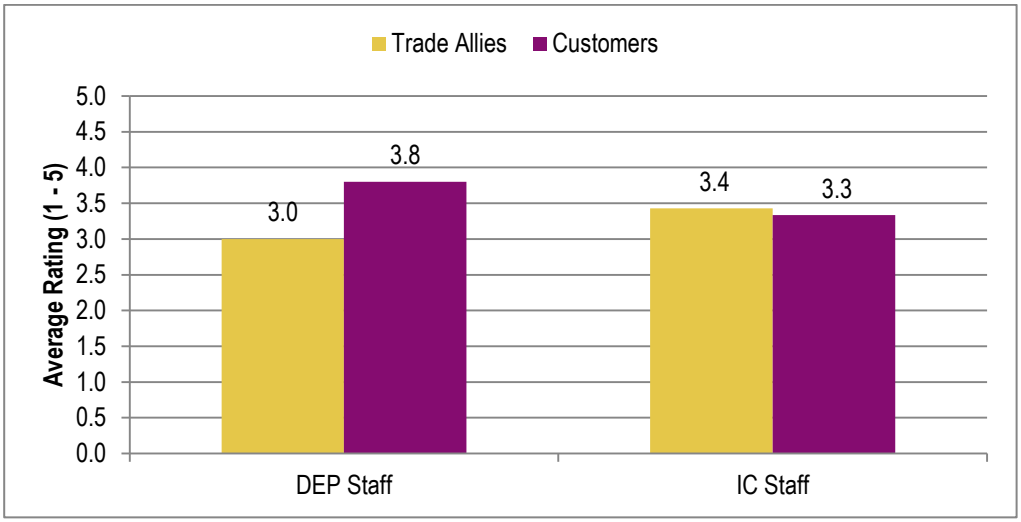
> *"The customers see the savings in their bills and they are satisfied."* IC Staff Member
>
> "[We] *try to handle customer concerns right away."* DEP Staff Member
>
> *"We receive so few complaints, whenever we get one we jump on it. Things get fixed today, we do not sit on them."* IC Staff Member

Overall, participants are highly satisfied with the EEB Program, and the EEB team reports that they handle customer issues in a timely manner such that they rarely become an official "complaint".

4.1.2 Program Participation

The EEB team reports that the program is meeting participation expectations, and Figure 4-1 shows ratings between three and four, indicating that expectations are slightly above average. Interviewees provided feedback on their expectations for both customer and trade ally participation, which are described in the following subsections.

Figure 4-1: Participation of Customers and Trade Allies Meeting Expectations



Source: Navigant interviews with EEB Program and IC staff

4.1.2.1 Trade Ally Participation

The program has cultivated a strong group of (increasingly) regionally diverse trade allies. The program has also taken steps to ensure that the EEB website only lists the active trade allies (ones who are generating leads that turn into rebate applications).[17] The EEB team emphasizes the importance of training both field staff and office sales staff within each firm to ensure that the companies can fully understand and promote the program. Feedback also included that some trade allies do not follow through on the paperwork necessary to complete the EEB application, after winning the job using the EEB marketing collateral. The EEB team provided the following comments about trade ally participation:

> *"We do real well in metro areas and in the rural areas we could have a stronger presence."* DEP Staff Member
>
> *"We have trade allies that would like to be associated with the program that do not deliver benefits to the program. They want their work associated with DEP but they do not want to do the extra work to get the incentive paperwork filled out."* DEP Staff Member
>
> *"…some missed opportunities with distributors' as well as the trade allies'* [sales staffs]. *Recommend continue training trade allies on-site. The field* [staff] *would know about the program but the inside* [sales staff] *would not."* DEP Staff Member

4.1.2.2 Customer Participation

EEB team feedback included the challenge of reaching the small- to mid-size commercial customers for whom energy use and energy costs are not a high priority.[18] The interviewees also suggested that most

[17] In November 2012, the EEB team sent a letter to trade allies to alert some that, due to inactivity, the program would be removing their company's name from the website, although they will remain an EEB trade ally.
[18] DEP launched a small commercial direct install program in 2013.

trade allies do not actively seek out small and mid-size businesses. In addition, feedback also included that most of the large customers who would benefit from this program have opted out:

> *"We are making tremendous strides in South Carolina. Trade allies reach more than we could ever reach."* IC Staff Member

> *"Opt-out has* [played] *a significant role* – [this program] *is more beneficial to customers that have huge energy use. The programs have to* [reach out] *to customers whose top priorities do not include energy use. They are worried about cash flow and inventory."* DEP Staff Member

> *"I think there is a lot more we could do for customers…more* [companies] *we could reach with this program…the trade allies are the significant resource that we use to reach customers."* IC Staff Member

4.1.3 Program Delivery

When asked about the effectiveness of the EEB delivery process, both IC and program staff provided an average rating of four out of five. The EEB team indicated they are utilizing many of the industry best practices, such as hand-held devices to capture data, submit applications, and expedite the application process. Regionally based staff interacts with trade allies and trade ally professional associations to help recruit additional trade allies. The EEB team reports that the pre-approval process helps manage customer expectations, as well as avoid confusion over critical items, such as eligibility for rebates.

Another area that needs further exploration is the HVAC incentives. Several staff commented that the HVAC incentives could be "tweaked" to encourage greater participation for the HVAC measures:

> "[We] *continuously tried to improve program delivery…* [we] *recently improved the application process* [and began] *using iPads to process applications electronically."* DEP Staff Member

> "[It is a] *team effort – DEP* [account executives] *working with managed customers,* [IC staff] *working with trade allies and customers coming through trade allies…all working together to deliver the program."* DEP Staff Member

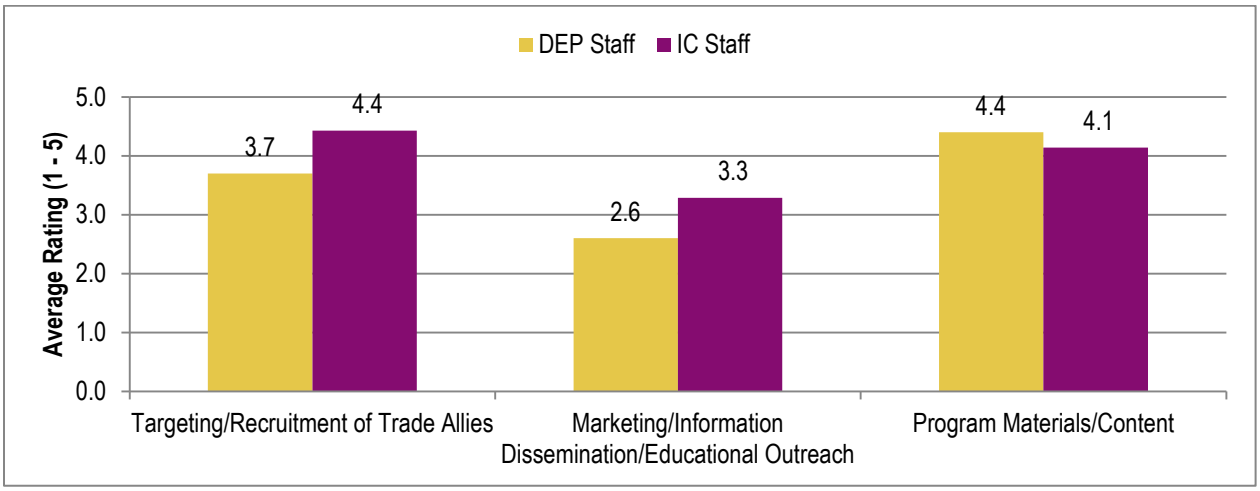
> *"It is a well-oiled machine that has gotten better each year. How many times that people call up and complain? 1 in 500 applications."* DEP Staff Member

4.1.4 Program Outreach and Marketing

The evaluation team asked staff how effective they felt certain program elements (trade ally targeting/recruitment, marketing/outreach, and program materials/content) were at meeting program goals. Figure 4-2 shows that both DEP and IC staff gave lower ratings (respectively, 2.6 and 3.3) to the marketing and outreach component of the program than other program components. Interviewees indicated that the website and marketing efforts are perhaps not used to their full potential, though some suggested that, since the program is currently achieving its stated energy savings goals, it might not be the best expenditure of resources to increase marketing and outreach budgets. However, the EEB team recommended some low-cost strategies for the website, such as periodically including a clickable

banner on the utility home page for businesses to "jump to" the EEB page, perhaps in conjunction with targeted marketing. Another observation was that targeting different business segments (e.g., retail, healthcare, etc.) would increase the effectiveness of the program's message.

Figure 4-2: Effectiveness of Program Elements at Meeting Goals



Source: Navigant interviews with EEB Program and IC staff

The EEB team provided the following feedback about program outreach and marketing:

> *"Web site could be improved – a lot of people go to the Internet and if the info is not there jumping out at them, they will not find it."* IC Staff Member
>
> "[Marketing] *meets the basic needs of the internal goals, but it does not begin to address the potential of the program. We do not spend marketing dollars beyond what is needed to meet our goals – we try to be good stewards of our rate payer dollars."* DEP Staff Member
>
> *"We could use more marketing; more ads in professional associations, newsletters, radio ads, and periodically a banner on the web site…specifically to attract customers…that would make someone think 'I can save X amount of dollars'."* IC Staff Member
>
> *"Other than posting on our web site, and passing out information in* [trade ally training classes], *I do not know if we have given* [the trade allies] *a lot of tools to sell* [the EEB Program.]" IC Staff Member
>
> *"For small businesses, we do not do any marketing. For the larger customers, we have the relationship through the account execs who promote the EEB Program if the customer asks about energy efficiency. I think there are missed opportunities there."* DEP Staff Member
>
> *"A lot of our material gets drowned out by the portfolio perspective. Customers are interested in 'me and my business.'* [The customers] *are segmented in their approach to information and as a*

program, we have not gotten there yet. We need to take on a more business-segmented targeted approach." DEP Staff Member

4.1.5 Incentives

The consensus among the EEB team is that the lighting incentives are motivating customers to upgrade to an energy efficient installation but that the HVAC incentives are not sufficient. The interviewees recommend increasing the HVAC incentives to convince customers to purchase more energy efficient replacement HVAC:

> "[The incentives are adequate for] *lighting- definitely*. *The incentives are not adequate for HVAC* [upgrades]. [However, raising the incentives for HVAC measures is] *not cost effective*. [The current incentives are] *not enough to move the market.* [For most] *HVAC* [projects], *the intent is going with a more efficient system than would otherwise be purchased to replace a failed system."* IC Staff Member

> *"One thing I have been hearing recently is that other utility companies are giving much larger incentives on HVAC measures. Our product mix is heavy on lighting. And the* [current HVAC] *incentive does not make* [enough of] *a difference* [for the customer] *to buy the energy efficiency equipment."* IC Staff Member

4.1.6 Other Barriers

Overall, interviewees cited the downturn in the economy as the biggest barrier to increasing the participation in the program, especially for new construction projects. The complexity of understanding energy efficiency is also a barrier for architects and engineers (A&Es) in new construction. The EEB team also pointed to other barriers, such as lack of financing, contractors' aversions to filling out paperwork, lack of awareness of the program, and uncertainty due to the merger between Duke and PEC. Comments on these barriers included the following:

> *"We have not done as* [many rebates for] *new construction due to the economy. In some cases,* [the EEB Program] *has been a call to action for some customers. Some have paid the rider to make the change now and start saving money now."* DEP Staff Member

> "[Another barrier is] *how* [best] *to deal with the new construction market – reaching engineers and architects for new construction is a barrier. I think A&Es are a different class of trade allies – the engineers in the program need to help with* [recruiting A&Es]…*The time commitment is great and they do not want to do it unless they are going after LEED."* DEP Staff Member

> *"I think* [the EEB Program] *has been impacted – the average size [of a project] has shrunk over the last year, year and a half – due to the economic down turn.* [The customers are] *doing some of the recommended projects but not everything that is recommended. Financing is a big issue – especially lighting projects – we like on-bill financing."* IC Staff Member

"We have seen a turn down this year definitely. Until recently, the dollar amount invested has been steadily decreasing for the projects. Territories are cut up and the trade allies have to figure out who is the utility for a facility." IC Staff Member

"[A barrier is lack of] *awareness of the program. There are still a lot of small business owners that do not know about the* [EEB] *program and are doing these implementations anyway. For me, one solution is building the relationships with the local contractors that have been hitting the streets that are working with the small businesses."* IC Staff Member

"The economic downturn has had an impact on the program. The other negative impact of the program over the last year or so is the uncertainty from the merger. Both internally within our team and from the end use customers' standpoint." IC Staff Member

4.2 *Trade Ally Feedback*

The evaluation team interviewed 17 companies in January 2012. Fifteen were trade allies, and two were highly participating, non-trade allies. For PY 2012, these companies represented a significant portion of the overall savings for the EEB Program. The interviewed trade allies contributed 27 percent of the total energy savings (kWh), and the two non-trade allies contributed an additional 4 percent.

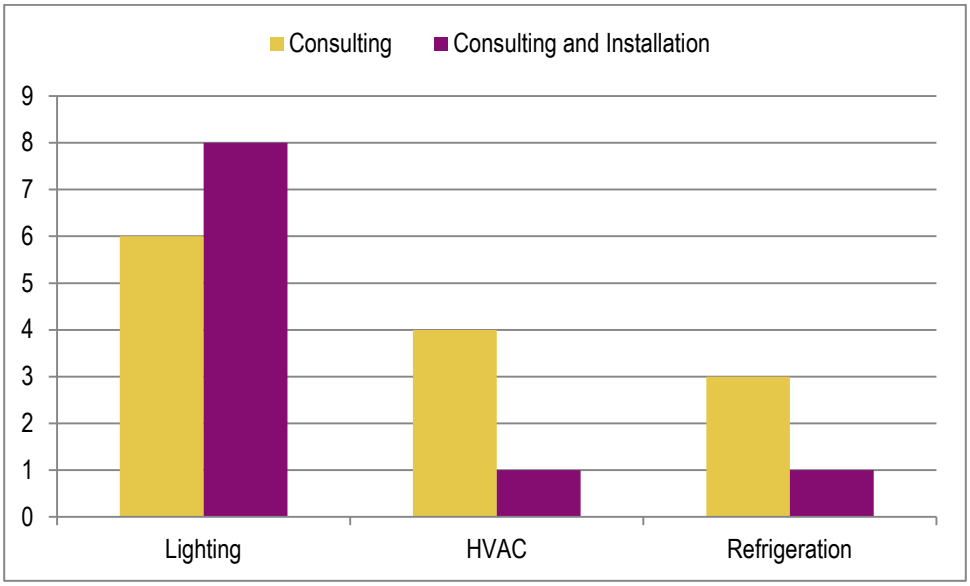
The following section describes the characteristics of the companies interviewed. Subsequent sections provide the feedback on key topics related to the EEB Program.

4.2.1 Company Information

4.2.1.1 Services Provided

For the trade ally group, most of the companies were in the lighting industry, with eight reporting that they provided both consulting and installations and six providing consulting alone (Figure 4-3). Several of these trade allies also provided services in the HVAC and refrigeration industries. In addition, three trade allies reported that they were equipment vendors, four reported that they provided engineering services, and one reported that they provided architectural services (for lighting design only). In addition to these services, several trade allies also reported that they provided energy management systems, solar and wind energy systems, and daylighting harvesting control systems.

Figure 4-3: Distribution of Trade Allies' Services



Source: Navigant interviews

4.2.1.2 Company Size (Staff)

Ten of the trade allies reported employing between one and 100 people, and four of the trade allies reported employing between 101 and 1,000 people, with one trade ally reporting a staff of 7,500.

4.2.1.3 Company Locations

Ten of the interviewed trade allies are located in North Carolina, with various locations across the state, Three trade allies are located in South Carolina, and two are in other states. One highly participating, non-trade ally is based in North Carolina, and the other is based in another state.

4.2.2 Training

Fourteen of 15 interviewed trade allies believe that the training benefited their business. Most would like additional training on federal legislation that affects the lighting industry, such as the phase-out of the T-12 fluorescent lamps, as well as more in-depth training on lighting technologies and other components of the program. The following quotes from interviewees provide feedback on the training provided by DEP:

> "[The training] *gave us the PEC contacts so when we did submit either a prescriptive or custom application, we could do as much correctly on the first submittal. Some of our customers did not even know who their account manager was. We could involve their account manager in the process, and we could ensure that we had all the required documents in the first submittal.*" DEP EEB Trade Ally

> "[Training on] *any changes to the rebates to keep me in the loop.*" DEP EEB Trade Ally

"Training on understanding components of the program, [for example] the Consortium for Energy Efficiency products and what that means and how do they fit with the program." DEP EEB Trade Ally

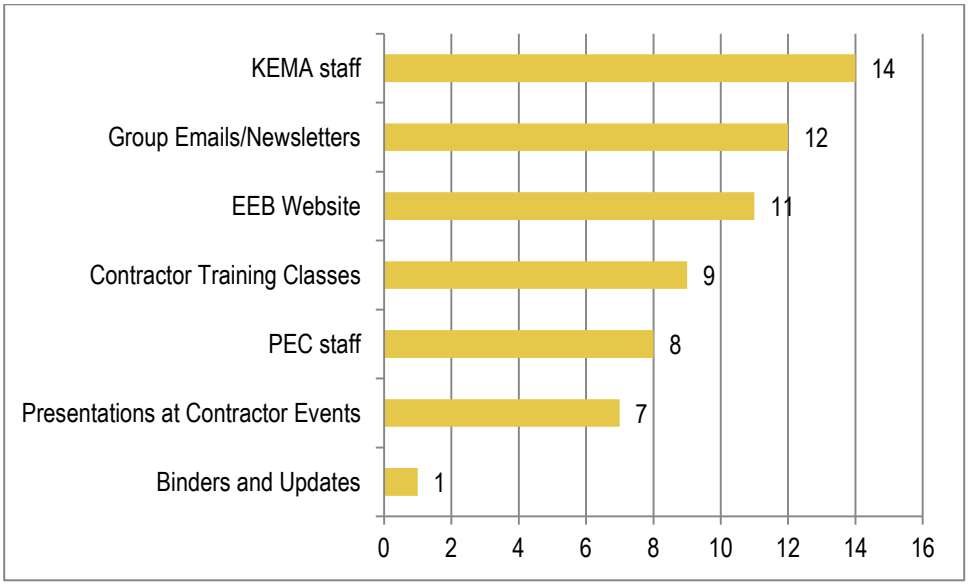
"I would like to see a more in depth lighting training session – I know there have been some instances for some customers where they did not get the best solution for them. I have gotten calls from two people where another company did a project and there were light level problems." DEP EEB Trade Ally

"KEMA does yearly trade ally training [for the trade allies to] *keep their status. We would appreciate seminars that focus on the technology and bring it full circle to say how it fits in the program. Utilities want their customers to be educated. Our customers, national accounts, have a team of individuals that understand demand side management, and they do not need* [additional training on demand side management]. *We participate in the training because it is good to know about the different technologies."* DEP EEB Trade Ally

4.2.3 Marketing and Outreach

Fourteen of the 15 interviewed trade allies reported that they received their program information from communication with KEMA staff, and 12 reported getting information via group emails and newsletters. Eleven of the trade allies reported that they get information about the program from the program's website, and nine get information from contractor training classes. Figure 4-4 shows the reported sources of program information. All of the trade allies reported that email is their *preferred* method of communication.

Figure 4-4: Reported Sources of Program Information



**Interviewees could select more than one response*
Source: Navigant interviews

Trade allies provided the following feedback on marketing and outreach:

> "[I would like an] *annual review of the program* [including] *the changes and modifications to the program and the direction of the program for our long term training programs.* [There is a] *rumor on the street that the program is ending December 31, 2013 – '*[customers] *get your lighting done now'* [and it looks like a] *hidden agenda due to the merger."* DEP EEB Trade Ally

All interviewed trade allies actively promote the EEB Program to their customers. All 15 interviewed trade allies use word-of-mouth to promote the EEB Program. Additionally, seven have the EEB Program information and/or logo on their company website, four send email "blasts" with information on the EEB Program, four use print ads, and four use newsletters. Other marketing strategies that trade allies reported using include making cold calls on a regular basis, using an account management team to communicate directly and daily with their clients, and incorporating information about the EEB Program in building audit reports that the trade ally provides.

> "*High efficiency* [equipment] *is more expensive.* [Our company] *has to go through the math to sell the high efficiency equipment,* [including the] *cost of ownership, cost to operate and the incentives offset the difference.*" DEP EEB Trade Ally

Five trade allies report that the EEB website is among the most effective outreach tools, while six trade allies report the opposite. The following quotations provide some feedback on the EEB website:

> "[The EEB Program] *gave* [our company] *some marketing collateral – somewhat vetted. There are customers that look on the [DEP] web site for a company for someone to contact.*" DEP EEB Trade Ally

> "*I do not think a lot of customers go to the website. They* [hear about the program] *from the flyer or newsletter.*" DEP EEB Trade Ally

> "*It took me a month working with the website to understand it. It took an inordinate amount of time to get fluent.*" DEP EEB Trade Ally

The following quotations provide feedback on the utility bill inserts:

> "[In] *90% of the companies, the power bill does not go to the decision-makers. Not reaching your true target audience.*" DEP EEB Trade Ally

> *"National accounts use third party bill pay services, they do not get the bill."* DEP EEB Trade Ally

> "*The person that opens the utility bill is different from decision maker. The accounts payable person sees it as an advertisement. The inserts do not get to the people in facility maintenance.*" DEP EEB Trade Ally

4.2.4 Incentives

Most of the trade allies believe that the incentive levels are appropriate for the program, with the exception of LEDs[19], occupancy sensors, and HVAC equipment, for which some trade allies would like to have increased incentive levels. Trade allies believed that the watts reduced incentive for lighting made it easier for them to sell higher efficiency lighting. Trade allies provided the following feedback on incentives:

> "*In a perfect world, I would offer more incentives for LED technologies simply because it will last longer. A bonus for LED technology. Both the customer and the utility will realize a benefit for a longer period of time.*" DEP EEB Trade Ally

> "*Occupancy sensors in manufacturing applications need to be re-evaluated. The reality is that if you are controlling a sensor in a 24/7 environment, there needs to be a higher rebate for a 24/7 use than an office use"* DEP EEB Trade Ally

> "*HVAC monetary incentive is kind of low.*" DEP EEB Trade Ally

> "*Keep it fresh. Update the incentives as technology marches on. What makes this program good – they are willing to think outside the box via custom. Important to have a true watts [reduction] program*." DEP EEB Trade Ally

> "*Being in the lighting business, we want to be an attractive business – early in the game we signed up with Duke and PEC. The PEC rebate was always more attractive than Duke's. It is easier to manage and understand, easier to understand what the amount is. But, they are structured differently due to the Commission. I'm not sure what will happen with merger. PEC's program is professional in communication and training, ease of participation and actual incentive amount is better compared to Duke. And I have a very close relationship with Duke; they have a great program but it is more bureaucratic*" DEP EEB Trade Ally

> "[We] *knew it would be a profit center for the company.* [We] *analyzed the EEB Program* [to determine if it was] *sufficient to get the customer off-center.* [We] *ran proformas to see if* [the EEB incentive] *was sufficient to move the market.* [With the incentive contributing] *25% - 30%* [of the overall project], [this] *gets 40-50% people to pursue the lighting upgrades. Pretty good success.*" DEP EEB Trade Ally

4.2.5 Customer Decision-Making

Trade allies' responses reflected a high degree of variability when asked, "How important energy efficiency was to your customers?" Using a scale of 1–10, trade allies reported a low response of 3, a high response of 10, and an average response of 7.5. One trade ally that provided a 6 for their response to this question remarked on the overall significance of the EEB Program:

[19] For PY 2012, Duke Energy Progress did not offer prescriptive incentives for LED equipment (customers applied for a custom rebate). DEP plans to offer prescriptive LED incentives through the EEB program in late 2013.

> "*This program is very important to the economic health of North Carolina. We have increased our employment by 15 – 20% as a result of this program. In today's economic climate, I could not have done it without these two programs* [Duke's and PEC's]. [This reflects] *income that we are able to put back into the community…If the program was pulled it would be a disaster. I would hate to see it go – especially for the small business owners. If we cannot get down to a 2.5 year payback,* [fewer companies would invest in the efficient lighting]. *Without the rebates the jobs are in the 3.5 year payback, with the rebate it is a 2.5 year payback."* DEP EEB Trade Ally

Another trade ally who responded to the above question with a 5.5commented on the importance of energy efficiency relative to cost:

> "[Importance of energy efficiency] *balances out with the first cost. Everyone is all for energy efficient lighting, like LED lights, until they find out how much they cost. And it is the same with HVAC systems.*" DEP EEB Trade Ally

A fourth trade ally, who responded with an 8 for this question, remarked the following:

> "*Most companies these days, especially the larger companies, are looking for anyway to drop costs – to reduce their electric bill helps them from a maintenance cost – new energy efficiency products are under warrantee.* [There are also] *mandatory green initiatives for large companies. Some customers have an initiative where they have to cut emissions 5 – 10% every year – lighting is an easy way to meet their corporate requirements.*" DEP EEB Trade Ally

Trade allies also answered the question "What are the barriers to the adoption of energy efficiency technologies in commercial buildings?" Most (12) believe that energy efficient technologies are "not well understood":

> "*About half the time, people just do not get it. When they realize that these energy efficiency projects can pay for the upgrades in their machines, it benefits them in the long run.*" DEP EEB Trade Ally

Another question that trade allies considered was "What are the barriers to the adoption of energy efficiency technologies in commercial buildings?" All (15) believe that a barrier is present when "the facility manager wants to adopt but does not have their management's support":

> "*The facilities manager has* [their] *operational requirements and the comptroller has* [their] *separate requirements and they are different.*" DEP EEB Trade Ally

> "*Big factor – after our company met with the facility managers, their upper management would not do it.*" DEP EEB Trade Ally

4.2.6 Feedback on Implementation Contractors

Trade allies report a high level of satisfaction with both DEP and KEMA. On a scale of 1–10, with 10 being extremely satisfied, the average for DEP was 9, and the average for KEMA was 9.2. Trade allies provided the following feedback on the implementation contractors:

> "*We work with Duke, PEC, and Dominion. Our favorite is Progress. It is simpler by far to manage the process. The paperwork is simpler; the people are great to work with. It appears that KEMA and Progress are more eager to giving rebates for energy efficiency projects. Their rebate accomplishes more for energy efficiency than the others. With Progress, the more efficient the project is, the greater the rebate. The other utilities pay more in rebates for a less efficient lighting solution.*" DEP EEB Trade Ally

> "*Actually, I wanted more* [rebates], *but I am surprised at the amount, it keeps on coming. I thank the administrators on the ground – KEMA.* [KEMA employee] *is phenomenal and a real asset and is local and looks at the project with me when needed.*" DEP EEB Trade Ally

> "*That is where KEMA makes a difference. I have been an accredited lighting professional for 27 years. That is where the training that PEC and KEMA offer is phenomenal.*" DEP EEB Trade Ally

> "*KEMA is excellent. KEMA has done some things to standardize processes between utility programs [including the] format for the incentive applications themselves.*" DEP EEB Trade Ally

> "[KEMA employee] *legitimizes me and my company and puts a face on the program.* [It is] *so beneficial to have that personal contact. That makes a big difference.*" DEP EEB Trade Ally

> "*The way KEMA does* [presentations] *with the outreach is phenomenal and I would be very disappointed if they stopped that.*" DEP EEB Trade Ally

> "*For EEB it comes down to ease of working within the program. In some cases the payouts are not as good as other projects but due to the time value of money, if a program is able to issue a check in 6 weeks versus 6 months, it makes a big difference. Our customers do not want to wait 6 months to have their application approved. Timeliness is important. EEB is customer -focused and wants to give the customers the money for the rebates.*" DEP EEB Trade Ally

A trade ally who gave the EEB Program a 10 provided the following comments:

> "*97% is the KEMA outreach the rest of it is the ease of the program and the ease of the accessibility of the KEMA folks. We have built everyday relationships with these people and that adds so much to it.*" DEP EEB Trade Ally

> "[KEMA] *went above and beyond. They have done their best for everyone. Everyone that I know in the business loves KEMA* [and it is probably due to] *the staff that they have for the Progress* [EEB Program]." DEP EEB Trade Ally

4.2.7 EEB Program Satisfaction

Trade allies rated their customers' satisfaction with the EEB Program as extremely high. The question was on a 1–10 scale, and the responses ranged from 6 to 10, with an average score of 9. Trade allies provided the following feedback about customer satisfaction with the EEB Program:

> "[The customers] *said it was very easy to go through, and we make it easy to go through. Almost like free money for* [the customers]." DEP EEB Trade Ally
>
> "[Our customers] *love the program.*" DEP EEB Trade Ally
>
> "[Our customers] *keep giving referrals to the program.*" DEP EEB Trade Ally
>
> "*Good payout, get things done quickly, customer focused, friendly*." DEP EEB Trade Ally
>
> "*Anyone who got a rebate was extremely satisfied*." DEP EEB Trade Ally
>
> "*Because we have had several* [customers] *that have come back to do more lighting. They pass the word on to other customers*." DEP EEB Trade Ally

Trade allies also rated their own level of satisfaction with the EEB Program on a scale from 1–10. Scores ranged from 6.5 to 10, with an average score of 8.7. Trade allies provided the following comments about their own satisfaction with the EEB Program:

> "*Because it is easy to work with and people are responsive, good service*." DEP EEB Trade Ally
>
> "*Helps sales.*" DEP EEB Trade Ally
>
> "*I think the program has been fantastic; the one thing that I would have liked to see with the program is a little more due diligence for the contractor/trade ally. There are some really good trade allies out there and not good trade allies out there. If* [DEP] *gets more than two complaints, they should eliminate the trade ally. The trade allies represent themselves as well as Progress*." DEP EEB Trade Ally
>
> "*We love the program and we do not want it to ever go away.*" DEP EEB Trade Ally
>
> "[I like] *how Progress gives the customer a pre-approval letter. Some other utility companies have a different approach which puts the customer more at risk. With Duke, if you do not do the custom application, Duke may run out of funds*." DEP EEB Trade Ally
>
> "*PEC is very responsive when we have had questions. PEC has been flexible when we have come up with issues/changes – they have been solution oriented.*" DEP EEB Trade Ally
>
> "*Good working relationship with the PEC and KEMA guys*." DEP EEB Trade Ally

4.2.8 Suggested Improvements

Trade allies made some specific suggestions to improve the EEB Program (besides increasing incentives), including the following:

- Increasing customer awareness by offering case studies of successful installations
- Differentiating the top tier of contractors from the rest of the field
- Sending specific case studies or newsletters to the end users, (e.g., gas stations, small manufacturing operations, etc.)
- Providing a pack of flyers about the program for distribution to customers or potential customers
- Providing a monthly or quarterly newsletter to the trade allies about any updates or expected changes to the program, including any upcoming marketing campaigns that DEP is planning (e.g., radio ads)

Several trade allies (and one non-trade ally) requested faster processing time for the applications:

> *"DEP takes a little more time for pre-approval than what we see nationally – 27 days for a national average. When the retailers are ready to install [new lighting], they want to do it the next day or in a week. Average [time for pre-approval] for PEC is 35 days."* DEP EEB Trade Ally

Several trade allies recommended that DEP include LED lighting options on the prescriptive list, rather than make it a custom application, and suggested including wall sconces, LEDs in refrigerated cases, and "can" lights on the list.

4.2.9 Feedback on PEC and Duke Programs

Due to the timing of the PY 2012 evaluation and the Duke-PEC merger, the evaluation team specifically collected feedback from trade allies that participate in both the PEC EEB and Duke Smart $aver® Incentive Programs. The feedback was mixed, as respondents indicated likes and dislikes of certain aspects of each program:

> "*PEC EEB Program – I like the* continuing *education about lighting and about the program. I work with several different programs and they do not take it half as seriously as PEC. It is difficult to get answers to questions* [from Duke] *when I need it. I hope the PEC EEB Program does not become Duke-like in any way shape or form. The PEC is based on watts savings and the Duke program is measure codes. It takes* [a lot of effort] *to do a custom project with Duke, so I generally try not to do them.*" DEP EEB Trade Ally

> "*I cannot tell you what the rebate is going to be with* [Duke's] *program – it is a pie-in-the-sky number. At least with PEC's program,* [the rebate amount] *is very simple and a great move. I would stay away from Duke's program, but* [Duke] *pays more quickly; 2 weeks versus 8 weeks. I think KEMA is understaffed on the process payment sides, and WECC is undersized because Duke wants to over engineer everything.*" DEP EEB Trade Ally

> "*Duke's* [incentives are] *straightforward* – '[select the kind of lighting] *you are* [removing], [select the kind of lighting] *you are* [installing].' [As opposed to the] *wattage calculator for*

PEC. [However,] *Duke* [offers] *less money for the incentives. Now that Duke is taking over* [the PEC EEB Program] *it is really going to be difficult to convince a company* [to install] *the higher efficiency lighting. For a $10,000* [lighting upgrade, the company] *will only get a $300* [rebate]." DEP EEB Trade Ally

"*Duke brought us into a piece of the business. Their sales representatives made a lot of connections with the end users. When* [end users asked Duke sales representatives,] *'Who should we call?' Duke would recommend two or three trade allies. The PEC program did not have a thorough vetting process on the trade allies and Duke had a more thorough process, and did not have a massive list of unknowns. Duke had confidence in their trade allies.*" DEP EEB Trade Ally

5. Conclusions and Recommendations

The evaluation team performed extensive fieldwork and telephone surveys to determine gross and net verified savings and presents the overall conclusions and recommendations in the following sections.

5.1 Conclusions

Table 5-1 summarizes the **primary findings** of the PY 2012 EEB evaluation:

Table 5-1: Summary of EEB Program Impacts

Verified Gross Savings	PY 2012
Energy Savings Realization Rate (Verified Gross Energy Savings)	83% (48.5 GWh)
Demand Savings Realization Rate (Verified Gross Summer Coincident Peak Demand Savings)	91 % (12.7 MW)
Verified Net Savings	
NTG Ratio (Net Energy Savings / Net Demand Savings)	0.95 (46.1 GWh/ 12.0 MW)

Source: Navigant analysis

The **key drivers behind the program-level energy realization** rates are the 78 percent realization rate for the prescriptive lighting measure category and the 94 percent realization rate for the custom measure category.

Free ridership and net savings. The evaluation effort determined that free ridership for the EEB Program is relatively low and that the overall NTG ratio is high. The EM&V team calculated overall free ridership for the EEB Program at 23 percent, implying that approximately 77 percent of the savings generated by the program are due to the influence of the program itself. The team determined program spillover to be 18 percent of total reported program savings, indicating that the program is influencing EEB customers to generate an additional 18 percent of program savings at participant facilities or other sites within the DEP territory. Deducting for the 23 percent free ridership and accounting for the 18 percent spillover, the EM&V team calculated an overall program NTG ratio of 0.95.

5.2 *Recommendations*

The evaluation team recommends eight discrete actions for improving the EEB Program, based on insights gained through the comprehensive evaluation effort for PY 2012. These recommendations provide DEP with a roadmap to fine-tune the EEB Program for continued success and include the following four broad objectives:

1. Increasing program participation
2. Enhancing marketing/outreach efforts
3. Improving custom measure realization rates
4. Enhancing program evaluation efforts

Table 5-2 summarizes these program recommendations.

Table 5-2: Summary of Recommendations

Increasing Program Participation	
1. Recruit trade allies in rural areas as well as metropolitan areas	Expand the trade ally network into rural areas in order to capture new participants
2. Use a business segment-targeted approach to marketing	a. Tailor marketing efforts toward specific building types (retail, healthcare, hospitality, etc.) b. Distribute case studies to end users that are specific to their building segment (e.g., gas stations, offices, etc.)
3. Offer prescriptive lighting incentives for LED measures	
4. Consider increasing the incentive amount for prescriptive HVAC measures	
Enhancing Marketing/Outreach Efforts	
5. Implement low-cost marketing strategies for the EEB web site	Periodically include a clickable banner on the utility home page for businesses to "jump to" the EEB page
Improving Custom Measure Realization Rates	
6. Collect pre-retrofit metering data on projects that retrofit refrigerated cases with doors	There is uncertainty over the projected energy savings for retrofitting existing refrigeration cases with glass doors. DEP can improve realization rates by collecting more information about the energy use of existing cases prior to retrofits.
Enhancing Program Evaluation Efforts	
7. Provide more supporting files with calculations for new construction lighting projects	Customers receive new construction prescriptive lighting incentives based on reductions in lighting power density (W/SF) below code. DEP should include supporting files from software such as COM*check*™ (or similar spreadsheets) with the application.
8. Include more detail in project files on certain prescriptive HVAC and refrigeration measures in project	a. Specify whether the customer installed a variable frequency drive (VFD) on a fan or a pump
	b. Specify whether the refrigerated case is a low- or medium-temperature case for both Electrically Commutated Motors (ECM) measures and anti-sweat heater control measures

Source: Navigant analysis

5.2.1 Recommendations for Increasing Program Participation

1. **Recruit trade allies in rural areas, as well as in metropolitan areas.** Program staff and IC staff suggested that the trade ally network is strongest in metropolitan areas and that the program needs to recruit more trade allies in rural areas. Expanding the trade ally network should increase program participation by exposing more customers to the program via their trusted contractors and equipment vendors.

2. **Use a business segment-targeted approach to marketing.** The EEB Program should tailor marketing messages to customers based on their primary business type. For example, the EEB Program should distribute marketing materials, such as case studies, to customers based on relevance to their business (e.g., convenience stores should receive case studies about energy efficiency projects in similar stores).

3. **Offer prescriptive lighting incentives for LED measures.**[20] As the price of LED lighting decreases, more customers are choosing LEDs to replace outdated incandescent or fluorescent lighting. The EEB Program currently processes LED measures as custom projects. Offering prescriptive rebates for LEDs eases the application process and improves the ability for trade allies to market these retrofits.

4. **Consider increasing the incentive amount for prescriptive HVAC measures.** Feedback from stakeholder interviews indicates that the incentive amounts for prescriptive HVAC are typically too low to move the market toward energy efficiency. The EEB Program should investigate the cost-effectiveness of increasing rebates for this measure category.

5.2.2 Enhancing Marketing/Outreach Efforts

5. **Implement low-cost marketing strategies for the EEB website.** DEP should consider targeting customers with clickable banners that would allow user to "jump to" the EEB web page. DEP can expose more customers to the EEB Program and easily enable them to access the web page for information on the program offerings.

5.2.3 Recommendations for Improving Custom Measure Realization Rates

6. **Collect pre-retrofit metering data on projects that retrofit refrigerated cases with doors.**[21] Several participants applied for custom rebates to add doors to existing refrigeration cases. The EM&V team verified that the customers overestimated energy savings and used flawed assumptions about pre-retrofit energy use. DEP should collect detailed information about the operating conditions of these cases prior to the retrofits in order to develop savings estimates to apply across similar projects.

[20] DEP indicates that the program will offer prescriptive lighting rebates for LEDs in late 2013. At the time of this report, LEDs are only available as a custom measure.
[21] At the time of this report, Navigant is actively working with DEP and select EEB participants to obtain this data.

5.2.4 Recommendations for Enhancing Program Evaluation Efforts

7. **Provide more supporting files with calculations for new construction lighting projects.** Customers receive incentives for new construction lighting measures based on the reduction in lighting power density (W/SF), as compared to the energy code. The EM&V team recommends that customers provide detailed calculations that show how the lighting power density values were calculated. Customers can use free software, such as COM*check*™[22], or submit a spreadsheet that calculates the values. These supporting files will illustrate whether the project used the building area method or the space-by-space method and include lighting counts by space types. For projects that lack this level of detail, the EM&V team must make assumptions that might affect project realization rates.

8. **Include more detail in project files on certain prescriptive HVAC and refrigeration measures in project.** Certain project applications lack information that assists the evaluation team to review and verify savings. DEP should address the following measure types for future program years:

    a. Application files for prescriptive HVAC VFD measures need to include whether the measure applies to a fan or a pump
    b. Application files for prescriptive refrigeration ECM measures need to include whether the refrigerated case is a low- or medium-temperature case
    c. Application files for prescriptive refrigeration anti-sweat heater controls measures need to include whether the refrigerated case is a low- or medium-temperature case

[22] The U.S. Department of Energy provides free COM*check*™ software at http://www.energycodes.gov/comcheck

2012 EM&V Report for the Energy Efficiency for Business Program

Appendices

Prepared for:
Duke Energy Progress

Navigant Consulting, Inc.
1375 Walnut Street
Suite 200
Boulder, CO 80302

303.728.2500
www.navigant.com

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NAVIGANT

Prepared for

Duke Energy Progress
Raleigh, North Carolina

Presented by

Stuart Schare
Tim Guiterman
Chris Wassmer
Marca Hagenstad

Navigant Consulting, Inc.
1375 Walnut Street
Suite 200
Boulder, CO 80302
phone 303.728.2500
fax 303.728.2501

www.navigant.com

NAVIGANT

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Appendix A. Glossary of Terms

Deemed savings: assumed unit savings values used in program design and tracking.

EM&V: short for evaluation, measurement, and verification; the assessment and quantification of the energy and peak demand impacts of an energy efficiency program.

Energy savings: kWh savings over a given period of time, generally expressed in savings per year.

Gross realization rate: the ratio of verified gross savings to reported gross savings.

Gross savings: reductions in energy consumption and peak demand based on engineering estimates for known quantities and types of measure installations; gross savings do not account for whether the measures were installed as a result of the program.

Measure characteristic verification rate (MCVR): reflects discrepancies between the assumptions used in deemed savings values and the actual verified values. This does not include the quantity of installed equipment but does include operating characteristics such as operating hours and coincidence factor.

Net savings: savings attributable to the program, after adjustments for free ridership and spillover.

Peak demand reductions: the reduction in peak power demand that is coincident with the utility system peak. When the season is not specified, the implicit assumption is that peak demand reductions are summer peak demand reductions.

In-Service Rate (ISR): reflects disparities in quantity between the program database and the actual, on-site conditions verified by the EM&V team. It is the ratio of the quantity of a given measure verified on site to the quantity of a given measure that was reported.

Reported gross savings: the program savings as reported in the Energy Efficiency for Business (EEB) program database.

Unit savings: the energy or peak demand reductions of a given measure *per unit* installed. Units differ by measure; for example, unit savings may be given as kWh per lamp or peak kW per watt reduced.

Verified gross savings: the gross savings verified by the EM&V team; these are the final third-party-verified gross savings for the program.

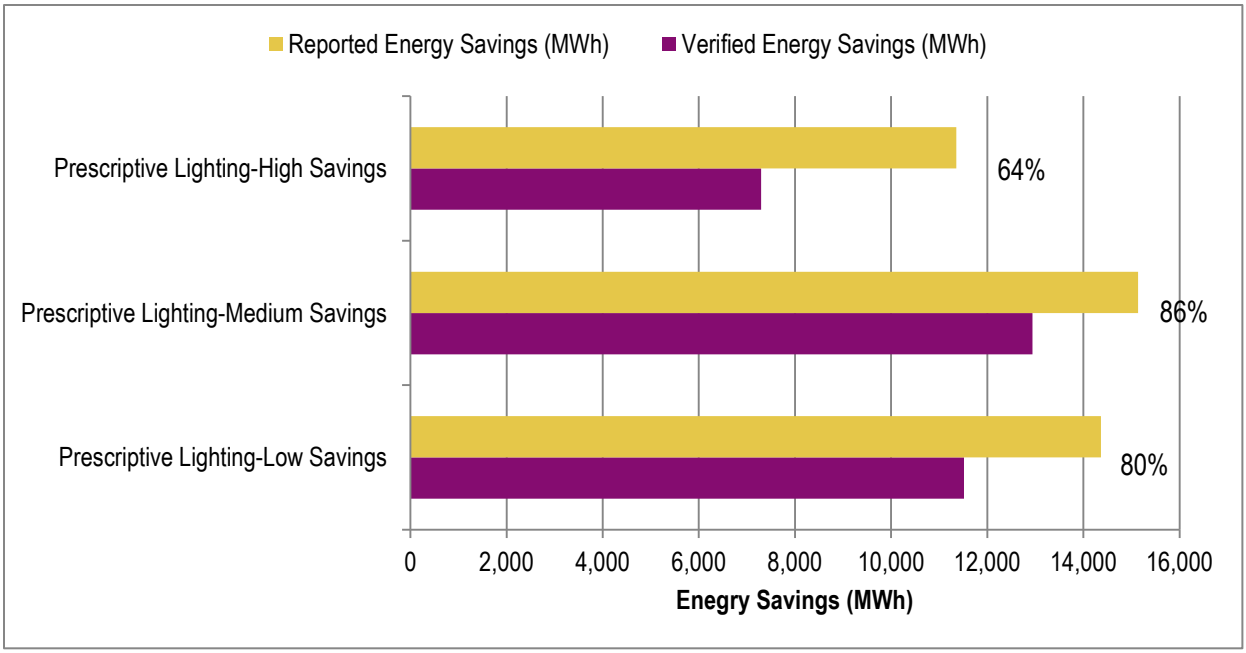
Appendix B. Supplemental Findings

This section includes additional evaluation findings for prescriptive lighting measures, as well as supplemental information on peak demand impacts.

B.1 Prescriptive Lighting Verification Results

Figure B-1 shows the verified energy savings results for the prescriptive lighting strata. The realization rate for all prescriptive lighting projects in the sample is 78 percent. The High Savings stratum achieved a 64 percent realization rate, primarily due to several large projects with low metered operating hours. The Medium and Low Savings strata achieved, respectively, 86 percent and 80 percent realization rates. Section B.1.1 provides detailed results for all sites within each stratum.

Figure B-1. Reported and Verified Savings by Prescriptive Lighting Stratum[a]



a. Percentage values represent gross realization rates for each stratum.
Source: EEB program database and Navigant analysis

B.1.1 Prescriptive Lighting Results by Sampling Site

The overall prescriptive lighting realization rate for PY 2012 is 78 percent, driven by low verified savings (64 percent of reported) for the large projects within the High Savings stratum. Table B-1 shows the results for the eight sites included in the on-site sample, ranked by level of reported energy savings. Several projects had realization rates below 40 percent (including the largest project), which indicates that the verified energy savings are less than half of what was reported. Only one site in the large stratum had verified energy savings higher than the reported value. These sites had low metered

operating hours when compared to the deemed hours used to generate the reported savings values. The largest site in the sample (ID 43530) had verified hours that were only approximately 25 percent of the deemed value of 4,671 MWh, which drove the realization rate down significantly. Section B.1.5 provides a summary of verified operating hours for the program.

These sites received rebates for a mix of T5/T8 Fixture, High Performance T5/T8 and Fluorescent Lamp Only measures, all of which had lower operating hours on a measure level than reported. This led to low realization rates for most projects in this stratum. Section B.1.2 provides details about measure-level verification rates.

Table B-1. Verified Gross Energy Savings
Prescriptive Lighting – High Savings Stratum

Sample Count	Site ID	Building Type	Reported Energy Savings (MWh)	Verified Energy Savings (MWh)	Realization Rate (%)
L-1	43530	Miscellaneous	1,295	288	22%
L-2	46530	Light Industrial	1,344	995	74%
L-3	49080	Warehouse	1,253	1,001	80%
L-4	45790	Light Industrial	1,115	985	88%
L-5	48200	Warehouse	983	1,051	107%
L-6	48280	Warehouse	847	421	50%
L-7	48640	Retail/Service	495	148	30%
L-8	400490	Miscellaneous	468	125	27%
Stratum Population			**7,801**	**5,015**	**64%**

Source: EEB program database and Navigant analysis

The evaluation team performed on-site verification at 13 sites in the Medium Savings stratum, and the overall realization rate for this group was 86 percent, as shown in Table B-2. Six sites in this stratum achieved realization rates above 100 percent, attributable to high metered operating hours. Site 50090 only realized 26 percent of reported savings, due to a reporting issue where fixtures that should have been classified as "High Performance T5/T8" were classified as "Delamp." Low metered operating hours was the primary driver of the lower realization rates at the remaining sites, particularly at sites 51260, 501780, 500460, and 501170. Site 51261 was the only new construction site in the sample and had a realization rate of 57 percent. The low realization rate was due to higher overall verified lighting power density (LPD) than what was claimed in the application files. The verified LPD at this site was 0.96 watts per square foot (W/ft^2), as opposed to the claimed value of 0.73 W/ft^2.

Table B-2. Verified Gross Energy Savings
Prescriptive Lighting – Medium Savings Stratum

Sample Count	Site ID	Building Type	Reported Energy Savings (MWh)	Verified Energy Savings (MWh)	Realization Rate (%)
L-9	500460	Miscellaneous	355	227	64%
L-10	50090	Light Industrial	312	80	26%
L-11	51261	Light Industrial	186	107	57%
L-12	501170	Light Industrial	183	118	64%
L-13	501780	Miscellaneous	183	109	60%
L-14	51020	Light Industrial	153	283	185%
L-15	50990	Warehouse	137	137	100%
L-16	500150	Retail/Service	129	147	114%
L-17	501370	Grocery	129	151	117%
L-18	51260	Office	124	67	54%
L-19	500830	Warehouse	119	123	104%
L-20	51290	Miscellaneous	107	79	73%
L-21	502330	Retail/Service	105	272	259%
Stratum Population			**2,223**	**1,900**	**86%**

Source: EEB program database and Navigant analysis

The Low Savings stratum achieved an overall realization rate of 80 percent and the evaluation team performed on-site verification at 14 sites in this stratum. Table B-3 shows the verified savings and realization rates for each site in this stratum. Five of the 14 sites achieved realization rates of 100 percent or greater, but there were three sites with verified savings below 50 percent of reported values. Sites 60070 and 600110 were the two lowest realization rates in this stratum and had very low metered operating hours (below 2,000 hours per year) compared to the deemed hours of 4,290 for Light Industrial and 4,671 for Miscellaneous building types.

Table B-3. Verified Gross Energy Savings
Prescriptive Lighting – Low Savings Stratum

Sample Count	Site ID	Building Type	Reported Energy Savings (MWh)	Verified Energy Savings (MWh)	Realization Rate (%)
L-22	600210	Retail/Service	86	108	125%
L-23	60081	Warehouse	50	29	58%
L-24	600180	Retail/Service	29	17	56%
L-25	600060	Office	21	20	92%
L-26	600160	Medical	21	9	45%
L-27	60080	Retail/Service	20	12	58%
L-28	600100	Retail/Service	19	12	67%
L-29	60070	Light Industrial	18	6	34%
L-30	600250	Retail/Service	13	13	100%
L-31	600110	Miscellaneous	11	4	34%
L-32	600010	Office	4	4	100%
L-33	60041	Office	3	2	52%
L-34	60040	Office	2	3	112%
L-35	60000	Office	2	3	117%
Stratum Population			**300**	**240**	**80%**

Source: EEB program database and Navigant analysis

B.1.2 Prescriptive Lighting Field Verification Rates

This section examines findings from the evaluation of lighting measures in order to identify the main drivers of the final verified savings values.

The EM&V team uses the **field verification rate (FVR)** to describe the overall verified savings relative to the reported savings for each measure. FVRs reflect differences between the quantity of equipment installed on-site and the quantity reported in the program-tracking database, as well as differences between operating characteristics verified in the field and assumed operating characteristics in the program deemed savings estimates. The EM&V team calculates the field verification rate as the product of the ISR and the MCVR, described as follows and as shown in Equation B-1.

1. **In-Service Rate**[1] **(ISR)** is the ratio of the verified (i.e., installed) quantity to the reported quantity. For lighting measures, the ISR reflects disparities in quantity of installed lamps, fixtures, or *Watts Reduced* (for T5/T8 Fixture and Fluorescent Lamp Only) between the program database and actual, on-site conditions verified by the EM&V team.

2. **Measure characteristic verification rate (MCVR)** reflects discrepancies between reported and verified *characteristics related to the operating conditions* (e.g., operating hours or coincidence

[1] In-Service Rate is an industry-standard term that describes verified quantities of installed equipment relative to reported quantities.

factors). A measure can have different rates for energy savings or peak demand reductions. The calculation of MCVR is shown in Equation B-1:

Equation B-1. Calculation of Field Verification Rate

$$FVR = ISR \times MCVR$$

Among the sampled sites, the EEB program rebated seven unique types of lighting measures in 2012, yet two measures, T5/T8 Fixture and Fluorescent Lamp Only, accounted for over 70 percent of total savings for the lighting category. For clarity, these two measures are described as follows:[2]

» **T5/T8 Fixture** – This measure consists of replacing one or more existing fixtures with new fixtures containing T5 or T8 lamps and electronic ballasts. Pre-approval, as well as pre- and post-inspection, is required, and the incentive is calculated on the reduction in connected watts.

» **Fluorescent Lamp Only** – This is catch-all for measures rebated on a reduced watts basis. Incentives for this measure are calculated based on the reduction in connected watts. Documentation supporting the reduced wattage calculation showing existing fixture input wattages and the proposed fixture input wattages must be included with the application. Acceptable values for input wattages of existing fixtures can be found in the prescriptive lighting application tab, entitled "Fixture Wattage Table". Use of other input wattage values will be considered on a case-by-case basis and must be supported by verifiable documentation. Incentives are available for new fixtures, retrofit with same length lamp length, retrofit with modified lamp length, and complete space redesign with new or retrofitted fixtures. The Fluorescent Lamp Only measure includes the following measures:

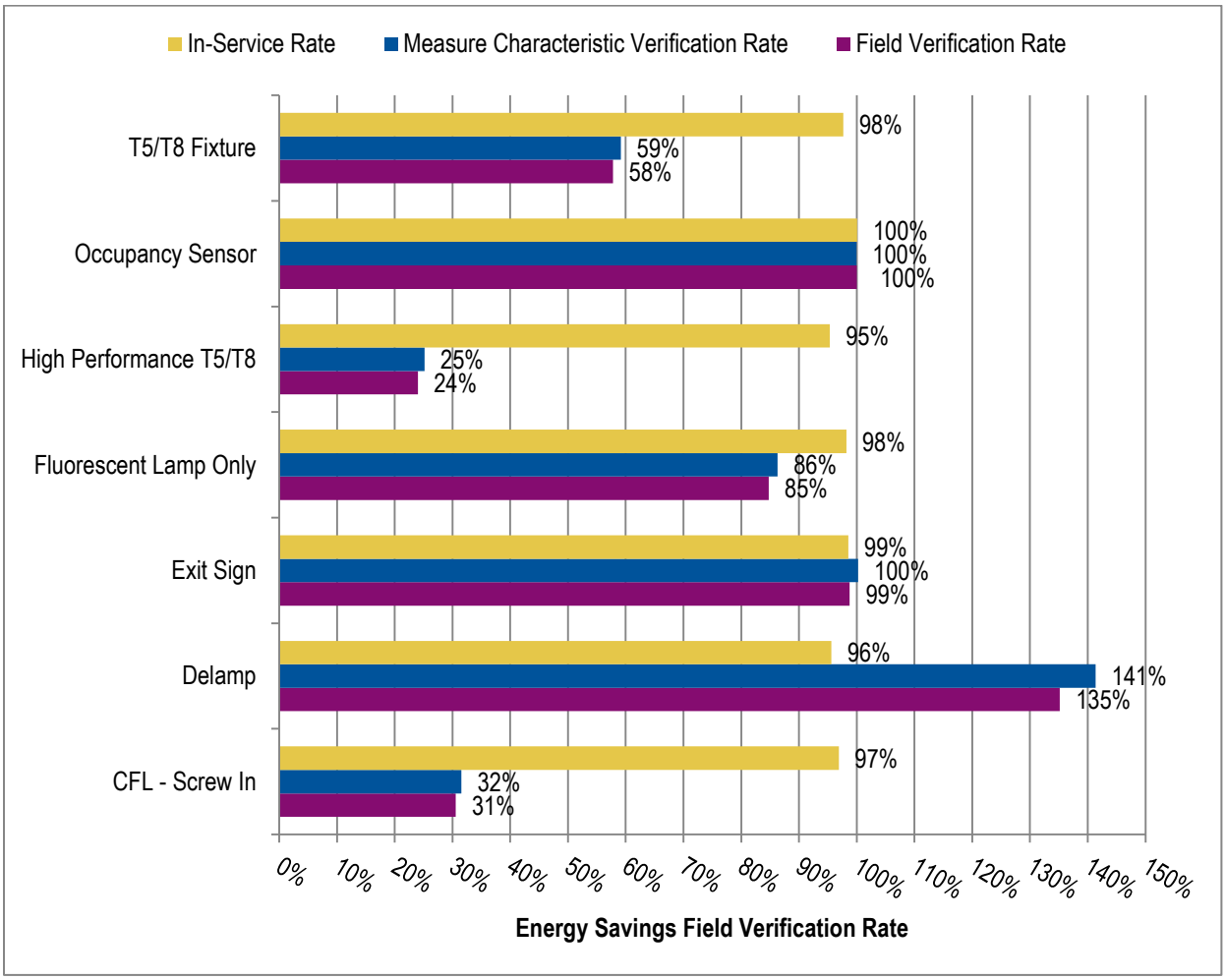
- Fixture Removal (in conjunction with retrofit or reconfiguring existing fixtures)
- New/Retrofit T8 or T5 Fixture/New T8 or T5 Fixture
- High Performance T8
- Reduced Wattage 4-foot T8
- Reduced Wattage 8-foot T8
- T5/T5 high output
- CFL Pin-based (hardwired)
- Cold Cathode
- Ceramic or Pulse Start HID

The FVR for the T5/T8 Fixture measure is 58 percent, while the FVR for the Fluorescent Lamp Only measure is 85 percent, as shown in Figure B-2. The FVRs for these two measures are primarily driven by low verified operating hours and differences between the lamp wattages verified on-site and those in the deemed savings values (see Section B.1.5 for discussion of verified operating hours and measure characteristics).

[2] Measure descriptions sourced from *Progress Energy – Energy Efficiency for Business Program: Policies and Procedures Manual,* Version 3.0 Rev. 12/12/2011.

The MCVR is effectively 125 percent for the permanent lamp removal (Delamp); this is due to a small sample size and high verified hours at those sites. The FVR for occupancy sensors and exit sign measures is nearly 100 percent. The evaluation team verified a 97 percent ISR for the CFL – Screw In measure but only a 31 percent MCVR, which was due to low operating hours at primarily one site (ID-48640). This site accounted for over 96 percent of the total CFL bulbs rebated among the sampled sites. The evaluation team verified a MCVR of only 24 percent for the High Performance T5/T8, and this was primarily due to low operating hours and a lower watts reduced between the verified retrofitted fixture and the baseline fixture.

Figure B-2. Energy Savings Field Verification Rates



Source: Navigant analysis

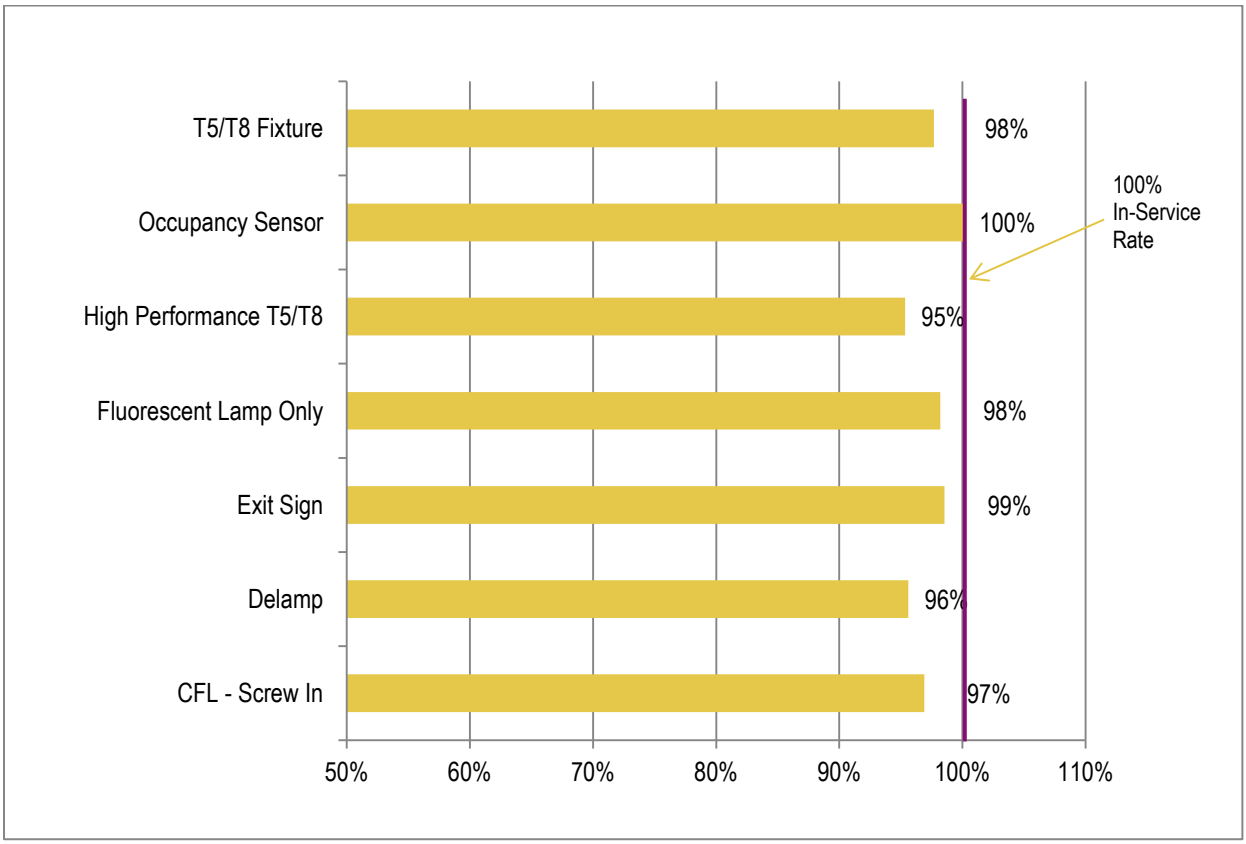
The remainder of this section discusses the ISRs for all sampled measures, as well as the MCVRs for *energy savings* for the T5/T8 Fixture and High-Performance T8 measures.

B.1.3 In-Service Rates

One of the primary functions of evaluation, particularly for lighting, is to verify the quantity of the installed equipment relative to the reported quantity. The resulting ratio is the ISR.[3] ISRs significantly below or above 100 percent deserve investigation into the main drivers (e.g., program process issues or issues with specific technologies).

Figure B-3 shows the verified ISRs for sampled lighting measures.[4] All measures have ISRs at or above 95 percent. The evaluation team did not encounter any individual sites having significant issues with fixtures or missing lamps. In a few cases, the building operator indicated that a very small number of the lamps that were part of the rebate were never installed. At some of the more complex sites, the application paperwork was missing location information, making it difficult for evaluators to locate every retrofitted measure on site. The EM&V team verified 100 percent of the reported occupancy sensors at all sites.

Figure B-3. Prescriptive Lighting In-Service Rates



[3] Measure-level ISRs are used to provide feedback to the EEB program and are not currently applied to past or future program years as measure-level "adjustment factors."

[4] This chart shows seven of the nine measures rebated during the sample period. The two not shown are Metal Halide and CFL-Hardwired measures. The random sample did not include any sites with the CFL-Hardwired measure or Metal Halide measure.

Source: Navigant analysis

The EM&V team calculated an ISR of 99 percent for Exit Signs and 96 percent for the permanent lamp removal (Delamp) measure. The ISR for the High Performance T8 measure is 95 percent. While visiting site 51290, the evaluation team determined that none of the High Performance T5/T8 lamps that were part of the rebate were installed. This accounts for the small drop in ISR for this measure. The ISRs across all measures raise no concerns from an evaluation perspective and warrants no specific actions for the EEB team to take.

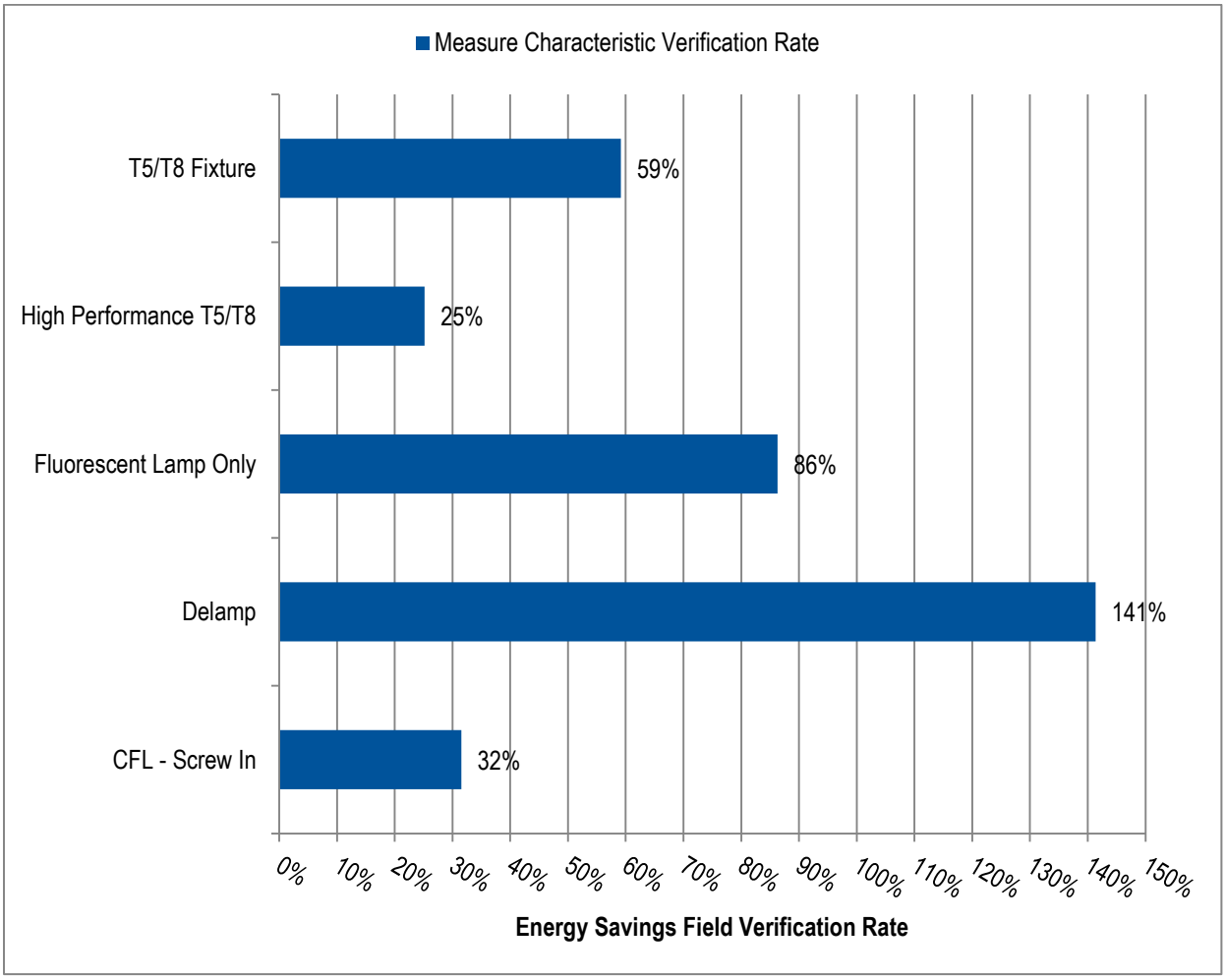
B.1.4 Measure Characteristic Verification Rates – Energy Savings

As described in Section B.1.2, the MCVR is calculated for the T5/T8 Fixture, High-Performance T8, Fluorescent Lamp Only, and Delamp measures. This section describes the drivers behind the MCVR calculations for energy savings.

Figure B-4 shows the MCVR for the measures listed above. The MCVRs vary from a very low 25 percent for High-Performance T5/T8 to 141 percent for the Delamp measure. The drivers behind these findings are verified operating hours, heating, ventilation, and air conditioning (HVAC) interaction factors, and, in the case of the High-Performance T8 measure, differences between the lamp wattages verified on-site and those in the deemed savings values.[5] The following sections describe each of these measure characteristics in greater detail.

[5] These wattage differences only apply to the High-Performance T5/T8 measure because for the T5/T8 Fixture measure and Fluorescent Lamp Only measures, there are no deemed assumptions for lamp/fixture wattages, as deemed savings are based on a project-specific calculated Watts Reduced, which is then multiplied by a deemed number of operating hours and an interaction factor to arrive at an estimated kWh savings value.

Figure B-4. Energy Savings Measure Characteristic Verification Rates

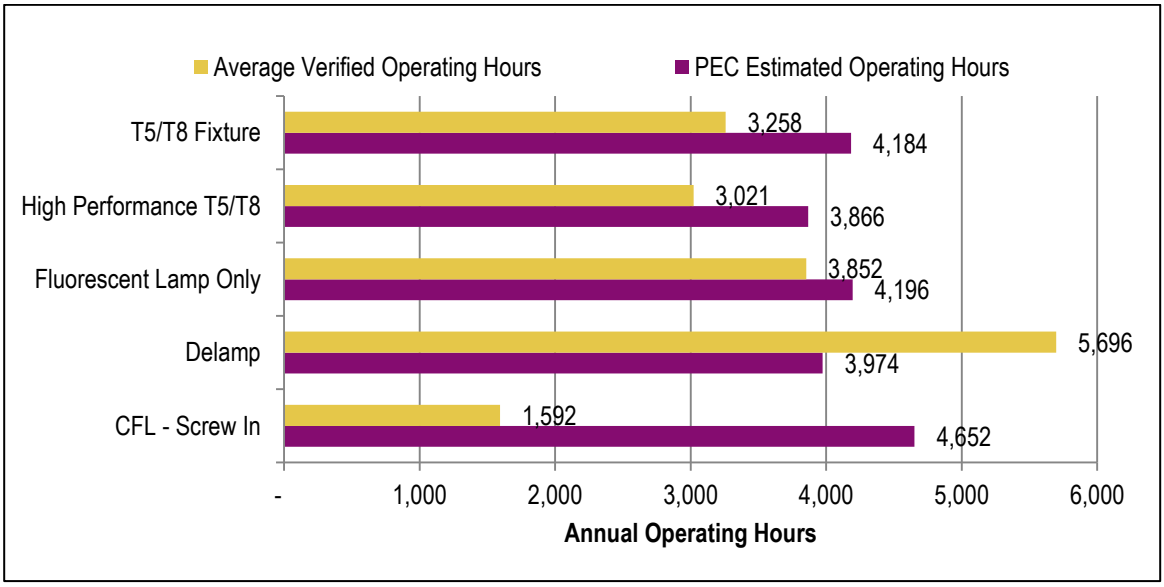


Source: Navigant analysis

B.1.5 Verified Operating Hours

Figure B-5 shows that the verified operating hours for the T5/T8 Fixture measure are only 78 percent of the deemed hours, indicating that this operational characteristic is one of the main drivers behind the high MCVR (59 percent) for this measure. Similarly, the verified operating hours for the High Performance T5/T8 measure are 78 percent of the deemed operating hours, and verified operating hours for Fluorescent Lamp Only are 92 percent, revealing that operating hours are also driving the lower MCVRs (respectively, 25 percent and 86 percent) for these measures. For CFL – Screw In, the story is similar; verified hours are only 34 percent of deemed hours, and the MCVR is a correspondingly low 32 percent. The only measure where verified hours were higher than deemed hours was the Delamp measure (this may have been driven by a small sample size). While it is impossible to measure the hours of use for something that does not exist, the evaluation team used verified hours for fixtures remaining in the space as a proxy where the delamped fixtures were removed.

Figure B-5. Verified and Deemed Operating Hours by Measure



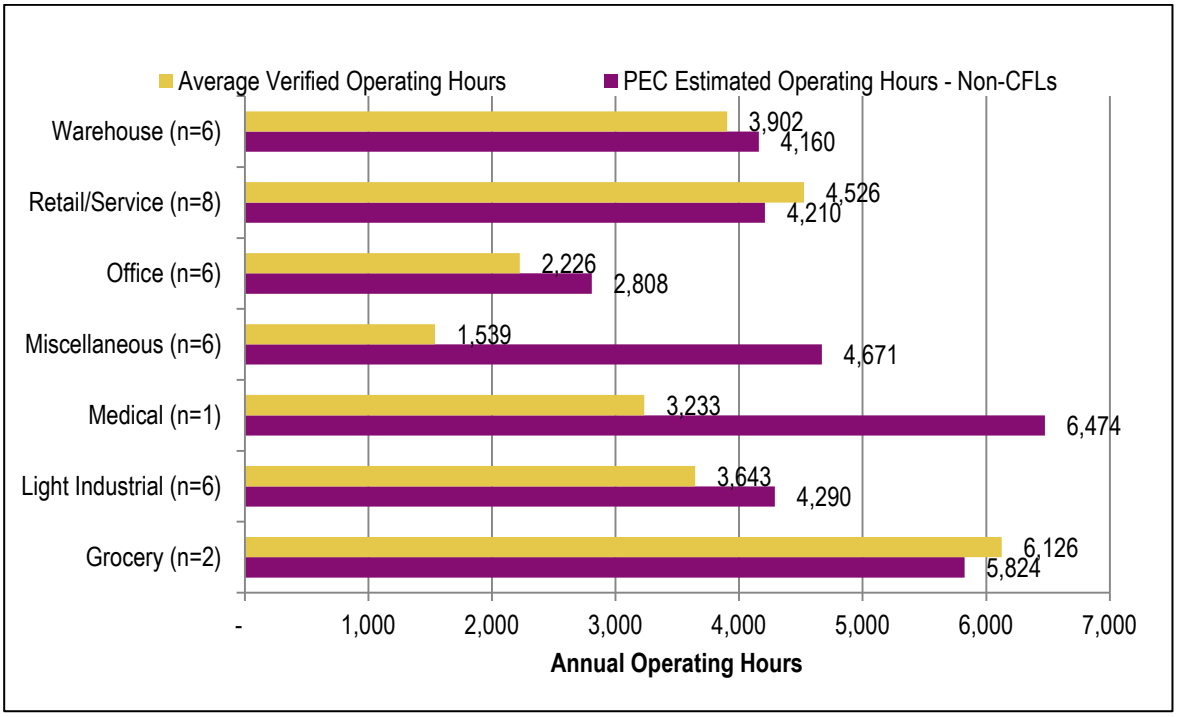
Source: Navigant analysis

The low verified operating hours for the High Performance T5/T8 Fixtures are a result of low metered run-times in the Miscellaneous and Office building types (where most of this measure appeared). Figure B-6 shows the verified and deemed hours by building type for each measure.

The majority of savings for the Delamp measure were from a single warehouse site that had verified hours of 5,696, or 137 percent of deemed hours for this building type. Similarly, almost all of the CFL – Screw In measures were installed at a single Retail/Service site where verified hours were approximately 1,500, which is only 36 percent of the deemed value for this building type.

The remainder of the measures was from a variety of building types, so there was no obvious building type that was driving down savings at a measure level. The largest sites in the sample were made up of two Miscellaneous, two Light Industrial, three Warehouse, and one Retail/Service building types. For all building types but Retail/Service, the verified hours were lower than the deemed values, and for Miscellaneous (also the largest site in the sample), the verified hours were only 33 percent of the deemed value.

Figure B-6. Verified and Deemed Operating Hours by Building Type



Source: Navigant analysis and EEB deemed savings

B.1.6 Deemed Savings Inputs

The low MCVR for the T5/T8 Fixture, Fluorescent Lamp Only, and CFL – Screw In measures are driven by low operating hours, but the low MCVR of 25 percent for the High-Performance T5/T8 measure is driven by lower operating hours *and* by incorrectly reporting measures as "Delamp" that should have been "High Performance T5/T8". Two sites (49080 and 50090) had higher reported savings because the kWh/lamp value being used in the deemed savings was assuming a Delamp measure and not High Performance T5/T8.

B.1.7 HVAC Energy Interaction Factors

The final component of the MCVR for all measures is the HVAC interaction factor (IF). Reductions in lighting energy generally increase a building's heating requirements (load) and decrease cooling requirements. The interaction factor accounts for these secondary effects on the HVAC system energy use and acts as a multiplier in the energy savings algorithms.

For PY 2012, DEP adopted Navigant's recommended HVAC IFs by building type when calculating deemed savings values. These are the same HVAC IFs used for verification. Table B-4 shows the HVAC IFs recommended and implemented by DEP.

Table B-4. HVAC Energy Interaction Factors by Building Type

Building Type	Recommended Navigant Energy Interaction Factors
Office	0.63
College/University	0.76
Retail/Service	0.91
Warehouse	0.97
Light Industrial	1.02
Heavy Industrial	1.02
Miscellaneous	1.04

Source: Navigant analysis and EEB deemed savings

When DEP revised the IFs, there was an oversight in failing to remove the original IF that was implicit in the per-unit deemed savings value. This led to an overstatement in reported savings for prescriptive lighting by approximately 4 percent. DEP did not correct this error in the PY 2012 database, but DEP reports that it was corrected for PY 2013. Table B-5 illustrates the impact of this error on the PY 2012 reported savings, where the "Adjusted Reported Savings" column includes the correct IF application.

Table B-5. Adjusted Reported Savings with Correct IFs

Reported Metrics	Unadjusted Reported Savings	Adjusted Reported Savings	% Difference
Prescriptive Lighting Savings	40,848	38,336	-6.1%
Total EEB Savings	58,492	55,979	-4.3%

Source: EEB Program database and Navigant Analysis

B.2 Supplemental Information on Demand Impacts

This section provides additional information relating to summer and winter demand impacts and is meant to supplement Section 3 of the main report.

B.2.1 Verified Gross Peak Demand Reductions

Table B-6 shows the reported and verified gross summer and winter peak demand reductions. The gross realization rate for demand savings is 91 percent for summer and 78 percent for the winter period.

Table B-6. 2012 Annual Gross Peak Demand Reductions

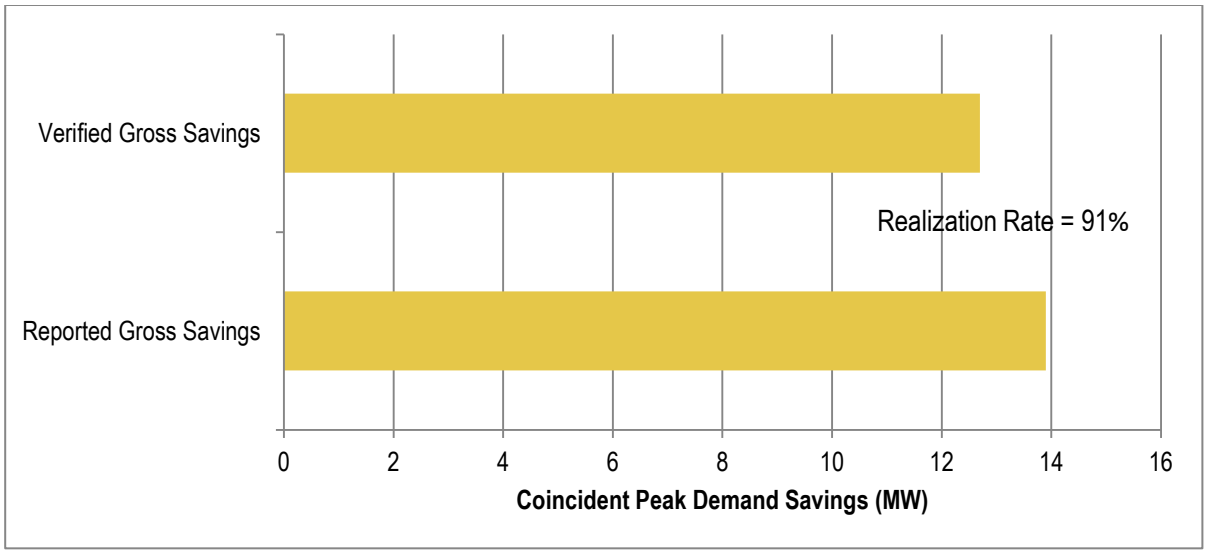
	Summer Coincident Peak Demand Savings (MW)	Winter Coincident Peak Demand Savings (MW)
Reported Gross Savings	13.9	13.7
Verified Gross Savings	12.7	10.7
Gross Realization Rate	91%	78%

a. The relative precisions for summer and winter peak demand reductions are, respectively, 10% and 6% at a 90% level of confidence.

Source: Navigant analysis

Figure B-7 illustrates the reported and verified gross summer peak demand reductions.

Figure B-7. Reported and Verified Gross Summer Peak Demand Reductions



Source: Navigant analysis and EEB deemed savings

B.2.2 Verified Gross Peak Demand Reductions by Measure Category

Table B-7 shows the PY 2012 reported and verified gross summer peak demand savings for each measure category.

Table B-7. 2012 Annual Summer Demand Reductions by Measure Category

Measure Category	Reported Gross Summer Demand Savings (MW)	Realization Rate	Verified Gross Summer Demand Savings (MW)
Prescriptive Lighting	8.6	90%	7.7
Custom	4.8	92%	4.5
Prescriptive – Other[a]	0.5	100%	0.5
Total	13.9	91%	12.7

a. Prescriptive Other includes the prescriptive HVAC, refrigeration, and motor categories.

Source: Navigant analysis

B.2.3 Verified Net Peak Demand Savings

Table B-8 shows verified gross and net summer and winter peak demand savings.

Table B-8. Verified Net Peak Demand Reductions

	Summer Coincident Peak Demand Savings (MW)	Winter Coincident Peak Demand Savings (MW)
Verified Gross Savings	12.7	10.7
Net-to-Gross Ratio	0.95	0.95
Verified Net Savings	12.1	10.2

a. The relative precision for summer and winter peak demand reductions is, respectively, 10% and 6%.

Source: Navigant analysis

Table B-9 shows gross and net verified summer peak demand savings by measure category.

Table B-9. PY 2012 Verified Net Summer Peak Demand Savings by Measure Category

Measure Category	Verified Gross Summer Peak Demand Savings (MW) [A]	Net-to-Gross Ratio [B]	Verified Net Summer Peak Demand Savings (MW)[a] [C = A x B]
Prescriptive Lighting[b]	7.7	1.02	7.9
Custom	4.5	0.79	3.5
Prescriptive Other	0.5	1.02	0.5
Total	12.7	0.95	12.0

a. The sum of the verified net savings across all measure categories does not equal total net verified savings shown, due to rounding.

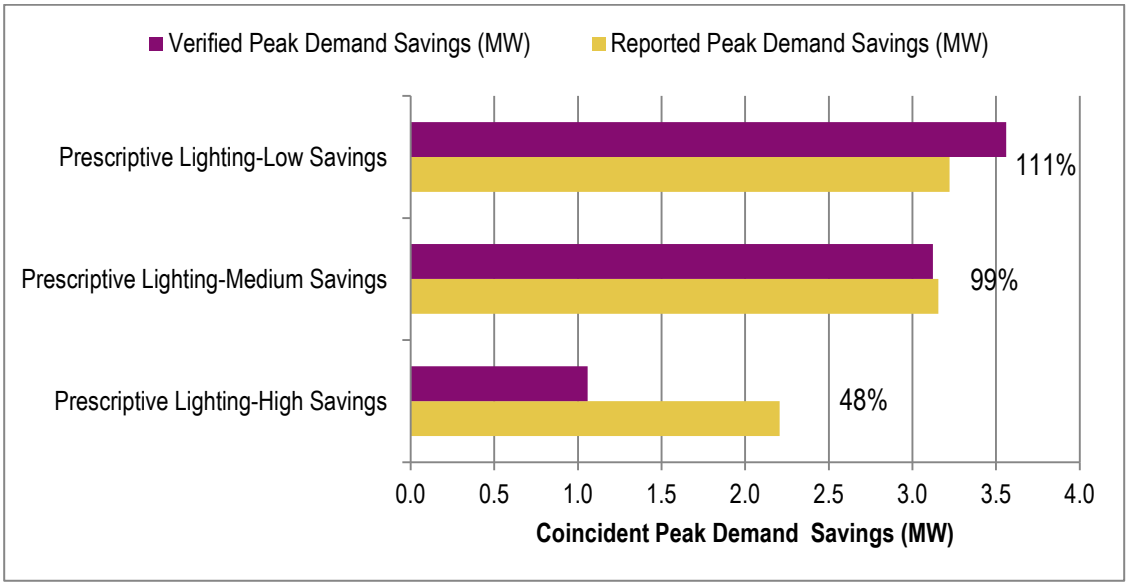
b. The NTG ratio for the prescriptive lighting category is the weighted average of the NTG ratios for all lighting strata.

Source: EEB Program database and Navigant analysis

B.2.4 Prescriptive Lighting Verification Results – Peak Demand Reductions

Figure B-8 shows the verified demand savings results for the prescriptive lighting strata.

Figure B-8. Reported and Verified Demand Savings by Prescriptive Lighting Stratum[a]



a. Percentage values represent gross realization rates for each stratum.
Source: EEB program database and Navigant analysis

B.2.5 Prescriptive Lighting Results by Sampling Site –Peak Demand Reductions

Table B-10 through Table B-12 show the verified gross peak demand reductions for each site in the prescriptive lighting field sample.

Table B-10. Verified Gross Peak Demand Savings
Prescriptive Lighting – High Savings Stratum

Sample Count	Site ID	Building Type	Reported Summer Peak Demand Savings (kW)	Verified Summer Peak Demand Savings (kW)	Realization Rate (%)
L-1	43530	Miscellaneous	235	79	34%
L-2	46530	Light Industrial	250	73	29%
L-3	49080	Warehouse	243	95	39%
L-4	45790	Light Industrial	225	182	81%
L-5	48200	Warehouse	213	161	75%
L-6	48280	Warehouse	165	103	63%
L-7	48640	Retail/Service	123	26	21%
L-8	400490	Miscellaneous	73	13	17%
Stratum Population			**1,527**	**732**	**48%**

Source: EEB program database and Navigant analysis

Table B-11. Verified Gross Peak Demand Savings Prescriptive Lighting – Medium Savings Stratum

Sample Count	Site ID	Building Type	Reported Summer Peak Demand Savings (kW)	Verified Summer Peak Demand Savings (kW)	Realization Rate (%)
L-9	500460	Miscellaneous	55	20	36%
L-10	50090	Light Industrial	57	19	34%
L-11	51261	Light Industrial	36	26	73%
L-12	501170	Light Industrial	37	28	75%
L-13	501780	Miscellaneous	28	32	114%
L-14	51020	Light Industrial	31	53	172%
L-15	50990	Warehouse	27	29	107%
L-16	500150	Retail/Service	26	42	162%
L-17	501370	Grocery	17	26	153%
L-18	51260	Office	37	28	76%
L-19	500830	Warehouse	25	26	106%
L-20	51290	Miscellaneous	20	28	140%
L-21	502330	Retail/Service	20	53	265%
Stratum Population			**416**	**412**	**99%**

Source: EEB program database and Navigant analysis

Table B-12. Verified Gross Peak Demand Savings Prescriptive Lighting – Low Savings Stratum

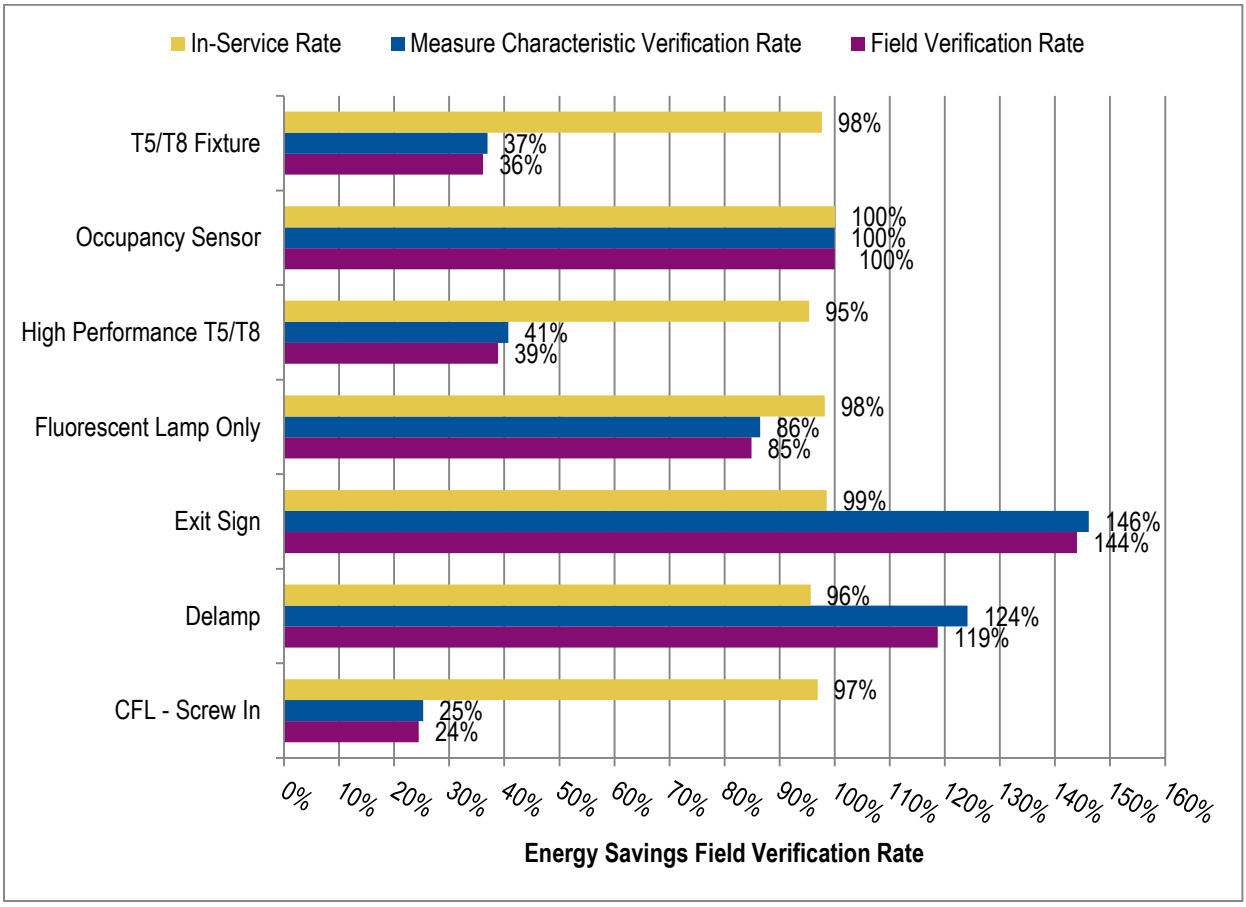
Sample Count	Site ID	Building Type	Reported Summer Peak Demand Savings (kW)	Verified Summer Peak Demand Savings (kW)	Realization Rate (%)
L-22	600210	Retail/Service	17	33	195%
L-23	60081	Warehouse	10	5	54%
L-24	600180	Retail/Service	6	0	0%
L-25	600060	Office	5	6	114%
L-26	600160	Medical	1	3	278%
L-27	60080	Retail/Service	4	3	85%
L-28	600100	Retail/Service	4	5	122%
L-29	60070	Light Industrial	3	2	68%
L-30	600250	Retail/Service	3	3	100%
L-31	600110	Miscellaneous	2	0	21%
L-32	600010	Office	1	1	100%
L-33	60041	Office	1	1	66%
L-34	60040	Office	1	0	31%
L-35	60000	Office	0	1	N/A
Stratum Population			**58**	**64**	**111%**

Source: EEB program database and Navigant analysis

B.2.6 Prescriptive Lighting Field Verification Rates – Demand Reductions

Figure B-9 shows the peak demand savings field verification rate for all sampled measures.

Figure B-9. Peak Demand Savings Field Verification Rates

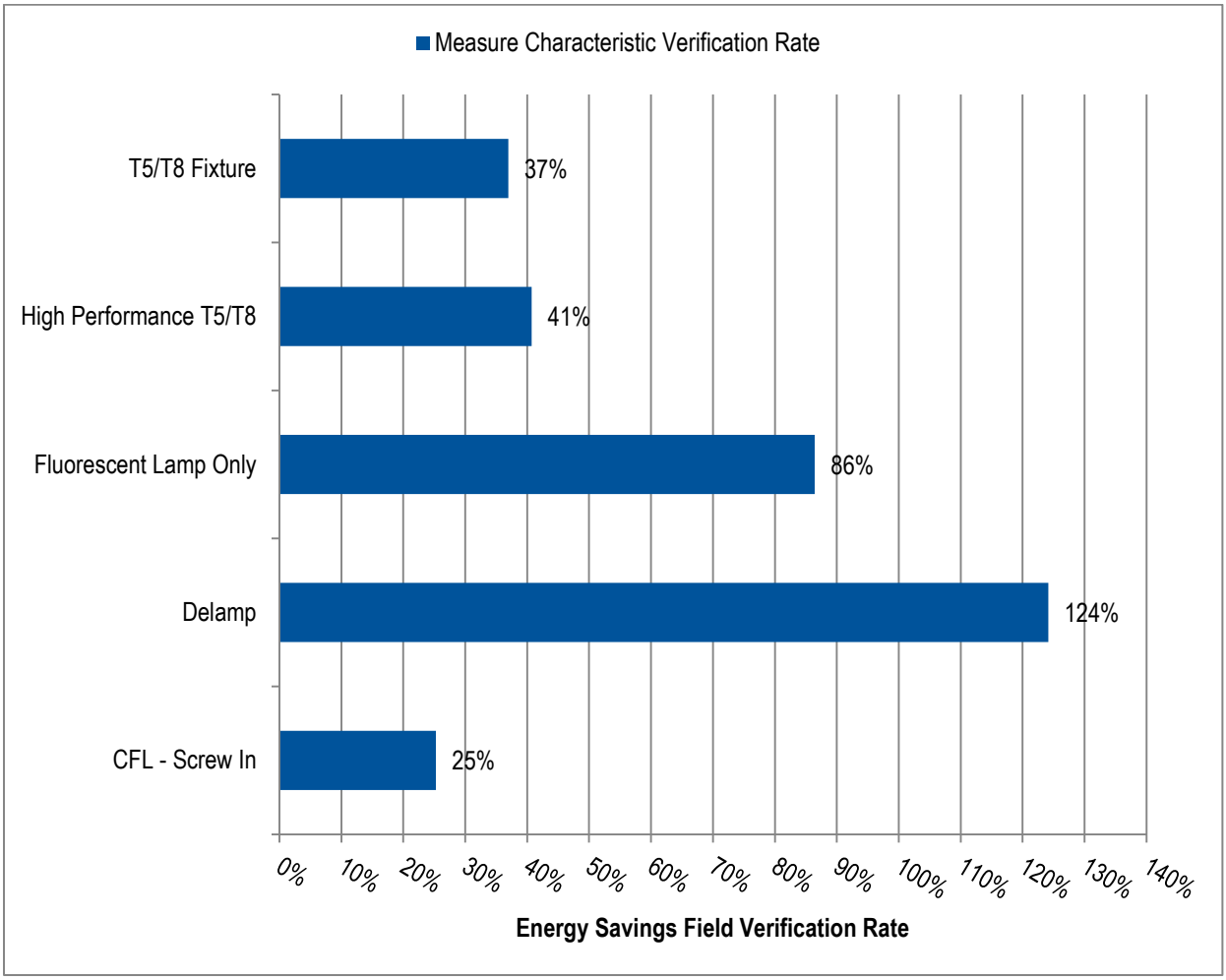


Source: Navigant analysis

B.2.7 Prescriptive Lighting Measure Characteristic Verification Rates – Demand Reductions

Figure B-10 shows the MCVRs for the T5/T8 Fixture, High- Performance T5/T8, CFL – Screw In, Fluorescent Lamp Only, and Delamp measures.

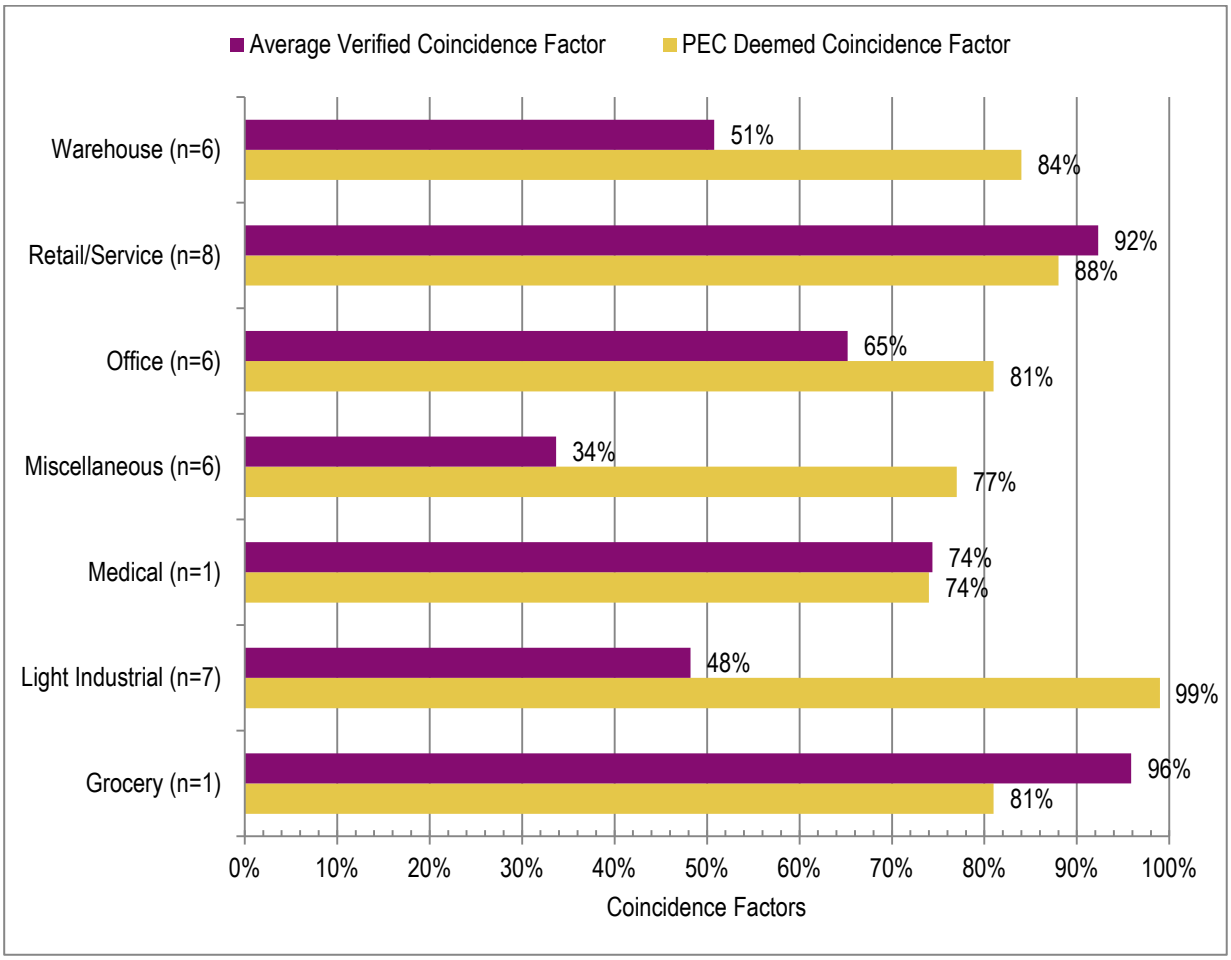
Figure B-10. Peak Demand Savings Measure Characteristic Verification Rates



Source: Navigant analysis

In the 2010–2011 evaluation report, the evaluation team recommended that DEP adjust the deemed coincidence factor (CF) by building type. In PY 2012, DEP applied this recommendation. Figure B-11 compares the verified coincidence factor for each building type with the deemed values. Several of the building types were lower than the deemed values; this correlates with the lower metered hours at these same building types.

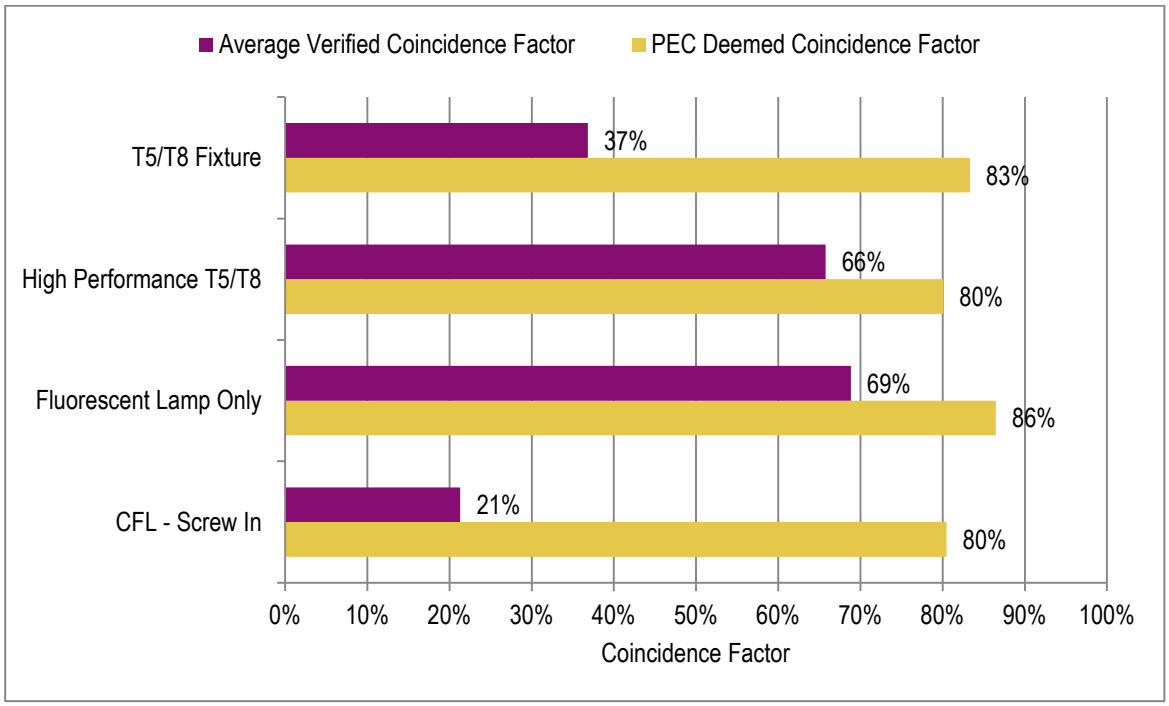
Figure B-11. Verified Summer Coincidence Factors by Building Type



Source: Navigant analysis and EEB deemed savings

Figure B-12 shows the verified CFs for the T5/T8 Fixture, High-Performance T5/T8, Fluorescent Lamp Only, and CFL – Screw In measures. Across the board, the verified CFs are lower than the deemed values. Similar to energy savings, these findings reflect the lower metered operating hours for all of the measures, especially CFL – Screw In. Lower hours indicate less likelihood of the lights to be on during system peak periods.

Figure B-12. Verified Summer Coincidence Factor by Measure



Source: Navigant analysis and EEB deemed savings

Appendix C. Custom Field Verification Reports

Table C-1 through Table C-3 provide the site-level realization rates for all custom projects included in the PY 2012 sample, organized by stratum.

Table C-1. Verified Savings for Custom High Savings Stratum

Sample Count	Site ID	Building Type	Reported Energy Savings (MWh)[a]	Verified Energy Savings (MWh)	Realization Rate (%)
C-1	13470	Light Industrial	782	589	75%
C-2	105440	Office	771	593	77%
C-3	15520	Grocery	620	372	60%
C-4	107860	School	550	566	103%
C-5	12100	Light Industrial	400	354	89%
C-6	13210	Light Industrial	331	331	100%
Stratum Population			**3,452**	**2,804**	**81%**

a. Sites are ordered from highest to lowest energy savings.

Source: EEB program database and Navigant analysis

Table C-2. Verified Savings for Custom-Medium Savings Stratum

Sample Count	Site ID	Building Type	Reported Energy Savings (MWh)[a]	Verified Energy Savings (MWh)	Realization Rate (%)
C-7	24720	Miscellaneous	241	241	100%
C-8	207830	College/University	127	256	202%
C-9	24460	Miscellaneous	122	121	100%
C-10	23570	Warehouse	112	93	83%
Stratum Population			**602**	**711**	**118%**

a. Sites are ordered from highest to lowest energy savings.

Source: EEB program database and Navigant analysis

Table C-3. Verified Savings for Custom-Low Savings Stratum

Sample Count	Site ID	Building Type	Reported Energy Savings (MWh)	Verified Energy Savings (MWh)[a]	Realization Rate (%)
C-11	30680	Retail/Service	36	46	128%
C-12	31010	Retail/Service	18	8	42%
C-13	300130	Retail/Service	9	11	117%
C-14	30000	Retail/Service	1	1	100%
Stratum Population			**65**	**66**	**102%**

a. Sites are ordered from highest to lowest energy savings.

Source: EEB program database and Navigant analysis

The following sections include individual site reports for all custom projects in the PY 2012 sample.

C.1 Site ID 13470, Projects EEB-11-01447 and EEB-12-03074

Site ID	13470
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-11-01447 and EEB-12-03074
Building or Site Type	Light Industrial

C.1.1 Project Summary

The project EEB-11-01447 involves replacing T-12 fluorescent lighting fixtures with lower-wattage LED high-bay fixtures. LEDs replaced fluorescent tubes in wall-pack lighting fixtures. This project included a number of prescriptive upgrades that are not included in the following analysis.

The project EEB-12-03074 involves replacing T-12 and T-5 fluorescent lighting fixtures with LED high-bay fixtures. A summary of reported and verified custom savings for this project appears in Table C-4 and Table C-5. Table C-6 combines these summaries.

Table C-4. Summary of Reported and Verified Custom Savings: EEB-11-01447

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-11-01447 Lighting Replacement	Reported	304,077 kWh	37 kW	$ 24,326
	Verified	304,077 kWh	37 kW	N/A
	Realization Rate	100%	100%	N/A

Source: EEB database and Navigant analysis

Table C-5. Summary of Reported and Verified Custom Savings: EEB-12-03074

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-12-03074 Lighting Replacement	Reported	284,718 kWh	35 kW	$ 22,777
	Verified	284,718 kWh	35 kW	N/A
	Realization Rate	100%	100%	N/A

Source: EEB database and Navigant analysis

Table C-6. Combined Summary of Reported and Verified Custom Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Combined Lighting Replacements	Reported	588,795 kWh	72 kW	$47,103
	Verified	588,795 kWh	72 kW	N/A
	Realization Rate	100%	100%	N/A

Source: EEB database and Navigant analysis

C.1.2 Verification Approach

The Measurement and Verification (M&V) approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager
  - Inspect the new fixtures
  - Install lighting loggers in each work area
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.1.3 Description of Baseline

The baseline lighting equipment is listed in Table C-7.

Table C-7. Baseline and As-Built Lighting Equipment

Project Number	Baseline Equipment	As-Built Equipment
EEB-11-01447	1 lamp, T-12 (95 W), fixtures (125 W with ballast) 2 lamp, T-12 (60 W), fixtures (138 W with ballast) wallpacks: 175 W and 400 W fluorescent	144 W high-bay LEDs 234 W T5s LED wallpacks: 22 W, 70 W, 100 W
EEB-12-03074	2 lamp T-12s and several T-5s	144 W high-bay LED

Source: Customer application and Navigant site visit

C.1.4 Description of As-Built Equipment and Operation

Refer to Table C-7 for as-built lighting equipment.

C.1.5 Applicant Energy Savings Algorithm

Table C-8 and Table C-9 show the pre-retrofit and post-retrofit annual energy and demand savings calculations for the two projects.

Table C-8. Customer's Lighting Calculations: EEB-11-01447

OLD LIGHTING SYSTEM						NEW LIGHTING SYSTEM				
Description	Wattage	Number	Hours	kWh		Description	Wattage	Number	Hours	kWh
1 lamp T12	125	90	8760	98,550		highbay LED	144	110	8760	138,758
2 lamp T12	138	274	8760	331,233		4 lamp T5	234	2	8760	4,100
wallpack	208	3	4000	2,496		wallpack LED	22	3	4000	264
wallpack	458	10	4000	18,320		wallpack LED	70	5	4000	1,400
						wallpack LED	100	5	4000	2,000
Old System	kW	54	kWh	450,599			kW	17	kWh	146,522
New System	kW	17	kWh	146,522						
Annual Savings	kW	37	kWh	304,077						

Source: Customer's application

Table C-9. Customer's Lighting Calculations: EEB-12-03074

OLD LIGHTING SYSTEM						NEW LIGHTING SYSTEM				
Description	Wattage	Number	Hours	kWh		Description	Wattage	Number	Hours	kWh
2 lamp T12	138	309	8760	374,280		highbay LED	144	71	8760	89,562
Old System	kW	45	kWh	374,280						
New System	kW	10	kWh	89562						
Annual Savings	kW	35	kWh	284718						

Source: Customer's application

C.1.6 Uncertainties

The uncertainty associated with these projects is the annual operating hours of the lighting fixtures.

C.1.7 On-Site Energy Monitoring

The International Performance Measurement and Verification Protocol (IPMVP) option adopted for this project is M&V Option B – Retrofit Isolation. Five lighting loggers were installed at various locations in the facility for a period of three weeks. The data were downloaded and analyzed to determine the "on" time for the fixtures. Table C-10 summarizes the monitoring equipment utilized in this project.

Table C-10. Monitoring Equipment

Equipment	Equipment Description
Light Logger	Onset Computer Corporation HOBO U12-12 Temp/RH/Light logger

Source: Navigant analysis

C.1.8 Verified Energy Savings

The data from the light loggers confirmed that the main high-bay lights were "on" continuously, which confirms 8,760 annual operating hours. The data also confirmed that the "wallpack" fixtures averaged 80 hours per week, or 4,000 annual hours. Therefore, it has been verified that the calculations shown in Table C-8 and Table C-9 are correct.

A summary of the verified savings is shown in Table C-11.

Table C-11. Verified Annual Savings

Project Number	Annual Energy Savings (kWh)	Annual Demand Savings (kW)
EEB-11-01447	304,077	37
EEB-12-03074	284,718	35
Combined Total	588,795	72

Source: Navigant analysis

C.1.9 Conclusions

These two projects have obtained energy savings and demand savings realization rates of 100 percent.

C.2 Site ID 20001, Project EEB-11-02224

Site ID	20001
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-11-02224
Building or Site Type	Light Industrial

C.2.1 Project Summary

This project involves the replacement of a 75 horsepower (HP) and a 40 HP constant speed air compressor with a new, high-efficiency, variable-speed, 94 HP air compressor. Table C-12 shows the "reported" and "verified" savings in annual energy consumption and in electrical demand.

Table C-12. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace two air compressors with VSD compressor	Reported	192,720 kWh	22.0 kW	$15,417.60
	Verified	184,660 kWh	28.2* kW	N/A
	Realization Rate	96%	128%	N/A

*Note that the "reported" demand savings is based on the average weekly demand, whereas the "verified" demand savings is based on *maximum* observed hourly demand. Refer to section 1.8.3.

Source: EEB database and Navigant analysis

C.2.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager
  - Inspect the new compressor
  - Install data logger on electrical service to the new compressor
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.2.3 Description of Baseline

This factory manufactures a wide variety of LED lighting fixtures, including high-bay LED fixtures, traffic lights, and pedestrian control lights. The facility manufactures nearly all the components, including the LED lights, the plastic housings and lenses, and the heat sinks for the LED fixtures. Compressed air is an integral part of the manufacturing processes. Many of the molding machines are operated by compressed air. Compressed air is also used in automated and manual surface plating processes. Although the factory operates continuously, the consumption of compressed air is variable. Prior to the retrofit project, the two constant-speed air compressors (75 HP and 40 HP) were sequenced in order to match the demand for compressed air. As the compressors were constant speed, and as the demand for compressed air is variable, the compressed air operation was inefficient.

C.2.4 Description of As-Built Equipment and Operation

A new 94 HP, variable speed compressor was installed to replace the two older units. This new compressor is designed for variable demand applications and consumes less energy. The factory operates around the clock, and production occurs approximately 360 days per year. On holidays, production is shut down for only a single shift. As a result, the compressed air system is not shut down because it takes too much time to re-pressurize the system. An older, 150 HP compressor is used for backup when the new compressor is being serviced.

C.2.5 Applicant Energy Savings Algorithm

C.2.5.1 Baseline Analysis

An air compressor contractor conducted a week-long, baseline analysis of the pre-retrofit compressed air system. The contractor determined that the 75 HP compressor ran continuously and the 40 HP unit operated during the work week (Monday through Friday) from 10:00 AM until 2:00 PM to accommodate peak load conditions. Both existing compressors were at least 20 years old and had a full load efficiency of 3.43 cubic feet per minute (CFM) per kW.

The contractor determined that the 75 HP compressor operated at an electrical demand of 67.1 kW, while the 40 HP compressor operated at an electrical demand of 33.9 kW, for a total electrical load of 101 kW. Accounting for the operating hours of the two compressors, the weighted average electrical demand for the system was 69.3 kW when the average flow was 237.8 CFM.

Given that the compressed air system operates 8,760 hours per year, the estimated annual electrical consumption is 607,068 kWh. The pre-retrofit instantaneous electrical demand was reported to be 152.9 kW, which occurred during compressor start-up. The pre-retrofit baseline energy use summary is shown in Table C-13.

Table C-13. Baseline System Summary

Average Flow (CFM)	Dynamic Efficiency	Average kW Demand as logged	Annual Operating Hours	Annual Energy (kWh)
237.8	3.43	69.3	8,760	607,068

Source: Customer application

C.2.5.2 Preliminary Savings Projection

The air compressor contractor projected the post-retrofit annual energy consumption of the new compressor based on an improved dynamic efficiency of 5.14 CFM per kW. Based on a flow rate of 237.8 CFM and a dynamic efficiency of 5.14 CFM per kW, the projected average electrical demand for the new compressor is (237.8/5.14) = 46.2 kW. The preliminary post-retrofit annual energy consumption projection is summarized in Table C-14.

Table C-14. Preliminary Post-Retrofit Energy Consumption Projection

Average Flow (CFM)	Dynamic Efficiency	Av kW Demand	Annual Op. Hours	Annual Energy (kWh)
237.8	5.14	46.2	8,760	404,712

Source: Customer application

C.2.5.3 Post-Retrofit Sub-Metered Energy Consumption

The contractor installed a data logger on the new compressor and collected data for one week following its installation. Based on the data, the contractor determined that the actual dynamic efficiency of the new compressor was 4.76 CFM per kW, rather than 5.14 CFM per kW. The results of this study are summarized in Table C-15.

Table C-15. Post-Retrofit Energy Consumption

Average Flow (CFM)	Dynamic Efficiency	Av kW Demand as logged	Annual Op. Hours	Annual Energy (kWh)
222.7	4.76	47.3*	8,760	414,348
* Note that the maximum recorded kW demand during the week-long data collection was 74.9 kW.				

Source: Customer application

C.2.5.4 Contractor-Projected Annual Savings

The "reported" annual energy savings (based on the pre-and post-retrofit measurements) is 192,720 kWh. The post-retrofit electrical demand was reported to be 47.3 kW, a value that was based on the *average* weekly electrical demand. These results are presented in Table C-16.

Table C-16. Reported Savings

Analysis Category	Pre-Retrofit Data	Post-Retrofit Data	Reported Savings
Annual Electrical Consumption (kWh)	607,068 kWh	414,348 kWh	192,720 kWh
Average Electrical Demand (kW)	69.3 kW	47.3 kW	22.0 kW

Source: Data abstracted from customer application file

C.2.6 Uncertainties

The reported savings that the customer provided is based on one week of energy use data. One week of data collection produces one data point, which may not be a statistically significant sample. In addition, the contractor's energy measuring equipment did not monitor voltage or power factor, which can result in inaccuracies, especially since the new compressor has a variable speed drive.

C.2.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. An air compressor contractor took pre-retrofit energy measurements for a period of one week. The results from this monitoring effort are stipulated to represent the baseline electrical energy consumption for the pre-retrofit compressed air system. Following the retrofit, the contractor collected an additional seven days of data, and the annual energy savings reduction included in the customer's application are based on the results from these two weeks of data collection.

Navigant collected post-retrofit energy data for a period of four weeks. The verified annual energy savings and the demand reduction are calculated by comparing the four-week results to those of the baseline. It should also be noted that the plant engineer commented that one of the spray booths had been recently expanded, and he estimated that the use of compressed air had increased by 10 to 15 percent.

Table C-17 lists the monitoring equipment that Navigant used for the data collection.

Table C-17. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-meter	Continental Control Systems: Watt Node Pulse, True RMS wattmeter that monitors voltage, current, and phase angle several thousand times per second to result in 0.5% accuracy. Installed with a 250 amp current transformer
Pulse Logger	Madgetech 101A Pulse Logger
Note: The Madgetech Pulse logger was programmed to output hourly energy values.	
Source: Navigant analysis	

C.2.8 Verified Energy Savings

For air compressor replacement projects, the contractor measures the weekly energy consumption and air flow rate of the system prior to and following the retrofit. The EM&V team extrapolates the energy savings determined from this one week of monitoring to an annual savings figure that is included in the customer's rebate application.

The M&V analysis typically occurs six months after the retrofit has been completed. The objectives of the M&V study are as follows:

1. Confirm that the new compressor(s) is still in operation
2. Based on a discussion with the operating engineer, determine if demand for compressed air has changed (which might result from a change in operating hours of the factory or the addition or removal of equipment)
3. Based on a discussion with the operating engineer, determine if the control sequence for the compressor(s) has changed (which might occur if the compressor line-up has changed)
4. Install energy data loggers on the compressor(s) for a period of three to five weeks
5. Using the monitored energy data, compare the daily and weekly operational profiles of the compressed air system to the profile described in the customer's application
6. Using the monitored energy data, compare the weekly energy consumption with the post-retrofit energy consumption included in the customer's application
7. If permanent changes to the compressed air system have occurred or if the operating profile of the compressor(s) has changed, calculate the annual energy savings based on the new operating conditions

C.2.8.1 Baseline Consumption Analysis

A contractor measured the baseline electrical energy and electrical demand for the compressed air system prior to the retrofit. It is stipulated that the annual energy use of 607,068 kWh is the pre-retrofit baseline for this project. It is also stipulated that the measured average weekly demand was 69.3 kW, the connected load was 101 kW, and the maximum measured instantaneous demand was 152.9 kW.

Navigant reviewed the data and the calculations and concluded that this annual energy estimate was accurate. However, the "reported" demand was based on the average weekly demand and not the maximum 15-minute demand. In addition, the plant engineer indicated that the paint booth operation was recently expanded, and he estimated that the use of compressed air had increased by an estimated 10 to 15 percent. As such, the baseline value of 607,068 kWh was adjusted for this M&V analysis. Refer to Table C-20.

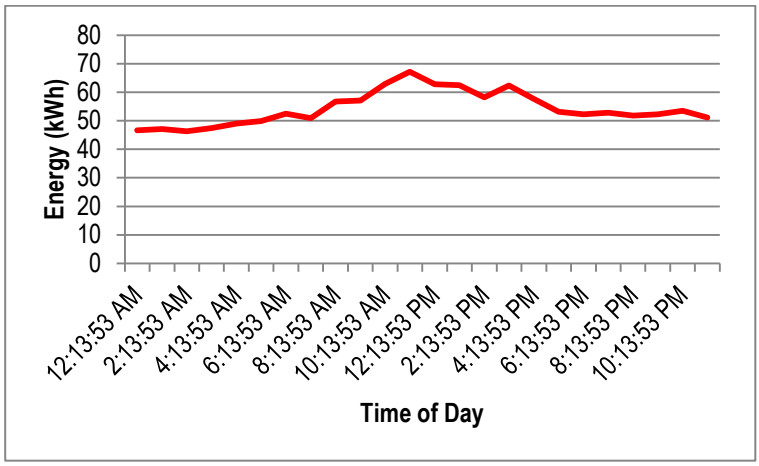
C.2.8.2 Post-Retrofit Analysis

In order to establish the post-retrofit annual energy consumption of the new air compressor, energy use data were collected for four weeks beginning on August 30, 2012 and ending on October 3, 2012.

Energy Profiles

The following hourly, daily, and weekly energy use profiles were developed in an effort to confirm that the new air compressor was being operated as the facility manager described.

Figure C-1. Weekday Energy Profile

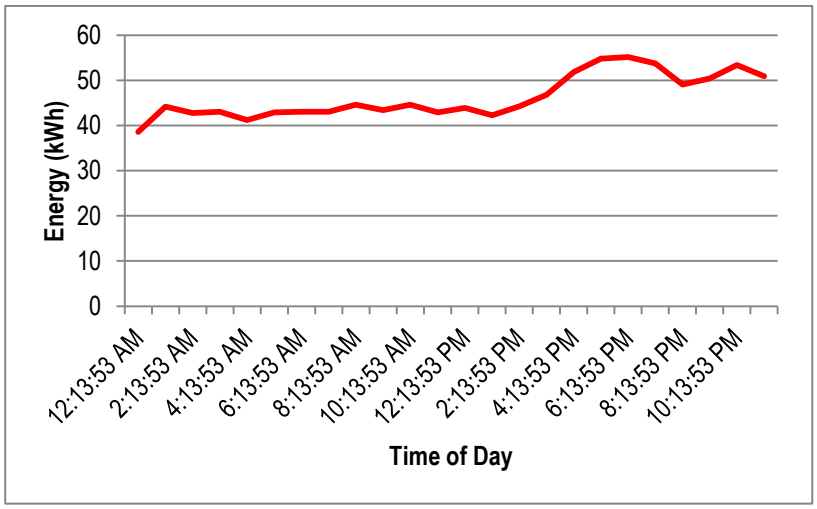


Source: Navigant analysis

Figure C-1 shows the energy profile for a typical weekday. As shown in Figure C-1, the use of compressed air increases for several hours during midday. This profile is consistent with the facilities manager's explanation. Recall that, prior to the installation of the new compressor, both of the original compressors had to run during the midday in order to maintain system pressure.

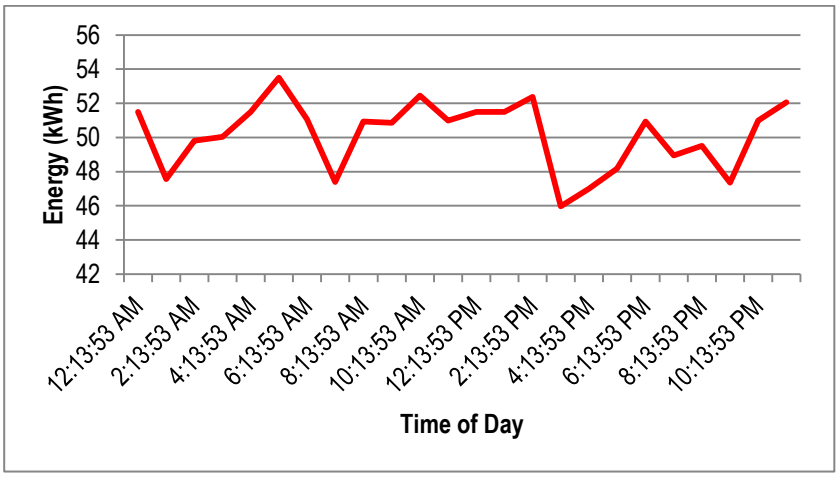
Figure C-2 and Figure C-3 show the energy profiles, respectively, for Saturday and Sunday.

Figure C-2. Saturday Energy Profile



Source: Navigant analysis

Figure C-3. Sunday Energy Profile

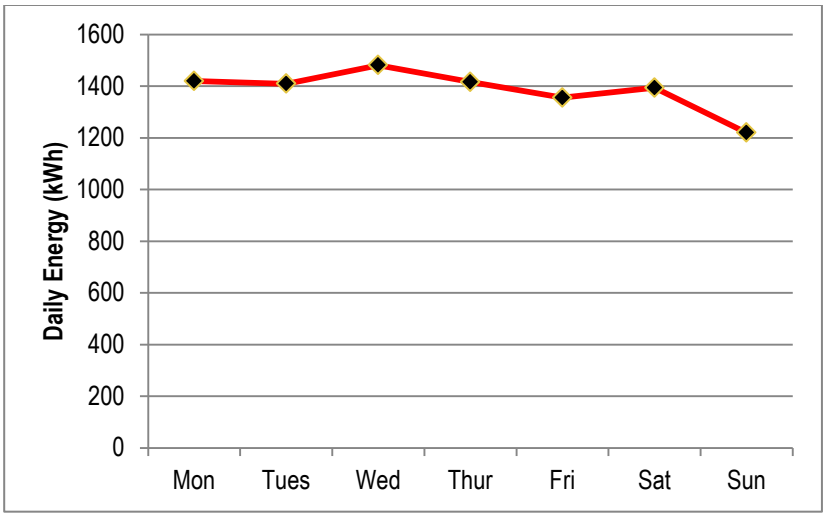


Source: Navigant analysis

Note that the energy profile for Saturday indicates a slight energy-use increase in the late afternoon but that the consumption never reaches 60 kWh. On Sundays, the hourly energy profile is below 50 kWh, and the electrical demand is highly variable. This fluctuation probably results from fewer people working on Sundays.

Figure C-4 shows the energy profile for a typical week.

Figure C-4. Weekly Energy Profile



Source: Navigant analysis As shown in Figure C-4, the energy profile for the five weekdays and for Saturday is fairly consistent, averaging approximately 1,400 kWh per day. Energy use is significantly lower on Sundays.

Table C-18 shows the logged energy results for the four complete weeks of monitoring.

Table C-18. Logged Energy Results

Weekly Logged Energy (kWh)	Average Demand (kW)
8,785	52.3
9,201	54.8
8,792	52.3
9,760	58.1
Average	54.4
Std. Deviation	2.75

Source: Navigant analysis As shown in Table C-18, the average electrical demand is 54.4 kW, which is the value used to calculate the post-retrofit annual energy consumption shown in Table C-19.

Table C-19. Verified Post-Retrofit Energy Consumption (Preliminary)

Average Flow (CFM)	Dynamic Efficiency	Av kW Demand as logged	Annual Op. Hours	Annual Energy (kWh)
258.9	4.76	54.4	8,760	476,544

Source: Navigant analysis

As previously stated, the use of compressed air recently increased. Therefore, the baseline "Average Flow" in Table C-18 was adjusted using the following calculation:

Average flow (CFM) = 54.4 kW x 4.76 CFM/kW = 258.9 CFM

This calculated result indicates that the expansion of the paint spray booth operation resulted in a flow increase from 222.7 CFM to 258.9 CFM, which represents a 16 percent increase. The revised flow rate is entered in Table C-20 and used to calculate the adjusted baseline kW demand, using the following calculation:

Average kW demand (adjusted) = 258.9 CFM /3.43 kW/CFM = 75.48 kW

Table C-20. Adjusted Baseline Energy Consumption

Average Flow (CFM)	Dynamic Efficiency	Av kW Demand (Adjusted)	Annual Op. Hours	Annual Energy (kWh)
258.9	3.43	75.48	8,760	661,204

Source: Navigant analysis

Therefore, the Adjusted Baseline kW is 75.48, which is the value used to calculate the Adjusted Baseline annual energy consumption value of 661,204 kWh (at a flow of 258.9 CFM).

C.2.8.3 Verified Annual Energy and Demand Savings

Table C-21 shows a summary of the results based on the Adjusted Baseline and the Verified Savings results from Navigant's monitoring.

Table C-21. Verified Annual Energy and Demand Savings

	Average kW Demand	Annual Op. Hours	Annual Energy (kWh)	Peak Demand (kW)
Baseline	75.48	8,760	661,204	101.0
Post-Retrofit	54.40	8,760	476,544	72.8
Verified Savings	21.08		184,660	28.2

Source: Navigant analysis

As shown in Table C-21, the baseline energy consumption was adjusted from 607,068 kWh to 661,204 kWh because of the recent expansion of the spray booth. The post-retrofit energy consumption is 476,544 kWh, and the verified annual energy savings is 184,660 kWh.

As shown in Table C-21, the average annual reduction in electrical demand is 21.08 kW. However, this figure does not represent the reduction in peak electrical demand as defined by the utility company.

The verified demand savings of 28.2 kW is calculated as follows. The 101.0 kW is the combined steady-state, full load demand of the two original air compressors. This demand occurred when the second compressor was brought on-line at 10 AM in order to boost the system pressure. Although the contractor reported a maximum instantaneous demand of 152.9 kW, this high demand probably occurred during start-up and lasted only a few minutes. Therefore, the full load demand of 101kW was adopted for the baseline condition. The post-retrofit maximum hourly demand was recorded to be 72.8kW, which results in a verified demand savings of 28.2 kW.

C.2.9 Conclusions

The following conclusions result from the above analyses:

1. The sub-metered data indicate that the new compressor is operated at all hours, except when being serviced (typically one day every other month). The energy consumption of the new compressed air system averages 1,400 kWh per day for six days each week and 1,200 kWh on Sundays and holidays.

2. Based on four weeks of monitoring, the average weekly electrical demand of the new air compressor was 54.4 kW, with a standard deviation of 2.75 kW. Based on 8,760 annual operating hours, the projected post-retrofit annual energy consumption is 476,544 kWh.

3. The recent expansion of the paint shop increased the use of compressed air by 16 percent. As a result of this increase in air use, the baseline annual energy projection was increased from 607,068 kWh to 661,204 kWh.

4. The verified annual electrical savings is 184,660 kWh, which results in a realization rate of 96 percent.

5. The verified annual electrical demand savings (based on observed maximum data) was 28.2 kW, which results in a realization rate of 128 percent. This reduction is greater than reported in the customer's application because the customer used average weekly demand values, rather than maximum observed hourly values, in the calculation.

6. The M&V Results are based on Navigant's four weeks of data collection, through which Navigant determined and calculated that the new flow is to be 16 percent higher than the 222.7 CFM that the contractor measured. This flow increase is consistent with the estimate that the operating engineer provided. Had the flow not increased, the post-retrofit data would be unchanged, and the realization rate would be 100 percent. However, the flow did increase, and the customer expects the system to operate at this new flow of 258.9 CFM for the foreseeable future. Since the system flow increase, it has been Navigant's policy to modify the baseline by calculating what energy would have consumed at the new flow rate. These calculations result in a realization rate of 96 percent.

C.3 Site ID 105440

Site ID	105440
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-12-03072
Building or Site Type	Office

C.3.1 Project Summary

The project involves the replacement of T-12 fluorescent troffer fixtures, strip fixtures, and incandescent downlights with LEDs. For four-tube T-12 fixtures, only two LED tubes were installed. Table C-22 shows the reported and verified energy and demand savings for this project.

Table C-22. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace fluorescent and incandescent lights with LEDs	Reported	770,586 kWh	184 kW	$61,646
	Verified	592,756 kWh	186 kW	
	Realization Rate	77%	101%	N/A

Source: EEB database and Navigant analysis

C.3.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review the project files
  - Review the customer's energy savings calculations
- Conduct a phone interview with corporate contact
- Conduct a site visit
  - Interview the facilities manager

- Install data loggers on the 277-volt (V) lighting panels
  - Take one-time power readings on the three-phase breakers that sub-feed 120-V transformers and receptacle circuits.
- Take a power measurement of a group of fixtures in a conference room
- Inspect the troffer fixtures to confirm that the original ballasts have been removed

» Retrieve data loggers
- Analyze data
- Analyze utility bills

» Prepare preliminary report, which the Navigant Project Manager reviews

» Submit final report

C.3.3 Description of Baseline

The baseline lighting for this 96,000-square-foot office building included four-tube, T-12, 277-V, fluorescent troffer fixtures and recessed "can" fixtures with 120-V incandescent bulbs. According to the customer's application, the total installed wattage of the fluorescent fixtures was 194.5 kW, and the total wattage of the incandescent fixtures was 49.0 kW. The combined lighting wattage was 243.5 kW, which equated to a power density of 2.53 W/ft². Although the emergency lights were "on" 8,760 hours per year, the majority of lights operated 60 hours per week (3,120 hours per year).

C.3.4 Description of As-Built Equipment and Operation

According to the customer's application, the as-built lighting system includes two-tube, 277-V LED fixtures and recessed "can" fixtures with 120-V LED bulbs installed. According to the customer's calculations, the total wattage of the 277-V troffer fixtures is 50.85 kW, and the total wattage of the LED "can" fixtures is 8.66 kW, for a power density of 0.62 W/ft².

Figure C-5. Retrofitted Troffer LED Fixture (lens removed)

Source: Navigant analysis

C.3.5 Applicant Energy Savings Algorithm

Table C-23 and Table C-24 show the customer's calculation of the power and annual energy consumption for the baseline lighting system. Note that most of the lighting is "on" for 60 hours per week (3,120 hours per year), while emergency lighting is "on" for 8,760 hours per year.

Table C-23. Lighting Calculations (Incandescent Fixtures)—Pre-Retrofit

Existing Lighting	No.	Fixture	Fixture	Total	Op.	Annual
	bulbs	Qnty	Watts	Watts	Hours	kWh
150 w Par 38	5	5	150	750	3120	2,340
120 W Par 30	9	9	120	1080	3120	3,370
68 W Par 30	5	5	68	340	3120	1,061
75 W Par 30	227	227	75	17025	3120	53,118
65 W Par 30	284	284	65	18460	3120	57,595
75 W Par 30	76	76	75	5700	8760	49,932
50 W MR16	35	35	50	1750	8760	15,330
60 w Incand	48	48	60	2880	8760	25,229
50 w Par 20	18	18	50	900	8760	7,884
Incandescent "Can" Totals			**kW**	**48.89**	**kWh**	**215,858**

Source: Customer's application

Table C-24. Lighting Calculations (Fluorescent Tubes)—Pre-Retrofit

Existing Lighting	No.	Fixture	Fixture	Total	Op.	Annual
	bulbs	Qnty	Watts	Watts	Hours	kWh
T12 4L@34w	232	58	144	8352	3120	26,058
T12 4L@34w	2496	624	144	89856	3120	280,351
T12 4L@40 w	692	173	172	29756	3120	92,839
T12 4L@34w	68	17	144	2448	3848	9,420
T12 4L@40 w	16	4	172	688	3848	2,647
T12 4L@34w	116	29	144	4176	3360	14,031
T12 4L@40 w	40	10	172	1720	3360	5,779
T12 4L@34w	60	15	144	2160	3360	7,258
T12 4L@40 w	20	5	172	860	3360	2,890
T12 4L@34w	240	60	144	8640	3384	29,238
T12 4L@40 w	84	21	172	3612	3384	12,223
T12 4L@34w	508	127	144	18288	8760	160,203
T12 4L@40 w	172	43	172	7396	8760	64,789
T12 2L@40w	56	28	86	2408	3120	7,513
T12 2L@40w	152	76	86	6536	8760	57,255
8 foot T12	8	4	136	544	3120	1,697
T12U 2L@40w	102	51	86	4386	3120	13,684
T12U 2L@40w	30	15	86	1290	3848	4,964
T12U 2L@40w	2	1	86	86	3360	289
T12U 2L@40w	4	2	86	172	3360	578
T12U 2L@40w	4	2	86	172	3384	582
T12U 2L@40w	12	6	86	516	8760	4,520
T12U 2L@ 34w	14	7	72	504	3120	1,572
Fluorescent Totals				**194.6**		**800,381**

Source: Customer's application

Adding the total kW in Table C-23 and Table C-24, the pre-retrofit lighting demand was 243.5 kW, while the annual energy consumption was 1,016,239 kWh.

Table C-25 and Table C-26 show the customer's post-retrofit calculations. Note that the lighting "on" hours are the same as the pre-retrofit hours.

Table C-25. Lighting Calculations (LED Bulbs) – Post-Retrofit

Proposed Lighting	No.	Fixtture	Fixture	Total	Op.	Annual
	bulbs	Qty	Watts	Watts	Hours	kWh
Par 30 13W LED	5	5	13	65	3120	203
Par 30 13W LED	9	9	13	117	3120	365
Par 30 13W LED	5	5	13	65	3120	203
Par 30 13W LED	227	227	13	2951	3120	9207
Par 30 13W LED	284	284	13	3692	3120	11519
Par 30 13W LED	76	76	13	988	8760	8655
LED MR16 6 w	35	35	6	210	8760	1840
Globe 9 W LED	48	48	9	432	8760	3784
Par 20 LED 8 w	18	18	8	144	8760	1261
LED "Can" Totals			**kW**	**8.664**	**kWh**	**37037**

Source: Customer's application

Table C-26. Lighting Calculations (LED Tubes) – Post-Retrofit

Proposed Lighting	No.	Fixtture	Fixture	Total	Op.	Annual
	bulbs	Qty	Watts	Watts	Hours	kWh
1 lamp LED	58	58	20	1160	3120	3619
2 lamp LED	1248	624	40	24960	3120	77875
2 lamp LED	346	173	40	6920	3120	21590
2 lamp LED	34	17	40	680	3848	2617
2 lamp LED	8	4	40	160	3848	616
2 lamp LED	58	29	40	1160	3360	3898
2 lamp LED	20	10	40	400	3360	1344
2 lamp LED	30	15	40	600	3360	2016
2 lamp LED	10	5	40	200	3360	672
2 lamp LED	120	60	40	2400	3384	8122
2 lamp LED	42	21	40	840	3384	2843
2 lamp LED	254	127	40	5080	8760	44501
2 lamp LED	86	43	40	1720	8760	15067
2 lamp LED	56	28	40	1120	3120	3494
1 lamp LED	76	76	20	1520	8760	13315
2 lamp LED	8	4	20	80	3120	250
2 lamp 2 foot LED	102	51	22	1122	3120	3501
2 lamp LED	30	15	22	330	3848	1270
2 lamp LED	2	1	22	22	3360	74
2 lamp LED	4	2	22	44	3360	148
2 lamp LED	4	2	22	44	3384	149
2 lamp 2 foot LED	12	6	22	132	8760	1156
2 lamp LED	14	7	22	154	3120	480
LED Troffer Totals			**kW**	**50.85**	**kWh**	**208616**

Source: Customer's calculations

Table C-27 summarizes the demand and annual energy savings calculations submitted in the customer's application.

Table C-27. Demand and Energy Savings Results

Pre-Retrofit Totals				Post-Retrofit Totals		Annual
	Fluorescent	Incandescent		LED	LED	Savings
	Troffers	Rec. Cans		Troffers	Rec. Cans	
kW	194.6	48.89		50.85	8.66	184
kWh	800,381	215,858		208,616	37,037	770,586

Source: Customer's application

The savings shown in Table C-27 represent the reduction in lighting load and energy only. The reduction in summer air conditioning and the increase in winter heating (electrical resistance) were not included in the customer's energy savings analysis. (This omission is fairly common because, given the North Carolina climate, the increase in winter heating typically offsets the reduction in summer cooling.)

C.3.6 Uncertainties

The demand and energy savings shown in Table C-27 assume that the building is 100 percent occupied and that every light fixture is "on" for the number of annual hours included in the above tables. Experience in building analysis indicates that all the lights being "on" for the estimated hours is unusual. In addition, according to the owner's representative, the building occupancy was only 75 percent at the time the application was prepared (pre-retrofit), and it recently increased to 90 percent (post-retrofit).

C.3.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. Although an analysis of pre-retrofit and post-retrofit utility bills was conducted, the verification process relied primarily on the sub-metered energy data collected from the 277-V lighting panels.

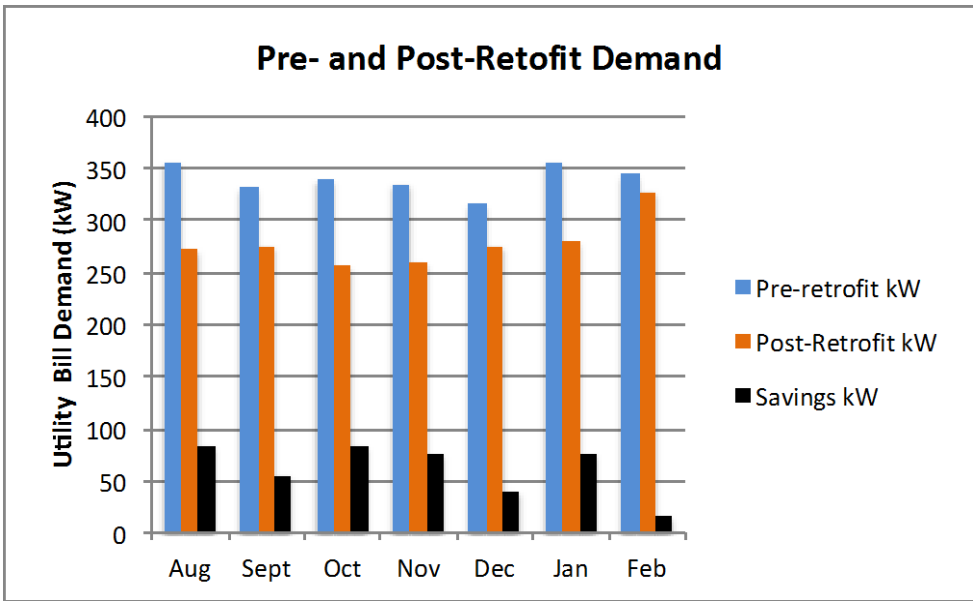
Navigant collected post-retrofit energy data from the 277-V lighting panels for a period of three weeks. The verified annual energy savings and the demand reduction were calculated by comparing the three-week results to those of the baseline.

C.3.8 Verified Energy Savings

C.3.8.1 Utility Bill Analysis

According to the building manager, the lighting retrofit was completed during July 2012. Utility bill demand data for seven months following the retrofit (i.e., August 2012 through February 2013) were compared to the same seven months prior to the retrofit. Figure C-6 shows the monthly results.

Figure C-6. Pre- and Post-Retrofit Utility Bill Demand



Source: Navigant analysis

Table C-28 shows the results of this comparison.

Table C-28. Pre- and Post-Retrofit Utility Bill Demand Comparison

Utility Bill (Aug - Feb)	Pre-Retrofit	Post-Retrofit	Reduction
Maximum Demand (kW)	356	328	28
Average Demand (kW)	340	278	62

Source: Customer's utility bills and Navigant analysis

Referring to Table C-27, the customer's calculations projected a decrease in the lighting demand of 184 kW. The data presented in Figure C-6 and Table C-28 indicate that, based on utility bill data, the electrical demand decreased an average of 62 kW.

The average pre- and post-retrofit energy consumptions for the seven months of utility data are shown in Table C-29. Also shown are the annual consumption and the estimated savings, based on utility bill analysis.

Table C-29. Pre- and Post-Retrofit Utility Bill Consumption Analysis

Utility Bill (Aug-Feb)	Pre-Retrofit	Post-Retrofit	Reduction
Average Consumption (kWh)	156,800	133,829	22,971
Annual Projection (kWh)	1,881,600	1,605,948	275,652

Source: Customer's utility bills and Navigant analysis

Table C-29 shows the annual energy savings, based on a comparison of the pre-retrofit and post-retrofit consumption data, are 275,652 kWh. This value is only 36 percent of the annual savings estimated in the customer's calculations (770,586 kWh).

Adjustments for Occupancy and Weather

According to the building manager, the post-retrofit occupancy was an estimated 15 percent higher than the pre-retrofit occupancy. Since the tenant space makes up approximately 80 percent of the building, a 15 percent increase in tenant occupancy translates to 0.8 times 15 percent, or a 12 percent, increase in the total building energy. In order to normalize the post-retrofit consumption to the pre-retrofit occupancy, the post-retrofit energy must be reduced by 12 percent. Applying this correction to Table C-28 results in the values shown in Table C-30.

Table C-30. Utility Consumption Adjusted for Occupancy

Utility Bill (Aug-Feb)	Pre-Retrofit	Post-Retrofit	Reduction
Average Consumption (kWh)	**156,800**	**113,754**	**43,046**
Annual Projection (kWh)	**1,881,600**	**1,365,048**	**516,552**

Source: Customer's utility bills and Navigant analysis

As shown in Table C-30, adjusting for the 15 percent increase in occupancy, the projected annual energy savings is 516,552 kWh. This value is 67 percent of the annual savings estimated in the customer's calculations.

The second adjustment to the building energy consumption is for changes in weather. The cooling and heating degree day figures for the seven pre-retrofit and post-retrofit months are shown in Table C-31.

Table C-31. Pre-Retrofit and Post-Retrofit Weather (Seven Months)

Pre-Retrofit	Pre-Retrofit	Post-Retrofit	Post-Retrofit
DD Htg	DD Clg	DD Htg	DD Clg
2143	790	2448	637

Source: U.S. Weather Bureau

As shown in Table C-30, the pre-retrofit weather was 14 percent milder during the winter months and 20 percent hotter during the summer months (primarily August). These differences offset one another, and the net result would not have a significant impact on the savings results.

The above analysis of the pre- and post-retrofit utility data did not confirm the customer's projected electrical demand and energy use reduction projections. Additional discussions with the property manager and the building engineer were conducted. These two individuals were asked if any increases in electrical loads occurred after the lighting retrofit. Navigant specifically asked if any tenants might have added a data center. The response to this line of questioning was that there was no single tenant who significantly increased the electrical load in their space but that all the new tenants appeared to have more computers and peripheral equipment than the earlier tenants did. Neither the building manager nor the building engineer was able to quantify the increased electrical load.

C3.8.2 Sub-Metering Lighting Load Analysis

The following table lists the monitoring equipment that Navigant used for the data collection.

Table C-32. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Power Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

As described in Section C.3.6, the customer's energy savings calculations were based on the assumptions that the building was 100 percent occupied and that 100 percent of the lights were "on" during the occupied hours. Since the results from the utility bill analysis do not support these assumptions, sub-metering was conducted and this data, in conjunction with utility bill data, was analyzed to determine more accurate assumptions.

Demand Analysis

Based on the customer's lighting fixture data, the troffer lighting accounts for approximately 86 percent of the total lighting in the building. The troffer lighting serves primarily the office spaces; this is the lighting that the tenants switch "on" and "off." (The "can" recessed fixtures serve primarily the lobby areas and these lights are left "on" whenever the building is occupied.)

The troffer lighting is relatively easy to monitor because it is served by four 277-V lighting panels, one on each floor. Unfortunately, each of these panels has one, two, or three 3-phase breakers that sub-feed transformers that serve 120-V receptacle panels. One-time power measurements were taken (using a multi-meter) on each of the 277-V feeders to the panels. Measurements were also taken on the 21 conductors connected to the 3-phase breakers. Data loggers were installed on each of the 277-V feeders for a period of three weeks.

Table C-33 shows the daytime troffer lighting loads (based on multi-meter measurements) on each of the four 277-V lighting panels.

Table C-33. Troffer Lighting Loads

Building Floor	Total Panel (kW)	Sub-Feeders (kW)	Lighting (kW)
First floor	34.4	25	9.4
Second Floor	24.9	18.8	6.1
Third Floor	26.9	15.4	11.5
Fourth Floor	28.9	21.2	7.8
Total	115.1	80.4	34.8

Source: Navigant data collection

As indicated in Table C-33, the daytime measured electrical load of the 277-V troffer fixtures was 34.8 kW. The daytime (total) power for the three-phase (receptacle) breakers was 80.4 kW.

As shown in Table C-26, the customer calculated the total post-retrofit electrical load of the 277-V troffer lighting to be 50.85 kW when all these lights were "on." At the time of Navigant's data collection, the building was 90 percent occupied, which would have reduced the calculated load to 45.76 kW.

Additionally, power measurements were taken on 10 two-tube fixtures, and the input power was determined to be 19.4 watts per tube, rather than 20 watts per tube used in the customer's calculations. Therefore, the total calculated load of the troffers is reduced from 45.76 kW to 44.38 kW. The measured troffer load from Table C-33 is 34.8 kW, which is 22 percent lower than the customer's calculations predicted. This result indicates that only 78 percent of the troffer lighting is "on" during weekdays in the occupied spaces.

Therefore, in occupied areas of the building, the 78 percent "on" figure will replace the owner's 100 percent "on" figure for the troffer lighting whenever the building is occupied. (The owner's 100 percent "on" figure for the recessed "can" figures will not be changed.)

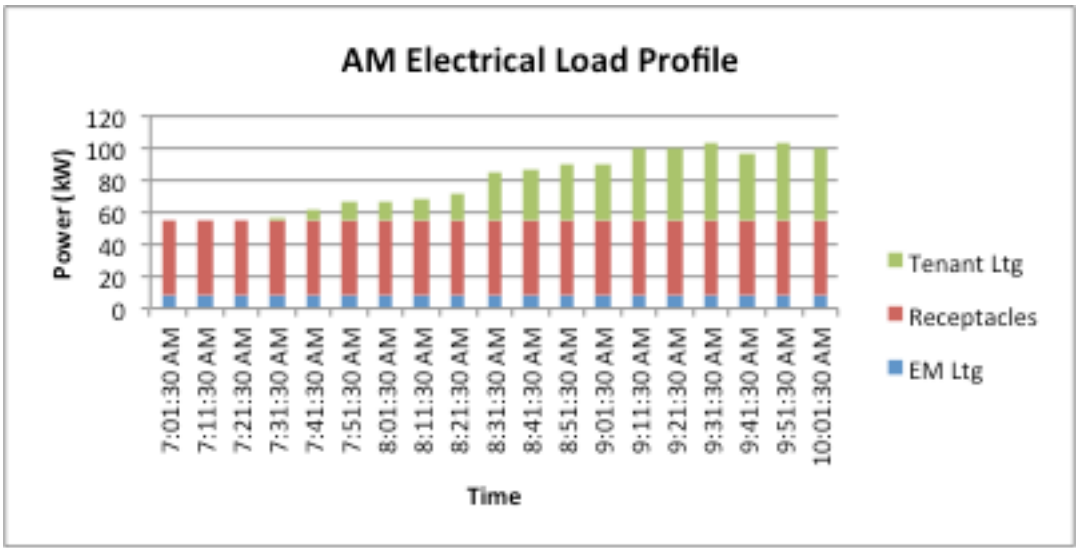
Daily Electrical Load Profiles

The previous analysis determined that 78 percent of the troffer lights were "on" during the day. In order to calculate annual energy consumption, sub-metered data were analyzed, and the average number of hours the troffer lights are "on" during workdays was determined.

Sub-metered data from the four 277-V electrical panels indicate that the average load on the panels at night and on the weekends is 55.5 kW. Since emergency lights account for 8.4 kW, the average plug load at night and on the weekends is 47.1 kW.

Figure C-7 shows the typical early morning electrical load profile for the four 277-V panels.

Figure C-7. Electrical Load- Morning Profile

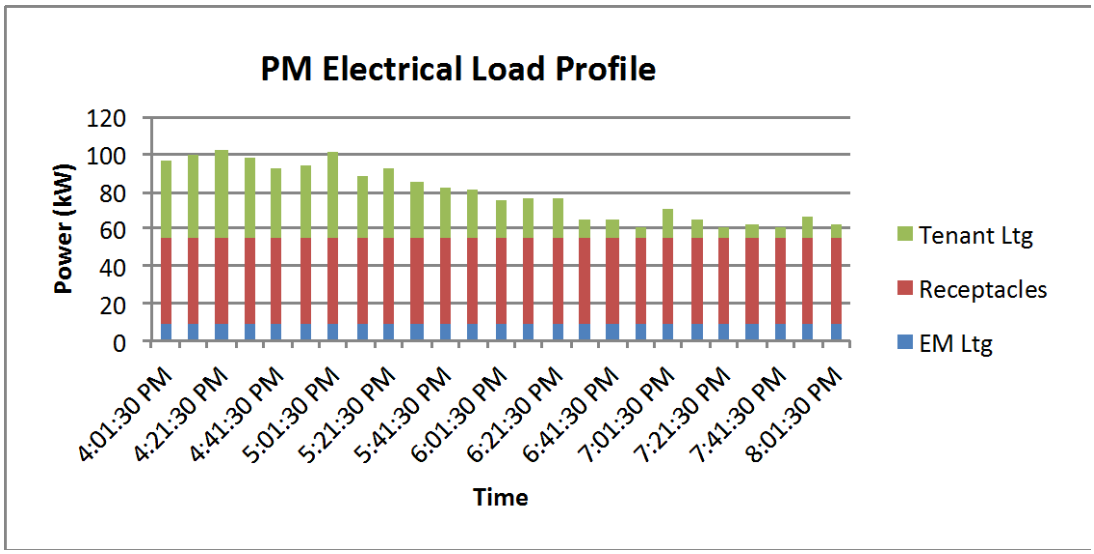


Source: Navigant sub-metering

As indicated in Figure C-7, the tenant lighting is switched "on" (full load equivalent) at 8:45 AM.

Figure C-8 shows the typical later afternoon electrical load profile for the four 277-V panels.

Figure C-8. Electrical Load- Morning Profile



Source: Navigant sub-metering

As indicated in Figure C-8, the tenant lighting is switched "off" (full load equivalent) by 6:00 PM.

Based on the above analysis, the tenant troffer lighting during weekdays is "on" from 8:45 AM until 6:00 PM, or 10 hours, 15 minutes per day, or 51 hours, 15 minutes per week. (This assumes that occasional weekend occupancy is offset by holiday vacancy.)

Annual Energy Analysis

The sub-metered data suggest that 78 percent of the tenant troffers are "on" during the day in the occupied offices and that these lights operate an equivalent of 51 hours, 15 minutes per week (2,665 hours per year).

Table C-34 revises Table C-24 for 75 percent occupancy, 78 percent of the switched troffer lights "on" in the occupied offices, and the troffers being "on" for 2,665 hours per year.

Table C-34. Verified Pre-Retrofit Annual Energy Calculation – Troffer Fixtures

Existing Lighting	No.	Fixture	Fixture	Total	Op.	Annual
REVISED	bulbs	Qnty	Watts	Watts	Hours	kWh
T12 4L@34w	232	58	144	4885.92	2665	13,021
T12 4L@34w	2496	624	144	52565.76	2665	140,088
T12 4L@40 w	692	173	172	17407.26	2665	46,390
T12 4L@34w	68	17	144	1432.08	2665	3,816
T12 4L@40 w	16	4	172	402.48	2665	1,073
T12 4L@34w	116	29	144	2442.96	2665	6,510
T12 4L@40 w	40	10	172	1006.20	2665	2,682
T12 4L@34w	60	15	144	1263.60	2665	3,367
T12 4L@40 w	20	5	172	503.10	2665	1,341
T12 4L@34w	240	60	144	5054.40	2665	13,470
T12 4L@40 w	84	21	172	2113.02	2665	5,631
T12 4L@34w	508	127	144	18288.00	8760	160,203
T12 4L@40 w	172	43	172	7396.00	8760	64,789
T12 2L@40w	56	28	86	1408.68	2665	3,754
T12 2L@40w	152	76	86	6536.00	8760	57,255
8 foot T12	8	4	136	318.24	2665	848
T12U 2L@40w	102	51	86	2565.81	2665	6,838
T12U 2L@40w	30	15	86	754.65	2665	2,011
T12U 2L@40w	2	1	86	50.31	2665	134
T12U 2L@40w	4	2	86	100.62	2665	268
T12U 2L@40w	4	2	86	100.62	2665	268
T12U 2L@40w	12	6	86	516.00	8760	4,520
T12U 2L@ 34w	14	7	72	294.84	2665	786
Fluorescent Totals				**127.41**		**539,064**

Source: Navigant analysis

As shown in Table C-34, the revised pre-retrofit annual energy consumption of the troffer lighting is 539,064 kWh. The customer's pre-retrofit annual energy consumption calculation for the troffer lighting was 800,381 kWh.

Table C-35 shows the customer's post-retrofit calculation (Table C-26) after it was revised for 90 percent occupancy, 78 percent of the switched troffer lights "on" in the occupied offices, and these lights being "on" for 2,665 hours per year.

Table C-35. Verified Post-Retrofit Annual Energy Calculation – Troffer Fixtures

Proposed Lighting	#	Fixtture	Fixture	Total	Op.	Annual
REVISED	bulbs	Qty	Watts	Watts	Hours	kWh
1 lamp LED	58	58	20	814	2665	2170
2 lamp LED	1248	624	40	17522	2665	46696
2 lamp LED	346	173	40	4858	2665	12946
2 lamp LED	34	17	40	477	2665	1272
2 lamp LED	8	4	40	112	2665	299
2 lamp LED	58	29	40	814	2665	2170
2 lamp LED	20	10	40	281	2665	748
2 lamp LED	30	15	40	421	2665	1122
2 lamp LED	10	5	40	140	2665	374
2 lamp LED	120	60	40	1685	2665	4490
2 lamp LED	42	21	40	590	2665	1571
2 lamp LED	254	127	40	5080	8760	44501
2 lamp LED	86	43	40	1720	8760	15067
2 lamp LED	56	28	40	786	2665	2095
1 lamp LED	76	76	20	1520	8760	13315
2 lamp LED	8	4	20	56	2665	150
2 lamp 2 foot LED	102	51	22	788	2665	2099
2 lamp LED	30	15	22	232	2665	617
2 lamp LED	2	1	22	15	2665	41
2 lamp LED	4	2	22	31	2665	82
2 lamp LED	4	2	22	31	2665	82
2 lamp 2 foot LED	12	6	22	132	8760	1156
2 lamp LED	14	7	22	108	2665	288
LED Troffer Totals			**kW**	**38.214**	**kWh**	**153355**

Source: Navigant analysis

As shown in Table C-35, the revised post-retrofit annual energy consumption of the troffer lighting is 153,355 kWh. The customer's pre-retrofit annual energy consumption calculation for the troffer lighting was 208,616 kWh.

Table C-36 shows a summary of the verified electrical demand savings and annual energy savings.

Table C-36. Verified Demand and Energy Savings Summary

	Pre-Retrofit Totals			Post-Retrofit Totals		Annual
	Fluorescent	Incandescent		LED	LED	Savings
	Troffers	Rec. Cans		Troffers	Rec. Cans	
kW	127.4	48.89		38.20	8.66	129
kWh	539,064	215,858		153,355	37,037	564,530

Source: Navigant analysis

The following interaction factors between lighting and HVAC were applied to this project:

» Energy Interaction Factor = 1.05

» Demand Interaction Factor = 1.44

These are the same interaction factors applied to prescriptive lighting projects. Applying these factors results in a verified energy savings of 592,756 kWh and a verified demand savings of 186 kW.

C.3.9 Conclusions

The following conclusions can be drawn from the above analyses:

1. Based on an analysis of pre-retrofit and post-retrofit utility bills, this project achieved an annual energy savings was 516,552 kWh. A sub-metering analysis was also conducted and this analysis projected an annual energy savings of 592,756 kWh. Since the sub-metered analysis was significantly more detailed, the latter figure was adopted.
2. The verified demand savings for the project is 186 kW, which is 101 percent of the customer's prediction of 184 kW.
3. The verified energy savings for the project is 592,756 kWh, which is 77 percent of the customer's prediction of 770,586 kWh.
4. The reasons that the verified demand savings and verified energy savings were less than those that the customer predicted are as follows:
    a. The customer assumed the building was 100 percent occupied, which was inaccurate.
    b. The customer assumed that 100 percent of the lights were "on" in every occupied space. This assumption was also inaccurate.
    c. The customer assumed that all the tenant light fixtures were "on" 60 hours per week. Monitoring indicated that the lights were actually "on" 51 hours, 15 minutes per week.
5. This project is significant in that it is one of only a few buildings with 100 percent LED lighting.

C.4 Site ID 15520

Site ID	15520
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-11-02066, -02083, -02087, -02242, -02361
Building or Site Type	Grocery

C.4.1 Project Summary

This facility is a medium-size grocery store that had a significant number of open refrigerated display cases for dairy, deli meats, ice cream, and frozen foods. Several energy conservation retrofits were implemented at this site, including five custom projects and two prescriptive projects. These projects all involve reducing the energy consumption of the refrigerated display cases.

The following is a list of the rebated custom and prescriptive projects.

Custom Projects
EEB-11-02006:

» Replace T-12 lights and ballasts with LED lights in deli open display case

EEB-11-02083:

» Replace T-12 lights and ballasts with LED lights in display cases with doors (low- and medium-temperature cases)

EEB-11-02087:

» Replace air curtain, install doors on beer display cases, and add anti-sweat heaters
» Replace T-12 lights with LED lights

EEB-11-02242:

» Replace air curtain, install doors on dairy display cases, and add anti-sweat heaters
» Replace T-12 lights with LED lights. Install motion detectors to control lights

EEB-11-02361:

» Replace T-12 lights with LED lights in lunch meat open display cases
» Substitute LED lights for T-8 lights and add doors to new salad case

Prescriptive Projects
EEB-12-02983:

» Replace 168 fans with 9-W, high-efficiency fans

EEB-12-02601:

» Install door heater controls on 282 units

Table C-37 shows the combined reported and verified energy and demand savings for the custom projects listed above.

Table C-37. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Summary of all Custom Projects	Reported	620,152 kWh	57.7 kW	$48,109
	Verified	375,073 kWh	31.0 kW	
	Realization Rate	60%	53%	N/A

Source: EEB database and Navigant analysis

Table C-37 shows that the overall realization rate for annual energy savings is only 53 percent. The reasons for this low rate are as follows:

1. When the applicant calculated savings for replacing air curtains with doors on display cases, the applicant used a savings estimate that was much higher than the test results documented in professional journals for similar projects.
2. With respect to the calculated savings for the anti-sweat door heater controls, data from the control panel display and data from sub-metering the door heater power circuits confirm that the customer used a savings estimate that was much too high. It is suggested that the controller be adjusted to provide improved savings.
3. The performance of the motion detector-based dimming system for the case lighting is questionable because monitored data indicate that the energy use is occasionally high at night, when the store is unoccupied.
4. While LED lights were installed in the dairy case, the motion detectors were not installed per the customer's application.

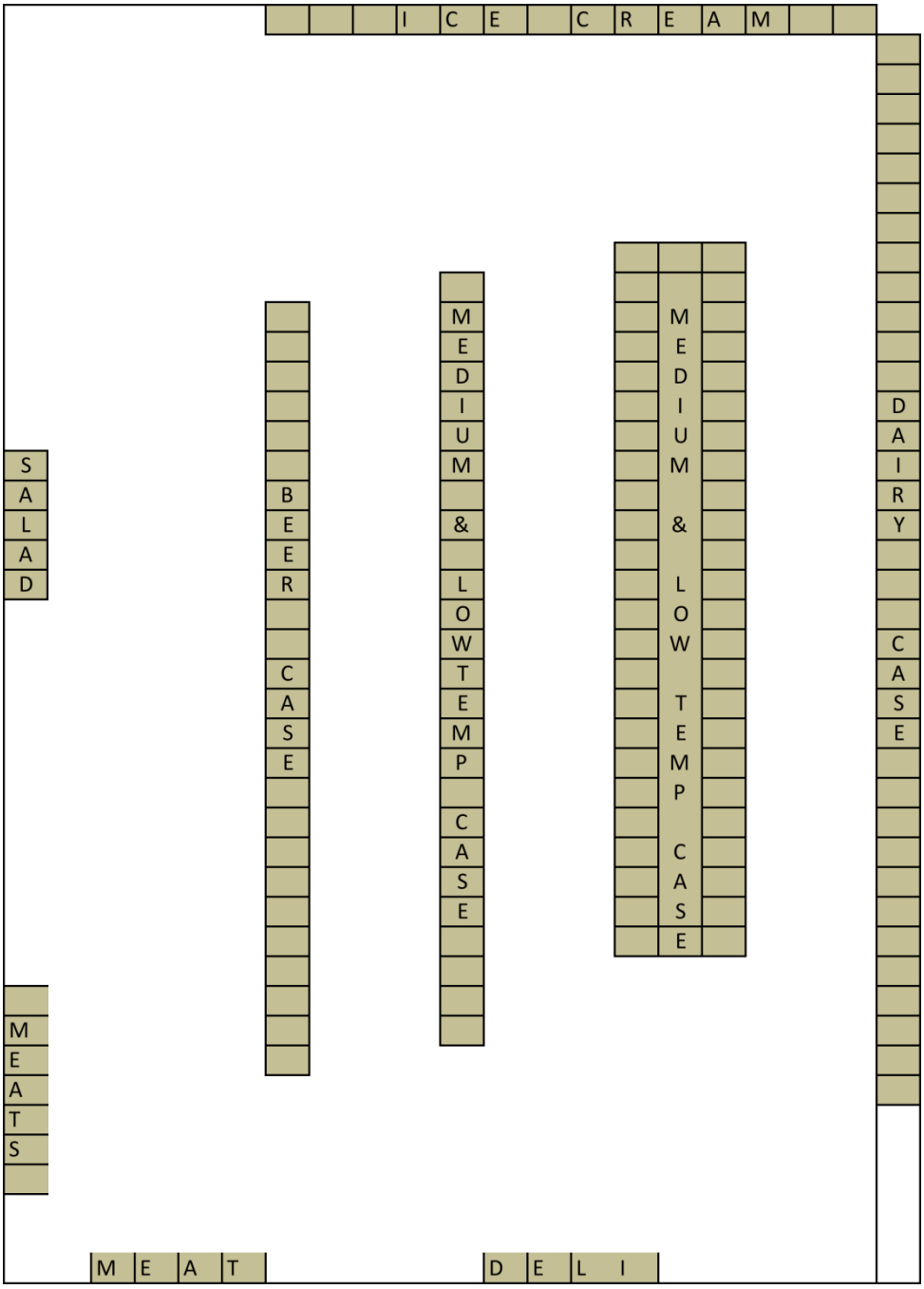
C.4.2 Verification Approach

The M&V approach for this project involved the following steps:

» Review the project files
  - Review the customer's energy savings calculations
  - Review research projects involving energy savings from adding doors to display cases
» Conduct a phone interview with corporate contact
» Conduct a site visit
  - Interview the facilities manager
  - Install data loggers on several display case lighting and door heater circuits
» Retrieve data loggers
  - Analyze data
» Prepare preliminary report, which the Navigant Project Manager reviews
» Submit final report

Figure C-9 shows a schematic of the refrigerated display cases in the store. Each square represents a door opening. Navigant developed the schematic.

Figure C-9. Schematic of Display Case Layout



Source: Navigant analysis

C.4.3 Project EEB-11-02006

C.4.3.1 Description of Baseline

The baseline for the deli display case included three fluorescent fixtures (with ballasts), each with 3- to 4-foot T-12 tubes. The fixtures were reported to be "on" 8,760 hours per year.

Figure C-10. Deli Display Case

Source: Navigant photo

C4.3.2 Description of As-Built Equipment and Operation

In the as-built configuration, LED tubes replaced the three fluorescent fixtures (three T-12 tubes and one ballast per fixture).

C4.3.3 Applicant Energy Savings Algorithm

Table C-38. Customer's Savings Calculations for EEB-11-02006

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
T12 lamps	136	3	8760	3,574	LED	23	3	8760	604
Old System	kW	0.408	kWh	3,574					
New System	kW	0.069	kWh	604					
Annual Savings	kW	0	kWh	2,970					

Source: Customer application

As shown in Table C-38, the annual energy savings projection for this retrofit is 2,970 kWh. The demand savings is insignificant.

C4.3.4 Uncertainties

Navigant conducted a site visit to confirm that the three 3-tube fluorescent fixtures had been replaced. In addition, the facilities manager and the facilities engineer stated that the display case lights were not "on" 8,760 hours per year. Instead, the lights were supposed to be "on" approximately 16 hours per day, or 5,840 hours per year.

C.4.3.5 On-Site Energy Monitoring

Energy meters were installed on four lighting circuits in order to confirm the operating hours and to determine the energy reduction for those display cases that were retrofitted with motion detector dimmers. Table C-39 lists the monitoring equipment that Navigant used in this project.

Table C-39. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.4.3.6 Verified Energy Savings

During the second site visit, the on-duty store manager was asked how she turned off the lights at the end of the day. She demonstrated by turning off two light switches in her office. This action resulted in nearly all of the overhead lights turning off, but none of the display case lights. In addition, data that the energy meters collected confirmed that the case lights are not turned off at night.

A further inspection of the deli case indicated that two of the T-12 fixtures (three tubes each) had been removed, but one three-tube T-12 fixture remained. One three-tube LED was installed where the two T-12 fixtures had been removed. The lumen output of the new LED fixture provided more than adequate lighting for the case.

Table C-40 shows the calculations for the verified energy savings.

Table C-40. Verified Savings Calculations: EEB-11-02006

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
T12 lamps	136	3	8,760	3,574	LED	23	1	8,760	201
					T12 Lamps	136	1	8,760	1,191
Old System	kW	0.408	kWh	3,574					
New System	kW	0.159	kWh	1393					
Annual Savings	kW	0	kWh	2,181					

Source: Navigant analysis

As shown in Table C-39 and Table C-40, the difference between the reported and verified energy savings stems from the fact that only one LED was installed and one three-tube T 12 fixture was not replaced.

C4.3.7 Conclusions

Table C-41 shows the reported and verified energy and demand savings for this project.

Table C-41. Reported and Verified Energy and Demand Savings (EEB-11-02006)

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-11-02006	Reported	2,970 kWh	0 kW	$237.60
	Verified	2,181 kWh	0 kW	
	Realization Rate	74%	100%	N/A

Source: Customer application and Navigant analysis

C.4.4 Project EEB-11-02083

C.4.4.1 Description of Baseline

T-12 lights and ballasts were replaced with LED lights indoors on low- and medium-temperature display cases. The fixtures were reported to be "on" 8,760 hours per year.

Figure C-11. Low- and Medium-Temperature Display Cases

Source: Navigant photo

C.4.4.2 Description of As-Built Equipment and Operation

In the as-built configuration, LED lamps replaced the T-12 lamps and ballasts. In addition, motion detectors were installed to dim the LED lights when no customers were near the display case.

C.4.4.3 Applicant Energy Savings Algorithm

Table C-42 shows the applicant's energy savings calculations associated with replacing the T-12 lights and ballasts with LED lights.

Table C-42. Customer's Savings Calculations for EEB-11-02083

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
5 - door cases	990	9	8,760	78051.6	5 - door	88.8	9	5,168	4130
4 - door cases	887	11	8,760	85471.3	4 - door	71.7	11	5,168	4076
3 - door cases	330	2	8,760	5781.6	3 - door	52.8	2	5,168	545.7
Old System	kW	19.33	kWh	169,305					
New System	kW	1.69	kWh	8752					
Annual Savings	kW	17.63	kWh	160,724					

Source: Customer's application

Note in Table C-42 that the operating hours for the pre-retrofit system is 8,760 hours. The new LED lights are controlled by a motion sensor, and the customer predicted that the effective operating hours would be reduced by 60 percent to 5,168 hours per year.

As these cases have doors, reduced lighting energy reduces the refrigeration load inside the cases. The customer's calculation for this savings is as follows:

Reduced Compressor Annual Energy (kWh)

$$= \frac{\text{Annual Lighting Energy Savings (kWh) x 3,413 (BTU/kWh) x 1.98 kW/ton}}{\text{12,000 BTU/ton}}$$

$$= (160{,}724 \times 3{,}413 \times 1.98)/12{,}000 = 92{,}425 \text{ kWh}$$

The combined energy savings that result from the lighting replacement is as follows:

$$\text{Combined Energy Savings} = 160{,}724 \text{ kWh} + 92{,}425 \text{ kWh} = 251{,}418 \text{ kWh}$$

Note that a refrigeration efficiency of 1.98 kW/ton was applied in the customer's calculations.

C.4.4.4 Uncertainties

Navigant conducted a site visit to confirm that the fluorescent tubes had been replaced. Also, sub-metering a sample of lighting circuits determined the hours of operation of the lights .

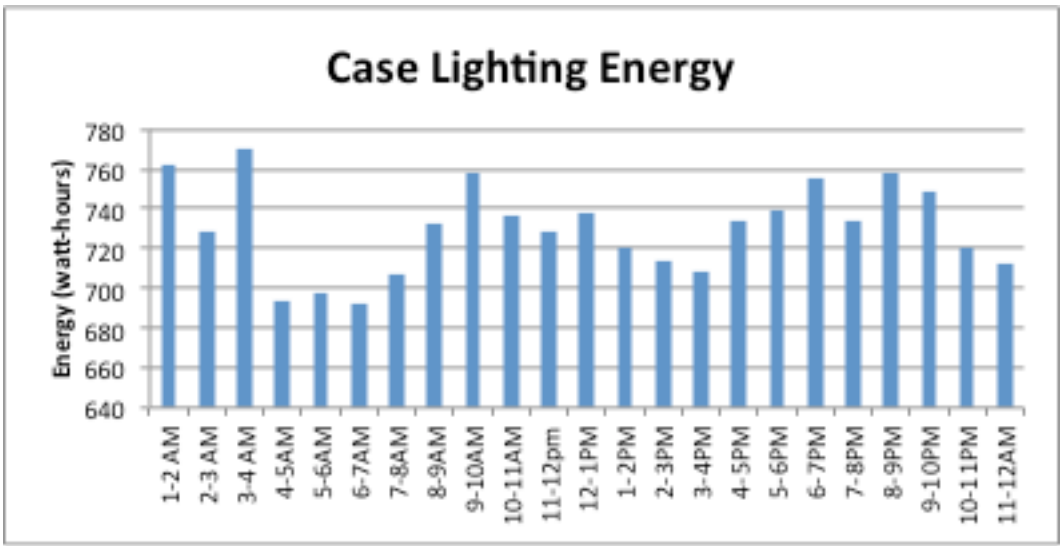
C.4.4.5 On-Site Energy Monitoring

Energy meters were installed on four lighting circuits in order to confirm the operating hours and to determine the energy reduction for those display cases that were retrofitted with motion detector dimmers.

C.4.4.6 Verified Energy Savings

Energy sub-meters were installed on four of the case lighting circuits for a period of one month. Figure C-12 shows a graph of energy consumption pattern of the case lights during a typical 24-hour period.

Figure C-12. Post-Retrofit Case Lighting Energy



Source: Navigant sub-metering

Figure C-12 shows the case lighting energy consumption. The data indicate that the motion detectors (and the resulting dimming of the lights) reduce the energy consumption by 35 percent. Therefore, the equivalent annual hours of operation were verified to be 5,694 hours per year. Note in Figure C-12 that the maximum energy consumption occurred during the 3 AM–4 AM period when the store was unoccupied.

Table C-43 shows the calculations for the verified energy savings.

Table C-43. Verified Savings Calculations, EEB-11-02083

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
5 - door T-12	990	9	8,760	78051.6	5 - door	88.8	9	5,694	4551
4 - door T-12	887	11	8,760	85471.3	4 - door	71.7	11	5,694	4491
3 - door T-12	330	2	8,760	5781.6	3 - door	52.8	2	5,694	601.3
Old System	kW	19.33	kWh	169,305					
New System	kW	1.69	kWh	9643					
Annual Savings	kW	17.63	kWh	159,662					

Source: Navigant analysis

As these cases have doors, reduced lighting energy reduces the refrigeration load inside the cases. The calculation for this savings is as follows:

Reduced Compressor Annual Energy (kWh)

$$= \frac{\text{Annual Lighting Energy Savings (kWh) x 3,413 (BTU/kWh) x 1.98 kW/ton}}{\text{12,000 BTU/ton}}$$

$$= (159{,}662 \times 3{,}413 \times 1.98)/12{,}000 = 90{,}821 \text{ kWh}$$

The combined energy savings that result from the lighting replacement is as follows:

Combined Energy Savings = 159,662 kWh + 90,821 kWh = 250,483 kWh

C.4.4.7 Conclusions

Table C-44 shows the reported and verified energy and demand savings for this project.

Table C-44. Reported and Verified Energy and Demand Savings (EEB-11-2083)

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-11-02083	Reported	251,418 kWh	17.6 kW	$18,613
	Verified	250,483 kWh	17.6 kW	
	Realization Rate	99%	100%	NA

Source: Customer application and Navigant analysis

Note that the verified energy savings for this project was slightly less than the customer predicted. The reason is that the effective annual operating hours of the lights was determined via monitoring and was found to be 5,694 hours, rather than the 5,168 hours that the customer predicted.

C.4.5 Project EEB-11-02087

C.4.5.1 Description of Baseline

The baseline for the four 12-foot beer cases included air curtain cooling and T-12 lights that operated 8,760 hours per year.

Figure C-13. Beer Case Photo

Source: Navigant photo

C.4.5.2 Description of As-Built Equipment and Operation

In the as-built configuration, the four 12-foot beer cases have new doors with anti-sweat door heaters and new LED lights that are dimmed by motion detectors.

C.4.5.3 Applicant Energy Savings Algorithm

Replacing Air Curtain with Glass Doors

In order to calculate the daily energy savings that resulted from replacing an air curtain with glass doors, the customer used an energy savings figure of 5.45 kWh per day per foot of display case. This figure was obtained from another company that measured the compressor energy of one of their open display cases. Doors were then installed, and the compressor energy was again measured. While the length of the case was provided, it is not known if the case was a front-loading unit or a larger, back-loading unit. During the test, the space temperature and indoor humidity of the building were not reported. Therefore, the test did not comply with any recognized protocol. Table C-45 shows the customer's calculation of energy savings from the addition of doors.

Table C-45. Air Curtain Replacement Savings Calculation

Case Length (ft)	Savings/ft/day (kWh)	Savings per Day (kWh)	Savings per Year (kWh)
48	5.45	261.6	95,484

Source: Customer's application

Table C-45 shows that adding doors to the display cases would save an estimated 95,484 kWh, if anti-sweat door heaters were not installed.

Adding Anti-Sweat Heaters

Anti-sweat heater controls were installed as part of Prescriptive Project EEB-11-02601. However, the owner is taking credit for the resulting energy reduction as part of the current retrofit.

According to the manufacturer's literature included in the customer's application, the energy consumption of the door heaters (without controls) is 283.8 kWh per foot of case per year (kWh/ft/year), or 0.0777 kWh per foot per day (kWh/ft/day). Table C-46 shows the customer's calculation of the door heater annual energy use without controls installed.

Table C-46. Anti-Sweat Heater Energy Consumption (without controls)

Case Length (ft)	Energy Use/ft/day (kWh)	Energy Use/Day (kWh)	Energy Use/Year (kWh)
48	0.777	37.29	13,613

Source: Customer's application

The customer's calculations include an annual energy use figure for the door heaters of 1,907 kWh, which implies that the heater control system reduced the energy consumption of the door heaters by 86 percent (1 – [1,907/13,613] = 0.86).

Lighting Replacement Savings

Table C-47 shows the customer's calculations for the lighting replacement savings. As shown in Table C-47, the dimming system effectively reduces the hours of operation of the lights by 30 percent.

Table C-47. Customer Savings Calculations: EEB-11-02087

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
12' Case T-12	520	4	8760	18,221	LED	60	4	6175	1,482
Old System	kW	2.08	kWh	18,221					
New System	kW	0.24	kWh	1482					
Annual Savings	kW	1.84	kWh	16,739					

Source: Customer's application

As these cases have doors, reduced lighting energy reduces the refrigeration load inside the cases. The calculation for this savings is as follows:

Reduced Compressor Annual Energy (kWh)

$$= \frac{\text{Annual Lighting Energy Savings (kWh) x 3,413 (BTU/kWh) x 1.98 kW/ton}}{\text{12,000 BTU/ton}}$$

$$= (16{,}739 \times 3{,}413 \times 1.98)/12{,}000 = 9{,}445 \text{ kWh}$$

Note that the customer used a refrigeration performance factor of 1.98 kW/ton.

Table C-48. Applicant's Energy Savings Summary

Description	Annual Savings (kWh)
Air Curtain Replacement Savings	95,484
Anti-Sweat Door Heaters (Increase)	- 1,907
T-12 replacement with LED Savings	16,739
Compressor Savings	9,445
Total	119,761

Source: Customer application

As shown in Table C-48, the customer projected an annual energy savings of 119,761 kWh. The customer also projected a demand savings of 12.7 kW, but the calculations associated with the demand savings were not included in the application. If one divides the energy savings of 119,761 kWh by 8,760 hours, the result is 13.7 kW.

C.4.5.4 Uncertainties

The M&V team conducted a site visit to confirm that the air curtain had been replaced and that LED tubes (with dimming) had been installed. The visit also confirmed that the controls for the anti-sweat doors were installed. The uncertainties include the effectiveness of the dimming system and the anti-sweat controls.

The most significant uncertainty is the compressor savings that result from replacing the air curtain with doors. The savings figure of 5.45 kWh per day per foot of display case was obtained from another company's before and after energy measurements. The other company's test did not follow a recognized testing protocol.

C.4.5.5 On-Site Monitoring

Energy meters were installed on four lighting circuits and four door heater circuits in order to confirm the operating hours and to determine the energy reduction for those display cases that were retrofitted with motion detector dimmers and door heaters.

The post-retrofit energy use of the compressors that serve the beer coolers could not be measured because the coolers are on the same refrigerant circuit as several other coolers, some of which were open and some of which had doors installed.

C.4.5.6 Verified Savings

Replacing Air Curtain with Glass Doors

Table C-49 shows the results of a 2010 University of Missouri-Kansas City study, which was funded by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and examined front-loading display cases, which are the same type of case retrofitted in this project.

Table C-49. Mean Electrical Energy Consumption of a 24-Foot, Open and Doored Display Case[6]

Component	Doored Display Case	Open Display Case	Savings
Compressor	11.7 kWh/day	42.2 kWh/day	30.5 kWh/day
	.487 kWh/day/ft.	1.75 kWh/day/ft.	1.27 kWh/day/ft.
Anti-Sweat Door Heater*	15.5 kWh/day	0	-15.5 kWh/day
	.645 kWh/day/ft.	0	-.645 kWh/day/ft.

*Note that the anti-sweat heaters had no controls installed.

Source: "Energy Use of Doored and Open Vertical Refrigerated Display Cases," Brian Fricke and Bryan Becker, International Refrigeration and Air Conditioning Conference, 2010, paper 1154[7]

As shown in Table C-49, the results of this scientific study included a compressor energy savings of 1.27 kWh per day per foot of case (kWh/day/ft), rather than 5.45 kWh/day/ft used in the customer's calculations. The anti-sweat heater energy consumption reported in the ASHRAE study was 0.645 kWh/day/ft, which was fairly close to the 0.777 kWh/day/ft used in the customer's calculations.

A 2011 Portland Energy Conservation (PECI) whole-building simulation study concluded that replacing air curtains with doors in climate zone 3 for medium-temperature cases saved compressor energy of 1.32 kWh/day/ft. This is close to the 1.27 kWh/day/ft result shown in Table C-49.

Based on the above study results, the verified savings for medium-temperature refrigerated cases is 1.30 kWh/day/ft. Table C-50 shows the verified savings calculation using the 1.30 kWh figure.

Table C-50. Verified Air Curtain Replacement Savings

Case Length (ft)	Savings/ft/day (kWh)	Savings per Day (kWh)	Savings per Year (kWh)
48	1.3	62.4	22,776

Source: Navigant analysis

[6] Calculated using American National Standards Institute (ANSI)/Air-Conditioning and Refrigeration Institute (ARI) Standard 1200-2006.

[7] http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2153&context=iracc

Adding Anti-Sweat Heaters

According to the manufacturer's literature included in the customer's application, the energy consumption of the door heaters (without controls) is 283.8 kWh/ft/year, or 0.0777 kWh/ft/day. Table C-51 shows the calculation of annual heater energy use without controls.

Table C-51. Anti-Sweat Heater Energy Consumption (without controls)

Case Length (ft)	Energy Use/ft/day (kWh)	Energy Use/Day (kWh)	Energy Use/Year (kWh)
48	0.777	37.29	13,613

Source: Navigant analysis

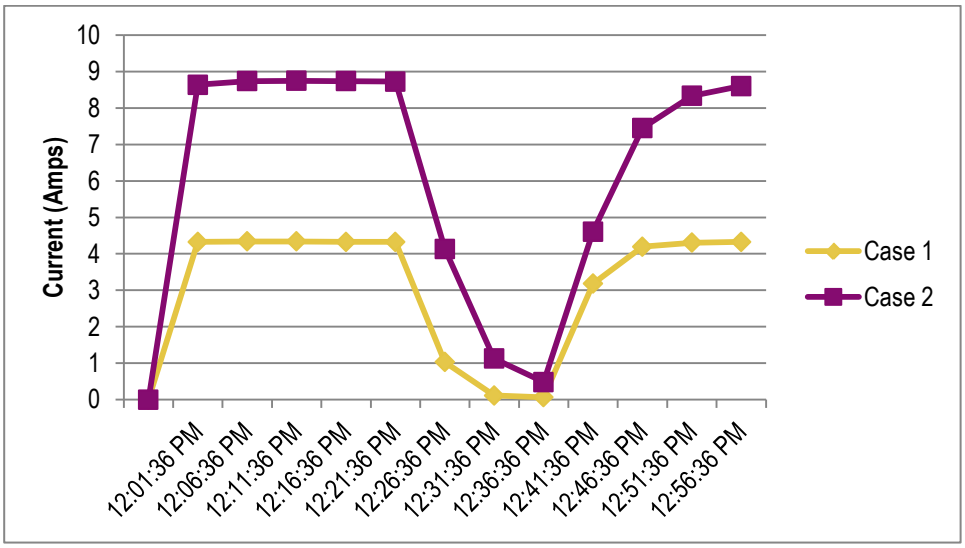
Anti-sweat door heaters were installed in order to prevent condensation on the doorframes of the display cases. The maximum capacity of the heaters prevents condensation on the doors when the humidity inside the building is high. The heater controller measures the building inside air temperature and humidity and cycles the heaters "on" and "off" when the dew point is low. Figure C-14 shows the display inside the heater control panel.

Figure C-14. Sweat Heater Control Panel

Source: Navigant photoAs indicated in Figure C-14, at the time the picture was taken the Relative Humidity in the store was very low at 37 percent, the dew point was 46 °F, the percent savings (in door heater energy) was 25 percent, and the store temperature was 74 °F. Given the low dew point inside the building, one would expect the controller to save more than 25 percent of the door heater energy. (The customer applied an 86 percent savings factor in their calculations.)

The operation of two door heaters was monitored for a period of four weeks. Figure C-15 shows the typical operational pattern of the controller for the two cases.

Figure C-15. Door Heater Control Cycling



Source: Navigant analysis

Figure C-15 shows the typical cycle that was observed throughout the testing. The heaters operate at full power for 20 minutes and at partial power for 30 minutes.

The results from the four-week monitoring program indicate that the addition of the door heater controls reduces the energy at this store by 35 percent. Based on these results, the annual energy consumption of the door heaters is calculated as follows:

Annual Door Heater Energy Use = 13,613 kWh x .65 = 8,848 kWh

Lighting Replacement Savings

Table C-52 shows the verified calculations for the lighting replacement savings.

Table C-52. Verified Lighting Savings Calculations, EEB-11-02087

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
12' Case T-12	520	4	8760	18,221	LED	60	4	5,694	1,367
Old System	kW	2.08	kWh	18,221					
New System	kW	0.24	kWh	1367					
Annual Savings	kW	1.84	kWh	16,854					

Source: Navigant analysis

The equivalent hours for the new lighting are based on sub-metering results, which indicated a savings of 35 percent.

Since these cases have doors, reduced lighting energy reduces the refrigeration load inside the cases. The calculation for this savings is as follows:

Reduced Compressor Annual Energy (kWh)

$$= \frac{\text{Annual Lighting Energy Savings (kWh) x 3,413 (BTU/kWh) x 1.98 kW/ton}}{\text{12,000 BTU/ton}}$$

$$= (16{,}854 \times 3{,}413 \times 1.98)/12{,}000 = 9{,}604 \text{ kWh}$$

The total verified savings appear in Table C-53.

Table C-53. Verified Energy Savings Summary

Description	Annual Savings (kWh)
Air Curtain Replacement Savings	22,776
Anti-Sweat Door Heaters (Increase)	- 8,848
T-12 replacement with LED Savings	16,884
Compressor Savings	9,064
Total	39,876

Source: Navigant analysis

The estimated demand savings is 4.5 kW, which was obtained by dividing the energy savings by 8,760 hours.

C.4.5.7 Conclusions

Table C-54 shows the reported and verified energy and demand savings for this project.

Table C-54. Reported and Verified Energy and Demand Savings (EEB-11-2083)

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-11-02087	Reported	119,761 kWh	12.7 kW	$9,580
	Verified	39,876 kWh	4.5 kW	
	Realization Rate	33%	35%	NA

Source: Customer application and Navigant analysis

The realization rates for this project are low for two reasons. First, in Navigant's opinion, the applicant's savings figure associated with replacing air curtain with doors is not accurate for front-loading display cases. Second, the anti-sweat door heater controls reduced the heater energy use by a measured 35 percent rather than the 86 percent that the manufacturer suggested.

C.4.6 Project EEB-11-02242

C.4.6.1 Description of Baseline

The existing dairy display cases (six 12-foot and two 8-foot cases) were cooled by air curtains. Baseline lighting included T-12 lights that were "on" 8,760 hours per year.

Figure C-16. Dairy Case

Source: Navigant photo

C.4.6.2 Description of As-Built Equipment and Operation

In the as-built configuration, the air curtains were replaced with doors. Anti-sweat door heaters with controls were added. The T-12 lights were replaced with LED lights controlled by motion detectors that dimmed the lights.

C.4.6.3 Applicant Energy Savings Algorithm

Replacing Air Curtain with Glass Doors

In order to calculate the daily energy savings that results from replacing an air curtain with glass doors, the customer used a figure of 5.45 kWh/day/ft. Table C-55 shows the energy savings calculation.

Table C-55. Air Curtain Replacement Savings Calculation

Case Length (ft)	Savings/ft/day (kWh)	Savings per Day (kWh)	Savings per Year (kWh)
88	5.45	479.6	175,054

Source: Customer's application

Adding Anti-Sweat Heaters

Anti-sweat heaters were installed as part of Prescriptive Project EEB-11-02601. However, the customer is taking credit for the resulting energy reduction as part of the current retrofit. Table C-56 shows the annual energy use of the door heaters if no controls were applied.

Table C-56. Anti-Sweat Heater Annual Energy Use (Without Controls)

Case Length (ft)	Energy Use/ft/day (kWh)	Energy Use/Day (kWh)	Energy Use/Year (kWh)
88	0.777	68.38	24,958

Source: Customer's application

The customer assumed that the heater controls would reduce the energy use by 86 percent. An annual energy figure of 3,497 kWh was used in the customer's calculations.

Lighting Replacement Savings

Table C-57 shows the customer's calculations for the lighting replacement savings. As shown in Table C-57, the customer assumed that the motion detectors would reduce the hours of operation of the lighting by 65 percent, which would result in 3,087 annual hours.

Table C-57. Customer Savings Calculations: EEB-11-02242

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
12' Case T-12	520	6	8760	27,331	LED	216	6	3,087	4,001
8' Case T-12	288	2	8760	5,046	LED	72	2	3,087	889
Old System	kW	3.12	kWh	32,377					
New System	kW	1.296	kWh	4891					
Annual Savings	kW	1.824	kWh	27,486					

Source: Customer's application

Since these cases have doors, reduced lighting energy reduces the refrigeration load inside the cases. The calculation for this savings is as follows.

Reduced Compressor Annual Energy (kWh)

$$= \frac{\text{Annual Lighting Energy Savings (kWh)} \times 3{,}413 \text{ (BTU/kWh)} \times 1.98 \text{ kW/ton}}{12{,}000 \text{ BTU/ton}}$$

$$= (27{,}486 \times 3{,}413 \times 1.98)/12{,}000 = 15{,}510 \text{ kWh}$$

The total savings that the customer reported is as follows in Table C-58.

Table C-58. Applicant's Energy Savings Summary

Description	Annual Savings (kWh)
Air Curtain Replacement Savings	175,054
Anti-Sweat Door Heaters (Increase)	- 3,497
T-12 replacement with LED Savings	27,486
Compressor Savings	15,510
Total	214,553

Source: Customer application

As shown in Table C-58, the customer projected an annual energy savings of 214,553 kWh. The customer also projected a demand savings of 23.4 kW, but the calculations associated with the demand savings were not included in the application. If one divides the energy savings (214,553 kWh) by 8,760 hours, the result is 24.4 kW.

C.4.6.4 Uncertainties

Navigant conducted a site visit to confirm that the air curtain had been replaced and that LED tubes (with dimming) had been installed. Navigant also confirmed that the controls for the anti-sweat doors were installed.

The uncertainties include the effectiveness of the dimming system and the anti-sweat controls. The most significant uncertainty is the compressor savings that result from replacing the air curtain with doors.

C.4.6.5 On-Site Monitoring

Energy meters were installed on four lighting circuits and four door heater circuits in order to confirm the operating hours and to determine the energy reduction for those display cases that were retrofitted with motion detector dimmers and door heater controls.

The post-retrofit energy use of the coolers could not be measured because the coolers were on the same refrigerant loop as several other coolers, some of which were open and some of which had doors installed.

C.4.6.6 Verified Energy Savings

Replacing Air Curtain with Glass Doors

Based on the study results described in Section C.4.4.3, the verified savings for medium-temperature refrigerated cases is based on a savings figure of 1.30 kWh/day/ft, rather than the owner's figure of 5.45 kWh/day/ft. Table C-59 shows the verified savings calculation using the 1.30 kWh figure.

Table C-59. Verified Air Curtain Replacement Savings

Case Length (ft)	Savings/ft/day (kWh)	Savings per Day (kWh)	Savings per Year (kWh)
88	1.3	114.4	41,756

Source: Navigant analysis

Adding Anti-Sweat Heaters

According to the manufacturer's literature included in the customer's application, the energy consumption of the door heaters (without controls) is 283.8 kWh/ft/year, or 0.0777 kWh/ft/day. Anti-sweat heater energy consumption is shown in Table C-60.

Table C-60. Anti-Sweat Heater Energy Consumption (Without Controls)

Case Length (ft)	Energy Use/ft/day (kWh)	Energy Use / Day (kWh)	Energy Use per Year (kWh)
88	0.777	68.37	24,957

Source: Navigant analysis

Based sub-metering results of two door heater circuits and two observations of the heater control panel, the energy consumption has been reduced by 35 percent. Therefore, the annual energy use of the door heaters is 16,222 kWh.

Lighting Replacement Savings

Table C-61 shows the verified calculations for the lighting replacement savings.

Table C-61. Verified Lighting Savings Calculations, EEB-11-02087

Pre-retofit Lighting System						Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh		Description	Wattage	Number	Hours	kWh
12' Case T-12	520	6	8,760	27,331		LED	216	6	8,760	11,353
8' Case T-12	288	2	8,760	5,046		LED	72	2	8,760	1261
Old System	kW	3.12	kWh	32,377						
New System	kW	1.296	kWh	12614						
Annual Savings	kW	1.824	kWh	19,763						

Source: Navigant analysis

As shown in Table C-61, the lighting hours did not change because the motion detectors (refer to Figure C-1) do not appear to have been installed. The facilities engineer was asked about the lack of motion

detectors and he did not know why they were not installed. Figure C-17 shows the motion detectors that were installed on other cases but not on the dairy case.

Figure C-17. Motion Detector (Dimming System)

Source: Navigant photoSince these cases have doors, reduced lighting energy reduces the refrigeration load inside the cases. The calculation for this savings is as follows:

Reduced Compressor Annual Energy (kWh)

$$= \frac{\text{Annual Lighting Energy Savings (kWh) x 3,413 (BTU/kWh) x 1.98 kW/ton}}{\text{12,000 BTU/ton}}$$

$$= (19{,}763 \times 3{,}413 \times 1.98)/12{,}000 = 11{,}241 \text{ kWh}$$

The total savings that the customer reported is as follows in Table C-62.

Table C-62. Applicant's Energy Savings Summary

Description	Annual Savings (kWh)
Air Curtain Replacement Savings	41,756
Anti-Sweat Door Heaters (Increase)	- 16,222
T-12 replacement with LED Savings	19,763
Compressor Savings	11,241
Total	56,538

Source: Navigant analysis

As shown in Table C-62, the verified energy savings is 56,538 kWh. The verified demand savings is estimated to be 6.4 kW, which was obtained by dividing the energy savings by 8,760 hours.

C.4.6.7 Conclusions

Table C-63 shows the reported and verified energy and demand savings for this project.

Table C-63. Reported and Verified Energy and Demand Savings (EEB-11-2083)

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-11-02087	Reported	214,553 kWh	23.4 kW	$9,580
	Verified	56,538 kWh	6.4 kW	
	Realization Rate	26%	27%	N/A

Source: Customer application and Navigant analysis

The realization rates for this project are low for three reasons:

1. In Navigant's opinion, the customer's savings figure associated with replacing air curtain with doors is not accurate for front-loading display cases.
2. The anti-sweat door heater controls reduced the heater energy use by a measured 35 percent, rather than the 85 percent that the manufacturer suggested.
3. The motion detectors for the new lighting have not been installed.

C.4.7 Project EEB-11-02361

C.4.7.1 Description of Baseline

There are two energy savings opportunities in this project. The first involves a new, 12-foot salad case. The baseline assumed the salad case had T-8 fluorescent lights and no doors. The second baseline involved fluorescent lights in 40 feet of open lunch meat cases. The lights were "on" 8,760 hours per year.

C.4.7.2 Description of As-Built Equipment and Operation

In the as-built configuration, the salad case is equipped with doors and LED lights. The door heaters and motion-detector dimming of the lights were not included in this application. The lights operate 8,760 hours per year.

The lunch meat cases are equipped with LED lights. The LED lights operate 8,760 hours per year.

C.4.7.3 Applicant Energy Savings Algorithm

Salad Case Doors and Lighting

Figure C-18. Salad Case

Source: Navigant photoTable C-64 shows the customer's calculation of the reduction in lighting energy.

Table C-64. Customer's Salad Case Savings Calculation (Lighting)

Pre-retrofit Lighting System					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
12' Case T-12	1200	1	8760	10,512	LED	240	1	8760	2,102
Old System	kW	1.2	kWh	10,512					
New System	kW	0.24	kWh	2102					
Annual Savings	kW	0.96	kWh	8,410					

Source: Customer's application

The customer calculated the compressor energy saved by adding doors to the display case by comparing the rated cooling capacities of an open case to the rated cooling capacity of a closed case, as follows:

Open Case Cooling Capacity = *16,980 BTUH*
Closed Case Cooling Capacity = *3,612 BTUH*
BTUH Reduction = *13,368 BTUH*

The customer applied the heat reduction from replacing the lighting as follows:

Combined BTUH Reduction = 13,368 BTUH + 588 BTUH = 13,956 BTUH

Using the conversion factor of *1 kW = 3,413 BTU*, the demand reduction is as follows:

13,956 BTU/3,413 = 4.090 kW

The kWh annual savings was calculated as follows (the constant *0.5643* is the case efficiency):

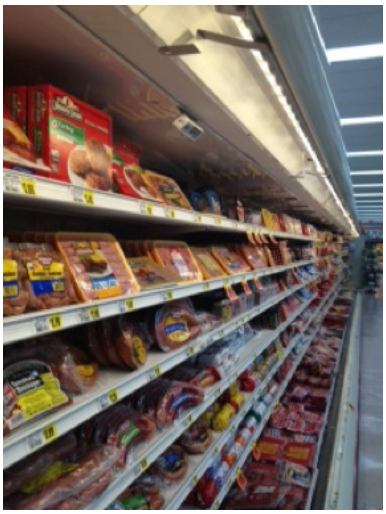
Annual Energy Savings = 4.090 kW x 8760 hours x .5643 = 20,219 kWh

Combined Lighting and Compressor Savings = 8,410 kWh + 20,219 kWh = 28,628 kWh

Lunch Meat Case Lighting Replacement

Figure C-19 shows a photo of the meat case with the new LED lights in place.

Figure C-19. Lunch Meat Case



Source: Navigant

Table C-65 shows the customer's savings calculations for the energy savings that results from replacing the lighting in the meat case.

Table C-65. Energy Savings Calculations for Replacing the T-8s with LED

Pre-retrofit Lighting Sytem					Post-retrofit Lighting System				
Description	Wattage	Number	Hours	kWh	Description	Wattage	Number	Hours	kWh
40' Case T-8	560	1	8760	4,905	LED	238	1	8760	2,084
Old System	kW	0.56	kWh	4,905					
New System	kW	0.238	kWh	2084					
Annual Savings	kW	0.322	kWh	2,821					

Source: Customer's application

Table C-66 summarizes the reported energy savings for this project.

Table C-66. Reported Energy Savings

Project Descriptions	Annual Energy Savings (kWh)	Annual Demand Savings (kW)
Salad Case Doors and Lighting	28,628	3.6
Meat Case Lighting	2,821	0
Combined	31,449	3.6

Source: Customer's application

Table C-66 shows an annual savings of 31,449 kWh and a demand savings of 3.6 kW. Although the customer's application does not include a demand savings calculation, dividing the energy savings by 8,760 hours results in the value of 3.59 kW.

C.4.7.4 Uncertainties

Navigant conducted a site visit to confirm that the doors and the LED lights had been installed on the salad case. Navigant also confirmed that the LED lights were installed in the lunch meat cases.

The most significant uncertainty is the compressor savings that result from replacing the air curtain with doors on the salad case. The customer's calculation is based on the difference between the cooling capacities of the open case and the doored case. The customer then assumed that the cases would have operated continuously at 100 percent capacity.

C.4.7.5 On-Site Monitoring

Although energy meters were installed at this site in order to evaluate the effectiveness of the motion detector dimming system and the door sweat heater controls, neither of these features was included in the customer's application for this project.

C.4.7.6 Verified Savings

The LED lighting in the salad case and the lunch meat cases was verified during a site visit. It was also confirmed that the lighting is "on" 8,760 hours per year. The savings calculations for the lighting have been reviewed and found to be correct.

Navigant's analysis is based on the 2012 U.S. DOE Energy Efficiency and Renewable Energy (EERE) energy performance standards for new commercial refrigerators and display cases. These standards establish the maximum daily energy consumption for various types of cases. The calculations are shown in Equation C-1.

Equation C-1. Remote-Condensing Commercial Refrigerators and Display Cases (T >= 32 °F)

Vertical Open: Maximum kWh/Day = 0.82 x Total Display Area + 4.07

Vertical Closed: Maximum kWh/Day = 0.16 x Total Display Area + 1.95

The salad case in question is 12 feet long and has 5-foot-high doors, for a total display area of 60 square feet. Table C-67shows the annual energy calculations.

Table C-67. Annual Energy Calculations, Remote-Condensing Commercial Refrigerators and Display Cases

	Total Door Area (SF)	Maximum Energy (kWh/Day)
Vertical Open Case	60	53.27
kWh/Day = 0.82xTDAx4.07		
Vertical Closed Case	60	15.15
kWhDay=.22xTDAx1.95		
Savings/Day (kWh/Day)		38.12
Savings/Yearb(kWh/Year)		13913.8

Source: 2012 EERE energy performance standards

The annual savings, based on 2012 efficiency standards, is 13,913 kWh. Comparing this savings result to the customers' suggests that Navigant's approach is based on the coolers operating at an average load of 72 percent, rather than the 100 percent load that the customer assumed—i.e., the coolers operate as follows:

19,359 kWh x 72% = 13,913 kWh

The total savings that the customer reported is as follows in Table C-68.

Table C-68. Verified Salad Case Energy Savings Summary

Description	Annual Savings (kWh)
Air Curtain Replacement Savings	13,913
Anti-Sweat Door Heaters (Increase)	NA
T-12 replacement with LED Savings	8,410
Compressor Savings for lighting	851
Total	23,174

Source: Navigant analysis

Table C-69 shows the verified combined savings for this project.

Table C-69. Savings Summary

Project Descriptions	Annual Energy Savings (kWh)	Annual Demand Savings (kW)
Salad Case Doors and Lighting	23,174	2.6
Meat Case Lighting	2,821	0
Combined	25,995	2.6

Source: Navigant analysis

Table C-69 shows an annual energy savings of 25,995 kWh and a demand savings estimate of 2.6 kW, which was calculated by dividing the annual savings by 8,760 hours.

C.4.7.7 Conclusions

Table C-70 shows the reported and verified energy and demand savings for this project.

Table C-70. Reported and Verified Energy and Demand Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
EEB-11-02361	Reported	31,450 kWh	3.6 kW	$2,515
	Verified	25,995 kWh	2.6 kW	
	Realization Rate	83%	72%	NA

Source: Navigant analysis

The realization rate for this project is 83 percent. The reason it is low is that, in Navigant's opinion, the customer's savings figure associated with replacing air curtain with doors is not accurate for front-loading display cases.

C.5 Site ID 107860

Site ID	107860
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-11-02326
Building or Site Type	Education

C.5.1 Project Summary

The project includes the installation of a building automation system for three rooftop packaged units (RTUs), including wireless thermostats, and the retrofit of outside air economizer controls. The new automation system will provide a 6 °F setback at night and on the weekends, when the building is unoccupied. Table C-71 provides a summary of reported and verified energy and demand savings for the project.

Table C-71. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Building automation system for 3 RTUs	Reported	550,000 kWh	34 kW	$44,000
	Verified	565,800 kWh	0 kW	
	Realization Rate	102 %	0%	N/A

Source: EEB database and Navigant analysis

C.5.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review the project files
  - Review energy savings calculations
- Conduct a phone interview with corporate contact
- Conduct a site visit
  - Interview facilities manager
  - Inspect the building automation system
  - Install data loggers on three RTUs
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.5.3 Description of Baseline

New Hanover County School Administration Building is a three-story office building. The building is occupied from 8:00 AM until 5:00 PM, five days per week.

The baseline HVAC system consisted of three rooftop units (each serving a separate floor). In addition, there were two small split system units (2-3 tons) that air conditioned a server room and a printer room.

The rooftop units were variable air volume (VAV), and the air distribution system included fan-powered VAV boxes with electric heating. The rooftop units had outside air economizer capability. The RTUs were only two years old, but the control system and room thermostats were at least ten years old and functioned erratically. The RTUs ran continuously.

Prior to this retrofit project, many office computers, printers, and a significant number of lights were left "on" during unoccupied hours.

C.5.4 Description of As-Built Equipment and Operation

The current project involves installing a new central building automation system for the HVAC system. The automation system includes new wireless thermostats and controls for the outside air economizers. According to the energy manager, the new hours of operation are shown in Table C-72.

Table C-72. As-Built HVAC System Operating Hours

HVAC Operating Schedule	Hours per Day	Days per Week
June 10 – August 17	11	4
August 18 – June 9	9	5

Source: Customer interview

The thermostat set points are 74 °F during the summer and 70 °F during the winter, and the night, weekend, and holiday setbacks are 80 °F during the summer and 64 °F during the winter. The set points and hours of operation are controlled from a central maintenance facility location.

Following the retrofit, an awareness program was instituted to encourage employees to shut off computers, printers, and lights during unoccupied hours.

The BAS project began in March 2011 and was completed in November 2011.

C.5.5 Applicant Energy Savings Algorithm

The applicant's energy savings algorithm is based on an analysis of utility meter readings for nine months prior to and following the retrofit. Table C-73 shows the savings calculation.

Table C-73. Applicant's Energy Savings Projection

Pre-Retrofit Consumption		Post-Retrofit Consumption	
Month	Utility Bill	Month	Utility Bill
7/12/11	74,000	7/11/12	37,000
6/13/11	90,400	6/11/12	36,800
5/10/11	81,400	5/10/12	34,800
4/8/11	93,400	4/10/12	36,000
3/8/11	97,800	3/8/12	39,600
2/7/11	97,000	2/8/12	34,200
1/11/11	133,000	1/10/12	36,400
12/8/10	137,000	12/9/11	40,200
11/5/10	95,200	11/9/11	50,400
Total	899,200	Total	345,400

Source: Customer's application

The annual savings is based on the following calculation:

Nine-Month Savings = 899,200 kWh – 345,400 kWh = 553,800 kWh.

Note that extrapolating the nine-month savings to a twelve-month, annual savings figure would result in an estimated savings of 738,400 kWh. However, the customer's annual savings estimate is 550,000 kWh:

Customer's Reported HVAC Annual Savings = 550,000 kWh

C.5.6 Uncertainties

There are several uncertainties associated with this project. The first involves the fact that only nine months of utility data were used to calculate the combined annual savings, and no adjustments were made for variations in weather conditions. The final uncertainty is whether the new control system is operating as intended. This uncertainty prompts certain questions, such as "Are the rooftop air conditioning units operating less when the building is unoccupied?" and "Are the outside air economizers operating as intended?"

C.5.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. Current sub-meters were installed on each RTU for a period beginning August 13, 2012, and ending October 16, 2012. The data obtained from these sub-meters were analyzed, in conjunction with monthly utility bills and weather data, to achieve the following objectives.

The M&V objectives for this project are as follows:

1. Calculate the post-retrofit HVAC system energy usage for three months using the sub-metered, RTU energy data.
2. For those three months, calculate the lighting and plug load (post-retrofit base load) of the building by subtracting the RTU monthly sub-metered energy consumption from the monthly utility bill.
3. Calculate the post-retrofit annual HVAC energy by subtracting the annual base load from the annual post-retrofit utility bill.
4. Estimate the pre-retrofit base load from the post-retrofit base load.
5. Calculate the pre-retrofit annual HVAC energy by subtracting the annual pre-retrofit base load from the annual pre-retrofit utility bill.
6. Calculate the HVAC savings by subtracting the post-retrofit HVAC energy from the pre-retrofit HVAC energy, making adjustments for differences in weather conditions.
7. Use the monitored energy data to analyze the operation of the HVAC system during occupied and unoccupied periods.

Table C-74 lists the monitoring equipment that Navigant used for the data collection.

Table C-74. Monitoring Equipment

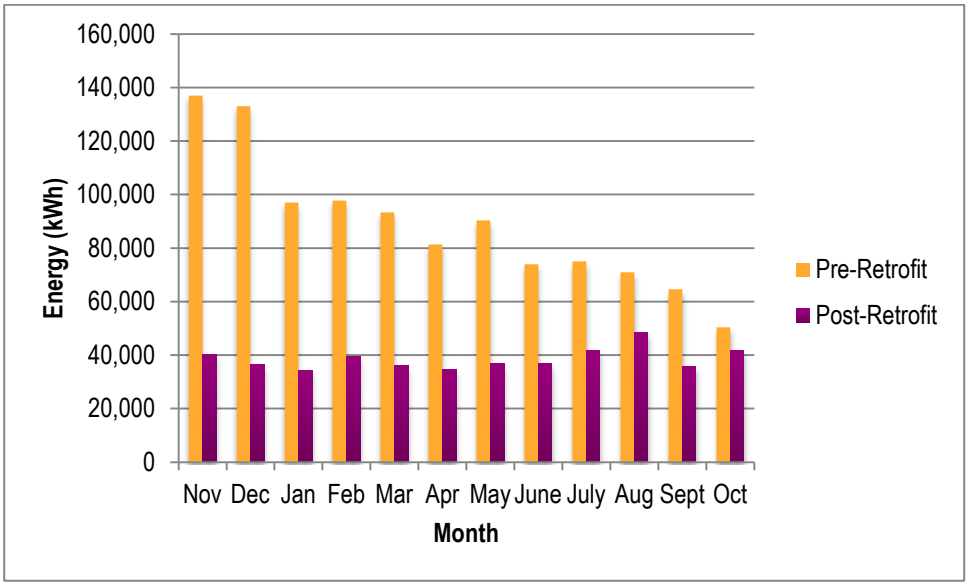
Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.5.8 Verified Energy Savings

Figure C-20 shows twelve months of pre-retrofit and post-retrofit utility bills.

Figure C-20. Pre- and Post-Retrofit Utility Bill Comparison



Source: Navigant analysis (data presented in customer's application)

As shown in Figure C-20, the largest reduction in monthly consumption occurs during winter months. The approximate reduction in energy consumption during the winter months is 70 percent, and this probably results from the thermostat setback during cold winter nights.

C.5.9 Calculating the Post-Retrofit HVAC Energy Consumption

Buildings with a significant amount of computers and printers can have a highly variable energy consumption pattern. Therefore, relying only on utility bills to calculate the savings that results from an HVAC controls retrofit may produce inaccurate results. As such, a more detailed analysis, using sub-metered data, was adopted.

Energy sub-meters were installed on the three RTUs for a period of three months. Table C-75 shows the monthly utility bills and the energy use that the sub-meters recorded. The difference between these two values is the lighting load, the plug load, and miscellaneous loads, which are included as the final column in Table C-75.

Table C-75. Lighting and Plug Load Calculation

Month (2012)	Utility Bill (kWh)	HVAC System (Metered)	Lighting & Plug Load (kWh)
August	48,600	25,587	23,012
September	35,800	19,195	16,604
October	41,800	19,877	21,922
Average			20,513

Source: Utility bills and Navigant metering

As shown in Table C-75, the monthly average post-retrofit lighting and plug loads (which includes computers and printers) for this building is 20,513 kWh per month. The annual total lighting and plug load energy is 246,156 kWh. The total 12-month, post-retrofit utility bill is 463,000 kWh. Subtracting 246,156 kWh from this figure provides a post-retrofit HVAC system annual energy use estimate of 216,844 kWh.

C.5.9.1 Calculating Annual HVAC System Energy Savings Using Utility Bill and Metered Data

The post-retrofit lighting and plug load is estimated to be 20,513 kWh per month. The pre-retrofit lighting and plug load is estimated to be 10 percent higher because of the energy awareness program that was implemented following the retrofit. Therefore, the total annual, pre-retrofit lighting and plug load is estimated to be 270,771 kWh. The total 12-month, pre-retrofit utility bill is 1,065,000 kWh. Subtracting 270,771 kWh from this figure provides a post-retrofit HVAC system annual energy use estimate of 794,229 kWh. Table C-76 provides a summary of the preliminary savings estimates.

Table C-76. Savings Summary

	Annual Utility Bill (kWh)	Estimated Annual Lighting and Plug Energy (kWh)	Estimated Annual HVAC Energy (kWh)
Pre-retrofit	1,065,000	270,771	794,229
Post-Retrofit	463,000	246,156	216,884
Annual Savings	602,000	24,615	577,345

Source: Navigant analysis

As shown in Table C-76, the preliminary estimate of savings is 577,345 kWh.

Demand Savings

Table C-77 shows the demand statistics for the 12 months prior to the retrofit and for the 12 months following the retrofit.

Table C-77. Demand Statistics

Monthly Demand (kW)	Pre-Retrofit	Post-Retrofit
Maximum	270	314
Average	197	194
Minimum	152	114

Source: Customer's utility bills

This controls project basically reduces run-time at night and on weekends. The project has no influence on daytime operation of the HVAC system (other than controlling thermostat set points). As shown in Table C-77, the average yearly demand differs by only 4 kW, and the maximum demand occurred during the post-retrofit period. Therefore, Navigant concludes that this project will not reduce electrical demand.

The annual energy savings projection shown in Table C-76 is not normalized for weather. The following analysis refines the annual savings estimate by normalizing for weather.

C.5.9.2 Weather Analysis and the Verified Savings

Table C-78 shows the pre-retrofit and post-retrofit heating degree days and cooling degree days for Wilmington, NC.

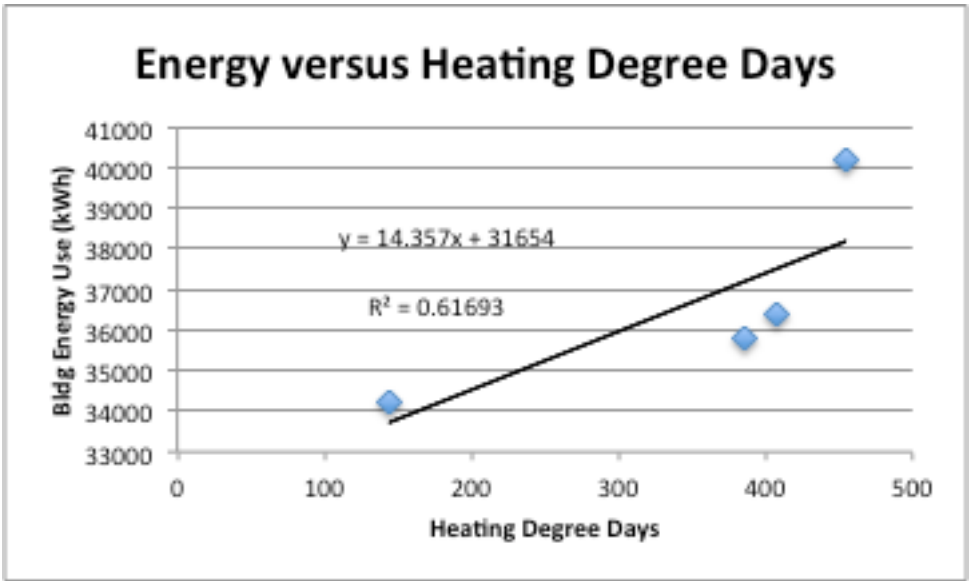
Table C-78. Cooling and Heating Degree Days

Weather Conditions			
Pre-Retrofit		Post-Retrofit	
Heating DD	Cooling DD	Heating DD	Cooling DD
2778	2336	1979	2165

Source: Wilmington, NC weather data

As indicated in Table C-78, the number of pre-retrofit heating degree days is 40 percent higher than the post-retrofit weather. Similarly, the number of pre-retrofit cooling degree days is 7 percent higher than the post-retrofit weather (which is not considered statistically significant). In order to normalize the weather, adjustments will be made to the building energy use during the winter months. In order to accomplish this task, the relationship between building energy consumption and heating degree days must be developed. Figure C-21 shows that relationship.

Figure C-21. Correlation between Post-Retrofit Energy Use and Heating Degree Days



Source: Navigant analysis

As shown in Figure C-21, the relationship between heating degree days and monthly post-retrofit building energy use (November through February) is 14.35 kWh per degree day. Had the weather following the retrofit been equivalent to the weather before the retrofit, the energy use would have been higher. Refer to the following equation:

Post-Retrofit Increase in Energy Use = 799 DD Htg x 14.35 kWh/DD = 11,465 kWh

The preliminary savings estimate shown in Table C-76 is 577,345 kWh. Adjusting for weather differences reduces the savings to 565,800 kWh, which is the verified savings for this retrofit project.

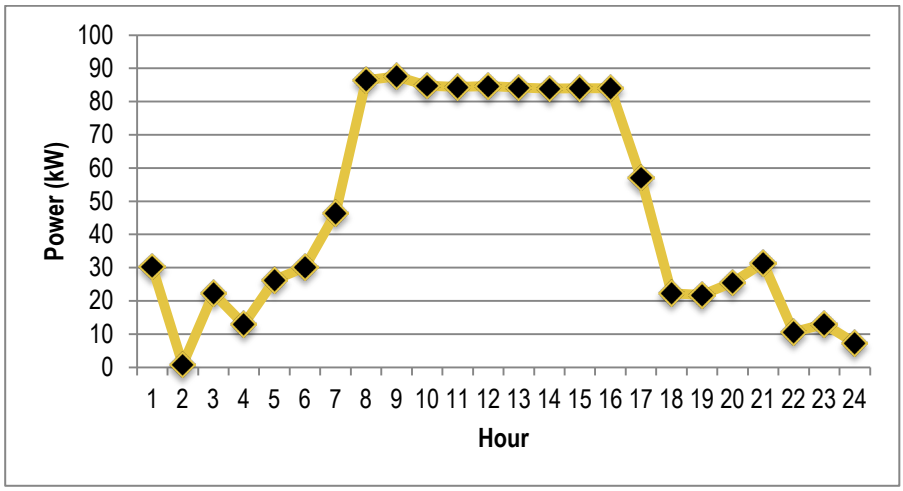
C.5.9.3 HVAC System Operation

The above analysis provides an estimate of the annual energy savings that result from the installation of the building automation system. The following analysis of the sub-metered energy data determines if the automation system is performing as intended.

The automation system is programmed so that the thermostats are set back at night and on the weekends, when the building is unoccupied. In addition, the energy use of the HVAC system should track the cooling degree days. Finally, the rooftop units should remain "off" whenever the outside air temperature is below 55 °F (because of the economizer).

Figure C-22 shows the HVAC system power consumption for 24 hours of a typical workday.

Figure C-22. Workday Energy Use Profile

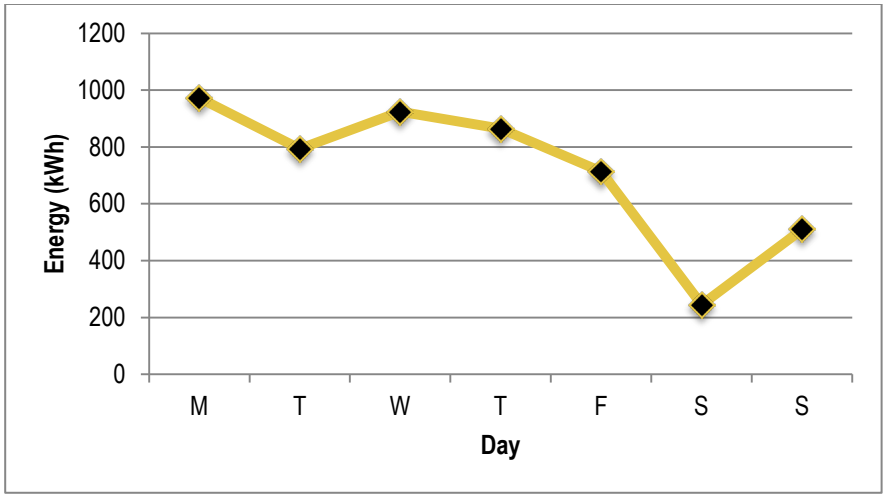


Source: Navigant sub-metering

As shown in Figure C-22, the power consumption of the HVAC system averages 84 kW for nine hours when the building is occupied. During the unoccupied hours, the power consumption varies from a low of 0 kW to a high of 55 kW. The conclusion is that the night setback feature is operational.

Figure C-23 shows the energy consumption for seven days.

Figure C-23. Post-Retrofit Daily HVAC Energy

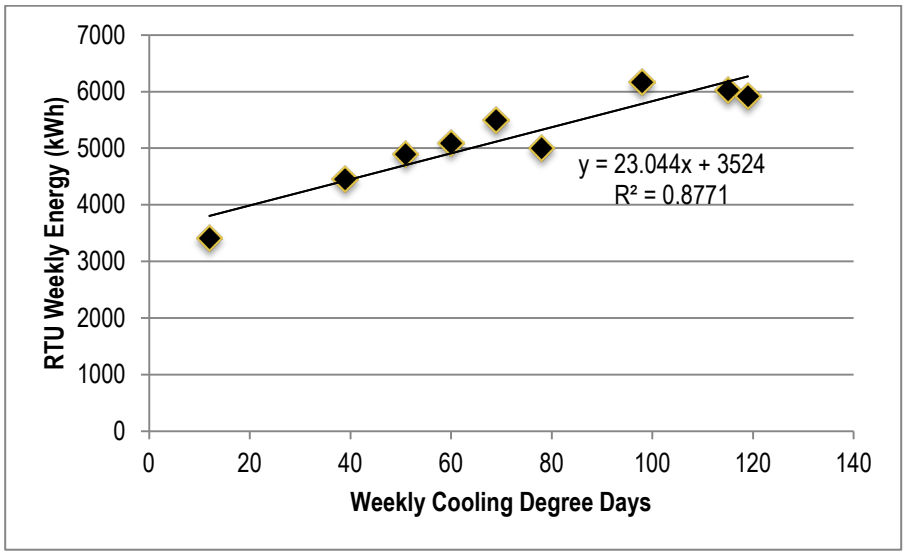


Source: Navigant sub-metering

As shown in Figure C-23, the average weekday energy consumption is 850 kWh. The energy consumption for the weekend is less, with an average daily energy consumption of 375 kWh.

Figure C-24 shows the correlation between weekly HVAC energy use and cooling degree days.

Figure C-24. Energy versus Cooling Degree Days



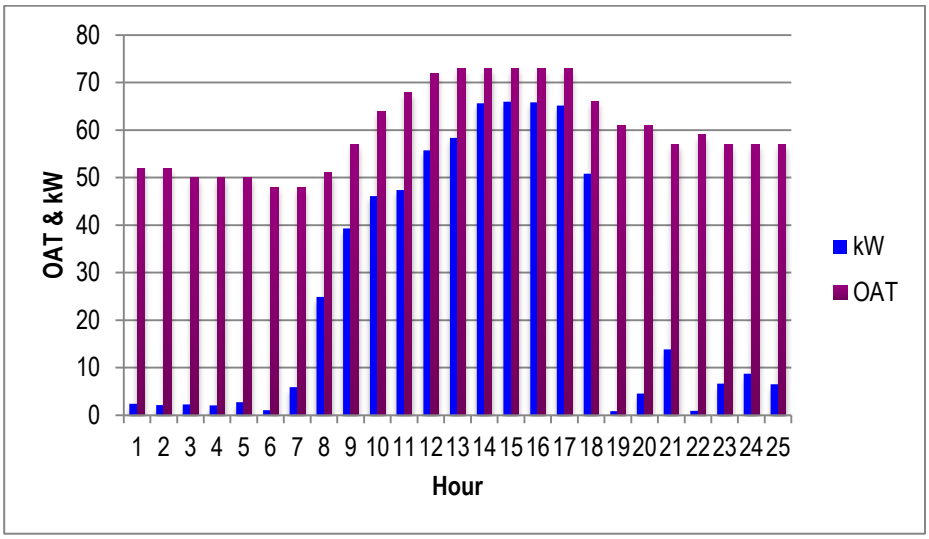
Source: Navigant sub-metering

As shown in Figure C-24, the correlation is strong ($R^2 = 0.877$), which indicates that the control system has the HVAC units tracking the cooling load closely.

Outside Air Economizer

Each of the rooftop units has an outside air economizer that allows the compressor to be "off" when the outdoor temperature is below 55 °F. Figure C-25 shows a graph of HVAC hourly power and outdoor temperature.

Figure C-25. Outside Air Economizer Operation



Note: OAT refers to outdoor air temperature
Source: Navigant sub-metering and Wilmington, NC weather data

Note in Figure C-25 that there is insignificant HVAC energy use from midnight until 8:00 AM. This energy use is probably the result of some of the RTU fans (not compressors) coming "on." The RTU compressors appear to begin operating between 8:00 AM and 9:00 AM when the outside air temperature is 56 °F. After 10:00 AM, several of the compressors are operating and the outside air temperature is above 55 °F. The operation of the outside air economizers is consistent with the design objective.

C.5.10 Conclusions

The following conclusions result from the analysis presented above:

1. The verified energy savings, corrected for weather, is 565,800 kWh. Dividing this 12-month figure by the customer's projected savings results in a realization rate of 102 percent.
2. The verified demand savings is 0 kW because the control system does not affect the daytime demand of the HVAC system.
3. The unoccupied setback feature of the HVAC automation system appears to be performing well.
4. The new HVAC automation system results in a strong correlation (R^2= 0.877), which indicates the system is accurately tracking the cooling load.
5. The outside air economizer is performing as expected.

C.6 Site ID 12100

Site ID	12100
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-11-02297
Building or Site Type	Light Industrial

C.6.1 Project Summary

This project involves the replacement of a 125-HP, constant-speed compressor with a 75-HP, variable-speed drive (VSD) compressor. Except for monthly service, the compressor runs continuously. Table C-79 provides a summary of reported and verified energy and demand savings associated with the project.

Table C-79. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace 125 HP air compressor with 75 HP VSD	Reported	399,500 kWh	47 kW	$31,126.35
	Verified	353,600 kWh	41 kW	N/A
	Realization Rate	89%	87%	N/A

Source: EEB database and Navigant analysis

C.6.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager
  - Inspect the new compressor
  - Install data logger on electrical service to the new compressor
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.6.3 Description of Baseline

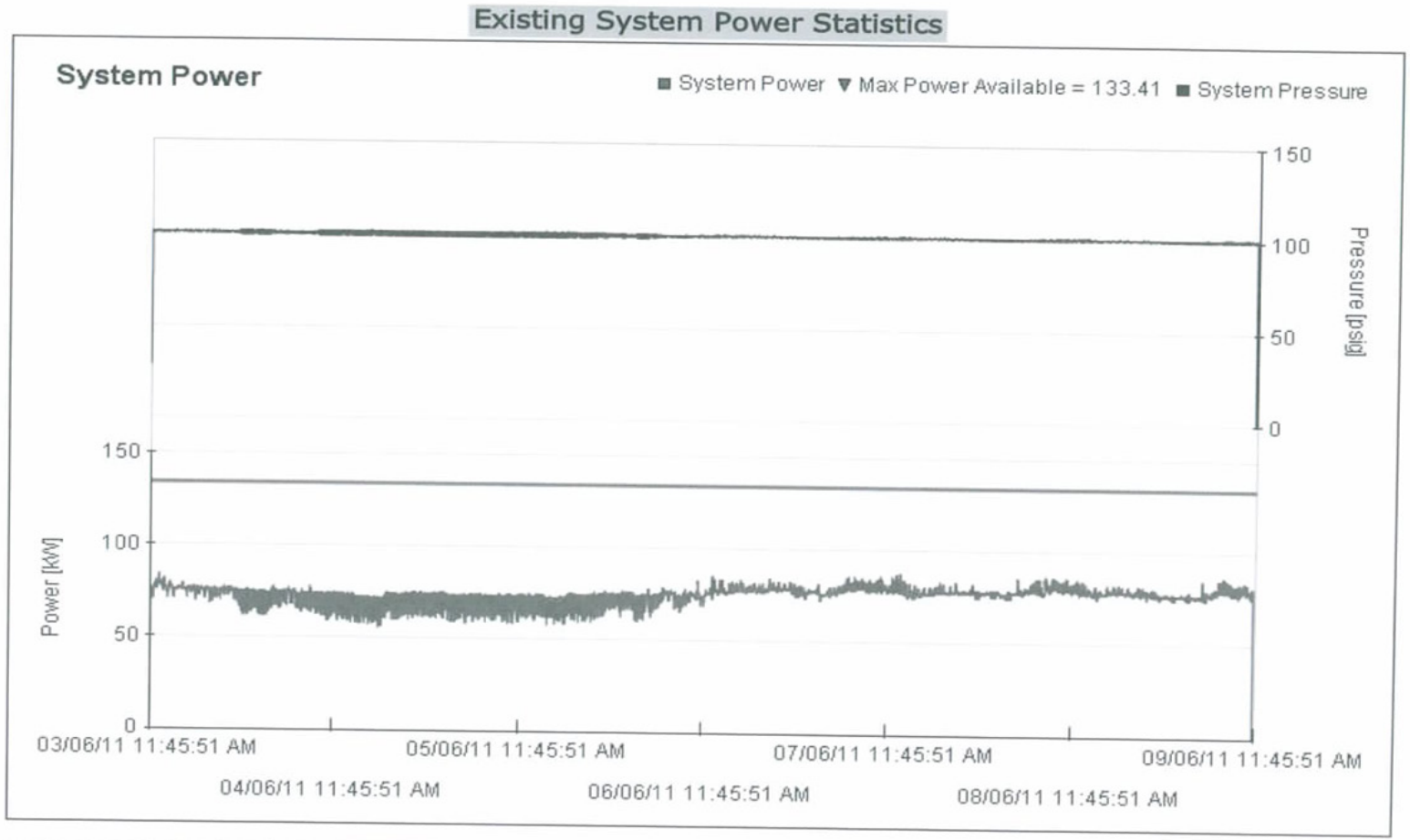
This manufacturing facility uses compressed air to operate machinery. The plant works a full first shift, a reduced second shift, and a skeleton third shift. The compressed air system is never shut down.

An air compressor contractor collected flow and energy data for the 125-HP air compressor for seven days. The results indicated that the average flow rate was 215 CFM, the average system pressure was 101 pounds per square inch (psi), and the average electrical power was 75 kW. Based on these results, the

average compressor efficiency was 2.86 CFM per kW. Figure C-26 shows the pressure and demand over the seven-day test period.[8]

[8] Note the dates in the vendor chart are shown in DD/MM/YY format.

Figure C-26. Pre-Retrofit Pressure and Electrical Demand



	Min	Max	Average
Pressure	12 psig at 6/9/2011 11:27 AM	102 psig at 6/5/2011 5:47 PM	101 psig
Power	9.1 kW at 6/3/2011 11:45 AM	87.3 kW at 6/7/2011 1:31 PM	75 kW

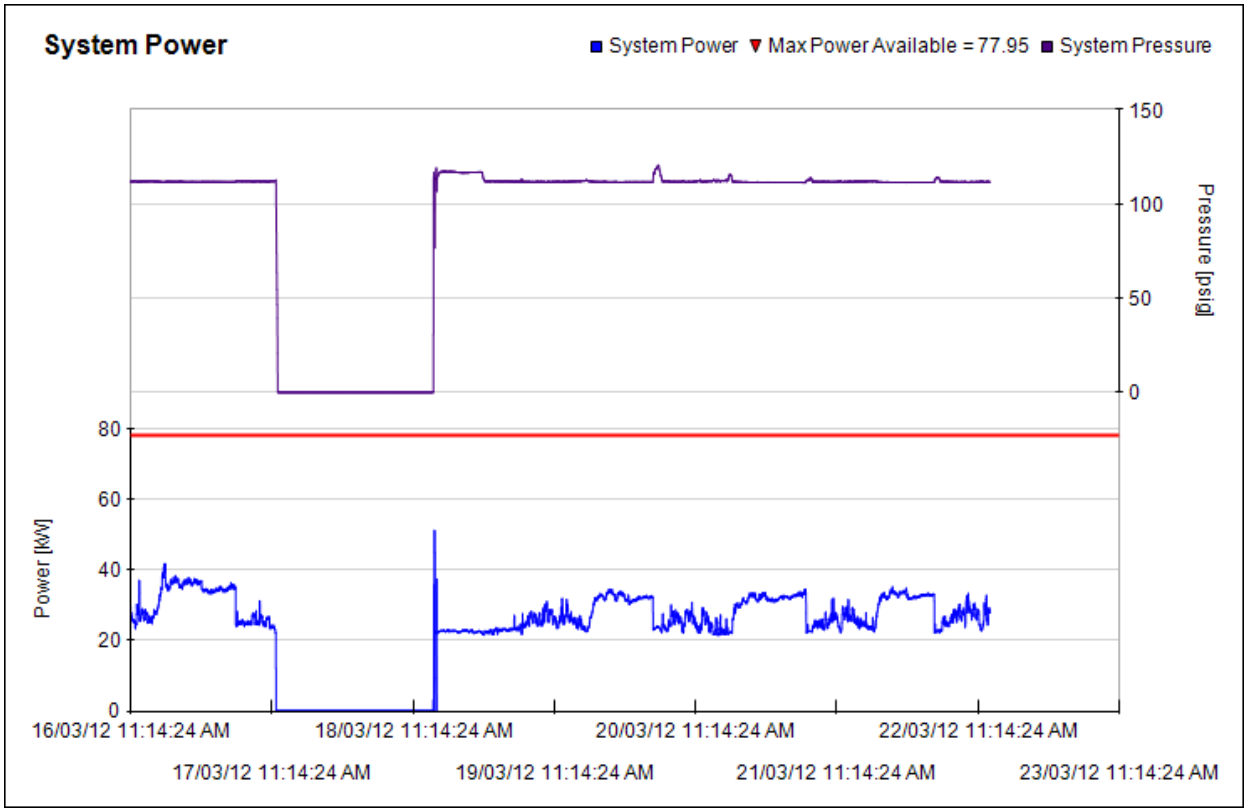
Source: Customer's application file

As seen in Figure C-26, the system pressure remained constant over the test period. The electrical demand decreased slightly on June 4 and 5, which were weekend days.

C.6.4 Description of As-Built Equipment and Operation

Following the retrofit, the same contractor collected flow and energy data for the new 75 HP air compressor for seven days. The results indicate that the average flow rate was 156 CFM, the average system pressure was 112 psi, and the average electrical power was 28.06 kW. Based on these results, the average compressor efficiency is 5.57 CFM per kW. Figure C-27 shows the system pressure and demand for the seven-day test period.[9]

Figure C-27. Post-Retrofit Pressure and Demand



Source: Customer application file

Note that the obvious difference between Figure C-26 and Figure C-27 is that, in the latter, the compressor appeared to shut down on March 17, which was a Saturday. The compressor restarted on Sunday.

[9] Note the dates in the vendor chart are shown in DD/MM/YY format.

C.6.5 Applicant Energy Savings Algorithm

The applicant's savings algorithm is shown in Table C-80. The data resulted from one week of pre-retrofit monitoring and a second week of post-retrofit monitoring.

Table C-80. Applicant's Savings Data and Calculations

	Monitored Average Demand (kW)	Annual Operating Hours	Annual Energy Consumption (kWh)	Monitored Peak Demand (kW)
Pre-Retrofit	75	8,500	637,500	87
Post-Retrofit	28	8,500	238,000	42
Savings	47	8,500	399,500	45

Source: Customer's application file

As shown in Table C-80, the customer projected an annual savings of 399,500 kWh and a demand savings of 45 kW. Note that the above savings calculation takes credit for the reduction in flow from 215 CFM to 156 CFM.

C.6.6 Uncertainties

There are two uncertainties associated with this project. First, it appears that the new compressor shut down on Saturday, March 17. It is not known if the shutdown resulted from low system air demand or some other reason. Weekend operation of the compressor is uncertain; therefore, a five-week monitoring program will be initiated to better define the compressor operation. The second uncertainty results from the flow and pressure changes that occurred after the new compressor was installed. The customer's savings calculations did not normalize for changes in flow and pressure.

C.6.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. An air compressor contractor took pre-retrofit energy measurements for a period of one week. The results from this monitoring effort are stipulated to represent the baseline electrical energy consumption for the pre-retrofit compressed air system. Following the retrofit, the contractor took an additional seven days of data. The annual energy savings reduction included in the customer's application is based on the results from these two weeks of data collection.

Navigant collected post-retrofit energy data for a period of five weeks. The verified annual energy savings and the demand reduction are calculated by comparing the five-week results to those of the baseline.

Table C-81 lists the monitoring equipment that Navigant used for the data collection.

Table C-81. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.6.8 Verified Energy Savings

The M&V analysis typically occurs six months after the retrofit. The objectives of the M&V study are as follows:

1. Confirm that the new compressor(s) is still in operation.
2. Based on a discussion with the operating engineer, determine if demand for compressed air has changed (which might result from a change in operating hours of the factory or the addition or removal of equipment).
3. Based on a discussion with the operating engineer, determine if the control sequence for the compressor(s) has changed (which might occur if the compressor line-up has changed).
4. Install energy data loggers on the compressors for a period of three to five weeks.
5. Using the monitored energy data, compare the daily and weekly operational profiles of the compressed air system to the profile described in the customer's application.
6. Using the monitored energy data, compare the weekly energy consumption with the post-retrofit energy consumption included in the customer's application.
7. If permanent changes to the compressed air system have occurred or if the operating profile of the compressor(s) has changed, calculate the annual energy savings based on the new operating conditions.

C.6.8.1 Adjusting the Baseline Energy Consumption

Noted in the contractor's report is the fact that the flow and pressure changed after the new compressor was installed. Table C-82 shows the pre-retrofit and post-retrofit operating data.

Table C-82. Pre and Post Operating Point

	Flow (CFM)	Pressure (PSIG)	Efficiency (kW/100 CFM)
Pre-Retrofit	215	101	34.9
Post-Retrofit	156	112	17.9

Source: Customer's application file

As shown in Table C-82, the data provided in the customer's application indicate a significant reduction (215 CFM to 156 CFM) in compressed air consumption following the retrofit. The customer was asked whether this reduction might have resulted from repairing air leaks or from the removal of equipment

from production. The customer stated that no leaks were repaired and that no equipment was removed from production. The air compressor contractor responded to the question as follows:

> *"The 215 CFM is a calculated flow based on the amp draw of this compressor at the 101 psi average pressure. Because it is a fixed speed compressor running at far below rated capacity the unit was cycling on/off line (full load amp load to unload amp load) and therefore drawing more amperage than the subsequent variable speed unit which is much more accurately matching energy requirement with true actual load."*

Based on a follow-up conversation with the contractor, Navigant confirmed that the pre-retrofit flow rate was not based on a direct measurement; rather, it was based on an assumption regarding the efficiency of the replaced compressor. Navigant concludes that the baseline flow of 215 CFM is incorrect because the contractor assumed an incorrect operating efficiency. Therefore, it is stipulated that the baseline flow is 156 CFM and that no baseline adjust is required.

C.6.8.2 Post-Retrofit Monitoring Results

The energy consumption of the new compressor was monitored for a period of five weeks. A total of 43,428 amp readings were taken at one-minute intervals, and the average current was 40.3 amps.

The average power consumption is given by the following equation, in which the power factor is 1:

$$Power = (1.73 \times 480 \times 40.3 \times 1) / 1000 = 33.4\ kW$$

Table C-83 summarizes the calculations of the verified energy and demand savings.

Table C-83. Verified Savings

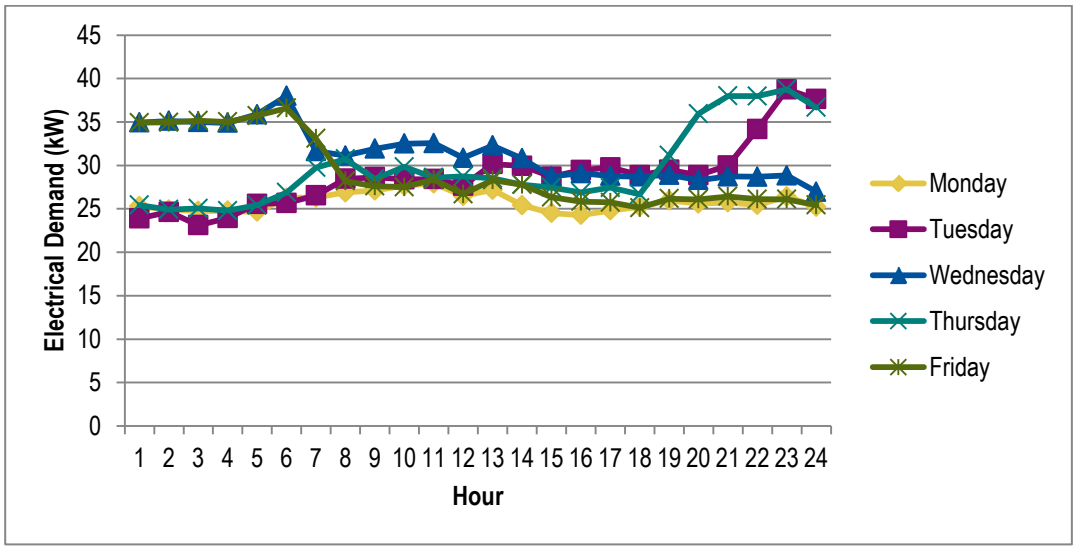
	Average Demand (kW)	Annual Operating Hours	Annual Energy (kWh)	Peak Demand (kW)
Pre-Retrofit	75	8,500	637,500	87
Post-Retrofit	33.4	8,500	283,900	53
Savings	41.6	8,500	353,600	34

Source: Navigant analysis

C.6.8.3 Post-Retrofit System Performance

The following graphs demonstrate the operational performance of the air compressor during the monitoring period. Table C-83 shows the hourly electrical demand for five typical working days.

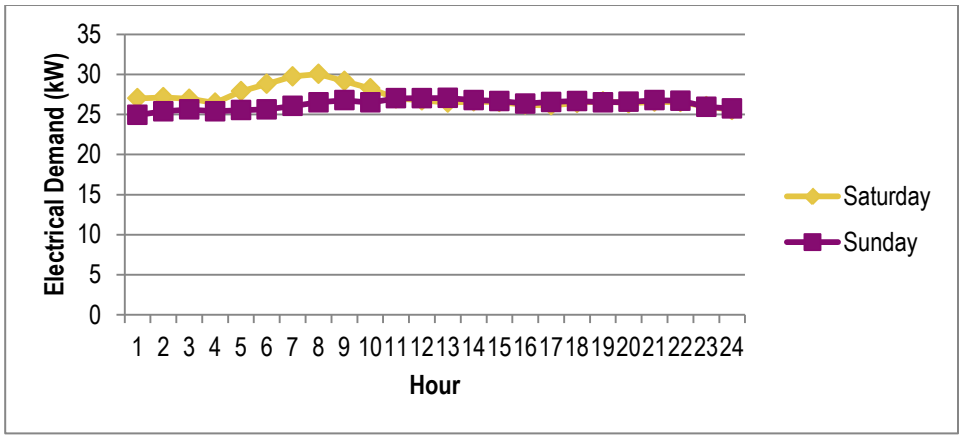
Figure C-28. Hourly Workday Electrical Demand



Source: Navigant monitoring

Note that Figure C-28 shows a high demand for Wednesday and Thursday in the early morning and late at night. The cause of this increased demand is unknown. Also note that the typical workday demand averages 31 kW. Figure C-29 shows the typical weekend electrical demand.

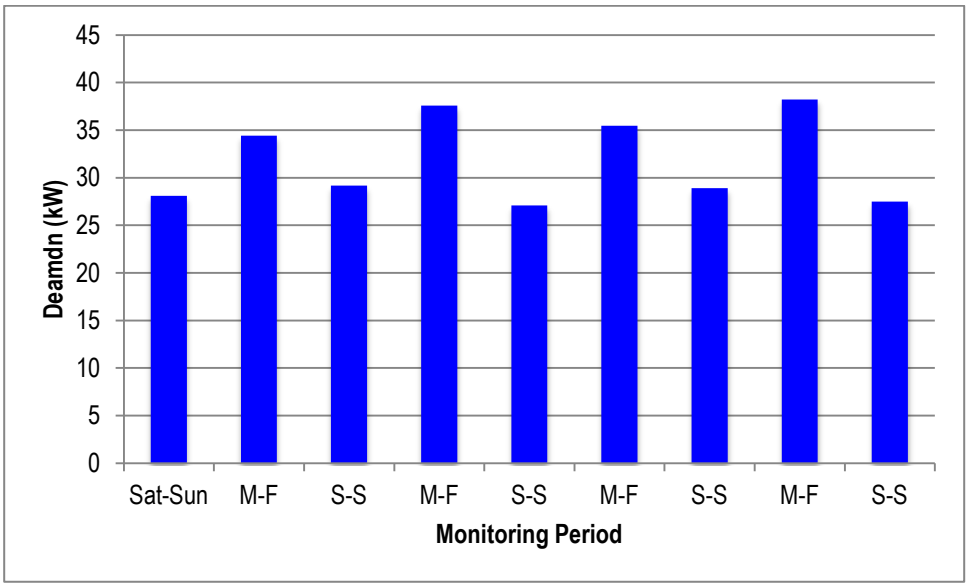
Figure C-29. Hourly Weekend Electric Demand



Source: Navigant monitoring

As indicated in Figure C-29, the typical weekend demand averages 27 kW. Figure C-30 shows the average weekday and weekend compressor electrical demand during the entire monitoring period.

Figure C-30. Average Weekday and Weekend Compressor Demand



Source: Navigant monitoring

C.6.9 Conclusions

The following conclusions result from the sub-metered data and from the subsequent analyses:

1. The verified energy savings realization rate for this project is 88.5 percent. The contractor's savings estimate was based on six days of post-retrofit monitoring, while Navigant's estimate is based on five weeks of monitoring.
2. The verified demand savings realization rate is 87 percent.
3. This has been a successful retrofit project.

C.7 Site ID 13210

Site ID	13210
Sampling Stratum	Custom—High Savings
Rebate Number	EEB-12-02653
Building or Site Type	Light Manufacturing

C.7.1 Project Summary

This project involves the replacement of ten small packaged chillers, ranging in size from 5 to 25 tons (total chiller capacity of 99.5 tons), with a central chiller (120 tons). The chiller provides process cooling water for pharmaceutical tubing production. A summary of the project's reported and verified energy and demand savings appears in Table C-84.

Table C-84. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace M-H lighting with T-8 fluorescent	Reported	330,538 kWh	53 kW	$26,443.04
	Verified	330,538 kWh	53 kW	N/A
	Realization Rate	100%	100%	N/A

Source: EEB database and Navigant analysis

C.7.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager
  - Inspect the new chiller installation
  - Install a data logger on electrical service to the new chiller installation
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.7.3 Description of Baseline

This facility manufactures pharmaceutical tubing, and the production line includes ten machines. Each machine requires chilled water to cool the machine and the final product. The baseline operation included ten packaged chillers (one for each machine). These air-cooled chillers rejected the condenser heat inside the factory.

The majority of the product cooling involves long, stainless-steel troughs through which the tubing is drawn. The troughs are filled with cooling water, and the cooling water absorbs heat from the hot tubing. Prior to the retrofit, the stainless-steel troughs were uncovered. Therefore, the process cooling water also absorbed heat from the hot air inside the factory. Even though the facility has large outside air ventilation fans, the typical summertime indoor temperature approached 100 °F, while the wintertime indoor temperature averaged 80 °F. Thus, the chillers operated in a very high-temperature environment and at low efficiency.

The facility operates three shifts per day, five days per week. Occasionally, the facility operates one or two shifts on Saturday.

C.7.4 Description of As-Built Equipment and Operation

The new chiller installation includes six, 20-ton chillers that are connected to outdoor condensing units. As such, the condenser heat is now rejected outdoors, rather than into the manufacturing area. The condensing units have a total of nine, 5-HP fans.

With the new chillers, the typical indoor summertime temperature is now 85 °F, while the typical indoor wintertime temperature is 75 °F. The manufacturing process operates 24 hours per day, five days per week.

Even though the process cooling load has been significantly reduced (by rejecting condenser heat outdoors), the customer decided to install a chiller with more capacity. The customer selected a larger chiller so that four packaged rooftop air-conditioning units that were used for air conditioning the break room, the clean room, and two product storage areas could be replaced. New air handling units have been installed, and chilled water from the new chiller installation is used for cooling these areas. Another recent change that the owner made is adding covers to the stainless-steel troughs. These covers reduce heat transfer from the factory to the cooling water in the troughs. Note that installing covers on the stainless-steel troughs and replacing the rooftop air conditioning units were not included in the customer's incentive application.

C.7.5 Applicant Energy Savings Algorithm

The applicant's saving algorithm involved estimating the peak and average electrical demand for the ten packaged chillers prior to the retrofit. According the application file, the combined, maximum electrical demand for the ten chillers was estimated to be 112 kW. The average, annual combined electrical demand for the ten chillers was estimated to be 94.8 kW. The annual hours of operation were 6,240 hours per year.

The applicant monitored the power consumption of the new chiller for several months following the retrofit; the average electrical demand was determined to be 41.9 kW, and the peak demand was 59 kW. Table C-85 summarizes the customer's energy savings calculations. Note that the covers for the troughs had not been insulated, nor had the new air-handling units been installed when the post-retrofit monitoring took place.

Table C-85. Customer's Savings Calculations

	Average Demand (kW)	Annual Operating Hours	Annual Energy (kWh)	Maximum Demand (kW)
Pre-retrofit	94.8	6,240	591,552	112
Post-retrofit	41.9	6,240	261,456	59
Savings	52.97	6,240	330,538	53

Source: Customer's application

As shown in Table C-85, the customer's projected annual saving is 330,538 kWh. The projected demand savings is 53 kW.

C.7.6 Uncertainties

Since the retrofit, the customer has made several changes, including adding covers to the stainless-steel troughs. The customer has also removed four rooftop packaged units, and the new chiller plant now supplies chilled water to new air handlers. As such, the chiller energy now includes two components: the process cooling water and the chilled water used for air conditioning several rooms inside the factory. Additional energy measurements were conducted during the M&V study in order to confirm the post-retrofit process cooling energy and demand.

C.7.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. The owner calculated the baseline annual energy use and the electrical demand using the specifications for the ten packaged chillers. The results from this calculation are stipulated to represent the baseline electrical energy consumption for the pre-retrofit chiller configuration.

Navigant collected post-retrofit chiller energy data for a period of seven weeks. The verified annual energy savings and the demand reduction were calculated by comparing the seven-week results to those of the baseline. Table C-86 lists the monitoring equipment that Navigant used for the data collection. The amperage that the chillers drew was monitored and recorded at five-minute intervals during the data-collection period.

Table C-86. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.7.8 Verified Energy Savings

Data loggers were installed on the electrical service to the chiller for a period of seven weeks, beginning on October 17, 2012, and ending December 6, 2012. Table C-87 shows the results of this seven-week study.

Table C-87. Monitoring Results

Time of Week	Daily Energy (kWh)	Average Demand (kW)
Weekday (Process and AHUs)	2,192	91.3
Weekend (AHUs)	1,458	60.8
Process (only)	734	30.5

Source: Navigant monitoring

As shown in Table C-87, the weekday energy use is the sum of process cooling plus the energy used for cooling the four rooms inside the factory. There is no production on the weekends, so all weekend energy use is for cooling the four rooms. Therefore, subtracting the weekend energy from the weekday energy results in the process cooling energy. As shown in Table C-87, the process cooling energy is 734 kWh/day. The average electrical demand for process cooling is 30.5 kW.

The energy use of the nine condenser fans was not monitored, and the 30.5 kW represents only the compressor demand. It is estimated that the condenser fans would add an additional 7.5 kW to the process cooling compressor load. (Note that the 7.5 kW fan load is approximately 25 percent of the 30.5 kW process chiller load.) Therefore, the average electrical demand associated with process cooling is 38.0 kW. Table C-88 shows the verified energy savings of 354,432 kWh.

Table C-88. Verified Annual Energy and Demand Savings

	Average Demand (kW)	Annual Operating Hours	Annual Energy (kWh)	Maximum Demand (kW)
Pre-retrofit	94.8	6,240	591,552	112
Post-retrofit	38.0	6,240	237,120	N/A
Savings	56.8	6,240	354,432	N/A

Source: Customer application and Navigant analysis

The pre-retrofit data shown in Table C-88 were presented in the customer's application. Since this is the only pre-retrofit data available, Navigant has stipulated that this is the baseline energy use and demand. The verified annual energy savings shown in Table C-88 is 354,432 kWh. The savings is 7 percent more than the customer predicted. The reason for this increased savings is that covers have been installed on the stainless-steel troughs. These covers reduce heat flow into the troughs, which reduces chiller energy. Since the covers were not included in the customer's application, the additional 7 percent savings will not be included in the verified energy savings. In addition, as Navigant's sub-metering did not occur during the hot summer months, the demand savings could not be verified. Therefore, the customer-reported demand savings of 53 kW is stipulated to be accurate.

C.7.9 Conclusions

The customer's application involved the replacement of ten chilled-water, packaged units with a new, central chiller plant. The chiller plant that was installed has a capacity of 120 tons, and the total capacity of the replaced chillers was 99.5 tons. The reduction of the process water demand and the higher tonnage of the new chiller plant have enabled the customer to replace old, inefficient rooftop air conditioning units with new air handlers that receive chilled water from the new chiller plant. This replacement of the air conditioning units and the addition of covers to the process troughs were not included in the customer's application. The following conclusions can be drawn from the sub-metered data and from the subsequent analyses:

1. Establishing the baseline energy use for this project was unusually difficult because of the unusual circumstances associated with the pre-retrofit chiller operation. For unusual projects of this nature, Navigant recommends that pre-retrofit energy measurements be taken and that those measurements used to establish the baseline energy consumption. Without such measurements, the verified savings figures are subject to a high degree of variation.

2. The energy savings realization rate for this project was verified to be 100 percent. It is stipulated that the demand savings realization rate is also 100 percent.

3. This project has not only saved energy, but it has significantly improved the environmental conditions inside this facility.

4. The incentive amount could have been higher had the customer included the replacement of old, inefficient rooftop air conditioning units in the application.

C.8 Site ID 24720

Site ID	24720
Sampling Stratum	Custom—Medium Savings
Rebate Number	EEB-11-02302
Building or Site Type	Miscellaneous—Parking Garage

C.8.1 Project Summary

This project involves the replacement of 210, 175-W metal halide (MH) lighting fixtures in a parking garage with an equal number of 80-W LED fixtures.

Table C-89. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace M-H lighting with HID	Reported	241,172 kWh	27.5 kW	$19,293/76
	Verified	241,172 kWh	27.5 kW	
	Realization Rate	100%	100%	N/A

Source: EEB database and Navigant analysis

C.8.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager
  - Take current measurements on three feeders to the two lighting panels
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.8.3 Description of Baseline

The lighting layout for this parking garage consisted of 210, 175-W (nominal) MH fixtures. The lighting was "on" for 8,760 hours per year.

C.8.4 Description of As-Built Equipment and Operation

The post-retrofit layout for the parking garage consists of 210, 80-W (nominal) LED fixtures. The lighting operates 8,760 hours per year. This project is considered a custom project because LED lights are not included as a prescriptive option in the PY 2012 EEB.

C.8.5 Applicant Energy Savings Algorithm

The applicant's energy and demand savings calculations are shown in Table C-90.

Table C-90. Lighting Calculations—Pre-Retrofit

Fixtures	Fixture Watts	Quantity	Annual Hours	Annual Energy kWh	Peak Demand kW
175 Watt MH	207	210	8,760	382,208	43.6
80 Watt LED	76.9	210	8,760	141,036	16.1
Total	N/A	N/A	N/A	241,172	27.5

Source: Customer application file

C.8.6 Uncertainties

The two uncertainties for this project include the number of new fixtures installed and the annual hours of operation.

C.8.7 On-Site Energy Monitoring

Navigant conducted a site visit to inspect the facility and to discuss the operation of the new lighting with the facilities manager. It was determined that the new lights were located in the interior of the parking garage and, therefore, were left "on" continuously. Other, non-LED lights along the perimeter of the garage have photocell controls. The garage provides private parking for the bank owner, executives, and employees.

There are two 120- to 208-V, three-phase lighting panels in the garage. While the panels feed the elevator and control arm motors, these loads are intermittent. There were also approximately 20 perimeter lights that were "on" because one of the controllers was malfunctioning (refer to Section C.8.8.) Amperage measurements were taken on the three-phase conductors that feed both lighting panels, as shown in Table C-91.

Table C-91. Energy Measurements

Phase	Voltage	Amperage	Watts
A	114	61	6,954
B	115	44	5,060
C	113	70	7,910
Total	N/A	N/A	19,924

Source: Navigant measurements

The voltage and current measurements were taken with the multi-meter indicated in Table C-92.

Table C-92. Monitoring Equipment

Equipment	Equipment Description
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.8.8 Verified Energy Savings

The lighting energy shown in Table C-91 is 19,924 W. Subtracting the energy consumed by the 20 perimeter lights that were "on" because of the faulty controller results in a net lighting power of approximately 16.1 kW. Therefore, Navigant's investigation and analysis indicates that the owner's calculated energy and demand savings are verified at 100 percent. Refer to Table C-93.

Table C-93. Verified Annual Energy and Demand

Verified Energy and Demand	
Measured Power	19,924 watts
"Other" Lighting	3,824 watts
Verified Demand	16,100 watts
Annual Operating Hours	8,760
Verified Annual Energy	141,036 kWh

Source: Navigant analysis

C.8.9 Conclusions

The realization rate for this project has been verified to be 100 percent.

C.9 Site ID 207830

Site ID	207830
Sampling Stratum	Custom—Medium Savings
Rebate Number	EEB-11-02238
Building or Site Type	College/University

C.9.1 Project Summary

This project involves the installation of a centralized building automation system in the Student Services Building and the Learning Resources Center. The new automation system includes an unoccupied mode that provides temperature setbacks to reduce energy consumption. Variable frequency drives were also installed on the two major air-handling units in the Student Services Building. Table C-94 shows the reported and verified energy and demand savings.

Table C-94. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Building automation system and VFD drives	Reported	126,800 kWh	0 kW	$10,144
	Verified	255,648 kWh	0 kW	N/A
	Realization Rate	202%	N/A	N/A

Source: EEB database and Navigant analysis

C.9.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review the project files
  - Review energy savings calculations
- Conduct a phone interview with corporate contact
- Conduct a site visit
  - Interview facilities manager
  - Inspect the building automation system
  - Install data loggers on the two chillers and the air handlers in the Student Services Building
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.9.3 Description of Baseline

The Student Services Building is a single-story, 21,000-square-foot facility that includes a kitchen and cafeteria, student lounge, financial aid office, counseling office, and campus security office. The Learning Resources Center is a 40,000-square-foot building that includes a library, offices, and classrooms. Both buildings are occupied from 6:30 AM until 10:30 PM, five days per week.

The original control system in the buildings was pneumatic. Prior to the completion of the retrofit project, the HVAC system operated continuously (24/7), and the controls were non-functional. The outside air economizers were inoperable, the VAV air handlers had inlet vanes that did not work, and VAV boxes in the Student Services Building did not operate reliably.

The HVAC system for the Student Services Building included one 40-ton (nominal), air-cooled chiller and two variable air volume air handling units with VAV boxes. The HVAC system for the Learning Resources Center included one 60-ton (nominal), air-cooled chiller and four variable air volume air-handling units. Natural gas provided heating and domestic hot water for both buildings.

C.9.4 Description of As-Built Equipment and Operation

The retrofit project includes a new, direct-digital building automation system that is interfaced with the campus-wide system. The facilities engineer controls room temperature set points and setbacks from a central location. The retrofit includes the installation of new digital thermostats in both buildings. The outside air economizers in both buildings were also refurbished.

In the Student Services Building, the VAV boxes were modified by replacing the internal volume dampers with external volume dampers, and new actuators were installed. Variable-frequency drives were also installed on the two main air handling units.

Following the installation of the new automation system, the HVAC systems now operate from 5:30 AM until 10:30 PM, five days per week. During unoccupied periods, the room set-point temperatures are set back 4 °F. The retrofit project began in January 2011 and was completed in August 2011.

C.9.5 Applicant Energy Savings Algorithm

The applicant's energy savings algorithm is based on an analysis of utility meter readings prior to, and following, the retrofit. Each building has an air-cooled chiller, and a utility meter serves both chillers and only those chillers. In addition, a separate utility meter serves each of the two buildings. The applicant's algorithm includes the analysis of pre- post-retrofit utility data for the utility meter that serves the two chillers. Table C-95 shows the two chillers' pre-retrofit and post-retrofit energy consumption. The annual energy savings calculated in the customer application file is 126,800 kWh.

Table C-95. Customer Savings Calculations

Pre-retrofit Date	Pre-retrofit kWh	Post-retrofit Date	Post-retrofit kWh	Savings kWh
8/23/11	39,320	8/23/12*	22,410*	16,910*
7/22/11	43,240	7/22/12*	24,647*	18,593*
6/23/11	51,480	6/23/12*	29,344*	22,137*
5/20/11	36,440	5/23/12	15,520	20,920
4/22/11	20,960	4/23/12	12,200	8,760
3/22/11	15,920	3/21/12	7,920	8,000
2/18/11	4,720	2/21/12	2,720	2,000
1/21/11	2,040	1/23/12	1,160	880
12/21/10	5,840	12/21/11	4,840	1,000
11/18/10	14,280	11/21/11	6,800	7,480
10/21/10	23,000	10/21/11	17,440	5,560
9/22/10	41,800	9/21/11	27,240	14,560
Total	299,040		Total	126,800

*Estimated data.

Source: Customer application

C.9.6 Uncertainties

There are a number of uncertainties associated with the project. The first uncertainty is the actual utility bills for June, July, and August 2012. Second, the utility data do not confirm that the chillers and air handlers are shutting down according to the programmed schedule or that the outside economizers are functioning as intended. Third, the energy savings calculations are based only on the utility meter that serves the chiller. The savings associated with the shutdown of the air handling units is not included in the energy savings calculation.

C.9.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. Given that there is a dedicated utility meter serving the two chillers, the data from this meter will be used to calculate the post-retrofit energy consumption of the chillers. As the utility meter provides only monthly energy use, sub-meters were also installed on each chiller in order to monitor their hour-by-hour operation. Sub-meters were also installed on the two main air handlers in the Student Services Building in order to monitor their hour-by-hour operation.

The M&V objectives for this project are as follows:

1. Analyze 12 months of post-retrofit utility data to verify annual energy savings for the chillers.
2. Analyze sub-metered energy data and weather data to verify that the chillers are shutting down when the buildings are unoccupied and when the outdoor air temperature is below 55 °F.
3. Analyze sub-metered data to verify that the air handlers are shutting down when the buildings are unoccupied. Use these results to calculate the annual energy savings associated with the unoccupied building shutdown of the air handling units.
4. Calculate the annual energy savings for the chillers and the air handling units.
5. Develop a correlation of monthly chiller energy use and monthly cooling degree days in order to ascertain how effective the HVAC control system tracks the cooling load.

Table C-96lists the monitoring equipment that Navigant used for the data collection.

Table C-96. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.9.8 Verified Energy Savings

C.9.8.1 Baseline Consumption Analysis

As shown in Table C-95, the baseline annual energy consumption for the chillers is 299,040 kWh. The air handler (fan motor) demand for the two buildings is estimated to be 33 kW. Multiplying 33 kW by 8,760 hours equals 289,080 kWh per year of fan energy. The total baseline energy consumption for the chillers and air handlers for the two buildings is stipulated to be 588,120 kWh.

C.9.8.2 Post-Retrofit Analysis

Chiller Energy Savings

Table C-97 shows the pre-retrofit and post-retrofit utility data with actual data for June, July, and August 2012.

Table C-97. Estimated Chiller Energy Savings Based on Utility Bills

Pre-retrofit	Pre-retrofit	Post-retrofit	Post-retrofit	Savings
Date	kWh	Date	kWh	kWh
8/23/11	39,320	8/23/12	26,600	12,720
7/22/11	43,240	7/22/12	32,000	11,240
6/23/11	51,480	6/23/12	22,560	22,137
5/20/11	36,440	5/23/12	15,520	20,920
4/22/11	20,960	4/23/12	12,200	8,760
3/22/11	15,920	3/21/12	7,920	8,000
2/18/11	4,720	2/21/12	2,720	2,000
1/21/11	2,040	1/23/12	1,160	880
12/21/10	5,840	12/21/11	4,840	1,000
11/18/10	14,280	11/21/11	6,800	7,480
10/21/10	23,000	10/21/11	17,440	5,560
9/22/10	41,800	9/21/11	27,240	14,560
Total	299,040		Total	115,257

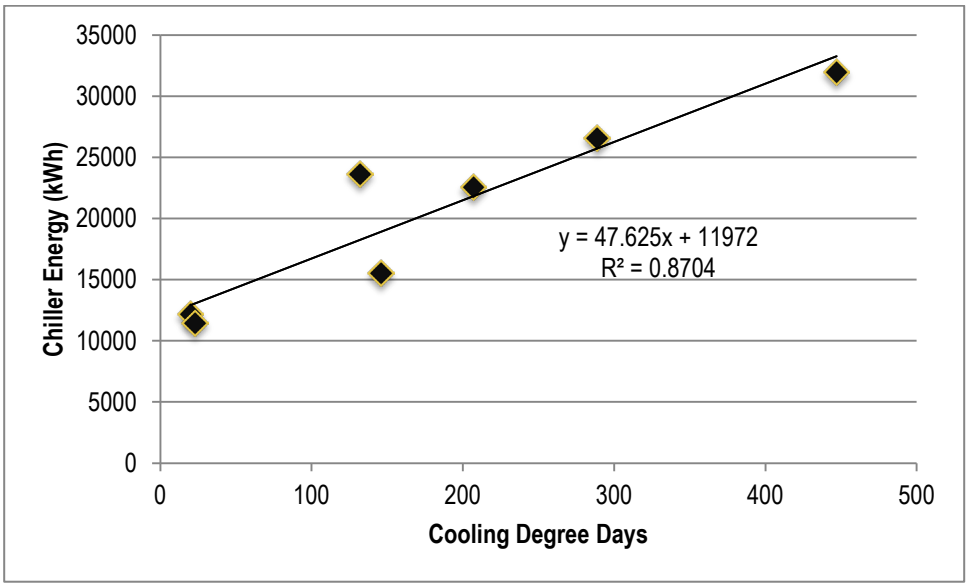
Source: Customer utility bills

As shown in Table C-97, the estimated annual chiller savings is 115,257 kWh.

Degree Day Analysis

The total cooling degree days (65 °F) for the 12 months prior to the retrofit is 1,539 degree days. The total for the 12 months following the retrofit is 1,294 degree days, which represents a reduction of 15.9 percent. Figure C-31 shows the correlation between cooling degree days and chiller energy consumption.

Figure C-31. Post-Retrofit Chiller Energy vs. Cooling Degree Days



Source: Navigant analysis

As shown in Figure C-31, the slope of the correlation curve is 47.625 kWh per cooling degree days. Since there were 245 fewer degree days during the 12 months following the retrofit, the corresponding energy reduction is 11,662 kWh.

Verified Chiller Savings

The estimated annual chiller savings shown in Table C-97 is 115,257 kWh. Adjusting for the cooler weather during the post-retrofit period results in a verified chiller savings of 103,595 kWh.

Fan Energy Savings

In addition to the chiller energy savings, the new building automation system also results in air handler fan energy savings. The operating schedule for the buildings is from 5:30 AM until 10:30 PM, five days per week. Therefore, the air handlers are programmed to operate 85 hours per week. Based on this schedule, the total annual shutdown hours (including 14 holidays) is 4,486 hours per year.

Both chillers and the two major air handling units (in the Student Services Building) were sub-metered, and the results are shown in Table C-98.

Table C-98. Annual Savings from Fan Shutdown

Building	AHU Fan Power (kW)	Fan "Shutdown" (Hours/Year)	Fan Annual Savings (kWh)
Student Services Building	11*	4,831	53,141
Learning Resources Building	22	4,496	98,912

*Note that the fan kW takes into account that new VFD drives were installed on these fans as part of the retrofit project. The Fan "Shutdown" column includes 14 days of holiday shutdown.

Source: Navigant sub-metering

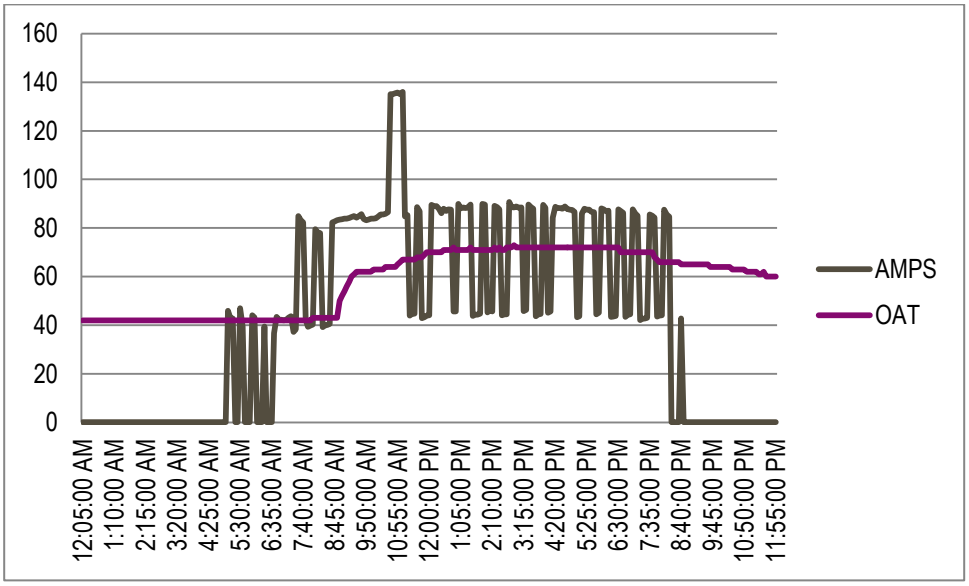
As shown in Table C-98, the verified annual savings that results from shutting down the air handler fans when the building is unoccupied is 152,053 kWh. It should also be noted that the HVAC system in the Learning Resources Center is shut down 335 hours less than the system in the Student Services Building.

In summary, the verified annual savings is the sum of the chiller savings (103,595 kWh) and the fan energy savings (152,053 kWh) for a total of 255,648 kWh.

C.9.8.3 Outside Air Economizer Operation

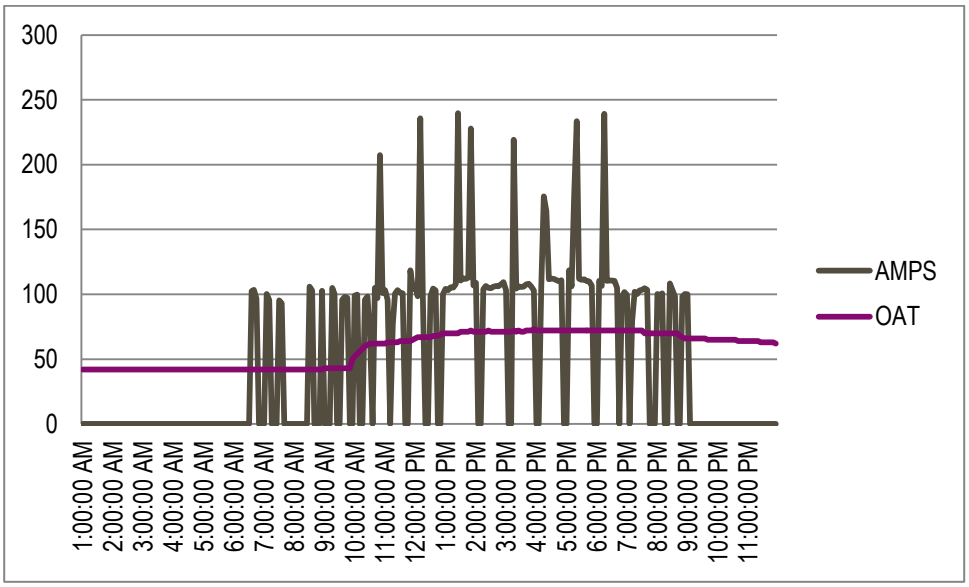
One of the major retrofit items was to repair outside air-economizer controls on the air handler. According to the facilities manager, the chillers should not be operating when the outside air temperature is below 55 °F. Figure C-32 and Figure C-33 show outside air temperature versus chiller amps.

Figure C-32. Outside Air Economizer Operation – Student Services Building



Source: Navigant sub-metering

Figure C-33. Outside Air Economizer Operation – Learning Resource Center



Source: Navigant sub-metering

As shown in Figure C-32 and Figure C-33, the chillers operated for several hours while the outside air temperature was below 55 °F. Navigant conducted a site visit on the morning of September 27, 2012, when the outside air temperature was below 55 °F and observed that both chillers were in operation. Both hydronic boilers were also in operation. When asked why the chillers and boilers were operating simultaneously, the facilities manager stated that they were trying to control humidity.

C.9.8.4 Load Tracking

The correlation coefficient (R^2) shown in Figure C-31 is 0.87, which indicates a strong correlation between chiller energy and cooling degree days.

C.9.9 Conclusions

Navigant's analysis shows that this retrofit have been very effective. However, our sub-metering indicates that additional adjustment of the controls could result in additional energy savings. The following conclusions can be drawn from the sub-metered data and from the subsequent analyses:

1. The retrofit of the HVAC controls at the Student Services Building and the Learning Resources Center resulted in a 62 percent reduction in annual chiller energy usage and a 48 percent reduction in air handler fan energy usage. The HVAC system in the Student Services Building is being shut down when the building is unoccupied. However, the Learning Resources Center operates an additional 335 hours each year than are scheduled. The control system in the Learning Resources Center should be inspected to determine the cause of these additional operating hours.

2. The outside air economizer controls do not appear to be adjusted properly because both chillers were observed to operate when the outside air temperature was 55 °F and below.

3. The realization rate for this project is 202 percent because the fan energy savings was not included in the customer's savings calculations.

4. There are no summertime demand savings because the chillers continue to operate a maximum capacity during hot weather. Wintertime demand savings could be achieved if the operation of the outside air economizers was corrected.

C.10 Site ID 24460

Site ID	24460
Sampling Stratum	Custom—Medium Savings
Rebate Number	EEB-11-02113
Building or Site Type	Parking Garage

C.10.1 Project Summary

The project involves replacing 91, 190-W, high-pressure sodium (HPS) fixtures with 91, 66-W, T-8 fixtures and controlling 66 of the new fixtures by a photocell. A summary of reported and verified savings associated with the project appears in Table C-99.

Table C-99. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace parking garage HPS lighting with T-8s	Reported	121,644 kWh	12.5 kW	$9,731
	Verified	121,066 kWh	12.5 kW	N/A
	Realization Rate	99.5%	100%	N/A

Source: EEB database and Navigant analysis

C.10.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager and electrical contractor
  - Inspect the new fixtures and the photocell control system
  - Install data logger on appropriate electrical circuits
- Retrieve data loggers

- Analyze data
» Prepare preliminary report, which the Navigant Project Manager reviews
» Submit final report

C.10.3 Description of Baseline

The baseline consisted of 91, 150-W HPS (190-watt including ballast) parking garage fixtures that operated continuously.

C.10.4 Description of As-Built Equipment and Operation

The as-built lighting system consists of 91, 53-W, 2-lamp, vapor-tight, T-8 fixtures. Twenty-five fixtures operate continuously, and 66 fixtures are controlled by a single photocell. The photocell is located on the north exposure of the ground floor of the three-story parking structure. There are trees and shrubbery adjacent to the north exposure of the garage. As these plants grow, their leaves could interfere with the photocell that controls the perimeter lighting.

C.10.5 Applicant Energy Savings Algorithm

Table C-100 shows the pre-retrofit and post-retrofit annual energy use calculations.

Table C-100. Customer's Lighting Calculations

	Pre-Retrofit Baseline	Post-Retrofit (Uncontrolled)	Post-Retrofit (Controlled)
Number of Fixtures	91	25	66
Fixture Watts	190	53	53
Hours per Day	24	24	14
Days per Week	7	7	7
Weeks per Year	52	52	52
Annual Energy (kWh)	151,045	11,575	17,826

Source: Customer application

As shown in Table C-100, the projected annual energy use is 29,401 kWh, for a savings of 121,644 kWh. The electrical demand for the baseline is 17.3 kW, while the demand for the post-retrofit system is 4.8 kW, for a demand savings of 12.5 kW.

C.10.6 Uncertainties

The customer's calculations assume that the photocell-controlled lights operate an average of 14 hours per day. The main uncertainty for this project is whether that assumption is correct. The other uncertainty is whether the photocell controller operates in a consistent manner, given its mounting location.

C.10.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. It is stipulated that the baseline annual energy use is 151,045 kWh and that the baseline demand is 17.3 kW.

Navigant collected post-retrofit energy data for a period of four weeks. The verified annual energy savings and the demand reduction are calculated by comparing the four-week results to those of the baseline.

Table C-101 lists the monitoring equipment that Navigant used for the data collection.

Table C-101. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model
Volt Meter	Extech Multi-Meter

Source: Navigant analysis

There are three lighting circuits that the photocell does not control. A data logger and three current transformers were installed on these circuits. The photocell controls three additional lighting circuits , and a second data logger and three current transformers were installed on these circuits.

C.10.8 Verified Energy Savings

Table C-102 shows the connected electrical loads as presented in the customer's application and the measured connected load data from the data logger results.

Table C-102. Lighting Connected Loads

	Not Controlled (watts)	Controlled (watts)	Total (watts)
Customer Application	1,325	3,498	4,823
Navigant Monitoring	1,100	3,723	4,823

Source: Customer application and Navigant monitoring

As shown in Table C-102, the data indicate that the actual installation has fewer fixtures that operate continuously and more fixtures that the photocell controls. The total installed wattage is consistent with the customer's application.

The assumption included in the customer's application is that the controlled lights will operate an average of 14 hours per day, which is adjusted to 15 hours per day during the month of October. The four weeks of monitoring data that Navigant obtained during the month of October indicate that the controlled lights operated 67.2 percent of the time, or 16.1 hours per day. The monitored results indicate that the controlled lights operate 7.3 percent more than projected.

Table C-103 shows the baseline and the verified results.

Table C-103. Verified Lighting Calculations

	Pre-retrofit Baseline	Monitored (Uncontrolled)	Monitored (Controlled)
Number of Fixtures	91	21	70
Fixture Watts	190	53	53
Hours per Day	24	24	15
Days per Week	7	7	7
Weeks per Year	52	52	52
Annual Energy (kWh)	151,045	9,723	20,256

Source: Customer application and Navigant monitoring

As indicated in Table C-103, the monitored post-retrofit annual energy use is 29,979 kWh, for a savings of 121,066 kWh. The monitored savings is 99.5 percent of the projected savings. The demand savings is 12.5 kW, which is 100 percent of the projected value.

C.10.8.1 Photocell Operation

Table C-104 shows the "on" and "off" times for the controlled lights during the first week of monitoring. Note that sunrise is 7:13 AM, and sunset is 6:52 PM.

Table C-104. Lighting Operation-Week One

Date	9/29/2012	9/30/2012	10/1/2012	10/2/2012	10/3/2012	10/4/2012	10/5/2012
"Off" Time	9:13 AM	8:13 AM	9:33 AM	7:48 AM	8:43 AM	9:13 AM	8:53 AM
"On" Time	5:30 PM	6:40 PM	6:28 PM	5:48 PM	6:33 PM	6:38 PM	6:38 PM
Weather	Rain	Rain	Rain	Rain	Clear	Rain	Rain

Source: Navigant monitoring

As shown in Table C-104, the time of day when the lighting switched "off" in the morning was erratic, varying from a minimum of 35 minutes after sunrise to a maximum of 2 hours and 20 minutes after sunrise. The time of day when the lights switched back "on" was less erratic, but it also varied by more than 1 hour and 10 minutes.

Table C-105 shows the "on" and "off" times for the controlled lights during the last week of monitoring. Note that sunrise is 7:33 AM, and sunset is 6:24 PM.

Table C-105. Lighting Operation-Week Four

Date	10/21/2012	10/22/2012	10/23/2012	10/24/2012	10/25/2012	10/26/2012	10/27/2012
"Off " time	1:18 PM	12:03 PM	11:23 AM	10:58 AM	11:03 AM	9:38 AM	9:13 AM
"On" Time	6:03 PM	6:03 PM	5:58 PM	6:03 PM	6:13 PM	5:58 PM	5:38 PM
Weather	Clear	Fog	Clear	Clear	Clear	Fog	Clear

Source: Navigant monitoring

As shown in Table C-105, the time of the day when the lighting switched "off" changed significantly. The worst case was October 21, when the lights stayed "on" until 1:18 PM, which is more than five hours after sunrise (on a clear day). In contrast, the time of day when the lights switched back "on" was consistently 20 to 30 minutes before sunset.

C.10.9 Conclusions

The following conclusions result from the above analyses:

1. The project realized 99.5 percent of the projected annual energy savings and 100 percent of the demand savings.

2. The erratic operation of the photocell lighting controller indicates that its location is not optimal, and the lights appear to stay "on" approximately one more hour per day than is necessary. An extreme example is on October 21, when the lights stayed "on" until 1:18 PM, which is more than five hours after sunrise (on a clear day). As the trees on the north side of the garage grow, their leaves may block the sunlight, which could affect the operation of the photocell even more.

3. The data indicate that the installation contractor changed four fixtures from the "continuous" group of lights to the "switched" group. Had this change not been made, the realization rate would have been lower.

C.11 Site ID 23570

Site ID	23570
Sampling Stratum	Custom—Medium Savings
Rebate Number	EEB-11-02027
Building or Site Type	Warehouse

C.11.1 Project Summary

This project involves replacing lamps in 481 six-lamp fixtures, which reduces the fixture wattage from 351 W per fixture to 306 W per fixture. Table C-106 provides a summary of the project's reported and verified energy and demand savings.

Table C-106.Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace lamps in 481, 6-lamp fixtures	Reported	108,225 kWh	22.0 kW	$8,658*
	Verified	93,480 kWh	22.0 kW	
	Realization Rate	86%	100%	N/A

* Custom only

Source: EEB database and Navigant analysis

C.11.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview facilities manager
  - Install data loggers on various lighting circuits
- Retrieve data loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.11.3 Description of Baseline

The lighting layout for this warehouse facility consisted of 481 six-lamp fluorescent fixtures. The baseline wattage per fixture was 351 W. The lighting operated an estimated 5,000 hours per year, which made this project a custom project as opposed to a prescriptive application.

C.11.4 Description of As-Built Equipment and Operation

The project involves replacing the fluorescent tubes in all of the fixtures with lower wattage tubes, which reduces the fixture wattage from 351 W to 306 W per fixture.

C.11.5 Applicant Energy Savings Algorithm

The applicant savings algorithm is shown in Table C-107.

Table C-107. Customer's Lighting Calculations

Fixtures	Watts	Qty	Ann. Hrs.	kWh	kW
351 Watt Fixtures	351	481	5,000	844,155	168.8
306 Watt Fixtures	306	481	5,000	735,930	147.2
Total				108,225	21.6

Source: Customer's application file

C.11.6 Uncertainties

The warehouse consists of several different areas, and it is unclear that the lighting in all areas operates 5,000 hours per year. In addition, approximately 10 percent of the 481 fixtures are emergency lights that operate continuously. Finally, this project includes a prescriptive component that includes the installation of occupancy sensors on 154 fixtures. Therefore, the baseline energy use will be revised to include the impact of the occupancy sensors. The average operating hours of the lights in this warehouse will be confirmed.

C.11.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. It is specified that the wattage reduction is from 351 W per fixture to 306 W per fixture. Navigant monitored the operating hours of the lighting in various areas of the building for a period of six weeks. These data were analyzed in order to determine the average annual operating hours for the entire building. The result will be used to verify the annual energy savings.

The building has three electrical panels. One panel is the emergency panel that contains the emergency circuits for lighting and for a conveyor. The second panel contains only lighting, while the third panel contains both lighting and non-lighting loads. Navigant's monitoring strategies for these panel designations are shown in Table C-108.

Table C-108. Monitoring Plan

Panel Designation	Monitoring Strategy
Emergency Panel	3 panel feeders and one phase of the 3-phase conveyor circuit
Lighting Panel #1	Phase A and Phase C of the panel feeders
Lighting Panel #2	4 lighting circuits – each from a different area of the building. This panel includes non-lighting loads.

Source: Navigant analysis

Table C-109 lists the monitoring equipment that Navigant used for the data collection.

Table C-109. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO current meter, model U12-006; Current Transformer model CTV
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.11.8 Verified Energy Savings

The results from the data-collection task indicate that there are four categories of lighting in this building. The lighting categories include emergency lighting, emergency lighting with occupancy sensors, general lighting, and general lighting with occupancy sensors.

C.11.8.1 Emergency Lighting

The lighting fixtures powered from the emergency panel are not switched "off" at night or on the weekends. However, some fixtures had occupancy sensors installed so that they switch "off" at night when the areas are unoccupied. The data indicate that these fixtures are typically "off" from 1:00 AM until 5:15 AM during the weekdays, and they are "off" on the weekends. The light fixtures equipped with occupancy sensors typically operate 50 percent of the time.

Table C-110 shows the annual energy use calculations for these fixtures.

Table C-110. Post-Retrofit Emergency Lighting Annual Energy Consumption

Category	Description	No. of Fixtures	Total Load (kW)	Equivalent Load (kW)	Hours/ Week	Weekly Energy (kWh)	Annual Energy (kWh)
1	Emergency lighting w/occupancy sensors	52	15.9	7.95	98.75	785.1	40,823
2	Emergency lighting w/o occupancy sensors	69	21.1	21.1	168	3,544.8	184,329
Total		121	37	N/A	N/A	4,329.9	225,152

Source: Navigant metering

C.11.8.2 General Lighting

The general lighting consists of 360 fixtures, of which 102 fixtures are equipped with occupancy sensors. According to the data, these light fixtures are powered "on" for 19.75 hours each weekday. They are "off" on the weekends. The fixtures with occupancy sensors typically operate 50 percent of the time. Table C-111 shows the annual energy use calculation for general lighting.

Table C-111. Post-retrofit Lighting Annual Energy Consumption

Category	Description	No. of Fixtures	Total Load (kW)	Equivalent Load (kW)	Hours/ Week	Weekly Energy (kWh)	Annual Energy (kWh)
3	Non-Emergency lighting w/occupancy sensors	102	31.2	15.6	98.75	1,540	77,000
4	Non-emergency lighting w/o occupancy sensors	258	78.9	78.9	98.75	7,791	389,568
Total		360	110.1	N/A	N/A	8,576.1	466,568

Source: Navigant monitoring

C.11.8.3 Post-Retrofit Annual Energy Consumption

Based on the results presented in Table C-110 and Table C-111, the total post-retrofit annual lighting energy consumption is 691,720 kWh. The customer's post-retrofit energy use estimate (Table C-107) was 735,930 kWh, but that calculation did not include emergency lighting or the occupancy sensors.

C.11.8.4 Revised Baseline Calculation

As the customer's savings calculations did not include the different operating hours of the emergency lighting or the installation of the occupancy sensors, the baseline calculation is being revised. Table C-112 shows the revised results.

Table C-112. Revised Pre-Retrofit Lighting Annual Energy Consumption

Category	Description	No. of Fixtures	Total Load (kW)	Equivalent Load (kW)	Hours/ Week	Weekly Energy (kWh)	Annual Energy (kWh)
1	Emergency lighting w/occupancy sensors	52	18.2	9.1	98.75	898	46,696
2	Emergency lighting w/o occupancy sensors	69	24.2	24.2	168	4,065	203,280
3	Non-Emergency lighting w/occupancy sensors	102	35.8	17.9	98.75	1,767	88,381
4	Non-emergency lighting w/o occupancy sensors	258	90.5	90.5	98.75	8,936	446,843
Total		481	168.7	N/A	N/A	15,666	785,200

Source: Navigant analysis

Based on the results shown in Table C-112, the revised pre-retrofit annual energy consumption is 785,200 kWh, which is lower than the customer's estimate of 844,155 kWh, which is shown in Table C-103. Table C-113 shows the verified annual energy and demand savings calculations.

Table C-113. Verified Annual Energy and Demand Savings

	Annual Energy Use (kWh)	Demand (kW)
Pre-retrofit	785,200	168.8
Post-retrofit	691,720	147.2
Savings	93,480	21.6

Source: Navigant analysis

As shown in Table C-113, the verified annual energy savings is 93,480 kWh, which results in a realization rate of 86 percent.

C.11.9 Conclusions

The following conclusions result from the above analyses:

1. This project included a prescriptive component (occupancy sensors) and a custom component (installing higher efficiency fluorescent tubes). Since the prescriptive component affects the custom realization rate, the custom calculations should have taken the effect of the occupancy sensors into account.

2. The custom calculations also neglected the fact that 121 lighting fixtures were emergency fixtures that are not switched "off" at night or on the weekends.

3. After the adjustments for the occupancy sensors and emergency lighting were taken into consideration, the annual energy realization rate for this project was calculated to be 86 percent. The demand Realization rate was 100 percent.

4. It is unusual that occupancy sensors were installed on some of the emergency lights. This action might have an impact on safe egress in case of an emergency.

C.12 Site ID 30680

Site ID	30680
Sampling Stratum	Custom—Low Savings
Rebate Number	EEB-12-02670
Building or Site Type	Retail

C.12.1 Project Summary

This project involves the replacement of 132, 90-W halogen display lighting fixtures with an equal number of 15-W LED fixtures. A summary of reported and verified energy and demand savings associated with the project appears in Table C-114.

Table C-114. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace halogen with LED	Reported	36,036 kWh	9.9 kW	$2,882.88
	Verified	46,036 kWh	9.9 kW	
	Realization Rate	127%	100%	N/A

Source: EEB database and Navigant analysis

C.12.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview store manager
  - Install lighting loggers
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.12.3 Description of Baseline

The display lighting layout for this store consisted of 132, 90-W halogen fixtures. The manually switched lighting operated an estimated 3,640 hours per year.

C.12.4 Description of As-Built Equipment and Operation

The post-retrofit display lighting layout for this store consists of 132, 15-W LED fixtures.

C.12.5 Applicant Energy Savings Algorithm

The applicant's energy and demand savings calculations are shown in Table C-115.

Table C-115. Lighting Calculations—Pre-Retrofit

Fixtures	Fixture Watts	Quantity	Annual Hours	Annual Energy kWh	Demand kW
90 W Halogen	90	132	3,640	42,952	11.8
15 Watt LED	15	132	3,640	6,916	1.9
Total				36,036	9.9

Source: Customer's application

C.12.6 Uncertainties

The uncertainty associated with this project is the annual operating hours of the display lighting.

C.12.7 On-Site Energy Monitoring

The IPMVP option adopted for this project is M&V Option B – Retrofit Isolation. It is specified that the wattage reduction is from 90 watts per fixture to 15 watts per fixture. Navigant monitored the operating hours of the lighting in two areas of the building for a period of four weeks. These data were analyzed in order to determine the average annual operating hours for the display lighting. The result will be used to verify the annual energy savings. The monitoring equipment that Navigant used is described in Table C-116.

Table C-116. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO U12-012: Temperature, Humidity, Light Level
Volt Meter	ExTech Model 6052 Multi-meter

Source: Navigant analysis

C.12.8 Verified Energy Savings

Based on four weeks of data collection for the display lighting, the average weekly hours of operation was 90.2 hours per week, or 4,690 hours per year. As the store is closed 40 hours per year for holidays, the net annual hours of operation is 4,650 hours. This number is used in Table C-117 to calculate the verified savings.

Table C-117. Verified Lighting Calculations—Post-Retrofit

Fixtures	Fixture Watts	Quantity	Ann. Hrs.	Ann. Energy kWh	Demand kW
90 Watt Halogen	90	132	4,650	54,870	11.8
15 Watt LED	15	132	4,650	8,836	1.9
Total				46,036	9.9

Source: Navigant analysis

As shown in Table C-117, the verified energy savings is 10,000 kWh higher than the customer's projection. The reason for this increase is that the display lights were "on" 1,010 hours per year more than the customer's application indicated.

C.12.9 Conclusions

The realization rate for this project has been verified to be 127 percent of the annual energy savings and 100 percent of the demand savings. The reason the energy savings exceeded the customer's projection is the hours of operation were 27 percent higher.

C.13 Site ID 31010

Site ID	31010
Sampling Stratum	Custom—Low Savings
Rebate Number	EEB-12-02373
Building or Site Type	Retail/Service

C.13.1 Project Summary

The project involves the replacement of 22, 320-W MH canopy lights with 150-W induction lamps. A summary of reported and verified energy and demand savings appears in Table C-118.

Table C-118. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace M-H lighting with induction lamps	Reported	18,058 kWh	5 kW	$1,444.64
	Verified	7,595 kWh	5 kW	
	Realization Rate	42%	100%	N/A

Source: EEB database and Navigant analysis

C.13.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with store manager
- Conduct site visit
  - Interview store manager
  - Monitor lighting times of operation
  - Analyze data
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.13.3 Description of Baseline

The baseline consisted of 22, 365-W (including ballast) MH canopy lights that reportedly operated 11 hours per day, 365 days per year.

C.13.4 Description of As-Built Equipment and Operation

The as-built condition consists of 22, 160-W (including ballast) induction canopy lights that reportedly operate 11 hours per day, 365 days per year. Figure C-34 shows the canopy lights.

Figure C-34. Canopy Lighting Fixtures

Source: Navigant photo

C.13.5 Applicant Energy Savings Algorithm

Table C-119 shows the energy and demand savings calculations.

Table C-119. Pre- and Post-Retrofit Lighting Calculations

Fixtures	Watts	Quantity	Annual Hours	kWh	kW
Watt MH	365	22	4,004	32,152	8.03
Induction	160	22	4,004	14,094	3.52
Savings				18,058	4.51

Source: Customer's application

C.13.6 Uncertainties

The only uncertainty associated with this project is the annual hours of operation of the canopy lights.

C.13.7 On-Site Energy Monitoring

According to the store manager, the store operates 365 days per year, from 6 AM until 11 PM. The canopy lights are turned "on" manually at 6 AM and turned "off" shortly after the sun comes up. The lights are turned "on" at sunset, and turned "off" when the store closes at 11 PM. A light logger was installed to monitor the "on-off" switching times. Navigant also made two site visits just after sunrise and just before sunset.

Based on this data collection, Navigant confirmed that the canopy lights are turned "on" at 6:00 AM and that they are turned "off" approximately one hour after sunrise. In the evening, the lights are turned "on" approximately 30 minutes before sunset and are turned "off" at 11:00 PM, when the store closes. The new induction bulbs produce 12,000 lumens, whereas the output of the MH bulbs is estimated to be 22,000 lumens. The lighting level that the new induction lights produces is approximately 10 foot-candles at 6 feet above the ground.

Table C-120 shows the equipment that Navigant used to verify that the lights were turned "on" at 6:00 AM and turned "off" at 11:00 PM.

Table C-120. Monitoring Equipment

Equipment	Equipment Description
Energy Sub-Meter	Onset Computer Corporation HOBO Datalogger model U12-12. Temperature/RH/Light Logger

Source: Navigant analysis

C.13.8 Verified Energy Savings

Based on the data collected on-site, the canopy lights operate less than the 11 hours per day claimed in the customer's application. Table C-121 shows the verified number of hours per year the canopy lights are operated. These results are based on the interview with the store manager and the data collected on-site.

Table C-121. Canopy Lights – Annual Operating Hours

Month	AM Hours	PM Hours	Hours/Day	Hours/Month
Jan	2.6	5.7	8.3	250
Feb	2.2	3.2	5.4	145
Mar	2.5	3.8	6.3	196
Apr	1.8	3.4	5.2	156
May	1.4	3.0	4.3	133
Jun	1.3	2.7	4.0	119
Jul	1.5	2.8	4.3	133
Aug	1.9	3.3	5.2	161
Sep	2.3	4.0	6.3	190
Oct	2.7	4.7	7.4	230
Nov	2.2	6.2	8.4	251
Dec	2.6	6.2	8.8	272
			Annual Total	2236

Source: Navigant analysis

As shown in Table C-121, under normal operating conditions the annual operating hours of the lighting is 2,236 hours per year. However, as the lights are manually switched, and as there probably are times when the store is busy, it is reasonable to expect that the lights may occasionally be left "on" longer than expected. Therefore, a 25 percent increase in annual lighting hours is used in the verified savings calculations shown in Table C-122.

Table C-122. Verified Demand and Energy Savings Calculations

Fixtures	Watts	Qty	Ann. Hrs.	kWh	kW
Watt MH	365	22	2,795	22,443	8.03
Induction	160	22	2,795	9,838	3.52
Savings				7,595	4.51

Source: Navigant analysis

C.13.9 Conclusions

The following conclusions result from the above analyses:

1. The customer's savings calculations assumed the canopy lights operated 11 hours per day, 365 days per year. Based on the data collected on-site, the lights operate 8.8 hours per day during the winter and 4.0 hours per day during summer.

2. The realization rate for annual energy savings for this project is 42 percent. The reason that the realization rate is so low is that the customer used an inaccurate number of annual operating hours for the canopy lights in their calculations. The realization rate for demand savings is 100 percent.

C.14 Site D 300130

Site ID	300130
Sampling Stratum	Custom—Low Savings
Rebate Number	EEB-12-02857
Building or Site Type	Retail/Service

C.14.1 Project Summary

This project involves the replacement of T-12 fluorescent tubes with LEDs in refrigerated display cases. A summary of reported and verified energy and demand savings associated with the project appears in Table C-123.

Table C-123. Summary of Reported and Verified Savings (Custom Only)

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace T-12s with LED	Reported	9,374 kWh	1 kW	$5,249
	Verified	10,949 kWh	1.25 kW	
	Realization Rate	117%	125%	N/A

Source: EEB database and Navigant analysis

C.14.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview on-site manager
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.14.3 Description of Baseline

The baseline consisted of soft drink refrigerated cases (ten doors), which were lighted by 11 F72 T-12 HO lamps. There was also a walk-in cooler for beer that had a glass door and a display window in each side of the door. The beer cooler was lighted by two F72 T-12 HO fluorescent tubes.

C.14.4 Description of As-Built Equipment and Operation

The post-retrofit soft drink lighting consists of 11, 29-W, LED tubes. The beer cooler includes two LED tubes.

C.14.5 Applicant Energy Savings Algorithm

The applicant's energy and demand savings calculations are shown in Table C-124.

Table C-124. Applicant's Savings Calculations

PRE-RETROFIT LIGHTING						POST-RETROFIT LIGHTING				
Description	Wattage	Number	Hours	kWh		Description	Wattage	Number	Hours	kWh
Soft Drink	110	11	8763	10,555		LED	29	11	8,763	2,795
Beer	110	2	8763	1,928		LED	19	2	8,763	333
Pre-Retroift	kW	1.4245	kWh	12,483						
Post-Retrofit	kW	0.357	kWh	3128						
Annual Savings	kW	1.0675	kWh	9,374						

Source: Customer's application

C.14.6 Uncertainties

The one uncertainty for this project is the number of tubes replaced and their annual hours of operation.

C.14.7 On-Site Energy Monitoring

Both the corporate contact and the on-site manager confirmed that the facility operated 8,763 hours per year and that the lighting in the display cases remained "on" at all times. Therefore, on-site monitoring was not conducted. During the on-site visit, Navigant confirmed that the walk-in beer cooler has four LED tubes, rather than two.

C.14.8 Verified Energy Savings

Table C-125 shows the verified energy calculations. The only difference between the applicant's calculations and the verified calculations is the addition of two LED tubes to the beer cooler.

Table C-125. Verified Energy Calculations

PRE-RETROFIT LIGHTING						POST-RETROFIT LIGHTING				
Description	Wattage	Number	Hours	kWh		Description	Wattage	Number	Hours	kWh
Soft Drink	110	11	8763	10,555		LED	29	11	8,763	2,795
Beer	110	4	8763	3,856		LED	19	4	8,763	666
Pre-Retroift	kW	1.6445	kWh	14,411						
Post-Retrofit	kW	0.395	kWh	3461						
Annual Savings	kW	1.2495	kWh	10,949						

Source: Navigant analysis

C.14.9 Conclusions

This has been a successful project. The realization rate for this project for energy savings has been verified to be 117 percent, while the Realization rate for demand savings is 125 percent.

C.15 Site ID 30000

Site ID	30000
Sampling Stratum	Custom—Low Savings
Rebate Number	EEB-10-00586
Building or Site Type	Retail

C.15.1 Project Summary

This project involves the replacement of 65 T-4 fixtures with 65 LED fixtures in a cosmetic case. A summary of reported and verified energy and demand savings associated with the project appears in Table C-126.

Table C-126. Summary of Reported and Verified Savings

Measure Description		Energy Savings	Demand Savings	Incentive Value
Replace T-4 lighting with LED	Reported	1,125 kWh	.22 kW	$90.00
	Verified	1,125 kWh	.22 kW	
	Realization Rate	100%	100%	N/A

Source: EEB database and Navigant analysis

C.15.2 Verification Approach

The M&V approach for this project involved the following steps:

- Review project files
  - Review energy savings calculations
- Conduct phone interview with corporate contact
- Conduct site visit
  - Interview store manager
  - Inspect the cosmetic case lighting
- Prepare preliminary report, which the Navigant Project Manager reviews
- Submit final report

C.15.3 Description of Baseline

The lighting layout for the cosmetic case included 65 T-4 fixtures (8-inch and 12-inch). The total power equaled 455 W. Annual hours of operation were 5,096 hours.

C.15.4 Description of As-Built Equipment and Operation

The post-retrofit layout included 37, 3-W LEDs and 28, 4.4-W LEDs for a total power of 234.2 W. Annual operating hours remained 5,096 hours.

C.15.5 Applicant Energy Savings Algorithm

The applicant's energy and demand savings calculations are shown in Table C-127.

Table C-127. Lighting Calculations—Pre-Retrofit

PRE-RETROFIT LIGHTING						POST-RETROFIT LIGHTING				
Description	Wattage	Number	Hours	kWh		Description	Wattage	Number	Hours	kWh
T4 lamps	7	65	5096	2,319		LED	3	37	5,096	566
						LED	4.4	28	5,096	628
Pre-Retroift	kW	0.455	kWh	2,319						1,193
Post-Retrofit	kW	0.2342	kWh	1193						
Annual Savings	kW	0.2208	kWh	1,125						

Source: Customer's application

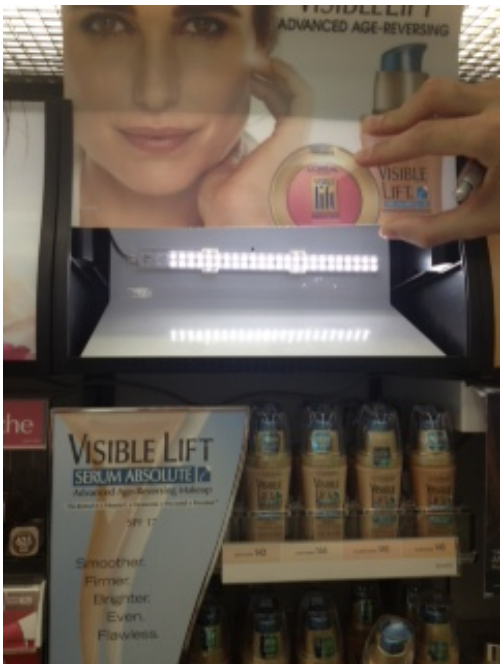
C.15.6 Uncertainties

The only uncertainties were the annual operating hours and whether the T-4 lamps had been replaced with the LED lamps.

C.15.7 On-Site Energy Monitoring

Navigant did not conduct on-site monitoring for this project. The replacement of the T-4 lighting fixtures was confirmed. Refer to Figure C-35. The annual operating hours were also confirmed with the store manager.

Figure C-35. LED Back-Lights in the Cosmetic Display



Source: Navigant photo

C.15.8 Verified Energy Savings

The verified annual energy savings and the demand savings are consistent with the calculations shown in Table C-127.

C.15.9 Conclusions

The realization rate for this project is verified at 100 percent.

Appendix D. Impact Analysis Methodology

Appendix C described the impact analysis methodology for each custom site. The following sections describe the impact analysis methodology for the prescriptive lighting sites.

D.1 Impact Analysis of Prescriptive Lighting Measures

The EM&V team employed the following steps to conduct the impact analysis for the prescriptive lighting measures:

1. The team first determined the ISR of the equipment for each measure found on-site. The field technicians accomplished this by visually verifying and counting all lighting equipment included in the incentive at each site.

2. The team then calculated the difference in watts between the base-case fixtures and the energy efficient fixtures for each fixture type installed on-site. The efficient fixture wattage was verified on-site through visual inspection. Base-case fixture wattage was derived from customer-provided data found in the documentation review, if available, or from information found by field technicians during the site visits. It should be noted that there is typically little to no information about the specifications of base-case equipment that has been removed from a site. If both customer data and field data were insufficient, the team utilized similar baseline fixtures verified as part of the PY 2012 evaluation.

3. Operating hours and CFs were then calculated from the logged data.

4. Finally, the evaluation team calculated site-level energy and demand savings for each site in the sample.

Algorithms and Parameters

Navigant utilized data collected from the field and the engineering review to calculate site-level energy and demand savings, using the following algorithms. Table D-1 shows the algorithms that the EM&V team used to calculate verified savings for lighting measures. The evaluation effort is focused on verifying the inputs for these algorithms.

Table D-1. Verified Savings Algorithms for Lighting Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
T5/T8, Fixture/Fluorescent Lamp Only & High-Performance T5/T8	kWh_Verified = Fixture_Qty_Verified x Hours x Verified_Watts_Reduced x IF_Energy	kW_Verified = Fixture_Qty_Verified x CF x Verified_Watts_Reduced x IF_Demand
All Other Lighting Measures	kWh_Verified = ISR x kWh_Reported	kW_Verified = ISR x kW_Reported

Where:
ISR = In-Service Rate
Fixture_Quantity_Verified = quantity of equipment verified on site
Hours = Verified (metered) operating hours
CF = Coincidence factor
IF_Energy = HVAC Interaction factor for energy savings calculations
IF_Demand = Interaction factor for demand savings calculations
Verified Watts Reduced = Watts of baseline equipment - Watts of energy-efficient equipment
Source: Navigant analysis

The detailed description of each parameter and any related assumption is as follows:

Fixture Quantity Verified

The gross quantity and type of lighting equipment installed through the program was gathered by counting fixtures on-site.

In-Service Rate (ISR)

The EM&V team calculated the ISR as the ratio between the findings from the on-site verification compared to the quantity reported in the program-tracking databases. On-site verifications determined the total number of installed measure-level equipment.

Watts

The team calculated base and efficient watts on a measure level. Efficient nameplate wattages were determined using manufacturer specifications based on fixture-level data collected on-site. Field technicians also assigned each fixture to a measure and tallied the total number of fixtures metered on-site. The project files and reduced watts calculations determined base wattages . In the cases where efficient fixture data were unavailable, due to inaccessible fixtures, customer project file measure-level averages were used for both the base and efficient wattages.

Interaction Factor (IF)
IFs are the HVAC system interaction factors for peak demand and annual energy consumption. Reductions in lighting energy generally increase a building's heating requirements (load) and decrease cooling requirements. The IF accounts for these secondary effects on the HVAC system energy use and acts as a multiplier in the energy savings algorithms. The EM&V team applied IFs sourced from a 2011 Navigant study (including over 120 buildings) in Maryland that used building energy models of field-verified building characteristics (i.e., HVAC, lighting, and envelope) and actual billing data to assess the interactive effects of lighting energy reductions on HVAC system energy use. The resulting interaction factors are specific to both building type (e.g., office, warehouse) and heating/cooling systems. See Appendix B for additional details.

Annual Operating Hours
Measure-level operating hours were calculated as the average of the extrapolated annual operating hours weighted by the fixture-level demand reduction of all logged fixtures installed as part of the same measure. The weighted metered operating hours were used as the base and efficient annual operating hours.

Coincidence Factor (CF)
CFs were calculated for the utility peak period using the extrapolated metered data.[10] Similar to the measure-level operating hours, the CFs were calculated as the average on-time during the designated peak period weighted by the fixture-level demand reduction of all logged fixtures installed as part of the same measure. The weighted metered CF values were used as the base and efficient CFs.

On-Site Data Collection

The EM&V team conducted on-site verification at 35 sites. At each site, the team installed time-of-use (TOU) lighting loggers in a representative sample of fixtures and deployed them from March 2013 to May 2013. While on-site, the team conducted customer interviews to collect data on building operation, HVAC system details, and seasonal and holiday schedules. Key evaluation parameters came primarily from on-site data; however, where these data were lacking or were deemed unusable, customer application data were used in its place. As there are many parameters inputs to the savings calculation for each site, this approach ensures that the *best available data* are used for each site's savings estimation.

On-Site Metering
For on-site metering, the evaluation team used IPMVP Option A (Partially Measured Retrofit Isolation/Stipulated Measurement) to determine annual energy and peak demand site-level savings. To meet Option A requirements, the following M&V activities were undertaken for each site in the sample:

» Metered the time of use for a representative number of retrofit lighting fixtures

[10] The summer utility peak period includes the time between 3:00 PM and 5:00 PM ET on Mondays through Thursdays during the months of June through August, excluding holidays. The winter peak period includes the time between 7:00 AM and 9:00 AM ET on Mondays through Thursdays during the months of December through February, excluding holidays.

- Performed on-site verification of in-service rates for all implemented measures
- Collected fixture details for all unique retrofit fixtures, including lamp and ballast make and model data
- Performed on-site customer interviews to collect data on building operation, HVAC system details, and seasonal and holiday schedules

During the field visits, the Navigant team collected information to determine the total number of switched circuits containing retrofit equipment on-site. A "switched circuit" refers to all lighting fixtures controlled by the same switch.

Field crews followed a thorough on-site protocol to determine which specific switched circuits and how many to meter. Field technicians first identified up to six activity areas for the site (see Table D-1 below for the full list of activity areas). Within each activity area, the field crew counted the total number of switched circuits. The protocol then required meters to be installed on separate switched circuits within each activity area, according to the following rules:

- At least one meter was to be installed in each activity area
- If any activity area had more than 25 percent of the rebated fixtures installed, then an additional meter was required in that area
- If any activity area had four or more switched circuits, then another meter was required for that area
- Additional meters could be installed within activity areas for reasons that the field crew documented

If the site contact objected to the field crews installing meters on any prescribed switched circuit, the field crew fully documented the reasons the site contact provided.

Figure D-1. Activity Area Table Used for On-Site Data Collection

AA Code	Activity Area Type Description	AA Code	Activity Area Type Description	AA Code	Activity Area Type Description
1	Auditorium/Gym	22	Guest Rooms (Hotel/Motel)	42	Religious Worship
2	Auto Repair Workshop	23	Kitchen/Break room & Food Prep.	43	Residential
3	Bank/Financial	24	Laboratory	44	Restrooms
4	Bar Cocktail Lounge	25	Laundry	45	Retail Sales/Showroom
5	Barber/Beauty Shop	26	Library	46	Smoking Lounge
6	Casino/Gaming	27	Loading Dock	47	Storage (Conditioned)
7	Classroom/Lecture	28	Lobby (Hotel)	48	Storage (Unconditioned)
8	Clean Room	29	Lobby (Main Entry and Assembly)	49	Storage (Refrigerated/Freezer), Walk-in
9	Computer Room/Data Processing	30	Lobby (Office Reception/Waiting)	50	Storage (Refrigerated/Freezer), Building
10	Comm/Ind Work (General High Bay)	31	Locker and Dressing Room	51	Surgery Rooms
11	Comm/Ind Work (General Low Bay)	32	Mall Arcade and Atrium	52	Theater (Motion Picture)
12	Comm/Ind Work (Precision)	33	Mechanical/Electrical Room	53	Theater (Performance)
13	Conference Room	34	Medical Offices and Exam Rooms	54	Unknown
14	Convention and Meeting Center	35	Office (Executive/Private)	55	Vacant (Conditioned)
15	Copy Room	36	Office (General)	56	Vacant (Unconditioned)
16	Corridor / Hallways	37	Office (Open Plan)	57	Vocational Areas
17	Courtrooms	38	Patient Rooms	**98**	**Non Rebated Area**
18	Dining Area	39	Patio Area	**99**	**Other Unlisted Activity Types**
19	Dry Cleaning	40	Pool/Spa Area		
20	Exercise Centers/Gymnasium	41	Police/Fire Station	**0**	**Outside/Outdoor Area**
21	Exhibit Display Area / Museum				

Source: Navigant analysis

Meter data was collected through two types of loggers, lighting and current state loggers. Lighting state loggers use a small photocell to determine whether a light is on or off, as determined by a user-defined light-level. Current state loggers use a current transducer to clamp around the live wire that feeds a lamp and use a user-defined current threshold to determine whether the light is on or off. Both Onset and Dent brand loggers were used.

Field Data Review

In PY 2012, Navigant utilized an electronic data collection system. Throughout the meter installation visits and meter retrieval visits, Navigant analysts uploaded all collected site data and logger files to the online system as soon as they were completed. Navigant performed quality control verifications for all field data collection forms and online data entry. This included a thorough inspection of each site's building characteristic inputs, operating schedules, measure-level in-service rates, and switched-circuit descriptions.

Meter Data Review and Cleaning

Meter data were collected on-site for approximately 1-2 months between March 2013 and May 2013. Navigant analysts reviewed all 256 logger files deployed across the sampled sites and designated each file as usable or unusable. Unusable logger files included loggers that had not been launched or loggers with improper sensitivity adjustments (which results in consistent flickering throughout the logged period).

The usable logger files were cleaned and analyzed using Statistical Analysis Software (SAS). First, all meter data were converted to percent "on" per hour. Then, all meter data outside of and including the installation and retrieval dates were removed. Finally, the logger files were plotted and visually inspected for reasonableness. Any logger filed deemed questionable at any point during this multi-step process was removed from the analysis.[11]

Extrapolation of Meter Data

Site-level data collected which reported normal business hours, holidays and seasonal schedules and were sent with the cleaned logger files to Navigant statisticians. The logger files were then extrapolated to provide percent on per hour data for 8760 hours. The EM&V team compared two extrapolation methods to determine the method with the lowest coefficient of variation (CV), or standard deviation divided by mean:

1. The average percent-"on"-per-hour when facility is open versus closed (from customer interview)
2. The average percent-"on"-per-hour for each hour of the day and day of the week

The second method was selected, as it resulted in a lower CV. Statisticians applied the average percent-"on"-per-hour for each hour of the day and day of the week to non-metered months to develop a full year profile (8,760 hours), accounting for customer-reported seasonal and holiday schedules.

[11] Ultimately, 7 logger files were deemed unusable.

D.1.1 Statistical Significance

The EM&V team determined the sampling precision for the field verification using a 90 percent confidence interval. Precision values were calculated using stratified ratio estimation, in which the stratum verification rate (i.e., the weighted average ratio between verified and reported savings for sample projects within a given stratum) is multiplied by the reported savings for each sampled project in the stratum to yield a set of predicted savings values for each sampled project.[12] The difference between each verified savings value and the same project's predicted value was then the basis for determining a variance for the stratum that was used for purposes of statistical precision calculations.

The confidence and precision of the energy and peak demand verification rates are 90/9 and 90/10, indicating a relative precision, respectively, of 9 percent for energy savings and 10 percent for peak demand savings at a 90 percent level of confidence. The verified gross and net savings, as well as relative precision for the energy and peak demand savings estimates are shown in Table D-2.

Table D-2. Statistical Significance of Verified Savings

	Annual Energy Savings (MWh)	Summer Coincident Peak Demand Savings (MW)	Winter Coincident Peak Demand Savings (MW)
	2012	2012	2012
Verified Gross Savings	48,493	12.7	10.7
Verified Net Savings	46,067	12.0	10.2
Relative Precision (%) at 90% Level of Confidence	9%	10%	6%

Source: Navigant analysis

[12] The evaluation team stratified the sample by reported savings. Ratio estimation refers to the method of assessing the statistical significance of reported savings. Rather than merely analyzing the verified savings values for each project in the sample, the evaluation analyzed the ratio of verified savings to reported savings, which generally reduces the variability of data across sampled sites, and thus lowers the coefficient of variation.

Appendix E. EEB Program Attribution

This appendix provides definitions, methods, and further detail on the analysis and findings of the net savings assessment. The discussion is divided into the following three sections:

1. Defining free ridership, spillover, and net-to-gross (NTG) ratio
2. Methods for estimating free ridership and spillover
3. Results for free ridership, spillover, and NTG ratio

E.1 Defining Free Ridership, Spillover, and Net-to-Gross Ratio

The methodology for assessing the energy savings attributable to a program is based on a NTG ratio. The NTG ratio has two main components: free ridership and spillover.

Free ridership is the share of the gross savings that is due to actions participants would have taken anyway (i.e., actions that the program did not induce). This is meant to account for naturally occurring adoption of energy efficiency measures. The EEB Program and most other DEP programs cover a wide range of energy efficiency measures and are designed to move the overall market for energy efficiency forward. However, it is likely that some participants would have wanted to install, for various reasons, some high efficiency measures (possibly a subset of those installed under the EEB Program), even if they had not participated in the program or been influenced by the program in any way.

Spillover captures program savings that go beyond the measures installed through the program. Also called "market effects," the term "spillover" is often used because it reflects savings that extend beyond the bounds of the program records. Spillover adds to a program's measured savings by incorporating indirect (i.e., non-incentivized) savings and effects that the program has had on the market above and beyond the directly incentivized or directly induced program measures.

Total spillover is a combination of non-reported actions to be taken at the project site itself (*within-facility spillover*) and at other sites (*outside-facility spillover*). Each type of spillover is meant to capture a different aspect of the energy savings caused by the program, but not included in program records. Since one goal of DEP's EEB program is to transform markets through a variety of strategies, including education, promotion, and increasing awareness of the benefits of energy efficiency, it is not surprising that spillover occurs in the market.

The overall NTG ratio accounts for both the net savings at participating projects and spillover savings that result from the program but are not included in the program's accounting of energy savings. When the NTG ratio is multiplied by the estimated gross program savings, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program).

The basic equation is shown in Equation E-1:

Equation E-1. Net-to-Gross Ratio

$$NTG = 1 - Free\ Ridership + Spillover$$

The underlying concept inherent in the application of the NTG formula is that *only* savings caused by the program should be included in the final net program savings estimate but that this estimate should include *all* savings caused by the program.

E.2 Methods for Estimating Free Ridership and Spillover

E.2.1 Estimating Free Ridership

Data to assess free ridership were gathered through the self-report method—a series of survey questions asked of EEB participants. Free ridership was asked in both direct questions, which aimed at obtaining respondent estimates of the appropriate free ridership rate that should be applied to them, and in supporting or influencing questions, which could be used to verify whether the direct responses are consistent with participants' views of the program's influence.

The direct free-ridership questions for participants were posed to each respondent for one measure that was reported to the program (e.g., lighting, HVAC, and motors). Respondents were asked three categories of program-influence questions:

- **Likelihood:** to estimate the likelihood that they would have incorporated measures "of the same high level of efficiency," if not for the assistance of the EEB Program. In cases where respondents indicated that they may have incorporated some, but not all, of the measures, they were asked to estimate the share of measures that would have been incorporated anyway at high efficiency. This flexibility in how respondents could conceptualize and convey their views on free ridership and allowed respondents to give their most informed response, thus improving the accuracy of the free-ridership estimates.
- **Prior planning:** to further estimate the probability that a participant would have implemented the measures without the program. Participants were asked the extent to which they had considered installing the energy-efficient measure prior to participating in the program. The general approach holds that if customers were not definitively planning to install all of the efficiency measures prior to participation, then the program can reasonably be credited with at least a portion of the energy savings resulting from the high-efficiency measures. Strong free ridership is reflected by those participants who indicated they had already allocated funds for the purchase and selected the equipment and an installer.
- **Program importance:** to clarify the role that program components (e.g., information, incentives) played in decision-making, and to provide supporting information on free ridership. Responses to these questions were analyzed for each respondent, not just in aggregate, and were used to identify whether the direct responses on free ridership were consistent with how each respondent rated the "influence" of the program.

Free-ridership scores were calculated for each of these categories[13] and then averaged and divided by 100 to convert the scores into a free-ridership percentage. Next, a timing multiplier was applied to the average of the three scores to reflect the fact that respondents indicating that their energy efficiency actions would not have occurred until far into the future may be overestimating their level of free ridership. Participants were asked, without the program, when they would have installed the equipment. Respondents who indicated that they would not have installed the equipment for at least two years were not considered free riders and had a timing multiplier of 0. If they would have installed at the same time as they did, they had a timing multiplier of 1; within one year, 0.67; and between one and two years, 0.33. Participants were also asked when they learned about the financial incentive; if they learned about it after the equipment was installed, then they had a timing multiplier of 1.

E.2.2 Estimating Spillover

The basic method for assessing participant spillover (both within-facility and outside-facility) was an approach that asked a set of questions to determine the following:

- **Whether spillover exists at all.** These were yes/no questions that asked, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records. Questions related to extra measures installed at the project site (within-facility spillover) and to measures installed in non-program projects (outside-facility spillover) within DEP territory.
- **The share of those savings that could be attributed to the influence of the program**. Participants were asked if they could estimate the energy savings from these additional extra measures to be less than, similar to, or more than the energy savings from the DEP program equipment.

[13] Scores were calculated by the following formulas:

- Likelihood: The likelihood score is 0 for those that "definitely would NOT have installed the same energy efficient measure" and 1 for those that "definitely WOULD have installed the same energy efficient measure." For those that "MAY HAVE installed the same energy efficient measure," the likelihood score is their answer to the following question: "On a scale of 0 to 10 where 0 is DEFINITELY WOULD NOT have installed and 10 is DEFINITELY WOULD have installed the same energy efficient measure, can you tell me the likelihood that you would have installed the same energy efficient measure?" If more than one measure was installed in the project, then this score was also multiplied by the respondent's answer to what share they would have done.
- Prior planning: If participants stated they had considered installing the measure prior to program participation, then the prior planning score is the average of their answers to the following two questions: "On a scale of 0 to 10, where 0 means you 'Had not yet planned for equipment and installation' and 10 means you 'Had identified and selected specific equipment and the contractor to install it', please tell me how far along your plans were" and "On a scale of 0 to 10, where 0 means 'Had not yet budgeted or considered payment' and 10 means 'Already had sufficient funds budgeted and approved for purchase', please tell me how far along your budget had been planned and approved."
- Program importance: This score was calculated by taking the maximum importance on a 0 to 10 scale of the four program importance questions and subtracting from 10 (i.e., the higher the program importance, the lower the influence on free ridership).

» **Program importance**. Estimates were derived from a question asking the program importance, on a 0 to10 scale. Participants were also asked how the program influenced their decisions to incorporate additional energy efficiency measures.

If respondents said no, they did not install additional measures, they had a zero score for spillover. If they said yes, then the individual's spillover was estimated as the self-reported savings as a share of project savings, multiplied by the program-influence score. Then, a 50 percent discount was applied to reflect uncertainty in the self-reported savings and divided by 10 to convert the score to a spillover percentage.

E.2.3 Combining Results Across Respondents

The evaluation team determined free ridership and spillover estimates for each of the following:

» Individual respondents, by evaluating the responses to the relevant questions and applying the rules-based approach discussed above
» Measure categories:
  - For free ridership: by taking the average of each respondent's score within each category
  - For spillover: by taking the sum of the individual spillover results for each measure category and weighting each category by the population
» The program as a whole, by combining measure-level results
  - For free ridership: measure category results were subsequently weighted by each category's share of total savings
  - For spillover: measure category results were summed and then weighted by the sum of the reported savings for the sample (which were also weighted by the population)

E.3 Results for Free Ridership, Spillover, and Net-to-Gross

This section presents the results of the attribution analysis, both by measure type and in aggregate for the EEB Program. Specifically, results are presented for free ridership and spillover (within-facility and outside-facility), which are used collectively to calculate a NTG ratio.

E.3.1 Review of Data Collection Efforts for Attribution Analysis

The EM&V team conducted surveys with EEB participants to estimate free ridership, spillover, and NTG ratios. Table E-1 shows the number of completions, by measure group, specific to the attribution data gathered.

Table E-1. Attribution Survey Completes by Measure Type

Measure Category	Measures Included	Participant Surveys
Prescriptive Lighting-High	T5/T8 Fixture, Delamp, High- Performance T5/T8, CFL – Screw In, Occupancy Sensor, Fluorescent Lamp Only, Exit Sign	7
Prescriptive Lighting-Medium		30
Prescriptive Lighting-Low		44
Custom	Custom HVAC, Custom Motor and Drive, Custom Lighting, Custom Refrigeration and Custom Whole Building	50
Prescriptive Other	Prescriptive HVAC, Prescriptive Motors, Prescriptive Refrigeration	24
Total		155

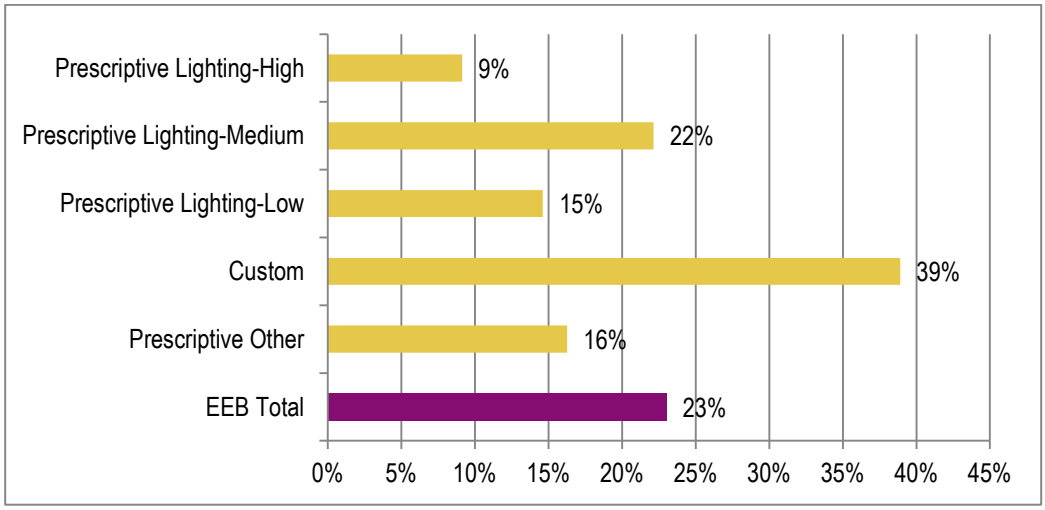
Source: Navigant analysis

E.3.2 Free-Ridership Results

The EM&V team asked participants a series of questions regarding the likelihood, scope, and timing of the investments in energy efficiency if the respondent had not participated in the program. The purpose of the surveys was to elicit explicit estimates of free ridership and perspectives on the influence of the program. Figure E-1 shows the free-ridership estimates for each measure category. The free-ridership scores range from 9 percent for the Lighting–High Savings stratum to a high of 39 percent for the custom stratum. The Prescriptive Other measures averaged 16 percent free ridership.

The EM&V team estimates free ridership for the EEB Program (i.e., across all measures) at 23 percent of program-reported savings, weighting the measure-specific free-ridership values according to each category's share of total savings. The weighted free ridership for the prescriptive lighting measure category is 16 percent, and lighting represents 70 percent of all program savings. Thus, these low free-ridership values drive program-wide free ridership more by than the higher free-ridership value (39 percent) for custom projects.

Figure E-1. : Free Ridership by Measure Category (n = 155)



Source: Navigant analysis

E.3.3 Spillover Results

The EEB Program influenced approximately 21 percent of participants to install additional energy efficiency measures on-site and influenced 14 percent to install additional measures at other locations. On average, respondents reported spillover savings to be approximately 54 percent of the savings from the program-incented project. The EM&V team discounted the reported impact of spillover by 50 percent to account for uncertainty in the self-reported energy savings. Based on the survey findings, the EM&V team estimates the overall program spillover to be 18 percent of program-reported savings.

E.3.4 Net-to-Gross Ratio

As stated in Section A.1.1.1E.1, the NTG ratio is defined as follows in Equation E-2:

Equation E-2. Net-to-Gross Ratio

$$NTG = 1 - \textit{free ridership} + \textit{spillover}$$

Using the overall free ridership value of 23 percent and the overall spillover value of 18 percent, the NTG ratio is 1 – 0.23 + 0.18 = 0.95. The estimated NTG ratio of 0.95 implies that for every 100 MWh of realized savings recorded in EEB records, 95 MWh is attributable to the program.