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# 2014 Nonresidential Downstream Deemed ESPI Lighting Impact Evaluation Report

## Prepared for California Public Utilities Commission

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# 1

# Executive Summary

This report documents the activities undertaken by the Nonresidential Downstream Lighting Impact Evaluation of the 2013-2014 investor-owned utilities' (IOU) energy efficiency programs.[1] The overall goal of this study is to perform an impact evaluation on specific nonresidential deemed lighting measures and/or measure-parameters that were identified in the Efficiency Savings and Performance Incentive (ESPI) decision.[2]

The objective of this study is to perform a measure and/or measure-parameter impact evaluation, utilizing existing evaluation data and new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for specific lighting measures identified in the ESPI decision. The parameters associated with deemed measure verification include measure installation/verification, unit energy savings, net-to-gross ratios (NTGRs), gross and net energy savings values, effective useful life (EUL), and impact load shapes. The ESPI decision lists, in Attachment 3, a number of deemed nonresidential measures that are subject to some level of ex post evaluation for the 2014 program year. Below is a list of the lighting measures that were identified in that decision:

- Screw-in CFLs
- T5 fluorescent lamps and fixtures replacing metal halides
- LED lighting (surface, pendant, track, accent and recess down lighting)
- Occupancy sensor lighting controls (integrated and wall/ceiling mount)
- Delamping of T12 lamps in existing fixtures

Rather than develop a full, comprehensive analysis for all measures, this evaluation focuses on evaluating specific parameters within the savings algorithms for some measures while implementing a more comprehensive analysis of others. For lighting measures that represent less than significant levels of claimed ex ante savings and have been evaluated throughout previous program cycles, existing data are relied on to estimate savings values.

[1] This report focuses on the ESPI measures that were identified for the 2014 program cycle.

[2] D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K775/76775903.PDF

In order to implement this approach in meeting the overall study goal, a number of research objectives have been targeted. The following tasks have been performed, either by leveraging existing data from past evaluation efforts or collecting new primary data from participant phone surveys and/or on-site verification analyses. A more thorough discussion of how these research objectives are applied to each of the studied measures and the algorithm by which they have been evaluated are discussed in Section 4, but to summarize:

- Confirm installations (verification). This included on-site verification of measure installation to confirm the installations reported by the PAs.
- Estimate baseline (both pre-retrofit and code/ISP based) and replacement (post-retrofit) equipment wattages, operating hours, and use shapes to support the estimate of energy savings values and 8,760 impact load shapes.
- Estimate participant free-ridership to support the development of net-to-gross ratios and net savings values.
- Estimate remaining useful life values for selected measures, and update effective useful life estimates based on ex post operating hours.
- Based on the above, estimate first year and lifetime gross and net ex post impacts (kWh, kW).

## 1.1 Overview of Analysis

Two distinct evaluation activities were performed, as summarized below.

***Gross Energy Savings Analysis.*** The primary objective of this activity was to develop gross and net unit energy savings values (UES) that can be applied to the participant population for the studied deemed lighting measures, such that population estimates of gross savings can be estimated for both first year and lifecycle savings. This involved updating various parameters, such as operating hours, baseline and installed wattages, installation rates, remaining useful life and effective useful life. These parameters, and ultimately the final UES values, were based on utilizing data from roughly 2,000 on-site audits and 7,500 lighting loggers that were collected as part of this evaluation and other relevant evaluations over the 2006-08 and 2010-12 program cycles.

***Net-To-Gross Analysis.*** The objective of this analysis was to develop NTGRs for the measures studied under this evaluation. The approach for estimating NTGRs was based on a self-report methodology utilizing survey phone responses from 1,700 participants. This methodology was based on the large non-residential free ridership approach developed by the NTGR Working Group and documented in Appendix C of that report, *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers*. The methodology estimated three separate measurements of free ridership from different inquiry routes and then averaged the values to derive the final free ridership estimate at the measure level.

Table 1-1 to Table 1-4 present the kWh and kW first year and lifecycle gross and net realization rates (GRRs and NRRs) along with the corresponding ex ante and ex post gross kW and kWh savings for the overall nonresidential deemed lighting population, by PA and ESPI measure.

**Table 1-1: 2014 First Year Gross kWh and kW Realization Rates by PA and Measure**

| PA<br>ESPI Measure | Ex Ante Gross kWh Savings | Ex Post Gross kWh Savings | GRR kWh | Ex Ante Gross kW Savings | Ex Post Gross kW Savings | GRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 1,957,197 | 1,281,180 | **65%** | 354 | 248 | **70%** |
| Delamping | 8,677,833 | 6,449,361 | **74%** | 1,970 | 1,543 | **78%** |
| LED | 18,932,771 | 23,886,799 | **126%** | 3,779 | 5,449 | **144%** |
| Occupancy Sensors | 5,234,301 | 3,743,447 | **72%** | 985 | 1,055 | **107%** |
| T5 | 11,720,599 | 12,423,521 | **106%** | 2,873 | 2,884 | **100%** |
| **SCE** | | | | | | |
| CFL | 384,040 | 315,649 | **82%** | 81 | 64 | **79%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 5,304,656 | 5,329,126 | **100%** | 1,222 | 1,251 | **102%** |
| T5 | 15,236,610 | 18,490,148 | **121%** | 3,956 | 4,175 | **106%** |
| **SDG&E** | | | | | | |
| CFL | 2,545,288 | 2,271,703 | **89%** | 501 | 469 | **94%** |
| Delamping | 1,029,499 | 1,029,499 | **100%** | 241 | 241 | **100%** |
| Occupancy Sensors | 1,949,708 | 780,211 | **40%** | 451 | 191 | **42%** |

## Table 1-2: 2014 Lifecycle Gross kWh and kW Realization Rates by PA and Measure

| PA<br>ESPI Measure | Ex Ante Gross kWh Savings | Ex Post Gross kWh Savings | GRR kWh | Ex Ante Gross kW Savings | Ex Post Gross kW Savings | GRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 5,958,759 | 5,873,220 | **99%** | 1,154.28 | 1,275.59 | **111%** |
| Delamping | 42,266,209 | 33,088,753 | **78%** | 9,644.54 | 8,017.45 | **83%** |
| LED | 118,790,594 | 208,025,334 | **175%** | 23,827.04 | 46,329.66 | **194%** |
| Occupancy Sensors | 41,874,409 | 29,947,575 | **72%** | 7,879.95 | 8,441.26 | **107%** |
| T5 | 175,324,695 | 157,213,574 | **90%** | 43,014.33 | 36,370.27 | **85%** |
| **SCE** | | | | | | |
| CFL | 1,110,345 | 1,372,893 | **124%** | 238.54 | 283.31 | **119%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 42,136,515 | 42,459,753 | **101%** | 9,708.40 | 9,976.94 | **103%** |
| T5 | 212,413,587 | 237,774,263 | **112%** | 55,357.47 | 53,717.73 | **97%** |
| **SDG&E** | | | | | | |
| CFL | 7,094,821 | 6,660,783 | **94%** | 1,405.57 | 1,391.35 | **99%** |
| Delamping | 14,927,526 | 14,927,526 | **100%** | 3,513.12 | 3,513.12 | **100%** |
| Occupancy Sensors | 15,235,200 | 6,114,321 | **40%** | 3,566.31 | 1,494.16 | **42%** |

### Table 1-3: 2014 First Year Net kWh and kW Realization Rates by PA and Measure

| PA<br>ESPI Measure | Ex Ante Net kWh Savings | Ex Post Net kWh Savings | NRR kWh | Ex Ante Net kW Savings | Ex Post Net kW Savings | NRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 1,412,023 | 850,770 | **60%** | 253 | 163 | **64%** |
| Delamping | 6,473,821 | 4,730,275 | **73%** | 1,452 | 1,128 | **78%** |
| LED | 13,879,652 | 13,658,199 | **98%** | 2,770 | 3,140 | **113%** |
| Occupancy Sensors | 3,248,333 | 2,257,142 | **69%** | 618 | 632 | **102%** |
| T5 | 9,142,154 | 7,465,809 | **82%** | 2,227 | 1,735 | **78%** |
| **SCE** | | | | | | |
| CFL | 257,188 | 197,008 | **77%** | 54 | 40 | **74%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 3,409,838 | 3,077,549 | **90%** | 788 | 720 | **91%** |
| T5 | 10,305,678 | 11,031,573 | **107%** | 2,689 | 2,504 | **93%** |
| **SDG&E** | | | | | | |
| CFL | 1,525,106 | 1,380,643 | **91%** | 300 | 286 | **95%** |
| Delamping | 625,284 | 625,730 | **100%** | 146 | 143 | **97%** |
| Occupancy Sensors | 1,190,783 | 443,704 | **37%** | 275 | 107 | **39%** |

### Table 1-4: 2014 Lifecycle Net kWh and kW Realization Rates by PA and Measure

| PA<br>ESPI Measure | Ex Ante Net kWh Savings | Ex Post Net kWh Savings | NRR kWh | Ex Ante Net kW Savings | Ex Post Net kW Savings | NRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 4,311,051 | 3,863,478 | **90%** | 825 | 836 | **101%** |
| Delamping | 31,465,807 | 24,263,874 | **77%** | 7,094 | 5,854 | **83%** |
| LED | 88,035,840 | 118,108,060 | **134%** | 17,648 | 26,510 | **150%** |
| Occupancy Sensors | 25,986,666 | 18,057,133 | **69%** | 4,946 | 5,057 | **102%** |
| T5 | 136,712,799 | 94,460,044 | **69%** | 33,330 | 21,884 | **66%** |
| **SCE** | | | | | | |
| CFL | 745,539 | 856,919 | **115%** | 160 | 177 | **111%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 27,098,266 | 24,523,866 | **90%** | 6,265 | 5,743 | **92%** |
| T5 | 144,667,372 | 141,895,984 | **98%** | 37,868 | 32,226 | **85%** |
| **SDG&E** | | | | | | |
| CFL | 4,250,548 | 4,051,217 | **95%** | 842 | 848 | **101%** |
| Delamping | 9,019,117 | 9,072,960 | **101%** | 2,120 | 2,077 | **98%** |
| Occupancy Sensors | 9,308,788 | 3,478,601 | **37%** | 2,177 | 840 | **39%** |

## 1.2 Key Recommendations

This section presents recommendations and key findings that support each recommendation. Section 6 of the report explains each of these recommendations in more detail.

- Conclusion 1 [Section 4.4.4]: Measures installed under programs that assume a program-induced early retirement and utilize a dual baseline were split between the ex post classification of early replacement (ER) and replace on burnout (ROB), as opposed to being all ER.
- Recommendation 1: Programs that are allowed to claim program-induced early retirement for lighting measures should only assume that a portion of the installations are actually early retirement.
- Conclusion 2 [Section 4.4]: The average replaced wattages for screw-in LED A-lamps have decreased over the 2010-12 to 2013-14 evaluation cycles.
- Recommendation 2: Future evaluations should continue to track the replaced/baseline wattage of LED installations to determine if an increasing percentage of CFLs are being replaced over time.
- Conclusion 3 [Section 4.4]: There are measure names for high bay fixtures that do not specify the baseline equipment, and others that combine T5 and T8 fixtures as the installed measure.
- Recommendation 3: Measure names for high bay linear fluorescent technologies should specify both the installed equipment (T5 or T8) and the baseline equipment being replaced (metal halide or linear fluorescent).
- Conclusion 4 [Section 6]: The workpapers for some early replacement linear fluorescent high bay measures were claiming savings for code compliant lighting controls during the RUL period.
- Recommendation 4: High Bay Lighting Installations should not be allowed to take credit for a reduction in operating hours due to the installation of code compliant lighting controls, if controls are offered under the IOU portfolio of measures.
- Conclusion 5 [Section 4.6]: Programs installing dual baseline measures can influence both the timing and the efficiency of the measure installed.
- Recommendation 5: Further research should be done to consider a framework for NTGRs that can be applied to measures that have a dual baseline, where separate NTGRs are developed for the RUL and post-RUL periods to incorporate the program's influence on both the timing and efficiency of the installed equipment.
- Conclusion 6 [Section 4.2]: Installation rates were found to be less than 100% for all measures studied.

- Recommendation 6: Apply installation rates to ex ante claims by measure and by gross program group.

# 2

# Introduction and Overview of Study

This report documents the activities undertaken by the Nonresidential Downstream Lighting Impact Evaluation of the 2013-2014 IOUs' energy efficiency programs.[3] The overall goal of this study is to perform an impact evaluation on specific nonresidential deemed lighting measures and/or measure-parameters that were identified in the ESPI decision.[4]

This report is informed by Attachment 2 and 3 of the ESPI decision for program year (PY) 2014 and details the goals and objectives of the impact evaluation to meet those requirements. Likewise, the report will discuss the researchable issues, information on the measure groups evaluated as well as the data sources used, the approach for sampling, the verification analysis and the methods used to determine ex post energy and demand impacts. Finally, the report will present the results and findings from the analysis that can then be used to update the impact parameters, UES, NTGRs, and gross/net first year and lifecycle savings for the measures detailed in the ESPI decision.

## 2.1 Evaluation Research Objectives

The objective of this study is to perform a measure and/or measure-parameter impact evaluation, utilizing existing evaluation data and new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for specific lighting measures identified in the ESPI decision. Attachment 2 of the ESPI decision provides an overview of the portfolio parameters that have been identified as potentially requiring ex post verification. The parameters associated with deemed measure verification include measure installation/verification, UES, NTGRs, gross and net energy savings values, EUL, and impact load shapes. The ESPI decision lists, in Attachment 3, a number of deemed nonresidential measures that are subject to some level of ex post evaluation for the 2014 program year. Below is a list of the lighting measures that were identified in that decision. It is important to note that the parameters associated with these measures represent potential areas of focus and that the ex post evaluation is not limited in scope to any specific parameters. The evaluation team has determined, with guidance from the CPUC, what measure and measure-parameters are subject to

3 This report focuses on the ESPI measures that were identified for the 2014 program cycle.

4 D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K775/76775903.PDF

ex post evaluation. This determination is based on a number of factors, which will be presented in more detail throughout this report.

- Screw-in CFLs
- T5 fluorescent lamps and fixtures replacing metal halides
- LED lighting (surface, pendant, track, accent and recess down lighting)
- Occupancy sensor lighting controls (integrated and wall/ceiling mount)
- Delamping of T12 lamps in existing fixtures

Rather than develop a full, comprehensive analysis for all measures, this evaluation focuses on evaluating specific parameters within the savings algorithms for some measures while implementing a more comprehensive analysis of others.

In order to implement this approach in meeting the overall study goal, a number of research objectives have been targeted. The following tasks have been performed, either by leveraging existing data from past evaluation efforts or collecting new primary data from participant phone surveys and/or on-site verification analyses. A more thorough discussion of how these research objectives are applied to each of the studied measures and the algorithm by which they have been evaluated are discussed in Section 4, but to summarize:

- Confirm installations (verification). This includes on-site verification of measure installations that represent a significant percentage of ex ante claimed savings or measures that have not previously been evaluated. For lighting measures that represent less than significant levels of claimed ex ante savings and have been evaluated throughout previous program cycles, existing data on installation rates are applied to these measures.
- Estimate baseline (both pre-retrofit and code based) and replacement (post-retrofit) equipment wattages, operating hours, and use shapes to support the estimate of unit energy savings values and 8,760 impact load shapes. For lighting measures that represent less than significant levels of claimed ex ante savings and have been evaluated throughout previous program cycles, existing data on these impact parameters will be leveraged.
- Estimate participant free-ridership to support the development of net-to-gross ratios and net savings values. For lighting measures that represent less than significant levels of claimed ex ante savings and have been evaluated throughout previous program cycles, existing data on ex post NTGRs are leveraged.
- Estimate remaining useful life values for selected measures, and update effective useful life estimates based on ex post operating hours.

- Based on the above, estimate first year and lifetime gross and net ex post impacts (kWh, kW) for select measures.

## 2.2 Studied Measure Groups

The five lighting measures listed in Attachment 3 of the ESPI decision are aggregate measures that comprise sixteen unique measure groups. The ex post analysis has been conducted at the measure group level, but not all 16 measure groups have been targeted for evaluation. Table 2-1 presents each measure group's contribution to each PA's 2014 portfolio energy savings[5] (as well as the statewide contribution). Table 2-2 provides a comparison of each measure's contribution to portfolio energy savings for 2014.

5 These savings do not include those associated with Codes and Standards

**Table 2-1: Summary of Nonresidential Downstream Deemed Lighting ESPI Measure Groups – Expressed as a Percentage of the PA's 2014 Portfolio Gross Ex Ante Savings**

| Measure Group | 2014 kWh Savings | | | | 2014 kW Savings | | | |
|---|---|---|---|---|---|---|---|---|
| | SW | PG&E | SCE | SDG&E | SW | PG&E | SCE | SDG&E |
| Lighting Indoor CFL > 30 Watts | 0.0% | 0.0% | 0.0% | | 0.0% | 0.0% | 0.0 % | |
| Lighting Indoor CFL Basic | 0.1% | 0.2% | 0.0% | | 0.1% | 0.2% | 0.0 % | |
| Lighting Indoor CFL Fixture | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0 % | 0.1% |
| Lighting Indoor CFL Other | 0.1% | | | 0.9% | 0.1% | | | 0.9% |
| Lighting Indoor CFL Reflector | 0.1% | 0.0% | 0.0% | 0.6% | 0.1% | 0.0% | 0.0 % | 0.6% |
| Lighting Indoor Controls Wall Or Ceiling Mounted Occupancy Sensor | 0.3% | 0.3% | 0.2% | 1.0% | 0.4% | 0.3% | 0.3 % | 1.2% |
| Lighting Indoor Fixture Integrated Occupancy Sensor | 0.2% | 0.2% | 0.3% | 0.1% | 0.3% | 0.2% | 0.4 % | 0.1% |
| Lighting Indoor High Bay Fluorescent* | 1.4% | 1.5% | 1.5% | 0.3% | 1.9% | 1.8% | 2.3 % | 0.4% |
| Lighting Indoor LED Fixture | 0.6% | 0.2% | 0.7% | 1.8% | 0.7% | 0.3% | 0.8 % | 1.8% |
| Lighting Indoor LED Lamp | 2.4% | 0.6% | 3.2% | 6.5% | 2.4% | 0.6% | 3.6 % | 5.4% |
| Lighting Indoor LED Reflector Lamp | 1.9% | 1.8% | 1.7% | 3.1% | 2.1% | 1.8% | 2.1 % | 2.9% |
| Lighting Indoor Linear Fluorescent Delamping | 0.4% | 1.1% | | | 0.5% | 1.3% | | |
| Lighting Outdoor CFL > 30 Watts | 0.0% | 0.0% | | | 0.0% | 0.0% | | |
| Lighting Outdoor CFL Basic | 0.0% | 0.0% | | | 0.0% | 0.0% | | |
| Lighting Outdoor CFL Fixture | 0.0% | 0.0% | 0.0% | | 0.0% | 0.0% | 0.0 % | |
| Lighting Outdoor LED Fixture | 0.3% | 0.3% | | 2.2% | 0.0% | 0.0% | | 0.0% |

* The High Bay Fluorescent measure group contains the T5 replacing metal halides ESPI measure. Note: Values with 0.0% have a positive claim, but that claim is less than one tenth of one percent.

**Table 2-2: Comparison of Nonresidential Downstream Deemed Lighting ESPI Measure Groups – Expressed as a Percentage of the PA's 2013 and 2014 Portfolio Gross Ex Ante kWh Savings**

| Measure Group | 2013 kWh Savings | | | | 2014 kWh Savings | | | |
|---|---|---|---|---|---|---|---|---|
| | SW | PG&E | SCE | SDG&E | SW | PG&E | SCE | SDG&E |
| Lighting Indoor CFL > 30 Watts | 0.0% | 0.0% | 0.0% | | 0.0% | 0.0% | 0.0% | |
| Lighting Indoor CFL Basic | 0.2% | 0.3% | 0.1% | | 0.1% | 0.2% | 0.0% | |
| Lighting Indoor CFL Fixture | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% | 0.1% |
| Lighting Indoor CFL Other | 0.1% | | | 0.6% | 0.1% | | | 0.9% |
| Lighting Indoor CFL Reflector | 0.2% | 0.1% | 0.1% | 0.5% | 0.1% | 0.0% | 0.0% | 0.6% |
| Lighting Indoor Controls Wall Or Ceiling Mounted Occupancy Sensor | 0.6% | 0.6% | 0.5% | 0.4% | 0.3% | 0.3% | 0.2% | 1.0% |
| Lighting Indoor Fixture Integrated Occupancy Sensor | 0.4% | 0.4% | 0.5% | 0.1% | 0.2% | 0.2% | 0.3% | 0.1% |
| Lighting Indoor High Bay Fluorescent* | 2.3% | 2.8% | 2.2% | 0.5% | 1.4% | 1.5% | 1.5% | 0.3% |
| Lighting Indoor LED Fixture | 0.1% | 0.0% | 0.1% | 0.2% | 0.6% | 0.2% | 0.7% | 1.8% |
| Lighting Indoor LED Lamp | 0.8% | 0.0% | 1.6% | 0.8% | 2.4% | 0.6% | 3.2% | 6.5% |
| Lighting Indoor LED Reflector Lamp | 1.4% | 0.7% | 1.8% | 2.5% | 1.9% | 1.8% | 1.7% | 3.1% |
| Lighting Indoor Linear Fluorescent Delamping | 0.2% | 0.5% | 0.0% | | 0.4% | 1.1% | | |
| Lighting Outdoor CFL > 30 Watts | 0.0% | 0.0% | | | 0.0% | 0.0% | | |
| Lighting Outdoor CFL Basic | 0.0% | 0.0% | | | 0.0% | 0.0% | | |
| Lighting Outdoor CFL Fixture | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | |
| Lighting Outdoor LED Fixture | 0.1% | 0.0% | | 1.4% | 0.3% | 0.3% | | 2.2% |

* The High Bay Fluorescent measure group contains the T5 replacing metal halides ESPI measure. Note: Values with 0.0% have a positive claim, but that claim is less than one tenth of one percent.

Each of the measures that were identified in the ESPI decision contributes varying levels of ex ante gross portfolio savings and, overall, these savings contributions do not change significantly from 2013 to 2014 with the exception of a few measures. For example, in 2014, the savings contribution for indoor LED lamps have tripled, while indoor high bay fluorescents have dropped from 2.3% to 1.4% overall. The reasons for these changes will be discussed in Section 3 along with how these changes have affected the sample design for select measures across the two program periods.

As a result, different levels of rigor have been applied to each of the measures and measure-parameters, given the fact that some measures contribute an insignificant percentage of overall savings while others represent more significant savings. These levels of rigor are also informed by the availability and reliability of existing data sources along with the need to gather new primary data. These levels of rigor are presented in Table 2-3 and discussed in more detail below.

**Table 2-3: Percent Statewide Portfolio kWh Savings, Levels of Rigor and Data Sources for 2014 Deemed ESPI Measure Groups**

| Measure Group | 2014 Ex Ante Savings | Level of Rigor | Existing Data Source | New Data Collection | | Monitor Source |
|---|---|---|---|---|---|---|
| | | | | Phone Survey | On-Site | |
| Lighting Indoor CFL > 30 Watts | 0.0% | Low | Yes | No | No | Existing |
| Lighting Indoor CFL Basic | 0.1% | Low | Yes | No | No | Existing |
| Lighting Indoor CFL Fixture | 0.0% | Do Nothing | No | No | No | Do Nothing |
| Lighting Indoor CFL Other | 0.1% | Do Nothing | No | No | No | Do Nothing |
| Lighting Indoor CFL Reflector | 0.1% | Low | Yes | No | No | Existing |
| Lighting Indoor Controls Wall Or Ceiling Mounted Occupancy Sensor | 0.3% | Medium | Yes | Yes | No | Existing |
| Lighting Indoor Fixture Integrated Occupancy Sensor | 0.2% | Medium | Yes | Yes | No | Existing |
| Lighting Indoor High Bay Fluorescent | 1.4% | High | Yes | Yes | Yes | New/Existing |
| Lighting Indoor LED Fixture | 0.6% | Do Nothing | No | No | No | Do Nothing |
| Lighting Indoor LED Lamp | 2.4% | High | Yes | Yes | Yes | New/Existing |
| Lighting Indoor LED Reflector Lamp | 1.9% | High | Yes | Yes | Yes | New/Existing |
| Lighting Indoor Linear Fluorescent Delamping | 0.4% | Low | Yes | No | No | New/Existing |
| Lighting Outdoor CFL > 30 Watts | 0.0% | Do Nothing | No | No | No | Do Nothing |
| Lighting Outdoor CFL Basic | 0.0% | Do Nothing | No | No | No | Do Nothing |
| Lighting Outdoor CFL Fixture | 0.0% | Do Nothing | No | No | No | Do Nothing |
| Lighting Outdoor LED Fixture | 0.3% | Do Nothing | No | No | No | Do Nothing |

Note: Values with 0.0% have a positive claim, but that claim is less than one tenth of one percent.

The energy and demand savings associated with each level of rigor (as a percentage of the statewide Deemed ex ante ESPI savings) is provided below along with a brief discussion of how these levels of rigor have been applied:

- **High** – 72% and 75% of deemed lighting ESPI kWh and kW savings
  - For LED and T5 measures, new primary data has been collected utilizing a phone and on-site survey instrument, including the installation of lighting loggers. Likewise, as part of the 2013 Nonresidential Downstream Deemed ESPI Lighting Impact Evaluation[6] and the 2010-12 Nonresidential Downstream Lighting Impact Evaluation (NRL),[7] LED lamps and reflectors and high bay linear lighting were also evaluated. For these evaluations, installation rates, NTGRs and impact parameters were developed for these measures. The results from these impact evaluations have been combined with those from this evaluation in order to meet the ESPI requirements for these measures. For example, LED logger data collected in the 2010-12 and 2013 studies have been combined with data collected for this study in order to develop operating hours by building type that can then be used as an input into developing UES values for LEDs.
- **Medium** – 7% and 8% of deemed lighting ESPI kWh and kW savings
  - For occupancy sensor measures, new primary data has been collected utilizing a phone survey instrument to update existing NTGRs. These measures were also evaluated in 2010-12 and 2013, so the results from these impact evaluations have been applied to these measures. No new primary data was collected on-site.
- **Low** – 8% and 8% of deemed ESPI kWh and kW savings
  - For indoor screw-in CFLs and delamping measures, no new primary data has been collected. These measures were also evaluated as part of the 2010-12 NRL. Installation rates, impact parameters, NTGRs, and gross/net ex post energy and demand savings were developed for each of these measures. The results from that study serve as inputs into the portfolio parameter estimates for the ESPI evaluation. In the course of the evaluation, some measures that were classified as high bay in the tracking data were actually found to be low bay linear fluorescent measures. Several of these measures were monitored as part of the on-site verification effort and these logger data were combined with the existing logger data to update operating hours for delamping measures (even though delamping measures were not targeted in 2013-2014).

6 http://www.energydataweb.com/cpuc/deliverableView.aspx?did=1294&uid=0&tid=0&cid=

7 http://www.energydataweb.com/cpuc/deliverableView.aspx?did=1155&uid=0&tid=0&cid=

- **Do Nothing** – 13% and 9% of deemed ESPI kWh and kW savings
  - For the remaining measures (outdoor lighting and CFL/LED fixtures) there are no existing data sources to utilize and no new primary data has been collected. It is important to note that the majority of the savings in this group (12% of kWh and 8% of kW) is from LED fixtures. Savings from this measure group did not become significant until the third quarter of 2014.

## 2.3 Overview of Impact Evaluation Approach

For lighting measures, the general approach that will be used to estimate ex post gross unit energy savings values is based on developing hourly impacts to create an impact load profile. From this profile, impacts can then be aggregated to develop an annual ex post gross kWh savings value, or averaged over a set of specific hours to develop an ex post gross kW savings value. The general algorithm applied to estimate energy savings for a specific hour is:

$$\text{Impact\_Hour\_i} = \text{Installation\_Rate} \times \begin{bmatrix} (\text{Baseline\_Wattage} \times \text{Percent\_On\_Pre\_Hour\_i}) \\ -(\text{Post\_Wattage} \times \text{Percent\_On\_Post\_Hour\_i}) \end{bmatrix}$$

Where,

Installation_Rate = the percentage of claimed measures found to have been installed and operable based on on-site visits.

Baseline_Wattage = the wattage associated with the measures that were replaced or with measures corresponding to the industry standard practice for the type of retrofit. As discussed in detail below, some measures will employ a dual baseline over the life of the measure, while others are based solely on industry standard practice (or solely on the replaced wattage).

Post_Wattage = the wattage associated with the measures that were installed.

Percent_On_Pre = the percentage of time the baseline equipment is on during a specific hour i, which is obtained from adjusted self-reported operating hours gathered on site.

Percent_On_Post = the percentage of time the installed equipment is on during a specific hour i, which is obtained from either logger data usage or adjusted self-reported operating hours gathered on site. The Percent_On_Pre and Percent_On_Post are assumed to be equal for all measures, except occupancy sensors.

To develop the UES values, each of the above set of parameters was estimated. For CFLs, delamping (supplemental data was collected to update operating hours as discussed above) and control measures, all of these parameters are based on existing data sources collected as part of the 2006-08 Small Commercial Contract Evaluation and the 2010-12 NRL evaluation. For T5 and LED measures, these parameters are based on the 2013 ESPI and 2010-12 NRL data supplemented by new primary data collection.

The remainder of this report will discuss how these UES values were generated for each ESPI measure along with the following:

- Section 3 discusses the data sources that were utilized to estimate each of the individual measure-parameters, the sample design and resulting data used in the evaluation.
- Section 4 presents the methods used for estimating each individual impact parameter, including the installation rate, the various wattage values, the pre- and post-operating hours and the NTGRs.
- Section 5 presents the final study results, including a discussion of how the UES values were applied to the population to develop GRRS and NRRs and total population level ex post energy savings values.
- Section 6 presents key conclusions to support recommendations developed from this study.
- Appendix A presents the participant telephone survey instrument.
- Appendix B presents the on-site survey instrument.
- Appendix C presents the phone survey banners.
- Appendix AA presents the standardized high level savings for both gross and net first year and lifecycle.
- Appendix AB presents the standardized per unit savings for both gross and net first year and lifecycle.
- Appendix AC presents the summary of recommendations for the Response to Recommendations (RTR).

# 3

# Data Sources, Sample Design, and Data Collection

## 3.1 Data Sources

A number of data sources were utilized to support the development of each impact parameter in order to update UES values, installation rates and NTGRs for the ESPI measures in this study. These data sources were leveraged from past impact evaluation activities as well as from new primary data collection. As discussed in Section 2, the impacts associated with CFL and delamping measures rely almost exclusively on existing data sources. For occupancy sensors, existing on-site data has been leveraged to update gross impacts, but new phone survey data has been collected to update NTG ratios. For T5 and LED measures, new primary on-site data has been combined with existing data to evaluate the gross impacts associated with those measures and new phone surveys have been implemented to generate NTGRs. The various sources of data are discussed in more detail below.

### *3.1.1 On-Site Data Collection*

On-site visits were conducted in order to gather data that supports a number of parameters used in the impact algorithm. This includes measure verification to support installation rates, storage rates, replacement rates, etc., as well as to confirm post-retrofit wattages. Self-report data was also gathered on the wattage of pre-existing equipment when actual equipment replaced was not on site to help support the estimate of pre-retrofit wattages. Likewise, self-report data was gathered on lighting equipment usage schedules to aid in the development of pre- and post-retrofit load shapes.

For CFLs, linear delamping and occupancy sensor measures, data from past evaluations were leveraged as the source to update the gross impact parameters associated with these measures. The 2010-12 NRL was the source for updating verification rates and baseline/replaced wattage information for these measures and a combination of logger data from NRL and the 2006-08 Small Commercial Contract Evaluation (SmCom) as well as select logger data collected from 2013-2014 served as inputs into updating operating hours for these measures. For LED and T5 measures, the data that was collected from 2013 ESPI and NRL studies has been combined with new primary data collection in order to update the impacts associated with those measures. The use of the verification data to develop installation rates, the development of operating schedules using self-report data and the development of wattage values are all discussed in Section 4.

### *3.1.2 Time of Use Lighting Loggers*

As part of the on-site visit for LED and T5 measures, a majority of installed lighting equipment was monitored to gather time-of-use data to support the development of operating hours. Lighting loggers using optical sensors were the predominant type used for this study. However, when lighting was not accessible for optical sensors, logging was done at the electrical panel where circuit amperage was collected in order to develop lighting load shapes. The development of lighting usage load shapes using logger data is discussed in detail in Section 4.

### *3.1.3 Participant Phone Survey*

A phone survey was conducted to recruit customers for the on-site visit – for LED and T5 measures – as well as to collect data useful for the NTG analysis and various other components of the evaluation – for LED, T5 and occupancy sensor measures. Since no new data collection was performed on CFL and delamping measures, the NTGRs that were generated from the NRL evaluation have been updated and will serve as inputs into the net savings analysis for these measures. For T5 measures, the phone survey data was also used to identify if customer installations were early replacement (ER) or replacement on burnout (ROB). The ER analysis and the NTG analysis are discussed in more detail in Section 4.

### *3.1.4 Commercial Market Share Tracking Study Data*

The Commercial Market Share Tracking study provided information on lighting equipment installations that occurred outside of the CPUC programs. This information was utilized to develop estimates of industry standard practices for lighting retrofits and is discussed in Section 4.

### *3.1.5 2006-08, 2010-12 and 2013 Logger Data*

As mentioned above, logger data from previous evaluations were combined to generate operating hours for several of the ESPI measures. These data were also utilized to adjust customer self-reported operating schedules for LED and T5 measures. The use of these data to adjust the self-reported operating schedules is discussed in detail in Section 4.

## 3.2 Data Collection

### *3.2.1 On-Site Sample Design and Achieved Data Collection*

As mentioned above, the on-site visits collected data to support a number of the impact parameters including the installation rates, pre- and post-wattages and pre- and post-operating hours for LED and T5 measures. The on-site sample was designed to develop statistically significant results at the technology-building type segment level. The 2013-14 Nonresidential

Downstream Deemed ESPI Impact Evaluation Research Plan[8] for this study discusses the sample design in greater detail, but the resulting design focuses on developing estimates of key impact parameters that can be used to augment existing data in order to update ex ante net and gross kW and kWh energy savings values for each ESPI measure.

***T5 Sample Design***

The 2013 Deemed Lighting ESPI Impact Evaluation for T5s developed UES values for 7 different building types plus one additional miscellaneous building type. For 2014, there are no new building types that had sufficient levels of participation that warranted a separate sample quota so the same 8 segments are used for the 2014 evaluation.

The objective of the incremental sample design for 2014 is to have a sample size of at least 30 sites for each of the 8 segments for which the replaced technology is a metal halide. Table 3-1 summarizes the population data associated with high bay linear fluorescent measures, the expected sample quotas and the achieved analysis sample from the on-site verification. Desired and achieved sample sizes are show for high bay linear measures overall, and only those that replaced metal halides.

**Table 3-1: T5 On-Site Sample Design and Existing On-sites by Building Type**

| | | 2014 Gross Ex Ante kWh | | Expected 2014 Analysis Sample | | Actual 2014 Analysis Sample | |
|---|---|---|---|---|---|---|---|
| **Building Type** | **2014 Sites** | **Total** | **Percent** | **Total** | **Replace MH** | **Total** | **Replace MH** |
| Industrial | 255 | 5,214,764 | 19% | 93 | 49 | 112 | 83 |
| Miscellaneous | 411 | 4,250,816 | 15% | 45 | 30 | 77 | 33 |
| Office Large | 59 | 1,107,162 | 4% | 16 | 13 | 13 | 9 |
| Office Small | 230 | 3,104,676 | 11% | 34 | 30 | 14 | 7 |
| Retail Large | 120 | 4,318,549 | 16% | 48 | 30 | 52 | 41 |
| Retail Small | 211 | 2,481,250 | 9% | 68 | 30 | 107 | 59 |
| Storage | 195 | 3,336,010 | 12% | 53 | 30 | 61 | 53 |
| Warehouse | 163 | 3,733,194 | 14% | 45 | 33 | 46 | 35 |
| **Total** | **1644** | **27,546,421** | **100%** | **402** | **245** | **482** | **320** |

Based on this combined sample design and the results of the 2013 ESPI study, it is expected that a sample size of around 30 will provide a relative precision for most parameters at the 90/20 confidence level. Across all building types, a 90/10 relative precision or better should be achieved.

8 http://www.energydataweb.com/cpucFiles/pdaDocs/1210/PY2013-2014%20Deemed%20ESPI%20Research%20Plan_PDA.pdf

***T5 Sample Achieved***

The totals in Table 3-1 represent the number of sites for which new data was collected that supported the development of installation rates, wattage estimates, and operating schedules for T5 linears. While this impact evaluation focuses specifically on T5 linear fluorescents replacing metal halides, the measure names associated with the high bay linear fluorescent measure group in the tracking data were not always comprehensive or accurate. Sometimes, the baseline lamp type was not included in the measure name description (just a replaced wattage range was furnished). Likewise, the on-site audit would also determine that the retrofit equipment was actually a high bay T8 system rather than a T5 system or the baseline equipment was not a metal halide. Given these nuances, the evaluation team utilized the on-site data differently depending upon the parameter that was being updated. For example, all high bay measures were included in the operating hour analysis regardless of whether or not the baseline equipment was metal halide, whereas the wattage analysis focused exclusively on the on-site data that represented a metal halide to T5 retrofit.

***LED Lamp Sample Design***

The 2013 Deemed Lighting ESPI Impact Evaluation for LED lamps developed UES values for 6 different building types plus one additional miscellaneous building type. For 2014, there were two new building types that had sufficient levels of participation that warranted a separate sample quota: assembly and health clinics. Therefore, a total of 9 segments were used for the 2014 evaluation. It is important to note that the 2013 study included participants from the first two quarters of 2014, so all new data collection was comprised of customers participating in Q3 and Q4 of 2014.

The objective of the incremental sample design for 2014 was to have a sample size of 20 sites for the two new building types. For the existing building types, only three had existing sample sizes under 40; lodging, large retail and miscellaneous. Lodging contributed 50% of the total 2014 ex ante savings for LED lamps, so a targeted sample size of 40 was desired, which required 14 new onsites to be conducted. Retail large contributed 4% of the savings, and there is a more limited sample frame available, so a sample size of 30 was desired, which required 24 new onsites. Miscellaneous contributed 14% of the savings. A desired sample size of 30 was also prescribed for this building type. For those building types with more than 40 onsites, no new data collection was planned, however, the evaluation team was able to complete more on-site verifications for these segments, given changes to building type classification in the tracking data. For example, the evaluation team did not target small retail in the incremental sample design, but the on-site audit could have confirmed that a building type that was initially classified in the "miscellaneous" category was, in fact, a retail establishment.

Based on the combined sample design and the results of the 2013 ESPI study, for LED lamps, it was expected that a sample size of around 40 would provide a relative precision for most parameters at the 90/15 confidence level, a sample size of 30 would provide around a 90/20 relative precision, and a sample size of 20 around a 90/25 relative precision. Across all building types, a 90/10 relative precision or better was expected to be achieved for LED lamp measures.

The resulting 2014 analysis sample size across all building types was targeted at 333 sites, which required 78 new onsites to be conducted. This sample size is summarized below along with the total sample achieved for the overall 2014 analysis.

### Table 3-2: LED Lamps On-Site Sample Design and Achieved On-sites by Building Type

| Building Type | 2014 Sites | 2014 Gross Ex Ante kWh | | Expected 2014 Analysis Sample | Achieved 2014 Analysis Sample |
|---|---|---|---|---|---|
| | | Total | Percent Savings | | |
| Assembly | 453 | 2,163,278 | 5% | 20 | 38 |
| Health Clinic | 460 | 2,453,694 | 5% | 20 | 29 |
| Lodging | 1,073 | 23,959,390 | 50% | 40 | 63 |
| Miscellaneous | 2,803 | 6,492,939 | 14% | 30 | 43 |
| Office Small | 1,660 | 2,815,045 | 6% | 40 | 53 |
| Restaurant - Fast Food | 849 | 1,202,645 | 3% | 40 | 49 |
| Restaurant - Sit Down | 1,302 | 4,534,052 | 9% | 40 | 60 |
| Retail Large | 162 | 1,727,769 | 4% | 30 | 25 |
| Retail Small | 3,344 | 2,708,389 | 6% | 40 | 82 |
| **Total** | **12,106** | **48,057,203** | **100%** | **333** | **442** |

***LED Lamp Sample Achieved***

Table 3-2 summarizes the population data associated with LED lamps, the expected sample quotas and the achieved analysis sample from the on-site verification. Overall, sample targets were reached for all but one segment (retail large). These totals represent the total number of sites for which new data was collected that supported the development of installation rates, wattage estimates, and operating schedules for LED lamps. The total number of onsites that were used to develop each of the impact parameters may differ from those reported above. For example, all 442 sites were included in the installation rate analysis, however, they may have not been included in the operating hour or wattage analysis given the fact that measures may have not have been installed and operable at the time of the on-site audit. As discussed above, lodging represented roughly 50% of the total ex ante population savings for LED lamp measures and the target for that segment was surpassed by 23. Overall, the sample target for LED lamps was surpassed by 109 (442 compared to 333).

***LED Reflector Sample Design***

The 2013 Deemed Lighting ESPI Impact Evaluation for LED reflector lamps also developed UES values for 6 different building types plus one additional miscellaneous building type. For 2014, there was only one new building type that had a sufficient level of participation that warranted a separate sample quota: assembly. Therefore, a total of 8 segments was used for the 2014 evaluation. As with the LED lamps, the 2013 study included participants from the first two quarters of 2014, so any new data collection was comprised of customers participating in Q3 and Q4 of 2014.

The objective of the incremental sample design for 2014 was the same as for LED lamps – a sample size of 20 sites for the new building type. For the existing building types, the same three had sample sizes under 40; lodging, large retail and miscellaneous. Lodging contributed 9% of the 2014 ex ante savings, so a targeted sample size of 40 is desired, which required 30 new onsites to be conducted. Retail large contributed 27% of the savings, so a targeted sample size of 40 was also desired, which required 26 new onsites to be conducted. However, the sample frame was limited for these two building types, so it was expected that meeting these targets would be difficult to achieve. Miscellaneous contributed 25% of the savings. A desired sample size of 30 was prescribed for this building type. Finally, for those with more than 40 onsites, no new data collection was performed. However, some sites were post-stratified based on the information collected throughout the on-site audit (as discussed above in the LED lamp sample design section).

Based on the combined sample design and the results of the 2013 ESPI study, for LED reflector lamps, it was expected that a sample size of around 40 would provide a relative precision for most parameters at the 90/15 confidence level, a sample size of 30 would provide around a 90/20 relative precision, and a sample size of 20 around a 90/25 relative precision. Across all building types, a 90/10 relative precision or better was expected to be achieved

The targeted 2014 analysis sample size across all building types was 312 sites, which required 82 new onsites to be conducted. This sample size is summarized below along with the total sample achieved for the overall 2014 analysis.

**Table 3-3: LED Reflector Lamps On-Site Sample Design and Achieved On-sites by Building Type**

| Building Type | 2014 Sites | 2014 Gross Ex Ante kWh | | Expected 2014 Analysis Sample | Achieved 2014 Analysis Sample |
|---|---|---|---|---|---|
| | | Total | Percent | | |
| Assembly | 364 | 1,320,145 | 4% | 20 | 28 |
| Lodging | 266 | 3,308,065 | 9% | 40 | 31 |
| Miscellaneous | 2,633 | 9,346,545 | 25% | 30 | 42 |
| Office Small | 1,002 | 2,629,370 | 7% | 40 | 44 |
| Restaurant - Fast Food | 496 | 1,043,785 | 3% | 40 | 42 |
| Restaurant - Sit Down | 697 | 2,395,839 | 7% | 40 | 57 |
| Retail Large | 392 | 9,902,139 | 27% | 40 | 26 |
| Retail Small | 2,198 | 6,912,273 | 19% | 40 | 71 |
| **Total** | **8,048** | **36,858,161** | **100%** | **312** | **341** |

***LED Reflector Sample Achieved***

Table 3-3 summarizes the population data associated with LED reflector lamps, the expected sample quotas and the achieved analysis sample from the on-site verification. Overall, sample targets were reached for all but two segments (retail large and lodging). These totals represent the number of sites for which new data was collected that supported the development of installation rates, wattage estimates, and operating schedules for LED reflector lamps. As mentioned above, the total number of onsites that were used to develop each of the impact parameters may differ from those reported above because specific measures may not have been installed and operable at the time of the on-site audit. Large retail, miscellaneous and small retail represent the majority of the total ex ante population savings for LED reflector lamp measures. The miscellaneous and small retail targets were met, however, the large retail was not. Overall, the sample target for the LED reflector lamps was surpassed by 29 (341 compared to 312).

### *3.2.2 New and Existing On-Site Data Used to Support Pre- and Post-Retrofit Wattage Estimates*

As part of the on-site lighting inventory, detailed information was gathered for each rebated measure found on site. This information included a full inventory of fixture/lamp type, lamp wattage, ballast information and fixture configuration. More specifically, information was collected on the lamp manufacturer, model number, lamp quantity, lamp length and diameter (for linear fluorescent measures) and ballast manufacturer and model number. These data were used to perform look-ups, based on product cut sheets, on the manufacturer's rated wattage for the specific fixture. For all measures, these lookups were used to develop post-retrofit wattage values for all measures found on site. Likewise, for many of the high bay fluorescent installations, panel metering was performed as discussed above, and spot watt measurements were collected. These spot watt measurements provided an additional source of information regarding the post-retrofit wattage values.

For pre-retrofit wattages, a combination of approaches was utilized. First, if any of the equipment that was replaced was still on site, the auditor would collect the make and model information of that equipment and wattage values were generated as discussed above. Second, if there was equipment still in place that had not been retrofitted, but was reported to be the same as that replaced, the same approach would be taken. Finally, if no existing equipment was found on site, then customer self-report information was used to estimate wattages.

The following tables provide summaries of the wattage data collected on site for each of ESPI measures. The wattage observations for CFLs, linear delamping and occupancy sensors are based on the on-site data collection activities performed throughout the 2010-12 NRL evaluation. For LED and T5 measures, these observations represent a combination of 2010-12, 2013 and 2014 on-site data. The pre- and post-wattage values that were generated for each of these measures are discussed in more detail in Section 4.

### Table 3-4: CFL Basic and Reflector Manufacturer Look-Ups for Pre- and Post-Wattage Estimates by Measure Category (2010-12)

| Measure Category | CFL Basic | | CFL Reflectors | |
|---|---|---|---|---|
| | Pre-Retrofit | Post-Retrofit | Pre-Retrofit | Post-Retrofit |
| 5-13W CFL replacing < 26W | 3 | 3 | | |
| 5-13W CFL replacing 26-40W | 4 | 4 | 1 | 1 |
| 5-13W CFL replacing 41-60W | 42 | 42 | 3 | 3 |
| 5-13W CFL replacing 61-90W | 2 | 2 | 2 | 2 |
| 5-13W CFL replacing 91-125W | 1 | 1 | | |
| 14-24W CFL replacing < 26W | 1 | 1 | 2 | 2 |
| 14-24W CFL replacing 26-40W | 5 | 5 | 1 | 1 |
| 14-24W CFL replacing 41-60W | 42 | 39 | 25 | 25 |
| 14-24W CFL replacing 61-90W | 27 | 27 | 15 | 15 |
| 14-24W CFL replacing 91-125W | 12 | 12 | 6 | 6 |
| 14-24W CFL replacing 126-200W | | | 2 | 2 |
| 14-24W CFL replacing 201-300W | 2 | 2 | | |
| 25-30W CFL replacing 26-40W | | | 1 | 1 |
| 25-30W CFL replacing 41-60W | 8 | 8 | 5 | 5 |
| 25-30W CFL replacing 61-90W | 2 | 2 | 3 | 3 |
| 25-30W CFL replacing 91-125W | 2 | 2 | 3 | 3 |

### Table 3-5: Delamping Manufacturer Look-Ups for Pre- and Post-Wattage Estimates by Measure Configuration (2010-12)

| Measure Category | Pre-Retrofit |
|---|---|
| (1) 4FT-T12 removed | 4 |
| (1) 8FT-T12 removed | 6 |
| (2) 4FT-T12 removed | 37 |
| (2) 8FT-T12 removed | 1 |

### Table 3-6: Occupancy Sensor Manufacturer Look-Ups for Controlled Wattage Estimates by Measure Category (2010-12)

| Measure Category | Post-Retrofit | Spot Watt Measurement | Total Post-Retrofit |
|---|---|---|---|
| Integrated Control (High wattage) | 28 | 35 | 63 |
| Integrated Control (Low wattage) | 23 | 16 | 39 |
| Mounted Control (High wattage) | 10 | 0 | 10 |
| Mounted Control (Low wattage) | 173 | 1 | 174 |

### Table 3-7: LED Lamp Unique Wattage Observations Performed by Measure Category (2010-14)

| Measure Category | Pre-Retrofit | Post-Retrofit |
|---|---|---|
| < 4W LED replacing < 26W | 1 | 1 |
| < 4W LED replacing 26-40W | 1 | 1 |
| < 4W LED replacing 41-60W | 1 | 1 |
| 4-7W LED replacing < 26W | 13 | 13 |
| 4-7W LED replacing 26-40W | 8 | 8 |
| 4-7W LED replacing 41-60W | 15 | 14 |
| 4-7W LED replacing 61-90W | 8 | 8 |
| 8-11W LED replacing < 26W | 39 | 35 |
| 8-11W LED replacing 26-40W | 30 | 28 |
| 8-11W LED replacing 41-60W | 116 | 115 |
| 8-11W LED replacing 61-90W | 36 | 35 |
| 8-11W LED replacing > 90W | 5 | 5 |
| 12-17W LED replacing < 26W | 16 | 15 |
| 12-17W LED replacing 26-40W | 9 | 8 |
| 12-17W LED replacing 41-60W | 12 | 11 |
| 12-17W LED replacing 61-90W | 18 | 17 |
| 12-17W LED replacing > 90W | 13 | 13 |
| > 17W LED replacing 26-40W | 1 | 1 |
| > 17W LED replacing 41-60W | 1 | 1 |
| > 17W LED replacing 61-90W | 1 | 1 |
| > 17W LED replacing > 90W | 4 | 2 |

**Table 3-8: LED Reflector Unique Wattage Observations Performed by Measure Category (2010-14)**

| Measure Category | Pre-Retrofit | Post-Retrofit |
|---|---|---|
| 4-7W LED replacing < 26W | 7 | 7 |
| 4-7W LED replacing 26-40W | 16 | 16 |
| 4-7W LED replacing 41-60W | 54 | 53 |
| 4-7W LED replacing 61-90W | 2 | 2 |
| 4-7W LED replacing > 90W | 1 | 1 |
| 8-11W LED replacing < 26W | 6 | 5 |
| 8-11W LED replacing 26-40W | 7 | 7 |
| 8-11W LED replacing 41-60W | 24 | 23 |
| 8-11W LED replacing 61-90W | 21 | 21 |
| 8-11W LED replacing > 90W | 13 | 13 |
| 12-17W LED replacing < 26W | 8 | 6 |
| 12-17W LED replacing 26-40W | 6 | 4 |
| 12-17W LED replacing 41-60W | 26 | 24 |
| 12-17W LED replacing 61-90W | 41 | 38 |
| 12-17W LED replacing > 90W | 43 | 42 |
| > 17W LED replacing < 26W | 1 | 1 |
| > 17W LED replacing 26-40W | 9 | 7 |
| > 17W LED replacing 41-60W | 6 | 4 |
| > 17W LED replacing 61-90W | 7 | 7 |
| > 17W LED replacing > 90W | 18 | 18 |

**Table 3-9: T5 Manufacturer Look-Ups and Spot Watt Measurements Performed by Measure Configuration for T5 Linears (2010-2014)**

| Measure Category | Pre-Retrofit | Post-Retrofit | Spot Watt Measurement | Total Post-Retrofit |
|---|---|---|---|---|
| 4FT-2L-T5 replacing < 400W | 1 | 1 | 1 | 2 |
| 4FT-2L-T5 replacing 400-600W | 3 | 0 | 0 | 0 |
| 4FT-3L-T5 replacing 400-600W | 1 | 1 | 0 | 1 |
| 4FT-4L-T5 replacing < 400W | 42 | 25 | 21 | 46 |
| 4FT-4L-T5 replacing 400-600W | 106 | 39 | 38 | 77 |
| 4FT-6L-T5 replacing < 400W | 4 | 1 | 3 | 4 |
| 4FT-6L-T5 replacing 400-600W | 16 | 8 | 3 | 11 |
| 4FT-6L-T5 replacing > 600W | 1 | 0 | 1 | 1 |

### *3.2.3 2006-08, 2010-12 and 2013-14 Loggers Used for Adjustments*

Logger data that was collected throughout the 2006-08, 2010-12, and 2013-14 evaluation periods have been leveraged to develop factors that can be used to adjust the self-reported operating hour schedules that were garnered from the on-site visit. That analysis was performed by combining all the CFL, LED, and linear fluorescent logger data that was collected from these three evaluations. The adjustments were made at the technology, market segment and activity area level. These adjustments were also made at the control type level. Logger data, self-reports and business schedules were combined for each of the measures based on whether or not the measure was controlled by a switch or an occupancy sensor. The measures were also combined across technologies to create two general lighting technology categories – a linear category and a non-linear category. For the purposes of developing adjustment factors, all screw- in CFL and LED measures were combined to represent the non-linear technology and all linear measures were combined under the linear category. It was thought that, since LED lamps and reflectors were often replacing incandescent and halogen lighting, that could very well be replaced with CFLs and have similar (or identical) operating schedules, that these adjustments could be applied to LED lighting as well. This approach was tested and the results are presented in Section 4.

Table 3-10 and Table 3-11 present the number of sites and number of loggers that were used in the adjustment analysis of measures controlled by switches and controls for each technology by market segment and activity area. Only market segment-activity area combinations for which at least 6 sites were monitored were used in the analysis to ensure reliability in the adjustment factors. For market segment-activity area combinations that were not well-represented, adjustments were also created at the technology-market segment level and at the technology level alone. In total, over 8,000 loggers representing 1,900 sites were used in the adjustment process for measures installed on a switch. For controls, roughly 1,300 loggers were represented in over 400 sites.

**Table 3-10: 2006-08, 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Switches**

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | **Total Sites** | **Total Loggers** | **Total Sites** | **Total Loggers** |
| **Agriculture** | | | | |
| OtherMisc | 8 | 17 | 9 | 39 |
| **Total Agriculture** | **8** | **17** | **9** | **39** |
| **Assembly** | | | | |
| Auditorium/Gym | 10 | 24 | 7 | 11 |
| Classroom | 12 | 19 | 28 | 80 |
| Dining | 18 | 27 | 14 | 26 |
| HallwayLobby | 79 | 140 | 28 | 54 |

## Table 3-10 (Cont'd): 2006-08, 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Switches

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | **Total Sites** | **Total Loggers** | **Total Sites** | **Total Loggers** |
| Kitchen/Break Room | 18 | 21 | 28 | 36 |
| Office | 30 | 49 | 40 | 91 |
| OtherMisc | 40 | 69 | 25 | 67 |
| Recreation | 7 | 14 | 10 | 33 |
| Religious Worship | 37 | 64 | 7 | 13 |
| Restrooms | 57 | 79 | 14 | 25 |
| Storage | 42 | 54 | 21 | 36 |
| **Total Assembly** | **143** | **560** | **66** | **472** |
| **Education - Primary/Secondary** | | | | |
| Classroom | | | 46 | 188 |
| HallwayLobby | | | 20 | 30 |
| Kitchen/Break Room | | | 21 | 30 |
| Office | | | 29 | 56 |
| OtherMisc | 18 | 35 | 23 | 58 |
| Restrooms | 12 | 18 | 19 | 33 |
| Storage | | | 8 | 14 |
| **Total Education - Primary/Secondary** | **22** | **53** | **55** | **409** |
| **Government** | | | | |
| OtherMisc | | | 11 | 55 |
| **Total Government** | | | 11 | 55 |
| **Grocery** | | | | |
| OtherMisc | 7 | 7 | 6 | 10 |
| RetailSales | | | 14 | 38 |
| Storage | 6 | 8 | 7 | 12 |
| **Total Grocery** | **9** | **15** | **14** | **60** |
| **Health/Medical - Clinic** | | | | |
| Comm/Ind Work | 7 | 8 | 14 | 24 |
| HallwayLobby | 52 | 88 | 39 | 86 |
| Kitchen/Break Room | 9 | 10 | 19 | 26 |
| Office | 29 | 47 | 42 | 120 |
| OtherMisc | 22 | 49 | 16 | 51 |
| Patient Rooms | | | 10 | 25 |
| Restrooms | 33 | 48 | 12 | 15 |
| Storage | 21 | 27 | 16 | 21 |
| **Total Health/Medical - Clinic** | **93** | **277** | **52** | **368** |

**Table 3-10 (Cont'd): 2006-08, 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Switches**

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | Total Sites | Total Loggers | Total Sites | Total Loggers |
| **Laundry** | | | | |
| OtherMisc | | | 6 | 14 |
| **Total Laundry** | | | **6** | **14** |
| **Lodging** | | | | |
| Comm/Ind Work | 16 | 19 | | |
| Dining | 13 | 15 | | |
| Guest Rooms | 98 | 570 | | |
| HallwayLobby | 54 | 104 | | |
| Kitchen/Break Room | 14 | 16 | | |
| Office | 13 | 16 | | |
| OtherMisc | 16 | 30 | 15 | 37 |
| Restrooms | 35 | 67 | | |
| Storage | 14 | 15 | | |
| **Total Lodging** | **129** | **852** | **15** | **37** |
| **Office - Large** | | | | |
| Comm/Ind Work | | | 7 | 28 |
| Conference Room | | | 12 | 19 |
| HallwayLobby | 20 | 39 | 14 | 45 |
| Kitchen/Break Room | | | 13 | 19 |
| Office | 6 | 10 | 21 | 103 |
| OtherMisc | 9 | 18 | 10 | 22 |
| Restrooms | 10 | 17 | | |
| Storage | | | 8 | 22 |
| **Total Office - Large** | **26** | **84** | **28** | **258** |
| **Office - Small** | | | | |
| Comm/Ind Work | | | 16 | 41 |
| Conference Room | 12 | 14 | 22 | 26 |
| Copy Room | | | 9 | 10 |
| HallwayLobby | 51 | 76 | 49 | 82 |
| Kitchen/Break Room | 16 | 16 | 32 | 38 |
| Office | 43 | 65 | 90 | 283 |
| OtherMisc | 9 | 12 | 15 | 27 |
| Restrooms | 75 | 93 | 12 | 14 |
| Storage | 23 | 27 | 31 | 38 |
| **Total Office - Small** | **142** | **303** | **101** | **559** |

**Table 3-10 (Cont'd): 2006-08, 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Switches**

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | Total Sites | Total Loggers | Total Sites | Total Loggers |
| **Other** | | | | |
| OtherMisc | 12 | 27 | 10 | 50 |
| **Total Other** | **12** | **27** | **10** | **50** |
| **Other Commercial** | | | | |
| Comm/Ind Work | | | 7 | 20 |
| HallwayLobby | | | 7 | 10 |
| Office | | | 11 | 24 |
| OtherMisc | 11 | 39 | 15 | 28 |
| Restrooms | 13 | 16 | | |
| Storage | | | 6 | 12 |
| **Total Other Commercial** | **16** | **55** | **21** | **94** |
| **Other Industrial** | | | | |
| Comm/Ind Work | | | 74 | 188 |
| Conference Room | | | 16 | 18 |
| HallwayLobby | 16 | 24 | 37 | 51 |
| Kitchen/Break Room | | | 26 | 36 |
| Office | 13 | 19 | 65 | 172 |
| OtherMisc | 11 | 13 | 28 | 49 |
| Restrooms | 23 | 32 | 23 | 33 |
| Storage | 9 | 11 | 41 | 85 |
| **Total Other Industrial** | **50** | **99** | **120** | **632** |
| **Restaurant** | | | | |
| Dining | 117 | 214 | 21 | 31 |
| HallwayLobby | 50 | 62 | | |
| Kitchen/Break Room | 37 | 40 | 27 | 39 |
| Office | 12 | 14 | | |
| OtherMisc | 22 | 28 | 16 | 28 |
| Restrooms | 70 | 96 | | |
| Storage | 56 | 77 | 8 | 9 |
| **Total Restaurant** | **197** | **531** | **36** | **107** |
| **Retail - Large** | | | | |
| Auto Repair Workshop | | | 13 | 29 |
| Comm/Ind Work | | | 7 | 15 |
| Conference Room | | | 7 | 7 |

## Table 3-10 (Cont'd): 2006-08, 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Switches

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | Total Sites | Total Loggers | Total Sites | Total Loggers |
| HallwayLobby | | | 10 | 17 |
| Kitchen/Break Room | | | 11 | 12 |
| Office | 6 | 6 | 28 | 90 |
| OtherMisc | 7 | 8 | 8 | 16 |
| Restrooms | 9 | 13 | 10 | 13 |
| RetailSales | 38 | 72 | 35 | 80 |
| Storage | 7 | 15 | 26 | 58 |
| **Total Retail - Large** | **53** | **114** | **59** | **337** |
| **Retail - Small** | | | | |
| Auto Repair Workshop | 6 | 9 | 52 | 113 |
| Comm/Ind Work | 9 | 16 | 42 | 73 |
| HallwayLobby | 27 | 34 | 39 | 60 |
| Kitchen/Break Room | 12 | 12 | 27 | 29 |
| Office | 31 | 36 | 86 | 150 |
| OtherMisc | 13 | 16 | 21 | 30 |
| Restrooms | 109 | 138 | 15 | 22 |
| RetailSales | 93 | 159 | 108 | 266 |
| Services | 9 | 13 | 15 | 37 |
| Storage | 35 | 43 | 71 | 116 |
| **Total Retail - Small** | **242** | **476** | **227** | **896** |
| **Warehouse** | | | | |
| Comm/Ind Work | | | 12 | 36 |
| Conference Room | | | 13 | 18 |
| HallwayLobby | | | 19 | 33 |
| Kitchen/Break Room | | | 17 | 25 |
| Office | | | 42 | 125 |
| OtherMisc | 15 | 33 | 19 | 37 |
| Restrooms | 12 | 18 | 15 | 18 |
| Storage | | | 44 | 101 |
| **Total Warehouse** | **23** | **51** | **74** | **393** |
| **All Building Types** | **1,046** | **3,531** | **889** | **4,780** |

## Table 3-11: 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Controls

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | Total Sites | Total Loggers | Total Sites | Total Sites |
| **Assembly** | | | | |
| HallwayLobby | 7 | 8 | | |
| OtherMisc | 4 | 7 | 16 | 47 |
| Restrooms | 18 | 27 | 12 | 18 |
| Storage | 7 | 9 | 6 | 10 |
| **Total Assembly** | **30** | **51** | **24** | **75** |
| **Education - Primary/Secondary** | | | | |
| Classroom | | | 6 | 18 |
| Office | | | 7 | 13 |
| OtherMisc | 2 | 3 | 8 | 29 |
| Restrooms | 6 | 13 | 7 | 11 |
| **Total Education - Primary/Secondary** | **6** | **16** | **14** | **71** |
| **Health/Medical - Clinic** | | | | |
| OtherMisc | 4 | 14 | | |
| Restrooms | 9 | 12 | | |
| **Total Health/Medical - Clinic** | **12** | **26** | | |
| **Lodging** | | | | |
| Guest Rooms | 16 | 97 | | |
| HallwayLobby | 7 | 15 | | |
| OtherMisc | 9 | 17 | | |
| **Total Lodging** | **27** | **129** | | |
| **Office - Large** | | | | |
| OtherMisc | | | 8 | 27 |
| **Total Office - Large** | | | **8** | **27** |
| **Office - Small** | | | | |
| OtherMisc | 3 | 4 | 8 | 16 |
| Restrooms | 20 | 23 | | |
| **Total Office - Small** | **21** | **27** | **8** | **16** |
| **Other** | | | | |
| OtherMisc | 24 | 43 | 31 | 120 |
| **Total Other** | **24** | **43** | **31** | **120** |

### Table 3-11 (Cont'd): 2010-12 and 2013-14 Logger Data Used for Adjustment Factors by Building Type and Activity Area for Controls

| Building Type<br>Activity Area | Non-Linear | | Linear | |
|---|---|---|---|---|
| | Total Sites | Total Loggers | Total Sites | Total Sites |
| **Other Industrial** | | | | |
| Comm/Ind Work | | | 24 | 85 |
| Office | | | 7 | 22 |
| OtherMisc | 1 | 1 | 10 | 22 |
| Restrooms | 13 | 16 | 7 | 10 |
| Storage | | | 20 | 70 |
| **Total Other Industrial** | **14** | **17** | **55** | **209** |
| **Restaurant** | | | | |
| OtherMisc | 7 | 11 | | |
| Restrooms | 8 | 11 | | |
| **Total Restaurant** | **15** | **22** | | |
| **Retail - Large** | | | | |
| OtherMisc | | | 12 | 36 |
| Restrooms | | | 8 | 12 |
| Storage | | | 16 | 58 |
| **Total Retail - Large** | | | **26** | **106** |
| **Retail - Small** | | | | |
| Auto Repair Workshop | | | 9 | 12 |
| Comm/Ind Work | | | 8 | 18 |
| OtherMisc | 5 | 6 | 20 | 33 |
| Restrooms | 36 | 42 | 6 | 8 |
| Storage | | | 9 | 13 |
| **Total Retail - Small** | **39** | **48** | **44** | **84** |
| **Warehouse** | | | | |
| OtherMisc | 2 | 4 | 17 | 45 |
| Restrooms | 9 | 15 | 7 | 15 |
| Storage | | | 36 | 119 |
| **Total Warehouse** | **10** | **19** | **52** | **179** |
| **All Building Types** | **171** | **398** | **262** | **887** |

### *3.2.4 New and Existing On-site Data Used to Support Pre- and Post-Retrofit Operating Hours*

Two sources of data were discussed above that provide data to support the development of 8,760 operating schedules for pre- and post-retrofit lighting usage: lighting logger data and adjusted self-report data. For LED and T5 measures, these data sources include new data collection for this 2014 evaluation that is combined with existing data from previous studies. For ESPI measures, where no new on-site data collection has been performed – CFL, linear delamping and occupancy sensors – the logger data and adjusted self-reports from the past evaluations have been used to update the PY 2014 operating hours for these measures.

Table 3-12 through Table 3-18 present the number of sites, loggers and unique schedule observations that were developed from these two data sources and were available for use in the development of operating hours. For CFL lamps and reflectors and occupancy sensor measures, these counts represent the data actually used to update the operating hour parameters for these measures in 2014. The “total observations” field in the tables below represents the actual logger data combined with all the adjusted self-report data that was generated from the 2006-08 and 2010-12 evaluations. For linear fluorescents, high bay fluorescents and LED lamp measures these data represent all the data collected for these measures from 2006-08 through 2014. These data are aggregated, as discussed in the operating analysis section, to create a single load shape for that activity area.

It is also important to note that the classification of customers into the building types presented below was based on actual data collected during the on-site visit from the previous evaluations. While the population of 2014 program participants are classified based on tracking data information, we believe the data collected during the on-site visit provides a more accurate assessment of the customer’s building type and improves the reliability of the overall results. However, when developing population level results to update load shape impacts, which will be discussed in Section 4, the analysis building types presented below will be aggregated up to building types found in the tracking data.

**Table 3-12: Number of Unique Sites, Loggers and Observations for CFL Lamps by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Assembly** | | | |
| Assembly | 7 | 3 | 8 |
| HallwayLobby | 25 | 30 | 40 |
| Kitchen/Break Room | 6 | 6 | 7 |
| Office | 11 | 11 | 14 |

**Table 3-12 (Cont'd): Number of Unique Sites, Loggers and Observations for CFL Lamps by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| OtherMisc | 15 | 25 | 31 |
| Outdoor | 3 | 0 | 4 |
| Religious Worship | 6 | 11 | 11 |
| Restrooms | 22 | 22 | 32 |
| Storage | 14 | 14 | 18 |
| **Total Assembly** | **43** | **122** | **165** |
| **Education - Primary/Secondary** | | | |
| OtherMisc | 14 | 20 | 37 |
| Outdoor | 2 | 0 | 2 |
| Restrooms | 19 | 25 | 37 |
| **Total Education - Primary/Secondary** | **23** | **45** | **76** |
| **Grocery** | | | |
| OtherMisc | 9 | 14 | 17 |
| **Total Grocery** | **9** | **14** | **17** |
| **Health/Medical - Clinic** | | | |
| HallwayLobby | 13 | 18 | 22 |
| OtherMisc | 15 | 40 | 57 |
| Restrooms | 18 | 23 | 32 |
| **Total Health/Medical - Clinic** | **30** | **81** | **111** |
| **Lodging** | | | |
| Guest Rooms | 22 | 207 | 207 |
| HallwayLobby | 6 | 14 | 14 |
| OtherMisc | 6 | 14 | 14 |
| Outdoor | 1 | 0 | 5 |
| Restrooms | 7 | 17 | 17 |
| **Total Lodging** | **26** | **252** | **257** |
| **Office - Large** | | | |
| OtherMisc | 6 | 14 | 14 |
| Outdoor | 1 | 0 | 1 |
| **Total Office - Large** | **6** | **14** | **15** |

**Table 3-12 (Cont'd): Number of Unique Sites, Loggers and Observations for CFL Lamps by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Office - Small** | | | |
| HallwayLobby | 10 | 5 | 11 |
| Office | 7 | 2 | 9 |
| OtherMisc | 10 | 8 | 14 |
| Restrooms | 44 | 45 | 55 |
| **Total Office - Small** | **54** | **60** | **89** |
| **Other** | | | |
| OtherMisc | 19 | 25 | 35 |
| Outdoor | 2 | 0 | 2 |
| **Total Other** | **19** | **25** | **37** |
| **Other Industrial** | | | |
| OtherMisc | 8 | 8 | 15 |
| Outdoor | 2 | 0 | 2 |
| Restrooms | 21 | 20 | 30 |
| **Total Other Industrial** | **24** | **27** | **46** |
| **Restaurant - Sit Down** | | | |
| Dining | 13 | 14 | 29 |
| OtherMisc | 6 | 8 | 12 |
| Outdoor | 2 | 0 | 2 |
| Restrooms | 14 | 9 | 16 |
| Storage | 6 | 6 | 7 |
| **Total Restaurant - Sit Down** | **23** | **37** | **66** |
| **Retail - Large** | | | |
| OtherMisc | 10 | 9 | 16 |
| Outdoor | 3 | 0 | 3 |
| Restrooms | 13 | 13 | 20 |
| RetailSales | 16 | 23 | 33 |
| **Total Retail - Large** | **31** | **44** | **71** |
| **Retail - Small** | | | |
| HallwayLobby | 9 | 7 | 10 |
| Office | 8 | 5 | 8 |
| OtherMisc | 14 | 10 | 18 |
| Outdoor | 2 | 0 | 3 |
| Restrooms | 91 | 76 | 109 |
| RetailSales | 16 | 10 | 20 |

### Table 3-12 (Cont'd): Number of Unique Sites, Loggers and Observations for CFL Lamps by Building Type and Activity Area (2006-08 and 2010-12)

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| Storage | 23 | 14 | 25 |
| **Total Retail - Small** | **115** | **122** | **193** |
| **Storage** | | | |
| OtherMisc | 2 | 3 | 3 |
| Restrooms | 7 | 9 | 13 |
| **Total Storage** | **8** | **12** | **16** |
| **Warehouse** | | | |
| OtherMisc | 1 | 1 | 1 |
| Restrooms | 7 | 6 | 11 |
| **Total Warehouse** | **8** | **7** | **12** |

The on-site data collection for CFL lamps extended from the 2006-2008 program period through 2010-2012. In general, the distribution of CFL lamp installations is fairly consistent across building types. Restrooms, hallway and lobbies represent the most significant share of installations for most building types. In the lodging sector, individual guest rooms represent the most significant share with 207 loggers installed in 22 of the 26 unique sites that were audited. For small retail, of the 115 stores that were evaluated from 2006-08 and 2010-12, unique site level restrooms were represented in 91 of them, 76 loggers monitored activity within those restrooms and a total of 109 unique observations were collected (combined logger and adjusted self-report data). The "other miscellaneous" category for each building type represents all of the activity areas that did not represent at least 6 unique observations at the building type-activity area level. Likewise, any CFL lamps that were installed outside have been reported separately regardless of the number of unique site-activity area combinations. No monitoring was done on outdoor measures.

### Table 3-13: Number of Unique Sites, Loggers and Observations for CFL Reflectors by Building Type and Activity Area (2006-08 and 2010-12)

| Building Type<br>Activity Areas | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Assembly** | | | |
| HallwayLobby | 6 | 9 | 16 |
| OtherMisc | 14 | 25 | 39 |
| Outdoor | 4 | 0 | 4 |
| **Total Assembly** | **18** | **32** | **57** |

**Table 3-13 (Cont'd): Number of Unique Sites, Loggers and Observations for CFL Reflectors by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Areas | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Health/Medical - Clinic** | | | |
| HallwayLobby | 10 | 14 | 18 |
| OtherMisc | 11 | 11 | 23 |
| **Total Health/Medical - Clinic** | **17** | **24** | **40** |
| **Lodging** | | | |
| OtherMisc | 5 | 19 | 21 |
| Outdoor | 1 | 0 | 1 |
| **Total Lodging** | **6** | **19** | **22** |
| **Office - Small** | | | |
| HallwayLobby | 6 | 2 | 8 |
| Office | 6 | 3 | 11 |
| OtherMisc | 9 | 2 | 13 |
| **Total Office - Small** | **13** | **7** | **30** |
| **Other** | | | |
| OtherMisc | 23 | 39 | 63 |
| Outdoor | 8 | 0 | 10 |
| **Total Other** | **29** | **39** | **73** |
| **Other Industrial** | | | |
| OtherMisc | 9 | 13 | 19 |
| Outdoor | 1 | 0 | 1 |
| **Total Other Industrial** | **9** | **13** | **20** |
| **Retail - Large** | | | |
| OtherMisc | 6 | 8 | 15 |
| **Total Retail - Large** | **6** | **8** | **15** |
| **Retail - Small** | | | |
| OtherMisc | 16 | 15 | 26 |
| Outdoor | 7 | 0 | 7 |
| Restrooms | 9 | 3 | 10 |
| RetailSales | 13 | 12 | 22 |
| **Total Retail - Small** | **34** | **30** | **65** |

While on-site data collection for CFL reflector lamps began in the 2006-2008 program cycle, the majority of data collected for the measure took place in 2010-2012. CFL reflector lamps were generally represented in many of the same building types as CFL lamps, but the activity area distribution of those installations is a bit different. Restroom installations are less prominent with reflector lamps and the overall spread of measure installations is more evenly distributed throughout a variety of activity areas. Again, the "other miscellaneous" category combines all the unique site-activity areas that are less than 6.

**Table 3-14: Number of Unique Sites, Loggers and Observations for High Bay Linears by Building Type and Activity Area (2006-08, 2010-12 and 2013-14)**

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Agriculture** | | | |
| OtherMisc | 8 | 20 | 30 |
| Outdoor | 4 | 0 | 2 |
| **Total Agriculture** | **10** | **20** | **32** |
| **Assembly** | | | |
| Classroom | 9 | 21 | 29 |
| HallwayLobby | 10 | 8 | 12 |
| Kitchen/Break Room | 8 | 4 | 6 |
| Office | 13 | 20 | 21 |
| OtherMisc | 15 | 21 | 26 |
| Outdoor | 1 | 0 | 0 |
| Recreation | 13 | 29 | 38 |
| Restrooms | 8 | 6 | 11 |
| Storage | 9 | 5 | 9 |
| **Total Assembly** | **30** | **111** | **149** |
| **Education - Primary School** | | | |
| Classroom | 10 | 38 | 55 |
| HallwayLobby | 6 | 7 | 9 |
| Kitchen/Break Room | 6 | 6 | 7 |
| Office | 9 | 9 | 16 |
| OtherMisc | 9 | 24 | 33 |
| Restrooms | 7 | 8 | 15 |
| **Total Education - Primary School** | **14** | **89** | **129** |
| **Education - Secondary School** | | | |
| OtherMisc | 7 | 30 | 36 |
| **Total Education - Secondary School** | **7** | **30** | **36** |
| **Office - Large** | | | |
| OtherMisc | 7 | 48 | 61 |
| Storage | 10 | 17 | 20 |
| **Total Office - Large** | **13** | **64** | **80** |

**Table 3-14 (Cont'd): Number of Unique Sites, Loggers and Observations for High Bay Linears by Building Type and Activity Area (2006-08, 2010-12 and 2013-14)**

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Office - Small** | | | |
| Comm/Ind Work | 6 | 9 | 10 |
| OtherMisc | 9 | 7 | 47 |
| **Total Office - Small** | **14** | **16** | **57** |
| **Other** | | | |
| OtherMisc | 15 | 40 | 46 |
| Outdoor | 2 | 0 | 1 |
| **Total Other** | **16** | **40** | **47** |
| **Other Industrial** | | | |
| Comm/Ind Work | 77 | 162 | 221 |
| Kitchen/Break Room | 8 | 7 | 10 |
| Office | 20 | 35 | 48 |
| OtherMisc | 25 | 27 | 40 |
| Outdoor | 1 | 0 | 1 |
| Restrooms | 6 | 9 | 11 |
| Storage | 37 | 89 | 112 |
| **Total Other Industrial** | **112** | **324** | **438** |
| **Retail - Large** | | | |
| Auto Repair Workshop | 9 | 7 | 12 |
| Comm/Ind Work | 13 | 13 | 23 |
| Office | 7 | 16 | 17 |
| OtherMisc | 10 | 8 | 11 |
| Outdoor | 1 | 0 | 1 |
| RetailSales | 22 | 28 | 42 |
| Storage | 29 | 49 | 69 |
| **Total Retail - Large** | **52** | **116** | **169** |
| **Retail - Small** | | | |
| Auto Repair Workshop | 45 | 58 | 91 |
| Comm/Ind Work | 24 | 34 | 50 |
| HallwayLobby | 8 | 7 | 11 |
| Office | 21 | 13 | 26 |
| OtherMisc | 17 | 18 | 25 |
| Outdoor | 2 | 0 | 0 |
| RetailSales | 31 | 25 | 62 |
| Storage | 21 | 18 | 31 |
| **Total Retail - Small** | **107** | **173** | **295** |

**Table 3-14 (Cont'd): Number of Unique Sites, Loggers and Observations for High Bay Linears by Building Type and Activity Area (2006-08, 2010-12 and 2013-14)**

| Building Type<br>Activity Area | Unique Site-Activity Areas | Total Loggers | Total Observations |
|---|---|---|---|
| **Storage** | | | |
| Comm/Ind Work | 8 | 21 | 32 |
| OtherMisc | 11 | 27 | 36 |
| Outdoor | 2 | 0 | 1 |
| Storage | 53 | 129 | 173 |
| **Total Storage** | **61** | **177** | **242** |
| **Warehouse** | | | |
| Comm/Ind Work | 13 | 20 | 21 |
| OtherMisc | 5 | 16 | 17 |
| Outdoor | 1 | 0 | 0 |
| Storage | 30 | 41 | 58 |
| **Total Warehouse** | **46** | **77** | **96** |

The on-site data collection for high bay linear measures began in the 2006-2008 program period and extended through the 2013-2014 program cycle. This measure group represents high output T5 and T8 linear fluorescent measures. As discussed above, in Section 3.2 high bay measures were generally installed in more commercial and industrial building types (warehouses, manufacturing, retail, etc.) and the activity area distribution for these installations is represented more predominantly in high bay storage areas and higher usage space types like commercial and industrial work spaces. In the industrial building type segment, commercial/industrial work space was represented in 77 of the 112 total sites. A total of 162 lighting loggers were analyzed from this building type-activity area. For small retail, the distribution of activity area installation and analysis loggers was fairly consistent between commercial/industrial work space, retail sales, offices and storage areas. For large retail, of the 116 loggers that were used in the analysis, 77 were installed in retail sales and storage areas.

**Table 3-15: Number of Unique Sites, Loggers and Observations for LED Lamps by Building Type and Activity Area (2010-12 and 2013-2014)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Assembly** | | | |
| Classroom | 6 | 5 | 7 |
| HallwayLobby | 22 | 17 | 30 |
| Kitchen/Break Room | 6 | 2 | 5 |
| OtherMisc | 16 | 18 | 23 |
| Outdoor | 11 | 0 | 3 |
| Religious Worship | 10 | 9 | 12 |
| Restrooms | 19 | 19 | 24 |
| Storage | 17 | 14 | 20 |
| **Total Assembly** | **35** | **80** | **118** |
| **Health/Medical Clinic** | | | |
| HallwayLobby | 13 | 8 | 12 |
| Office | 6 | 2 | 5 |
| OtherMisc | 15 | 14 | 22 |
| Outdoor | 4 | 0 | 0 |
| Patient Rooms | 6 | 5 | 10 |
| Restrooms | 15 | 13 | 19 |
| Storage | 12 | 11 | 13 |
| **Total Health/Medical Clinic** | **27** | **53** | **80** |
| **Lodging** | | | |
| Comm/Ind Work | 9 | 7 | 9 |
| Guest Rooms | 55 | 107 | 199 |
| HallwayLobby | 23 | 16 | 24 |
| OtherMisc | 26 | 13 | 19 |
| Outdoor | 16 | 1 | 2 |
| Restrooms | 9 | 5 | 8 |
| Storage | 7 | 4 | 7 |
| **Total Lodging** | **61** | **151** | **265** |
| **Office - Small** | | | |
| HallwayLobby | 12 | 8 | 14 |
| Office | 13 | 5 | 12 |
| OtherMisc | 6 | 2 | 5 |
| Outdoor | 6 | 0 | 1 |
| Restrooms | 42 | 28 | 45 |
| Storage | 8 | 3 | 8 |
| **Total Office - Small** | **53** | **42** | **81** |

**Table 3-15 (Cont'd): Number of Unique Sites, Loggers and Observations for LED Lamps by Building Type and Activity Area (2010-12 and 2013-2014)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Other** | | | |
| OtherMisc | 14 | 16 | 23 |
| Outdoor | 5 | 0 | 1 |
| **Total Other** | **17** | **16** | **24** |
| **Other Industrial** | | | |
| OtherMisc | 4 | 4 | 7 |
| Outdoor | 1 | 0 | 1 |
| Restrooms | 14 | 7 | 16 |
| **Total Other Industrial** | **15** | **11** | **23** |
| **Restaurant - Fast Food** | | | |
| Dining | 23 | 10 | 27 |
| OtherMisc | 13 | 7 | 15 |
| Restrooms | 19 | 17 | 22 |
| Storage | 12 | 6 | 15 |
| **Total Restaurant - Fast Food** | **46** | **40** | **77** |
| **Restaurant - Sit Down** | | | |
| Dining | 36 | 41 | 58 |
| HallwayLobby | 12 | 9 | 12 |
| Kitchen/Break Room | 11 | 6 | 9 |
| OtherMisc | 4 | 2 | 4 |
| Outdoor | 1 | 0 | 0 |
| Restrooms | 27 | 23 | 32 |
| Storage | 20 | 12 | 19 |
| **Total Restaurant - Sit Down** | **58** | **92** | **129** |
| **Retail - Large** | | | |
| OtherMisc | 7 | 9 | 10 |
| Outdoor | 2 | 0 | 0 |
| RetailSales | 19 | 25 | 32 |
| **Total Retail - Large** | **24** | **34** | **42** |

**Table 3-15 (Cont'd): Number of Unique Sites, Loggers and Observations for LED Lamps by Building Type and Activity Area (2010-12 and 2013-2014)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Retail - Small** | | | |
| Kitchen/Break Room | 6 | 6 | 7 |
| OtherMisc | 12 | 9 | 12 |
| Outdoor | 2 | 0 | 1 |
| Restrooms | 55 | 39 | 69 |
| RetailSales | 23 | 26 | 32 |
| Storage | 11 | 7 | 13 |
| **Total Retail - Small** | **77** | **87** | **133** |
| **Warehouse** | | | |
| OtherMisc | 6 | 5 | 9 |
| **Total Warehouse** | **6** | **5** | **9** |

The on-site data collection for LED lamps began in the 2010-2012 program period, with the most significant ex ante claims beginning in the last three quarters of 2012, and extended throughout the 2013-2014 program cycle. As discussed in Section 3.2 the 2014 incremental sample design for LED lamps included building types that were first analyzed under 2010-2012 and 2013 and included new data collection on building types that began to represent more significant ex ante savings claims. As part of the 2010-2012 program cycle (which included 2013 Q1 and Q2 participants), LED lamps were predominantly installed in retail establishments, small offices and restaurants. Beginning in the second quarter of 2013, installations in hotels/motels increased substantially and moving forward into 2014, assembly and health/medical clinics began to represent a more significant level of installations and savings.

For assembly and health/medical clinics, the installation of LED lamps and loggers was more evenly distributed than other building types. For small retail and offices, restrooms represented the majority of unique site-activity area installations – 42 of 53 sites for small office and 55 of 77 sites for small retail. The distribution of installations for restaurants included more high usage activity areas like dining areas as well as restrooms and storage areas. LED lamps installed in guest rooms were represented in 55 of the 61 hotel sites.

**Table 3-16: Number of Unique Sites, Loggers and Observations for LED Reflectors by Building Type and Activity Area (2010-12 and 2013-14)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Assembly** | | | |
| HallwayLobby | 7 | 7 | 8 |
| OtherMisc | 15 | 24 | 35 |
| Outdoor | 10 | 0 | 3 |
| Religious Worship | 8 | 4 | 8 |
| **Total Assembly** | **27** | **34** | **53** |
| **Health/Medical Clinic** | | | |
| OtherMisc | 7 | 10 | 13 |
| Outdoor | 1 | 0 | 0 |
| **Total Health/Medical Clinic** | **7** | **10** | **13** |
| **Lodging** | | | |
| Dining | 8 | 5 | 6 |
| Guest Rooms | 13 | 4 | 13 |
| HallwayLobby | 16 | 15 | 16 |
| OtherMisc | 12 | 10 | 12 |
| Outdoor | 4 | 0 | 0 |
| Restrooms | 6 | 4 | 5 |
| **Total Lodging** | **29** | **32** | **46** |
| **Office - Small** | | | |
| Conference Room | 7 | 5 | 7 |
| HallwayLobby | 16 | 16 | 20 |
| Kitchen/Break Room | 6 | 4 | 5 |
| Office | 23 | 17 | 26 |
| OtherMisc | 7 | 3 | 4 |
| Outdoor | 5 | 0 | 1 |
| Restrooms | 8 | 5 | 8 |
| **Total Office - Small** | **42** | **47** | **68** |
| **Other** | | | |
| OtherMisc | 17 | 14 | 21 |
| Outdoor | 5 | 0 | 0 |
| **Total Other** | 19 | 14 | 21 |
| **Other Industrial** | | | |
| OtherMisc | 6 | 8 | 15 |
| Outdoor | 3 | 0 | 1 |
| **Total Other Industrial** | **8** | **8** | **16** |

**Table 3-16 (Cont'd): Number of Unique Sites, Loggers and Observations for LED Reflectors by Building Type and Activity Area (2010-12 and 2013-14)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Restaurant - Fast Food** | | | |
| Dining | 24 | 11 | 23 |
| Kitchen/Break Room | 12 | 5 | 10 |
| OtherMisc | 9 | 6 | 11 |
| Outdoor | 5 | 0 | 1 |
| **Total Restaurant - Fast Food** | **41** | **20** | **43** |
| **Restaurant - Sit Down** | | | |
| Dining | 47 | 38 | 61 |
| HallwayLobby | 19 | 12 | 23 |
| OtherMisc | 6 | 3 | 6 |
| Outdoor | 9 | 0 | 5 |
| Restrooms | 7 | 2 | 7 |
| **Total Restaurant - Sit Down** | **54** | **51** | **93** |
| **Retail - Large** | | | |
| OtherMisc | 7 | 10 | 13 |
| Outdoor | 1 | 0 | 0 |
| RetailSales | 20 | 26 | 32 |
| **Total Retail - Large** | **23** | **34** | **43** |
| **Retail - Small** | | | |
| Office | 8 | 5 | 7 |
| OtherMisc | 13 | 7 | 10 |
| Outdoor | 10 | 0 | 6 |
| RetailSales | 50 | 64 | 96 |
| Storage | 6 | 4 | 5 |
| **Total Retail - Small** | **67** | **80** | **123** |
| **Warehouse** | | | |
| OtherMisc | 5 | 1 | 5 |
| Outdoor | 3 | 0 | 0 |
| **Total Warehouse** | **6** | **1** | **5** |

The on-site data collection for LED reflector lamps began in the 2010-2012 program period, with the most significant ex ante claims beginning in the last three quarters of 2012, and extended throughout the 2013-2014 program cycle. The 2014 incremental sample design for LED reflector lamps included building types that were first analyzed under 2010-2012 and 2013 and included new data collection on building types that began to represent more significant ex ante savings claims. As part of the 2010-2012 program cycle (which included 2013 Q1 and Q2 participants), LED reflector lamps were predominantly installed in retail establishments, small offices and restaurants. Beginning in the second quarter of 2013, installations in hotels/motels increased substantially and moving forward into 2014, assembly began to represent a more significant level of installations and savings.

The installation of LED reflector measures is, generally, more evenly distributed than that of LED lamps. While the same building types are represented, measures are being installed in activity areas with higher usage rates like retail sales and dining areas. For the small retail segment, unique retail sales installations were represented in 50 of the 67 sites visited with 64 loggers used in the analysis. For large retail, LED reflector lamps were installed in retail sales areas for 20 of the 23 sites (26 loggers represented those 20 unique activity area installations). For restaurants, dining areas are most represented and for small offices, installations in hallways, lobbies and offices are most significant. It's important to note that for some building type segments (especially the restaurants) total logger counts are less than the total number of sites visited. This is primarily driven by two factors – the directionality of some LED reflector measures made it difficult to install loggers and site contacts were often reluctant to allow logging within their restaurants.

**Table 3-17: Number of Unique Sites, Loggers and Observations for Linears by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Agriculture** | | | |
| OtherMisc | 7 | 28 | 36 |
| **Total Agriculture** | **7** | **28** | **36** |
| **Assembly** | | | |
| Classroom | 29 | 78 | 89 |
| Dining | 12 | 23 | 24 |
| HallwayLobby | 28 | 41 | 62 |
| Kitchen/Break Room | 25 | 31 | 42 |
| Office | 42 | 68 | 86 |
| OtherMisc | 37 | 61 | 95 |
| Outdoor | 3 | 0 | 6 |
| Recreation | 13 | 21 | 31 |
| Restrooms | 18 | 25 | 33 |
| Storage | 27 | 23 | 35 |
| **Total Assembly** | **61** | **357** | **488** |

**Table 3-17 (Cont'd): Number of Unique Sites, Loggers and Observations for Linears by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Education - Primary/Secondary** | | | |
| Classroom | 50 | 166 | 220 |
| HallwayLobby | 25 | 29 | 40 |
| Kitchen/Break Room | 29 | 28 | 43 |
| Office | 37 | 54 | 83 |
| OtherMisc | 25 | 34 | 55 |
| Outdoor | 1 | 0 | 2 |
| Restrooms | 33 | 35 | 59 |
| Storage | 15 | 14 | 28 |
| **Total Education - Primary/Secondary** | **52** | **346** | **511** |
| **Grocery** | | | |
| OtherMisc | 12 | 22 | 31 |
| Outdoor | 3 | 0 | 5 |
| RetailSales | 16 | 38 | 43 |
| **Total Grocery** | **17** | **60** | **79** |
| **Health/Medical - Clinic** | | | |
| Comm/Ind Work | 17 | 28 | 30 |
| HallwayLobby | 45 | 91 | 102 |
| Kitchen/Break Room | 23 | 26 | 31 |
| Office | 44 | 124 | 144 |
| OtherMisc | 16 | 51 | 53 |
| Patient Rooms | 12 | 25 | 29 |
| Restrooms | 17 | 20 | 22 |
| Storage | 20 | 22 | 25 |
| **Total Health/Medical - Clinic** | **55** | **374** | **422** |
| **Lodging** | | | |
| OtherMisc | 16 | 53 | 62 |
| Outdoor | 3 | 0 | 2 |
| **Total Lodging** | **16** | **53** | **64** |
| **Office - Large** | | | |
| Conference Room | 13 | 14 | 25 |
| HallwayLobby | 20 | 40 | 61 |
| Kitchen/Break Room | 15 | 13 | 23 |
| Office | 25 | 97 | 131 |
| OtherMisc | 13 | 23 | 49 |
| Storage | 16 | 19 | 32 |
| **Total Office - Large** | **28** | **198** | **313** |

**Table 3-17 (Cont'd): Number of Unique Sites, Loggers and Observations for Linears by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Office - Small** | | | |
| Comm/Ind Work | 17 | 35 | 38 |
| Conference Room | 31 | 23 | 40 |
| Copy Room | 17 | 11 | 18 |
| HallwayLobby | 67 | 74 | 123 |
| Kitchen/Break Room | 45 | 41 | 54 |
| Office | 112 | 280 | 350 |
| OtherMisc | 26 | 26 | 50 |
| Restrooms | 24 | 13 | 33 |
| Storage | 50 | 37 | 73 |
| **Total Office - Small** | **126** | **538** | **777** |
| **Other** | | | |
| Office | 9 | 21 | 26 |
| OtherMisc | 23 | 112 | 159 |
| Outdoor | 1 | 0 | 1 |
| **Total Other** | **23** | **132** | **185** |
| **Other Commercial** | | | |
| Comm/Ind Work | 6 | 16 | 16 |
| HallwayLobby | 8 | 12 | 12 |
| Office | 12 | 26 | 26 |
| OtherMisc | 15 | 31 | 31 |
| Storage | 7 | 14 | 14 |
| **Total Other Commercial** | **21** | **99** | **99** |
| **Other Industrial** | | | |
| Comm/Ind Work | 56 | 114 | 169 |
| Conference Room | 17 | 16 | 25 |
| HallwayLobby | 37 | 48 | 71 |
| Kitchen/Break Room | 27 | 31 | 52 |
| Office | 62 | 157 | 242 |
| OtherMisc | 33 | 54 | 94 |
| Outdoor | 2 | 1 | 3 |
| Restrooms | 27 | 27 | 45 |
| Storage | 44 | 53 | 82 |
| **Total Other Industrial** | **91** | **484** | **763** |

**Table 3-17 (Cont'd): Number of Unique Sites, Loggers and Observations for Linears by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Restaurant - Fast Food** | | | |
| Dining | 11 | 16 | 20 |
| Kitchen/Break Room | 13 | 18 | 22 |
| Office | 8 | 7 | 10 |
| OtherMisc | 7 | 8 | 11 |
| Storage | 8 | 7 | 9 |
| **Total Restaurant - Fast Food** | **17** | **56** | **71** |
| **Restaurant - Sit Down** | | | |
| Dining | 12 | 16 | 21 |
| Kitchen/Break Room | 16 | 22 | 27 |
| Office | 7 | 5 | 8 |
| OtherMisc | 7 | 7 | 12 |
| Outdoor | 1 | 0 | 0 |
| Storage | 8 | 7 | 10 |
| **Total Restaurant - Sit Down** | **21** | **57** | **74** |
| **Retail - Large** | | | |
| Comm/Ind Work | 14 | 20 | 36 |
| HallwayLobby | 15 | 22 | 32 |
| Kitchen/Break Room | 18 | 12 | 24 |
| Office | 34 | 70 | 108 |
| OtherMisc | 16 | 33 | 56 |
| Outdoor | 3 | 0 | 6 |
| Restrooms | 18 | 16 | 26 |
| RetailSales | 29 | 50 | 66 |
| Storage | 35 | 55 | 81 |
| **Total Retail - Large** | **56** | **272** | **419** |
| **Retail - Small** | | | |
| Auto Repair Workshop | 45 | 77 | 97 |
| Comm/Ind Work | 54 | 63 | 95 |
| HallwayLobby | 58 | 57 | 84 |
| Kitchen/Break Room | 42 | 32 | 45 |
| Office | 117 | 144 | 202 |
| OtherMisc | 25 | 22 | 30 |
| Outdoor | 6 | 0 | 8 |
| Restrooms | 30 | 22 | 35 |

**Table 3-17 (Cont'd): Number of Unique Sites, Loggers and Observations for Linears by Building Type and Activity Area (2006-08 and 2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| RetailSales | 144 | 259 | 330 |
| Services | 10 | 23 | 23 |
| Storage | 109 | 114 | 179 |
| **Total Retail - Small** | **261** | **808** | **1,123** |
| **Storage** | | | |
| Conference Room | 12 | 8 | 15 |
| HallwayLobby | 20 | 27 | 47 |
| Kitchen/Break Room | 13 | 16 | 21 |
| Office | 33 | 85 | 117 |
| OtherMisc | 24 | 28 | 53 |
| Outdoor | 1 | 0 | 2 |
| Restrooms | 22 | 17 | 33 |
| Storage | 28 | 46 | 77 |
| **Total Storage** | **43** | **221** | **359** |
| **Warehouse** | | | |
| Conference Room | 6 | 10 | 10 |
| HallwayLobby | 9 | 11 | 12 |
| Kitchen/Break Room | 7 | 7 | 9 |
| Office | 18 | 44 | 55 |
| OtherMisc | 8 | 10 | 24 |
| Storage | 13 | 23 | 27 |
| **Total Warehouse** | **26** | **104** | **136** |

The vast majority of on-site data collection for linear fluorescents extended from the 2006-2008 program period through 2010-2012. However, data collected from 2013-2014 was also utilized to update the operating hours and co-incidence factors. While the objective of this impact evaluation was to evaluate T5 linear fluorescents, in the course of the on-site verification effort, some high bay measures that were classified as T5 in the tracking data were actually found to be low bay T8 installations at the time of the on-site verification. While these measures were not included in the wattage or installation rate analysis they were used to help inform the operating hours estimates for delamping measures that had been rebated throughout the 2014 program cycle.

Linear fluorescents are well-represented across a number of different building types and a variety of space types within each of those building types. Likewise, there is a significant amount of logger data and unique observation points that have been collected and analyzed as a result of the three past evaluation efforts. In fact, 261 unique small retail establishments have been evaluated over those periods with 808 loggers used in the analysis.

**Table 3-18: Number of Unique Sites, Loggers and Observations for Occupancy Sensors by Building Type and Activity Area (2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Assembly** | | | |
| Assembly | 7 | 11 | 13 |
| HallwayLobby | 6 | 7 | 10 |
| Kitchen/Break Room | 8 | 6 | 8 |
| Office | 7 | 7 | 13 |
| OtherMisc | 14 | 26 | 33 |
| Restrooms | 17 | 31 | 39 |
| Storage | 11 | 9 | 14 |
| **Total Assembly** | **25** | **94** | **124** |
| **Education - Primary/Secondary** | | | |
| Office | 6 | 12 | 13 |
| OtherMisc | 11 | 24 | 44 |
| Restrooms | 11 | 20 | 29 |
| **Total Education - Primary/Secondary** | **15** | **52** | **82** |
| **Health/Medical - Clinic** | | | |
| OtherMisc | 8 | 32 | 43 |
| Restrooms | 17 | 17 | 31 |
| **Total Health/Medical - Clinic** | **17** | **49** | **74** |
| **Lodging** | | | |
| Guest Rooms | 8 | 13 | 24 |
| OtherMisc | 7 | 19 | 43 |
| **Total Lodging** | **8** | **31** | **66** |
| **Office - Small** | | | |
| OtherMisc | 6 | 25 | 34 |
| Restrooms | 11 | 10 | 17 |
| **Total Office - Small** | **12** | **35** | **51** |
| **Other** | | | |
| OtherMisc | 29 | 101 | 137 |
| **Total Other** | **29** | **101** | **137** |

**Table 3-18 (Cont'd): Number of Unique Sites, Loggers and Observations for Occupancy Sensors by Building Type and Activity Area (2010-12)**

| Building Type<br>Activity Area | Total Sites | Total Loggers | Total Observations |
|---|---|---|---|
| **Other Industrial** | | | |
| Comm/Ind Work | 23 | 79 | 101 |
| Office | 6 | 16 | 41 |
| OtherMisc | 11 | 22 | 33 |
| Outdoor | 1 | 0 | 1 |
| Restrooms | 18 | 15 | 25 |
| Storage | 18 | 51 | 69 |
| **Total Other Industrial** | **55** | **179** | **263** |
| **Retail - Large** | | | |
| OtherMisc | 7 | 16 | 29 |
| Restrooms | 7 | 14 | 17 |
| Storage | 10 | 39 | 53 |
| **Total Retail - Large** | **18** | **66** | **95** |
| **Retail - Small** | | | |
| Comm/Ind Work | 6 | 14 | 19 |
| Office | 6 | 3 | 7 |
| OtherMisc | 14 | 21 | 30 |
| Restrooms | 33 | 28 | 51 |
| Storage | 6 | 6 | 10 |
| **Total Retail - Small** | **46** | **72** | **117** |
| **Storage** | | | |
| OtherMisc | 5 | 8 | 11 |
| Outdoor | 1 | 0 | 1 |
| Restrooms | 9 | 19 | 22 |
| Storage | 22 | 54 | 94 |
| **Total Storage** | **30** | **81** | **128** |

On-site data collection for occupancy sensors occurred during the 2010-2012 program cycle. Occupancy sensors are represented by a variety of building types and space types. The vast majority of fixture integrated occupancy sensors were being installed in high bay applications associated with storage and industrial activities, where panel metering was performed. Wall and ceiling mount controls were installed, more generally, in lower usage space types like restrooms. In fact, 33 of the 46 sites that were evaluated in the small retail sector had controls installed in restrooms. Whereas, for storage facilities, 22 of the 30 sites had lighting controls installed within storage areas.

# 4

# Evaluation Methodology

This section provides an overview of the methods used to estimate the key impact parameters, the ex post UES values and the NTGRs for the deemed lighting ESPI measures identified for PY 2014.

## 4.1 Overview of Approach

The primary objective of this evaluation is to perform a measure and/or measure-parameter impact evaluation, utilizing existing evaluation data and new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for several measures that were identified in the ESPI decision. These parameters, that include operating hours, baseline wattages, installed wattages, installation rates, RULs and estimates of free ridership, can be used to measure ex post performance for PY 2014.

More specifically, these parameter-level results will be aggregated in order to develop kW and kWh UES values, impact load shapes, and NTGRs for the measures that were identified in Appendix 3 of the ESPI decision.

As discussed in more detail below, the impact parameter estimates were developed at different levels of segmentation in order to generate unique UES values by program, market segment and technology. For example, operating hours were generated by market segment and technology whereas pre- and post-wattage values were created based on measure configuration. Similarly, installation rates and NTGRs were developed at the program delivery level.

This section discusses, in detail, the inputs that were used to develop these parameter estimates. They also inform the general approach that was used to develop the UES values. The algorithm that was applied to estimate unit energy savings for a specific hour is:

$$\text{Impact\_Hour\_i} = \begin{bmatrix} (\text{Baseline\_Wattage} \times \text{Percent\_On\_Pre\_Hour\_i}) \\ -(\text{Post\_Wattage} \times \text{Percent\_On\_Post\_Hour\_i}) \end{bmatrix}$$

Where:

Baseline_Wattage = the wattage associated with the measures that were replaced.

Post_Wattage = the wattage associated with the measures that were installed.

Percent_On_Pre = the percentage of time the baseline equipment is on during a specific hour i, which is obtained from adjusted self-reported operating hours gathered on site. These estimates are associated with measures that were installed in conjunction with an occupancy sensor.

Percent_On_Post = the percentage of time the installed equipment is on during a specific hour i, which is obtained from either logger data usage or adjusted self-reported operating hours gathered on site. Often times the Percent_On_Pre and Percent_On_Post are assumed to be equal, except in the case where an occupancy sensor was installed in conjunction with another lighting measure.

The remainder of this section will discuss the following:

- The approach for estimating each individual impact parameter, including the installation rate, the various wattage values and the pre and post operating hours.
- The approach for estimating the NTGRs.

## 4.2 Installation Rate Analysis

The installation rate is defined as the percentage of equipment found to be installed and operable. The installation rate is estimated for each site based on data gathered during the on-site visit. As part of these on-site visits, an objective of the auditor was to attempt to identify all equipment installed along with a disposition of that equipment.

The key measure count that is identified on site is the number of measures that are currently installed and in working condition (operable). The installation rate is calculated directly from this measurement:

$$\text{Installation Rate} = \frac{\text{Quantity of measures installed and operable from on-site visit}}{\text{Quantity of measures reported installed in tracking system}}$$

In addition to identifying the amount of equipment that was installed and operable, the auditor also identified the amount of equipment that was:

- Failed and in place – The number of measures that are currently installed, but were not in working condition (failed).
- Failed and replaced – The number of measures that had been installed, but then had failed and were replaced with a different technology.

- Removed and not replaced - The number of measures that had been installed, but had been removed (either due to failure or other reasons), but were not replaced, such that the lamp socket is empty.
- In storage – The number of measures that were found in storage and have not yet been installed.

Although the installation rate is defined as the percent found to be in place and operable, an analysis was also conducted to determine the percent of rebated measures that were actually received by a participant (received rate). This would include those in place and operable, burned out or replaced or placed in storage.

Table 4-1 presents the installation rates (defined as installed and operable), received rates (percent of rebated measures determined to have actually been received by the participants), storage rates and failure/removal rates for each ESPI measure. For CFL, delamping and occupancy sensor measures, these installation rates were generated from existing data that was collected as part of the 2010-12 NRL Evaluation. For LED and T5 measures, the results that were garnered from that evaluation have been combined with new primary data collection of 2013 and 2014 participants in order to update the verification rates associated with those measures. Also shown are the sample sizes and resulting relative precision measured at the 90% confidence interval.

**Table 4-1: Disposition of Lighting Verification for ESPI Measures by Program Type**

| ESPI Measure Program Type | Sites | Received Rate | Failure Rate | Storage Rate | Removal Rate | Installation Rate | Installation Rate RP |
|---|---|---|---|---|---|---|---|
| **CFL Lamp** | | | | | | | |
| Direct Install | 91 | 90% | 0.9% | 0.3% | 7.8% | 81% | 7% |
| Non-Direct Install | 111 | 84% | 3.5% | 1.0% | 0.7% | 79% | 6% |
| **Total** | **202** | **85%** | **3.1%** | **0.9%** | **1.8%** | **79%** | **4%** |
| **CFL Reflector** | | | | | | | |
| Direct Install | 55 | 98% | 1.1% | 0.6% | 5.9% | 91% | 6% |
| Non-Direct Install | 61 | 93% | 0.5% | 2.1% | 0.1% | 90% | 6% |
| **Total** | **116** | **94%** | **0.6%** | **1.8%** | **1.3%** | **90%** | **4%** |
| **LED Lamp** | | | | | | | |
| Direct Install | 315 | 94% | 1.0% | 0.4% | 2.4% | 91% | 2% |
| Non-Direct Install | 127 | 94% | 0.0% | 3.6% | 0.5% | 90% | 3% |
| **Total** | **442** | **94%** | **0.1%** | **3.2%** | **0.7%** | **90%** | **2%** |
| **LED Reflector** | | | | | | | |
| Direct Install | 239 | 96% | 3.4% | 1.8% | 4.2% | 86% | 3% |
| Non-Direct Install | 102 | 92% | 0.0% | 1.7% | 0.0% | 91% | 4% |
| **Total** | **341** | **93%** | **0.5%** | **1.7%** | **0.7%** | **90%** | **2%** |
| **Linear Delamp** | | | | | | | |
| Direct Install | 17 | 92% | 0.0% | 0.0% | 0.0% | 92% | 13% |
| Non-Direct Install | 139 | 87% | 0.0% | 0.0% | 0.1% | 86% | 4% |
| **Total** | **156** | **87%** | **0.0%** | **0.0%** | **0.1%** | **87%** | **4%** |
| **Occupancy Sensor** | | | | | | | |
| Direct Install | 85 | 99% | 1.4% | 0.0% | 1.4% | 96% | 3% |
| Non-Direct Install | 177 | 96% | 0.4% | 0.3% | 2.3% | 93% | 2% |
| **Total** | **262** | **96%** | **0.4%** | **0.3%** | **2.3%** | **93%** | **2%** |
| **T5 Linear** | | | | | | | |
| Direct Install | 42 | 100% | 0.0% | 0.0% | 0.0% | 100% | 0% |
| Non-Direct Install | 146 | 100% | 0.2% | 0.1% | 0.5% | 99% | 1% |
| **Total** | **188** | **100%** | **0.2%** | **0.1%** | **0.4%** | **99%** | **1%** |

Overall, the installation rates for each ESPI measure range from 79% for non-direct install program CFL lamps to 100% for T5 linears installed under direct install programs. Reasons for why the installation rates were not 100% at the time of on-site inspection vary among measures. For CFL lamps, roughly 84% of measures were received by customers in non-direct install programs and failure/removal rates contributed to the lower installation rates as well. For LED lamps and reflectors in direct install programs, removal rates were 2.4% and 4.2%, respectively.

By and large, LEDs were removed because the lighting they provided was not aesthetically pleasing, too strong or too directional. T5 linears had the highest received rate and installation rate among all the ESPI measures.

The relative precisions are all within the 90/15 range or better for each measure at the program delivery level and within 90/5 or greater at the measure level alone.

## 4.3 Operating Hour Analysis

One of the primary inputs into the gross savings calculations are the 8,760 load shapes, or percent on, for lighting equipment. There were multiple methodologies employed to develop these percent on load shapes, which are discussed in this section. More specifically, this section will discuss the development of the following:

- Post-Retrofit 8,760 load shapes based on logger data
- Self-Report Adjustment Factors using 2006-08, 2010-12, and 2013-14 logger and self-report data
- Post-Retrofit 8,760 load shapes based on combining the logger based profiles with the adjusted self-report profiles
- Pre-Retrofit 8,760 load shapes based on self-report data and the self-report adjustment factors

### *4.3.1 Development of 8,760 Post-Retrofit Percent-On Load Shapes using Logger Data*

The objective of the lighting logger analysis was to develop 8,760 hourly load shapes of the percentage of the hour that the lights are on (percent on) for the post-retrofit equipment. The goal is to develop load shapes for each site and each specific measure monitored at the activity area (or space type) level.

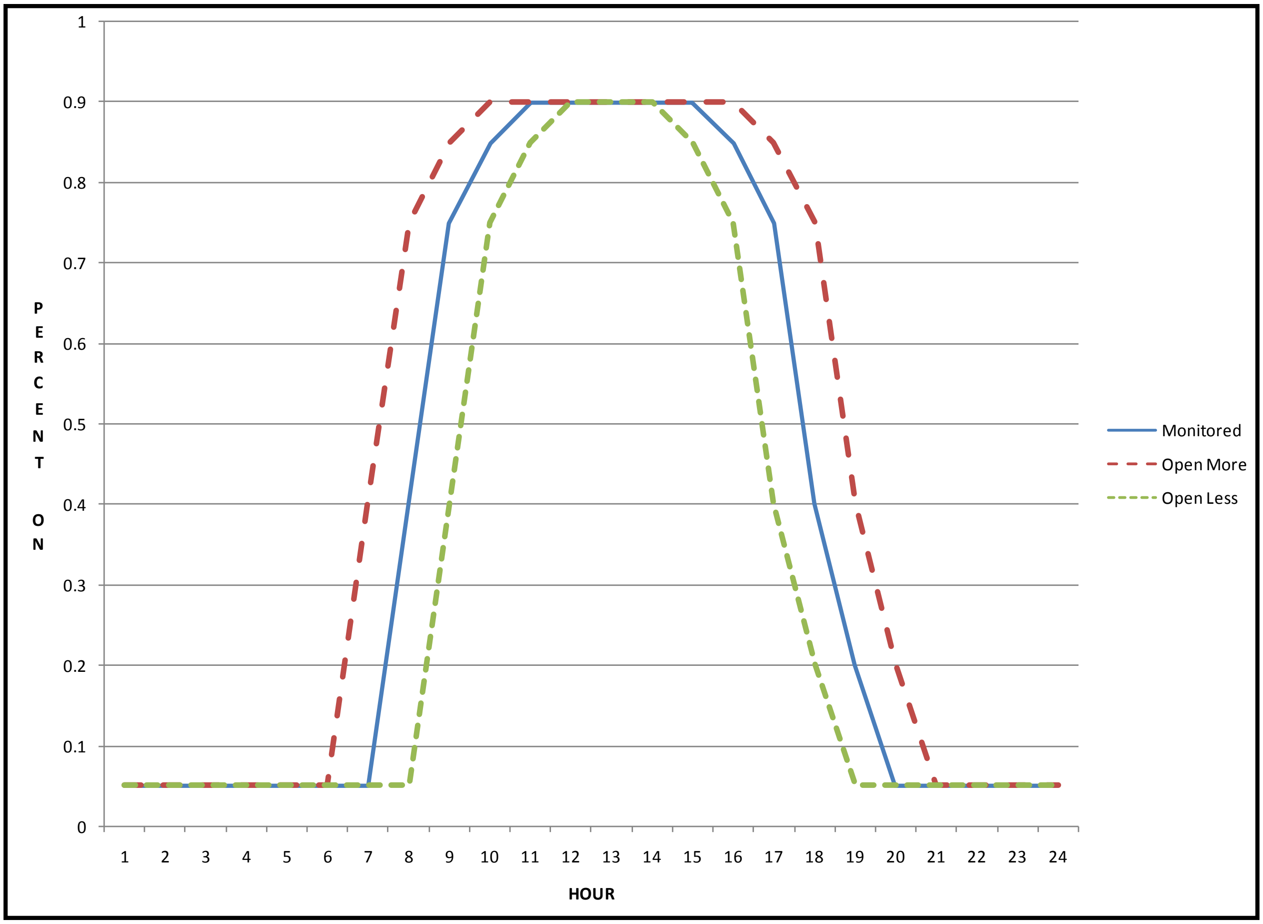
Because loggers were not installed for a full year, the logger data needed to be extrapolated out to a full year of 8,760 hours. The 2006-08 Small Commercial lighting logger study investigated the effects of changes in daylighting over the course of the year, and normal changes in business hours that some businesses experience over the course of the year. The study indicated that there was no discernable difference in usage over time that would be related to the effects of changes in daylighting. Therefore, our 8,760 extrapolation did not directly take into consideration the effects of changes in daylight levels over the year.

Customers did provide their current business hours, and reported if these hours changed over the course of the year. If a customer reported a change in business hours for a portion of the year, the 8,760 profile was adjusted accordingly. Using the monitored data, eight average daily profiles were developed for each day of the week, and separately for holidays, for each logger. For each profile, the midpoint of the open period and the midpoint for the closed period were determined. If a business reported being open more hours during another unmonitored time during the year, the profiles were shifted by expanding the profile around the open midpoint, and collapsing the profile around the closed midpoint. The opposite was true if the business reported being closed more hours, so that the profiles were shifted by expanding the profile around the closed midpoint, and collapsing the profile around the open midpoint. The shifting around the midpoints was chosen for two reasons. First, the load shapes tend to be most consistent for the hours around these two points (generally the peak and the trough of the load shape). Second, if a customer reported a shift in the business hours (same number of open hours, but at a different time) this approach would have the effect of simply just shifting the entire profile.[9]

Figure 4-1 provides an example of a business that was open from 9 a.m. to 5 p.m. during the monitored period, and how the load shape would change if the business hours changed from 10 a.m. to 4 p.m., or 8 a.m. to 6 p.m. Essentially the midpoint at 1 p.m. is being stretched out, or the hours around 1 p.m. are being collapsed; and the converse is true around the closed midpoint at 1 a.m.

[9] It is also important to note that this was the same methodology used for the 2006-08 Small Commercial Contract Group Direct Impact Evaluation

**Figure 4-1: Example of Load Shape Shift due to Business Hour Changes**




The final step after extrapolating each individual logger to an 8,760 load profile, is to aggregate each logger up to a site-activity area level by measure. This aggregation only occurs when there is more than one logger at a site in a similar space type. To aggregate the loggers, a weight is associated with each logger that is equal to the number of fixtures/lamps to which the logger corresponds. The result is an 8,760 post-retrofit percent-on load shapes, developed at the site, measure, activity area level.

### *4.3.2 Development of 8,760 Post-Retrofit Percent-On Load Shapes using Adjusted Self-Report Schedules*

As part of the 2006-08 Small Commercial evaluation, a set of adjustment factors were developed that can be used to adjust self-reported usage schedules to more accurately reflect actual usage, and develop use shapes. The methodology for developing and applying these self-report adjustment factors is described in the IEPEC conference paper "Is the Customer Always Right? A Cost-Effective Method for Estimating Lighting Usage in Commercial Buildings", provided in Appendix I of the NRL report.

This evaluation utilized this same approach, but incorporated the 2006-08, 2010-12 and 2013-14 logger data, to develop adjustment factors to apply to self-reported post-retrofit use shapes for sites that did not have loggers installed. Given the wealth of logger data that was collected and analyzed over the past two program cycles, adjustment factors and business hour rates were developed not only for measures that were installed on a switch, but those that were controlled by an occupancy sensor as well. For all measures, detailed self-report schedules were collected that could then be adjusted using the approach documented in Appendix I of the NRL report.

As mentioned, the adjustment factors utilized data collected from the 2013-14 ESPI studies, the 2010-12 study and the 2006-08 Small Commercial study. This analysis included over 3,500 loggers monitoring CFLs and LEDs on switches in more than 1,000 facilities and 4,700 loggers monitoring linear measures in almost 900 facilities. For controls, the analysis included almost 400 loggers monitoring CFLs and LEDs on occupancy sensors in over 170 facilities and 900 loggers monitoring linear measures in over 260 facilities.

As part of the on-site survey for all of these studies, participants were asked to estimate their lighting usage by activity area within their building and to provide their business lighting hours. For those customers that were monitored, it was possible to compare the participants' actual lighting usage to both their self-reported lighting usage and their business operating hours. Comparisons were made at the technology, building type and activity area level and control level. Furthermore, rather than simply comparing annual operating hours, comparisons were made for four different use periods (relative to self-reported business hours): Opening Shoulder, Open, Closed Shoulder, or Closed. The Open period was defined as all hours of the day for which the business was open. The Opening and Closing shoulders were defined as the two hours before opening and after closing, respectively. The Closed period was defined as all hours for which the business was closed, and not in one of the two shoulder periods. For the open period, a ratio of actual logger to self-report usage could be estimated by technology, building type, activity area, and usage period. Then these ratios, or adjustment factors, could then be applied to a self-report schedule by building type, activity area, for the open period. However, for the closed and shoulder periods, rather than develop and apply adjustment factors, average usages values were estimated from the logger sample and these usage values were used directly for those time periods. The reason why adjustment factors were not developed and applied to these periods is because the self-reported usage during these periods was often claimed to be zero. A zero value cannot be adjusted by a multiplicative factor, therefore a constant factor was used. Again, this constant factor was the actual average usage found in the logger sample for those time periods, and was applied by technology, building type and activity area.

By applying the adjustment factors to the open time period, and the usage values to the closed and shoulder time periods, 8,760 load shapes could be developed at the measure and activity area level. Since not all technology, building type and activity area combinations were well represented, adjustment factors and usage rates were also developed at the technology-building type level as well as at the technology level alone.

To validate this process, we took the sample of 2010-12 participants that were monitored in that study and created an adjusted self-report estimate of annual operating hours based on the 2006-08 and 2010-12 factors discussed above. For this sample of monitored participants, we then compared their actual logger results to their adjusted self-report results as well as their unadjusted self-reports. Table 4-2 presents a comparison of operating hours developed from the logger data and the adjusted/non-adjusted self-report method. The adjusted self-report operating hours compare very well to the actual monitored hours. The absolute differences range from 0.5% for LED reflectors to 5.5% for CFL lamps. The absolute difference between the actual logger data and the unadjusted self-reports range from 2% for linear measures to 15% for LED reflectors. Overall, the differences between the adjusted self-report results and the monitored data are not statistically significant.

**Table 4-2: Comparison of Logged Data, Adjusted/Unadjusted Self-Report Operating Hours by Technology**

| | Logged | | Adjusted Self Report | | Unadjusted Self Report | |
|---|---|---|---|---|---|---|
| HIM | HOU | SE | HOU | SE | HOU | SE |
| CFL Lamp | 1,970 | 160 | 2,079 | 102 | 1,760 | 122 |
| CFL Reflector | 3,407 | 264 | 3,461 | 183 | 3,736 | 241 |
| T5 Linear | 3,660 | 153 | 3,720 | 113 | 3,544 | 149 |
| LED Lamp | 3,833 | 198 | 3,892 | 159 | 3,571 | 179 |
| LED Reflector | 3,235 | 185 | 3,251 | 106 | 2,751 | 117 |
| Linear | 3,415 | 58 | 3,379 | 43 | 3,336 | 42 |

### *4.3.3 Final 8760 Post-Retrofit Percent-On Load Shapes*

As mentioned, both the logger data and adjusted self-report schedules were capable of developing 8,760 post-retrofit percent-on load shapes at the site, measure, activity area level. For the purpose of presenting results for this report, these site-measure-activity area level load shapes were aggregated to the building type level. To perform this aggregation, each site-space type profile is weighted to represent the number of lamps/fixtures being represented in the population.

As part of the on-site visit, business and building characteristics were collected and the customer was classified into a building type based on that information. This building type classification is referred to as an “analysis” building type and was leveraged to create the adjustment factors discussed in Section 4. It was felt that this process for classifying a customer’s building type was more accurate than the building type associated with the facility in the tracking data. Table 4-3 through Table 4-9 present the post-retrofit annual operating hours and peak coincidence factor (CF) developed at the analysis building type level for each ESPI measure.

In order to produce the final results, however, the intermediate results – at the measure, analysis building type and space type level – have been applied back to the building types that are associated with ESPI measure installations found in the tracking data. For example, in order to develop adjustment factors for high bay linears in warehouses, all conditioned and unconditioned facilities were combined as warehouses and load shapes were generated at the technology, warehouse, space type level. These adjusted self-reports were then combined with the impacts generated from logger data. The resulting operating hours and peak coincident factors for the "analysis" warehouse were applied to all conditioned and unconditioned warehouses found in the tracking data by technology.

**Table 4-3: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for CFL Lamps**

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Assembly | 43 | 1,277 | 15% | 20% | 18% |
| Education - Primary/Secondary | 23 | 1,108 | 29% | 24% | 32% |
| Grocery | 9 | 2,617 | 40% | 38% | 42% |
| Health/Medical - Clinic | 30 | 1,245 | 20% | 25% | 27% |
| Lodging | 26 | 667 | 20% | 5% | 31% |
| Office - Large | 6 | 3,285 | 25% | 84% | 17% |
| Office - Small | 54 | 565 | 28% | 13% | 31% |
| Other | 19 | 988 | 37% | 17% | 54% |
| Other Industrial | 24 | 835 | 30% | 23% | 25% |
| Restaurant | 23 | 1,776 | 27% | 32% | 29% |
| Retail - Large | 31 | 4,714 | 8% | 78% | 11% |
| Retail - Small | 115 | 1,075 | 20% | 23% | 17% |
| Storage | 8 | 343 | 66% | 12% | 68% |
| Warehouse | 8 | 661 | 160% | 9% | 160% |
| **All Building Types** | **419** | **1,144** | **7%** | **20%** | **9%** |

### Table 4-4: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for CFL Reflectors

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Assembly | 18 | 3,968 | 27% | 53% | 22% |
| Health/Medical - Clinic | 17 | 1,725 | 20% | 40% | 20% |
| Lodging | 6 | 2,846 | 84% | 35% | 91% |
| Office - Small | 13 | 1,457 | 23% | 37% | 18% |
| Other | 29 | 2,182 | 24% | 33% | 34% |
| Other Industrial | 9 | 1,548 | 42% | 54% | 24% |
| Retail - Large | 6 | 3,563 | 22% | 99% | 6% |
| Retail - Small | 34 | 3,042 | 9% | 72% | 11% |
| **All Building Types** | **132** | **2,656** | **9%** | **53%** | **8%** |

### Table 4-5: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for HB Linears

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Agriculture | 10 | 5,091 | 15% | 67% | 36% |
| Assembly | 30 | 2,356 | 15% | 46% | 9% |
| Education - Primary | 14 | 1,347 | 8% | 35% | 8% |
| Education - Secondary | 7 | 2,651 | 26% | 64% | 22% |
| Office - Large | 13 | 2,225 | 11% | 55% | 9% |
| Office - Small | 14 | 2,178 | 26% | 44% | 15% |
| Other | 16 | 2,390 | 19% | 57% | 21% |
| Other Industrial | 112 | 3,113 | 7% | 63% | 5% |
| Retail - Large | 52 | 4,343 | 8% | 84% | 4% |
| Retail - Small | 107 | 2,662 | 6% | 80% | 4% |
| Storage | 61 | 2,841 | 7% | 63% | 8% |
| Warehouse | 46 | 3,024 | 8% | 70% | 4% |
| **All Building Types** | **482** | **2,883** | **3%** | **64%** | **2%** |

**Table 4-6: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for LED Lamps**

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Assembly | 35 | 2,335 | 11% | 32% | 17% |
| Health/Medical - Clinic | 27 | 1,546 | 22% | 22% | 26% |
| Lodging | 61 | 1,542 | 16% | 16% | 17% |
| Office - Small | 53 | 1,229 | 11% | 36% | 14% |
| Other | 17 | 2,779 | 20% | 62% | 18% |
| Other Industrial | 15 | 666 | 43% | 14% | 46% |
| Restaurant - Fast Food | 46 | 3,685 | 10% | 67% | 11% |
| Restaurant - Sit Down | 58 | 4,077 | 6% | 66% | 7% |
| Retail - Large | 24 | 3,903 | 6% | 94% | 7% |
| Retail - Small | 77 | 1,995 | 12% | 52% | 13% |
| Warehouse | 6 | 1,602 | 63% | 43% | 83% |
| **All Building Types** | **419** | **1,959** | **6%** | **29%** | **7%** |

**Table 4-7: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for LED Reflectors**

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Assembly | 27 | 2,040 | 19% | 36% | 27% |
| Health/Medical - Clinic | 7 | 1,326 | 67% | 30% | 76% |
| Lodging | 29 | 2,396 | 30% | 27% | 31% |
| Office - Small | 42 | 2,042 | 14% | 52% | 12% |
| Other | 19 | 3,646 | 26% | 67% | 11% |
| Other Industrial | 8 | 2,000 | 44% | 52% | 46% |
| Restaurant - Fast Food | 41 | 3,405 | 9% | 68% | 12% |
| Restaurant - Sit Down | 54 | 3,939 | 7% | 67% | 8% |
| Retail - Large | 23 | 4,029 | 7% | 99% | 2% |
| Retail - Small | 67 | 3,234 | 7% | 81% | 5% |
| Warehouse | 6 | 3,341 | 26% | 45% | 73% |
| **All Building Types** | **323** | **3,066** | **5%** | **61%** | **5%** |

**Table 4-8: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for Linear Fluorescents**

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Agriculture | 7 | 1,590 | 52% | 50% | 32% |
| Assembly | 61 | 1,608 | 8% | 31% | 8% |
| Health/Medical Clinic | 55 | 2,311 | 9% | 54% | 7% |
| Education - Primary | 52 | 1,474 | 5% | 42% | 5% |
| Grocery | 17 | 4,694 | 11% | 87% | 9% |
| Lodging | 16 | 2,788 | 21% | 27% | 27% |
| Office - Large | 28 | 2,917 | 8% | 66% | 6% |
| Office - Small | 126 | 2,135 | 4% | 61% | 3% |
| Other | 23 | 3,150 | 7% | 71% | 4% |
| Other Commercial | 21 | 2,373 | 16% | 53% | 16% |
| Other Industrial | 91 | 2,549 | 5% | 61% | 4% |
| Restaurant - Fast Food | 17 | 4,247 | 12% | 68% | 10% |
| Restaurant - Sit Down | 21 | 3,677 | 12% | 56% | 15% |
| Retail - Large | 56 | 4,595 | 5% | 75% | 4% |
| Retail - Small | 261 | 2,905 | 3% | 79% | 2% |
| Storage | 43 | 2,198 | 8% | 53% | 7% |
| Warehouse | 26 | 1,927 | 11% | 63% | 12% |
| **All Building Types** | **921** | **2,916** | **2%** | **64%** | **1%** |

**Table 4-9: Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for Occupancy Sensors**

| Building Type | Sites | Operating Hours | RP | Coincidence Factor | RP |
|---|---|---|---|---|---|
| Assembly | 25 | 897 | 23% | 21% | 23% |
| Health/Medical - Clinic | 17 | 1,185 | 27% | 26% | 29% |
| Education - Primary/Secondary | 15 | 1,047 | 13% | 24% | 12% |
| Lodging | 8 | 642 | 49% | 7% | 51% |
| Office - Small | 12 | 1,225 | 33% | 28% | 29% |
| Other | 29 | 2,914 | 18% | 55% | 13% |
| Other Industrial | 55 | 2,452 | 11% | 57% | 7% |
| Retail - Large | 18 | 3,448 | 11% | 88% | 8% |
| Retail - Small | 46 | 1,083 | 16% | 34% | 13% |
| Storage | 30 | 2,261 | 10% | 49% | 10% |
| **All Building Types** | **255** | **1,827** | **6%** | **39%** | **6%** |

As discussed above and in Section 3, the operating hours that were generated for each measure are highly correlated to the activity areas where they were installed. For CFL and LED lamps, these measures were generally installed in lower usage space types like storage areas and restrooms. For certain building types, like retail and restaurants, the operating hours for these measures are higher because the distribution of activity area installations includes higher usage areas like retail space and dining areas. This is true for CFL and LED reflectors as well. These measures have higher operating hours than screw-in lamps because they are generally installed in buildings that have longer open hours and within higher usage areas.

### *4.3.4 Final 8,760 Pre-Retrofit Percent-On Load Shapes*

For all measures, except occupancy sensors, it is assumed that the pre-retrofit usage is equal to the post-retrofit usage. The 2006-08 Small Commercial Evaluation had a pre-post monitoring study, where it was found that there was no discernible difference between the pre- and post-retrofit usage for linear fluorescent and CFL measures (about a 1% difference was found, but it was not statistically significantly different from zero at the 90% confidence level[10]). Therefore, it was determined that the pre-retrofit load shape would utilize the post-retrofit load shape.

However, for the occupancy sensor measures, the savings is generated from a change in operation, making it necessary to have a separate estimate of pre-retrofit usage. For measures that are installed in conjunction with an occupancy sensor, the non-control measures are assumed to have an impact that corresponds to the same operating conditions as the previous equipment.

Therefore, for occupancy sensors and measures installed in conjunction with occupancy sensors, pre-retrofit load shapes were estimated in the same manner as discussed above. As part of the on-site visit, the auditor gathered self-reported pre-retrofit operating schedules from the on-site contact for the activity area prior to the installation of the occupancy sensor. These self-report schedules were adjusted in the same manner as described above to develop 8,760 load shapes at the site, measure and activity area level.

Since no new on-site data has been collected on occupancy sensors, the tables below represent the savings associated with controls from data collected from 2010-12 evaluation. For all LED and T5 lighting measures that were installed in conjunction with an occupancy sensor throughout the 2014 evaluation, the adjusted pre-retrofit operating hours were used for both the pre- and post-retrofit period.

Table 4-10 provides the average pre- and post-retrofit operating hours and coincident peak factors for the 2010-12 on-site sample for occupancy sensors by analysis building type.

[10] 2006-08 Small Commercial Contract Group Direct Impact Evaluation, Appendix G.7.2, page G-62.

**Table 4-10: Pre- and Post-Retrofit Annual Hours of Operation and Coincidence Factors by Building Type for Occupancy Sensors**

| Building Type | Sites | Pre-Operating Hours | Post-Operating Hours | Pre-Coincidence Factor | Post-Coincidence Factor |
|---|---|---|---|---|---|
| Assembly | 25 | 1,740 | 897 | 29% | 21% |
| Health/Medical - Clinic | 17 | 2,203 | 1,185 | 43% | 26% |
| Education - Primary/Secondary | 15 | 2,041 | 1,047 | 57% | 24% |
| Lodging | 8 | 714 | 642 | 10% | 7% |
| Office - Small | 12 | 1,825 | 1,225 | 42% | 28% |
| Other | 29 | 3,562 | 2,914 | 70% | 55% |
| Other Industrial | 55 | 3,244 | 2,452 | 69% | 57% |
| Retail - Large | 18 | 4,416 | 3,448 | 77% | 88% |
| Retail - Small | 46 | 1,835 | 1,083 | 54% | 34% |
| Storage | 30 | 2,957 | 2,261 | 75% | 49% |
| **All Building Types** | **255** | **2,463** | **1,827** | **53%** | **39%** |

Much like the lighting measures that they control, occupancy sensor impacts are highly correlated to the activity areas where they are installed. The segments that generate the greatest percent time off (PTO) are assembly, health/medical clinic, education – primary/secondary, and small retail building types. As presented in Section 3, occupancy sensors were generally installed in lower usage areas like restrooms and storage areas for these building types. Across all building types, the installation of controls contributed to roughly a 26% reduction in operating hours and peak demand.

## 4.4 Pre- and Post- Retrofit Wattages

Another key set of parameters are the pre- and post-wattages. Various approaches and data sources were utilized to develop these wattage values, which are discussed in this section. More specifically, this section will discuss the development of the following:

- Post-Retrofit Wattages – based on verified data on site
- Pre-Retrofit Wattages – based on self-report data and other information gathered on site
- Standard Practice Baseline Wattages – based on data collected for the Commercial Market Share Tracking (CMST) Study

### 4.4.1 Post-Retrofit Wattages

Post-retrofit wattages were primarily based on make and model information gathered on site. For some measures, like basic CFLs and LED lamps, the on-site auditor was able to gather the wattage directly from the lamp. For high bay sites where fixtures were not accessible or when it was not as efficient or accurate to use time-of-use data logging, electric panel logging was performed. When this was the case, spot watt measurements were taken and used to estimate post-retrofit wattages instead of the make and model information. In the limited cases where it was not possible to gather make and model information, or perform spot watt measurements, we attempted to use the IOU measure name, which often times would specify the wattage of the measure being installed. If this was not available, average wattage values were used from the sample that had populated values.

### 4.4.2 Pre-Retrofit Wattages

Four different approaches were utilized to gather pre-retrofit wattage for each measure on site. In each case, the auditor tried to gather the same information as described above for the post-retrofit wattages. The first was to locate fixtures that were not retrofitted but in the same area or type of area and matched the baseline fixture description. The second approach was to look for spare baseline lamps and ballasts in storage and maintenance areas. The third was to review any documentation regarding the previously installed lamps and fixtures. The fourth approach was to gather the contacts' or maintenance staffs' best recollection of the baseline fixture-lamp information. Finally, if pre-retrofit wattage information was not available, average wattage values were used, similar to what was done for the post-wattage values.

Table 4-11 through Table 4-13 provide estimates of pre- and post-wattage (by measure configuration) along with the number of observations associated with the estimate and the relative precision.

**Table 4-11: ESPI Measure Pre- and Post-Wattage Estimates by Measure Category**

| ESPI Measure<br>Measure Category | Wattage Observations | Pre-Retrofit Wattage | Relative Precision | Post-Retrofit Wattage | Relative Precision |
|---|---|---|---|---|---|
| **CFL Lamp** | | | | | |
| 5-13W CFL | 79 | 59 | 4% | 13 | 4% |
| 14-24W CFL | 146 | 73 | 6% | 20 | 3% |
| 25-30W CFL | 19 | 76 | 9% | 25 | 7% |
| **CFL Reflector** | | | | | |
| 5-13W CFL | 8 | 55 | 16% | 12 | 13% |
| 14-24W CFL | 101 | 66 | 5% | 19 | 3% |
| 25-30W CFL | 14 | 84 | 12% | 23 | 4% |

### Table 4-11 (Cont'd): ESPI Measure Pre- and Post-Wattage Estimates by Measure Category

| ESPI Measure<br>Measure Category | Wattage Observations | Pre-Retrofit Wattage | Relative Precision | Post-Retrofit Wattage | Relative Precision |
|---|---|---|---|---|---|
| **T5 Linear** | | | | | |
| 4FT-2L-T5 | 6 | 450 | 7% | 175 | 28% |
| 4FT-3L-T5 | 1 | 456 | | 147 | |
| 4FT-4L-T5 | 166 | 453 | 1% | 215 | 1% |
| 4FT-6L-T5 | 21 | 456 | 4% | 258 | 12% |
| **LED Lamp** | | | | | |
| 4-7W LED | 68 | 45 | 11% | 6 | 3% |
| 8-11W LED | 287 | 38 | 5% | 10 | 1% |
| 12-17W LED | 101 | 39 | 10% | 13 | 2% |
| > 17W LED | 7 | 118 | 27% | 38 | 46% |
| **LED Reflector** | | | | | |
| 4-7W LED | 101 | 47 | 4% | 6 | 3% |
| 8-11W LED | 99 | 55 | 6% | 9 | 3% |
| 12-17W LED | 172 | 69 | 4% | 14 | 2% |
| > 17W LED | 50 | 68 | 9% | 23 | 4% |

### Table 4-12: Linear Delamping Pre-Retrofit Estimates by Measure Category

| Measure Category | Wattage Observations | Pre-Retrofit Wattage | Relative Precision |
|---|---|---|---|
| (1) 4FT-T12 removed | 21 | 46 | 10% |
| (1) 8FT-T12 removed | 24 | 70 | 5% |
| (2) 4FT-T12 removed | 66 | 66 | 3% |
| (2) 8FT-T12 removed | 2 | 113 | 40% |

### Table 4-13: Occupancy Sensor Post-Retrofit Controlled Wattage by Measure Category

| Measure Category | Wattage Observations | Post-Retrofit Wattage | Relative Precision |
|---|---|---|---|
| Integrated Occupancy Sensor (High) | 67 | 192 | 3% |
| Integrated Occupancy Sensor (Low) | 39 | 131 | 19% |
| Non-Integrated (High) | 10 | 371 | 75% |
| Non-Integrated (Low) | 174 | 85 | 17% |

### *4.4.3 Industry Standard Practice Wattages*

Industry standard practice (ISP) baselines will apply only to delamping and T5 measures. For T5 measures replacing metal halides, customers that are ROB utilize a pulse start metal halide for the entire EUL of the measure, which is consistent with Title 20. For customers that are classified as ER, the wattage of the replaced equipment serves as the baseline throughout the RUL of the baseline equipment and the post-RUL period utilizes a pulse start metal halide as the ISP.

For delamping of linear fluorescent measures and T5 linears replacing linear fluorescents, the ISP baselines are developed using data collected for the CMST Study on linear fluorescent measures that were installed during 2009-12. Using the CMST, average wattages were developed by lamp length, the number of lamps per fixture, and if the fixture was installed in a high bay application or not (defined as greater than 12 feet in height). For example, an average wattage was developed for all 3-lamp, 4-foot fixtures that were not high bay applications. This serves as the ISP baseline wattage for all installed non-high bay linear fluorescent measures that were 3-lamp, 4-foot fixtures. Note that this ISP baseline wattage is comprised of various efficiencies of linear fluorescent measures including T8 and T5 fixtures.

Two different averages were taken, one which excluded T12 fixtures and one which excluded both T12 and 700 series T8 fixtures. T12 fixtures are excluded in both because T12 lamps began being phased out in 2012 and the CMST found that only 1% of all installations included T12s. Therefore, T12s were not considered to be industry standard practice. Although 700 series T8 fixtures are also being phased out, the phase out data has been pushed back to July 2014. The CMST also found that a significant portion of the installations during 2010-12 (approximately a third) included 700 series T8s. For customers that are classified as ROB, their ISP baseline is used for the full EUL, which would take affect when their installation was made. For these participants, their ISP baseline should include 700 series T8s. For customers classified as ER, their ISP baseline is used in the post-RUL period, which typically would begin approximately 5 years after their installation. By this time, 700 series T8s would not be available; therefore, for these participants, their ISP baseline should exclude 700 series T8s.

**Table 4-14: Industry Standard Practice Wattages by Lamp Length, Lamps per Fixture, and High Output/Non-High Output**

| Lamp Length | Lamps Per Fixture | High Output? | ROB ISP Site Count | ROB ISP Wattage | Post-RUL ISP Site Count | Post-RUL ISP Wattage |
|---|---|---|---|---|---|---|
| 2' | 2 | N | 15 | 31 | 10 | 31 |
| 3' | 1 | N | 4 | 27 | 3 | 27 |
| 3' | 2 | N | 4 | 45 | 1 | 45 |
| 4' | 1 | N | 25 | 28 | 22 | 30 |
| 4' | 2 | N | 198 | 58 | 153 | 58 |
| 4' | 2 | Y | 5 | 98 | 5 | 98 |
| 4' | 3 | N | 77 | 84 | 46 | 83 |
| 4' | 4 | N | 125 | 120 | 90 | 120 |
| 4' | 4 | Y | 18 | 206 | 18 | 206 |
| 4' | 6 | N | 19 | 181 | 16 | 179 |
| 4' | 6 | Y | 6 | 310 | 6 | 310 |
| 4' | 8 | N | 2 | 245 | 2 | 245 |
| 8' | 1 | N | 4 | 62 | 4 | 62 |
| 8' | 2 | N | 18 | 105 | 15 | 105 |

### *4.4.4 Measure Service Life*

The service life of the installed equipment has a significant impact on the overall lifecycle savings of the measure. For each measure, the service life was calculated at the post-retrofit configuration level much like the wattage estimates. The service life for LEDs and CFLs are based on the lamp life of the measure whereas the service life for linear measures is based on the ballast life. For CFL measures, the lamp service life of each measure was determined by multiplying the DEER operating hours for each measure (by post configuration) by the EUL reported in the tracking data. The lamp service life was then divided by the ex post site-specific operating hours for each measure to develop ex post EULs. Given the significant additional data that was collected for LED measures, an additional step was taken. As part of the make-model lookups, the evaluation team also collected manufacturer rated lamp life for each model found onsite. These values, collected from manufacturer cut sheets, were input for each LED measure and the lamp service life was developed for each measure group category (lamp and reflector lamp) by post-retrofit configuration. For T5 measures, the service life represents the ballast service life of the measure which is set at 70,000 hours. For delamping of existing T12 fixtures, however, the lamp service life (20,000 hours) is used rather the ballast service life, given the fact that T12s began being phased out in 2012.

Table 4-15 provides estimates of service life for each of the evaluated lamp measures. Only the lamp measures are displayed along with the relative precision given the fact that the same ballast service life is applied to each of the linear measure categories.

**Table 4-15: Lamp Service Life by Measure Configuration**

| ESPI Measure<br>Measure Category | Wattage Observations | Lamp Service Life | Relative Precision |
|---|---|---|---|
| **CFL Lamp** | | | |
| 5-13W CFL | 52 | 10,012 | 2% |
| 14-24W CFL | 134 | 8,848 | 3% |
| 25-30W CFL | 11 | 10,133 | 3% |
| **CFL Reflector** | | | |
| 5-13W CFL | 4 | 9,943 | 2% |
| 14-24W CFL | 89 | 8,449 | 4% |
| 25-30W CFL | 6 | 10,395 | 1% |
| **LED Lamp** | | | |
| 4-7W LED | 67 | 23,861 | 3% |
| 8-11W LED | 252 | 24,376 | 1% |
| 12-17W LED | 95 | 28,107 | 4% |
| > 17W LED | 6 | 17,400 | 40% |
| **LED Reflector** | | | |
| 4-7W LED | 92 | 25,786 | 4% |
| 8-11W LED | 88 | 26,388 | 4% |
| 12-17W LED | 142 | 26,190 | 4% |
| > 17W LED | 44 | 36,480 | 9% |

### *4.4.5 RUL Analysis*

In order to develop lifecycle savings for each measure, the EUL was calculated. The EUL is a function of the service life of the measure divided by the annual operating hours. For occupancy sensor measures the EUL is set to 8 years. For all other measures, the EUL is defined as:

$$\text{EUL} = \text{Minimum of either } \frac{Service\ Life\ (hours)}{Annual\ Hours\ of\ Use} \text{ or 15 years.}$$

Where,

Service Life = 70,000 for T8s and T5s, electronic ballasts; 20,000 for T12s (based on lamp life); lamp service life for CFL and LED measures

Annual Hours of Use = the site-specific estimate of post-retrofit annual hours of operation obtained from either logger data usage or adjusted self-reported operating hours gathered on site.

Another parameter that influences the lifecycle savings is the RUL which is represented in dual baseline measures. In order to estimate a site-specific impact for a participant, it must first be determined if the installation was ROB (or natural replacement [NR]) or ER. If it is determined that the installation was ER, the RUL is estimated as one third of the EUL, following the DEER methodology.

Then, as mentioned above, for ER installations, the replaced equipment will be used to determine baseline wattage during the RUL period and industry standard practice will be used to determine baseline wattage for the post-RUL period. For ROB/NR installations, industry standard practice will be used to determine baseline wattage for the full EUL period.

***ROB/NR/ER Algorithm***

In order to classify an installation as being ER, there must be "a preponderance of evidence that an energy efficiency program activity induced or accelerated equipment replacement. Early retirement measures must provide justification that the existing equipment being replaced would have continued to function and perform its original design intent for a period of time in absence of the replacement."[11]

Therefore, to determine if an installation is ER we first determined if the equipment was replaced on burnout, or was approaching the end of its useful life. If the equipment would not have been able to function as intended for at least a year, the installation is classified as an ROB. If not, we then examine if the program influenced an accelerated replacement, or if the customer was likely to have replaced the equipment at roughly the same time in the absence of the program. If the customer was likely to have replaced the equipment at roughly the same time in the absence of the program, they are considered NR. If not, then the customer will be classified as ER.

Table 4-16 presents the percentage of participants classified as ER by IOU and program delivery.

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[11] From CPUC guidance document "Project Basis (RET, ROB, etc.), EUL/RUL Definitions, & Preponderance of Evidence" dated 1/29/14.

## Table 4-16: Percent Early Replacement by Gross Program Group for T5 Early Replacers

| Program Administrator<br>Gross Program Group | n | Percent Early Replacement | Relative Precision |
|---|---|---|---|
| **PG&E** | | | |
| Deemed | 75 | 38% | 25% |
| Direct Install | 32 | 35% | 42% |
| Local Government Partnership | 17 | 79% | 22% |
| Third/Local Party Implementer | 30 | 40% | 38% |
| **Total PG&E** | **154** | **42%** | **16%** |
| **SCE** | | | |
| Deemed | 27 | 47% | 36% |
| Direct Install | 3 | 93% | 46% |
| **SCE Total** | **30** | **48%** | **33%** |
| **SDG&E** | | | |
| Deemed | 7 | 84% | 34% |
| Direct Install | 8 | 74% | 41% |
| **SDG&E Total** | **15** | **80%** | **24%** |
| **Statewide** | | | |
| Deemed | 109 | 42% | 19% |
| Direct Install | 43 | 43% | 30% |
| Local Government Partnership | 17 | 79% | 22% |
| Third/Local Party Implementer | 30 | 40% | 38% |
| **Statewide Total** | **199** | **45%** | **13%** |

**Table 4-17: Percent Early Replacement by Gross Program Group for Delamping Early Replacers**

| Program Administrator<br>Gross Program Group | n | Percent Early Replacement | Relative Precision |
|---|---|---|---|
| **PG&E** | | | |
| Deemed | 31 | 20% | 62% |
| Local Government Partnership | 42 | 65% | 19% |
| Third/Local Party Implementer | 24 | 75% | 21% |
| **Total PG&E** | **97** | **52%** | **16%** |
| **SCE** | | | |
| Deemed | 55 | 59% | 19% |
| Direct Install | 16 | 84% | 20% |
| Local Government Partnership | 4 | 53% | 116% |
| Third/Local Party Implementer | 4 | 68% | 84% |
| **SCE Total** | **79** | **69%** | **13%** |
| **SDG&E** | | | |
| Deemed | 14 | 73% | 30% |
| Direct Install | 1 | 100% | 0% |
| **SDG&E Total** | **15** | **73%** | **28%** |
| **Statewide** | | | |
| Deemed | 100 | 50% | 17% |
| Direct Install | 17 | 84% | 19% |
| Local Government Partnership | 46 | 64% | 19% |
| Third/Local Party Implementer | 28 | 72% | 21% |
| **Statewide Total** | **191** | **63%** | **9%** |

For T5 linears, at the program administrator level, the percentage of early replacement measures is 42% in PG&E, 48% in SCE and 80% in SDG&E. Across program types, LGP programs have the highest rate of ER (79%) while direct install, deemed and third party programs are fairly similar. While there is some variability across PAs, the overall statewide ER percentage is roughly 45%.

Similarly for delamping, SDG&E has a higher ER rate (73%) than both PG&E (52%) and SCE (69%). Also, DI (84%), LGP (64%) and third party programs (72%) are all higher than deemed (50%).

## 4.5 Development of Unit Energy Savings Values

The annual operating hours and peak demand estimates for each building type can then be multiplied by the delta wattage (or installed wattage for controls) associated with each measure configuration for all those segment combinations. Thousands of UES values were generated for each of the ESPI measures as a result. Given the fact that the UES analysis was done at this level of granularity, not all building types where represented. Average operating hours and coincidence factors were applied in the event that a building type was not well represented in the sample.

Table 4-18 presents UES values that were generated for small retail. As discussed in Section 3 and above, the operating hours are predicated on the distribution of activity areas where the measures are installed. A higher percentage of lower usage areas like restrooms and storage will translate over to lower operating hour estimates. This is true for CFL and LED lamps. For CFL and LED reflectors as well as the linear measures, operating hours tend to be higher as well as the peak demand estimates. The delta wattage values range from 26W (represented here in kW) to 80 watts for LED lamps and from 41W to 55W for LED reflector lamps. The controlled wattage associated with occupancy sensors is also affected by the application of the measure. Two ranges of controlled wattage were developed for both fixture integrated and non-integrated controls. Table 4-18 also presents the ex post EULs that were developed for each measure configuration.

While not presented here, for linear measures, there are actually three UES values that are generated. These correspond to the dual baseline classification. One UES is generated for the ROB case and two are generated for the ER installations – one for the RUL period and another for the post-RUL period.

### Table 4-18: Ex Post UES Values for Small Retail

| ESPI Measure Configuration | Delta Wattage | Pre Hours | Post Hours | UES kWh | Pre CF | Post CF | UES kW | EUL |
|---|---|---|---|---|---|---|---|---|
| **CFL Lamp** | | | | | | | | |
| 5-13W CFL | 0.045 | 1,075 | 1,075 | 48.4 | 23% | 23% | 0.010 | 9.3 |
| 14-24W CFL | 0.053 | 1,075 | 1,075 | 56.7 | 23% | 23% | 0.012 | 8.2 |
| 25-30W CFL | 0.050 | 1,075 | 1,075 | 54.3 | 23% | 23% | 0.012 | 9.4 |
| **CFL Reflector** | | | | | | | | |
| 5-13W CFL | 0.044 | 3,042 | 3,042 | 133.5 | 72% | 72% | 0.031 | 3.3 |
| 14-24W CFL | 0.048 | 3,042 | 3,042 | 145.2 | 72% | 72% | 0.034 | 2.8 |
| 25-30W CFL | 0.060 | 3,042 | 3,042 | 183.8 | 72% | 72% | 0.043 | 3.4 |
| **Linear Delamp** | | | | | | | | |
| (1) 4FT-T12 removed | 0.044 | 2,905 | 2,905 | 126.9 | 79% | 79% | 0.034 | 6.9 |
| (2) 4FT-T12 removed | 0.063 | 2,905 | 2,905 | 183.0 | 79% | 79% | 0.049 | 6.9 |
| (1) 8FT-T12 removed | 0.070 | 2,905 | 2,905 | 202.0 | 79% | 79% | 0.055 | 6.9 |
| (2) 8FT-T12 removed | 0.086 | 2,905 | 2,905 | 251.2 | 79% | 79% | 0.068 | 6.9 |
| **LED Lamp** | | | | | | | | |
| 4-7W LED | 0.038 | 1,995 | 1,995 | 76.2 | 52% | 52% | 0.020 | 12.0 |
| 8-11W LED | 0.028 | 1,995 | 1,995 | 55.4 | 52% | 52% | 0.014 | 12.2 |
| 12-17W LED | 0.026 | 1,995 | 1,995 | 52.3 | 52% | 52% | 0.014 | 14.1 |
| > 17W LED | 0.080 | 1,995 | 1,995 | 160.6 | 52% | 52% | 0.042 | 8.7 |
| **LED Reflector** | | | | | | | | |
| 4-7W LED | 0.041 | 3,234 | 3,234 | 133.7 | 81% | 81% | 0.033 | 8.0 |
| 8-11W LED | 0.046 | 3,234 | 3,234 | 148.4 | 81% | 81% | 0.037 | 8.2 |
| 12-17W LED | 0.055 | 3,234 | 3,234 | 177.9 | 81% | 81% | 0.044 | 8.1 |
| > 17W LED | 0.046 | 3,234 | 3,234 | 147.3 | 81% | 81% | 0.037 | 11.3 |
| **T5 Linear** | | | | | | | | |
| 4FT-2L-T5 | 0.126 | 2,662 | 2,662 | 335.7 | 80% | 80% | 0.101 | 15.0 |
| 4FT-3L-T5 | 0.309 | 2,662 | 2,662 | 821.3 | 80% | 80% | 0.247 | 15.0 |
| 4FT-4L-T5 | 0.194 | 2,662 | 2,662 | 515.3 | 80% | 80% | 0.155 | 15.0 |
| 4FT-6L-T5 | 0.135 | 2,662 | 2,662 | 358.0 | 80% | 80% | 0.108 | 15.0 |
| **Occupancy Sensor** | | | | | | | | |
| Integrated (High Watt) | 0.192 | 1,835 | 1,083 | 144.6 | 54% | 34% | 0.037 | 8.0 |
| Integrated (Low Watt) | 0.131 | 1,835 | 1,083 | 98.4 | 54% | 34% | 0.025 | 8.0 |
| Non-Integrated (High Watt) | 0.371 | 1,835 | 1,083 | 279.1 | 54% | 34% | 0.072 | 8.0 |
| Non-Integrated (Low Watt) | 0.085 | 1,835 | 1,083 | 63.5 | 54% | 34% | 0.016 | 8.0 |

## 4.6 Ex Ante and Ex Post Parameter Comparison

The objective of this study was to perform a measure and/or measure-parameter impact evaluation, utilizing existing evaluation data and new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for specific lighting measures identified in the ESPI decision. As presented throughout this report, the gross savings values incorporate several different variables, including installation rates, operating hours, coincidence factors, installed/replaced wattages, industry standard wattages and EULs. Likewise, some measures have a dual baseline, which affect the lifecycle savings associated with the measure. The differences in ex post savings relative to the ex ante claim are predicated on differences among these variables. The following section presents a high level comparison of the ex ante assumptions associated with two of the measures for which new data was collected – LEDs and T5 linears – to the ex post impacts that were calculated as a result of the gross analysis.

The ex ante assumptions combine data collected from reviewing the workpapers associated with each measure and the ex post impacts were developed using the information that was presented above throughout Section 4. The evaluation team developed comparisons for roughly 50 percent of the gross ex post lifecycle savings associated with LED and T5 linear measures by selecting the workpapers that corresponded to the measures with the largest savings, and for measures that ex ante savings in the program tracking data could clearly be matched to a specific workpaper. As a result, these summaries are intended to be instructive and are not presented to completely explain the differences in ex ante and ex post values. Rather, they are presented to provide a more general understanding of what specific parameters are driving the overall gross realization rates (GRR).

**Table 4-19: Ex Ante and Ex Post Comparison for PGE LED Reflectors**

| Measure Configuration | IR Ratio | Delta Wattage Ratio | CF Ratio | Op Hour Ratio | EUL Ratio |
|---|---|---|---|---|---|
| 8 to 11W | 90% | 220% | 113% | 103% | 114% |
| 12 to 17W | 90% | 150% | 122% | 102% | 120% |
| >17W | 90% | 89% | 135% | 111% | 156% |

The evaluation team compared over half of the savings associated with LEDs, focusing on reflector lamps as they represent roughly 76% of the gross ex post lifecycle savings for all evaluated LED measures in PG&E (LED lamps represent the remaining 24%). These comparisons are presented above in Table 4-19. The values shown are all expressed as the ratio of the ex post value to the ex ante value. Overall, the ex post installation rate for LED reflector lamps was roughly 10% less than the ex ante assumption of 100%. The most significant difference is the delta wattage ratio. For 8 to 11 watts LED reflectors lamps, the ex post delta wattage was more than twice that of the ex ante claim whereas the ex post delta wattage for the greater than 17 watt LED was roughly 10% less than the ex ante assumptions. Overall, the ex post operating hours are very similar to the ex ante operating hour assumptions and the ex post coincidence factor is roughly 13% to 35% higher. Likewise, the ex post EULs are much higher as well.

**Table 4-20: Ex Ante and Ex Post Comparisons for T5 Linears**

| PA | Measure Configuration | IR Ratio | Delta Wattage Ratio | CF Ratio | Op Hour Ratio | RUL Ratio | EUL Ratio |
|---|---|---|---|---|---|---|---|
| PG&E | 4FT-4L-T5 | 108% | 109% | 87% | 91% | 500% | 100% |
| SCE | 4FT-2L-T5 | 107% | 129% | 87% | 84% | 100% | 100% |
| SCE | 4FT-4L-T5 | 107% | 91% | 82% | 76% | 100% | 100% |
| SCE | 4FT-6L-T5 | 106% | 123% | 81% | 81% | 130% | 100% |

Overall, the evaluation team was able to compare roughly 95% of the gross ex post lifecycle savings for T5 linear fluorescents for PG&E and roughly 17% for SCE. Unlike the LED measure, ex post installation rates for T5 linears were 6% to 8% greater than ex ante assumptions. The ex post delta wattages were also generally greater, ranging from 9% less to 29% greater in SCE and 9% greater for PG&E. For PG&E, while the ex post baseline wattage was roughly 15% less than the workpaper assumptions, the ex post retrofit wattage was roughly 30% less than the ex ante measure case installed wattage. The ex post operating hours for PG&E were roughly 9% less than the ex ante claim and ranged from 16% to 24% less for SCE. Given the 70,000 ballast service life associated with T5 measures, the ex post EULs were almost identical to the ex ante claim (the EUL is capped at 15 years). The 500% ratio for PG&E's RUL ratio is due to PG&E claiming only a 1-year RUL (even though the EUL was 15 years) and the evaluation estimating the RUL to be 5 years (corresponding to a 15 year EUL, similar to ex ante).

## 4.7 Net-to-Gross Analysis

The approach for estimating NTGRs was based on the large non-residential free ridership approach developed by the NTGR Working Group and documented in Appendix C, *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Non-residential Customers*. The NTGR is calculated as the average of three program attribution indices (PAI) known as PAI-1, PAI-2, and PAI-3. Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure. The participant phone survey was the basis for the inputs to each score.

- **Program attribution index 1 (PAI–1)** is a score that reflects the influence of the most important of various program-related elements in the customer’s decision to select a given program measure. The PAI-1 score is calculated as the highest program influence factor divided by the sum of the highest program influence factor and the highest non-program influence factor. Some example non-program factors are: previous experience with the measure, recommendation from an engineer, standard practice, corporate policy, compliance with rules or regulations, organizational maintenance or equipment replacement policies and “other – specify.” Payback is treated as a program influence factor if the rebate/incentives played a major role in meeting payback criteria, but is treated as a non-program influence factor if it did not play a major role in meeting payback criteria.
- **Program attribution index 2 (PAI–2)** is a score that captures the perceived importance of program factors (including rebate/incentives, recommendation, and training) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents had made the decision to install the measure before learning about the program. The final score is divided by 10 to be put into decimal form, thus making it consistent with PAI-1.
- **Program attribution index 3 (PAI–3)** is a score that captures the likelihood of various actions the customer might have taken at the given time and in the future if the program had not been available (the counterfactual). This score is calculated as 10 minus the likelihood that the respondent would have installed the same measure in the absence of the program. The final score is divided by 10 to put into decimal form, thus making it consistent with PAI-1 and PAI-2.

The NTGR is estimated as an average of these three scores. If one of the scores is not available (generally due to respondents giving a “don’t know” or “refusal” response), then the NTGR is estimated as the average of the two available scores. If two or more scores were missing, results are discarded from the calculation.

### Table 4-21: NTGRs by Program Delivery

| ESPI Measure<br>Program Delivery | n | NTGR kWh | Relative Precision | NTGR kW | Relative Precision |
|---|---|---|---|---|---|
| **CFL** | | | | | |
| Deemed | 40 | 0.56 | 5% | 0.57 | 5% |
| Direct Install | 98 | 0.63 | 3% | 0.63 | 3% |
| Local Government Partnership | 137 | 0.61 | 3% | 0.62 | 3% |
| Third/Local Party Implementer | 95 | 0.66 | 3% | 0.66 | 2% |
| **Total** | **370** | **0.61** | **2%** | **0.62** | **2%** |
| **LED** | | | | | |
| Deemed | 185 | 0.54 | 4% | 0.54 | 4% |
| Local Government Partnership/Direct Install | 379 | 0.63 | 2% | 0.63 | 2% |
| Third/Local Party Implementer | 34 | 0.65 | 5% | 0.65 | 5% |
| **Total** | **598** | **0.57** | **2%** | **0.57** | **2%** |
| **Linear Delamp** | | | | | |
| Deemed | 100 | 0.61 | 4% | 0.59 | 4% |
| Direct Install | 29 | 0.73 | 4% | 0.73 | 5% |
| Local Government Partnership | 112 | 0.62 | 3% | 0.63 | 3% |
| Third/Local Party Implementer | 66 | 0.64 | 6% | 0.52 | 8% |
| **Total** | **307** | **0.65** | **2%** | **0.63** | **2%** |
| **Occupancy Sensors** | | | | | |
| Deemed | 53 | 0.56 | 7% | 0.55 | 7% |
| Direct Install | 50 | 0.62 | 5% | 0.62 | 5% |
| Local Government Partnership | 26 | 0.67 | 7% | 0.68 | 7% |
| Third/Local Party Implementer | 50 | 0.57 | 6% | 0.57 | 6% |
| **Total** | **179** | **0.57** | **3%** | **0.57** | **3%** |
| **T5 Linear** | | | | | |
| Deemed | 109 | 0.58 | 5% | 0.58 | 5% |
| Local Government Partnership/ Direct Install | 112 | 0.67 | 3% | 0.67 | 3% |
| Third/Local Party Implementer | 25 | 0.51 | 15% | 0.50 | 15% |
| **Total** | **246** | **0.61** | **3%** | **0.61** | **3%** |

Table 4-21 presents the NTGRs that were developed for each ESPI measure, weighted by ex post kWh and kW. Linear delamping have the highest NTGRs of all the evaluated measures, whereas, occupancy sensors and LEDs have the lowest at the overall measure level. Across programs, however, there is certainly more variability. Core statewide deemed programs have the lowest NTGRs for all measures with the exception of T5 linears.

As discussed throughout the report, CFL and linear delamping NTGRs relied on results from the 2010-12 NRL Evaluation. New phone surveys were administered for LED, T5, and occupancy sensors using 2013-14 program participation.

# 5

# Evaluation Results

This section presents the GRRs and NRRs for first year and lifecycle kW and kWh savings, as well as aggregate ex post population-level savings for first year and lifecycle kW and kWh.

## 5.1 Gross First Year Realization Rates

Once all the UES values have been created, as discussed in Section 4, these values can be applied to the population of participants. GRRs are then estimated for kWh and kW savings by looking at the ratio of the aggregate evaluated gross savings to the aggregate ex ante gross savings. Specifically, the GRR for PA-Measure segment j is estimated as:

$$Gross\_Realization\_Rate_j = \frac{\sum_{i=1}^{n} Gross\_Ex\_Post\_Impact_{i,j}}{\sum_{i=1}^{n} Gross\_Ex\_Ante\_Impact_{i,j}}$$

Where,

> $Gross\_Ex\_Post\_Impact_{i,j}$ is the site-specific gross ex post impact estimate for customer i, in the population, who is in PA-Measure segment j.
>
> $Gross\_Ex\_Ante\_Impact_{i,j}$ is the site-specific gross ex ante impact estimate for customer i, in the population, who is in PA-Measure segment j.

Table 5-1 presents the kWh and kW first year GRRs, by PA and measure, along with statewide totals. Also shown are the aggregate ex post and ex ante savings values by segment that were used to develop the realization rates.

### Table 5-1: 2014 First Year Gross kWh and kW Realization Rates by PA and Measure

| PA<br>ESPI Measure | Ex Ante Gross kWh Savings | Ex Post Gross kWh Savings | GRR kWh | Ex Ante Gross kW Savings | Ex Post Gross kW Savings | GRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 1,957,197 | 1,281,180 | **65%** | 354 | 248 | **70%** |
| Delamping | 8,677,833 | 6,449,361 | **74%** | 1,970 | 1,543 | **78%** |
| LED | 18,932,771 | 23,886,799 | **126%** | 3,779 | 5,449 | **144%** |
| Occupancy Sensors | 5,234,301 | 3,743,447 | **72%** | 985 | 1,055 | **107%** |
| T5 | 11,720,599 | 12,423,521 | **106%** | 2,873 | 2,884 | **100%** |
| **SCE** | | | | | | |
| CFL | 384,040 | 315,649 | **82%** | 81 | 64 | **79%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 5,304,656 | 5,329,126 | **100%** | 1,222 | 1,251 | **102%** |
| T5 | 15,236,610 | 18,490,148 | **121%** | 3,956 | 4,175 | **106%** |
| **SDG&E** | | | | | | |
| CFL | 2,545,288 | 2,271,703 | **89%** | 501 | 469 | **94%** |
| Delamping | 1,029,499 | 1,029,499 | **100%** | 241 | 241 | **100%** |
| Occupancy Sensors | 1,949,708 | 780,211 | **40%** | 451 | 191 | **42%** |

The first year GRRs vary significantly across measure. As discussed throughout Section 4, the ex post impacts and ex ante claims are products of several unique parameters that are generated in the impact algorithm. The underlying ex ante assumptions regarding each parameter vary by measure as do the ex post impacts. Below is a brief discussion of some of those underlying differences and how they affected the overall realization rates.

The CFL ESPI category represents both screw-in CFL lamps and reflector lamps. As discussed above in Section 4.3 the overall ex post operating hours were considerably higher for CFL reflector lamps (2,656 hours compared to 1,160 hours for CFL screw-in lamps). For PG&E, CFL reflector lamps represent only 0.15% of the overall first year ex ante savings for the CFL ESPI measure. The 65% GRR is best explained by higher ex ante operating hours for CFL lamps relative to ex post. For SCE, CFL reflector measures represent roughly 85% of the first year ex ante savings for CFL ESPI measures which helps explain a higher overall GRR (82%). SDG&E rebated only CFL reflector measures which also helps explain an even higher GRR (89%) than PG&E and SCE.

For PG&E delamping measures, the first year kWh GRR is 74%. The ex ante wattage assumptions are fairly similar, however the ex ante operating hours are higher than ex post and the ex post installation rates are lower than ex ante assumptions – 87% overall. For SCE, there was only one delamping claim which was zeroed out for 2014 which explains the 0% GRR. For SDG&E, the delamping measure is a 100% pass through because no T12 delamping measures where rebated in 2014 (just T8 delamps).

For LED measures, the GRR is much higher than any of the other ESPI measures (126% for kWh and 144% for kW). As discussed above in Section 4.6 while the ex post installation rates were roughly 10% less than ex ante assumptions, overall, the ex post operating hours were somewhat higher than ex ante (2% to 11% greater) and the delta wattages were significantly higher (120% higher for the 8 to 11W measure configuration category alone).

For occupancy sensors, the most significant differences in GRR are reflected in the controlled wattage for measures and, to a lesser extent, operating hours. For high and low wattage controlled integrated occupancy sensors, the ex ante assumptions compare well to the ex post actuals. However, for non-integrated occupancy sensors, the ex ante controlled wattage assumptions are much higher than ex post actuals. For PG&E, roughly 56% of the first year ex ante kWh savings associated with occupancy sensors were credited to non-integrated controls (72% GRR). For SCE, the GRR was roughly 100% and the percentage of first year savings associated with non-integrated sensors was only 16%. For SDG&E, the GRR was 40%. This is best explained by the fact that roughly 90% of the ex ante kWh savings associated with occupancy sensors were from non-integrated controls.

For T5 linears, the most significant differences in the GRR are reflected in the delta wattages, however, operating hours and installation rates also have an effect. As discussed above in Section 4.6 while the ex post installation rates were generally higher than ex ante assumptions (6% to 8% higher) the ex post delta wattages were higher and operating hours were all less than ex ante assumptions. For PG&E, the ex post delta wattages were roughly 9% greater than the ex ante assumptions and operating hours were roughly 9% less. For SCE, a similar trend was evident, although the difference in delta wattages played a more prominent role.

## 5.2 Lifecycle Gross Realization Rates

Because some measures have a dual baseline, the GRRs associated with the first year savings will differ from the GRRs associated with lifecycle savings. To estimate lifecycle savings, annual gross savings were estimated for each year through the measure's EUL and aggregated. No net present valuation was made, just a straight aggregation. For measures classified as ROB, the lifecycle savings will equal the first year savings times the EUL. For measures classified as ER, the lifecycle savings will equal the annual RUL period savings times the RUL plus the annual post-RUL savings times the EUL minus the RUL:

*ROB Lifecycle savings = EUL * First Year Savings*

*ER Lifecycle savings = RUL * RUL Period Savings + (EUL-RUL) * Post-RUL Savings*

Lifecycle GRRs were then estimated by looking at the ratio of the ex post gross lifecycle savings to the ex ante gross lifecycle savings. Table 5-2 presents the kWh and kW lifecycle GRRs, by PA and measure, along with PA and statewide totals. Also shown are the aggregate ex post and ex ante savings values by segment that were used to develop the realization rates.

### Table 5-2: 2014 Lifecycle Gross kWh and kW Realization Rates by PA and Measure

| PA<br>ESPI Measure | Ex Ante Gross kWh Savings | Ex Post Gross kWh Savings | GRR kWh | Ex Ante Gross kW Savings | Ex Post Gross kW Savings | GRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 5,958,759 | 5,873,220 | **99%** | 1,154.28 | 1,275.59 | **111%** |
| Delamping | 42,266,209 | 33,088,753 | **78%** | 9,644.54 | 8,017.45 | **83%** |
| LED | 118,790,594 | 208,025,334 | **175%** | 23,827.04 | 46,329.66 | **194%** |
| Occupancy Sensors | 41,874,409 | 29,947,575 | **72%** | 7,879.95 | 8,441.26 | **107%** |
| T5 | 175,324,695 | 157,213,574 | **90%** | 43,014.33 | 36,370.27 | **85%** |
| **SCE** | | | | | | |
| CFL | 1,110,345 | 1,372,893 | **124%** | 238.54 | 283.31 | **119%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 42,136,515 | 42,459,753 | **101%** | 9,708.40 | 9,976.94 | **103%** |
| T5 | 212,413,587 | 237,774,263 | **112%** | 55,357.47 | 53,717.73 | **97%** |
| **SDG&E** | | | | | | |
| CFL | 7,094,821 | 6,660,783 | **94%** | 1,405.57 | 1,391.35 | **99%** |
| Delamping | 14,927,526 | 14,927,526 | **100%** | 3,513.12 | 3,513.12 | **100%** |
| Occupancy Sensors | 15,235,200 | 6,114,321 | **40%** | 3,566.31 | 1,494.16 | **42%** |

For CFL measures, the lifecycle realization rates are most affected by the operating hours. When ex post operating hours are lower than ex ante, the ex post EUL generally increases. This explains why the GRRs for PG&E and SCE increase at a much greater scale from first year to lifecycle than SDG&E.[12] Since the ex post EULs for CFL reflector lamps are roughly 3 times less than those of CFL lamps and SDG&E rebated only reflector lamps, the kWh GRR increase from first year to lifecycle was only 5%.

For LED measures, while the ex post operating hours were generally higher than ex ante assumptions, the ex post EULs were greater than ex ante EULs. The main driver behind this is higher ex post lamp service life for LED measures. As presented in Section 4.6 the ex post

[12] Ex post operating hours for PG&E and SCE were lower than ex ante operating hours which resulted in a higher lifecycle gross savings realization rate.

EULs ranged from 14% to 56% higher than ex ante assumptions for the measures where a comparison could be drawn.

Occupancy sensors have a fixed EUL and are not affected by hours of operation. This is the reason why lifecycle and first year GRRs are virtually identical for those measures.

For linear delamp and T5 retrofits, the EUL is often capped at 15 years, so lower hours will not increase the EUL beyond the 15-year threshold. These measures are also subject to a dual baseline, so the post-RUL impacts are typically lower than the impact during the RUL period. For delamping, there is a marginal difference between first year and lifecycle savings in PG&E (74% and 78% for kWh). For T5s, the effect is more prominent as the lifecycle GRRs are less than first years, indicating that the ex post wattage associated with the post-RUL period is less than the ex ante assumptions.

## 5.3 Net First Year Realization Rates

Net savings are estimated in a manner similar to the gross savings. UES values are multiplied by the corresponding NTGRs to get net savings values. NRRs are then estimated for kWh and kW savings by looking at the ratio of the aggregate evaluated gross savings to the aggregate ex ante gross savings. Specifically, the NRR for PA-Measure segment j is estimated as:

$$Net\_Realization\_Rate_j = \frac{\sum_{i=1}^{n} Net\_Ex\_Post\_Impact_{i,j}}{\sum_{i=1}^{n} Net\_Ex\_Ante\_Impact_{i,j}}$$

Where,

> $Net\_Ex\_Post\_Impact_{i,j}$ is the site-specific net ex post impact estimate for customer i, in the population, who is in PA-Measure segment j.
>
> $Net\_Ex\_Ante\_Impact_{i,j}$ is the site-specific net ex ante impact estimate for customer i, in the population, who is in PA-Measure segment j.

Table 5-3 presents the kWh and kW first year NRRs, by PA and measure, along with statewide totals. Also shown are the aggregate ex post and ex ante savings values by segment that were used to develop the realization rates.

**Table 5-3: 2014 First Year Net kWh and kW Realization Rates by PA and Measure**

| PA<br>ESPI Measure | Ex Ante Net kWh Savings | Ex Post Net kWh Savings | NRR kWh | Ex Ante Net kW Savings | Ex Post Net kW Savings | NRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 1,412,023 | 850,770 | **60%** | 253 | 163 | **64%** |
| Delamping | 6,473,821 | 4,730,275 | **73%** | 1,452 | 1,128 | **78%** |
| LED | 13,879,652 | 13,658,199 | **98%** | 2,770 | 3,140 | **113%** |
| Occupancy Sensors | 3,248,333 | 2,257,142 | **69%** | 618 | 632 | **102%** |
| T5 | 9,142,154 | 7,465,809 | **82%** | 2,227 | 1,735 | **78%** |
| **SCE** | | | | | | |
| CFL | 257,188 | 197,008 | **77%** | 54 | 40 | **74%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 3,409,838 | 3,077,549 | **90%** | 788 | 720 | **91%** |
| T5 | 10,305,678 | 11,031,573 | **107%** | 2,689 | 2,504 | **93%** |
| **SDG&E** | | | | | | |
| CFL | 1,525,106 | 1,380,643 | **91%** | 300 | 286 | **95%** |
| Delamping | 625,284 | 625,730 | **100%** | 146 | 143 | **97%** |
| Occupancy Sensors | 1,190,783 | 443,704 | **37%** | 275 | 107 | **39%** |

The NRRs differ for the same reasons discussed above for GRRs, however, they are also influenced by differences between ex post and ex ante NTGRs. For the most part, the ex post NTGRs are less than ex ante NTGRs, which explains why NRRs are lower than GRRs. One exception to this is an increase from 89% GRR to 91% NRR kWh for SDG&E CFLs. This is because the ex post NTGR for this measure was slightly larger than the ex ante NTGR.

## 5.4 Lifecycle Net Realization Rates

Lifecycle NRRs are estimated in a similar way as lifecycle GRRs, by looking at the ratio of the evaluated ex post net lifecycle savings to the ex ante net lifecycle savings. The approach is identical to that for the lifecycle GRRs but using net savings instead of gross.

Table 5-4 presents the kWh and kW lifecycle NRRs, by PA and measure, along with PA and statewide totals. Also shown are the aggregate ex post and ex ante savings values by segment that were used to develop the realization rates.

**Table 5-4: 2014 Lifecycle Net kWh and kW Realization Rates by PA and Measure**

| PA<br>ESPI Measure | Ex Ante Net kWh Savings | Ex Post Net kWh Savings | NRR kWh | Ex Ante Net kW Savings | Ex Post Net kW Savings | NRR kW |
|---|---|---|---|---|---|---|
| **PG&E** | | | | | | |
| CFL | 4,311,051 | 3,863,478 | **90%** | 825 | 836 | **101%** |
| Delamping | 31,465,807 | 24,263,874 | **77%** | 7,094 | 5,854 | **83%** |
| LED | 88,035,840 | 118,108,060 | **134%** | 17,648 | 26,510 | **150%** |
| Occupancy Sensors | 25,986,666 | 18,057,133 | **69%** | 4,946 | 5,057 | **102%** |
| T5 | 136,712,799 | 94,460,044 | **69%** | 33,330 | 21,884 | **66%** |
| **SCE** | | | | | | |
| CFL | 745,539 | 856,919 | **115%** | 160 | 177 | **111%** |
| Delamping | 0 | 0 | **0%** | - | - | **0%** |
| Occupancy Sensors | 27,098,266 | 24,523,866 | **90%** | 6,265 | 5,743 | **92%** |
| T5 | 144,667,372 | 141,895,984 | **98%** | 37,868 | 32,226 | **85%** |
| **SDG&E** | | | | | | |
| CFL | 4,250,548 | 4,051,217 | **95%** | 842 | 848 | **101%** |
| Delamping | 9,019,117 | 9,072,960 | **101%** | 2,120 | 2,077 | **98%** |
| Occupancy Sensors | 9,308,788 | 3,478,601 | **37%** | 2,177 | 840 | **39%** |

As discussed above, the lifecycle NRRs differ for the same reasons discussed above for lifecycle GRRs, however, they are also influenced by differences between ex post and ex ante NTGRs.

# 6

# Recommendations

This section presents recommendations related to the findings developed for this evaluation.

**Conclusion 1 [Section 4.4.4]: Measures installed under programs that assume a program-induced early retirement and utilize a dual baseline were split between the ex post classification of early replacement (ER) and replace on burnout (ROB), as opposed to being all ER.**

**Recommendation 1: Programs that are allowed to claim program-induced early retirement for lighting measures should only assume that a portion of the installations are actually early retirement.** It may not be feasible or practical to gather enough evidence to determine if each customer should be classified as ER or ROB. Therefore, for deemed measures assuming program-induced early retirement and utilizing a dual baseline, an "average" case needs to be developed, where the RUL and post-RUL period UES values are developed as a combined value of the ER and ROB cases. When combining the ER and ROB values together, the results of this evaluation can be used to estimate the percentage of installations that are ER.

**Conclusion 2 [Section 4.4]: The average replaced wattages for screw-in LED A-lamps have decreased over the 2010-12 to 2013-14 evaluation cycles.** On-sites conducted as part of the 2010-12 Nonresidential Downstream Lighting Impact Evaluation, found that LED A-lamps rarely replaced CFL lamps (only in 1% of the onsite visits). As part of this and the 2013 ESPI evaluation, over a quarter of the on-sites (where the baseline equipment could be determined) found LED A-lamps replacing CFLs. Therefore, there has been a trend over time of more LED A-lamps replacing CFLs, which has resulted in a decrease in the baseline wattage.

**Recommendation 2: Future evaluations should continue to track the replaced/baseline wattage of LED installations to determine if an increasing percentage of CFLs are being replaced over time.**

**Conclusion 3 [Section 4.4]: There are measure names for high bay fixtures that do not specify the baseline equipment, and others that combine T5 and T8 fixtures as the installed measure**. Some measure names did not specify if the installed equipment was a T5 or T8 measure. The wattage associated with these two types of fluorescents can differ, making it important to specify the measure being installed. Other measure name did not specify if the baseline equipment was metal halide or linear fluorescent technologies. Again, the wattages associated with these two types of baseline equipment can differ, making it important to specify the equipment being replaced. Finally, some measure names that specify a T5 installation were actually found to be T8 systems.

**Recommendation 3: Measure names for high bay linear fluorescent technologies should specify both the installed equipment (T5 or T8) and the baseline equipment being replaced (metal halide or linear fluorescent).**

**Conclusion 4 [Section 6]: The workpapers for some early replacement linear fluorescent high bay measures were claiming savings for code compliant lighting controls during the RUL period.** The reasoning behind this is that a high bay retrofit may trigger code, requiring that lighting controls be installed. If the measure is early replacement, then the code required lighting control would be reducing operating hours during the RUL period. Then, in the post-RUL period, the lighting control would become part of the ISP baseline, so the reduction in operating hours could no longer be claimed. However, the evaluation found that only one percent of the on-site sample for high bay fluorescent participants installed a non-rebated lighting control as a result of their installation. Furthermore, in the instances when a lighting control was being installed along with the high bay installation (which occurred in 35% of the sample), the control received a rebate and savings was being claimed under the program 96% of the time. Therefore, significant double counting of the savings associated with the control was occurring.

**Recommendation 4: High Bay Lighting Installations should not be allowed to take credit for a reduction in operating hours due to the installation of code compliant lighting controls,** if controls are offered under the IOU portfolio of measures**.**

**Conclusion 5 [Section 4.6]: Programs installing dual baseline measures can influence both the timing and the efficiency of the measure installed.** During the RUL period, both timing and efficiency can be influenced by the program; however during the post-RUL period, the program can only influence the efficiency of the installed equipment.

**Recommendation 5: Further research should be done to consider a framework for NTGRs that can be applied to measures that have a dual baseline, where separate NTGRs are developed for the RUL and post-RUL periods to incorporate the program's influence on both the timing and efficiency of the installed equipment.**

**Conclusion 6 [Section 4.2]: Installation rates were found to be less than 100% for all measures studied.** Installation rates are a function of installed and operable measures and exclude the percentage in storage, failed and/or removed.

**Recommendation 6: Apply installation rates to ex ante claims by measure and by gross program group.** To develop ex ante claims, the ex ante savings values should be adjusted by installation rates. Because installation rates vary by measure and delivery mechanism, separate installation rates should be applied by measure and by gross program group (or some combination of deemed, direct installation, third party and LGP program groupings).