2014-2015
Energy Efficiency Program
Evaluation Report

Prepared for

Lodi Electric Utility

energy & resource solutions

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Contents

1 Executive Summary

This report documents the evaluation activities undertaken by ERS for the Lodi Electric Utility (LEU). The evaluation focuses on the energy savings impacts of LEU's commercial projects completed under the commercial rebate program. The evaluated program and projects were completed during the 2014–2015 program year (July 1, 2014 through June 30, 2015).

The primary objective of the evaluation is to provide independent verification of LEU's reported energy savings. The secondary objective is to provide recommendations – based on the findings of this report – for program improvement.

The evaluation effort consisted of four primary sets of activities: conducting research, developing evaluation plans, collecting data, and estimating energy savings. ERS visited nine project sites and collected data to verify the energy-saving attributes of each energy efficiency measure implemented.

ERS combined the research and data collection results to analyze and develop energy savings estimates using standard engineering principles and evaluation methodologies. Table 1-1 provides the program energy savings results.

Table 1-1. Program Energy Savings

Description	Energy Savings (kWh)
Reported savings	436,618
Verified savings	449,810
Program realization rate	103%

Based on our observations and analysis, ERS offers the following recommendations for LEU's consideration.

- Require rebate applicants to determine if code applies to their project, and if so, require that the appropriate Title 24 paperwork be submitted with the application. See Appendix B for a flow chart that outlines the process to determine whether a lighting project triggers code.
- For lighting retrofits, use the default values in the TRM calculator for preexisting fixture wattages. On average, the lighting projects evaluated had lower energy savings than was reported by the program, due in large part to discrepancies in preexisting fixture wattages.
- When reporting program savings, use the default net-to-gross factors in the E3 reporting tool.

Going forward, best practices for reporting lighting retrofit savings will be to use an accelerated replacement/dual baseline methodology. Under that methodology, the existing conditions baseline will be used for the first baseline and also used to report annual savings. The joint associations (CMUA, NCPA, SCPPA) will soon be developing a baseline methodology tailored for publicly owned utilities, which we recommend LEU use once finalized.

Introduction

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This report documents the evaluation activities undertaken by ERS for the Lodi Electric Utility (LEU). The evaluation focuses on the energy savings impacts of specific programs and projects completed during the 2014–2015 program year (July 1, 2014 through June 30, 2015).

2.1 Focus of Evaluation

The commercial rebate program provides up to $27,500 in rebates to large commercial and industrial customers (G-3 to I-1 rate schedule customers). Projects that are typically rebated include pumps/motors, process equipment improvements, building envelope improvements, HVAC/chiller replacements, and high efficiency lighting retrofits.

2.2 Evaluation Objectives

The primary objective of the evaluation is to provide independent verification of LEU's reported energy savings for the program. The secondary objective is to provide recommendations – based on the findings of this report – for program improvement.

For this evaluation effort, nine projects funded under this program were randomly sampled by ERS for evaluation.

2.3 Overview of Evaluation Activities

The evaluation consisted of four primary sets of activities: conducting research, developing evaluation plans, collecting data, and estimating energy savings.

- **Conduct research** – ERS conducted initial research and review of the following:
  - Similar evaluation efforts
  - LEU program process and procedures
  - Publicly owned utility compliance reporting requirements and methodologies
  - Project-specific technologies used to save energy
- **Develop sampling and evaluation plans** – ERS developed a sampling plan to select projects for site evaluation and then developed measurement and verification (M&V) plans for each of the evaluated sites.
- **Collect data** – ERS visited each of the selected project sites to interview staff and collect data regarding energy efficiency measures installed at the site.

Estimate energy savings – ERS combined the research and data collection results to analyze and develop energy savings estimates per the methodologies described in Section 3 of this report.

Methodology

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This section describes the M&V objectives and methodologies used by ERS for sampling, data collection, and savings verification. It also provides a discussion on the reliability of energy savings estimates and our recommendations for reporting program influence in terms of net-to-gross energy savings.

3.1 Measurement and Verification Objectives

The overall objectives for this evaluation are:

- Determine whether the energy-saving measures are installed and operating properly.
- Verify energy savings, using the best available information.
- Determine the realization rate for the selected projects.
- Extrapolate results from the sample projects to estimate program savings.

3.2 Data Collection

ERS visited each program participant selected for evaluation. ERS engineers collected information on-site regarding the retrofit project to determine if the measures were installed and operational. Information was also gathered to assist with verifying energy savings estimates. Site visits were conducted between December 15, 2016 and January 13, 2017.

3.3 Verification of Energy Savings

All energy savings calculations performed by ERS for the sites evaluated are included in a separate zip file and are referenced as Appendix A to this report.

3.3.1 Reported Energy Savings

For custom project measure savings, LEU uses the savings analysis provided by the program participant. For lighting measures, the savings are estimated by LEU's third-party consultant, Efficiency Services Group (ESG), using a custom spreadsheet calculator (ESG lighting calculator).

3.3.2 Verified Energy Savings

ERS calculated energy savings as the difference between the baseline conditions and post-retrofit conditions. The appropriate baseline is the site's preexisting conditions except when code requirements or industry standard practice dictate that the preexisting conditions are not an option for continued (future) operation. In those cases, the code-required equipment

minimum efficiency or standard practice equipment efficiency is used to estimate baseline energy use.

For lighting measures, ERS used either actual lamp/ballast performance data, default lighting fixture power wattage values, or code-required lighting power allowances for calculating energy use. For hours of operation, we used typical facility end-use types and adjusted the hours if necessary based on information gathered during the site visit.

For lighting savings estimates, the baseline energy use is potentially impacted by the 2013 Title 24 lighting alteration requirements. The current best practice is to determine if a project is subject to code requirements, and if it is, determine if the code allowed lighting power allowance results in a lower baseline energy use estimate. If so, that baseline would be used to estimate savings. However, the current best practice is being revisited given that AB802 directs that an existing conditions baseline be considered and used where possible.

Based on the current CPUC proceedings to establish a baseline methodology, the joint associations (CMUA, NCPA, SCPPA) will soon be developing a baseline methodology tailored for publicly owned utilities. The methodology likely to be adopted for lighting retrofits is to report savings as accelerated replacement. Under this methodology an existing conditions baseline is used to report first-year savings, but a code baseline will be needed to estimate measure cost-effectiveness.

For all other measures, ERS calculated energy savings based on either the methodology used in the customer-provided calculations or an alternative methodology, depending on the available project information. Assumptions and rationale for the methodology used are provided in the site summaries.

3.4 Sampling

ERS developed a sample design to randomly select projects for site evaluation. Using stratified ratio estimation, a total of nine were selected for evaluation. The sample size was designed to achieve a relative precision of 10% at the 90% confidence level (precision of 90/10), which exceeds the recommendation precision levels of 90/30 found in the CPUC evaluation protocols[1] for verification level of rigor. All of the primary sample sites selected were evaluated and no backup sample sites were needed.

The sample realization rate was calculated for the nine sites and then expanded to the seventeen projects to estimate program level savings results. The resulting realization rate is 103%, the standard error is 0.9%, the error bound is 0.01, and the relative precision is 1.4% at the 90% confidence level.

[1] 2006 California Energy Efficiency Evaluation Protocols, California Public Utilities Commission

Table 3-1. Program Energy Savings

Description	Energy Savings (kWh)
Reported savings	436,618
Verified savings	449,810
Program realization rate	103%

3.5 Reliability

Energy savings cannot be measured directly. Energy savings estimates are a predictor of the absence of energy use; they account for the difference between how energy-consuming systems and equipment would operate (baseline conditions) and how they operate after being upgraded (post-retrofit conditions). To assess the reliability of the verified energy savings presented in this report, ERS reviewed all potential sources of error associated with our evaluation efforts. Although a verification level of rigor was used for most sites, we find the verified savings presented in this report to be a reasonably accurate estimate of the energy savings achieved.

The following is a list of the potential sources of error:

- **Preexisting conditions** – For the most part, ERS could not directly verify preexisting equipment or operating conditions while on-site. Information regarding preexisting conditions was obtained from the contractor (via rebate documentation) or through interviews with site personnel.
- **Equipment operating hours** – In general, operating hours were estimated based on on-site interviews and contractor-supplied estimates.
- **Annual operating load profile** – For Site 9, ERS developed savings estimates based on trend data measured over a period of 11 days in January. Although the site contact indicated that the operating load is consistent year-round, the limited number of days of trend data may not fully represent the actual annual load profile.

3.6 Program Influence (Net-to-gross energy savings)

It is important to understand and properly reflect the impact of utility energy efficiency programs. The net impact of the program is used to demonstrate that the program is cost-effective and thus is a wise use of ratepayer funds. One measure of program impact is net energy savings, which is the difference between total energy savings and savings expected to occur in the absence of the program.

To determine net energy savings, a net-to-gross (NTG) factor is used to adjust gross energy savings for free ridership and spillover. Free ridership describes program participants who would have implemented energy efficiency in the absence of the program, and spillover describes the program's ability to indirectly influence behavior (customer or market behavior) leading to increased energy efficiency.

Net energy savings are difficult to assess. And, the results of efforts to quantify it at the measure or program level have a high degree of uncertainty. Given this uncertainty and the relatively high cost to conduct primary research, most, if not all, small- to medium-sized utilities choose to use stipulated NTG factors for reporting program net savings.

The POU regulatory compliance reporting tool (E3) includes stipulated NTG factors from large investor-owned utility programs. Although the scale and program delivery methods for these larger programs can greatly differ from POU programs, their NTG factors are the best available resource.

The current version of the E3 reporting tool includes automatic selection of default NTG factors for deemed measures. For custom measures, the NTG factor can be selected from the table provided within the E3 tool. For LEU's lighting retrofit projects, we recommend using an NTG factor of 70%. For the VFD retrofit project, we recommend using an NTG factor of 85%.

Site 1 – Exterior Lighting LED Retrofit

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4.1 Project Summary

Site 1 included the retrofit of eighteen exterior metal halide fixtures with LED lamps at a manufacturing facility. Six 450-watt metal halide lamps were replaced with 100-watt LED lamps in wallpacks around the exterior of the building. Additionally, twelve 450-watt metal halide lamps were replaced with 100-watt LED lamps in poles surrounding the facility parking lot.

4.2 Energy Savings

Table 4-1 summarizes the energy savings for all measures evaluated at Site 1. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 4-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
Metal halide to LED exterior lighting retrofit	Reported	28,225	0.0
	Verified	29,870	0.0
	Realization rate	106%	N/A

Explanation of Realization Rate

The increase in savings is the result of the difference in preexisting lamp wattages. The reported savings used a preexisting fixture wattage of 456 watts, which did not have a documented source. The verified savings calculations used 480 watts per fixture based on the default fixture values from the TRM lighting calculator.

The hours of operation in the ESG calculator for fixtures operating on photocells was 4,380 hours, where the TRM lighting calculator uses a default of 4,180 hours for this type of measure.

Site Visit

The facility was visited on December 15, 2016. The facility manager was there to answer questions and to assist with the site inspection. All LED exterior lamps were observed and counted. The facility manager was interviewed to confirm the operating schedule and lighting control type, which were used to verify the hours of operation.

Table 4-2 provides the initial M&V plan and the results of the site visit.

Table 4-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from metal halide to LEDs	All 18 fixtures were counted at the site.
Equipment specification – Obtain wattages of new lamps	The lamp wattages could not be verified on-site. Wattages were verified using model numbers from the customer invoice.
Schedules – Obtain daily, weekly, and seasonal schedules	The lights operate from dusk until dawn.
Controls – Verify lighting control type	The lights are controlled via time clock with photocell backup.
Baseline determination – Verify wattage of replaced lamps, if possible	No existing lamps were available for inspection.

Savings Analysis

The reported savings use a preexisting fixture wattage of 456 watts, but the source was not documented. The post-installation wattages in the ESG lighting calculator were taken from the manufacturer's cut sheets.

For the verified savings, preexisting fixture wattages were obtained from the TRM lighting calculator. The installed lamp wattage was obtained from cut sheets provided in the rebate documentation, and the hours of operation were determined from site interviews. ERS interviewed facility staff and determined that both the preexisting and installed fixtures were controlled by photocells, which resulted in 4,180 hours of operation per year.

Table 4-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

Table 4-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for the reported savings	A spreadsheet model (TRM lighting savings calculator) was used for the analysis. Annual savings were estimated for each measure type based on the fixture wattage reduction and operating hours.
Baseline determination	N/A	Based on the quantity of fixtures retrofitted, a code baseline may have been applicable. Without the additional information necessary to assess code impacts, the verified savings are based on an existing conditions baseline.
Baseline description	Twelve 450-watt metal halide pole-mounted fixtures Six 450-watt metal halide wall packs	Default rated power for preexisting fixture types and verified wattages of installed fixtures were used in the analysis.
Operating hours	Dusk-to-dawn: 4,380 hours	Dusk-to-dawn: 4,180 hours
Equipment/system efficiency	Rated power used was default fixture type data from the ESG lighting calculator.	Rated power based on manufacturer default fixture type data.

Site 2 – Exterior Lighting LED Retrofit

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5.1 Project Summary

Site 2 is a commercial mixed-use building with secure boat parking in the rear of the facility. The lighting retrofit consisted of thirty-seven exterior metal halide fixtures with LED lamps, as follows:

- Eighteen pole-mounted 400-watt metal halide lamps were retrofitted with 171-watt LED lamps.
- One 400-watt metal halide wallpack was retrofitted with a 101-watt LED lamp.
- Eight 1,000-watt metal halide wallpacks were retrofitted with 412-watt LED lamps.
- Six 250-watt metal halide pole lamps were retrofitted with 106-watt LEDs.
- Four 250-watt metal halide wallpacks were retrofitted with 89-watt LED lamps.

5.2 Energy Savings

Table 5-1 summarizes the energy savings for all measures evaluated at Site 2. Energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 5-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
Metal halide to LED exterior lighting retrofit	Reported	60,038	13.0
	Verified	55,667	0.0
	Realization rate	93%	0%

Explanation of Realization Rate

The reported hours of operation for the fixtures was 4,380 hours, whereas the TRM lighting calculator uses a default of 4,180 hours. The ESG lighting calculator uses all user-defined inputs for the preexisting fixture wattages, and the source of the wattages is not documented.

While the lighting retrofit results in a demand reduction, there is no peak demand reduction associated with lights that operate only at night, as this is an off-peak period.

Site Visit

The facility was visited on December 15, 2016. The general manager was there to answer questions and to assist with the site inspection. All LED exterior lamps were observed and counted. The general manager was interviewed to confirm the operational schedule for the fixtures retrofit. Table 5-2 provides the initial M&V plan and the results of the site visit.

Table 5-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from metal halide to LEDs.	All 37 fixtures were counted at the site.
Equipment specification – Obtain wattages of new lamps.	Lamp wattages could not be verified on-site. Wattage was verified using model numbers from the customer invoice.
Schedules – Obtain daily, weekly, and seasonal schedules.	Lights operate from dusk to dawn.
Controls – Verify lighting control type	Fixtures were controlled via time clock with photocell backup.
Baseline determination – Verify wattage of replaced lamps, if possible.	No existing lamps were available for inspection.

Savings Analysis

For the reported savings, the post-installation wattages were taken from the manufacturer's cut sheets. For the verified savings, fixture wattages for the preexisting lamps were obtained from the TRM lighting calculator. The installed lamp wattage was obtained from cut sheets provided in the rebate documentation. The hours of operation were determined from site interviews. ERS interviewed facility staff and determined that the lights that were retrofitted were controlled by photocells and therefore operated 4,180 hours per year. Table 5-3 details the methodology used to estimate the energy savings.

Table 5-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for reported savings	A spreadsheet model (TRM lighting calculator) was used for the analysis. Annual savings was estimated for each measure type based on the fixture wattage reduction and operating hours.
Baseline determination	N/A	Based on the quantity of fixtures retrofitted, a code baseline may have been applicable. Without the additional information necessary to assess code impacts, the verified savings are based on an existing conditions baseline.
Baseline description	Ten 250-watt, nineteen 400-watt, and eight 1000-watt metal halide lamps	Default rated power for preexisting fixture type and inspected wattage of installed fixtures was used in the analysis.
Operating hours	Dusk-to-dawn: 4,380 hours	Dusk-to-dawn: 4,180 hours
Equipment/system efficiency	Rated power used was default fixture type data from the ESG lighting calculator.	Rated power based on manufacturer data.

Site 3 – High-Bay Lighting LED Retrofit

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6.1 Project Summary

Site 3 is a service repair center for tractor trailer trucks. The facility had thirty metal halide high-bay lamps that were retrofitted with equivalent LED lamps. Two projects were completed at this location and this section addresses one of those two projects. (See Site 4 for the second retrofit project that was submitted to LEU for rebates).

6.2 Energy Savings

Table 6-1 summarizes the energy savings for all measures evaluated at Site 3. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 6-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
Metal halide to LED interior lighting retrofit	Reported	60,875	5.9
	Verified	37,795	6.8
	Realization rate	62%	115%

Explanation of Realization Rate

The reported savings estimates are based on 6,552 hours of operation per year. During the site visit the site contact informed ERS that the shop ran two work shifts, which is estimated to be 5,824 hours of operation per year. This value was used in the verified savings calculations.

The ESG lighting calculator used all user-defined inputs for the preexisting fixture wattages. The source of these wattages was not provided.

Site Visit

The facility was visited on January 13, 2017. The shop foreman escorted the evaluator around the two shop areas confirming the installation of the lights and the hours of operation.

Table 6-2 provides the initial M&V plan and the results of the site visit.

Table 6-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from metal halide to LED high-bay fixtures.	All 30 fixtures were counted at the site.
Equipment specification – Obtain wattages of new lamps.	Lamp wattages were verified using invoice model numbers.
Schedules – Obtain daily, weekly, and seasonal schedules.	The shop operates two shifts per day.
Controls – Verify lighting control type.	Light fixtures are controlled manually.
Baseline determination – Verify wattage of replaced lamps, and ballasts if possible.	No existing lamps were available for inspection.

Savings Analysis

For the verified savings, the preexisting and installed fixture wattages were obtained from the TRM lighting calculator. According to ERS's interviews of facility staff and information gathered during the site visit, the facility operates with two shifts per day.

Table 6-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

Table 6-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for the reported savings.	A spreadsheet model (TRM lighting calculator) was used for the analysis. Annual savings were estimated for each measure type based on the fixture wattage reduction and operating hours.
Baseline determination	N/A	Based on the quantity of fixtures retrofitted, a code baseline may have been applicable. Without the additional information necessary to assess code impacts, the verified savings are based on an existing conditions baseline.
Baseline description	Thirty 400-watt metal halide fixtures	Default rated power for preexisting fixture type was used in the analysis.
Operating hours	6,552 hours	5,824 hours
Equipment/system efficiency	Rated power used was default fixture type data from the ESG lighting calculator.	Rated power based on fixture cut sheet data.

Site 4 – Office/Storage Lighting Retrofit

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7.1 Project Summary

Site 4 is a service repair center for tractor-trailer trucks. The lighting retrofit was performed in the office and storage areas in the facility. Most of the preexisting fixtures were 4-foot T8 lamps that were retrofitted to 4-foot linear LED lamps. Several fixtures previously had 8-foot T12 lamps installed that were replaced with 4-foot LED linear lamps. Two projects were completed at this location that were submitted to LEU for rebates, and this section addresses one of those two projects.

7.2 Energy Savings

Table 7-1 summarizes the energy savings for all measures evaluated at Site 4. Energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 7-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
T12 and T8 to LED interior lighting retrofit.	Reported	42,929	7.2
	Verified	42,840	7.8
	Realization rate	100%	107%

Explanation of Realization Rate

The ESG lighting calculator used all user-defined inputs for the preexisting fixture wattages. The source of these wattages was not provided. One of the fixtures was mislabeled in the ESG lighting calculator, but this had a minimal effect on the energy savings calculations.

Site Visit

ERS visited the facility on January 13, 2017. The shop foreman escorted the evaluator around the two shop areas confirming the installation of all the lights and hours of operation. Table 7-2 provides the initial M&V plan and the results of the site visit.

Table 7-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from linear fluorescent lamps to LEDs.	All of the fixtures were counted at the site.
Equipment specification – Obtain wattages of the new lamps.	Lamp wattages were verified using model numbers found on the project invoice.
Schedules – Obtain daily, weekly, and seasonal schedules.	Operational schedule used in the ESG lighting calculator was verified by the site contact during the site visit.
Controls – Verify lighting control type.	Light fixtures are controlled manually.
Baseline determination – Verify wattage of replaced lamps, and ballasts if possible.	No existing lamps were available for inspection.

Savings Analysis

For the verified savings, the preexisting and installed fixture wattages were obtained from the TRM lighting calculator. ERS interviewed the facility staff and verified the hours of operation for the fixtures included in this project.

Table 7-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

Table 7-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for reported savings	A spreadsheet model (TRM lighting calculator) was used for the analysis. Annual savings were estimated for each measure type based on the fixture wattage reduction and operating hours.
Baseline determination	N/A	Based on the quantity of fixtures retrofitted, the retrofit was not subject to code requirements. Therefore, an existing conditions baseline was used for the verified savings.
Baseline description	Thirty 400-watt metal halide fixtures	Default rated power for the preexisting fixture type was used in the analysis.
Operating hours	Vary by space (see spreadsheet)	Unchanged from the values used in the ESG lighting calculator.
Equipment/system efficiency	Rated power used was the default fixture type data from the ESG lighting calculator.	Rated power based on fixture cut sheet data.

Site 5 – High-Bay Lighting LED Retrofit

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8.1 Project Summary

Site 5 is a machine shop and fabrication facility where sixty-one metal halide fixtures were retrofitted with LED lamps in a high-bay area.

8.2 Energy Savings

Table 8-1 summarizes the energy savings for all measures evaluated at Site 5. Energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 8-1. Site 2 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
High-bay metal halide to LED retrofit	Reported	52,215	17.4
	Verified	53,469	18.0
	Realization rate	102%	103%

Explanation of Realization Rate

The ESG lighting calculator inputs for the preexisting fixture wattages were user-defined and the project documentation did not include the source of this data. The quantity of lights installed was verified on-site, which was one fixture greater than was reported.

Site Visit

The facility was visited on December 22, 2017. The owner was there to show the evaluator the shop floor where the retrofit took place. The owner also provided the hours of operation for the space. Table 8-2 provides the initial M&V plan and the results of the site visit.

Table 8-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from metal halide to LEDs.	Sixty-one high-bay fixtures were found to have LED lamps installed.
Equipment specification – Obtain wattages of new lamps	Lamp wattages could not be verified on-site. Wattages were verified using model numbers from the project invoice.
Schedules – Obtain daily, weekly, and seasonal schedules.	Monday through Friday 6 a.m. to 5 p.m. and most Saturdays 6 a.m. to 11 a.m.
Controls – Verify lighting control type.	Lighting is controlled by manual switches.
Baseline determination – Verify wattage of replaced lamps, if possible.	No existing lamps were available for inspection.

Savings Analysis

Table 8-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences. For the verified savings, the preexisting fixture wattages were obtained from the TRM lighting calculator. The installed fixture wattages were taken from the manufacturer's cut sheets. The operating hours were obtained from facility staff.

Table 8-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for reported savings.	A spreadsheet model (TRM lighting calculator) was used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction and operating hours.
Baseline determination	N/A	Based on the quantity of fixtures retrofitted, the project was not subject to code requirements. Therefore, an existing conditions baseline was used for the verified savings.
Baseline description	400-watt metal halide high-bay fixtures	The default rated power for the preexisting fixture type was used in the analysis.
Operating hours	2,912 hours	3,010 hours
Equipment/system efficiency	Rated power used was the default fixture type data from the ESG lighting calculator.	Rated power is based on manufacturer default fixture type data.

Site 6 – Retail Lighting Retrofit

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9.1 Project Summary

Site 6 is a retail store. The project consisted of retrofitting thirty-seven 4-foot T12 fixtures with new LED lamps.

9.2 Energy Savings

Table 9-1 summarizes the energy savings for all measures evaluated at Site 6. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 9-1. Site 2 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
T12 to LED interior lighting retrofit.	Reported	8,325	2.3
	Verified	7,826	2.7
	Realization rate	94%	117%

Explanation of Realization Rate

The hours of operation used in the ESG lighting calculator were 3,120 hours per year. During the site visit the site contact verified the hours of operation of the retail space to be 2,718 hours per year. This slightly reduced the kWh savings.

The verified preexisting fixture wattages were derived from the TRM lighting calculator and were slightly higher than those used by the applicant. This accounted for the increase in peak demand savings.

Site Visit

The facility was visited on January 13, 2017. The facility director was there to answer questions and to assist with the site inspection. The number of lamps installed in the retail space was verified. The site contact was interviewed to confirm the operating schedule and lighting control type to estimate the hours of operation.

Table 9-2 provides the initial M&V plan and the results of the site visit.

Table 9-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from fluorescent T12 fixtures to LED fixtures.	All fixtures were counted at the site.
Equipment specification – Obtain wattages of new lamps.	Lamp wattages were verified through cut sheet documentation.
Schedules – Obtain daily, weekly, and seasonal schedules.	Retail space is open from 10 a.m. to 6 p.m. in the summer and 10 a.m. to 5 p.m. in the winter.
Controls – Verify lighting control type.	Lighting is controlled by manual switches.
Baseline determination – Verify wattage of replaced lamps, and ballasts if possible.	No existing lamps were available for inspection.

Savings Analysis

For the reported savings, the source of the wattage used for the preexisting fixtures was not specified. The post-installation wattages in the calculator were taken from the manufacturer's cut sheets.

For the verified savings, the preexisting and installed fixture wattages were obtained from the TRM lighting calculator. ERS interviewed facility staff to determine the hours of operation.

The verified savings estimate used to determine the site realization rate is based on an existing conditions baseline. As is noted in Table 9-3 below, ERS also estimated the savings using a code baseline. The savings estimate (5,524 kWh) assuming code as a baseline lowers the realization rate to 66%. Going forward, the best practice for reporting lighting retrofit savings will be to use an accelerated replacement/dual baseline methodology. Under that methodology, the existing conditions baseline will be used for the first baseline and also to report annual savings. Therefore, ERS chose to use the existing conditions baseline savings estimate for verified savings.

Table 9-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

Table 9-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for reported savings.	A spreadsheet model (TRM lighting calculator) was used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction and operating hours.
Baseline determination	An existing conditions baseline was used in the analysis. There is no documentation assessing whether or not the project was subject to Title 24 code and lighting power allowances.	Verified savings are based on an existing conditions baseline. Savings estimates assuming a code baseline were also estimated using T8 linear fluorescent wattages.
Baseline description	Thirty-five two-lamp T12 fixtures	Thirty-five two-lamp T12 fixtures
Operating hours	3,120 hours	2,718 hours
Equipment/system efficiency	Rated power used was default fixture type data from the ESG lighting calculator.	Rated power based on wattage observed on-site.

Site 7 – Warehouse Lighting Retrofit

10

10.1 Project Summary

Site 7 is a warehouse space where fifty-seven two-lamp 4-foot T12 fixtures were retrofitted with new high-efficiency T8 lamps and ballasts. The warehouse operates 24 hours a day.

10.2 Energy Savings

Table 10-1 summarizes the energy savings for all measures evaluated at Site 7. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 10-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
T12 to T8 interior lighting retrofit	Reported	8,814	1.6
	Verified	7,829	0.8
	Realization rate	89%	51%

Explanation of Realization Rate

The reported hours of operation were 2,700 per year. During the site visit the site contact informed ERS that the warehouse lighting was on 24 hours a day, 7 days a week, or 8,760 hours per year.

The reported savings assumed a per-fixture wattage of 96 watts for the preexisting fixtures and 49 watts for the installed fixtures. The verified savings are based on 72 watts for the preexisting fixtures and 56 watts for the installed fixtures.

These discrepancies led to an overall decrease in the energy savings and peak demand reduction associated with this project.

Site Visit

The facility was visited on December 22, 2016. The Engineering and Operations Manager was there to answer questions and to assist with the site inspection. The quantity of lamps retrofitted inside the warehouse was verified. The site contact was interviewed to confirm the operating schedule and lighting control type, which were used to estimate the annual hours of operation.

Table 10-2 provides the initial M&V plan and the results of the site visit.

Table 10-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all fixtures that were retrofitted from fluorescent T12 fixtures to T8 fixtures.	All 57 fixtures were counted at the site.
Equipment specification – Obtain wattages of new lamps.	Lamp wattages were verified on-site.
Schedules – Obtain daily, weekly, and seasonal schedules.	Warehouse lights stay on 24 hours a day 7 days a week.
Controls – Verify lighting control type.	Lighting is controlled by manual switches.
Baseline determination – Verify wattage of replaced lamps, and ballasts if possible.	No existing lamps were available for inspection.

Savings Analysis

For the reported savings, the ESG lighting calculator was used. The project documentation did not provide the source of the wattage used for the preexisting fixtures. The post-installation wattages in the calculator were taken from the manufacturer's cut sheets.

For the verified savings, the preexisting and installed fixture wattages were obtained from the TRM lighting calculator. ERS interviewed facility staff, and based on information they provided during the site visit the hours of operation were determined to be 24 hours a day, 7 days a week.

The verified savings estimate used to determine the site realization rate is based on an existing conditions baseline. As noted in Table 10-3 below, ERS also estimated the savings using a code baseline. The savings estimate (979 kWh) assuming code as a baseline lowers the realization rate to 11%. Going forward, the best practice for reporting lighting retrofit savings will be to use an accelerated replacement/dual baseline methodology. Under that methodology the existing conditions baseline will be used for the first baseline and also to report annual savings. Therefore, ERS chose to use the existing conditions baseline savings estimate for verified savings.

Table 10-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

Table 10-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The ESG lighting calculator was used for reported savings.	A spreadsheet model (TRM lighting calculator) was used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, and HVAC interactive effects.
Baseline determination	An existing conditions baseline was used in the analysis. There is no documentation assessing whether or not the project was subject to Title 24 code and lighting power allowances.	Verified savings are based on an existing conditions baseline. Saving estimates for a code baseline also estimated using T8 linear fluorescent wattages in lieu of T12 wattages.

Description	Reported Savings Approach	Verified Savings Approach
Baseline description	Fifty-seven two-lamp T12 96-watt fixtures	A default rated power of 72 watts with energy-saving ballast was used for the preexisting fixture type.
Operating hours	2,700 hours	8,760 hours
Equipment/system efficiency	Rated power used was default fixture type data from the ESG lighting calculator.	Rated power based on wattage observed on-site.

Site 8 – Church A/C Replacement

11

11.1 Project Summary

Site 8 is a church that had a 4-ton packaged A/C unit replaced with a high-efficiency 4-ton packaged unit. The system installed serves the office spaces at this location.

11.2 Energy Savings

Table 11-1 summarizes the energy savings for all measures evaluated at Site 8. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 11-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
4-ton A/C unit replacement	Reported	951	0.22
	Verified	756	0.29
	Realization rate	79%	132%

Explanation of Realization Rate

The source of the reported savings estimate was not documented. The verified savings were taken from the CMUA TRM.

Site Visit

The facility was visited on January 13, 2017. The office secretary was there to provide the evaluator with access to the roof and to allow for the inspection of the unit. The hours of operation of the church office were also verified during the site visit.

Table 11-2 provides the initial M&V plan and the results of the site visit.

Table 11-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Verify the number and size of HVAC unit.	A new 4-ton packaged unit was inspected on the roof of the building.
Equipment specification – Verify size and efficiency of unit.	The size of the packaged A/C unit was verified by the model number on the HVAC unit. The efficiency of the unit was determined through cut sheet data.
Schedules – Obtain daily, weekly, and seasonal schedules.	Monday – Friday 6 a.m. to 5 p.m. and most Saturdays 6 a.m. to 11 a.m.

Data Collection Plan	As Implemented or Found
Controls – Verify control of the unit.	The unit is controlled by a programmable digital thermostat.
Baseline determination – Verify size and efficiency of baseline unit.	The baseline unit had been disposed. The size and efficiency could not be determined.

Savings Analysis

Table 11-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

The CMUA TRM was used to estimate reported savings.

Table 11-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	Unknown	The CMUA TRM deemed savings estimate was used to estimate the savings. The savings per ton for a 4-ton packaged unit rated at 14 SEER in climate zone 12 for a small office was selected from the TRM100 spreadsheet.
Baseline determination	N/A	Natural replacement
Baseline description	N/A	N/A
Operating hours	N/A	N/A
Equipment/system efficiency	4-ton 14 SEER packaged HVAC system	4-ton 14 SEER packaged HVAC system

Site 9 – Pump VFD Retrofit

12

12.1 Project Summary

Site 9 is a manufacturing facility where two variable frequency drives (VFDs) were installed on two 25 hp chilled water pumps.

12.2 Energy Savings

Table 12-1 summarizes the energy savings for all of the measures evaluated at Site 9. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 12-1. Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Peak Demand Reduction (kW)
VFDs on chilled water pumps	Reported	97,674	0
	Verified	137,739	0
	Realization rate	141%	N/A

Explanation of Realization Rate

The verified savings estimate is based on the average operating power of the pumps, obtained from data loggers installed at the site. The average operating power is lower than is assumed in the reported savings estimate.

Site Visit

ERS visited the facility on January 13, 2017. Metering equipment was installed to measure actual operating power. Trend data for 11 days of operation was measured and the data loggers were picked up on January 24, 2017. The maintenance superintendent was there to answer questions and to assist with the site inspection. The chilled water pump size and operation were verified.

Table 12-2 provides the initial M&V plan and the results of the site visit.

Table 12-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Verify installation of variable frequency drives chilled water pumps.	Both VFDs were confirmed to be installed during the site visit.
Equipment specification – VFDs controlling 25 hp motors on chilled water pumps	Size of motor was verified on-site by the motor nameplate.

Schedules – Obtain daily, weekly, and seasonal schedules.	The pumps operate one at a time and never simultaneously. Operating hours for this site is 24 hours a day, 7 days a week.
Controls – The VFD is controlled based on the temperature drop across the air-cooled chillers.	The control strategy could not be verified as there was no accessible control interface.
Baseline determination – Verify that there was not a VFD on the chilled water pump prior to project and the pump operated at a constant volume 24/7.	The site interview confirmed the baseline operation.

Savings Analysis

Amperage data was collected at this site over the period of 11 days. Two days' worth of the data was removed due to anomalies resulting from a storm that occurred in the area during the metering period.

An average demand reduction was calculated based on this data and multiplied by the hours of operation. The hours of operation were determined to be 8,520 per year based on the system constantly operating, except for 10 scheduled maintenance days per year. Given that the site contact indicated that the process served by the pumps is consistent throughout the year, the average operating power from the trend data was extrapolated to estimate the annual savings.

Table 12-3 compares the reported and verified energy savings estimation methodologies, details changes made in the final analysis, and provides a description of the key differences.

Table 12-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	Spreadsheet calculation using metered data from the site	A spreadsheet calculation using 11 days of metered data was used to determine savings.
Baseline determination	Natural replacement – existing conditions	Natural replacement – existing conditions
Baseline description	Constant speed 25 hp chilled water pump	Constant speed 25 hp chilled water pump
Operating hours	8,760 hours	8,520 hours
Equipment/system efficiency	Metered data	Metered data

Summary and Recommendations

13

Based on the results of the analysis, the total program savings are 436,618 kWh per year. The program reported savings, verified savings, and realization rate are provided in Table 13-1.

Table 13-1. Program Energy Savings

Description	Energy Savings (kWh)
Reported savings	436,618
Verified savings	449,810
Program realization rate	103%

Table 13-2 provides the savings and realization rate for the nine projects evaluated on-site.

Table 13-2. Combined Results for Rebate Projects Evaluated

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Site 1	Reported	28,225	0.0
	Evaluated	29,870	0.0
	Realization rate	106%	N/A
Site 2	Reported	60,038	3.2
	Evaluated	55,667	0.0
	Realization rate	93%	0%
Site 3	Reported	60,875	5.9
	Evaluated	37,795	6.8
	Realization rate	62%	114%
Site 4	Reported	42,929	7.2
	Evaluated	42,840	7.8
	Realization rate	100%	108%
Site 5	Reported	52,215	17.4
	Evaluated	53,469	18.0
	Realization rate	102%	103%
Site 6	Reported	8,325	2.3
	Evaluated	7,826	2.7
	Realization rate	94%	115%
Site 7	Reported	8,814	1.6
	Evaluated	7,829	0.8
	Realization rate	113%	51%

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Site 8	Reported	951	0.2
	Evaluated	756	0.3
	Realization rate	80%	133%
Site 9	Reported	97,674	0.0
	Evaluated	137,739	0.0
	Realization rate	141%	N/A

13.1 Recommendations

Based on our observations and analysis, ERS offers the following recommendations for LEU's consideration.

- For lighting retrofit projects, require rebate applicants to determine if code applies to their project, and if so, require that the appropriate Title 24 paperwork be submitted with the application. See Appendix B for a flow chart that outlines the process to determine whether a lighting project triggers code and lists the applicable Title 24 documentation.
- For lighting retrofits, use default values in the TRM calculator for preexisting fixture wattages. On average, the lighting projects evaluated had lower energy savings than were reported by the program, due in large part to discrepancies in preexisting fixture wattages.
- When reporting program savings, use the default net-to-gross factors in the E3 reporting tool.

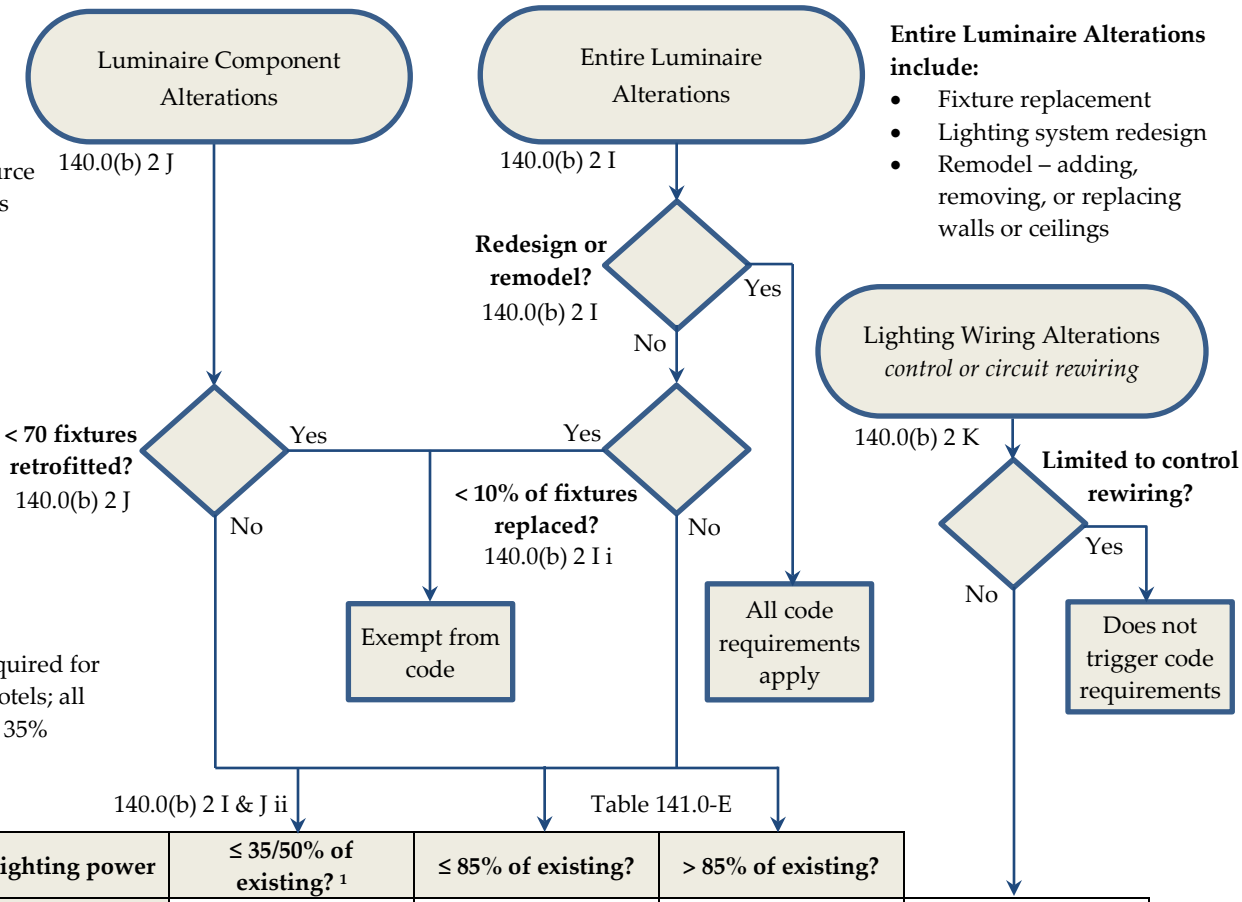
Going forward, the best practice for reporting lighting retrofit savings will be to use an accelerated replacement/dual baseline methodology. Under that methodology, the existing conditions baseline will be used for the first baseline and also to report annual savings. The joint associations (CMUA, NCPA, SCPPA) will soon be developing a baseline methodology tailored for publicly owned utilities, which we recommend that LEU use once it is finalized.

APPENDIX A: ENERGY SAVINGS CALCULATIONS FOR THE SITES EVALUATED (UNDER SEPARATE COVER)

APPENDIX B: TITLE 24 COMPLIANCE PATH OPTIONS FOR INTERIOR LIGHTING ALTERATIONS

Interior Lighting Alterations - 2016 Title 24 Compliance Path Options

Luminaire Component Alterations include:
- Ballast & lamp replacement
- Change of light source
- Change of reflectors



Entire Luminaire Alterations include:
- Fixture replacement
- Lighting system redesign
- Remodel – adding, removing, or replacing walls or ceilings

Exemptions
140.0(b) 2 I & J
- less than 2 fixtures
- portable fixtures
- disturbs asbestos

[1] 50% reduction required for office, retail, and hotels; all other space types - 35% reduction

Lighting power	≤ 35/50% of existing? [1]	≤ 85% of existing?	> 85% of existing?	
Lighting Power Allowance Section 140.6	N/A	Required	Required	Required
Area controls Section 131.1(a)1,2,&3	Required	Required	Required	Required
Multi-level controls Section 130.1(b) *Required when space > 100 sf or power exceeds 0.5 W/sf*	N/A	Bi-level control acceptable	Required	Bi-level control acceptable
Shut-off controls Section 130.1(c) *Occupancy sensors required for small office (<250 sf), multipurpose (<1,000 sf), classroom, conference, warehouse, library, corridors, stairwells, garages, and parking areas*	Required	Required	Required	Required
Daylight controls Section 130.1(d)	N/A	N/A	Required	Required if 10 or more fixtures
Demand response controls Section 103.1(e)	N/A	N/A	Required	N/A
Control acceptance testing Section 130.4	Required if 20 or more fixtures			
Compliance forms required	NRCC-LTI-01-E Certificate of Compliance NRCC-LTI-02-E Indoor Lighting Controls NRCC-LTI-06-E Indoor Lighting Alterations NRCI-LTI-01-E Certificate of Installation			