2013-2014
Energy Efficiency Program
Evaluation Report

Prepared for

Lodi Electric Utility

energy & resource solutions

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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 2013–2014 program year (July 1, 2013 through June 30, 2014). The evaluation also includes a review and assessment of the Lodi Energy Action Plan (LEAP) program for residential customers.

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 combined results for the nine commercial rebate projects.

Table 1-1. Combined Results for Commercial Rebate Projects

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Site 1	Reported	550,000	N/A
	Evaluated	550,000	N/A
	Realization rate	100%	N/A
Site 2	Reported	30,831	4.0
	Evaluated	25,104	2.8
	Realization rate	81%	70%
Site 3	Reported	94,080	11.2
	Evaluated	89,633	10.7
	Realization rate	95%	95%
Site 4	Reported	12,935	6.4
	Evaluated	7,943	3.1
	Realization rate	61%	49%
Site 5	Reported	39,006	8.0
	Evaluated	58,613	8.6
	Realization rate	150%	108%
Site 6	Reported	188,603	0.0
	Evaluated	162,768	0.0
	Realization rate	86%	N/A
Site 7	Reported	273,558	68.9
	Evaluated	114,486	34.8
	Realization rate	42%	51%
Site 8	Reported	282,056	21.8
	Evaluated	203,372	31.1
	Realization rate	72%	142%
Site 9	Reported	5,059	0.000
	Evaluated	7,214	0.000
	Realization rate	143%	N/A
Total	**Reported**	**1,202,570**	**120.0**
	Evaluated	**1,104,647**	**91.0**
	Realization rate	**92%**	**76%**

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

For the commercial rebate program:

- Require rebate applicants to consider baseline code limitations when estimating lighting energy savings. The 2013 Title 24 Building Energy Efficiency Standards went into effect on

July 1, 2014, when the code requirements were expanded to include most lighting retrofits. In order to assure that lighting project energy savings are not overestimated, consider requiring applicants to use a standardized lighting savings calculator to estimate savings.

- Require rebate applicants to provide detailed energy savings estimates, including descriptions of all key assumptions used in the savings estimate. Where spreadsheet calculations are used, require the spreadsheet files be provided before the project is approved for a rebate. Section 16 of the CMUA Technical Reference Manual provides guidance for documenting custom energy savings estimates. Consider requiring rebate applicants to document their energy savings using the format suggested in the TRM Table 16-1.
- For lighting retrofits, require rebate applicants to provide calculations showing how the lighting operating hours were estimated.
- Require energy efficiency measures to be installed and operating for a period of at least 5 years to ensure that energy savings are realized.

With regard to the LEAP program:

- Require clear descriptions of the proposed scope of work for each proposed measure.
- Pay rebates based on the results of post-installation savings estimates based on electric-only savings.
- Require that all test results and supporting documentation be submitted before rebates are paid.
- Require that post-installation true-up of the savings estimates be conducted based on the results of measure testing, utility bill comparison, and verification that all proposed measures were installed.
- Conduct post-installation site inspections (or post-inspect a sample of sites) to verify that the measures were implemented and assess the customer's overall satisfaction with their participation in the program.

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 2013–2014 program year (July 1, 2013 through June 30, 2014).

2.1 Focus of Evaluation

The commercial rebate program provides up to $25,000 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.

For this evaluation effort, nine projects funded under this program were randomly selected by LEU for evaluation.

The evaluation also included a review and assessment of the Lodi Energy Action Plan (LEAP) program for residential customers. This whole house retrofit program had a total eight participants.

2.2 Evaluation Objectives

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

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 evaluation plan** – ERS developed measurement and verification (M&V) plans for each of the commercial projects evaluated.

- **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.

2.4 Report Structure

The remainder of this report consists of four sections:

1. Section 3 describes the evaluation methodologies employed for data collection, sampling, and estimating energy savings. It also provides a discussion on the reliability of the results of the evaluation and provides recommendations for reporting program influence in terms of net-to-gross energy savings.
2. Section 4 provides a review and assessment of the LEAP program.
3. Sections 5 through 13 provide the individual site results.
4. Section 14 presents the combined results and provides recommendations for program improvement.

3 Methodology

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.
- For the commercial sites, determine the realization rate for the selected projects.

3.2 Data Collection

ERS visited each commercial 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 on April 21, 24, and 29 of 2015.

For the LEAP program, ERS reviewed the available program documentation.

3.3 Verification of Energy Savings

Note: All energy savings calculations performed by ERS will be provided to LEU in a spreadsheet file.

3.3.1 Reported Energy Savings Estimates

For custom project measure savings, LEU uses the savings analysis provided by the program participant.

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.

It should be noted that in future program years some of the lighting retrofits would have been subject to the new lighting alteration requirements of building energy efficiency standards (2013 Title 24) that went into effect on July 1, 2014. Going forward, we recommend that LEU ensure rebate applicants and that their lighting contractors address Title 24 requirements and apply appropriate baselines to their savings estimates. The CMUA technical resource manual (TRM) lighting calculator has the capability of estimating savings based on code. ERS has found that lighting contractors and utility staff with sufficient lighting expertise can easily use the lighting calculator. However, we understand that many program administers do not have the required lighting knowledge and are not comfortable using the calculator. To that end, ERS has developed – for an NCPA member utility – a simplified lighting calculator for use by program administrators. If desired, ERS can provide that tool to LEU.

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

For the commercial rebate program, LEU randomly selected nine projects for review. ERS conducted site-level reviews. As such, the project-level evaluation results are not statistically representative of the entire program results. For sampling measures at the site, ERS either conducted a census (count and observe all measures) or verified a representative number of similar measures.

The rebate documentation for all LEAP program participants was reviewed.

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. Given the limitations of the overall scope of this evaluation, 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.

Equipment counts – For one site, verifying equipment counts proved difficult because there was no clear documentation on which fixtures were retrofitted. Only an invoice of lamps purchased was provided. While ERS was able to verify a majority of the retrofitted fixtures and the type of lamps used, we were unable to verify all of the fixtures retrofitted.

Savings Methodology –For multiple sites a savings report was provided with no live engineering calculations. As a result, the verified savings are an approximate estimate with a relatively high degree of uncertainty.

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 utilities 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.

For the LEU measures evaluated, Table 3-1 lists the most-applicable stipulated NTG factors from the E3 reporting tool.

Table 3-1. NTG Factors

Measure	NTG Factor
Lighting	70%
HVAC VFD	85%
Air compressor	85%

LEAP Program Review

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ERS reviewed the Lodi Energy Action Plan (LEAP) program. This section provides the review findings and recommendations.

4.1 Program Summary

The LEAP program provided whole-house energy upgrades for LEU residential customers. The program was implemented by a third-party provider, Grupe HomeStar. The program offered rebates based on a percent savings basis. Up to $2,500 in rebates was available for a single-family residence.

The LEAP program is an extension of the whole-house rebate program that Grupe HomeStar offers to PG&E customers. The program is part of California Energy Home Upgrade, a statewide program funded by California investor-owned utilities. According to the company's website, Grupe is a verified contractor for the Environmental Protection Agency's (EPA) Home Performance with ENERGY STAR program and has received accreditation from the Building Performance Institute (BPI), a national organization that certifies home performance contractors.

No reported savings for the program were available. However, based on the eight rebate applications processed during the 2013–2014 program year, the program achieved 27,528 kWh of annual electric energy savings. The total rebates paid were $17,700, indicating a program cost of $0.643 per first year of kWh saved. Assuming an effective useful life of 10 years, the levelized life cycle program cost is approximately $0.09 per kWh.

4.2 Energy Savings Methodology

For each of the eight single-family homes that were upgraded, a total of forty-one energy-saving measures were reported as installed by the program. The highest measure count for a single home was eight installed measures; the lowest was three installed measures. Of the forty-one measures installed, there were twelve unique measure types. Both natural gas and electric measures were installed.

Energy savings were estimated for each home using a computer energy simulation software program, Energy Pro version 5.1.8.3. A custom version of Energy Pro was developed specifically for home performance contractors in the California Energy Home Upgrade program. Based on contractor inputs, the model estimates the home annual energy use before and after energy efficiency measures are installed. The program also provides estimated savings in units developed by the California Energy Commission for measuring the time-dependent

value (TDV) of energy. The TDV savings are shown as a percentage of savings and natural gas and electric savings into a single value.

4.3 Energy Savings Analysis

The Energy Pro model has been reviewed by the CPUC and while it is accepted for use, the CPUC has noted savings estimation discrepancies and has requested the IOUs to re-calibrate the model. Our understanding is that revised models are in development or have already been developed for future programs.

With regard to energy savings estimates for each home, there are several issues that limit our ability to evaluate – or cause us to question – the accuracy of the energy savings estimates.

- **TDV values used to determine total savings estimates include natural gas measures**. The total savings used to determine the eligible rebate amount were based on the program TDV percent savings outputs. These values include natural gas savings. If the rebates were paid limited to the savings that LEU can claim (electric savings), the total electric savings should have been used for determining total savings and rebate levels. Table 4-1 indicates that the percent electric savings is always lower than the TDV percent savings and significantly lower for site 3 and site 6.

Table 4-1. Comparison of Electric Savings to Time-Dependent Value (TDV) Savings

Site #	Rebate Amount	Annual Electric Savings (kWh)	Annual Electric Savings (%)	TDV Savings (%)
1	$2,500	6,083	52.1%	54.7%
2	$2,500	2,934	28.1%	26.7%
3	$2,500	1,587	13.0%	25.6%
4	$1,500	1,436	14.8%	17.2%
5	$1,200	1,289	9.0%	12.9%
6	$2,500	2,661	19.5%	30.8%
7	$2,500	4,934	21.3%	26.2%
8	$2,500	6,604	52.7%	54.2%
Total	**$17,700**	**27,528**		

- **Uncertainty of post-installation conditions** – The only form provided in the rebate documentation was the Energy Pro Energy Upgrade Recommendations form, which is an estimate of the potential energy savings estimates for the home. There is no post-installation documentation indicating which proposed measures were installed.
- **Measure descriptions are vague** – The form contains abbreviated names for the measures installed. However, without supporting documentation, it is unclear what work actually occurred. For example, the attic insulation measure indicates R38 levels of insulation. It does not provide the total amount of insulation installed, the preexisting level of insulation, or the R-value of the insulation installed (R38 could be a combination of

preexisting and new insulation). Detailed post-installation documentation should be provided.

- **Post-installation test results are missing** – Several measures, such as the HVAC distribution and building leakage repair, imply that pre- and post- tests were conducted to verify savings. The tests or the results of the tests were not provided. In order to produce an accurate estimate of savings, the energy savings model should have been re-run and calibrated to the results of the tests. It is not apparent that the tests were ever used to verify savings.
- **The energy savings estimates were not calibrated to utility bills**. In order for an energy model to produce accurate savings estimates, the model's predicted energy use should be compared to the home's actual utility bills and then re-calibrated if there is a significant discrepancy. It is not apparent that this essential quality control step was implemented.

4.4 Conclusion and Recommendations

Based on the available information, it is not possible to assess if the program's proposed savings were achieved. The whole-building retrofit approach for residential homes is a relatively new program approach to achieving energy savings. The concept has many positive attributes, but statewide the results have been mixed and program costs are relatively high, making the program not cost-effective using traditional utility program cost-effectiveness tests. That said, the program has the potential to capture energy savings that otherwise would not happen and it serves a customer sector (residential single family, multifamily, and low income homes) that is hard to reach through traditional utility programs offerings.

Should LEU choose to offer whole-building retrofits in the future, we recommend the following:

- Require clear descriptions of the proposed scope of work for each proposed measure.
- Pay rebates based on the results of post-installation savings estimates based on electric-only savings.
- Require that all test results and supporting documentation be submitted before rebates are paid.
- Require post-installation true-up of the savings estimates be conducted based on the results of measure testing, utility bill comparison, and verification that all proposed measures were installed.
- LEU should conduct post-installation site inspections (or post-inspect a sample of sites) to verify that the measures were implemented and assess the customer's overall satisfaction with participating in the program.

Site 1 – Hospital Central Plant Upgrades 5

5.1 Project Summary

A total of five variable frequency drives (VFDs) were installed on the primary chilled water (CHW) and condenser water (CW) loops of the hospital's central plant. The hospital's building management system also had control upgrades installed to optimize chiller operation and control the VFD speeds.

5.2 Energy Savings Summary

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

Table 5-1Site 2 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
VFDs for primary CHW and CW pumps	Reported	550,000	Not provided
	Verified	550,000	0
	Realization rate	100%	0

5.2.1 Explanation of Realization Rate

No detailed calculations were provided by the customer. ERS attempted to contact the engineer who conducted the reported savings analysis, but his contact information has changed. Without calculations or the results of pre- and post-measurement, it is not possible to assess the accuracy of the reported savings estimates. However, the documentation indicates that the savings estimate was reduced by 12% in order to make the savings estimate conservative. Based on our professional judgment, we find that the final savings estimate is within the range of expected savings for the type of retrofit project implemented.

5.3 Site Visit

The facility was visited on April 24, 2015. The facility manager was present for the site visit and escorted the ERS staff through the central plant.

A picture of central plant chillers and motors is included in the savings spreadsheet.

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 installed VFDs.	Five VFD installations were verified installed during site visit.
Equipment specification – Verify chiller make, model, and efficiency. Verify CHW and CW horsepower and installation of VFDs.	Chiller model numbers and efficiencies were verified through nameplate data and cut sheets. Motor horsepower was verified with nameplate data and VFD installation was visually verified.
Schedules – Verify the operation hours of the central plant.	Hospital operates 8760 hours a year.
Controls – Verify chiller sequence of operation and control setpoints.	Chiller sequence of operation was verified on-site. An air-cooled chiller handles base load, and the water-cooled chillers handle peak and surge load.
Baseline determination – Confirm the reported condition of preexisting chillers and verify their approximate age.	The evaluators verified the baseline conditions through interviewing the contact person. Units were determined to be less than 15 years old.

5.4 Savings Analysis

Table 5-3 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 savings documents provided with the incentive did not include live spreadsheet calculations. The initial plant savings estimate of 42% was discounted to 30%.

Table 5-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	The savings analysis provided in the report did not provide any live calculation spreadsheet that could be reviewed.	Measures implemented at the central plant are considered proven technologies. The savings estimate appears reasonable.
Baseline determination	N/A	System optimization.
Baseline description	Preexisting equipment sequence of operation without VFDs on CW pump motors and CHW pump motors.	The installation of VFDs on CW pump motors and CHW pump motors and a new sequence of operation were verified through inspection of setpoints and visual inspection.
Operating hours	Cooling is required at the hospital year-round.	The year-round cooling requirements were verified through site contact interview.
Equipment/system efficiency	Two water-cooled 550-ton chillers .495 kW/ton, CW motor size of 15 hp, and CWP motor size of 30 hp.	All equipment sizes were verified with visual inspection and efficiencies verified by provided cut sheets. VFD installation and operation were visually verified.

Site 2 – Lab Lighting Retrofit

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6.1 Project Summary

A total of 110 three-lamp T8 fixtures were retrofitted with 20 W LED linear T8 replacement lamps.

6.2 Energy Savings Summary

Table 6-1 summarizes the energy savings for all measures evaluated at Site 2. The energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 6-1. Site 2 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
T8 to linear LED retrofit	Reported	30,831	3.9
	Verified	25,104	2.8
	Realization rate	81%	70%

6.2.1 Explanation of Realization Rate

There is a slight reduction in the verified savings estimate due to the differences in the default values used. The verified savings estimates use default values obtained from the CMUA TRM lighting calculator.

6.3 Site Visit

ERS visited the site on April 24, 2015. The facility director was present during the visit.

The facility director and ERS staff members walked through and counted each fixture in the lab area that was retrofitted for the incentive.

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 T8 to LED tubes.	All 110 fixtures were counted and verified operating during the site visit.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	Lighting scheduled was verified by interview on-site. The lights are on 24 hours a day, 350 days a year.
Controls – Verify lighting control types and operating schedules	The lighting is controlled manually by wall switches.
Baseline Conditions – Verify wattage of replaced lamps, if possible.	No preexisting lamps were available for inspection.

6.4 Savings Analysis

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	A copy of a single-line calculation was provided	A spreadsheet model (TRM Lighting Savings Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement – existing conditions
Baseline description	Three-lamp T8 fixtures. A sample of 70 lamps was metered and usage was extrapolated to 330 lamps.	Default rated power for baseline fixture type and inspected wattage of installed fixtures was used in the analysis.
Operating hours	8,400 hours	According to interviews, lighting is on 24/7 for 350 days, resulting in 8,400 hours per year of run time.
Equipment/system efficiency	The source of data for the 32 W T8 lamps was not provided.	Rated power based on manufacturer default fixture type data.

Site 3 – Compressor Retrofit

7

7.1 Project Summary

The project consisted of replacing three air compressors – 70 hp combined – operating at 200 cfm and 104 psi. The air compressors were replaced with one 75 hp variable speed compressor operating at 200 cfm and 100 psi.

7.2 Energy Savings Summary

Table 7-1 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 7-1. Site 3 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Compressor retrofit	Reported	94,080	11.2
	Verified	89,633	10.6
	Realization rate	95%	95%

7.2.1 Explanation of Realization Rate

The realization rate reflects the fact that the trend data obtained to verify savings indicates a slightly smaller average power reduction.

7.3 Site Visit

The site visit took place on April 24, 2015. The facility director was present during the visit.

ERS verified the installation of a new 75 hp compressor and spot-measured the volts, amperes, power factor, and kW of the compressor. The operation setpoints were also visually verified on the compressor control screen.

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 installed measures and compare to reported quantities.	The installation of a new 75 hp air compressor was verified during the site visit.
Equipment specification – Verify air compressor model number, hp, and psi setpoint.	Nameplate and product ID information were obtained from the equipment installed on-site. The psi at the time of the site visit was 100.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules by space type.	Compressor operated all day year-round with 15 scheduled days of maintenance.
Energy use – Monitor equipment operation to confirm power use over time.	Spot measurements were taken to confirm power to amperage relationship and data loggers were installed to collect energy use data over a 3-week period.

7.4 Savings Analysis

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	One day of trend data was used to calculate baseline and post installation kW. The difference between the two was extrapolated to 1 year of data,	The compressor was trended for 3 weeks. The average kW from the trend data was subtracted from the provided baseline data. The difference was extrapolated to 1 year of savings.
Baseline determination	N/A	Natural replacement – existing equipment
Baseline description	Three air compressors that have a combined horsepower of 70.	The three air compressors were verified through site interviews and provided trend data. One of the compressors is still on-site for operation during maintenance cycles.
Operating hours	Reported hours of operation are 8,400.	Verified hours of operation are 8,400.
Equipment/system efficiency	New Kaeser 75 hp variable speed compressor operating at 100 psi and 200 cfm.	New Kaeser 75 hp variable speed compressor operating at 100 psi and 200 cfm.

Site 4 – Retail Lighting Retrofit

8

8.1 Project Summary

This retrofit consists of thirty-three 8-foot T12 lamps retrofitted with sixty-six 4-foot T8 lamps Thirty 8-foot T12 lamps were removed from existing fixtures. Fifteen four-lamp 4-foot T12 fixtures were retrofitted with 4-foot T8 lamps. Two 4-foot lamps were removed from each fixture.

8.2 Energy Savings Summary

Table 8-1 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 8-1. Site 4 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
T12 to T8 retrofit	Reported	12,935	6.3
	Verified	7,943	3.1
	Realization rate	61%	49%

8.2.1 Explanation of Realization Rate

Reported savings assumptions were not provided; therefore, the difference between reported and verified savings is uncertain.

Possible differences in the savings results may be attributable to a difference in default lamp wattages and hours of operation.

8.3 Site Visit

The facility was visited on April 29, 2015. The facility staff members present during the visit included the operations manager.

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 installed measures and verify total number of fixtures installed.	All of the fixtures were counted; thirty-three 8-foot fixtures were retrofitted to 4-foot T8s. Thirty 8-foot T12 fixtures were de-lamped, and fifteen four-lamp 4-foot T12 fixtures were retrofitted to two-lamp 4-foot T8s.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	Store operation manager verified that the store's hours of operation are 7:30 a.m. to 5:00 p.m. Monday through Friday.
Controls – Verify lighting control types and schedules	The lights are controlled by manual switches.
Baseline determination – Verify wattage of replaced lamps, if possible.	Site interview verified that the replaced lamps were T12 fluorescent tubes.

8.4 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.

Table 8-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	There were no savings calculations provided in the incentive documentation.	A spreadsheet model (TRM Lighting Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement – retrofit in place. For T12 lamps the calculator assumes T8 wattages (consistent with federal regulations).
Baseline description	Thirty-three 8-foot T12 lamps and sixty 4-foot T12 lamps. Existing lighting power of 5.7 kW.	Default rated power for fixture type replaced.
Operating hours	Not reported	According to interviews and data collected, the sales floor lights remain on 2,450 hours.
Equipment/system efficiency	Ninety six 4-foot T8s, installed lighting power of 2.6 kW	Total installed lighting power based on actual quantities.

Site 5 – Retail T8 Reduced Wattage Retrofit

9

9.1 Project Summary

The project consisted of retrofitting 1,800 4-foot 32 W T8 lamps with 4-foot 28 W T8 lamps, replacing 180 3-foot 24 W T8 lamps with 3-foot 21 W T8 lamps, and 20 2-foot 17 W T8 lamps with 2-foot 15 W T8 lamps.

9.2 Energy Savings Summary

Table 9-1 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 9-1. Site 5 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
T5 high bay light fixtures and T8/reduced wattage retrofit	Reported	39,006	8.0
	Verified	58,613	8.6
	Realization rate	150%	108%

9.2.1 Explanation of Realization Rate

The reported savings analysis used the rated wattage of the lamps for the savings calculation and did not account for the power consumed by the ballasts. The reported savings understate the hours of operation of the store. The verified savings used the hours reported by the site contact.

9.3 Site Visit

ERS visited the site on April 29, 2015. The facility staff members present during the visit included the store shift manager.

ERS staff members counted a sample of the lights installed and verified that the occupancy sensors worked. The store manager verified the hours of operation and use of the space. The entire store had gone through a re-lamping. The store manager indicated that this was a normal part of preventive store maintenance but could not give an exact cycle of how often this happens. Corporate personnel determine the maintenance schedule.

The 2-foot lamps that were invoiced for the project could not be found installed anywhere at the site. ERS did find a new and unused case of thirty 2-foot lamps in the stock room. These lamps appear to have been ordered but were not needed for this site.

The ERS staff took pictures of examples of post-installation lamps that were found in the maintenance closet and installed at the site. These pictures are available in the savings analysis spreadsheet.

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 installed measures and compare to reported quantities.	A sample of each lamp type was counted and verified.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	A schedule of the store's hours of operation was provided by the store manager.
Controls: Verify lighting control types and operating schedules.	Store and warehouse lights are controlled by a mix of switches, timers, and occupancy sensors.
Baseline determination – Verify wattage of replaced lamps, if possible.	Site contact could not verify the baseline lamp wattages that were replaced. The retrofit was a corporate scheduled re-lamp with very little local involvement.

9.4 Savings Analysis

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 scope of savings provided was incomplete. It was a PDF document with savings outputs and did not include hours of operation or ballast factors.	A spreadsheet model (TRM Lighting Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement – retrofit in place
Baseline description	The baseline was reported as 1800 4-foot 32 W T8 lamps, 180 3-foot 24 W lamps, and 30 2-foot 17 W lamps.	Baseline could not be verified by either inspection or site interview.
Operating hours	Hours of operation not stated in reported energy analysis.	5,742 hours of operation was used in the verified savings calculation.
Equipment/system efficiency	4-foot 32 W T8, 3-foot 25 W T8, and 2-foot 17 W T8. Source of data was not provided.	Rated power based on default TRM data.

Site 6 – Motel Parking Lot Lighting Retrofit

10

10.1 Project Summary

This project consisted of replacing fifty-one 1,000 W parking lot pole lamps with 152 W LED fixtures. The project also included retrofitting twenty 75 W high pressure sodium all packs with new 42 W compact fluorescent lamps.

10.2 Energy Savings Summary

Table 10-1 summarizes the energy savings for all measures evaluated at Site 6. Energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 10-1. Site 6 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Parking lot LED and CFL retrofit	Reported	188,603	0.0
	Verified	162,768	0.0
	Realization rate	86%	N/A

10.2.1 Explanation of Realization Rate

The realization rate is less than reported due to ERS not being unable to find three of the CFL fixtures, and the difference between the reported and verified operating hours.

10.3 Site Visit

The facility was visited on April 21, 2015. The facility staff members present during the visit included the business owner.

ERS verified the installation of each fixture in the parking lot. Three of the CFL wall packs were not found. These fixtures were removed from the savings calculation. The site interviewee said that the parking lot had both a timer and photocells to control the lighting hours. The timer would override the photocell if it did not function. The timer setting at the time of visit was 9 p.m. to 6 a.m.

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 installed measures and verify total number of fixtures installed.	All fixtures in the parking lot were counted. There were fifty-one LED pole lamps and seventeen CFL wall packs.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	Nightly schedule is dusk until dawn.
Controls – Verify lighting control types and schedules.	The lights are controlled by photocells that can be overridden by timers.
Baseline determination – Verify wattage of replaced lamps, if possible.	The site interview verified that the replaced lamps were 1,000 W metal halide and 75 W high pressure sodium lamps.

10.4 Savings Analysis

Table 10-3 compares the reported and verified energy savings estimation methodologies, details the 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 scope of savings provided was incomplete. Calculated savings were in the form of hand-written notes in the margins of application.	A spreadsheet model (TRM Lighting Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement copper from poles had been stolen prior to retrofit.
Baseline description	The baseline was reported fifty-one 1,000 W metal halide, and twenty 75 W high pressure sodium lamps.	Baseline was fifty-one 1,000 W metal halide and twenty 75 W high pressure sodium lamps; verified through an on-site interview with the owner.
Operating hours	Hours of operation not stated in reported energy analysis.	3,276 hours of operation was used in verification. Hours were supplied by site owner during interview.
Equipment/system efficiency	1,000 W metal halide fixture and 75 W high pressure sodium fixtures.	152 W LED pole lamp fixtures and 42 W CFL lamps.

Site 7 – Warehouse/Office Lighting Retrofit

11

11.1 Project Summary

This project consisted of an entire re-lamp of a facility. All the facilities T12 fixtures were retrofitted to T8 fixtures, incandescent exit signs were replaced with LED exit signs, and high pressure sodium fixtures were replaced with T5 fixtures.

11.2 Energy Savings Summary

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

Table 11-1. Site 7 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
T12 to T8 retrofit	Reported	273,558	68.86
	Verified	114,486	34.81
	Realization rate	42%	51%

11.2.1 Explanation of Realization Rate

The original savings estimate did not accurately account for all operating conditions. The run time and average loads were overstated, resulting in a reduction in savings.

A large portion of the facility is not occupied and the office space is in disrepair. Although the fixtures have been retrofitted, the space is abandoned and has been since the current occupants assumed responsibility for the space. The verified savings estimate assumes no savings for the lamps in the abandoned area.

11.3 Site Visit

ERS visited the site on April 21, 2015. The facility staff members present during the visit included the site engineer.

ERS staff and the site engineer toured the facility to view all the lights that had been installed throughout the facility. All lamps were counted and reconciled with an inventory provided by the installation contractor.

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 – Count all installed measures and verify total number of fixtures installed.	All fixtures were counted and reconciled with installation invoice.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	Monday through Friday 5 a.m. to 3:30 p.m. with occasional Saturday use.
Controls – Verify lighting control types and schedules.	The lights are controlled by manual switches.
Baseline determination – Verify wattage of replaced lamps, if possible.	Site inspection verified the wattage of the T8 lamps installed at the site. Ballasts could not be inspected at the site.

11.4 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.

Table 11-3. Energy Savings estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	A PDF copy of a spreadsheet calculation was provided in with the rebate documentation.	A spreadsheet model (TRM Lighting Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement. For T12 lamps, the calculator uses T8 wattages, consistent with federal regulations.
Baseline description	The baseline was a variety of T12 and high pressure sodium fixtures	Baseline was verified through site interview with facility engineer.
Operating hours	Between 3,000 and 4,100 hours, depending on fixture location.	Between 2,856 and 3,421 hours, depending on location.
Equipment/system efficiency	T12 and high pressure sodium fixtures to high efficiency T8 and T5 fixtures. Incandescent exit signs to LED exit signs.	T12 and high pressure sodium fixtures to high efficiency T8 and T5 fixtures. Incandescent exit signs to LED exit signs. Default values from TRM used for rated power.

Site 8 – Manufacturing Facility LED Retrofit

12

12.1 Project Summary

Project consists of retrofitting seventy-one 400 W, thirty-five 250 W, and twenty-three 175 W high pressure sodium fixtures with 150 W LED high bay fixtures. All fixtures include integrated occupancy sensors.

12.2 Energy Savings Summary

Table 12-1 summarizes the energy savings for all measures evaluated at Site 8. Energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 12-1. Site 8 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Total	Reported	282,056	21.83
	Verified	203,372	31.05
	Realization rate	72%	142%

12.2.1 Explanation of Realization Rate

The verified energy savings are less than the reported savings due to a reduction in hours of operation. The facility is in the process of being decommissioned and is no longer running three shifts a day. The high realization rate for the peak demand reduction indicates the default fixture power values are different from those used in the reported savings (which are not documented).

12.3 Site Visit

The facility was visited on April 29, 2015. The staff members present during the visit included the site engineer.

ERS and the site engineer walked through and verified the installation of each LED high bay fixture. Most fixtures were off due to the current low staffing and light use of areas.

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 – Count all installed measures and verify total number of fixtures installed.	All fixtures installed for the incentive were counted during the site visit.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	At the time of the site visit the facility was operating two shifts Monday through Friday with a reduced staffing level.
Controls – Verify lighting control types and schedules	The lights are controlled by occupancy sensors
Baseline determination – Verify wattage of replaced fixtures, if possible.	Site interview could not verify the quantity of each baseline fixture that was replaced. Only the total quantity of fixtures installed could be verified.

12.4 Savings Analysis

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	The calculation provided with the application is a PDF copy of a spreadsheet calculation. The actual calculation is not provided.	A spreadsheet model (TRM Lighting Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement – Project was part of an ongoing site fixture replacement.
Baseline description	400 W, 250 W, and 175 W high pressure sodium fixtures.	Baseline was verified through site interview of baseline fixture type but quantity of each wattage type could not be verified.
Operating hours	Hours of operation are assumed to be 24 hours a day with a 90% on time.	5,171 hours of operation used in verification; hours supplied by site contact during interview
Equipment/system efficiency	400 W, 250 W, and 175 W high pressure sodium fixtures retrofitted to 150 W LED fixtures with occupancy sensors	All 129 of the 150 W LED fixtures were verified installed during site inspection.

Site 9 – Exterior LED Fixture Retrofit

13

13.1 Project Summary

This project consists of replacing seven 250 W metal halide wall packs with seven new 52 W LED wall packs.

13.2 Energy Savings Summary

Table 13-1 summarizes the energy savings for all measures evaluated at Site 9. Energy savings reported by LEU are compared to the energy savings verified by ERS.

Table 13-1. Site 9 Energy Savings Summary

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
LED wall pack	Reported	5,059	0.0
	Verified	7,214	0.0
	Realization rate	143%	N/A

13.2.1 Explanation of Realization Rate

The increase in savings reflects that the verified savings estimation default hours of operation are higher than what was used in the reported savings. The reported savings used 3,650 hours of operation and the verified savings are based on exterior lighting with photocell control, or 4,100 hours of operation.

13.3 Site Visit

The facility was visited on April 29, 2015. The staff members present during the visit included the motel owner.

Table 13-2 provides the initial M&V plan and the results of the site visit.

Table 13-2. Measurement and Verification Plan

Data Collection Plan	As Implemented or Found
Quantities – Count all installed measures and verify total number of fixtures installed.	All fixtures replaced were counted on the exterior of the building.
Schedules – Obtain daily, weekly, and seasonal occupancy schedules.	Fixtures installed have integrated photocells and operate from dusk tell dawn.
Controls – Verify lighting control types and schedules	The lights are controlled by photocells.
Baseline determination – Verify wattage of replaced lamps, if possible.	Site interview verified that the replaced lamps that were 250 W metal halide fixtures. The identical fixture was still installed on the building next door.

13.4 Savings Analysis

Table 13-3 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 13-3. Energy Savings Estimation Methodology

Description	Reported Savings Approach	Verified Savings Approach
Calculation methodology	A copy of the savings calculations was not provided. Savings were hand-written in the margins of the application.	A spreadsheet model (TRM Lighting Calculator) is used for the analysis. Annual savings are estimated for each measure type based on the fixture wattage reduction, operating hours, control savings factors, and HVAC interactive effects.
Baseline determination	N/A	Natural replacement – The site interviewee stated that they were tired of replacing bulbs and so they replaced all of the fixtures with LEDs.
Baseline description	Preexisting fixtures were 250 W metal halide fixtures.	The site interviewee confirmed that the replaced lamps were 250 W metal halide fixtures. The identical fixture was still installed on the building next door.
Operating hours	3,650 hours	4,100 hours
Equipment/system efficiency	250 W metal halide fixtures replaced with 52 W LEDs	250 W metal halide fixtures replaced with 52 W LEDs

Summary and Recommendations

14

The summary results for commercial rebate programs indicate that a total annual energy savings of 1,104,647 kWh and a peak demand reduction of 91.0 kW were achieved by the nine commercial rebate projects. Table 14-1 provides the combined results for the ten commercial rebate projects.

Table 14-1. Combined Results for Commercial Rebate Projects

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Site 1	Reported	550,000	N/A
	Evaluated	550,000	N/A
	Realization rate	100%	N/A
Site 2	Reported	30,831	4.0
	Evaluated	25,104	2.8
	Realization rate	81%	70%
Site 3	Reported	94,080	11.2
	Evaluated	89,633	10.7
	Realization rate	95%	95%
Site 4	Reported	12,935	6.4
	Evaluated	7,943	3.1
	Realization rate	61%	49%
Site 5	Reported	39,006	8.0
	Evaluated	58,613	8.6
	Realization rate	150%	108%
Site 6	Reported	188,603	0.0
	Evaluated	162,768	0.0
	Realization rate	86%	N/A
Site 7	Reported	273,558	68.9
	Evaluated	114,486	34.8
	Realization rate	42%	51%
Site 8	Reported	282,056	21.8
	Evaluated	203,372	31.1
	Realization rate	72%	142%

Measure Name	Category	Energy Savings (kWh)	Demand Reduction (kW)
Site 9	Reported	5,059	0.000
	Evaluated	7,214	0.000
	Realization rate	143%	N/A
Total	**Reported**	**1,202,570**	**120.0**
	Evaluated	**1,104,647**	**91.0**
	Realization rate	**92%**	**76%**

14.1 Recommendations

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

For the commercial rebate program:

- Require rebate applicants to consider baseline code limitations when estimating lighting energy savings. The 2013 Title 24 Building Energy Efficiency Standards went into effect on July 1, 2014; the code requirements were expanded to include most lighting retrofits. In order to ensure that lighting project energy savings are not overestimated, consider requiring applicants to use a standardized lighting savings calculator to estimate savings.
- Require rebate applicants to provide detailed energy savings estimates, including descriptions of all key assumptions used in the savings estimate. Where spreadsheet calculations are used, require that the spreadsheet files be provided before the project is approved for a rebate. Section 16 of the CMUA Technical Reference Manual provides guidance for documenting custom energy savings estimates. Consider requiring rebate applicants to document their energy savings using the format suggested in the TRM Table 16-1.
- For lighting retrofits, require rebate applicants to provide calculations showing how the lighting operating hours were estimated.
- Require energy efficiency measures to be installed and operating for a period of at least 5 years to ensure that energy savings are realized.

With regard to the LEAP program:

- Require clear descriptions of the proposed scope of work for each proposed measure.
- Pay rebates based on the results of post-installation savings estimates based on electric-only savings.
- Require that all test results and supporting documentation be submitted before rebates are paid.

- Require that post-installation true-up of the savings estimates be conducted based on the results of measure testing, utility bill comparison, and verification that all proposed measures were installed.
- Conduct post-installation site inspections (or post-inspect a sample of sites) to verify that the measures were implemented and assess the customer's overall satisfaction with their participation in the program.