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Energy Efficiency Evaluation, Measurement and Verification (EM&V) Final Report

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1 EXECUTIVE SUMMARY

For the City of Palo Alto Utilities (CPAU), TRC conducted evaluation, measurement, and verification (EM&V) of CPAU's Fiscal Year (FY) 2017 energy efficiency programs. This report presents the findings of that evaluation.

TRC developed annual net and gross savings estimates of demand (kW), electric (kWh), and natural gas (therm) energy savings, as well as lifecycle electric energy savings, for the following programs:

- The Commercial and Industrial Energy Efficiency Program (CIEEP), for Ecology Action (EA) and BASE
- Commercial Advantage Program (CAP)
- Multifamily Plus program (MPP)
- Home Energy Report (HER) Program

Overall, TRC verified programs representing 5.6 GWh of gross annual ex ante savings, or 76% of the total 7.3 GWh portfolio-level gross annual ex ante savings. TRC verified a census of projects For the CIEEP-Enovity and CIEEP-BASE programs, and used a calculation based on regression analysis (i.e., did not use sampling) to calculate savings for HER. For programs in which TRC used sampling, we achieved 90% confidence with 22% precision (CAP) and 25% precision (MPP). The poor precision was due to different realization rate statistics (e.g., greater variation) than previous years, particularly for MPP. Each program chapter provides more detail on sampling methodologies and statistical rigor achieved.

1.1 Savings Summary

This section provides a summary of savings at the program and portfolio level.

1.1.1 Annual Demand (kW) and Electricity (kWh) Savings

Figure 1 shows gross annual savings for all programs. The programs that TRC verified for FY2017 are shown with an asterisk (*). Programs not evaluated (N.E.) do not have a realization rate, and TRC assumed (i.e., passed through) the ex ante savings.

As shown in Figure 1, the average annual kWh realization rate for the evaluated programs (weighted by ex post energy savings) was 88%. The primary energy savings adjustments included the following. As shown, some of these adjustments decreased savings, while others increased savings.

- **CIEEP**
  - **EA:** The largest savings came from six optimization measures and a lighting installation at a single site. TRC reduced electricity savings from the optimization measures because of changes to schedule and optimization parameter adjustments. EA implemented projects at four additional sites, three for lighting and one for a cooling tower variable frequency drive (VFD). For one lighting project, TRC reduced electricity savings to account for existing controls. TRC increased savings for the VFD measure based on revised assumptions to the base case operations. Overall, TRC's adjustments led to slightly lower savings than claimed, with a kWh realization rate of 95%.
  - **BASE**: BASE implemented three measures at a single site: a new energy management system (EMS), an LED parking lot upgrade, and variable frequency drive (VFD) control of supply fans. TRC verified savings for each measure with minor savings variances. The

largest variance was with the EMS project, where increased savings resulted from tighter schedules than had been projected (104% kWh realization rate).

- **HER: Updates to the calculation with parameters specific to FY2017**: Ex ante savings were calculated by assuming a persistence of 80% from the previous year. Because this was the second year of claiming persistence savings, the total ex ante savings were 64% of the FY2015 value. The FY2015 HER savings also included an attribution factor to account for factors (outside of HER) that contributed to savings. However, because the HER savings were calculated using a control group, these non-program factors were already accounted for. Consequently, as we did in the FY2016 HER evaluation, TRC removed this attribution factor, which increased savings. Additionally, TRC used FY2017 energy use, and (because FY2017 electricity use was lower) this slightly decreased electricity savings. Because the first adjustment was larger, the kWh realization rate was 110%.
- **CAP: Correction to lighting calculator:** The lighting calculator that the program used to calculate ex ante savings for CAP contained a glitch: If the user chose specific inputs, the calculator assumed zero electricity use for the efficiency measure, unbeknownst to the user. Two of the three projects sampled by TRC had this glitch. TRC corrected the calculator for these projects, which reduced electricity savings (75% kWh realization rate).
- **MPP: Reduction in hours of use (HOU) and adjustment to incandescent baseline:** TRC adjusted HOU for several projects to align with TRM[1] assumptions, including a reduction in HOU for the project with the largest kWh savings (Y3OC). Less significantly, TRC adjusted the baseline for incandescent lamp replacements to either align with the TRM (i.e., to a lamp compliant with federal regulations) or (for one project) to assume a dual baseline. Both adjustments reduced electricity savings (70% kWh realization rate).

The average demand (kW) realization rate for the evaluated programs was 81%. Many of the adjustments described above to electricity savings also affected demand savings. In addition, significant reductions in demand savings included the following:

- **CIEEP–Ecology Action (CIEEP-EA):** The lower realization rate for kW (54%) compared to kWh was because of the following: The implementer reduced the chilled water temperature from the base case settings for the design cooling set-point as part of a reset measure, which resulted in increased load. This measure contributed to a large reduction of kW savings for the optimization measures as compared to the claimed kW reduction (46 kW claimed, 5.7 kW realized). Additionally, TRC reduced kW savings for a project to account for existing controls, and removed the kW for another lighting project where the implementer had claimed kW reduction for fixtures operating only at night.
- **CAP:** TRC adjusted the kW reduction as part the correction to the lighting calculator as described above for kWh. TRC did not make other significant adjustments to kW claims.
- **MPP adjustments to coincident diversity factor (CDF)**: TRC used CDFs from the TRM. The program did not provide input assumptions for their calculations, including the CDF

[1] Energy and Resource Solutions (ERS) 2016, "Savings Estimation Technical Reference Manual for the California Municipal Utilities Association". Abbreviated in this report as the TRM. ERS also provides accompanying calculators for deemed savings measures such as lighting.

assumptions. However, ex post demand savings exceeded ex ante demand savings for MPP, indicating that, overall, the program assumed lower CDFs.

Both the program and TRC assumed zero kW savings for the CIEEP-BASE and HER programs, so there was no change in kW realization rate for those programs.

Note that TRC estimated savings for the Palo Alto Green Building Ordinance for CPAU (as a separate project to EM&V). Due to calculation updates, TRC's original savings values (shown as ex ante in Figure 1) varied slightly from our final values (shown as ex post). Two programs (Santa Clara Valley Water District – SCVWD and Solar Water Heating) delivered natural gas savings only, so are not shown in Figure 1.

Figure 1. Gross Annual FY2017 Demand and Electricity Savings

	Ex Ante		Ex Post		
CPAU Program	**Demand (kW)**	**Energy Savings (kWh)**	**Demand (kW)**	**Energy Savings (kWh)**	**Realization Rate (% kWh)**
COM Bus. New Constr.	110	217,048	110	217,048	N.E.
COM Com. Advantage (CAP)*	163	1,043,497	119	778,932	75%
COM CIEEP - BASE (ICE)*	0	76,680	0	79,853	104%
COM CIEEP - Ecology Action*	241	2,051,254	130	1,943,778	95%
COM CIEEP – Enovity	16	74,950	16	74,950	N.E.
COM EMPower (SMB)	43	323,679	43	323,679	N.E.
COM Green Bldg Ord. (Nonres)	0	779,902	0	780,678	N.E.
RES Green Bldg Ord. (Res)	0	137,284	0	137,284	N.E.
RES Home Efficiency Genie	0	17,874	0	17,874	N.E.
RES Home Energy Report (HER)*	0	1,026,734	0	1,124,746	110%
RES Multifamily Plus (MPP)*	162	1,400,252	180	975,822	70%
RES REAP Low Income	7	151,929	5	151,929	N.E.
RES Smart Energy	0	21,560	0	21,560	N.E.
Total	**742**	**7,322,643**	**603**	**6,628,133**	**88%**

*Programs evaluated by TRC

Figure 2 shows net annual savings. To calculate net savings, TRC multiplied the gross savings for each measure by the net-to-gross ratio (NTGR). To identify a NTGR:

1. TRC used the NTGR value if available in the stipulated values in the Northern California Power Agency (NCPA) Energy Efficiency (EE) Reporting Tool based on the E3 calculator (the "NCPA E3 Tool"), which took NTGR values from the Database of Energy Efficiency Resources (DEER) 2014.[1]
2. If the NTGR was not in the NCPA E3 Tool, TRC used the NTGR in DEER2014. Although DEER2016 was effective January 1, 2016, TRC used DEER2014 values to be consistent with the NCPA E3 Tool.

[1] The one exception was for ceiling insulation installed in multifamily buildings in the MPP. TRC assumed 100% NTGR for this measure, as described in Section 7.1.

3. If the NTGR was not available in either the NCPA E3 Tool or DEER, TRC used the NTGR for the most similar measure from the NCPA E3 Tool or DEER2014.

Based on this approach, TRC assumed the following NTGR values:

- 0.8 for all commercial lighting measures (from the NCPA E3 Tool) in CIEEP and CAP. TRC also used the commercial lighting NTGR for both common area installations, and in-unit lighting installations in the MPP, because the bulk of in-unit installations occurred in a multifamily complex where the facility manger (not tenants) are responsible for bulb replacements, and because surveys indicate that participants were likely to pay for only a small portion (one-quarter) of measure costs.
- 0.8 for Retro-commissioning (RCx) and optimization projects (from DEER2014), as well as Variable Frequency Drive (VFD) installations and Energy Management System (EMS) installations since they are similar to RCx and optimization.
- 1.0 for HER, since the savings were calculated based on results of a randomized control trial which accounted for free ridership.

For CIEEP-EA, CAP, and HER, TRC assumed the same NTGR as the programs. Thus, all adjustments to net savings for these programs were due to adjustments to gross savings, not adjustments to the NTGR. For CIEEP-BASE, the program had assumed 0.85 for the EMS installation, resulting in a program average NTGR of 0.82; TRC's assumption of 0.8 for the NTGR slightly reduced net savings.

For programs not evaluated, TRC assumed the ex ante net savings values.

Figure 2. Net Annual Demand and Electricity Savings

	Ex Ante			Ex Post		
CPAU Program	**Program Avg NTGR**	**Peak Savings (kW)**	**Energy Savings (kWh)**	**Program Avg NTGR**	**Peak Savings (kW)**	**Energy Savings (kWh)**
COM Bus. New Constr.	0.85	94	184,491	N.E.	110	184,491
COM Com. Advantage (CAP)*	0.80	130	834,797	0.80	119	623,146
COM CIEEP - BASE (ICE)*	0.82	0	63,046	0.80	0	63,882
COM CIEEP - Ecology Action*	0.80	192	1,641,003	0.80	104	1,555,022
COM CIEEP - Enovity	0.81	14	60,503	N.E.	16	60,503
COM EMPower (SMB)	0.67	30	215,354	N.E.	43	215,354
COM Green Bldg Ord. (Nonres)	0.80	0	623,922	N.E.	0	624,695
RES Green Bldg Ord. (Res)	0.58	0	79,625	N.E.	0	79,625
RES Home Efficiency Genie	0.45	0	8,000	N.E.	0	8,000
RES Home Energy Report (HER)*	1.00	0	1,026,734	1.00	0	1,124,746
RES Multifamily Plus (MPP)*	0.80	130	1,120,202	0.80	180	780,658
RES REAP Low Income	0.80	5	121,543	N.E.	5	121,543
RES Smart Energy	0.34	0	7,271	N.E.	0	7,271
Total (Avg NTGR weighted by kWh)	**0.83**	**595**	**5,986,491**	**N/A**	**577**	**5,448,936**

*Programs evaluated by TRC

1.1.2 Natural Gas Savings

Figure 3 shows ex ante and ex post natural gas savings for the programs evaluated. These savings include interactive effects – i.e., the increase in heating use, because efficient interior lighting and appliances release less waste heat. TRC also included interactive effects in the electricity (kWh) and demand (kW) calculations. The kWh and kW savings are slightly higher due to reduced cooling needs.

The CIEEP–EA and HER programs generated the majority of natural gas savings, and CIEEP-BASE contributed a small amount. Several programs, including EMPower, CAP, and MPP have negative natural gas savings through interactive effects of lighting measures.

Overall, TRC calculated a realization rate of 105% for natural gas savings. TRC's primary adjustments to gross natural gas savings were (in order of significance):

- An increase in natural gas savings for HER, because TRC removed the attribution factor compared with FY2015 (on which the ex ante assumptions were based).
- Reductions to natural gas savings for CIEEP-EA due to changes in optimization projects compared with claimed savings.
- Reductions to natural gas savings because of interactive effects. CIEEP-EA and CAP did not apply interactive effects for interior lighting measures. MPP accounted for natural gas interactive effects, but applied incorrect interactive effect factors in some cases (typically lower factors than DEER2014 assumptions). TRC applied DEER2014 interactive effects, which reduced natural gas savings for CIEEP-EA, CAP, and MPP. Total interactive effects for the programs verified (CIEEP, CAP, and MPP) were -7,487 therms. Including EMPower, portfolio level interactive effects totaled -7,830 therms, representing 3% of portfolio level natural gas savings. Without interactive effects, portfolio natural gas savings would be 247,375 therms.

Although CPAU does not claim net natural gas savings for reporting purposes, TRC provides net natural gas savings for comprehensiveness. For net natural gas savings, TRC assumed the same NTGR for natural gas as for electricity, since almost all natural-gas-saving measures also delivered electricity savings, and it is unknown whether the customer was motivated by electricity or gas savings.[1] For the Santa Clara Valley Water District (SCVWD) and Solar Water Heating Programs, which provided incentives to save water and natural gas only, TRC assumed a 1.0 NTGR, based on CPAU's historic assumption[2] that there is no free ridership for projects with only gas (not electricity) savings.

Note that, for programs where interactive effects dominated natural gas savings (e.g., CAP and MPP), net savings are higher than gross savings, because the net savings adjustment reduced the interactive effects (i.e., resulted in a smaller negative savings).

For programs not evaluated, TRC used the NTGR for kWh savings.

[1] The one exception was a boiler reset measure for CIEEP-EA. Because this measure delivered relatively low natural gas savings, TRC applied the DEER NTGR (0.8) for simplicity.

[2] According to CPAU EM&V staff communications in February 2016. Because CPAU does not report net therm savings to a regulatory agency, TRC did not investigate whether this assumption was valid.

Figure 3. Gross and Net Annual Natural Gas Savings

	Ex Ante		Ex Post		
CPAU Program	**NTGR**	**Gross Savings (Therms)**	**NTGR**	**Gross Savings (Therms)**	**Net savings (Therms)**
COM Bus. New Constr.	0.85	3,432	N.E.	3,432	2,917
COM Com. Advantage (CAP)*	0.80	0	0.80	(626)	(501)
COM CIEEP - BASE (ICE)*	0.82	9,425	0.80	9,715	7,772
COM CIEEP - Ecology Action*	0.80	104,722	0.80	89,503	71,602
COM CIEEP - Enovity	0.81	866	N.E.	866	699
COM EMPower (SMB)	0.67	(343)	N.E.	(343)	(228)
COM Green Bldg Ord. (Nonres)	0.80	(1,981)	N.E.	(1,981)	(1,563)
RES Green Bldg Ord. (Res)	0.79	5,481	N.E.	5,481	4,328
RES Home Efficiency Genie	0.45	2,660	N.E.	2,660	1,191
RES Home Energy Report (HER)*	1.00	93,540	1.00	121,373	121,373
RES Multifamily Plus (MPP)*	0.80	(1,888)	0.80	(3,327)	(2,662)
RES REAP Low Income	0.80	6,610	N.E.	6,610	5,288
RES Smart Energy	0.34	2,392	N.E.	2,392	807
ALL SCVWD	1.00	968	N.E.	968	968
ALL Solar Water Heating	1.00	2,823	N.E.	2,823	2,823
Total (Avg NTGR weighted by therms)	**0.88**	**228,707**	**N/A**	**239,546**	**214,814**

*Programs evaluated by TRC

1.1.3 Lifecycle Savings

Figure 4 shows gross and net lifecycle savings. For almost all measures, to calculate lifecycle savings for the programs evaluated, TRC multiplied the annual savings for each measure by the measure Effective Useful Life (EUL). TRC obtained the EUL values for each measure from the stipulate values in the NCPA tool. TRC also confirmed these EUL values using DEER2014. For one measure, TRC used a dual baseline, resulting in a more complicated calculation of the lifecycle savings, described in Section 7.2.2.

For programs not evaluated, TRC assumed the ex ante lifecycle savings.

As shown in Figure 4, the realization rate for lifecycle savings is 69%. The primary reasons for the adjustments for lifecycle savings include the following. Note that, because optimization and behavioral measures have an EUL of one year, the HVAC optimization projects in CIEEP and the HER savings only contributed one year of lifecycle savings. Instead, the lighting measures dominated lifecycle savings.

- **Adjustments to lighting measure EUL based on operating hours.** For the ex ante lifecycle savings estimate for lighting measures, CAP and MPP appeared to have used an average EUL for all measures without adjusting for the operating hours of where the measures was installed. By dividing ex ante lifecycle savings (in the CPAU SB1037 worksheet in the NCPA E3 Tool) by ex ante annual savings (from the program databases), TRC estimated that CAP and MPP assumed EUL values of 10 and 14 years, respectively, for all LED measures. Similarly, TRC estimated that CIEEP-EA assumed an average EUL of 6 years for lighting measures. For the ex post lifecycle savings estimate, TRC adjusted the EUL based on the operating hours, according to DEER assumptions. For example, for an LED lamp installed in an area for which lighting operates 4,350

hours per year, TRC divided 25,000 hours (the rated lifetime of an LED lamp[1]) by 4,350 to estimate a measure life of 5.7 years. The majority of the lifecycle savings reductions for CIEEP-EA, CAP, and MPP were because of this adjustment.

- **Adjustments to annual savings.** Several of TRC's adjustments to annual kWh savings also affected lifecycle kWh savings, including the adjustment to baseline wattage assumptions.

[1] TRM104 calculator v. 2016 for LED lighting measures.

Figure 4. Gross and Net Lifecycle Energy Savings

	Ex Ante Lifecycle		Input Values for Ex Post Lifecycle		Ex Post Lifecycle		
CPAU Program	**Gross Savings (kWh)**	**Net Savings (kWh)**	**Ex Post Annual Gross Savings (kWh)**	**Average Measure Life (Yr)**	**Gross Savings (kWh)**	**Net Savings (kWh)**	**Gross Realization Rate (%)**
COM Bus. New Constr.	3,255,720	2,767,362	217,048	15.0	3,255,720	2,767,362	N.E.
COM Com. Advantage (CAP)*	10,434,966	8,347,973	778,932	6.7	5,223,497	4,178,798	50%
COM CIEEP - BASE (ICE)*	927,218	758,796	79,853	13.1	1,044,291	835,433	113%
COM CIEEP - Ecology Action*	10,501,467	8,401,174	1,943,778	4.4	8,632,772	6,906,218	82%
COM CIEEP – Enovity	800,250	648,345	74,950	10.7	800,250	648,345	N.E.
COM EMPower (SMB)	3,878,112	2,557,589	323,679	12.0	3,878,112	2,557,589	N.E.
COM Green Bldg Ord. (Nonres)	10,918,633	8,734,902	780,678	14.0	10,929,497	8,745,735	N.E.
RES Green Bldg Ord. (Res)	1,510,121	875,872	137,284	11.0	1,510,121	873,906	N.E.
RES Home Efficiency Genie	298,159	128,008	17,874	16.7	298,159	128,008	N.E.
RES Home Energy Report (HER)*	1,026,734	1,026,734	1,124,746	1.0	1,124,746	1,124,746	110%
RES Multifamily Plus (MPP)*	19,683,264	15,746,611	975,822	6.4	6,237,121	4,989,697	32%
RES REAP Low Income	2,111,375	1,689,100	151,929	13.9	2,111,375	1,689,100	N.E.
RES Smart Energy	332,121	108,309	21,560	15.4	332,121	108,309	N.E.
Total	**65,678,140**	**51,790,775**	**6,628,133**	**6.8**	**45,377,782**	**35,553,244**	**69%**

*Programs evaluated by TRC

1.2 Key Findings

The measures in the programs evaluated in FY2017 that delivered significant electricity and natural gas savings were:

- HVAC optimization projects in CIEEP-EA and (contributing less savings) in CIEEP-BASE
- Persistence of savings from HER, a residential behavioral program
- Lighting measures installed in various programs, including CIEEP-EA, CAP, and MPP

Based on our evaluation results, the realization rates for savings were fairly high for gross annual kWh (88%), annual kW (81%), annual therms (105%), but lower for lifecycle savings (69%). Realization rates for net savings were also high, and almost all adjustments to net savings were due to adjustments to gross savings, not adjustments to the NTGR.

The lower realization rate for lifecycle savings was because lighting measures dominated lifecycle savings, and the programs assumed an EUL that did not account for the operating hours (i.e., the EUL was too high). When TRC adjusted the EUL to account for operating hours, lifecycle savings decreased.

TRC provides more detail and a description of all adjustments in each program chapter (and its associated appendix with project-level results), and program recommendations based on the evaluation findings in Section 8.

2 INTRODUCTION

The objective of this project was to verify FY2017 demand, electricity, and natural gas savings claims. To meet this goal, TRC verified annual and lifecycle gross and net impacts for select residential and commercial programs in CPAU's portfolio.

The primary purpose of this project was to meet CPAU's reporting requirements to the CEC. In addition, CPAU will use the findings for internal tracking purposes and to make improvements to programs going forward.

2.1 Overview of Programs Evaluated

For FY2017, TRC conducted impact evaluations of five programs (counting CIEEP-EA and CIEEP-BASE as separate programs). TRC collaborated with CPAU staff to identify programs for evaluation at a planning meeting on August 22, 2017. In general, TRC and CPAU prioritized a program for evaluation if it had high ex ante savings. TRC evaluated the four programs with the highest ex ante savings: CIEEP-EA, MPP, CAP, and HER. In addition, TRC evaluated CIEEP-BASE, because this was the first year that the implementer delivered savings through this program. Section 9.1 in the Appendix provides a more detailed description of why TRC and CPAU did or did not select each program for evaluation in FY2017.

As background on terminology and program roles, several programs (including CIEEP and MPP) have implementers, which are third party companies that manage the day-to-day activities of the program on behalf of CPAU, including managing the application process, developing project files and program databases, and calculating ex ante savings. Several programs (including CIEEP and CAP) use vendors, which are third party companies that recommend measures and install equipment or optimizations on behalf of a customer; vendors include lighting and HVAC contractors. Depending on the program, the implementer, vendor, and/or CPAU staff may be responsible for recruiting participants.

Below, TRC provides a summary of each program evaluated.

- **CIEEP (including CIEEP-EA and CIEEP-BASE)** provides energy assessments and incentives for custom efficiency projects to large customers. CIEEP is available to customers with buildings larger than 50,000 square feet. Incentives are calculated based on installed and verified energy savings. Three third party implementers provided projects through the program: EA, BASE, and Enovity. Because CPAU tracks savings separately for each implementer, TRC provides results by implementer (i.e., for EA separately from BASE). At least six sites participated in FY2017 – five through CIEEP-EA and one through CIEEP-BASE. (The number of Enovity projects is not included in this total, because TRC did not evaluate it this year.)
- **Commercial Advantage Program (CAP)** provides commercial and industrial customers with incentives for energy saving appliances, lighting, and custom retrofits. All CAP projects are implemented by the customer or their vendor. Eight projects participated in FY2017, all of which were lighting installations.
- **Multifamily Plus Program (MPP)** provides direct install savings measures to multifamily buildings, including assisted living facilities. In FY2017, approximately 35 customers participated through two hundred measures, almost all of which were LED lighting measures. One project also installed ceiling insulation.
- **Home Energy Report (HER) Program** provides residential customers with reports regarding their energy use and encourages them to take behavioral or measure-based actions to reduce energy consumption. CPAU had provided the HER program for several years but stopped sending reports to customers at the end of FY2015. As described in the program chapter (Section 6),

previous studies have found that some energy savings persist after discontinuation of the reports.

2.2 Methodology Overview

Figure 5 shows the total number of projects verified for each program evaluated, where a project refers to a site. Most sites had multiple measures installed.

Figure 5. Number of Projects Verified by Program

CPAU Program	Total Projects in FY2017	Verified Projects
CIEEP – EA	5	5
CIEEP-BASE	1	1
CAP	8	3
MPP	35	4
HER	N/A	N/A
Total	**49**	**13**

To conduct EM&V for FY2017, TRC used the following overall methodologies. For all programs except HER, TRC used a combination of on-site observations and desktop reviews of calculations to develop ex post savings:

- TRC verified a census of projects in CIEEP-EA and CIEEP-BASE, and used the following approach depending on project type:
  - For optimization projects, TRC reviewed trend data and compared actual operating conditions to the operating conditions assumed in the ex ante calculations; and verified, or adjusted as-necessary, the baseline energy efficiency assumptions.
  - For lighting projects, TRC compared operating hours, the wattage of the installed measure, location of the measure (for CDF), and other parameters with claimed savings, and compared the baseline assumption with TRM baseline values.
- For CAP and MPP, TRC identified a sample of projects for verification. For each project in this sample, TRC used the following approach, since all measures were lighting measures:
  - Conducted on-site verifications, in which we compared the number, efficiency, and location of the measures installed versus the claimed values.
  - Reviewed the savings calculations and assumptions to ensure that the baseline energy use was appropriate (aligned with the TRM). Because MPP is a deemed program, TRC verified that HOU aligned with TRM assumptions. Because CAP is a semi-custom program (allows custom hours), TRC verified that claimed operating hours aligned with facility-reported operating hours.
- For MPP, TRC also conducted an electronic survey of participants to gather feedback on the program and measures installed. TRC sent a link to the thirteen participants in the database with valid email addresses on February 7, 2018, and resent the invitation on February 21, 2018. For the remaining participants, the program database did not have an email address, so TRC could not administer the survey. Two participants completed the survey. Because TRC had sent almost

the same survey[1] to FY2016 participants in early 2017 and received three responses, TRC combined results from last year's and this year's survey.

- For HER program, TRC used the percent of energy saved through HER treatment that Navigant (2012)[2] calculated previously for CPAU, but updated the relevant calculation parameters based on FY2017 energy use. In addition, similar to our approach in the FY2016 evaluation, TRC applied a persistence factor because CPAU stopped sending HER reports at the end of FY2015.

The program-specific chapters provide more detail on the method that TRC applied to each program.

[1] The one change was that TRC added questions regarding electric vehicle chargers to this year's survey.

[2] Navigant, prepared for CPAU: "Evaluation of the Home Energy Report Program", 2012.

3 COMMERCIAL AND INDUSTRIAL ENERGY EFFICIENCY PROGRAM (CIEEP)

3.1 Program Overview

The Commercial and Industrial Energy Efficiency Program (CIEEP) provides energy assessments and incentives for custom efficiency projects to large customers. The program has three third party implementers: Enovity, EA, and BASE. BASE reported its savings through the Industrial and Commercial Efficiency (ICE) program. CIEEP is available to customers with buildings larger than 50,000 square feet. The program calculates incentives based on installed and verified energy savings, typically at a rate of $0.10 per kWh and $1.00 per therm saved over one year.

The CIEEP program accounted for the largest savings in the CPAU FY2017 portfolio, with the bulk of savings coming from CIEEP-EA.

In FY2017, TRC evaluated CIEEP-EA and CIEEP-BASE. Because TRC did not evaluate the CIEEP-Enovity program, we do not include Enovity projects in this description.

The CIEEP-EA and CIEEP-BASE programs delivered six projects (five from EA and one from BASE) through a total of ten measures. The majority of savings from the EA and BASE projects came from lighting measures and controls projects.

For each project, the implementer (EA or BASE) conducted an audit, developed a report identifying potential energy savings measures, and developed a final report showing the savings from the projects as installed. The implementer's calculated energy savings using custom spreadsheets and the Custom Building Optimization Analysis Tool (C-BOA) developed by the California Commissioning Collaborative. In some projects, a vendor worked with the customer and implementer to identify and install measures.

3.2 EM&V Approach

As noted above, for FY2017, TRC conducted EM&V for the CIEEP-EA and BASE programs. TRC did not evaluate the Enovity program, because it had significantly lower savings (74,950 kWh and 866 therms) and because the Enovity program had very high realization rates in the FY2015 and FY2016 evaluations. BASE ICE has similar savings as CIEEP - Enovity, but is a new program implementer.

TRC reviewed all six projects implemented through CIEEP-EA and CIEEP-BASE. As an overview of our data collection for each project, TRC reviewed all submitted documentation including reports, calculations, equipment submittals, as-built plan sets, and current trend data when available; and conducted site visits at sites to verify equipment installation and collect operational trend data.

Prior to the site visits, TRC reviewed the project investigation and verification reports and calculations (e.g., Excel spreadsheets) to become familiar with project scope, calculation methodology, and savings for each of the implemented measures. During the on-site field visits, TRC:

- Conducted brief staff interviews to determine any major operational or occupancy changes since measure implementation;

- Visually verified all lighting and equipment installation for quantity, make, and model[1];
- Reviewed Energy Management System (EMS) schedules and settings; and
- Obtained or requested EMS trend data, screenshots, and equipment performance and specification product submittals.

For the ex post savings, TRC used the data we collected to verify calculation and model inputs and to make the necessary changes to revise the savings to reflect current operating conditions.

As part of our verification, TRC reviewed the baseline assumptions used in the ex ante savings calculation and made adjustments where necessary. In general, TRC assumed existing conditions as the baseline for optimization projects, because these projects did not trigger code. The ex ante savings calculations were also developed using existing conditions, so TRC generally did not make baseline adjustments for optimization projects.

These adjustments and others are discussed in this chapter, with more detail in section 9.2 - CIEEP Project-Level EM&V Results.

3.3 Overview of Program EM&V Results

Figure 6 provides annual ex ante and ex post gross savings for each CIEEP-EA and CIEEP/ICE-BASE project. Overall, TRC calculated a decrease in annual savings from 2,127,934 kWh to 2,023,631 kWh, resulting in a gross realization rate of 95% kWh savings (95% for EA and 104% for BASE) compared with ex ante claims. TRC's kWh adjustments were primarily because:

- Actual operating conditions differed with claimed, which impacted electric savings.
- EA had not accounted for existing controls at one of the lighting installations.
- EA did not account for HVAC heating and cooling interactive effects in interior lighting projects, which slightly increased kWh cooling savings.

CIEEP had a significantly lower realization rate for annual kW (54%) than for annual kWh (95%) because of the following:

- The implementer reduced the chilled water temperature from the base case settings for the design cooling set-point as part of a reset measure, which resulted in increased load. This measure contributed to an overall reduction of kW savings for the optimization measures as compared to the claimed kW reduction (46 kW claimed, 6 kW realized).
- TRC removed the kW for a lighting project where the implementer had claimed kW reduction for fixtures operating only at night, and reduced kW savings in another lighting project to account for existing controls.

[1] For two fixture types, TRC was not able to remove the fixture cover to view the model number, because the cover was difficult to remove and the customer was concerned about damage to the fixture. For these fixtures, TRC verified the model number using invoices, and confirmed that photos of the fixture (found on-line) matched the fixtures we saw in the field.

TRC's adjustments decreased natural gas savings from 114,145 to 99,218 therms for a program realization rate of 87% for natural gas (85% for EA, and 103% for BASE). The majority of natural gas savings came from one CIEEP-EA project. The adjustments in natural gas savings were because:

- For CIEEP-EA projects, the ex ante calculations did not include heating offset interactive effects, but TRC incorporated them for ex post savings, resulting in a heating (therms) penalty. However, the positive therm savings from optimization measures outweighed the negative therms from lighting, resulting in positive therm savings at the program level.
- Differences in operating conditions reduced natural gas savings.

Figure 6. CIEEP Project Level Savings

		CLAIMED			REALIZED			Realization Rate		
Program	**Project Code**	**kWh Savings**	**kW Reduced**	**Therms Savings**	**kWh Savings**	**kW Reduced**	**Therms Savings**	**kWh**	**kW**	**Therms**
CIEEP - EA	PA-001-17 OPT	1,099,111	46	104,722	1,019,105	6	92,209	93%	12%	88%
	PA-001-17 LTS	331,038	82	0	311,124	72	(1,742)	94%	87%	N/A
	PA-004-16	15,630	2	0	15,630	1	0	100%	70%	N/A
	PA-005-15	5,212	0	0	9,038	0	0	173%	N/A	N/A
	PA-005-16	209,480	36	0	198,697	37	(964)	95%	104%	N/A
	PA-007-15	390,783	75	0	390,184	15	0	100%	19%	N/A
	CIEEP-EA Total	**2,051,254**	**241**	**104,722**	**1,943,778**	**130**	**89,503**	**95%**	**54%**	**85%**
ICE - BASE	**422-15-02**	**76,680**	**0**	**9,425**	**79,853**	**0**	**9,715**	**104%**	**N/A**	**103%**

Section 9.2 provides detailed results for each CIEEP project.

4 COMMERCIAL ADVANTAGE PROGRAM (CAP)

4.1 Program Overview

The Commercial Advantage Program (CAP) provides CPAU commercial and industrial customers with incentives for energy saving appliances, lighting, and custom retrofits. Projects can apply for either deemed rebates or custom incentives. For the deemed rebate track, program participants receive incentives for qualifying approved appliances or lighting, and program staff use a calculator based on the TRM to calculate ex ante savings. For custom retrofit measures, a professionally licensed engineer calculates the energy savings measures and CPAU staff or a CPAU representative conducts pre- and post-installation inspection to validate the savings. All CAP projects are implemented by the customer or their vendor, and CPAU or a third party (Energy and Resource Solutions - ERS) conducts project measurement and verification. In FY2017, eight projects participated in the program, all of which were lighting installations.

4.2 EM&V Approach

TRC verified savings for the CAP program by identifying a sample of projects and conducting on-site verifications for this sample. TRC used results from the sampled projects to calculate kWh, kW, and therm realization rates, which we applied across the program.

4.2.1 Sampling Methodology

TRC used a stratified ratio estimation design to select the sample for the CAP program. Using stratified ratio estimation reduced the total number of projects that TRC needed to verify to reach 90% confidence /10% precision compared to simple random sampling. TRC divided the sample into three strata to create an equivalent percentage of total savings in each stratum. This left only a few projects in each of the top two strata. To estimate the confidence and precision that would be achieved, TRC assumed the realization rate statistics from the FY2015 CAP evaluation.

Figure 7. CAP Sample Design

Stratum	Total Projects in FY2017	Sample	Estimated Confidence/Precision
1	1	1	100%
2	2	1	90% / 10%
3	5	1	90% / 20%
Total	**8**	**3**	**90% / 10%**

The actual confidence and precision achieved were 90% confidence and 22% precision for annual kWh savings for CAP. The actual precision was worse than anticipated because the realization rate for two of the three sampled projects was much lower than anticipated, due to a glitch in the lighting calculator (described in section 9.3). This resulted in different realization rate statistics (mean of 0.75, standard deviation of 0.24) than anticipated (mean of 0.97 and standard deviation of 0.35). In particular, the projects with the largest savings had low realization rates, and the large case weights of these projects reduced precision.

For the sample of projects, TRC conducted on-site verifications and a desktop review, as described below. Based on our on-site findings and desktop review, TRC adjusted input parameters for the savings calculation for each project.

4.2.2 On-Site Verification

For the on-site verification of projects, TRC verified that:

- The number of installed measures claimed had been installed and remained in operation;
- The lighting wattage met the specifications in program files;
- The location of the installed measures in conditioned and unconditioned space matched program files, since this influences heating and cooling interactive effects calculations.

4.2.3 Desktop Review

Based on on-site findings and desktop review, TRC adjusted input parameters for the savings calculation(s) for each project.

Calculations for the sampled projects had been created using the TRM404 "simplified non-res lighting calculator". For the desktop review, TRC reviewed the savings calculations to:

- Verify operating hours, based on observations made at the site and interviews with the facility operator. TRC used actual facility operating hours for all CAP projects.
- Verify baseline efficiency assumptions, according to the guidelines set by the TRM.
- Confirm that the correct TRM interactive effects and coincident diversity factors (CDFs) had been included in the TRM calculator.

TRC discovered some errors in two of the CAP program calculations that stem from how the user can enter data and arrive at a condition where the calculator does not account for post-implementation use. TRC notes that this error is not readily discernable to the user. The main issue is that the Proposed Fixture wattages used in the calculator are zero if the "Proposed Fixture Lamp Type" is not selected in the drop-down menu as "User-defined". Section 0 provides more detail on the calculator error.

As part of the lifecycle energy savings calculation, TRC calculated an EUL specific to each lighting measure installed, by dividing the measure life by the number of annual operating hours assumed for that measure. Based on the TRM104 calculator for LED measures[1], TRC used the following assumptions for measure lives:

- 50,000 hours for LED fixtures, and
- 25,000 hours for all LED lamps.

For example, for an LED replacement tube lamp installed in an area with annual operating hours equal to 3,380, TRC calculated the measure-specific EUL as 25,000 hours / 3,380 hours/yr = 7.4 years. For each lighting measure, TRC used the lower value of the calculated EUL, or 15 years (the maximum allowable by the TRM and DEER2014).

[1] The TRM104 v.2016 calculator states that DesignLights Consortium (DLC) requirements include a 50,000 hour lifetime for fixtures, and ENERGY STAR listed replacement lamps have an equipment lifetime requirement of 70% initial lumen output at 25,000 hours. Note that the TRM204 calculator (for residential measures) provides the same notes regarding lighting EUL, and the TRM400 and TRM404 calculators do not provide EUL guidance.

TRC also confirmed the use of an adjustment factor in the CAP calculations to account for Title 24 lighting power density (LPD) requirements. TRC agreed with this factor in the calculation, because the installations were fixtures which triggered Title 24, and made no adjustments.

4.3 Overview of EM&V Results

Figure 8 provides results for each CAP project verified. After applying sampling weights, the overall program realization rate was 75% for annual kWh[1], 73% for annual kW, and 50% for lifecycle kWh.

In general, TRC made the following adjustments, in descending order of significance for annual kWh savings:

- Adjusted the calculators for two projects, 1077 and 1078 to include the energy use of the installed measure in the calculation. This significantly reduced the savings.
- Made a few other minor adjustments, depending on the project. This included mainly adjusting kWh and kW interactive effects and CDFs. Some of these adjustments increased annual and lifecycle kWh savings while others decreased savings.
- TRC also accounted for negative natural gas (therm) savings due to interactive effects, which the program did not report. Consequently, TRC calculated -626 therms, while the program assumed zero therms.
- For the lifecycle kWh savings, TRC's most significant adjustment was to the EUL assumed for the installed lighting measures. As described in section 4.2.3, TRC adjusted the EUL of each measure to account for the annual hours of operation, or used the DEER maximum value (15 years) – whichever was lower. Overall, TRC's average EUL for CAP was 6.7 years, while the program assumed 10 years for all lighting projects. This adjustment significantly reduced lifecycle kWh savings. Secondarily, the annual kWh savings adjustments also affected the lifecycle savings.

Section 9.3 provides more detail for each project.

[1] The realization rate is different for the sampled projects compared with the program because of the different case weights for sampled projects.

Figure 8. CAP Project EM&V Results – Annual Gross Savings

					Ex Ante Annual		Ex Post Annual			
Project	**Measure Overview**	**No. of measures installed**	**Measure Efficiency**	**Operating Hours**	**Demand Savings (kW)**	**Energy Savings (kWh)**	**Demand Savings (kW)**	**Energy Savings (kWh)**	**Realization Rate (% kWh)**	**Natural Gas (therms)**
1077	Replacement of 529 interior fluorescent fixtures and 113 exterior metal halide fixtures with LED fixtures	✓	Ex ante calculation did not include energy use of installed measure; TRC corrected calculation	Increased from 3,704 to 4,100 for exterior measures	54.1	399,434	21.9	237,958	60%	0
1078	Replacement of 336 interior fluorescent fixtures and 50 exterior metal halide fixtures with LED fixtures	✓	Ex ante calculation did not include energy use of installed measure; TRC corrected calculation	Increased from 3,704 to 4,100 for exterior measures	32.8	250,483	12.8	142,842	57%	0
1082	Replacement of linear fluorescent lamps with LED tube lamps	✓	✓	✓	29.3	117,123	29.3	117,123	100%	(537)
Total for Projects Sampled					**116**	**767,040**	**64**	**497,923**	**69%**	**(537)**
Total for Program (After Extrapolating from Sampled Projects to Population)					**163**	**1,043,497**	**119**	**778,932**	**75%**	**(626)**

✓ = Confirmed

5 MULTIFAMILY PLUS PROGRAM (MPP)

5.1 Program Overview

The Multifamily Plus Program (MPP) provides direct install measures primarily to multifamily buildings, including assisted living facilities. A third party contractor, Synergy, implements the program. In FY2017, the program installed 200 measures (where a unique measure refers to an efficiency measure installed in the same building area) in approximately thirty-five (35) projects, based on unique addresses.

The FY2017 savings came almost entirely from lighting measures – primarily LED lamp and fixture installations. One project received lighting measures and attic insulation.

5.2 EM&V Approach

TRC verified savings for MPP by aggregating savings by project (i.e., by unique address), and conducting verifications for a sample of those sites.

TRC also conducted an electronic survey with a sample of MPP participants to gather feedback on the measures and program, as described in section 5.4.

5.2.1 Sampling Methodology

TRC used a stratified ratio estimation design to select the initial sample for the MPP. Using stratified ratio estimation reduced the total number of projects that TRC needed to verify to reach the same level of precision compared to simple random sampling.

TRC divided projects into three tiers based on savings. One project with 79 measures was responsible for over 60% of ex ante savings. Consequently, this project constituted the top two strata (stratum 1 and stratum 2). TRC assigned all remaining projects to the third strata.

TRC identified the following four projects based on our initial sample:

- The one project that comprised the top two strata: Y3OC
- Three projects in the third strata, by choosing the first of every 10 sites: Y3PAC, Y3COL, and Y3ASH.

TRC also added the one project with attic insulation (Y3HOM) to verify a census of (positive) natural gas savings. Using this sample design, and assuming the realization rate statistics that TRC found in the FY2016 evaluation for MPP (standard deviation of 0.23), TRC estimated that savings would be verified with 90% confidence, 20% precision.[1]

However, TRC made the following adjustments to the sample:

[1] Although TRC typically targets 90% confidence / 10% precision, achieving this level of precision would have required a much larger sample, and TRC believed the increase in precision did not warrant the additional EM&V resources.

- The owner of Y3COL did not respond to TRC's repeated request to verify savings at that project, where measures were installed in-units. Consequently, TRC selected the next project on the list for the sample: Y3SHDAN.
- The owner of Y3HOM did not respond to TRC's repeated request to verify savings at that project, which required access to a unit to verify the attic insulation. Because this was the only site with positive therm savings, TRC could not select a substitute project.

Overall, TRC achieved 90% confidence, 25% precision with the projects sampled for annual energy savings. The worse relative precision than anticipated was because there was greater variation in realization rates than anticipated. Specifically:

- One project (Y3OC) had a very low realization rate – 33%. As described in Section 9.4.1, the adjustment was primarily due to a reduction in assumed operating hours.
- One project (Y3ASH) had a very high realization rate – 225%. As described in 9.4.4, the adjustment was primarily due to an increase in operating hours to assume continuous operation of the lighting.

Consequently, the standard deviation for the realization rate was 0.81.

Note that the final sample included only lighting measures, since TRC was not able to obtain access to the one project with ceiling insulation.

5.2.2 Comparison with Ex Ante Claims

For each lighting measure, the program database provided kW, kWh, and therm savings, as well as the quantity of measures installed. However, because the implementer did not provide the savings calculations for each lighting measure, TRC could not identify the specific input parameters that differed between our calculations and the implementer's to explain why ex ante savings differed from ex post. For some measures, the measure description in the program database included a description of the wattage of measure installed, hours of use (HOU), and/or assumed baseline condition. The assumptions in the measure description did not align with TRM assumptions in some cases. When explaining differences between the ex ante and ex post savings value, TRC assumed that the implementer used the information in the measure description. For example:

- For the measure, "T8 to LED 1- bulb (11.4 hrs. per day) high usage", TRC believes the implementer assumed 11.4 hours per day. As described in Section 9.4, TRC adjusted the HOU in some cases (to align with the TRM), because HOU depends on where the measure is installed (by building type, and location within the building), rather than what measure is installed.
- For the measure, "LED A Type 10W replacing 60W Incandescent", TRC believes the implementer assumed the baseline condition in the measure name (60W). As described in Section 9.4, TRC adjusted the baseline to align with TRM assumptions (43W for this example).

For the demand (kW) ex ante savings, the program implementer did not provide their assumed value for CDF, so TRC could not compare assumptions for this value.

5.2.3 Verification Methodology

To verify energy savings for the sample of projects identified, TRC conducted on-site measurements and conducted a desktop review.

For each lighting measure, TRC used on-site observations to verify that:

- The number of installed measures claimed had been installed and remained in operation;
- The installed measure, including wattage, met the specifications in program files;
- The room locations of the installed measures matched what was claimed, since location affects HOU. TRC used DEER deemed assumptions for HOU (not actual facility operating hours), since MPP is a deemed (not custom) program.
- The location of the installed measures in conditioned and unconditioned space matched program files, since this influences heating and cooling interactive effects calculations. If projects did not have natural gas heating or electric space cooling, TRC did not apply the interactive effects.

For all but one project, TRC was able to verify all lighting measures. For one project (Y3OC), TRC verified a sample of measures.

TRC used the residential calculator (TRM204) for all lighting upgrades except for linear LEDs, since the TRM204 did not provide savings values for that measure. For linear LEDs, TRC used the TRM400 calculator, which provides assumptions for linear LEDs.

Although the TRM recommends assuming residential HOU for all multifamily lighting measures, TRC assumed nonresidential HOU for common areas and exterior applications to align with how Title 24 treats these areas. In addition, based on TRC's on-site observations, the nonresidential HOU were more accurate for these areas. Consequently, TRC assumed the following annual values for lighting measures installed in the MPP:

- Residential interior hours of use (541 hours) for measures installed in residential units,
- Nonresidential exterior operating hours (4,100) for measures installed on the exterior,
- Nonresidential interior operating hours (4,160) for measures installed in multifamily offices and common areas, such as hallways,
- Continuous operating hours (8,760) for a project with interior corridor lighting with no daylighting and for a parking garage.

For demand (kW) savings, TRC used the following CDFs for lighting measures based on DEER2014 (since the TRM did not provide values):

- 0.043 for measures installed in units,
- 0.676 for measures installed in common areas, except for those in a senior housing facility where we assumed 0.565 (based on DEER assumptions for Nursing Home)
- 1.000 for measures installed in interior hallways (with continuous lighting operation)
- 0 for exterior measures.

For the lifecycle savings, because all installations were LED lamps (not fixtures), TRC assumed 25,000 hours for all measures, based on the TRM v.2016 calculators (TRM104 for LED lighting and TRM204 for residential lighting). TRC identified the EUL for each lighting measure by taking the minimum of the following values:

- A project specific EUL, calculated by dividing the measure life by the HOU assumed for the measure. For example, for an LED lamp installed in an area with HOU equal to 4,160 TRC calculated the measure-specific EUL as 25,000 hours / 4,160 hours/yr = 6.0 years.

- A maximum value of 15 years, based on DEER2014 for all lighting measures. For example, because the HOU for all in-unit measures equals 541 hours per year (which translates into 37 years based on the calculation approach), TRC assumed 15 years for all in-unit measures.

TRC calculated interactive effects (negative natural gas savings) by multiplying the interactive effect factor for each space type (in therms/kWh for heating and total kWh/kWh lighting) by the lighting kWh savings. For projects that did not have natural gas heating or electric cooling, TRC did not apply the respective interactive effects.

5.3 Overview of Program EM&V Results

Figure 9 provides results for each verified MPP project. Extrapolating from the sampled projects to the population, TRC calculated the resulting realization rates of 70% for kWh[1], 110% for kW, 32% for lifecycle kWh, and 176% for therms[2].

As described in Section 5.2.2, because the program did not have project-specific calculations for ex ante savings, TRC could not identify all sources of the discrepancy between ex ante and ex post savings. However, based on the measure names in the project database, TRC believes that the majority of the discrepancy in ex ante and ex post savings is due to the following:

- **For kWh and kW adjustments:**
  - For several measures, the program assigned incorrect HOU (i.e., the HOU did not align with the TRM). The ex post HOU was generally lower than the ex ante HOU – often by more than a factor of two. This adjustment greatly reduced kWh and kW savings.
  - The program assumed an incorrect baseline (used an existing condition that did not align with the TRM) for a few measures. This led to a fairly small reduction to kWh and kW savings.
- **For kW adjustments:** Because the implementer did not provide their assumed value for CDFs, TRC could not compare assumptions. Overall, the program kW realization rate was higher than the program kWh realization rate, indicating the implementer generally assumed lower CDFs than appropriate.
- **For therm adjustments:** The program included interactive effects (negative therm savings) for lighting measure project (with gas heating), but used incorrect interactive effect factors (did not align with DEER2014) for some measures. TRC adjusted interactive effect factors, which led to a larger natural gas penalty (i.e., more negative therms).
- **For lifecycle savings adjustments:**
  - TRC calculated measure-specific EULs for each lighting measure. TRC used the maximum value (15 years) for many lighting measures, including all measures installed in-unit (with 541 hrs/yr), but a lower EUL for measures with greater than 1,333 hr/yr. TRC's average EUL was 6.4 years. Based on the ex ante lifecycle and annual savings provided by CPAU, CPAU

[1] The average annual kWh realization rate for the projects sampled (88%) differs from the program-level realization rate (85%) because of different case weights for the sampled projects.

[2] Because total therm savings are negative, the realization rate > 100% results in less natural gas savings.

assumed an average EUL equal to 14 years, suggests the implementer did not use a project-specific calculation. TRC's reduction in EUL assumption reduced lifecycle savings.

- Secondarily, TRC's adjustment to the baseline assumption (described above) decreased lifecycle savings.

In Figure 9, because the verified number of measures matched the program claim for all projects, TRC does not show that parameter (was confirmed for all projects).

Section 9.4 presents site-level results.

Figure 9. Multifamily Plus EM&V Results by Project- Annual Gross Savings

					Ex Ante Annual Savings			Ex Post Annual Savings			
Project ID	**Measure Overview**	**Measure Efficiency**	**Annual HOU (Based on TRM and DEER2014)**	**Baseline Energy Use (based on TRM)**	**Demand Savings (kW)**	**Energy Savings (kWh)**	**Natural Gas (therms)**	**Demand Savings (kW)**	**Energy Savings (kWh)**	**Realization Rate (% kWh)**	**Natural Gas (therms)**
Y3OC	Replacement of incandescent, CFL and T8 fluorescent lamps with LED lamps in MF tenant units	LED A-Lamp changed from 10 to 9 W	Assumed residential interior for MF tenant units (541 hr)	For existing 60W incandescent replacements, assumed dual baseline. For CFL and T8 replacements, used TRM wattages	118	882,354	(679)	28	287,043	33%	0
Y3PAC	Replacement of T8 fluorescent lamps with LEDs in interior common areas and parking garages	✓	Assumed Nursing Home hours (4,160 hr) for common areas and 8,760 hr for parking garage	Used TRM wattages for all baselines	3	58,559	(315)	10	60,160	103%	(594)
Y3SHDAN	Replacement of incandescent and T8 fluorescent lamps with LEDs in interior common areas	✓	Assumed Nursing Home hours (4,160 hr) for common areas	Used TRM wattages for all baselines	1	16,850	(86)	3	16,365	97%	(223)
Y3ASH	Replacement of incandescent and T8 fluorescent lamps with LEDs in common areas and replacement of CFL lamps with LEDs in exterior	LED A-Lamp changed from 10 to 9 W	Assumed continuous use (8,760 hr) for interior hallways, and exterior hours (4,100 hr) for exterior	Used TRM wattages for all baselines	0.2	3,198	(13)	0.8	7,184	225%	0
Total for Sampled Projects					**122**	**960,960**	**(1,093)**	**42**	**370,753**	**39%**	**(817)**
Total for Program (After Sample Extrapolation)					**162**	**1,400,252**	**(1,888)**	**180**	**975,822**	**70%**	**(3,327)**

✓ = Confirmed

5.4 MPP Participant Survey Results Summary

To inform program improvement, and to better understand participants' motivations, TRC administered an electronic survey to FY2017 MPP participants. TRC had originally developed the survey in FY2016; for FY2017, TRC used the same survey, and added two new questions on electric vehicles.

TRC sent a link to the survey to the sixteen FY2017 participants with valid email addresses in the MPP database[1]. Two responded to the survey. Because this was a small number of responses, because the program delivery had generally remained the same from FY2016 to FY2017, and because responses were generally similar for the FY2016 and FY2017 surveys, TRC combined responses when presenting results. TRC does identify the FY2017 responses in the description of results, as well as how results differ by the measure installed in the respondents' buildings (ceiling insulation versus lighting measures).

Full results are provided in Section 9.5 in the Appendix.

All survey respondents were property managers, and they represented a mix of multifamily building size and type (market rate and affordable). Although the survey allowed respondents to check owners or facility managers, all five reported to be rental or property managers. Three served primarily market rate multifamily buildings, while two served primarily affordable units; FY2017 respondents represented one participant in each category. The respondents represented a mix of multifamily building sizes.

Most participants learned about MPP from contacts from a program representative. Four received a personal visit from a program representative or a phone call. The fifth respondent (a FY2017 participant) learned about the program from on-line research.

Respondents reported "Lower energy bills" as the primary program benefit, and lighting recipients also reported lighting quality as a benefit. The two respondents that received ceiling insulation (both in FY2016) reported the only program benefit was lower energy bills (not comfort). The three respondents that received lighting measures reported that program benefits were both energy savings and improved lighting quality. When asked to select the most important benefit, two of the lighting-measure respondents selected "lower energy bills", while the third selected "improved light quality".

Customers were not willing to pay any, or only one-quarter, of the cost to install measures. The two participants that installed ceiling insulation (both in FY2016) were not willing to pay any incremental cost. The three participants that installed lighting measures (one in FY2016 and two in FY2017) reported they were willing to pay approximately one-quarter of the cost.

Most respondents were satisfied with the program, and would be willing to participate again or recommend it to a peer. The average satisfaction rating was 4.4 (on a 5-point scale). Participants reported they would be likely to participate again (average rank of 4.5 on a 5-point scale) and they would recommend it to another property manager (average rank of 4.8 on a 5-point scale).

The two FY2017 respondents reported moderate interest in a rebate for electric vehicle (EV) chargers. One respondent reported s/he currently has an EV charger, and expressed moderate likelihood (3 on a 5-point scale) of installing a charger with a CPAU rebate of $18,000. The other respondent does not have EV chargers, and expressed greater interest (4 on a 5-point scale) in the EV charger rebate.

[1] The database contained sixteen email addresses, but TRC removed bounceback email responses from three.

6 HOME ENERGY REPORT (HER) PROGRAM

6.1 Program Overview

The Home Energy Report (HER) Program provided residential customers with reports regarding their energy use and encouraged them to take behavioral or measure-based actions to reduce energy consumption. The reports included a summary of the home's recent and historical energy use, a comparison of the home's energy use to that of similar neighbors, and tips for reducing energy use. A third party (OPOWER) implemented the program for CPAU.

CPAU contracted with OPOWER to send HER to residential customers in 2010, and OPOWER sent the first batch of reports to customers in late 2010. CPAU discontinued OPOWER's service in 2015, and OPOWER sent the last reports to customers in August 2015. However, as described in Figure 10 below, a literature review supports that there is some persistence of savings. Consequently, TRC's scope for the HER evaluation was to calculate savings that occurred in FY2017, based on persistence of savings from Home Energy Reports sent through 2015, as described below.

6.2 EM&V Approach

TRC verified savings for the HER program by adjusting calculating input parameters to correspond to FY2017 values (e.g., for energy use). TRC also estimate HER savings from residential program participants, and removed these to avoid double counted savings.

6.2.1 Savings Calculation and Source of Inputs

TRC used the following equations to calculate HER FY2017 energy savings:

HER Net kWh Savings = (Residential electricity sales in FY2017 x FY2015 HER elec. recipient rate x HER Electricity Savings Rate x HER Persistence factor) – HER Elec. Savings from FY2017 Res Program participants

HER Net Therm Savings = (Residential natural gas sales in FY2017 x FY2015 HER nat. gas recipient rate x HER Nat. Gas Savings Rate x HER Persistence factor) – HER Gas Savings from FY2017 Res Program participants

Figure 10 shows the calculation input values and source for each input.

Figure 10. HER Calculation Input Values and Sources

Parameter	Description and Source	Value for kWh calc	Value for Therm calc
Residential energy sales in FY2017	HER savings are proportional to residential energy use. CPAU staff provided FY2017 residential electricity and natural gas sales.	142,220,200 kWh	10,246,536 therms
FY2015 HER recipient rate	Fraction of CPAU residential customers that received HER reports, as reported by CPAU staff. Some CPAU households did not receive the report, including low income households.	0.865	0.89
HER Savings Rate	Percent of residential savings from HER treatment, per household. Based on a study by Navigant (2012)[1] for CPAU which measured electricity and natural gas savings before and after (pre and post) HER treatment compared to a control group.	1.46%	2.1%
HER Persistence factor	Persistence of savings after HER treatment ends. TRC leveraged the literature review from our FY2016 CPAU EM&V Report, which found several studies that indicated a savings decay of approximately 20% each year: Cadmus 2015[2], Nexant 2016[3], NMR and Tetra Tech 2014[4]. Thus, TRC estimated that HER savings would decrease 20% each year after HER treatment ended – i.e., 80% x 80% = 64% of savings would persist in FY2017 compared with FY2015.	64%	64%
HER savings from Residential Program Participants in FY2017	To avoid double counting energy savings from other CPAU residential programs, TRC subtracted the HER savings from households that participate in overlapping residential programs – i.e., programs serving customers that receive HER treatment. This calculation is described below.	24,776 kWh (calculated below)	1,175 therms (calculated below)

[1] Navigant, prepared for CPAU: "Evaluation of the Home Energy Report Program", 2012.

[2] Cadmus, Long-run Savings and Cost-Effectiveness of Home Energy Report Programs, 2015.

[3] Nexant, PG&E 2015 Energy Savings Estimates from HER Programs, 2016.

[4] NMR and Tetra Tech, Evaluation of Year 2 Connecticut Light and Power (CL&P) Pilot Customer Behavior Program, 2014.

6.2.2 Methodology to Remove HER Savings from Residential Program Participants

To avoid double counting HER savings in both the HER program and residential programs, TRC calculated HER savings from residential program participants, and removed those savings from HER. TRC identified the programs with potential overlap in savings as:

- Residential Smart Energy, which rebated clothes washers and attic insulation resulting in electricity and natural gas savings,
- Home Efficiency Genie program, which provided direct install measures such as efficient lighting and low flow showerheads, resulting in electricity and natural gas savings, and
- The in-unit lighting measures in the Multifamily Plus Program (MPP), resulting in electricity savings only[1].

Note that low income customers did not receive HER, so there was no overlap in savings with the REAP Low Income program.

TRC developed the following calculation for HER savings from residential program participants for each residential program:

HER elec. savings from Res Program Participants = Number of households in res program x Average electricity use per household x HER elec. savings per household x Potential Overlap in Savings (%) x HER savings persistence

Similarly, for natural gas:

HER nat. gas savings from Res Program Participants = Number of households in res program x Average natural gas use per household x HER nat. gas savings per household x Potential Overlap in Savings (%) x HER savings persistence

For the number of households in the program, TRC used the number of unique program participants:

- Smart Energy: 80 participants
- Home Efficiency Genie: 102 participants
- For the MPP, some projects included in-unit lighting installations, the largest of which was the Y3OC project, which had 759 residential units and saved 287,043 kWh – an average of 378 kWh/unit. The other three sites sampled for verification did not include in-unit measures. Because TRC used a sampling approach for verifying MPP, and the program database does not designate which measures were installed in-unit vs. common areas (nor the number of units per project), TRC could not readily identify the number of units that had received in-unit lighting measures through the MPP. Consequently, TRC approximated the total number of units in MPP with in-unit lighting measures, by assuming that one-fourth of the remaining savings came from in-unit installations (since one-fourth of sampled projects had in-unit installations) and assuming 378 kWh of in-unit savings represented one unit (based on Y3OC). The calculation is as follows:

  Savings (kWh) from un-sampled projects = Total Program Savings – Savings from sampled projects

[1] Lighting installations also generate negative therm savings (from interactive effects), but for simplicity, TRC did not credit the HER program with positive therm savings (i.e., did not subtract negative therm savings).

=975,822 -370,752 = 605,070 kWh

In-unit savings (kWh) = Savings from un-sampled projects x Fraction of sampled projects with in-unit savings
=605,070 kWh x (1/4) = 151,268 kWh

Units in un-sampled projects with in-unit savings = In-unit savings / savings per unit (based on Y3OC)
=151,268 kWh / 378 kWh/unit = 400 units

MPP units with in-unit lighting measures = Units in Y3OC + Units in un-sampled projects with in-unit savings = 759+400 = 1,159 units

Thus, TRC estimated that 1,159 residential units (assumed to be unique households) received in-unit lighting installations.[1]

For the average energy use per household, TRC divided the total residential electricity use (142,220,200 kWh, provided by CPAU) by the number of residential electricity accounts[2] (24,682, provided by CPAU), to calculate an average electricity use of 5,762 kWh/household. Similarly for natural gas, TRC divided total natural gas use (10,246,536 therms, provided by CPAU) by the number of residential natural gas accounts (21,323, provided by CPAU) to calculate average natural gas use of 481 therms per household.

For the HER savings per household, TRC used the values shown in (Figure 7): 1.46% for electricity and 2.1% for natural gas.

For the potential overlap in savings as a percent of HER savings, TRC assumed 24% for the HER fraction of savings for lighting measures in MPP. This was based on a study by Smith et al. (2014)[3] that found 24% of HER savings were attributable to more efficient lighting installations. For the Smart Energy and Home Efficiency Genie programs, TRC conservatively assumed 100% of savings potentially overlapped between HER and the residential program – i.e., removed all HER savings from these households. This is because – while the HER program encouraged installation of measures rebated by these programs, TRC could not find a study which estimated the fraction of HER savings due to these measures. (In other words, TRC did not find a value analogous to 24% of HER savings from lighting installations for the other measures.)

For the HER persistence, TRC used the values shown in Figure 7: 64% for both electricity and natural gas.

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[1] Based on our attempts at verifying projects, TRC is aware of two other MPP sites with in-unit installations: Y3COL, with approximately 25 units, and Y3HOM, with approximately 12 units. Adding these to the number of units in Y3OC sums to total 786 units. Also, based on the MPP database, there were eight projects where installations occurred only in unconditioned space (the database shows 0 therms), indicating they did not receive in-unit installations. Because TRC extrapolated sampling results to the program (not site level), we could not remove the eight projects from the estimate of in-unit installations, so 1,159 is likely an overestimate.

[2] Although occasionally a residential account does not represent a household (e.g., one household may have two accounts for an auxiliary building), this was the best approximation that TRC could develop without significant more information regarding each account.

[3] Brian Smith and Lucy Morris, "Neighbor Comparison Reports Produce Savings, but HOW?" ACEEE Summer Study 2014.

6.3 EM&V Results

Removal of savings to avoid potential double counting: TRC calculated the savings from other residential programs that had the potential for double-counted savings as follows:

HER elec. savings from Res Program Participants = Average electricity use per household x Number of households in res program x HER elec. savings per household x Potential Overlap in Savings (%) x HER savings persistence

- For Smart Energy = 5,762 kWh/household x 80 households x 1.46% x 100% x 64% = 4,307 kWh
- For Home Efficiency Genie = 5,762 kWh/household x 102 households x 1.46% x 100% x 64% = 5,492 kWh
- For Multifamily Plus Program = 5,762 kWh/household x 1,159 households x 1.46% x 24% x 64% = 14,976 kWh

Total HER elec. savings from Res Program Participants = 4,307+5,492+14,976 = **24,776 kWh**

HER nat. gas savings from Res Program Participants = Number of households in res program x Average natural gas use per household x HER nat. gas savings per household x Potential Overlap in Savings (%) x HER savings persistence

- For Smart Energy = 481 therms/household x 80 households x 2.1% x 100% x 64% = 517 therms
- For Home Efficiency Genie = 481 therms/household x 102 households x 2.1% x 100% x 64% = 659 therms

Total HER nat. gas savings from Res Program Participants = 517 + 659 therms = **1,175 therms**

HER savings:

Based on these parameters, TRC calculated the following energy savings from HER for FY2017:

HER Net kWh Savings = (Residential electricity sales in FY2017 x FY2015 HER elec. recipient rate x HER Electricity Savings Rate x HER Persistence factor) – HER Elec. Savings from FY2017 Res Program participants

= (142,220,200 kWh x 0.865 x 1.46% x 64%) – 24,776 kWh
= 1,149,521 kWh – 24,776 kWh
= 1,124,746 kWh

HER Net Therm Savings = (Residential natural gas sales in FY2017 x FY2015 HER nat. gas recipient rate x HER Nat. Gas Savings Rate x HER Persistence factor) – HER Gas Savings from FY2017 Res Program participants

= (10,246,536 therms x 0.89 x 2.1% x 64%) – 1,175 therms
= 122,548 -1,175 therms
= 121,373 therms

Thus, TRC calculated 1,124,746 kWh and 121,373 therms for net and gross savings for FY2017. The EUL of these savings is one year, so the lifecycle kWh also equals 1,124,746 kWh.

Figure 11 shows claimed savings calculated by CPAU and realized savings calculated by TRC. CPAU calculated claimed savings by multiplying FY2015 HER savings by 64% (to account for reduced

persistence of savings). The following factors contributed to the differences between claimed and realized savings:

- The FY2015 HER savings calculated by CPAU included an attribution factor, whereby savings were multiplied by 67% for electricity and by 80% by natural gas, to account for other factors (besides HER) that contributed to energy savings. But because the HER savings were calculated based on savings differences compared to a control group (in a randomized control trial), attribution was already accounted for in the savings values (1.46% for electricity and 2.1% for natural gas). Consequently, TRC removed the attribution factor in the FY2017 HER evaluation (as we did in the FY2016 HER evaluation), which significantly increased electricity and natural gas savings.
- Less significantly, electricity use decreased from 153 GWh in FY2015 to 142 GWh in FY2017. Because HER savings are proportional to energy use, this adjustment slightly decreased electricity savings. Natural gas usage remained relatively flat (10.3 MMTherms in FY2015 and 10.2 MMTherms in FY2017).

The adjustment to remove the attribution factor was more significant, so TRC's adjustments increased both electricity and natural gas savings.

Figure 11. HER Program Savings

CLAIMED (Ex Ante)		REALIZED (Ex Post)		REALIZATION RATE	
kWh	Therms	kWh	Therms	kWh (%)	Therms (%)
1,026,734	93,540	1,124,746	121,373	110%	130%

7 CALCULATION OF NET AND LIFECYCLE SAVINGS

7.1 Net Savings

7.1.1 Net-to-Gross Ratio (NTGR) Assumptions

To calculate net savings, TRC multiplied the gross savings for each measure by the NTGR. To identify a NTGR, TRC used the following resources in this order:

1. The NTGR value in the stipulated values in the NCPA E3 Tool, which took NTGR values from the Database of Energy Efficiency Resources (DEER) 2014.
2. If the NTGR was not in the NCPA E3 Tool, TRC used the NTGR in DEER2014. Although DEER2016 was effective January 1, 2016, TRC used DEER2014 values to be consistent with the NCPA E3 Tool.
3. If the NTGR was not available in either the NCPA E3 Tool or DEER, TRC used the NTGR for the most similar measure in the NCPA E3 Tool or DEER. [1]

The following figure provides TRC's assumptions for NTG for each measure, and the rationale for those assumptions.

[1] DEER2014 provides miscellaneous NTG values for measures not available in DEER. However, since these are blanket values (not specific to equipment or measure type), TRC believes it was more accurate to assume a NTG for a similar measure.

Figure 12. NTGR Assumptions for Measure Types

Measure (Program)	NTGR in NCPA E3 Tool (based on DEER2014)	NTGR in other resources	NTGR Assumed	Rationale
Commercial lighting (CIEEP, CAP, and MPP common areas)	0.8	DEER2014: 0.8 DEER2016: 0.6	0.8	Align with NCPA assumptions
In-unit lighting (MPP)	0.54 for Res, 0.8 for comm	DEER2014: 0.54 for Res, 0.8 for comm. DEER2016: 0.6 for Res and Comm	0.8	Vast majority of in-unit installations occurred at Y3OC, where facility manager is decision maker for bulb change-outs, similar to commercial buildings. Also, survey responses indicate that participants were likely to pay for only a small portion (one-quarter) of measure costs.
Retro-commissioning (RCx) / optimization (CIEEP)	Not in NCPA E3 Tool	DEER2014: 0.8 (not updated in DEER2016)	0.8	Align with DEER2014
VFD (CIEEP-BASE)	VFD not in NCPA E3 Tool. HVAC equipment NTG = 0.85	VFD not in DEER. RCx/optimization NTG = 0.8.	0.8	Closest to RCx / optimization or HVAC equipment. Assumed lower value (for RCx/optimization) to be conservative
EMS (CIEEP-BASE)	Not in NCPA E3 Tool	EMS not in DEER. RCx/ optimization NTG = 0.8	0.8	Assumed value for RCx / optimization, since EMS is type of optimization
Behavioral (HER)	Not in NCPA E3 Tool	1.0 because of method for calculating savings	1.0	Navigant (2012) calculated savings (as percentages of energy use) using randomized control group that already accounted for free ridership.[1] Other HER evaluations[2] also assume 1.0

[1] Navigant, prepared for CPAU: "Evaluation of the Home Energy Report Program", 2012, calculated net savings compared to a control group. Thus, net savings are calculated directly.

[2] As described in Freeman, Sullivan & Co., "Evaluation of PG&E Home Energy Report Initiative for the 2010–2012 Program (2013): "The regression estimates based on the Randomized Control Trial (RCT) design directly produce a net savings estimate for the treatment conditions. No gross estimates exist. The only adjustment to the net savings estimate is a subtraction for savings claimed by other programs."

To summarize, TRC assumed:

- 0.8 for all lighting measures, RCx and optimization projects, EMS, and VFD installations,
- 1.0 for HER.

However, as described in the Recommendations (Section 8), TRC recommends that the NCPA E3 Tool adopt NTGRs in the more up-to-date versions of DEER (e.g., DEER2016) for future years. Because DEER2016 assumes a lower NTGR for lighting measures (0.6) than DEER2014, this would decrease net savings.

To calculate net natural gas savings, TRC assumed the same NTGR for electricity (kWh) and natural gas (therms) calculations, since almost all measures produced both electricity and natural gas savings. For lighting projects, because the therm savings were negative, the net-to-gross adjustment *increased* therm savings (i.e., the adjustment reduces the negative value).

For the two programs that produce natural gas and water savings (but no electricity savings) – Santa Clara Valley Water District (SCVWD) and Solar Hot Water – TRC used CPAU's historic assumption of 1.0 NTGR for natural gas measures[1].

7.1.2 Portfolio-level Net Savings Results

Figure 13 provides program level net annual savings results. The gross and net natural gas savings values in Figure 13 include interactive effects. Programs for which TRC conducted an impact evaluation are shown with an asterisk (*). For programs not evaluated in FY2017, Figure 13 shows ex ante net savings (i.e., TRC did not make adjustments to net savings).

- For the CIEEP-EA, CIEEP-BASE, and HER programs, TRC's adjustments to net kWh savings for these programs resulted from adjustment to gross savings, rather than adjustments to NTGR.
- For CAP, CPAU had assumed a NTGR of 0.85 for EMS. Because TRC assumed 0.8 for this measure, this slightly reduced net savings. However, the majority of net savings adjustments were due to TRC's adjustments to gross savings, rather than the NTGR adjustment.

[1] According to CPAU EM&V staff in February 2016, the rationale is that natural gas equipment is typically capital intensive, and natural gas is relatively inexpensive. Both of these should decrease the likelihood that the participant would have installed the same equipment in the absence of the program, making free ridership very low or nonexistent. Because net therm savings were for CPAU's internal purposes only (i.e., not reported to the CEC), TRC did not investigate the validity of this assumption.

Figure 13. Net Annual Savings

	Ex Post Gross			Ex Post Net			
CPAU Program	**Demand (kW)**	**Energy Savings (kWh)**	**Natural Gas (Therms)**	**NTGR (kWh)**	**Peak Savings (kW)**	**Energy Savings (kWh)**	**Natural Gas (Therms)**
COM Bus. New Constr.	110	217,048	3,432	0.85	110	184,491	2,917
COM Com. Advantage (CAP)*	119	778,932	(626)	0.80	119	623,146	(501)
COM CIEEP - BASE (ICE)*	0	79,853	9,715	0.80	0	63,882	7,772
COM CIEEP - Ecology Action*	130	1,943,778	89,503	0.80	104	1,555,022	71,602
COM CIEEP - Enovity	16	74,950	866	0.81	16	60,503	699
COM EMPower (SMB)	43	323,679	(343)	0.67	43	215,354	(228)
COM Green Bldg Ord. (Nonres)	0	780,678	(1,981)	0.80	0	624,695	(1,563)
RES Green Bldg Ord. (Res)	0	137,284	5,481	0.58	0	79,625	4,328
RES Home Efficiency Genie	0	17,874	2,660	0.45	0	8,000	1,191
RES Home Energy Report (HER)*	0	1,124,746	121,373	1.00	0	1,124,746	121,373
RES Multifamily Plus (MPP)*	180	975,822	(3,327)	0.80	180	780,658	(2,662)
RES REAP Low Income	5	151,929	6,610	0.80	5	121,543	5,288
RES Smart Energy	0	21,560	2,392	0.34	0	7,271	807
ALL SCVWD	0	0	968	N/A	0	0	968
ALL Solar Water Heating	0	0	2,823	N/A	0	0	2,823
Total	**603**	**6,628,133**	**239,546**	**0.82**	**577**	**5,448,936**	**214,814**

* Programs for which TRC conducted an impact evaluation in FY2017.

7.2 Lifecycle Savings

This section describes the methodology used to calculate ex post lifecycle savings. We begin by describing our EUL assumptions, and then describe how we calculated measure-level, project-level, and program level lifecycle savings.

7.2.1 Effective Useful Life (EUL) Assumptions

For all measures, TRC used the TRM assumptions to identify the effective useful life (EUL) where possible. If the TRM did not provide a measure-specific EUL, TRC used DEER2014 values.

For some lighting measures, the TRM provided a range for the EUL. In particular, the TRM provides the EUL for LED lamps and fixtures as, "Range of 5–15 years (rated fixture or lamp life divided by annual operating hours for each building type)."[1] To align with the TRM approach, TRC used the rated life from DEER2014 and divided it by the assumed operating hours for the particular building type. For example, for an LED lamp installed in a small retail store (DEER operating hours 3,380 hours per year, and measure life equal to 25,000 hours), TRC calculated an EUL of 7.4 years.

[1] TRM section 6.4, "LED Lighting", p. 6-7.

For controls projects, TRC assumed an EUL equal to one year, following current CPAU policy. The CPUC recently increased the assumed EUL for controls measures to three years[1]. However, because this change occurred during FY2017 (rather than before), and CPUC's requirements for projects to show savings persistence started during FY2017 (not before), TRC assumed one year for this evaluation. In future evaluations, TRC recommends that CPAU use an EUL of three years for controls measures.

For HER, TRC used the EUL of one year for residential behavioral programs, per the TRM[2].

7.2.2 Lifecycle Savings Calculations

TRC began by calculating lifecycle savings at the measure level, then the project-level, and then the program-level, as described below.

Measure level: For all measures except for one, TRC calculated lifecycle savings by multiplying annual savings by the EUL for each measure.

The only exception was the replacement of 60W lamps in the MPP project, Y3OC. TRC used a dual baseline approach to calculate first year savings.

Project level: For single-measure projects, project-level savings equaled measure-level savings, by definition.

For projects with multiple measures, such as in CIEEP-EA, TRC calculated a project measure life based on a weighted average, where the EUL of each measure was weighted by the annual savings of that measure.

$$\text{Project measure life} = \sum_{\text{measures in project}} [\text{measure ex post kWh} \times \text{measure EUL}] / \sum_{\text{measure in project}} [\text{measure ex post kWh}]$$

TRC then multiplied the project measure life by the annual savings to estimate project lifecycle savings.

Program level: For the CIEEP-EA and CIEEP-BASE programs, TRC summed the lifecycle savings across all projects for the program total lifecycle savings.

For programs where TRC conducted sampling (CAP and MPP), TRC applied sampling weights to the project-level lifecycle kWh results to develop a program level realization rate for lifecycle kWh. TRC multiplied the program ex ante lifecycle kWh total by the lifecycle kWh realization rate to determine ex post lifecycle kWh.

For HER, because the EUL is one, the lifecycle savings equals the annual savings.

[1] CPUC decision 16-08-019

[2] TRM Section 17.5 – "Home Energy Reports – Residential", p. 17-8.

7.2.3 Summary of Lifecycle Savings and Adjustments

Figure 14 provides the program-average EUL, and each program's lifecycle savings results. The differences between ex ante and ex post realization rates were primarily because TRC calculated measure-specific EUL values for lighting measures (based on operating hours and measure life). By dividing ex ante lifecycle savings by ex ante annual savings, TRC estimated that CAP and MPP assumed EUL values of 10 and 14 years, respectively, for all LED measures. Similarly, TRC estimated that CIEEP-EA assumed an average EUL of 6 years for lighting measures. For the ex post lifecycle savings estimate, TRC adjusted the EUL based on the operating hours, according to DEER assumptions. This resulted in lower EUL for many lighting measures, reducing lifecycle savings. Secondarily, TRC's reductions to annual kWh savings – particularly to some baseline wattage assumptions – reduced lifecycle kWh savings.

Figure 14. Gross and Net Lifecycle Energy Savings

	Ex Ante Lifecycle		Input Values for Ex Post Lifecycle		Ex Post Lifecycle		
CPAU Program	**Gross Savings (kWh)**	**Net Savings (kWh)**	**Ex Post Annual Gross Savings (kWh)**	**Average Measure Life (Yr)**	**Gross Savings (kWh)**	**Net Savings (kWh)**	**Gross Realization Rate (%)**
COM Bus. New Constr.	3,255,720	2,767,362	217,048	15.0	3,255,720	2,767,362	N.E.
COM Com. Advantage (CAP)*	10,434,966	8,347,973	778,932	6.7	5,223,497	4,178,798	50%
COM CIEEP - BASE (ICE)*	927,218	758,796	79,853	13.1	1,044,291	835,433	113%
COM CIEEP - Ecology Action*	10,501,467	8,401,174	1,943,778	4.4	8,632,772	6,906,218	82%
COM CIEEP – Enovity	800,250	648,345	74,950	10.7	800,250	648,345	N.E.
COM EMPower (SMB)	3,878,112	2,557,589	323,679	12.0	3,878,112	2,557,589	N.E.
COM Green Bldg Ord. (Nonres)	10,918,633	8,734,902	780,678	14.0	10,929,497	8,745,735	N.E.
RES Green Bldg Ord. (Res)	1,510,121	875,872	137,284	11.0	1,510,121	873,906	N.E.
RES Home Efficiency Genie	298,159	128,008	17,874	16.7	298,159	128,008	N.E.
RES Home Energy Report (HER)*	1,026,734	1,026,734	1,124,746	1.0	1,124,746	1,124,746	110%
RES Multifamily Plus (MPP)*	19,683,264	15,746,611	975,822	6.4	6,237,121	4,989,697	32%
RES REAP Low Income	2,111,375	1,689,100	151,929	13.9	2,111,375	1,689,100	N.E.
RES Smart Energy	332,121	108,309	21,560	15.4	332,121	108,309	N.E.
Total	**65,678,140**	**51,790,775**	**6,628,133**	**6.8**	**45,377,782**	**35,553,244**	**69%**

* Programs for which TRC conducted an impact evaluation in FY2017.
N.E. = Not Evaluated

8 PROGRAM RECOMMENDATIONS

In general, the CPAU FY 2017 programs were successful in providing energy, demand, and natural gas savings to CPAU customers. However, TRC identified opportunities for improvement for the programs for which we conducted impact evaluations. While it was beyond our scope to provide a comprehensive set of recommendations (such as those developed through a process evaluation), TRC provides the following recommendations based on the EM&V results.

For background, as described in more detail in Section 2.1, some programs work with one or both of the following third party companies:

- Implementers, which CPAU contracts to manage the daily operations of the program, and
- Vendors, such as HVAC or lighting contractors, which the customer contracts to install measures.

One overarching recommendation is for all programs to calculate project-specific EUL values for lighting measures based on DEER operating hours, rather than assuming a flat EUL (e.g., 10 years for all CAP lighting measures, 14 years for all MPP lighting measures) for ex ante lifecycle savings calculations. This would increase the accuracy of lifecycle savings. Although CPAU staff (not implementers or applicants) historically calculate lifecycle savings, implementers could assist them by providing the EUL for each lighting measure to facilitate CPAU's calculations, as CPAU staff does not always have access to the implementers' assumptions that are needed for determining EULs.

In addition, TRC recommends that CPAU work with NCPA to update the NCPA E3 Tool to use DEER2016 (not DEER2014) assumptions, including for NTGR assumptions.

8.1 Commercial and Industrial Energy Efficiency Program (CIEEP) / Industrial and Commercial Efficiency (ICE)

TRC's primary recommendations are:

- For CIEEP-EA and CIEEP/ICE-BASE, CPAU should increase the requirements for implementers' verification after project installation for all installed measures,
- For all CIEEP implementers, for optimization measures: CPAU should develop procedures for its staff to check that the implementers meet the persistence verification requirements (developed in FY2018), and should encourage implementers to follow the option for submitting yearly trend data,
- CPAU and all CIEEP implementers should discuss opportunities to reconfigure optimizations that the customer ultimately finds are not acceptable.

We provide details on these recommendations below.

Increase verification

For each project, the customer's vendor develops a pre-project inspection report that describes existing condition (typically used for the baseline), recommends measures for the project, and estimates savings. The vendor also develops a post-project verification report that describes the installed project and revises savings calculations as necessary. The implementer has the responsibility to verify the accuracy of the information in these reports.

In the CIEEP-EA program, TRC found several examples where the installed project did not match the documentation or where there were errors in calculations. For example:

- For one project (the lighting upgrade in EA Project PA-001-17) installed on a campus with over a dozen buildings, the project documentation did not specify in which buildings the upgrade would be installed, and the supporting calculations were for a different set of buildings than for the actual project scope. TRC emphasizes this was an isolated event.
- TRC found a lack of baseline conditions detail in some CIEEP-EA inspection reports. For example, it was not clear whether a single speed or two speed motor was in place for a fluid cooler variable speed drive project (which led to an adjustment in ex post savings).
- TRC found several errors in CIEEP-EA calculations (e.g., lack of coincidence diversity factors [CDFs] for some projects, and developing minimal power based on percent of peak kW, instead of fan speed, for the fluid cooler variable speed drive project).

The issues identified above were in CIEEP-EA projects. For the one CIEEP/ICE-BASE project, TRC made only small adjustments to the calculation based on slight discrepancies in optimal start schedules, supply air reset temperature set points, and boiler lockout temperature, which may have occurred after the project was implemented. However, because BASE implemented only one project and is a fairly new implementer of the program, TRC recommends that CPAU require BASE to follow the below recommendations until CPAU is confident of this implementer's submittals. For the third implementer (CIEEP-Enovity), TRC's FY2015 and FY2016 EM&V reports found high realization rates fairly minor discrepancies with installed projects[1], so we do not recommend additional verification requirements (beyond those for optimization projects, described in the next subsection).

TRC recommends that CPAU require EA and BASE to increase their verification and quality assurance, as follows:

- The inspection and verification reports should clearly define the project scope, including what buildings and what building areas will be affected (both reports), what measures will be replaced (inspection report), and the quantity and type of measure to be installed (inspection report) / were installed (verification report).
- The implementers should provide a closer review of the final verification report, inspection report, and calculations, to ensure that the information in the reports adequately support the calculation of claimed savings, and to check for errors in the calculations. Although the verification report provides the final calculation, the implementers should also carefully review the inspection report to check that it describes the existing condition accurately.
- The implementers should conduct field verifications for all large savings projects and a sample of small savings projects, to ensure the installed scope matches the verification report.
- CPAU program staff should increase quality assurance, particularly for large projects. For projects projected to have large savings, CPAU program staff should conduct site visits at the inspection stage to check on key assumptions (e.g., baseline assumptions, operating hours, and quantity of measures to be replaced). CPAU program staff should also review the inspection

[1] TRC made significant changes to CIEEP-Enovity optimization projects, but the next set of recommendations (for increasing persistence from optimization projects for al implementers) should address this.

report, to ensure that assumptions are documented and match conditions observed in the field; and the verification report to check that the scope of work and savings estimates are similar to the inspection report. If savings or the scope have changed significantly, CPAU program staff should discuss these with the implementer before issuing incentives.

Additional verification for optimization projects

TRC recommends that CPAU require all CIEEP implementers to follow the procedures that CPAU recently developed for optimization projects to increase savings persistence. In support of this, TRC recommends that CPAU develop procedures for CPAU program staff to confirm that CIEEP implementers meet the persistence requirements for each optimization project. This section provides background and detail on these recommendations.

In one of the two optimization projects reviewed by TRC, the set-points had changed substantially compared to the claimed conditions (EA Project PA-001-017 HVAC measures). Starting in FY2018, CPAU plans to increase the assumed EUL for optimization projects from one year to three years, to align with the recent CPUC ruling[1]. In the FY2016 EM&V report, TRC recommended that CPAU develop more stringent guidelines to increase savings persistence. In FY2018, CPAU developed requirements for their implementers that provided the following three pathways to increase persistence:

1. Staff training and documentation, including changes to the operation or procedures manuals to reflect the optimization measure,
2. Service contracts that include the performance specifications for the optimization measure, or
3. Submission of yearly trend data, for three years after the measure.

TRC reviewed the implementers' requirements and noted that CPAU requires proof that they will be met. For example, the following must be met (to align with the pathways above) before CPAU issues incentives:

1. Copies of training logs and manuals,
2. Copies of service contracts,
3. First year trend data.

TRC agreed that the requirements should be adequate for increasing persistence, particularly since incentive payments are held until these requirements are met.[2] However, TRC recommends that CPAU encourage the third option (submission of yearly trend data), since this provides documentation of system operation, so will have the highest likelihood of achieving real savings and identifying projects where savings do not persist. In addition, TRC recommends that CPAU develop procedures (one for each pathway) for CPAU program staff to confirm that the implementers followed these requirements. For example, for pathway 3, CPAU should provide procedures for how its staff should review submitted trend data, such as:

- Comparing new trend data with trend data submitted at the time of commissioning, to check that the system is operating the same, and

[1] CPUC's Final Decision (16-08-019) of Rulemaking 13-11-005

[2] CPAU could also consider withholding a portion of the incentive (instead of the entire payment) until the implementer meets the requirements.

- Confirming that there is a variance in speed for VFD projects, and a variance in supply temperature for temperature reset projects.

Because trend data analysis is project-specific, CPAU could request technical assistance from a third party to provide guidance on reviewing the data submitted by implementers.

Discuss opportunities to reconfigure optimizations rejected by customer

CPAU and the implementers should discuss opportunities to reconfigure optimizations that the customer ultimately finds are not acceptable. The implementer must describe and present optimizations in such a way as to make them acceptable to the customer. However, TRC recognizes that occasionally, optimization measures need to be adjusted to address unforeseen issues such as occupant comfort or changes in occupancy. The implementer should coordinate with the customer (e.g., facility manager), and (if applicable) the EMS programmer to identify measure adjustment needs post-implementation, and before receiving program incentives.

This recommendation is based on a finding from CIEEP-EA projects this year. However, TRC recommends it apply to all implementers, since we have found changes in set-points at CIEEP-Enovity projects in FY2015 and FY2016 EM&V, and because BASE is a new implementer.

8.2 Commercial Advantage Program (CAP)

TRC's primary recommendations are:

- CPAU evaluation staff should work with NCPA to fix an error in the TRM404 calculator. In the meantime, program staff should ensure customers do not use the calculator such that the error is triggered.
- Particularly for lamp (not fixture) replacements, CAP program staff should work with customers and contractors to ensure that an appropriate lighting product is installed, taking into account lamp-socket compatibility to avoid early lamp failure.
- CAP program staff should calculate project-specific EUL values for lighting measures for lifecycle savings.
- CAP program staff should work with customers and NCPA to include interactive effects.

The largest adjustment to annual kWh savings was a correction in the savings calculation due to an error in the Simplified Nonresidential Lighting Calculator (TRM404). As described in section 9.5, if the user chooses certain drop-down options, the calculator defaults to zero electricity use for the installed lighting measure. CPAU evaluation staff should work with the NCPA and its consultant that develops the calculators (ERS) to fix this calculator error. In the meantime, CAP program staff, and other CPAU program staff and implementers that use the TRM404 calculator should be made aware of the glitch, so they can ensure that applicants (e.g., vendors and customers) use it in a manner that does not trigger this error. CAP program staff should also check for the error in submitted applications.

CAP program staff should also ensure that an appropriate type of high efficacy lighting product is installed. In one CAP project, the customer had replaced approximately one-fifth of the program-installed LEDs with a different LED lamp product because many program LED lamps had burned out. CPAU program staff should work more closely with partnering contractors and customers (for

participant self-installation projects) to ensure that lighting measures installed are appropriate for each application – including meeting manufacturers' guidelines for lamp-socket compatibility[1].

In addition, CAP program staff should:

- Calculate project-specific EUL values for lighting measures and use these (rather than default values) for ex ante lifecycle savings calculations.
- Ensure that applicants include interactive effects for lighting measures installed in conditioned areas. If needed, program staff should work with applicants to select the appropriate interactive effect factors. This captures the actual impact of the measure and would increase the realization rate for natural gas (therms) savings.

8.3 Multifamily Plus Program (MPP)

TRC's primary recommendations are:

- For the implementer to follow TRM assumptions for HOU and baseline assumptions, and (per the TRM) to calculate measure-specific EUL values for lighting measures; and for MPP program staff to review the implementer's proposed savings claims – particularly the HOU assumptions,
- For the implementer to add columns in the database for the area of installation for lighting measures and (based on this area) for the HOU assumption. The implementer should also submit project-specific calculations, and obtain email addresses for all participants.

TRC noted that the quality of measure installation appears to be good. In addition, the MPP participant survey found high satisfaction with the program, and the two survey respondents reported high likelihood of participating in the program again or recommending it to a peer. (In the FY2016 evaluation, TRC administered the same survey and found high satisfaction from the three survey participants.)

However, TRC provides the following recommendations for the implementer, to help increase the accuracy of ex ante savings:

- Identify HOU assumptions based on where (e.g., residential unit, common area, exterior) the measure was installed (in accordance with the TRM), not what measure type was installed.
- Use baseline assumptions that align with the TRM. For any case where the program replaces an existing measure with a baseline that deviates from the TRM (e.g., incandescent lamps), the implementer should document the existing condition with a photograph, and apply a dual baseline (rather than assume the existing condition for the entire EUL of the replacement measure).

[1] There are three main types of Tubular LED products and each has its own set of compatibility requirements: UL Type A – Operate directly on a fluorescent ballast (like a fluorescent lamp does, using the FL lamp sockets), UL Type B – Integrated driver (User must remove the original FL ballast from the fixture and wire 120V power to the lamp sockets), and UL Type C – Remote driver (User removes the original FL ballast and replace it with an LED driver), as well as hybrid products. Manufacturers provide installation guides for products. For example, from the Philips website: *Philips LED T8 InstantFit lamps will only operate properly on compatible Instant-start and Programmed-start ballasts. Please refer to the Philips LED T8 InstantFit Installation Guide, which can be obtained through your local Philips Sales Representative, or visit* www.philips.com/instantfit

- Calculate measure-specific EUL values for lighting measures (instead of using one assumed value), so that MPP program staff can calculate lifecycle savings.
- Ensure that the interactive effect factors are appropriate, based on the building type and building area of the installed measure.

TRC recommends that CPAU program staff review the implementer's proposed savings claim, to ensure that the above recommendations are followed. In particular, CPAU program staff should review the HOU assumption for each project, since this led to the largest adjustment to savings. CPAU staff should also calculate lifecycle savings based on the project-specific EUL.

In addition, TRC provides the following recommendations to provide transparency, to assist CPAU program staff with reviewing assumptions, or to enable the collection of program feedback. The implementer should:

- Add a column in the program database to indicate what general area the measure is installed, and another column with the following HOU (as hours per year) based on this area: In-unit (541), common area (4,160), interior hallway / egress lighting (8,760), exterior (4,100), parking garage (8,760), and other (HOU to be specified). This would enable the CPAU program staff to more easily review the assumptions for HOU.
- Submit project-specific savings calculations for electricity and natural gas savings for all lighting measures, to facilitate CPAU program staff's review. (These project-specific calculations would also enable the evaluation to identify the source of discrepancies between ex ante and ex post results.) If the implementer proposes to assume any values that deviate from the TRM, these should be clearly identified.
- Obtain email addresses for all participants, so that the program can conduct follow up research, such as electronic surveys to gather participant feedback. Although the MPP database contained more email addresses in FY2017 than in FY2016, the FY2017 database lacked emails for approximately one-third of sites.

Finally, many of the measure descriptions in the implementer's contract assume a specific HOU - e.g., T8 to LED 4 - bulb (11.4 hrs. per day). In some cases, there are two HOU assumptions for the same efficiency measure – e.g., T8 to LED 4 - bulb (5.2 hrs. per day). Although it would lengthen the contract, the implementer should develop measure descriptions (and associated kWh savings) for each of the HOU scenarios (in hours/year) described above: In-unit (541), common area (4,160), interior hallway / egress lighting (8,760), exterior (4,100), and parking garage (8,760).

8.4 Home Energy Report Program

TRC's primary recommendation is for CPAU to identify one (or more) residential behavioral programs to implement, since HER has been discontinued.

HER is the largest residential program (for kWh and therm savings) and a major savings program in general for the CPAU portfolio. If this program continues to be inactive, HER savings will continue to decline each year as persistence declines.

Similar to the FY2016 EM&V report, TRC recommends that CPAU consider implementing at least one new residential behavioral program, to replace HER. Various studies provide an overview of different

behavioral program strategies such as a literature review by Illume Advising (2015[1]), and a list of behavioral programs compiled by the Consortium for Energy Efficiency[2]. CPAU could review such studies to consider which residential behavior program models could be a good fit for CPAU customers. If appropriate based on this research, CPAU could consider implementing different behavioral programs for certain customer segments, such as a different program for low-income households.

[1] Illume Advising, 2015: "Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines". For the MN Department of Commerce. http://mn.gov/commerce-stat/pdfs/card-report-energy-efficiency-behavorial-prog.pdf

[2] CEE, 2017, "2017 Behavior Program Summary": https://library.cee1.org/content/2017-behavior-program-summary-public-version

9 APPENDICES

This section includes the following appendices:

- 9.1. The rationale for why CPAU and TRC selected CIEEP, HER, CAP and MPP for FY2017 evaluation instead of other CPAU programs
- 9.2. CIEEP Project-level EM&V Results
- 9.3. CAP Project-level EM&V Results
- 9.4. MPP Project-level EM&V Results
- 9.5. The electronic survey guide and survey results for the MPP
- 9.6. A description of the error found in one of the TRM calculators (the Simplified Lighting Calculator)

9.1 Rationale for Selecting Programs for FY2017 Evaluation

Figure 15 presents each program in the CPAU FY2017 portfolio, its ex ante savings, when the program was last evaluated, whether or not the program was ultimately selected for FY2017 evaluation, and the final rationale for this decision.

Figure 15. FY2017 Program Evaluation Prioritization

Market Served	CPAU Program	Delivery Model	FY2017 Ex Ante kWh	FY2017 Ex Ante Therms	Last Evaluated	Evaluated in FY2017? Rationale
Nonres	CIEEP - Ecol Action	Custom	2,051,254	104,722	FY2016	Yes. High savings
Nonres	CIEEP – BASE	Custom	76,680	9,425	N/A - New	Yes. New Program
Nonres	CIEEP – Enovity	Custom	74,950	866	FY2016	No. Low savings, evaluated recently w/high realization rate
Nonres	CAP	Deemed & Custom	1,043,497	0	FY2015	Yes. High savings, not evaluated last year
Nonres	EMPower	Semi-Deemed	323,679	(343)	FY2016	No. Medium savings, evaluated recently w/high realization rate
Nonres	Bus. New Constr.	Custom	217,048	3,432	FY2015	No. Medium savings, evaluated somewhat recently.
Res	MultiFamily Plus	Direct Install	1,400,252	(1,888)	FY2016	Yes. High savings, medium realization rate last year
Res	HER	Behavioral	1,026,734	93,540	FY2016	Yes (update calculation inputs only). High savings
Res	REAP Low Income	Direct Install	151,929	6,610	FY2013	No. Low/medium savings
Res	Smart Energy	Deemed	21,560	2,392		No. Low savings, may be phased out
Res	Home Eff. Genie	Deemed, self-install	17,874	2,660	FY2016 (Process)	No. Low savings
Both	Green Building Ordinance		917,186	3,494	N/A - New	No. TRC calculated savings through technical assistance contract
Both	Solar Water Heating		0	2,823		No. Sustainability program (out of scope) and low savings
Both	SCVWD		0	968		No. Sustainability program (out of scope) and low savings

9.2 CIEEP Project-Level EM&V Results

This section provides a description of the EM&V results for each project that participated in the CIEEP-EA and CIEEP/ICE –BASE programs in FY2017.

TRC reviewed the five EA projects, three of which were lighting-only measures. One was an HVAC-only project. The other project had lighting and HVAC measures, as described in further detail below. All of the lighting measures consisted of upgraded LED lighting systems in office buildings, and parking structures and lots. The scope of the lighting upgrade changed in one project compared to the claimed scope, which resulted in decreased savings. In addition, EA did not account for HVAC heating and cooling interactive effects in interior lighting projects; TRC's inclusion of interactive effects slightly increased kWh cooling savings and decreased therm savings.

The one BASE project included an optimization project through an EMS installation, LED lighting retrofit, and variable frequency drive (VFD) installation. As described below, TRC made minor adjustments to the optimization project.

9.2.1 EA Project PA-001-17

9.2.1.1 Summary of Project Findings

The site is a large corporate campus with six buildings. The claimed energy savings measures for this project were:

- ECM 1.2 Deeper Heating Hot Water Temperature Reset
- EEM 1.4 Interlock Hot Water Pump Operation with Boiler
- EEM 2.2 Interlock Condenser Water Pump Operation with Chiller
- EEM 2.3 Implement Chilled Water Supply Temperature Reset
- EEM 3.1 Optimize AHU Operation Phase I
- EEM 5.1A Interior Lighting Upgrade

EEM-1.2 was heating hot water supply temperature reset on five boilers. During the site inspection, TRC determined from the EMS program that the measure was not currently implemented in four of the five boilers. TRC revised the energy savings calculation to account for HWR implemented for only boiler, which decreased the energy savings by 67%.

EEM 1.4 was implemented as an interlock between one of the boilers and its secondary hot water pump, turning off the pump when the boiler is disabled. As per the site inspection and EMS review, TRC confirmed that the secondary hot water pump was interlocked with the boiler.

EEM 2.2 was implemented as an interlock between the chillers and condenser water pump. TRC verified the measure savings claim and made no change to the energy savings calculation.

EEM 2.3 implemented chilled water supply temperature reset based on outside air temperature (OSA). Based on the EMS screenshot, TRC found no reset based on OSA and observed lower limit set-point. TRC revised the energy savings calculations to reflect the observed operating conditions, reducing the savings.

EEM-3.1 impacted 32 air handling units (AHUs), serving the offices, conference rooms, common areas, cafeteria and some laboratory spaces. As per the facility engineer's description, some of the AHUs operate continuously (24/7) regardless of the actual occupancy.

EEM-3.1 consisted of several optimization approaches as follows:

- Implemented time of day scheduling of AHU operation based on actual occupancy schedules,
- Re-commissioned the AHU economizer operation to utilize the full potential of free cooling,
- Implemented duct static pressure reset based on actual demand at the terminal units, and
- Implemented supply air temperature (SAT) reset based on the zone demand.

As per the submitted energy savings calculation, of the 32 AHUs, only 19 were considered for the AHU optimization project.

Based on review of submitted trend data, EMS screen shots and equipment nameplate information, TRC modified the submitted bin calculations due to a few discrepancies in operating hours, set-points and minimum outside air. The bin calculation modifications resulted in an overall decrease in both electricity and gas savings of approximately 10%.

EEM 5.1A upgraded the lighting system to LED. The ex ante calculation referred to a scope of lighting work which differed from the scope of work actually implemented. TRC discovered the discrepancy when arranging a site survey to verify the installation. TRC obtained project documents related to the implemented scope prior to the site inspection, and then performed spot verification of fixtures types, quantities, operating hours, and wattage based on the revised work scope. TRC adjusted the savings to account for the effects of scheduling controls previously implemented and incentivized by the FY2016 CIEEP program. TRC also made minor adjustments due to discrepancies in the fixture types between the revised work scope and what we observed in the field. Finally, TRC adjusted the savings by importing the project savings spreadsheet into an approved TRM calculator to account for interactive effects.

Overall, the optimization project had a high realization rate for kWh (93%) but a low realization rate for kW (12%). The lighting project had a high realization for both kWh (94%) and kW (87%).

The Verification Report submitted by EA shows the following ex ante savings:

- Electricity kWh Savings: 1,430,149 kWh
- Electricity Demand (kW) Savings: 128 kW
- Natural Gas Savings: 104,722 therms

The following ex ante savings estimate is from the Verification Report:

Figure 16. Claimed (Ex Ante) Savings for CIEEP-EA Project PA-001-017

EEM #	EEM Name	Peak Period Demand (kW) Savings	Annual Electric (kWh) Savings	Annual Gas (Therm) Savings
3.1	Optimize AHU Operation Phase 1	0	662,957	101,372
1.2	Deeper Heating Hot Water Temperature Reset	0	0	3,350
1.4	Interlock Hot Water Pump Operation with Boilers	0	3,793	0
2.2	Interlock Condenser Water Pump Operation with Chiller	13.5	335,871	0
2.3	Implement Chilled Water Supply Temperature Reset	32.5	96,490	0
5.1 A	Interior Lighting Upgrade	82	331,038	0
	Total	128	1,430,149	104,722

As per TRC's review, ex post savings are the following, as shown in Figure 17:

- Electricity kWh Savings: 1,453,088 kWh
- Electricity Demand (kW) Savings: 119 kW
- Natural Gas Savings: 89,779 therms

Figure 17. Verified (Ex Post) Savings for CIEEP-EA Project PA-001-017

EEM #	EEM Name	Peak Period Demand (kW) Savings	Annual Electric (kWh) Savings	Annual Gas (Therm) Savings
3.1	Optimize AHU Operation Phase 1	0	624,307	91,104
1.2	Deeper Heating Hot Water Temperature Reset	0	0	1,105
1.4	Interlock Hot Water Pump Operation with Boilers	0	3,793	0
2.2	Interlock Condenser Water Pump Operation with Chiller	13.5	335,871	0
2.3	Implement Chilled Water Supply Temperature Reset	(7.8)	55,134	0
5.1 A	Interior Lighting Upgrade	72	311,124	(1,742)
		78	1,330,229	93,951

The section below describes TRC's findings and adjustments.

9.2.1.2 Detailed Project Findings – Optimization Project

Site Inspection:

TRC completed the field inspection on Tuesday 11/21/2017.

During field inspection, the reviewer inspected all the mechanical equipment associated with building HVAC measures and also reviewed EMS programing to understand control settings. TRC provides EMS screenshots later in this subsection.

Measure Calculation Review:

The following analysis details the CIEEP measures implemented by EA under the FY2017 program year. The measure numbering system used below correlates with the EEM numbering used in the implementer's calculations and with the numbering system used in the summary table of the post-verification report, "B1-6 Energy Efficiency Post-Installation Report 1". The numbering does not correlate to the numbering system used in the body of the project file (the post-installation report).

ECM 1.2 Deeper Heating Hot Water Temperature Reset

Scope: As per the post installation report, the facility implemented heating hot water supply temperature reset based on outside air temperature on Boilers B1LE, B1LW, B2LE, B2LW and B3LW.

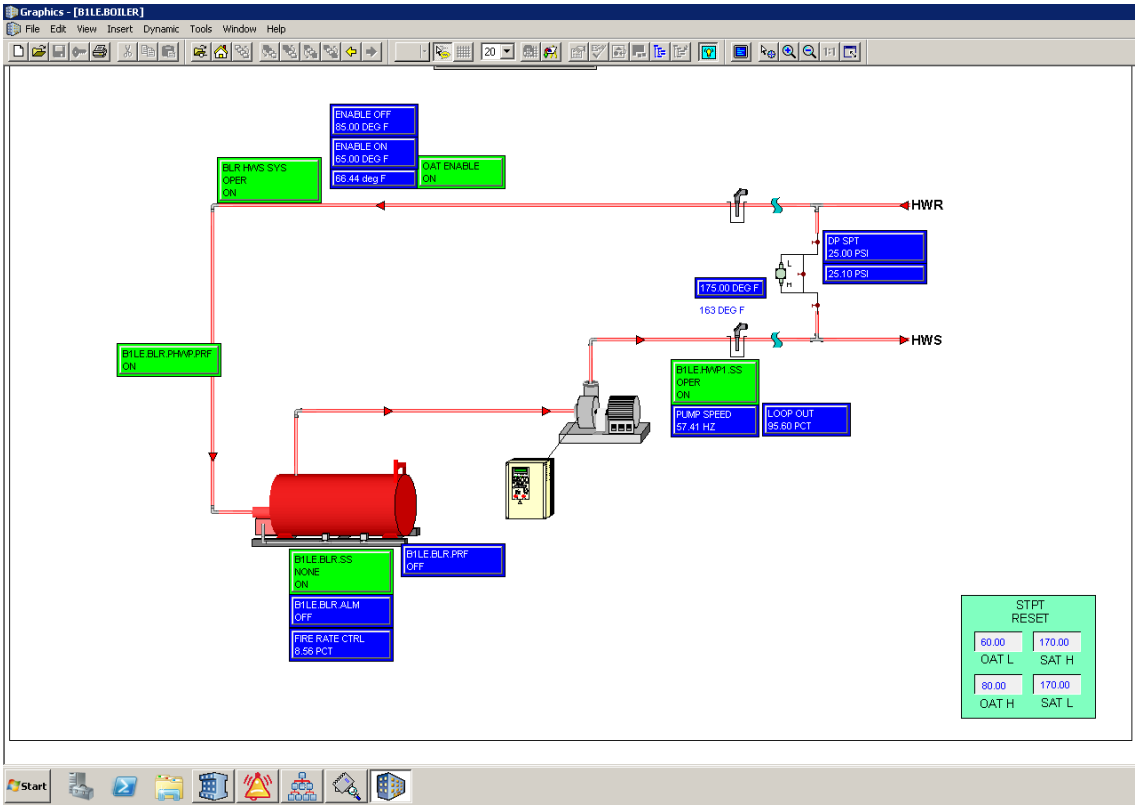
Boiler	Input (MBH)	Output (MBH)
B1LE	1,500	1,275
B1LW	1,500	1,275
B2LE	2,000	1,700
B2LW	2,000	1,700
B3LW	1,500	1,275

The post install report provided the following settings for all boilers, where HWST = hot water supply temperature, ΔT = delta Temperature, and OAT = outside air temperature.

Settings	HWST	ΔT	OAT
Heating Design Temperature	170	20	57.5
Balance Temperature	140	2	72.5

TRC Inspection Notes:

Boiler B1LE, B1LW, B2LW: The post-install report claims the hot water reset measure was implemented for these boilers. At the site inspection, TRC determined from the EMS program that the measure was not currently implemented. The facility representative explained that the measure settings had been disabled due to reports of occupant discomfort. This change was only discovered at the time of TRC's inspection.


Graphics - [B1LE.BOILER]
File Edit View Insert Dynamic Tools Window Help
ENABLE OFF
85.00 DEG F
ENABLE ON
65.00 DEG F
68.44 deg F
OAT ENABLE
ON
BLR HWS SYS
OPER
ON
HWR
DP SPT
25.00 PSI
25.10 PSI
175.00 DEG F
163 DEG F
HWS
B1LE.BLR PHWP PRF
ON
B1LE HWP1 SS
OPER
ON
PUMP SPEED
57.41 HZ
LOOP OUT
95.60 PCT
B1LE.BLR SS
NONE
ON
B1LE.BLR PRF
OFF
B1LE.BLR ALM
OFF
FIRE RATE CTRL
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STPT
RESET
60.00
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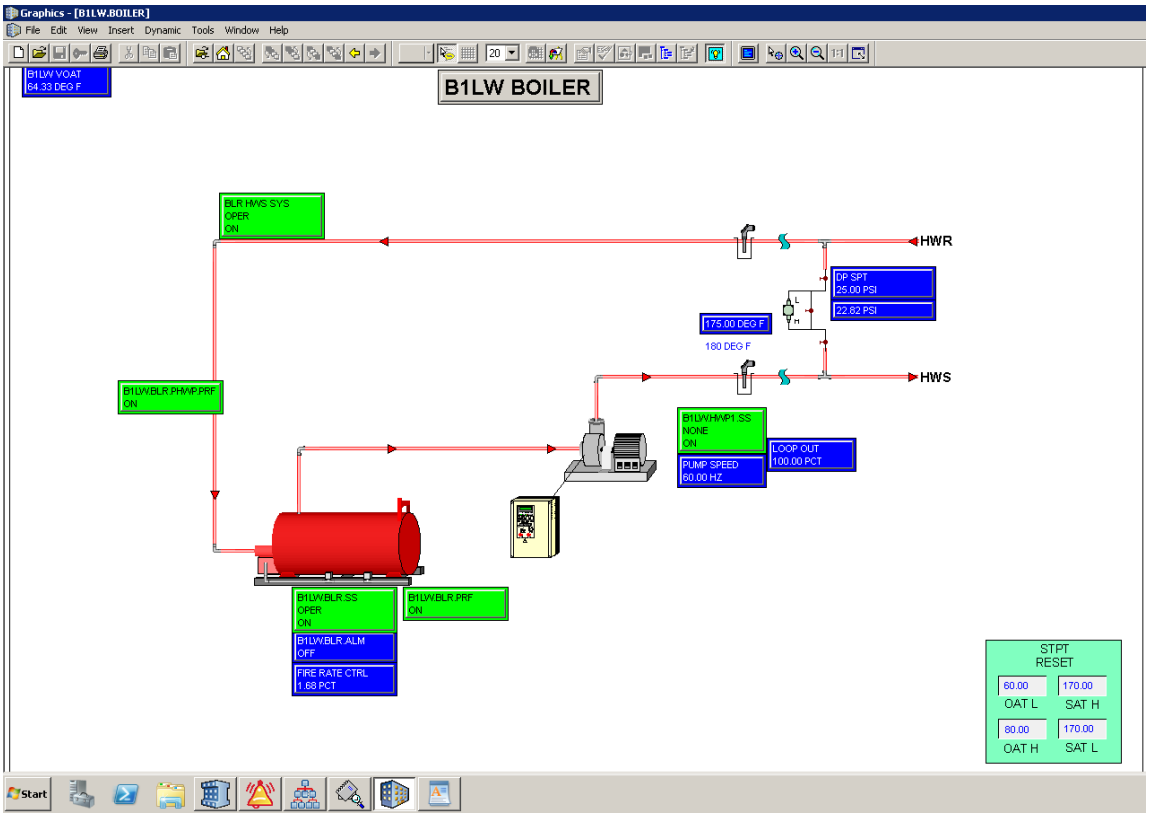
170.00
SAT H
80.00
OAT H
170.00
SAT L
Start


Graphics - [B1LW.BOILER]
File Edit View Insert Dynamic Tools Window Help
B1LW VOAT
64.33 DEG F
B1LW BOILER
BLR HWS SYS
OPER
ON
HWR
DP SPT
25.00 PSI
22.82 PSI
175.00 DEG F
180 DEG F
HWS
B1LW.BLR PHWP PRF
ON
B1LW/HWP1 SS
NONE
ON
PUMP SPEED
60.00 HZ
LOOP OUT
100.00 PCT
B1LW.BLR SS
OPER
ON
B1LW.BLR PRF
ON
B1LW.BLR ALM
OFF
FIRE RATE CTRL
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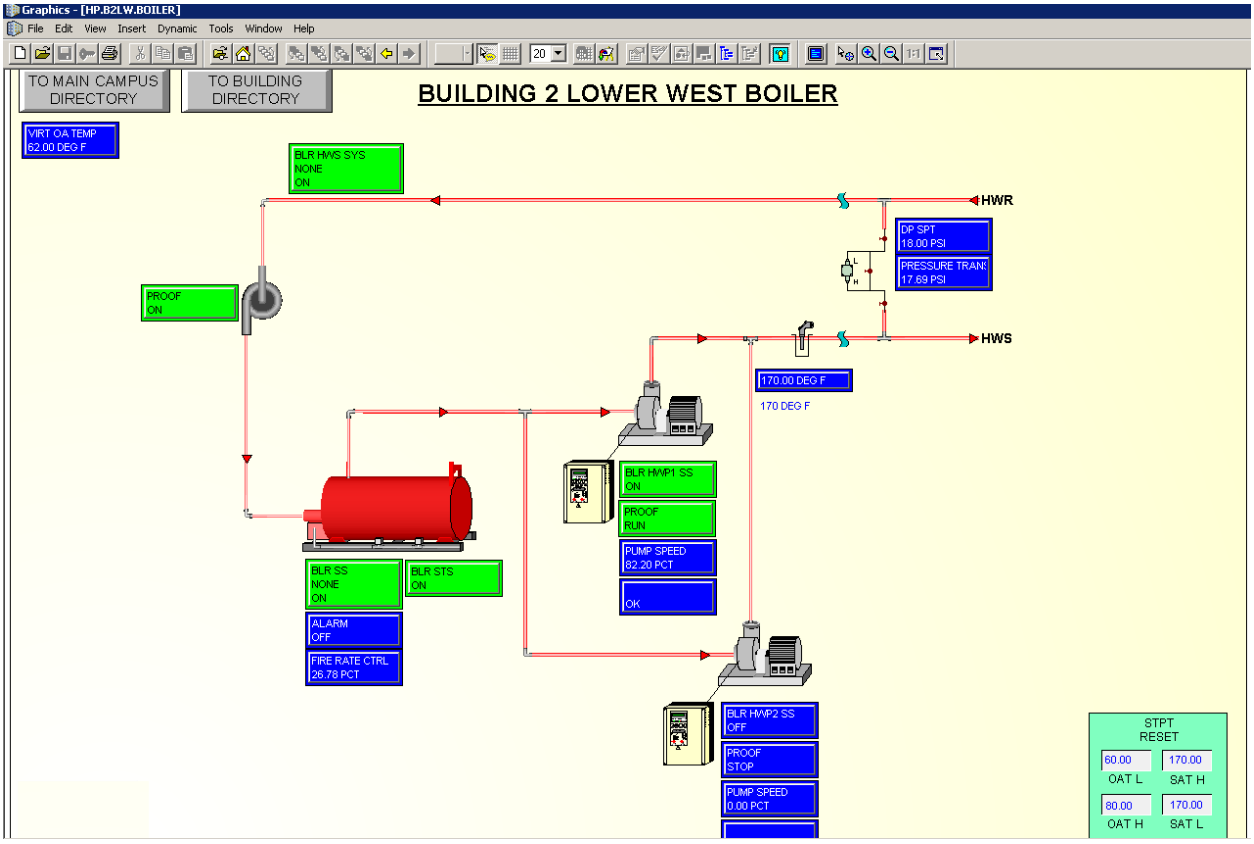
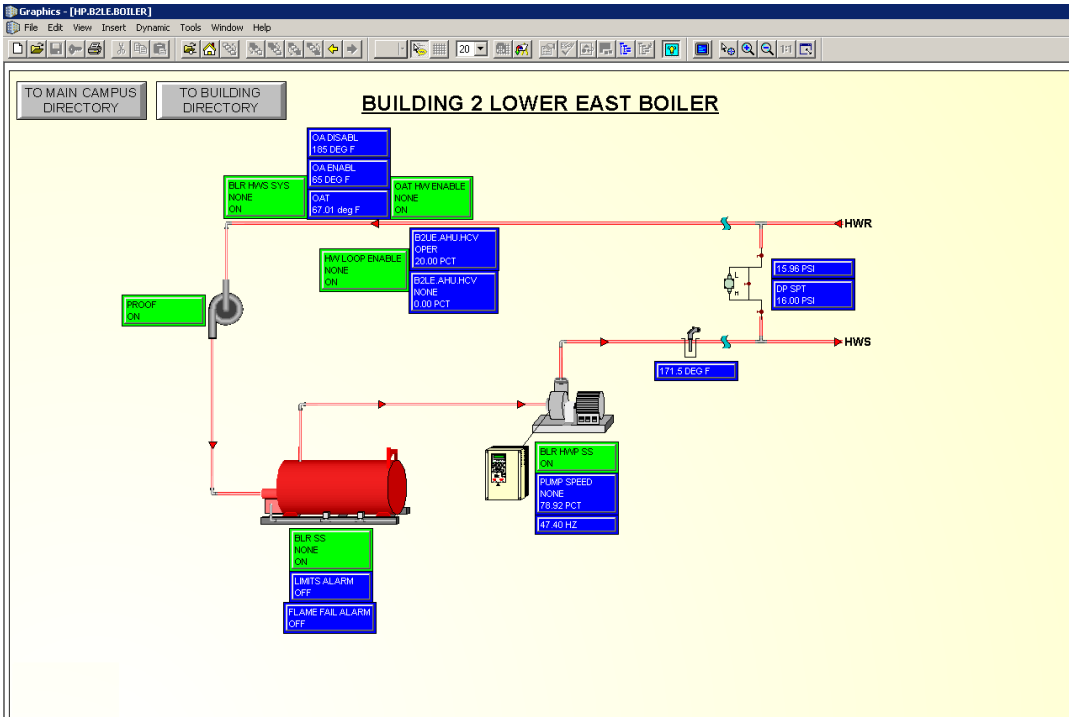
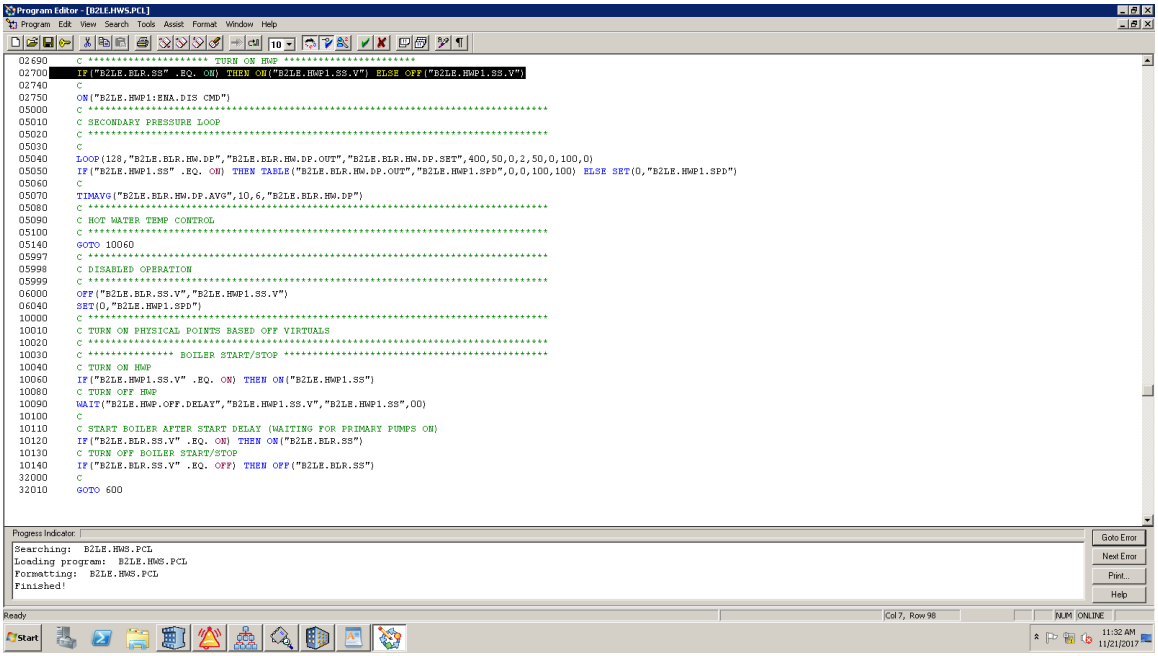
SAT H
80.00
OAT H
170.00
SAT L
Start



1. Boiler B2LE: The post-install report claims the hot water reset measure was implemented for this boiler. The controls engineer explained that the measure settings had been disabled due to reports of occupant discomfort after implementation.





Boiler B3LW – Hot Water Reset was observed by TRC to be implemented at the following levels, as supported by EMS screenshots:

Settings	HWST	ΔT	OAT
Heating Design Temperature	170	20	55
Balance Temperature	140	2	75

B3LW.HWS.PCL

```
01540     INITTO(0,"B3LW.HWP1.SS")
01550     RELEAS(@OPER,"B3LW.HW.RUN.TOTAL.RESET")
01560     OFF("B3LW.HW.RUN.TOTAL.RESET")
01600     C
01610     C SET RUN.TOTAL RUN TIME TO VIRTUAL POINTS
01620     C
01630     "B3LW.HWP1.RUN.TOTAL" = TOTAL("B3LW.HWP1.SS")
01700     C
01710     C OAT HW ENABLE
01720     C
01730     DBSWIT(1,"B3LW.AHU.OAT","B3LW.OAT.HW.ON","B3LW.OAT.HW.OFF","B3LW.OAT.HW.ENABLE")
01740     C RESET TEMP SPT BASED ON OAT
01750     TABLE("B3LW.AHU.OAT","B3LW.BLR.HWST.SET",55,170,75,140)
01770     C
01810     C LAG ENABLE
01820     C
01910     C LEAD SELECTION SCHEDULED WEEKLY
01930     C
02510     C CHECK TO SEE IF SYSTEM IS ENABLED
02520     C
02530     IF("B3LW.OAT.HW.ENABLE" .EQ. OFF)THEN GOTO 6000
02540     IF("B3LW.HW.SYS" .NE. ON) THEN GOTO 6000
```

TRC revised the energy savings calculation to account for HWST implemented for only boiler B3LW. Due to this change, natural gas savings decreased, as shown in the table below.

Boiler	Claimed Savings (therms)	Verified Savings (therms)
B1LE	469	0
B1LW	804	1,105
B2LE	804	00
B2LW	804	00
B3LW	469	00
Total	3,350	1,105

EEM 1.4 Interlock Hot Water Pump Operation with Boiler

Scope: As per the post-installation report, this measure was implemented as an interlock between the boiler and the secondary hot water pump for Boiler B2LE, turning off the pump when the boiler is disabled.

As per the site inspection and EMS review, TRC confirmed that 5 HP (150 GPM) secondary hot water pump was interlocked with Boiler B2LE.

The EMS screen shot below shows secondary hot water (B2LE.HWP1) pump turned 'ON' only when the boiler is 'ON'. Otherwise it is 'OFF'.

```
C ********************* TURN ON HWP ***********************
IF("B2LE.BLR.SS" .EQ. ON) THEN ON("B2LE.HWP1.SS.V") ELSE OFF("B2LE.HWP1.SS.V")
C
```

EEM 2.2 Interlock Condenser Water Pump Operation with Chiller

Scope: As per the post install report, this measure implemented an interlock between the chillers and condenser water pumps for the B6 chiller plant.

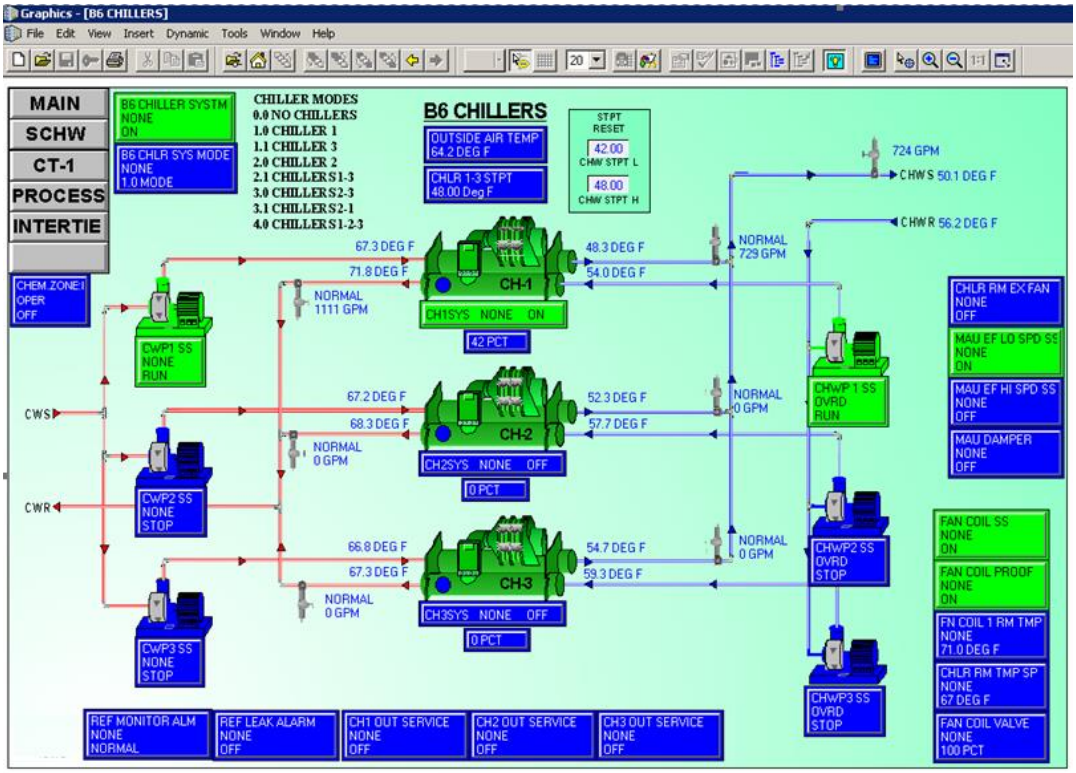
B6 chillers include three Trane Centravac chillers: Chiller 1 (485 ton), Chiller 2 (725 ton) and Chiller 3 (485 ton). The B6 chiller plant is configured as primary-secondary system. Each chiller has one primary chiller pump and one condenser water pump.

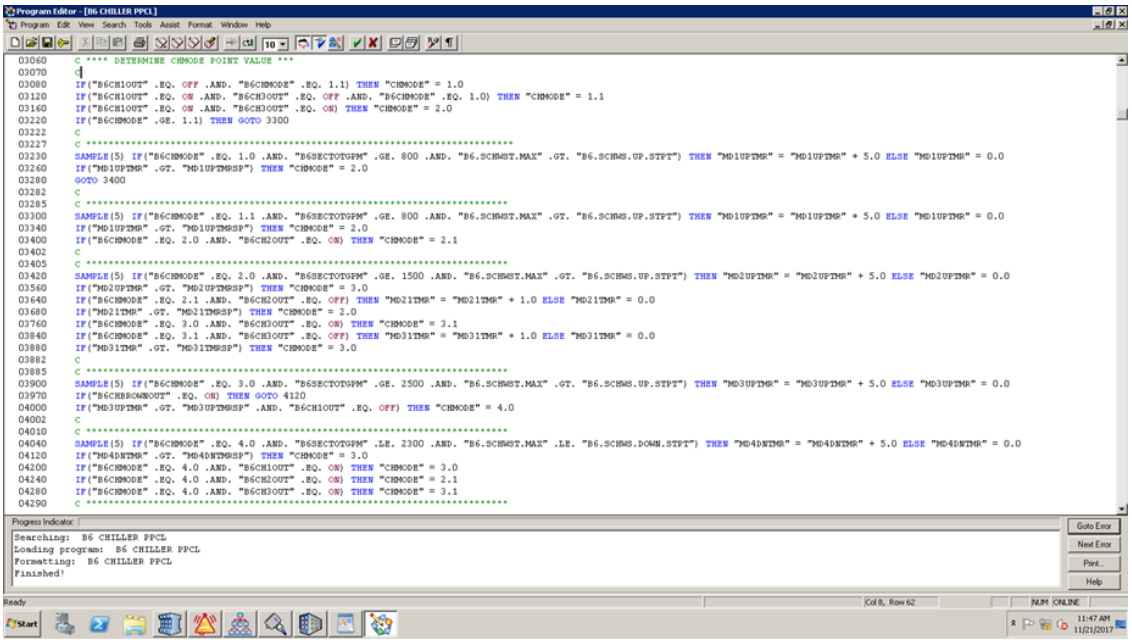
Submitted calculation: Three Condenser Water Pumps (CWP1 -20 HP, CWP2 - 40 HP and CWP3 -20 HP) without VFD.

Chiller and CW Pump Interlock Setting		
OSA	Load	Pump
Below 67.5 F	20% to 59%	1 Pump - 20 HP
Bet 70 F to 85 F	60% to 94%	1 Pump - 40 HP
Above 85 F	95% to 100%	2 Pumps - 20 HP and 40 HP

TRC Inspection Notes:

1. EMS screenshots below shows that condenser water pumps are interconnected with chiller sequencing.





At the time of inspection, OSA was low and only one 20 HP condenser pump was running. Based on the review of the sequence, TRC verified the measure savings claim and made no change to the energy savings calculation.

Additional Info:

TRC found Three Condenser Water Pumps (CWP1 -20 HP, CWP2 - 30 HP and CWP3 -20 HP) with VFD. Installation of lower capacity condenser water pump (30 HP instead on 40 HP) and installation of VFD's on all three CWP motors is part of Phase II and savings associated with this change in not considered as part of this project phase.

CWP -1 and 3 - (20 HP each with VFD)

CWP -2 (30 HP with VFD)

EEM 2.3 Implement Chilled Water Supply Temperature Reset

Scope - As per the post-installation report, the facility implemented chilled water supply temperature reset based on outside air temperature on B6 chiller plant.

B6 chillers includes (3) Trane Centravac chillers: (2) 485-ton and (1) 725-ton. The B6 chiller plant is configured as primary-secondary system. Each chiller has one primary chiller pump and one condenser water pump.

As per the submitted calculation:

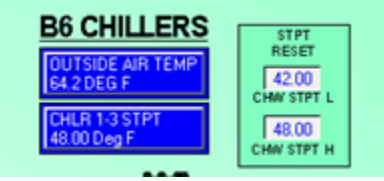
The post-installation calculation uses a constant chilled supply water temperature of 43° F for the baseline and 48°F for the proposed case. There is no reset based on OSA as per the screenshot of the savings calculation below.

Description of Input		Baseline	Proposed	Units
CHILLER SYSTEM INFORMATION				
Chilled Water Supply Temp at OSA =	80	43	48	°F
Chilled Water Supply Temp at OSA =	55	43	48	°F

TRC Review Notes:

As per EMS Screenshots:

1. Chilled Water Supply Temp (@ OSA 80 F): 42 F
2. Chilled Water Supply Temp (@ OSA 55 F): 48 F



TRC revised the energy savings calculations to reflect the observed lower limit set-point. Due to these changes, the required power draw increased relative to the base case, and energy savings decreased.

TRC found the following additional changes:

1. The facility has installed VFDs on all three primary chilled water pumps.
2. One of the 40 HP condenser water pump motor was replaced by a 30 HP pump motor.
3. The facility has also installed VFDs on all three condenser water pumps.

As per discussion with the facility engineer, all of these additional changes are associated with Phase II work (not conducted within FY2017), so savings associated with these changes are not considered here.

EEM 3.1 Optimize AHU Operation Phase I

Building 1 through 6 are served by multiple (32) air handling units. Most of the AHUs serve the offices, conference rooms, common areas, and cafeteria. Some AHUs serve the laboratory spaces. As per the facility engineer some of the AHUs operate 24/7 regardless of the actual occupancy.

Scope: This measure consisted of several optimization approaches as follows:

- Implemented time of day scheduling of AHU operation based on actual occupancy schedules,
- Re-commissioned the AHU economizer operation to utilize the full potential of free cooling,
- Implemented duct static pressure reset based on actual demand at the terminal units, and
- Implemented supply air temperature reset based on the zone demand.

As per the submitted energy savings calculation, of the total 32 AHUs, only 19 were considered for the AHU optimization project.

Based on a review of submitted trend data, EMS screen shots, and equipment nameplate information, TRC made the following changes in the submitted bin calculations. EA provide additional information where needed for the updated calculation.

AHU B3LW

Based on submitted calculation:

- Min. OSA: 10%
- AHU Operating hrs: 7:00 AM to 7:00 PM (Monday to Friday).

Based on submitted trend data review:

- Min. OSA: 5%
- AHU Operating hrs: 6:00 AM to 6:00 PM (Monday to Friday).

AHU B3UE

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 1:00 AM (7 days a week)

Based on submitted trend data review:

- AHU Operating hrs: 8,760

AHU B4A AHU4

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 8:00 PM (Monday to Friday)

Based on submitted trend data review:

- AHU Operating hrs: 8,760

AHU B4LE

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 7:00 PM (Monday to Friday)

Based on submitted trend data review:

- AHU Operating hrs: 4:00 AM to 6:00 PM (Monday to Friday).

AHU B4UE

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 7:00 PM (Monday to Friday)

Based on submitted trend data review:

- AHU Operating hrs: 4:00 AM to 6:00 PM (Monday to Friday).

AHU B4UW

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 7:00 PM (Monday to Friday)

Based on submitted trend data review:

- AHU Operating hrs: 4:00 AM to 6:00 PM (Monday to Friday).

AHU B5LW

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 9:00 PM (Monday to Saturday)

Based on submitted trend data review:

- AHU Operating hrs: 5:00 AM to 8:00 PM (Monday to Saturday)

AHU B5UE

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 7:00 PM (Seven days a week)

Based on submitted trend data review:

- AHU Operating hrs: 4:00 AM to 6:00 PM (Seven days a week).

AHU B6UE

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 7:00 PM (Seven days a week)
- SAT Reset:

OSA (F)	SAT (F)
75	58
56	68

Based on submitted trend data review:

- AHU Operating hrs: 8,760
- SAT Reset:

OSA (F)	SAT (F)
75	62
56	75

AHU B6UW

Based on submitted calculation:

- AHU Operating hrs: 5:00 AM to 7:00 PM (Seven days a week)
- SAT Reset:

OSA (F)	SAT (F)
75	58
56	68

Based on submitted trend data review:

- AHU Operating hrs: 5:00 AM to 8:00 PM (Seven days a week).
- SAT Reset:

OSA (F)	SAT (F)
75	62
56	75

The bin calculation modifications resulted in an overall decrease in both electricity and gas savings of approximately 10%.

9.2.1.3 Detailed Project Findings – Lighting Upgrade

Scope: As per the post-installation report, this measure upgraded the lighting system to LEDs. The existing lighting systems for the open office areas were a mix of recessed 2-lamp, 4ft, troffers and 2ft, 4ft, and 8ft pendant fixtures, mainly linear fluorescent T8 and T5. The entire lighting project includes linear LED upgrade and Enlighted lighting control system upgrade and is part of a complex, multi-phase implementation. However, the FY2017 claimed savings only covers the linear LED upgrade, since the controls were implemented (and savings were claimed) in FY2016.

The submitted calculation provides a line-by-line spreadsheet of building areas subject to lighting upgrades in Buildings 1, 2, 3, and 4. Scheduling documentation is provided based on screenshots of the EMS, and custom hours are used. The submitted calculation does not use TRM values for base case and proposed wattage, and interactive effects are not taken into account.

TRC conducted the site visit for the lighting upgrade at the same time as the optimization project. TRC held discussions with the implementer in preparation for the site visit. Based on these discussions, TRC determined that the actual implemented scope for 2017 included lighting upgrades in Buildings 4, 5, and 6, not the scope indicated in the Verification report. Please refer to "Lighting Phase Schedule" below, compiled from email correspondence provided by the installing contractor, Enlighted. The actual scope of work installed in program year FY2017 is referred to in the "Lighting Phase Schedule" as "Phase 2", whereas the scope of work provided in the Verification report appears to be for "Phase 3", which is pending implementation. TRC requested and received a copy of the line-by-line work scope for "Phase 2" prior to the site inspection, which included fixture types, quantities, and locations for the base case and the savings case.

TRC performed spot verification of fixtures types, quantities, and wattage based on the revised work scope. TRC noted minor discrepancies in the fixtures types between the listed work and what was observed in the field, primarily that the base case type "F10" fixtures actually contained two four foot lamps, rather than one four foot lamp. TRC reviewed the EMS lighting programs by control zone to ascertain the lighting system operating hours.

The provided scope did not include hours of operation or a savings calculation. TRC generated a calculation using TRM values for base and proposed lighting wattage, selecting operating hours based on the EMS screenshots in order to determine the savings for the implemented scope. TRC made adjustments to "F10" fixture discrepancy and transcribed the information into a savings calculation format based on the TRM 400 semi-custom lighting calculation tool. Finally, TRC made an adjustment to include interactive effects and TRM wattages.

Lighting Phase Schedule

Phase 0: Pilot (Prior to 2016)

- Bldg 2 small area over facilities GEN 1 sensors fluorescent dimming

Phase 1: Gen 1 Sensors and Fluorescent Dimming (Prior to 2016)

- Bldg 3 upper and lower GEN 1 sensors fluorescent dimming
- Bldg 4 upper GEN 1 sensors fluorescent dimming
- Bldg 5 upper GEN 1 sensors fluorescent dimming
- Bldg 6 upper GEN 1 sensors fluorescent dimming

Phase 1A: GEN2 Sensors and Fluorescent Dimming (Prior to 2016)

- Bldg 20D GEN2 sensors fluorescent dimming
- Bldg 4 lower GEN2 sensors fluorescent dimming
- Bldg 5 GEN2 sensors fluorescent dimming
- Bldg 6A (Data Center) GEN2 sensors fluorescent dimming (client subsequently converted to LED using NEXT LED drivers and LED tubes).

Phase 2: GEN 2 Sensors and LED Retrofit (Completed March 2017)

- Bldg 4 (A, Lower, Upper) Gen 2 sensors and LED retrofit
- Bldg 5 (Lower, Middle, Upper) Gen 2 sensors and LED retrofit
- Bldg 6 (Lower, Upper) Gen 2 Sensors and LED Retrofit

Phase 3 (Proposed): Gen 2 (or higher) Sensors and LED Retrofit of remaining Space and Removal of Legacy Controls (Target Install 2018)

- Bldg 1 (New Installation)
- Bldg 2 (New Installation)
- Bldg 3 - 6 (Remaining Accessible Space) Gen >2 Sensors and LED Retrofit
    - Bldg 3 (Lower) is excluded from Phase 3 because we did not have access to the area. It appears that a prior renovation resulted in the removal and disposal of the energy manager and sensors.
    - Bldg 5 (Lower) all prior Gen 2 sensors were removed and disposed of as a result of a subsequent remodel of the area.
- Space & Aire Application Quote, BMS Integration, and SAAS Agreement

9.2.2 EA Project PA-004-16

The building is a parking structure with two levels. The bottom level is covered and the top level is open. The parking area totals roughly 77,000 ft^2. The facility does not have mechanical heating or cooling.

The installed measure is an interior parking garage lighting upgrade. The project replaced the existing high pressure sodium (HPS) fixtures with LED Canopy light fixtures (66W CREE IG 4000K dimmable parking garage luminaires). Savings were realized from the new LED fixtures and from the multi-level dimming feature that use an occupancy sensor.

The submitted calculation was a spreadsheet. The baseline (pre-project) wattage assumes continuous operation. The proposed case (post-project) divides operation into Low Mode (42.9W) and High Mode (66W) operation. The calculation assigns each mode an average hours of operation based on a schedule: 43% operation in High Mode (during the day), and 57% operation in Low Mode (generally nights and on Sunday). The schedule assumes peak period always occurs during High Mode, and calculates demand reduction accordingly.

TRC confirmed the type and quantity of replacement fixtures during the site inspection. TRC observed occupancy sensors in the garage to control operation of the fixtures, which operate in High Mode when persons or moving vehicles were present, and in Low mode otherwise. TRC confirmed the continuous operational schedule based on discussions with the garage operator, who also stated that garage occupancy is low at night and on weekends. TRC noted that actual control is by sensor and not by schedule.

TRC transcribed the operating information into a savings calculation format based on the TRM 400 semi-custom lighting calculation tool. TRC assumed a weighted average post-case load of 52.8%, which is reasonable based on the proposed operating schedule and observed conditions. TRC's calculation thus provides the same kWh savings as claimed by the implementer (100% kWh realization rate). The space type of "unconditioned storage" provides a CDF of 0.7 in the TRM. TRC applied the CDF which reduced the demand savings (70% kW realization rate). TRC did not apply interactive effects, as this is an unconditioned space.

9.2.3 EA Project PA-005-15

This site is a four story 190,000 ft^2 office building. The building is conditioned by two central air handling units; cooling coils are located in the units, and reheat coils are located at the zone level.

The measure consisted of replacing the existing constant speed fluid cooler with variable speed unit, allowing the unit to modulate the fan speed based on demand. The project realizes energy savings during part load conditions.

TRC conducted a site visit and confirmed the existence of a new fluid cooler equipped with variable speed control. TRC revised the savings estimates based on motor horsepower and part load power calculation corrections, which increased saving.

The building has two separate refrigerant loops. The main loop, which meets the cooling load of the office spaces and conference rooms, rejects heat via a forced draft, constant speed fluid cooler. The project replaced the existing fluid cooler with a variable speed unit, and the new unit has a variable frequency drive (VFD) controlling the fan motor. This arrangement will allow the unit to modulate the fan speed based on demand. Energy savings are realized during part load conditions.

The submitted calculation was a spreadsheet. The program calculated pre- and post-project savings from a proration of design heat rejection requirements using a temperature-based bin calculation. The project did not claim demand (kW) savings, which TRC confirmed. The calculation included a set of trend data which indicates motor run time as 5 AM to 6 PM on weekdays. The project documentation did not provide power measurements.

Figure 18. Motor Nameplate for Fluid Cooler at CIEEP Project PA-005-015

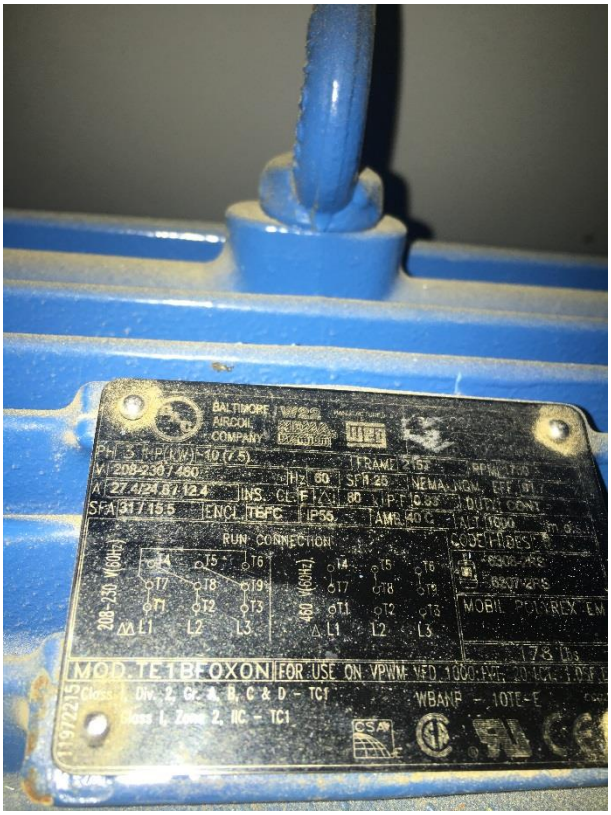
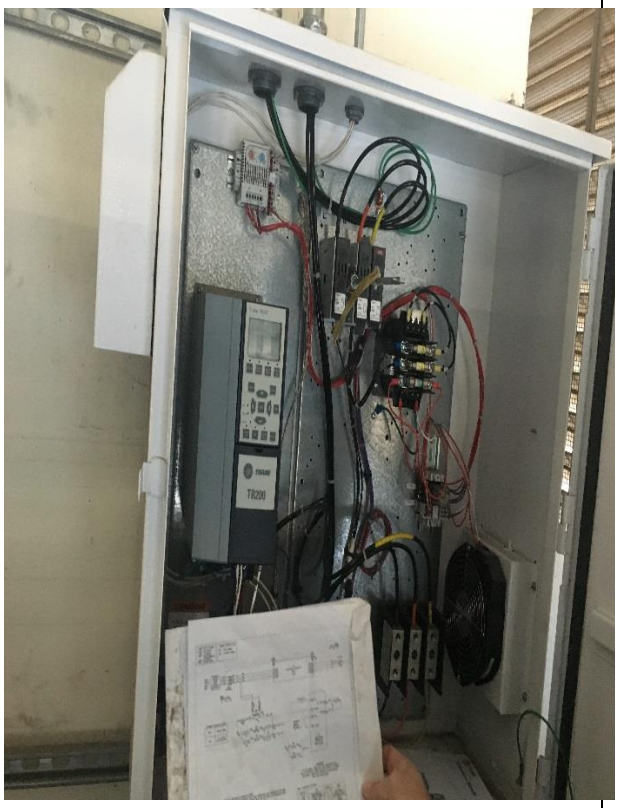


Figure 19. Fluid Cooler Control Enclosure with VFD at CIEEP Project PA-005-015



TRC noted that the calculation sets the minimal power based on percent of peak kW, and requested clarification from the implementer. EA acknowledged an error in the calculation sheet in that the minimum percentage should not be based on power, but on fan speed, to ensure the motor has minimum speed provide air movement and cooling. EA also indicated an additional error, that the base fan motor should be characterized as single speed, not two speed, which TRC independently verified: During project file review, TRC determined that the Baltimore Air Coil VC1-90 unit was the existing condition (baseline). Based on the specifications for this product, TRC found it comes with a single speed motor as "standard" (confirming the implementer's claim), and revised the baseline to a single speed. TRC also noted that the VC1-90 comes with a 7.5 hp motor, not 10 hp as was observed by EA. TRC adjusted the brake horsepower to proportionally decrease the assumed motor load from 80% to 60%, to take into account that the baseline motor was oversized as compared to design conditions.

Based on these various adjustments, TRC's electricity savings are larger than the initial savings claim (173% kWh realization rate).

9.2.4 EA Project PA-005-16

The project consisted of interior lighting retrofits in two buildings.

Building 1A is approximately 90,000 ft^2 on a single story and is a majority of office space; Building 2A is approximately 204,000 ft^2 and has two levels. The building is primarily used for product testing.

As per the post-installation report, this measure upgraded the lighting system to LED, with 26 replacements of 1000W metal halide fixtures with an equivalent number of 185W LED high bay fixtures

in Building 2. Additionally, 896 T8 fluorescent lamps in one, two, three, and four-lamp fixtures were converted to LED lamps in Buildings 1A and 2A. No operational changes were made.

The submitted calculation was a spreadsheet. The base case input wattage for the metal halide lamps was 1080W, and the fluorescent lamps were calculated at 31W each. Electrical energy interactive effects were calculated using a factor of 1.119, however, neither demand interactive effects nor CDFs were applied.

TRC confirmed the type and quantity of replacement fixtures during the site inspection. TRC verified the schedule with on-site personnel.

TRC transcribed the fixture information into a savings calculation format based on the TRM 400 semi-custom lighting calculation tool. The implementer's baseline wattage estimates were in accordance with the TRM, for the metal halide fixtures. TRC deemed the implementer's estimate of 31W per four-foot 1st generation T8 lamp to be reasonable based on the variance in lamp-ballast configurations and the lack of data about how the fixture ballasts are wired.

TRC applied a CDF of 0.92 for Building 2 (light industrial manufacturing) and a CDF of 0.71 for Building 1 (office). TRC added the TRM demand interactive effects of 1.15 for Building 2 and 1.28 for Building 1, which increased demand reduction overall. TRC also replaced the implementer's energy interactive effects value for cooling (1.119) with the TRM Climate Zone 4 energy interactive effects (1.05 for Building 2 and 1.12 for Building 1), which decreased the electrical energy savings. TRC added the interactive effects for natural gas (-0.0047 therms/kWh for Building 2 and -0.0056 for Building 1), which resulted in a gas heating penalty.

Overall, ex post savings were similar to claimed: 95% kWh and 104% kW realization rates.

9.2.5 EA Project PA-007-15

The project was an exterior lighting upgrade for a parking lot and a parking garage. The project replaced exterior parking lot and parking structure light fixtures (ranging from 250W through 1000W) with LED fixtures (varying from 72W to 275W). The parking lot fixtures operate at night only (both pre- and post-project). The baseline (pre-project) lighting in the parking structure consisted of linear fluorescent T8 fixtures. Fixtures are controlled by photocell or timer, with some fixtures operating continuously and others operating during nighttime hours only.

The submitted calculation was a spreadsheet which provides a line by line accounting of baseline and proposed wattage. Each fixture is associated with one of two schedules, either near continuous runtime (8,736 hours/year) or subject to photocell control (4,368 hours/year). Demand savings is calculated based on the entire load reduction.

TRC confirmed that the type and quantity of replacement fixtures matched the program's claim. TRC observed photocells to be controlling some of the lights in the parking structure, as claimed in the project documentation (verification report).

Figure 20. Photos of Lighting Measures in EA Project PA-005-016

TRC transcribed the operating information into a savings calculation format based on the TRM 400 semi-custom lighting calculation tool. TRC's calculation provides approximately the same kWh savings as claimed by the implementer (100% kWh realization rate, when rounded to the nearest whole number). The minor difference in ex post (390,184) and ex ante kWh savings (390,783) is because of slight differences between the claimed wattages and TRM assumptions. TRC eliminated the demand savings for fixtures subject to photocell control by setting the CDF for those fixtures to zero, which led to a major reduction in demand savings (19% kW realization rate). TRC did not apply interactive effects, because the interior space is unconditioned.

9.2.6 BASE 422-15-02

9.2.6.1 Summary of Project Findings

The facility is a two-story, 30,000 ft^2 office building. The implemented energy savings measures included:

- EEM-1: Install Energy Management System to Control the Operation of the HVAC System
- EEM-2: Retrofit Parking Lot Lighting with LED Lighting
- EEM-3: Install Variable Frequency Drives on Supply Fans

EEM-1 includes:

- Optimal start-stop
- Supply air reset
- Boiler lockout

The complete site inspection and verification report are provided in the Appendix, in Section 9.2.6.

The implementer performed savings calculations for the HVAC measures (EEM-1, EEM-3) in eQUEST. TRC visited the site to verify measure installation and collect EMS trend data. TRC used EMS spot and trend data to confirm the measure implementation and calculation inputs. The analyzed data included EMS screenshots, fan speed, supply, and outside air temperatures. EEM-1, TRC found slight discrepancies in optimal start schedules, supply air reset temperature set points, and boiler lockout

temperature. The overall impact of TRC's revision to the three separate optimization measures was an approximately 14% increase in kWh savings and 3% increase in therm savings. For EEM-3, TRC confirmed that the operation and schedules for the EEMs matched the values claimed at verification, and made no adjustments.

TRC verified parking lamp quantities and astronomical timeclock for EEM-2. TRC made no change to the energy savings calculation or savings associated with this measure.

Overall, TRC's calculated savings for the project were very similar to claimed (104% kWh realization rate).

9.2.6.2 Detailed Project Findings

As per Verification report submitted by BASE Energy

- Electricity Savings: 76,680 kWh
- Natural Gas Savings: 9,425 therms

The following table summarizes the measures from the implementer's submitted (i.e., the ex ante) energy savings calculations:

Figure 21. Claimed (Ex Ante) Savings for CIEEP (ICE) BASE Project 422-15-02

	Electricity			Natural Gas		
	Baseline	Proposed	Savings	Baseline	Proposed	Savings
EEM	kWh/yr	kWh/yr	kWh/yr	therms/yr	therms/yr	therms/yr
New EMS	257,182	223,140	34,043	14,500	5,075	9,425
LED Parking Lot	22,919	5,330	17,589	N/A	N/A	N/A
VFD on Supply Fans	108,905	83,857	25,048	N/A	N/A	N/A
Total	**389,006**	**312,327**	**76,680**	**14,500**	**5,075**	**9,425**

Note: TRC found that the total proposed energy consumption is mentioned incorrectly in the submitted verification report energy savings summary table (Table 2.2 in the verification report). It should be 312,327 kWh/yr instead of 302,487 kWh/yr.

As per TRC review, verified (ex post) savings are:

- Electricity Savings: 79,853 kWh
- Natural Gas Savings: 9,715 therms

The following table summarizes TRC's revised (ex post) energy savings estimate:

Figure 22. Verified (Ex Post) Savings for CIEEP (ICE) BASE Project 422-15-02

	Electricity			Natural Gas		
	Baseline	Proposed	Savings	Baseline	Proposed	Savings
EEM	kWh/yr	kWh/yr	kWh/yr	therms/yr	therms/yr	therms/yr
New EMS	257,182	218,345	38,838	14,500	4,785	9,715
LED Parking Lot	22,386	5,330	17,056	N/A	N/A	N/A
VFD on Supply Fans	108,905	84,946	23,959	N/A	N/A	N/A
Total	**388,473**	**308,621**	**79,853**	**14,500**	**4,785**	**9,715**

Facility Overview:

The facility is a two story 30,000 ft² office building located at 3330 Hillview Avenue., CA 94304. Typical operating hours are 10 hours per day (8 A.M. – 6 P.M.), 5 days per week, 52 weeks per year. Facility is served by two AC units. AC1 serving floor 2 and AC2 is serving floor 1.

Energy Efficiency Measures:

EEM 1: Install Energy Management System to Control the Operation of the HVAC System

TRC confirmed that the facility has Computrols/Compact Building Automation System and utilizes it to achieve energy savings by optimizing HVAC equipment operation.

As per the post installation report and submitted post installation eQUEST model, the following energy optimization measures were implemented by the facility to achieve energy savings:

1. **Optimal start-stop:** BASE energy engineer updated eQUEST model based on the actual observed operational hours at the time of post installation inspection.

   HVAC operating hours:

- Optimal start – 5:00 AM – 7:00 AM, Tuesday to Friday
- Normal operation – 7:00 AM – 8:00 PM, Tuesday to Friday
- Optimal start – 4:00 AM – 7:00 AM, Mondays
- Normal operation – 9:00 AM – 6:00 PM, Mondays

2. **Supply air reset:** Post verification report submitted by BASE Energy does not provide a detailed explanation about how the supply air reset measure was implemented on site. However, the submitted post installation eQUEST model has calculated energy savings based on following outside air temperature reset set points:

SAT RESET set points

OSA	SAT
75	55
40	65

3. **Boiler lockout:** BASE energy engineer observed boiler lockout temperature of 95°F and updated eQUEST model to calculate savings.

As per the TRC inspection findings and analysis:

1. **Optimal start-stop:** TRC observed the following HVAC operation schedule on the EMS.

- Optimal start – 5:00 AM – 7:00 AM, Tuesday to Friday
- Normal operation – 7:00 AM – 8:00 PM, Tuesday to Friday
- Optimal start – 4:00 AM – 7:00 AM, Mondays
- Normal operation – 9:00 AM – 6:00 PM, Mondays

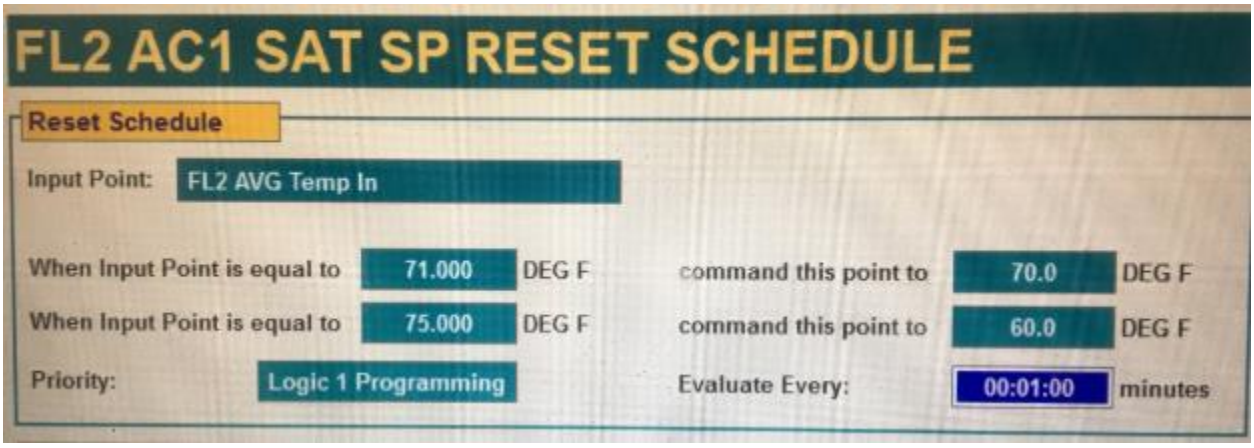
HVAC operating hours:

- Optimal start – 4:00 AM – 8:00 AM, Monday to Friday
- Normal operation – 8:00 AM – 6:00 PM, Monday to Friday

TRC revised the eQUEST model based on observed schedule. This change decreased energy savings by a small amount.

2. Supply air reset:

Based on the site inspection, EMS screenshots review and discussion with facility engineer, TRC confirmed that supply air reset measure is implemented based on average floor temperature instead of outside air temperature. The EMS screenshots below shows the Input Point as average floor temperature for both floors.



TRC analyzed the submitted trend data and found correlation between outside air temperature and supply air temperature. Please refer to the 'SAT Reset ECM - Trend Data Anlysis.xls' excel document provided in the appendix for more details.

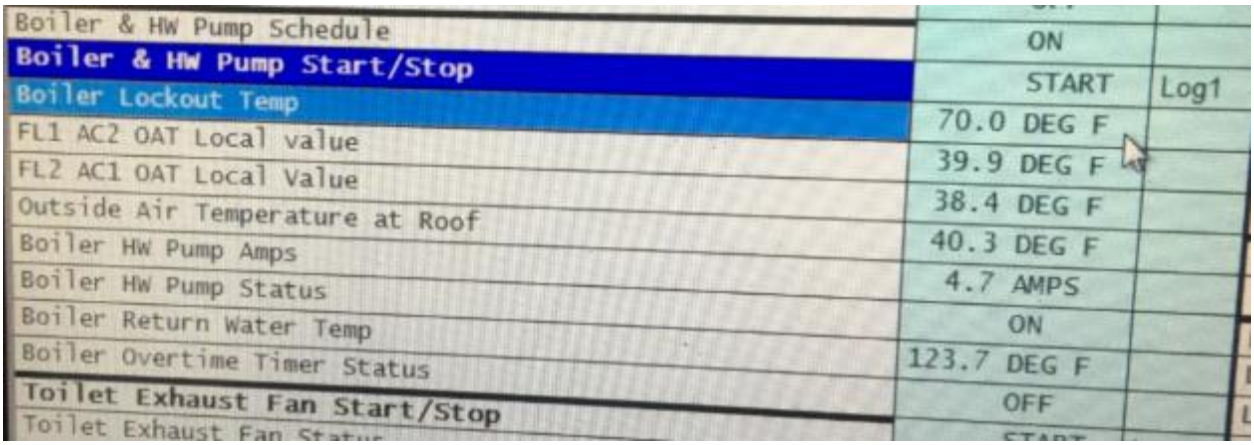
TRC revised the eQUEST model based on the following SAT reset set points, which varied from the proposed set points:

SAT RESET set points:

OSA	SAT
75	65
40	70

This change decreased energy savings by a small amount.

3. **Boiler Lockout:** TRC observed the boiler lockout temperature of 70°F based on the EMS review which is lower than the 95°F used by the implementer in the submitted calculation. Please see the EMS screenshot below. TRC revised the eQUEST model accordingly. This change increased energy savings.



The overall impact of TRC's revision to the three separate optimization measures was an approximately 14% increase in kWh savings and 3% increase in therm savings.

EEM 2: Retrofit Parking Lot Lighting with LED Lighting

During the site inspection, TRC verified that a total of twenty-six (26) 175W Metal Halide lamps used inside the pole lights of the parking lot were replaced with 50W LED replacement lamps.

TRC also confirmed that exterior pole lights were controlled by electronoic astronomical time clock. Lights turn ON at sunset and turn OFF at sunrise.

TRC made no change to the energy savings calculation or savings associated with this measure.

EEM 3: Install Variable Frequency Drives on Supply Fans

During the site inspection, TRC verified the installation of Variable Frequency Drive (VFD) on AC-1 and AC-2 supply fan.

AC-2 Supply Fan Motor

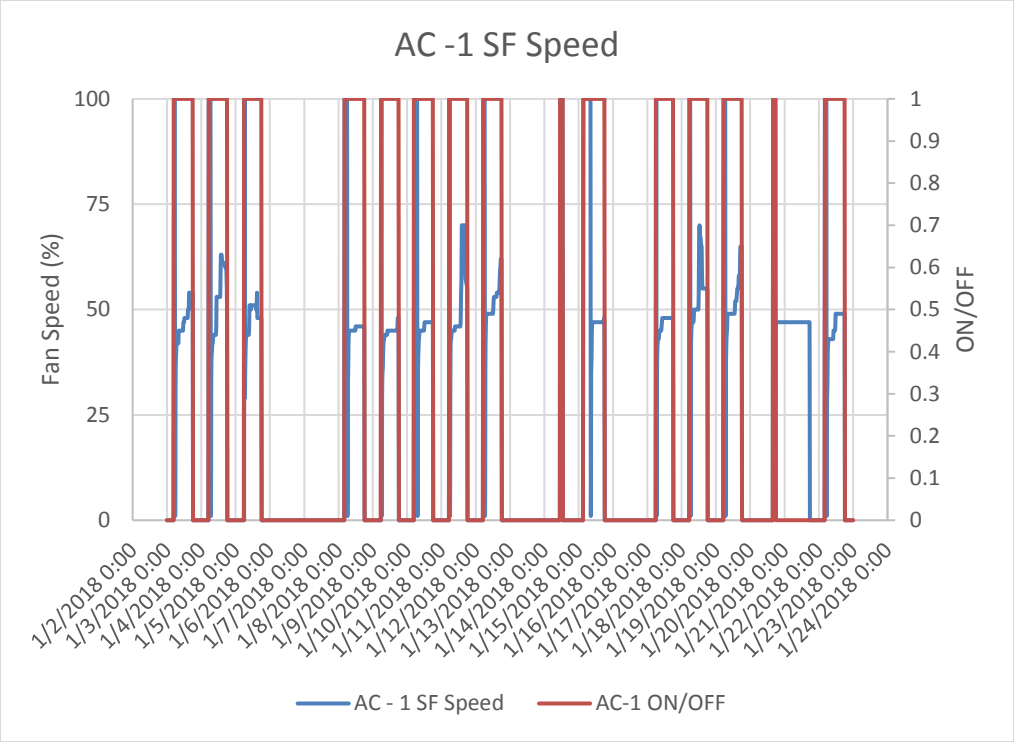
AC-2 Supply Fan Motor Nameplate

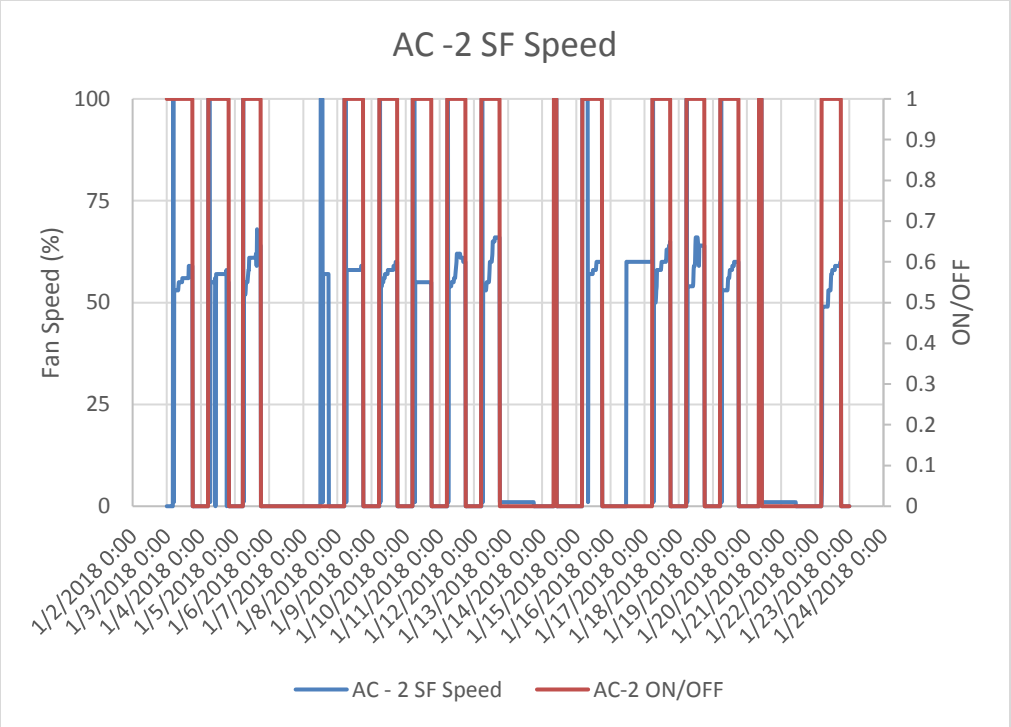
AC-1 VFD Frontend

Typical VFD control sytem inside AC unit

TRC verified the VFD installation based on analysis of submitted AC-1 and AC-2 supply fan speed trend data. The graphs below clearly show that supply fan (SF) speed varies when AC units are ON.

TRC made no change to the energy savings calculation or savings associated with this measure.


AC -1 SF Speed
Fan Speed (%)
ON/OFF
100
75
50
25
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/2/2018 0:00
1/3/2018 0:00
1/4/2018 0:00
1/5/2018 0:00
1/6/2018 0:00
1/7/2018 0:00
1/8/2018 0:00
1/9/2018 0:00
1/10/2018 0:00
1/11/2018 0:00
1/12/2018 0:00
1/13/2018 0:00
1/14/2018 0:00
1/15/2018 0:00
1/16/2018 0:00
1/17/2018 0:00
1/18/2018 0:00
1/19/2018 0:00
1/20/2018 0:00
1/21/2018 0:00
1/22/2018 0:00
1/23/2018 0:00
1/24/2018 0:00
AC - 1 SF Speed
AC-1 ON/OFF


AC -2 SF Speed
Fan Speed (%)
ON/OFF
100
75
50
25
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1/2/2018 0:00
1/3/2018 0:00
1/4/2018 0:00
1/5/2018 0:00
1/6/2018 0:00
1/7/2018 0:00
1/8/2018 0:00
1/9/2018 0:00
1/10/2018 0:00
1/11/2018 0:00
1/12/2018 0:00
1/13/2018 0:00
1/14/2018 0:00
1/15/2018 0:00
1/16/2018 0:00
1/17/2018 0:00
1/18/2018 0:00
1/19/2018 0:00
1/20/2018 0:00
1/21/2018 0:00
1/22/2018 0:00
1/23/2018 0:00
1/24/2018 0:00
AC - 2 SF Speed
AC-2 ON/OFF

9.3 CAP Project-Level EM&V Results

9.3.1 Project 1077

Project Description: Project 1077 is a central parking facility that includes interior and exterior parking areas. The interior areas are unconditioned. Lighting operates continuously within the structure and only at night in the outdoor areas. The project consisted of replacing 529 interior fluorescent fixtures and 113 exterior metal halide fixtures with new LED fixtures, throughout the facility. No operational changes were made.

Project Documentation: The project files included a savings calculation, which was derived from the TRM400 semi-custom lighting calculator. The submitted calculation included a significant error, because it did not include the energy use of the installed measure. The calculation error arose because of the following glitch in the calculator: The Proposed Fixture wattages used in the calculator are zero (unbeknownst to the user) if the "Proposed Fixture Lamp Type" is not selected (drop-down) as "User-defined", which was the case in this calculation. Additionally, the ex ante demand (kW) calculation included a claim for all the fixtures, including those subject to nighttime operation only (when demand savings should be zero).

EM&V Approach and Findings: TRC confirmed the type and quantity of replacement fixtures during the site inspection, and verified the schedule with on-site personnel. Figure 23 shows photos of the measure installations for this project, including the LED fixture replacements that replaced metal halides in the exterior lighting.

Figure 23. Lighting Measures for CAP Project 1077

TRC made the following adjustments:

- Adjusted the ex ante calculations in the TRM 400 calculator to include the energy use of the installed measure (by selecting "User-defined" in the "Proposed Fixture Lamp Type" field for all the fixtures).
- Increased operating hours for the exterior lights from 3,704 to 4,100 hours per year to reflect dusk-to-dawn operation using DEER defined hours
- For demand savings, removed the exterior lighting fixtures by setting the CDF to zero for that measure, and reducing the CDF for the interior garage from 0.92 for "other" to 0.70 for "outdoor lighting".

TRC did not include interactive effects for the project, because all measures are in unconditioned space (exterior or an unconditioned garage).

The figure below provides final results for CAP project 1077.

Figure 24. CAP Project 1077 Results

PROJECT	Ex-Ante			Ex-Post			
Project Name	**kWh Savings**	**kW reduced**	**Therm Savings**	**kWh Savings**	**kW reduced**	**Therm Savings**	**% kWh Realized**
CAP 1077: Ctrl Garage	399,434	54.1	0	237,958	21.9	0	60%

9.3.2 Project 1078

Project Description: Project 1078 is a central parking facility that includes interior and exterior parking areas. The interior areas are unconditioned. Lighting operates continuously within the structure and only at night in the outdoor areas. The same company operates the site at which projects 1077 and 1078 were implemented, but the sites are in different locations. Project 1078 consisted of replacing 336 interior fluorescent fixtures and 50 exterior metal halide fixtures with new LED fixtures, throughout the facility. No operational changes were made.

Project Documentation: The project files included a savings calculation, which was derived from the TRM400 semi-custom lighting calculator. As described for project 1077, the submitted calculation included a significant error, because it did not include the energy use of the installed measure, due to the TRM400 calculator glitch described in section 9.3.1. Additionally, the ex ante demand (kW) calculation included a claim for all the fixtures, including those subject to nighttime operation only (when demand savings should be zero).

EM&V Approach and Findings: TRC confirmed the type and quantity of replacement fixtures during the site inspection, and verified the schedule with on-site personnel. Figure 23 shows photos of the measure installations for this project. The fixture types installed were the same for projects 1077 and 1078.

Figure 25. Lighting Measures for CAP Project 1078

TRC made the following adjustments, which were the same adjustments as for Project 1077.

- Adjusted the ex ante calculations in the TRM 400 calculator to include the energy use of the installed measure.

- Increased operating hours for the exterior lights from 3,704 to 4,100 hours per year to reflect dusk to dawn operation using DEER defined hours
- For demand savings, removed the exterior lighting fixtures by setting the CDF to zero for that measure, and reducing the CDF for the interior garage from 0.92 for "other" to 0.70 for "outdoor lighting".

TRC did not include interactive effects for the project, because all measures are in unconditioned space (exterior or an unconditioned garage).

The figure below provides final results for CAP project 1078.

Figure 26. CAP Project 1078 Results

PROJECT	Ex-Ante			Ex-Post			
Project Name	**kWh Savings**	**kW reduced**	**Therm Savings**	**kWh Savings**	**kW reduced**	**Therm Savings**	**% kWh Realized**
CAP 1078: Crk Garage	250,483	32.8	0	142,842	12.8	0	57%

9.3.3 Project 1082

Project Description: Project 1082 is a retail department store. The facility is a conditioned space of approximately 222,000 square feet. The project consisted of replacing 2,194,896 T8 fluorescent lamps in two foot, three foot, and four foot lengths with LED lamps on the sales floor. No operational changes were made.

Project Documentation: The program documentation did not include a full savings calculation. However, it included a screenshot of portions of the CPAU Lighting Rebate Calculator for the project, which included measure descriptions operating hours, measure quantity, and the resulting kWh and kW savings. The ex ante (claimed) savings included cooling interactive effects (resulting in positive kWh savings) but not heating interactive effects (resulting in negative natural gas savings).

EM&V Approach and Findings: As described below, the one adjustment that TRC made to savings claims was to include heating interactive effects.

TRC confirmed the quantity of replacement fixtures during the site inspection, and verified the schedule with on-site personnel. For the measure type installed, TRC observed that some lamps were Sylvania LEDs, not the Philips LEDs incentivized by the program. The facility manager reported they were making the replacements because many of the Philips LED lamps installed through the program had already burned out. Because many lamps were in areas where TRC could not access the model number, TRC could not identify an exact fraction of lamps where the Philips lamps had been replaced with Sylvania lamps. However, based on conversations with the facilities manager, TRC estimated the fraction at one-fifth. TRC confirmed that all lamp replacements were LEDs from the light quality, from observing boxes of LED lamps in the storage room, and from conversations with the facilities manager.

TRC recreated the ex-ante calculations using the TRM 400 semi-custom lighting calculation tool, selected the proper settings for space type and climate zone, and calculated the same kWh and kW savings as the ex ante claims. In addition, TRC made no change to the measure wattage, because the Philips lamps (15W) were very similar to the Sylvania lamps (15.5W), and the calculator used TRM values of 18W per four-foot LED tube lamp. (The assumption of 18W is conservative but indicative of additional power

draw by the lighting fixture ballast.) TRC adjusted the calculator for the ex post savings by changing the age of the building to match the CAP application, but this did not change the savings amounts.

TRC used the appropriate interactive effects for the climate zone and the applicable CDF for the building type. Because the ex post kWh and kW savings match the ex ante value, the program appeared to have included the same cooling interactive effects and CDF. However, TRC included heating interactive effects (negative natural gas savings), which the program had not included.

The figure below provides savings results. As shown, TRC did not adjust kWh or kW savings. TRC's adjustment to therm savings reflected the inclusion of interactive effects.

Figure 27. CAP Project 1082

PROJECT	Ex-Ante			Ex-Post			
Project Name	**kWh Savings**	**kW reduced**	**Therm Savings**	**kWh Savings**	**kW reduced**	**Therm Savings**	**% kWh Realized**
CAP 1082: Retail Store	117,123	29.3	0	117,123	29.3	(537)	100%

9.4 MPP Project-Level EM&V Results

9.4.1 Project Y3OC

Project Y3OC consists of 79 lighting measures installed in several low-rise multifamily apartment buildings on one property. The program replaced the interior lamps (primarily incandescent bulbs – as shown in Figure 28), as well as CFL and fluorescent lamps, with the following types of LED lamps: 9W A-lamps, 11W A-lamps, and linear LEDs (replacing T8 lamps) in 1-lamp, 2-lamp, and 4-lamp fixtures. All FY2017 installations occurred in tenant units. (The program replaced common area lighting in FY2016.)

Figure 28. Incandescent Lamps Replaced at MPP Project Y3OC

TRC verified project savings through an on-site verification of the installed measures and a review of the claimed savings. Because of the size of the project (759 total residential units), and because the property manager requested that TRC limit our verifications to vacant units, TRC verified a sample of units as

follows: two studios, ten 1-Bedroom x 1 Bath, four 2-Bedroom x 1 Bath, and nine 2-Bedroom x 2 Bath, for a total of 24 total units.

TRC used the following key assumptions for calculating energy savings.

- Hours of operation (HOU): The adjustment that led to the greatest difference between ex ante and ex post savings was to operating hour assumptions. Based on the measure names, the implementer assumed hours of use based on the measure name (which ranged from 3.5 to 11.4 hours per day), regardless of where they were installed. However, because the implementer installed all measures in this project in tenant units, TRC followed TRM stipulations of 541 hours per year, or 1.5 hours per day. This adjustment reduced electricity savings by over 50% for each measure.
- For baseline assumptions:
  - For the largest savings measure – 10,474 occurrences of "LED A Type 10W replacing 60W Incandescent", TRC did not find any existing lamps on-site, because all lamps had been replaced. However, TRC was able to verify through photographs of removed lamps that the existing lamps were 60W incandescent lamps. Because 60W lamps do not meet current regulations (specifically, the Energy Independence and Security Act [EISA] of 2007), TRC adjusted the baseline lamp wattages using a dual baseline approach. This approach used the existing condition (60W lamp) for the first baseline, and the TRM assumption for a 60W-equivalent A-lamp – a 43W EISA-compliant halogen, as the second baseline. The estimated EUL for an incandescent lamp is 1000 hours. Per CPUC guidelines, TRC assumed the existing condition would remain for the first one-third of the measure's EUL, and the code compliant condition would apply for remaining time. Thus, TRC calculated the baseline as follows:

    (1000 hr / 3)/ (541 hrs / year) = 0.6 year for Baseline 1 (60W)

    0.4 year for Baseline 2 (43 W)

    Average for Year 1: 0.6 x 60W + 0.4 x 43 W = 53W

    Assumption for remaining measure life (Years 2-15): 43W

    TRC's dual baseline approach reduced kWh savings, compared with the implementer's claim of 60W incandescent for the entire baseline. However, this was a fairly small adjustment to the first year savings (reduction of 4% for the overall project). Because TRC assumed 43W for all years after Year 1, the adjustment to lifecycle savings was significant: a reduction of 27% for the project.
  - For the 11W LEDs, because these replaced R30 CFLs, TRC assumed 22W per lamp based on the TRM-204 baseline value for CFL R30s. Based on the measure description in the program database, "43 - 11W LED replacing 23W R30 CFL (11.4 hrs. per day) high usage", TRC believes the implementer used a baseline of 23W. The baseline adjustment from 23W to 22W slightly reduced savings.
  - For T8 baseline fixture wattage assumptions, TRC assumed 29W (1 lamp), 56W (2 lamp) and 112W (4 lamp) based on the TRM-400 baseline values for T8 fixtures.
- To verify the quantity of lamps installed, and to ensure that lamp installations claimed this year did not overlap with lamps claimed in FY2016, TRC estimated total lamps installed and compared to claimed lamps as follows: The property manager provided TRC with the number of units by type. Based on our observations of the sampled units, all of the 4' T8 lamps (kitchens) and A-type incandescent lamps in the tenant units were upgraded with LED replacement lamps, and the number of lamps installed for the same type of unit were similar (deviated by 1 to 2

lamps). Consequently, TRC used results of the sampled units to calculate lamp counts for the unverified units of the same type to estimate the total number of lamps installed in all units. Because TRC's calculation of total lamp installations (14,852 lamps) was slightly higher than the total number of in-unit lamps claimed (14,041 total: 697 in FY2016 and 13,344 in FY2017), TRC assumed that the number of lamps claimed by the program was correct.

- For type and wattage of measure, TRC adjusted the wattage for the A-lamp replacing the 60W incandescent from 10W (claimed) to 9W (based on our on-site observations). This slightly increased savings. For the other measures, TRC's on-site data collection matched the implementer's claim for lamp type and wattage.
- For demand (kW) savings, TRC assumed CDFs of 0.043, consistent with DEER2014 and TRM for tenant multi-family spaces.
- For interior lighting measures, TRC assumed DEER2014 interactive effect factors for multifamily buildings. However, TRC did not apply the therms interactive effects, because the property is all electric and does not use gas. The tenant units have either package terminal air conditioner (PTAC) units with electric resistance space heating, or electric resistance baseboard heating. Because DEER2014 does not provide interactive effects for electrically heated buildings, TRC assumed 0 for the heating interactive effect factor. However, TRC assumed the cooling interactive effect factor for multifamily units: 0.989 total kWh per kWh lighting savings[1].

Based on these assumptions, TRC calculated 287,043 annual kWh, 28.4 kW, and 0 therms for the Y3OC measures, which represent realization rates of 33% for kWh and 24% for kW. The low realization rate for kWh and kW was primarily for changes in HOU, followed by adjustments to the baseline. The lower realization rate for kW indicates that the implementer assumed a higher CDF.

9.4.2 Project Y3PAC

Project Y3PAC consists of eight lighting measures installed in two low-rise assisted living apartment buildings. Through the program, the implementer replaced the interior fluorescent lamps with linear LED lamps in common areas and the parking garage.

TRC verified project savings through an on-site verification of the installed measures and a review of the claimed savings. The number of measures claimed by the program matched TRC's on-site data collection.

TRC used the following key assumptions for calculating energy savings. Because this is an assisted living facility, TRC applied deemed savings assumptions for nursing homes for several parameters, as described below:

- The type and wattage of lamps claimed matched TRC's on-site data collection for all measures.
- For T8 baseline fixture wattage assumptions, TRC assumed 29 W (1 lamp), 56 W (2 lamp) and 112 W (4 lamp) based on the TRM-400 baseline values for T8 fixtures.
- TRC assumed DEER2014 HOU: for a Nursing Home 4,160 hours per year, for measures installed in the common areas and for the exterior parking garage: 8,760 hours per year (continuous

[1] Although cooling interactive effects typically increase electricity savings, the DEER2014 interactive effect value for multifamily units show a slight decrease in savings.

operation) per DEER. TRC also confirmed that the parking garage lights were on during our day-time site visit.

- For demand (kW) savings, TRC assumed a CDF of 0.676, consistent with DEER2014 for Nursing Homes.
- TRC applied DEER2014 interactive effects for nursing homes to the common area interior spaces, which had electric space cooling and natural gas space heating. For exterior lighting measures, TRC did not apply interactive effect factors as the spaces are not conditioned.

Based on these assumptions, TRC calculated 60,160 annual kWh, 10 kW, and -594 therms for the Y3PAC measures, which represent realization rates of 103% for kWh and 349% for kW. The high realization rate for kW indicates that the implementer assumed a lower CDF.

9.4.3 Project Y3SHDAN

Project Y3SHDAN consists of two lighting measures installed in a low-rise assisted living apartment building. Through the program, the implementer replaced the interior lamps – primarily linear fluorescent and some A-lamps, with LED lamps in the common areas.

TRC verified project savings through an on-site verification of the installed measures and a review of the claimed savings. The number of measures claimed by the program matched TRC's on-site data collection.

TRC used the following key assumptions for calculating energy savings. Because this is an assisted living facility, TRC applied deemed savings assumptions for nursing homes for several parameters, as described below.

- For baseline assumptions:
  - For the T8 lamp upgrades, TRC assumed 56 W (2 lamp fixture) for the baseline, based on the TRM-400 baseline values for T8 fixtures.
  - For the measure, "LED A Type 10W replacing 60W Incandescent", because this project did not have evidence (such as a photograph) supporting an existing condition of a 60W lamp, TRC adjusted the baseline to an EISA compliant wattage of 43W, following the TRM. Because the program installed only 15 of these measures, this reduced savings very slightly.
- For HOU, because all measures were installed in common areas (interior) of the facility, TRC used HOU for Nursing home: 4,160 hours per year.
- The measure type and wattage claimed by the implementer matched TRC's on-site data collection for the linear LED. However, for the LED A-lamp, TRC adjusted the installed wattage from 10W to 9W, which slightly increased electricity savings.
- For demand (kW) savings, TRC assumed a CDF of 0.676, consistent with DEER2014 for Nursing Home buildings.
- TRC assumed DEER2014 interactive effect factors for Nursing Home buildings. Because the common area hallways with lamp replacements are heated (using natural gas) but not cooled, TRC only applied the heating interactive effect factors.

Based on these assumptions, TRC calculated 16,365 annual kWh, 2.7 kW, and -223 therms for the Y3SHDAN measures, which represent realization rates of 97% for kWh and 296% for kW. The high realization rate for kW indicates that the implementer assumed a lower CDF.

9.4.4 Project Y3ASH

Project Y3ASH consists of three lighting measures installed in a low-rise multi-family apartment building. Through the program, the implementer replaced interior A-lamp and linear fluorescent lamps, with LED lamps, in the common areas and on the exterior facade (including signage).

TRC verified project savings through an on-site verification of the installed measures and a review of the claimed savings. The number of measures claimed by the program matched TRC's on-site data collection, and the type and wattage of measures claimed matched TRC's on-site data collection.

TRC used the following key assumptions for calculating energy savings.

- For baseline assumptions:
  - For the "LED A Type 10W replacing 60W Incandescent" lamp, TRC adjusted the baseline lamp wattages to an EISA-compliant wattage (43W) per the TRM, because the program did not provide evidence (such as a photograph) supporting 60W as the existing condition. This reduced kWh savings for the 12 instances of this measure.
  - For the T8 lamp upgrades, TRC assumed 56 W (2 lamp fixture) for the baseline, based on the TRM-400 baseline values for T8 fixtures.
  - For the measure, "15W LED fixture (replacing fixtures with 30W CFL circular lights)". TRC assumed 30W for the baseline fixture.
- For HOU, TRC assumed the following. The measure name did not include HOU, so TRC does not have an indication of the HOU assumed by the implementer for comparison.
  - Constant operation (8,760 hours per year), which aligns with Non-residential (Hotel) interior. This is because these lights are located in interior common areas with no daylighting. TRC observed these lights in operation during our site visit (conducted during the day), and confirmed with the facility manager that the lights are operated continuously without dimmers.
  - Exterior lighting hours (4,100 hours per year) from DEER2014 for the exterior fixtures.
- For demand (kW) savings, TRC assumed DEER2014 (Hotel) CDF of 1.00 for the interior fixtures that operate continuously. The exterior fixtures did not have the CDF applied (assumed zero), because the fixtures operate at night (during DEER non-peak hours).
- TRC did not apply interactive effect factors because the common areas are unconditioned.

Based on these assumptions, TRC calculated 7,184 annual kWh, 0.8 kW, and 0 therms for the Y3ASH measures, which represent realization rates of 225% for kWh and 336% for kW. The high realization rates indicate that the implementer likely assumed lower HOU than TRC.

9.5 MPP Participant Survey Questions and Detailed Results

9.5.1 Survey Methodology

To inform program improvement, and to better understand participants' motivations, TRC conducted a survey for MPP participants. TRC had developed and administered the survey for the FY2016 evaluation. For FY2017, TRC asked the same questions, and added two new questions (Q17 and Q18) on electric vehicle chargers, per the MPP program manager's request.

The program database contained 16 email addresses, with "N/A" listed for approximately 12 sites.[1] TRC emailed the 16 participants on February 7, 2018, requesting that they complete the 5-10 minute survey. Three emails bounced back, indicating that 13 participants received the request. Two participants completed the survey. TRC sent another invitation on February 21, 2018, but no more participants completed the survey.

9.5.2 MPP Participant Survey Guide

The following survey was administered in Survey Monkey in January – February 2017, and February 2018.

Introduction

The City of Palo Alto Utilities is seeking input from Multifamily Plus Program participants to improve this program. As a former program participant, we greatly appreciate your feedback! Please forward the survey link if someone else is better suited to respond to this survey.

This survey has 3 sections and asks questions regarding program benefits; satisfaction with the energy saving measures installed and purchasing decisions; and overall program satisfaction and recommendations. It takes approximately 10 minutes. All answers are anonymous. Thank you so much for your time.

This survey was developed by an independent consultant: TRC Energy Services. Please direct any questions or concerns regarding this survey to [TRC contact], or to the CPAU Multifamily Plus Program Manager: [CPAU contact - withheld in report for confidentiality]

Background and Program Benefits

Q1. How would you best describe your role for the building(s) that participated in the Multifamily Plus Program?

- Owner
- Facility manager
- Property or rental manager
- Other. Please specify

Q2. For the building(s) that participated, are the multifamily units mostly market rate, affordable housing, or a mix of both?

- Mostly market rate
- Mostly affordable housing
- Mixed – specify what percent of each

Q3. Approximately how large is the multifamily property(s) that participated? If the property has more than 1 building, total the number of units across all buildings.

- Small: <10 units per property

[1] Although the database lists 35 total sites, the same property manager manages more than one site in some cases – e.g., the addresses for 630, 634, 636, and 638 on the same street. TRC estimates 12 missing emails based on unique addresses that are not located close to each other.

- Medium: 10-50 units per property
- Large: >50 units per property

Q4. How did you first learn about the Multifamily Plus program?

- Personal visit from program representative
- Mail insert
- Phone call
- Email from program
- Referral (not from program representative)

Q5. In your opinion, what are the benefits of the Multifamily Plus program? Select all that apply.

- Lower energy bills
- Improved safety
- Improved light quality
- Increased comfort

Q6. Of those, which do you view as the ***most important*** program benefit?

- Lower energy bills
- Improved safety
- Improved light quality
- Increased comfort

Energy Efficiency Measures

Q7. What energy savings measures were installed at your multifamily building(s) through the program? Select all that apply.

- T8 linear fluorescent lighting
- LED lights
- Attic insulation

Q8. On a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied, how satisfied were you with the energy savings measures installed through the program?

- 1
- 2
- 3
- 4
- 5
- Don't know

Q9. Please provide any feedback (e.g. from you, the facility manager, or your tenants) regarding satisfaction (or dissatisfaction) with the measures installed. Be sure to note which energy efficiency measure (e.g. T8, LED, attic insulation) you are describing.

_____

Q10. Would you have installed these energy savings measures if the program required that you pay a portion of the cost for the equipment?

- Yes

- No
- Maybe
- Only for some measures (please specify which measures):

Q11. What portion would you be willing to pay?

- None (0%)
- About one-fourth (1/4)
- About half (1/2)
- About three-fourths (3/4)
- All (100%)

Q12. Based on your experience with the lighting installed through the program, will you continue to buy similar lighting products for this or other multifamily buildings you manage?

- Not Applicable: No lights installed
- Yes
- No

Overall Program Satisfaction and Closing

Q13. On a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied, please rate your overall satisfaction with the program.

- 1
- 2
- 3
- 4
- 5

Q14. On a scale of 1 to 5, with 1 being very unlikely and 5 being very likely, how likely would you be to participate in the program with another building?

- 1
- 2
- 3
- 4
- 5
- Not Applicable: I don't manage or own other multifamily buildings in Palo Alto.

Q15. On a scale of 1 to 5, with 1 being very unlikely and 5 being very likely, how likely would you be to recommend this program to other multifamily property owners or managers?

- 1
- 2
- 3
- 4
- 5

Q16. Please provide any comments or suggestions for improving the program:

The following two questions (Q17 and Q18) were added in the FY2017 survey.

Q17. We're almost finished . . . CPAU is interested in learning about their customers and electric vehicle chargers. Do you currently have any electric vehicle chargers installed at your multifamily property?

- No
- Yes. Enter number of EV chargers:

Q18. On a scale of 1 to 5, with 1 being very unlikely and 5 being very likely, how likely would you be to consider installing electric vehicle chargers with a City rebate of up to $18,000?

- 1
- 2
- 3
- 4
- 5

9.5.3 Survey Results

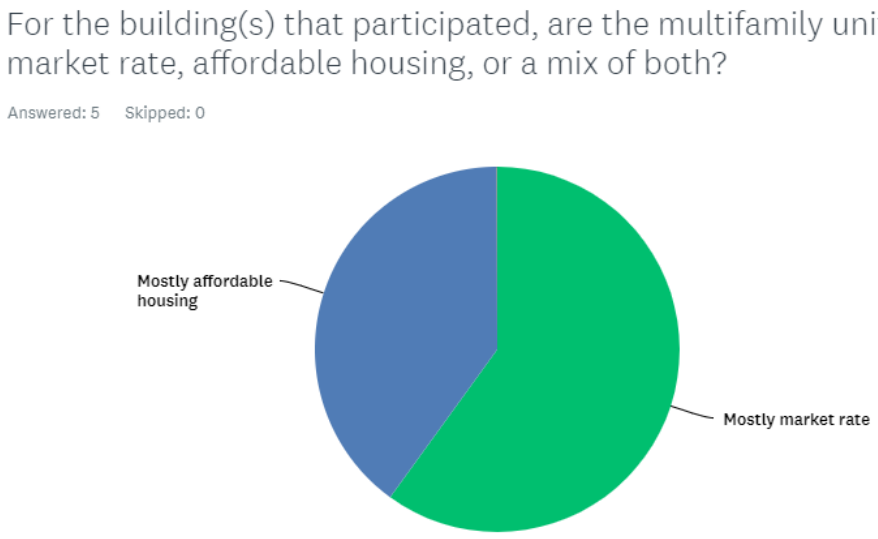
The following presents survey results. Because of the low response rate in FY2017, because program design and implementation have generally stayed the same from FY2016 to FY2017, the figures in section 9.3.3 present combined responses from the three FY2016 and two FY2017 respondents. TRC emphasizes these results are anecdotal, given the small number of responses. However, the results provide some indications of participant motivation and satisfaction. In addition, although the supporting description identifies the FY2017 responses, readers should not draw "trends" in responses between FY2016 and FY2017, since only a few participants completed each survey.

9.5.3.1 Respondent Role and Type of Multifamily Building Served

The following results show responses related to the role of the survey respondent and they types of multifamily buildings they serve.

All survey respondents were property managers, and they represented a mix of multifamily building size and type (market rate and affordable). Although the survey allowed respondents to check owners or facility managers, all five reported to be rental or property managers. (Responses are not graphed, since all responses are the same.)

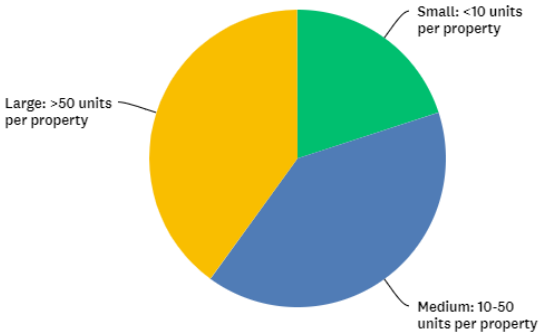
Of the FY2016 respondents, two served primarily market rate multifamily buildings, while the third served primarily affordable units. The FY2017 survey indicated one respondent served market rate units and the other affordable units.



The respondents represented a mix of multifamily building sizes. Of the FY2017 respondents, one oversees a medium site (10-15 units) and the other a large site (>50 units).

Approximately how large is the multifamily property(s) that participated? If the property has more than 1 building, total the number of units across all buildings.

Answered: 5 Skipped: 0



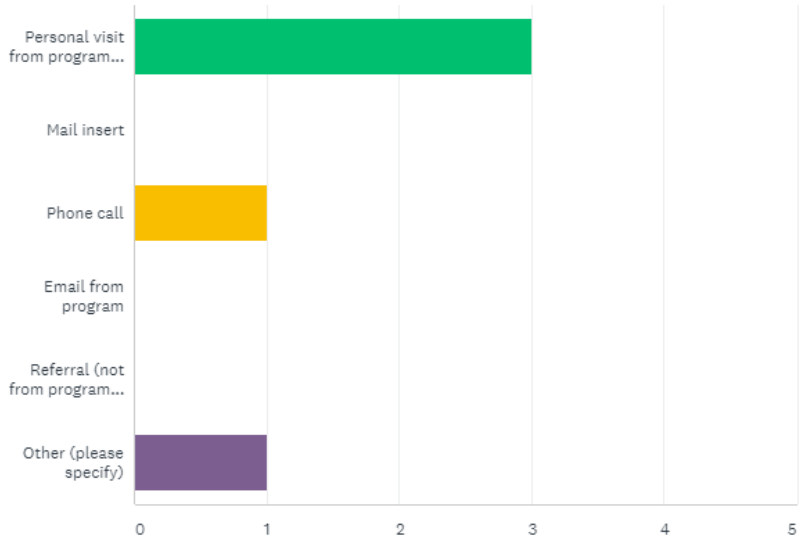
9.5.3.2 Respondents' Source of Program Awareness

The following result show responses to how respondents learned about the program.

These participants learned about MPP mostly from contacts from a program representative. In FY2016, two received a personal visit from a program representative, while the third received a phone call. In FY2017, one also learned from a personal visit, while the other found the program through online research.

How did you first learn about the Multifamily Plus program?

Answered: 5 Skipped: 0



9.5.3.3 Reported Program Benefits

The following results show responses to what respondents consider to be benefits of the MPP.

Lower energy bills and improved light quality were the motivations for participation. To help interpret the results of participant motivation responses, note that (as described when presenting results for a later question):

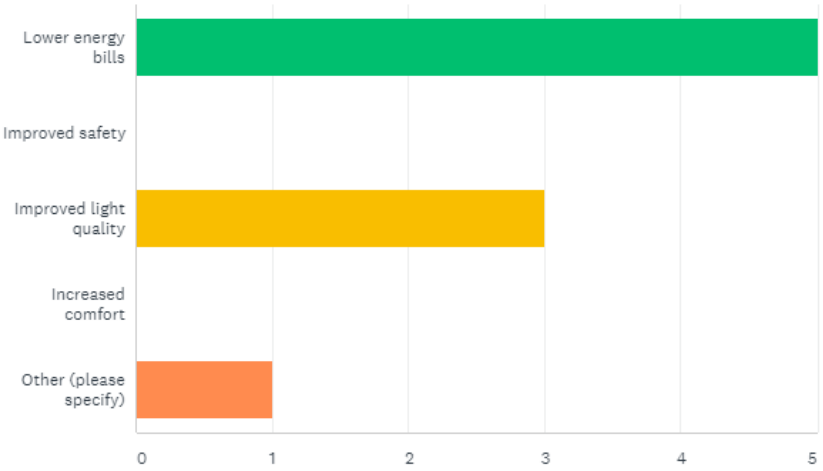
- In the FY2016 survey, two participants had received lighting measures and one received ceiling insulation.
- In the FY2017 survey, both participants had received lighting measures.

  Thus, across both years, three respondents had received lighting measures, and two had received attic insulation.

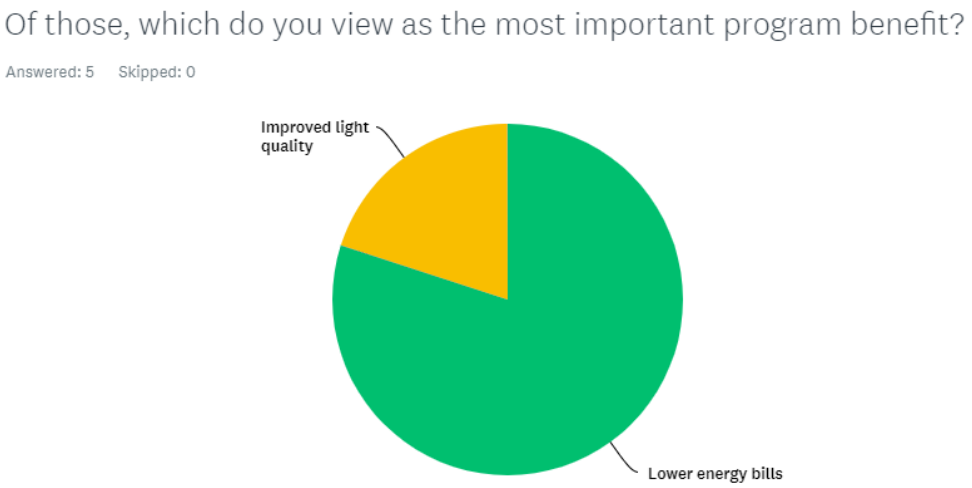
All five respondents reported identified lower energy bills as a motivation for participating. Also, all three respondents that had received lighting measures reported improved lighting quality as a motivation. No one selected improved safety, or increased comfort. One respondent selected "Other" as an additional motivation, but did not specify this motivation in the text box.

In your opinion, what are the benefits of the Multifamily Plus program? Select all that apply.

Answered: 5 Skipped: 0



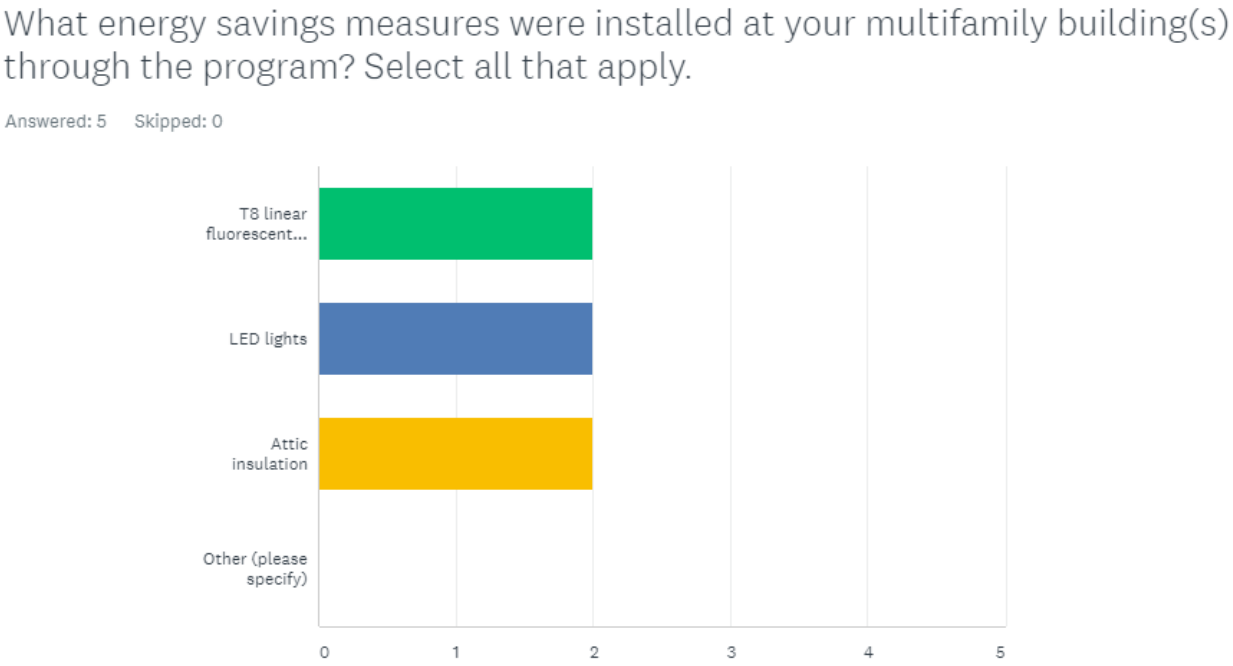
In terms of the *most important* program benefit, two of the respondents with lighting measures selected lower energy bills, while the third (a FY2017 respondent) selected improved light quality. The two FY2016 respondents with ceiling insulation selected lower energy bills. (This is consistent with their previous response, since they had only selected "lower energy bills" in the prior question that allowed them to select multiple benefits.)



9.5.3.4 Measures Installed and Satisfaction with Measures

The following results show responses to what measures the respondents received, and their satisfaction with these measures.

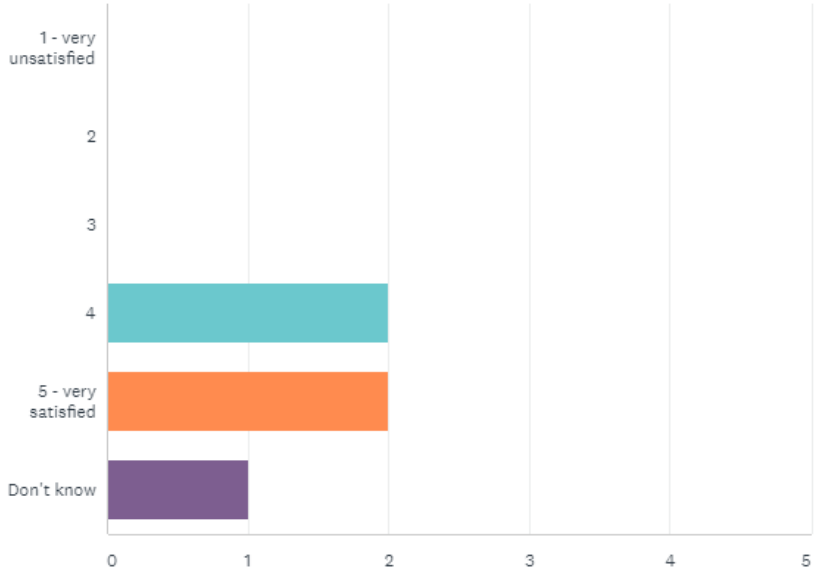
- Two FY2016 respondents reported receiving attic insulation.
- Three respondents reported receiving lighting measures:
  - One (for FY2016) reported receiving T8 linear fluorescent lighting
  - One (for FY2017) reported receiving LEDs
  - One (for FY2017) respondent reported receiving LEDs and T8 linear fluorescent lighting. However, the program database indicates that only LEDs (including linear LEDs to replace T8s) were installed in FY2017. Consequently, TRC believes that this respondent incorrectly identified linear LED tube lamps as T8s.



The following figure illustrates satisfaction with the measures installed. **The FY2017 respondents answered similarly to FY2016 participants that they were satisfied with the measures. One was very satisfied (5 of 5) and the other was satisfied (4 of 5).** The "don't know" response was a FY2016 respondent.

On a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied, how satisfied were you with the energy savings measures installed through the program?

Answered: 5 Skipped: 0



No respondents provided an answer to open-ended question 9, which requested feedback on the measures installed.

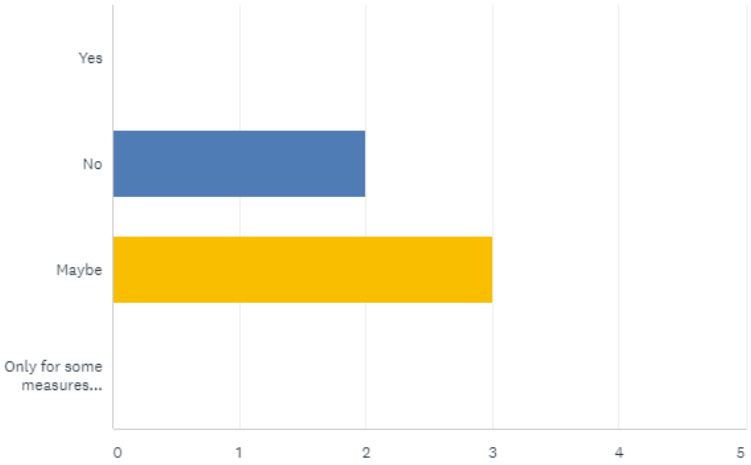
9.5.3.5 Willingness-to-Pay for Measures and Likelihood of Installing Similar Measures

The following results show responses to whether the respondents would be willing to pay for a portion of the program measures.

Ceiling insulation participants would not pay any cost of the measure, while lighting participants would pay ~1/4 of cost. The two respondents (from FY2016) that installed ceiling insulation were not willing to pay any incremental cost. All three respondents that received lighting measures (one in FY2016, and two in FY2017) reported they would "maybe" have installed the measures if the program had required they pay a portion of the cost, and all three reported they would pay approximately one-quarter of the cost. Note that no respondents reported "Yes" to the question that they would have installed the measures in the absence of the program.

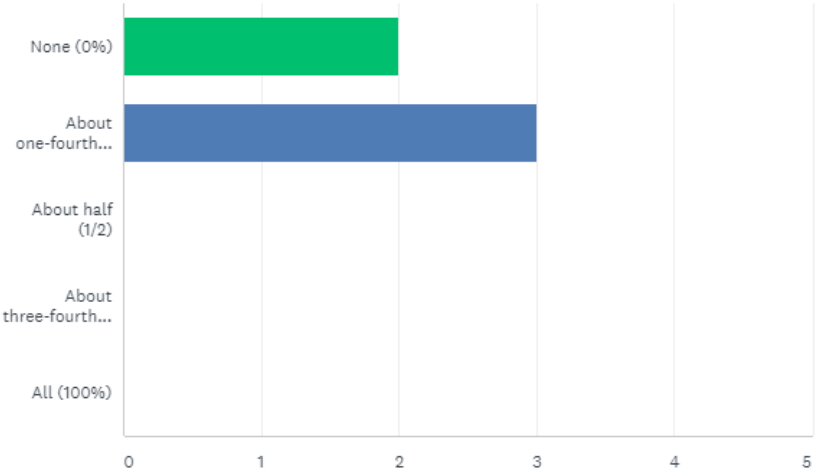
Would you have installed these energy savings measures if the program required that you pay a portion of the cost for the equipment?

Answered: 5 Skipped: 0



What portion would you be willing to pay?

Answered: 5 Skipped: 0

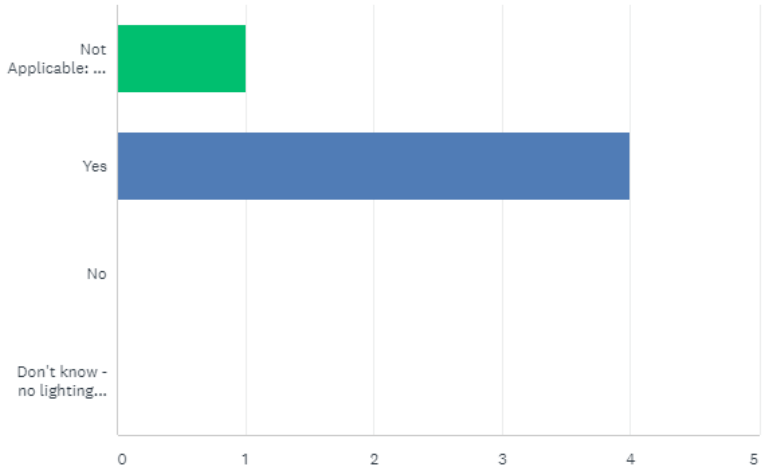


However, all three lighting participants, and one respondent that reported only receiving attic insulation, reported they would continue to buy similar lighting products at the participating site or other multifamily buildings. While this somewhat contradicts the results of the previous questions, possible explanations are:

- Respondents interpreted the question to mean that they would "buy" similar lighting products with financial assistance from CPAU (e.g., receive them through MPP), or
- Now that respondents have experienced the program-installed lighting measures, they are willing to pay in the future for similar measures.

Based on your experience with the lighting installed through the program, will you continue to buy similar lighting products for this or other multifamily buildings you manage?

Answered: 5 Skipped: 0



9.5.3.6 Program Satisfaction and Likelihood of Participating Again or Recommending It to Peer

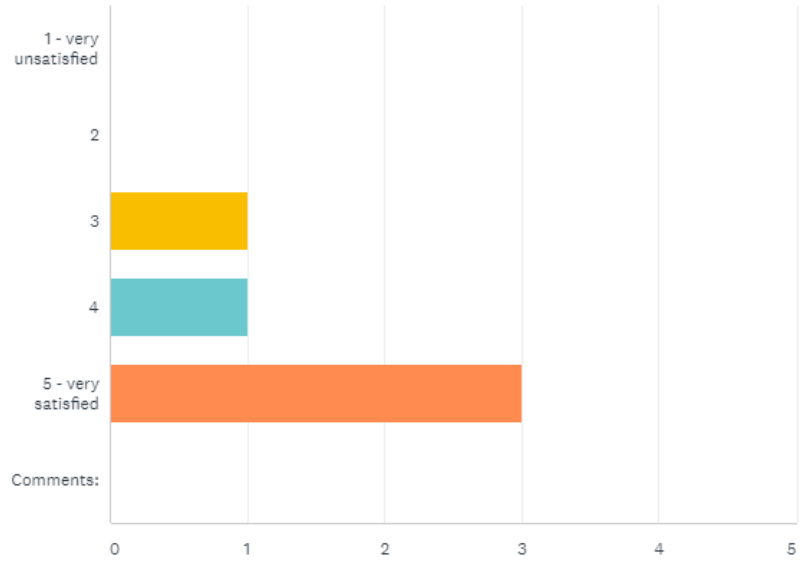
The following results show responses to the respondent's overall satisfaction with MPP, whether they would participate again, and whether they would recommend it to a peer.

Respondents generally reported high satisfaction with the measures and with the program, and would be willing to participate again or recommend it to a peer. The average satisfaction rating was 4.4 (on a 5-point scale). The one response for medium satisfaction (rank of 3) was from a FY2016 participant. Participants reported they would be likely to participate again (average rank of 4.5 on a 5-point scale) and they would recommend it to another property manager (average rank of 4.8 on a 5-point scale).

In terms of responses specific to FY2017: Both FY2017 participants were very satisfied with the program (rank of 5), and would be very likely to recommend it to another property manager (rank of 5). One FY2017 respondent reported a high likelihood of participating again (rank of 5), while the other chose "not applicable" because s/he does not manage another multifamily building in Palo Alto.

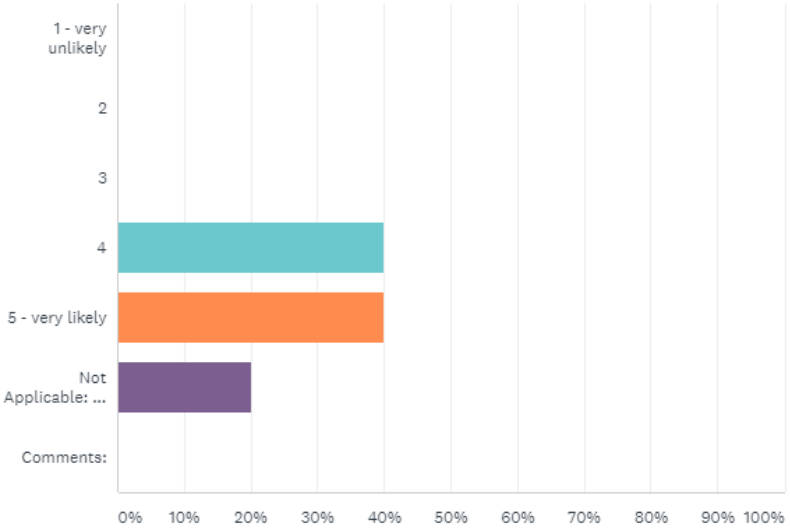
On a scale of 1 to 5, with 1 being very unsatisfied and 5 being very satisfied, please rate your overall satisfaction with the program.

Answered: 5 Skipped: 0



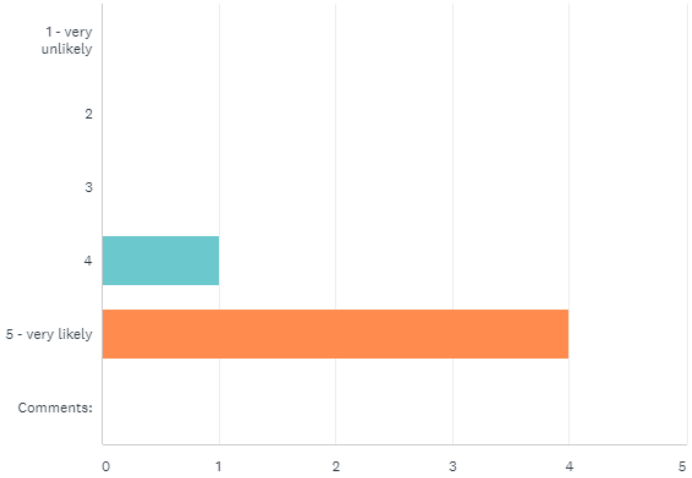
On a scale of 1 to 5, with 1 being very unlikely and 5 being very likely, how likely would you be to participate in the program with another building?

Answered: 5 Skipped: 0



On a scale of 1 to 5, with 1 being very unlikely and 5 being very likely, how likely would you be to recommend this program to other multifamily property owners or managers?

Answered: 5 Skipped: 0



One FY2017 participant provided feedback about the program in an open-ended question, and commented about the difficulties of scheduling the lighting replacements and lack of apparent electricity savings. However, the respondent was pleased with the work completed.

9.5.3.7 Interest in Electric Vehicle (EV) Chargers

For the FY2017 survey administered, TRC added two new questions (Q17 and Q18) regarding EV chargers. **Initial results suggest moderate interest in electric vehicle (EV) chargers.** Due to the small number of responses, TRC describes the results, rather than providing figures of the responses.

- One of the two respondents reported that they currently have one EV charger on site; the other reported no EV chargers.
- In response to the question of how likely they would be to consider installing chargers with a city rebate of up to $18,000, the respondent with the existing charger ranked his/her interest as medium (3 out of 5) while the other reported a fairly high interest (4 out of 5).

9.6 Simplified Lighting Calculator Error

This section describes the error in the Simplified Lighting Calculator that led to the lower realization rates for CAP projects 1077 and 1078.

The calculator that was provided for CAP projects 1077 and 1078 had upprotected workbooks (i.e., the user could change input values). The original version that is available on the CPAU website provides the Administrator with a password to unlock the workbook and the individual sheets (in the Program Administrator tab).

Program Administrator Page

1	**Spreadsheet passwords**				
	Sheet/tab password		tbd		
	Workbook password		tbd		

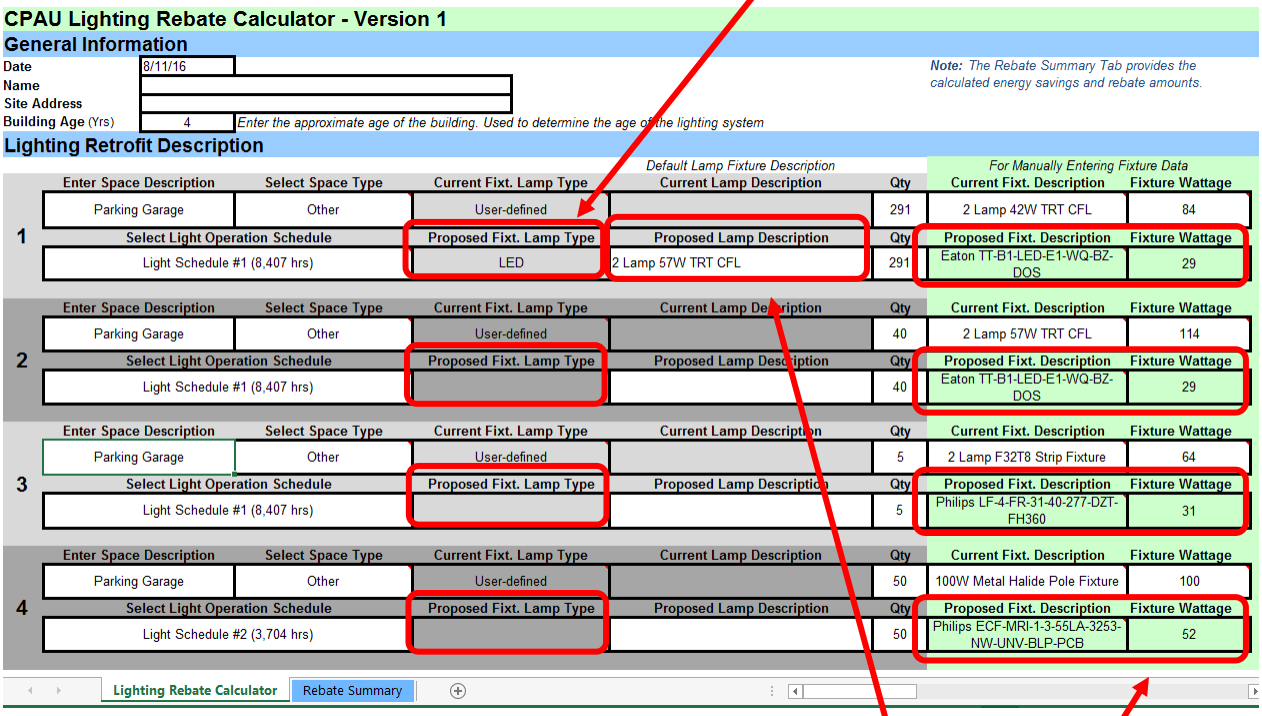
The main issue is that the Proposed Fixture wattages used in the calculator are zero if the "Proposed Fixture Lamp Type" is not selected (drop-down) as "User-defined". Since the tabs were unprotected, the user could have entered values into cells a number of ways. The following description of the error/issue is just one way in which the user might have entered the information into the worksheet.

How data was mis-entered

There are two tabs (**Lighting Rebate Calculator, Rebate Summary**) available to the user.

In the **Lighting Rebate Calculator** tab:

1) The user entered LED (Retrofit #1) for the first **Proposed Fixt.Lamp Type** field and left the others blank (Retrofit #2,3,4).



CPAU Lighting Rebate Calculator - Version 1

General Information

Date: 8/11/16
Name:
Site Address:
Building Age (Yrs): 4 — *Enter the approximate age of the building. Used to determine the age of the lighting system*

Note: The Rebate Summary Tab provides the calculated energy savings and rebate amounts.

Lighting Retrofit Description

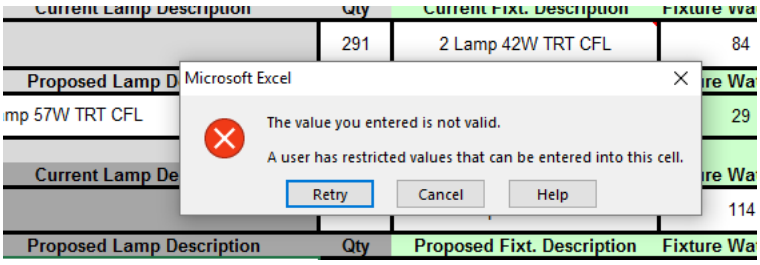
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Default Lamp Fixture Description: Current Lamp Description	Qty	For Manually Entering Fixture Data: Current Fixt. Description	Fixture Wattage
1	Parking Garage	Other	User-defined		291	2 Lamp 42W TRT CFL	84
	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		LED	2 Lamp 57W TRT CFL	291	Eaton TT-B1-LED-E1-WQ-BZ-DOS	29
2	Parking Garage	Other	User-defined		40	2 Lamp 57W TRT CFL	114
	Light Schedule #1 (8,407 hrs)				40	Eaton TT-B1-LED-E1-WQ-BZ-DOS	29
3	Parking Garage	Other	User-defined		5	2 Lamp F32T8 Strip Fixture	64
	Light Schedule #1 (8,407 hrs)				5	Philips LF-4-FR-31-40-277-DZT-FH360	31
4	Parking Garage	Other	User-defined		50	100W Metal Halide Pole Fixture	100
	Light Schedule #2 (3,704 hrs)				50	Philips ECF-MRI-1-3-55LA-3253-NW-UNV-BLP-PCB	52

Lighting Rebate Calculator | Rebate Summary

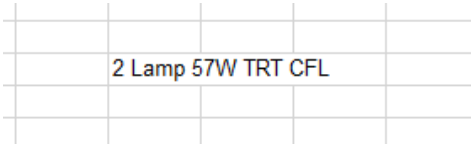
2) The "**Proposed Fixt. Description** and **Fixture Wattage**" fields are entered properly.

3) For Retrofit #1, values were manually entered (forced) into the **Proposed Lamp Description.** Typically entries into this cell are not allowed. A drop down menu is usually used to enter values there. As you can see in, **LED** is selected for the **Proposed Fixt. Lamp Type** and a custom fixture (2 Lamp 57W TRT CFL) is entered in the **Proposed Lamp Description** field.

4) Typically if a value is manually entered in this cell a warning pops up alerting you of the entry:



5) To get around the restriction, the user may have copied the custom lamp fixture (2 Lamp 57W TRT CFL) from a simularly formatted cell (3 cells merged, see below), and used "Paste Value" for the **Proposed Lamp Description** field.



Determining the savings discrepancy

In the **Rebate Summary** tab:

1) Reviewing the savings summary, the savings appear to be correctly calculated (no red flags or warnings). The "Note" at the bottom of the Rebate Summary indicates that savings and rebates would not be reported by the calculator if information is missing.

CPAU Rebate Calculator - Project Summary Page

Date
Customer Name
Site Address
Building Age

KWh Savings 250,483
Peak kW Reduction 32.790
Rebate Amount $25,048.31

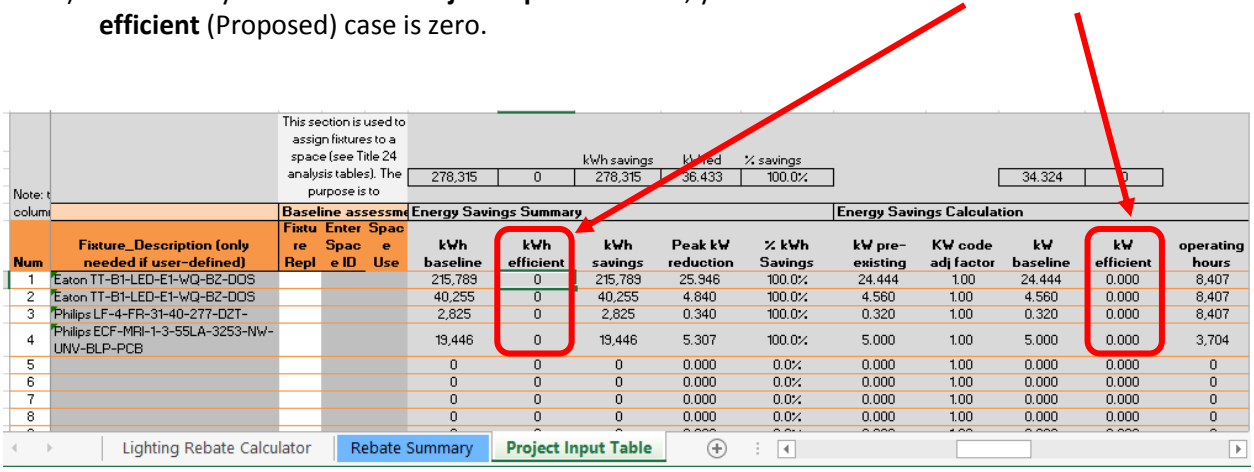
	Current Lighting		Proposed Lighting					
Space Description	Qty	Lamp Type	Meas Qty	New Lamp Type	kWh Savings	Peak kW Re-duction	Op Hrs	Rebate Amount
Parking Garage	291	2 Lamp 42W TRT CFL	291	Eaton TT-B1-LED-E1-WQ-BZ-DOS	194,210	23.351	8,407	$19,420.97
Parking Garage	40	2 Lamp 57W TRT CFL	40	Eaton TT-B1-LED-E1-WQ-BZ-DOS	36,230	4.356	8,407	$3,622.96
Parking Garage	5	2 Lamp F32T8 Strip Fixture	5	Philips LF-4-FR-31-40-277-DZT-FH360	2,542	0.306	8,407	$254.24
Parking Garage	50	100W Metal Halide Pole Fixture	50	Philips ECF-MRI-1-3-55LA-3253-NW-UNV-BLP-PCB	17,501	4.777	3,704	$1,750.14
Total	**386**		**386**		**250,483**	**32.790**		**$25,048.31**

Note: Savings and rebate amounts will be not be reported if there is missing information in the Lighting Rebate Calculator. For each measure, verify a space use type and proposed lighting quantity and lamp type have been correctly entered.

Lighting Rebate Calculator | Rebate Summary

READY

2) But when you unhide the **Project Input Table** tab, you can see that the kWh and kW for the **efficient** (Proposed) case is zero.



Num	Fixture_Description (only needed if user-defined)	Fixture Repl	Enter Space ID	Space Use	kWh baseline	kWh efficient	kWh savings	Peak kW reduction	% kWh Savings	kW pre-existing	KW code adj factor	kW baseline	kW efficient	operating hours
	This section is used to assign fixtures to a space (see Title 24 analysis tables). The purpose is to				278,315	0	278,315	36.433	100.0%			34.324	0	
		Baseline assessme			Energy Savings Summary					Energy Savings Calculation				
1	Eaton TT-B1-LED-E1-WQ-BZ-DOS				215,789	0	215,789	25.946	100.0%	24.444	1.00	24.444	0.000	8,407
2	Eaton TT-B1-LED-E1-WQ-BZ-DOS				40,255	0	40,255	4.840	100.0%	4.560	1.00	4.560	0.000	8,407
3	Philips LF-4-FR-31-40-277-DZT-				2,825	0	2,825	0.340	100.0%	0.320	1.00	0.320	0.000	8,407
4	Philips ECF-MRI-1-3-55LA-3253-NW-UNV-BLP-PCB				19,446	0	19,446	5.307	100.0%	5.000	1.00	5.000	0.000	3,704
5					0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
6					0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
7					0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
8					0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0

Lighting Rebate Calculator | Rebate Summary | Project Input Table

Fixing the errors in savings

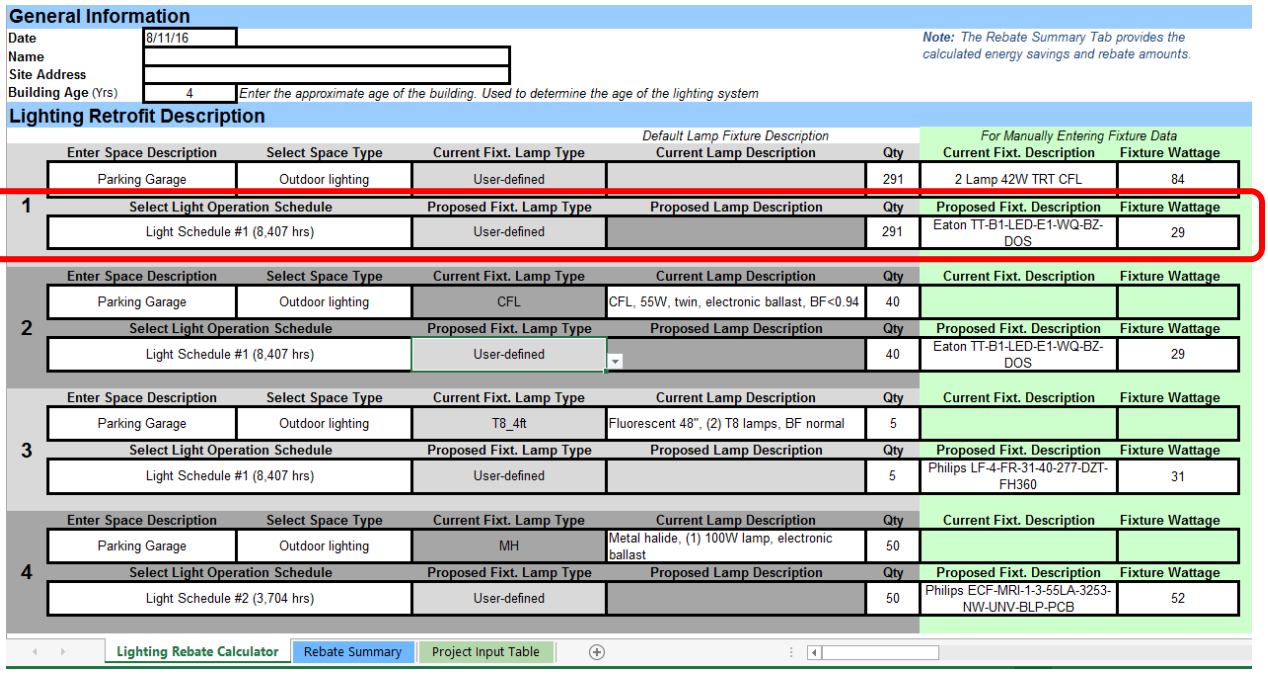
In the **Lighting Rebate Calculator** tab:

1) In order to fix the error for the Retrofit #1, you first need to delete the entries in the **Proposed Fixt. Description** and **Fixture Wattage** fields (green Manual Entry section on right)

2) You can then delete the custom fixture entered into the **Proposed Lamp Description** field (just to the left of the **Qty**).

3) You can then select "User-defined" from the drop-down menu in the **Proposed Fixt.Lamp Type** field

4) Re-enter the "**Proposed Fixt. Description** and **Fixture Wattage"** (green Manual Entry section on right) that you previously deleted.



General Information

Date: 8/11/16
Name:
Site Address:
Building Age (Yrs): 4 — *Enter the approximate age of the building. Used to determine the age of the lighting system*

Note: *The Rebate Summary Tab provides the calculated energy savings and rebate amounts.*

Lighting Retrofit Description

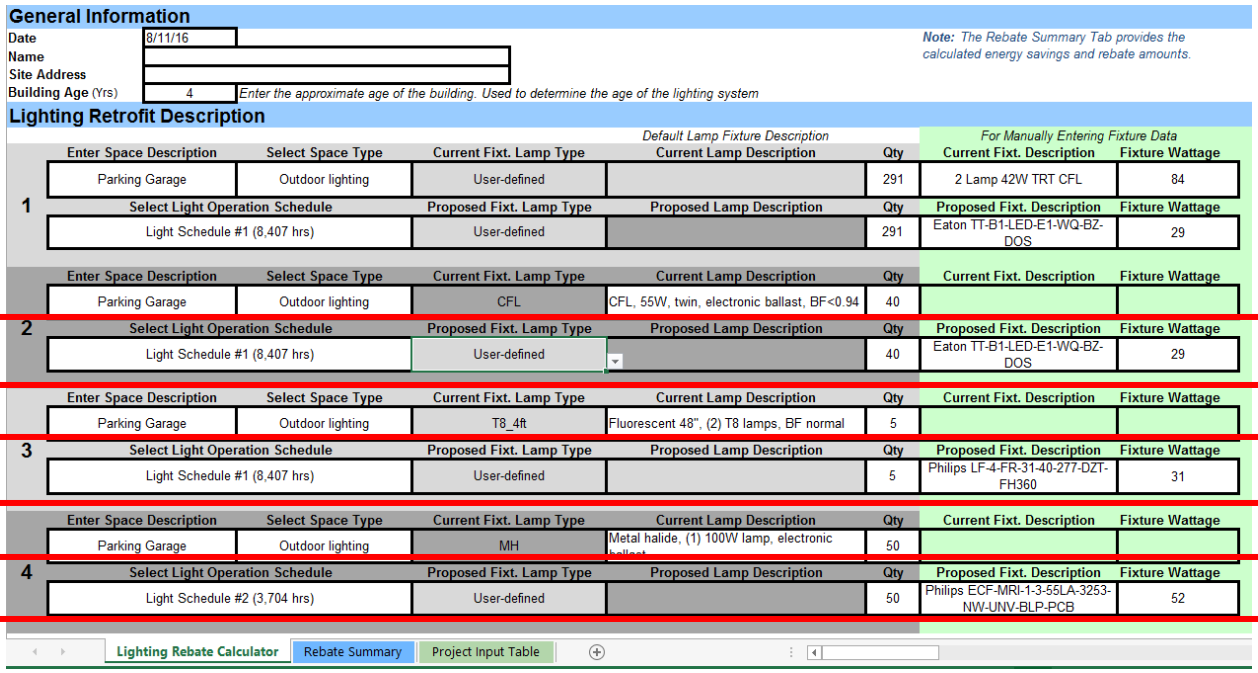
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
			Default Lamp Fixture Description			*For Manually Entering Fixture Data*	
	Parking Garage	Outdoor lighting	User-defined		291	2 Lamp 42W TRT CFL	84
1	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		User-defined		291	Eaton TT-B1-LED-E1-WQ-BZ-DOS	29
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Parking Garage	Outdoor lighting	CFL	CFL, 55W, twin, electronic ballast, BF<0.94	40		
2	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		User-defined		40	Eaton TT-B1-LED-E1-WQ-BZ-DOS	29
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Parking Garage	Outdoor lighting	T8_4ft	Fluorescent 48", (2) T8 lamps, BF normal	5		
3	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		User-defined		5	Philips LF-4-FR-31-40-277-DZT-FH360	31
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Parking Garage	Outdoor lighting	MH	Metal halide, (1) 100W lamp, electronic ballast	50		
4	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #2 (3,704 hrs)		User-defined		50	Philips ECF-MRI-1-3-55LA-3253-NW-UNV-BLP-PCB	52

Lighting Rebate Calculator | Rebate Summary | Project Input Table

1) In order to fix the error for the Retrofit #2-4, in the **Lighting Rebate Calculator** tab, you need to delete the entries in the **Proposed Fixt. Description** and **Fixture Wattage** fields (green Manual Entry section on right).

2) You can then select "User-defined" from the drop-down menu in the **Proposed Fixt.Lamp Type** field.

3) Re-enter the "**Proposed Fixt. Description** and **Fixture Wattage"** (green Manual Entry section on right) for each measure (Retrofits #2 - #4) that you previously deleted.



General Information

Date: 8/11/16
Name:
Site Address:
Building Age (Yrs): 4 — *Enter the approximate age of the building. Used to determine the age of the lighting system*

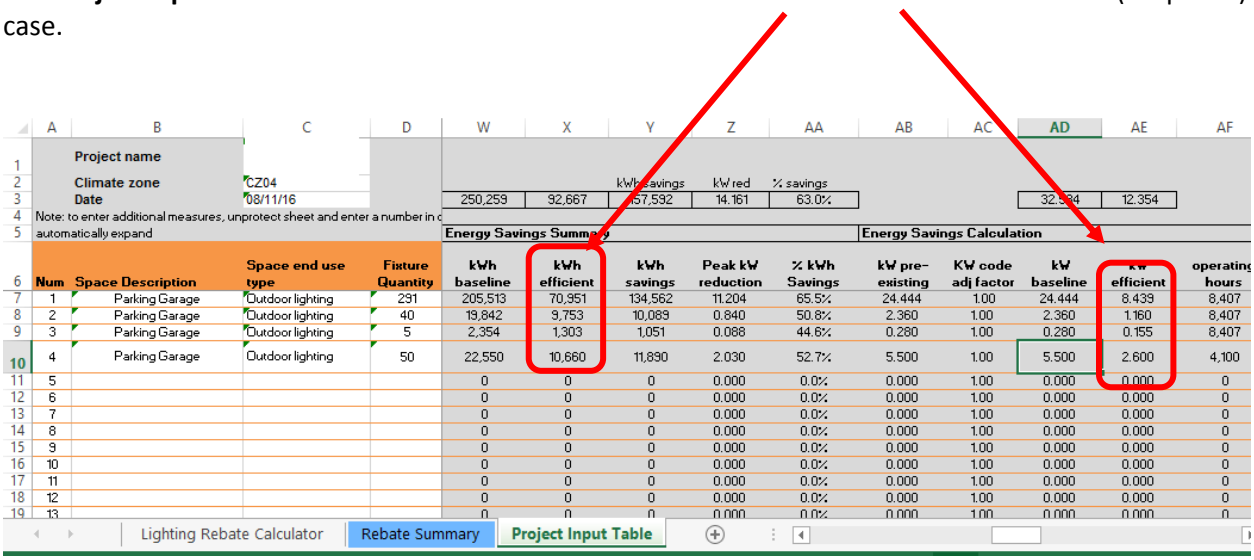
Note: The Rebate Summary Tab provides the calculated energy savings and rebate amounts.

Lighting Retrofit Description

	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Default Lamp Fixture Description					*For Manually Entering Fixture Data*	
1	Parking Garage	Outdoor lighting	User-defined		291	2 Lamp 42W TRT CFL	84
	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		User-defined		291	Eaton TT-B1-LED-E1-WQ-BZ-DOS	29
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Parking Garage	Outdoor lighting	CFL	CFL, 55W, twin, electronic ballast, BF<0.94	40		
2	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		User-defined		40	Eaton TT-B1-LED-E1-WQ-BZ-DOS	29
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Parking Garage	Outdoor lighting	T8_4ft	Fluorescent 48", (2) T8 lamps, BF normal	5		
3	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #1 (8,407 hrs)		User-defined		5	Philips LF-4-FR-31-40-277-DZT-FH360	31
	Enter Space Description	Select Space Type	Current Fixt. Lamp Type	Current Lamp Description	Qty	Current Fixt. Description	Fixture Wattage
	Parking Garage	Outdoor lighting	MH	Metal halide, (1) 100W lamp, electronic ballast	50		
4	Select Light Operation Schedule		Proposed Fixt. Lamp Type	Proposed Lamp Description	Qty	Proposed Fixt. Description	Fixture Wattage
	Light Schedule #2 (3,704 hrs)		User-defined		50	Philips ECF-MRI-1-3-55LA-3253-NW-UNV-BLP-PCB	52

Lighting Rebate Calculator | Rebate Summary | Project Input Table

The **Project Input Table** tab now shows non-zero values for the kWh and kW for the **efficient** (Proposed) case.



	A	B	C	D	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1		Project name												
2		Climate zone	CZ04				kWh savings	kW red	% savings					
3		Date	08/11/16		250,259	92,667	157,592	14.161	63.0%			32.394	12.354	
4	Note: to enter additional measures, unprotect sheet and enter a number in c													
5	automatically expand				Energy Savings Summary					Energy Savings Calculation				
6	Num	Space Description	Space end use type	Fixture Quantity	kWh baseline	kWh efficient	kWh savings	Peak kW reduction	% kWh Savings	kW pre-existing	KW code adj factor	kW baseline	kW efficient	operating hours
7	1	Parking Garage	Outdoor lighting	291	205,513	70,951	134,562	11.204	65.5%	24.444	1.00	24.444	8.439	8,407
8	2	Parking Garage	Outdoor lighting	40	19,842	9,753	10,089	0.840	50.8%	2.360	1.00	2.360	1.160	8,407
9	3	Parking Garage	Outdoor lighting	5	2,354	1,303	1,051	0.088	44.6%	0.280	1.00	0.280	0.155	8,407
10	4	Parking Garage	Outdoor lighting	50	22,550	10,660	11,890	2.030	52.7%	5.500	1.00	5.500	2.600	4,100
11	5				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
12	6				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
13	7				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
14	8				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
15	9				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
16	10				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
17	11				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
18	12				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0
19	13				0	0	0	0.000	0.0%	0.000	1.00	0.000	0.000	0

Lighting Rebate Calculator | Rebate Summary | Project Input Table