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ENERGY EFFICIENCY PROGRAM EVALUATION, VERIFICATION, AND MEASUREMENT STUDY

FY 2010 Electricity Efficiency Program

Prepared for:

The City of Palo Alto Utilities

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Introduction and Executive Summary

The City of Palo Alto Utilities (CPAU) is the only city-owned utility in California that includes electric, fiber optic, natural gas, water, and wastewater services for its citizens. CPAU has been providing quality services to the citizens and businesses of Palo Alto since 1896.

CPAU has a number of electricity energy efficiency programs in both the residential and non-residential sectors. Nearly 90% of the FY 2010 *ex-ante* electricity savings is from the non-residential sector. Of this 90%, nearly 98% is from the Commercial Advantage and Right Lights Programs. Because of this very large share of overall *ex-ante* electricity savings, this FY 2010 EM&V effort focuses on these two programs.

Background

Two legislative bills (SB1037 and AB2021) were signed into law a year apart. SB1037 requires that the Publically Owned Utilities (POUs), similar to the Investor Owned Utilities (IOUs), place cost effective, reliable, and feasible energy efficiency and demand reduction resources at the top of the loading order. Additionally, SB1037 (signed September 29, 2005) requires an annual report that describes the programs, expenditures, expected energy savings, and actual energy savings.

Assembly Bill 2021, signed by the Governor a year later (September 29, 2006), reiterated the loading order and annual report stated in SB1037 as well as expanding on the annual report requirements. The expanded report must include investment funding, cost-effectiveness methodologies, and an independent evaluation that measures and verifies the energy efficiency savings and reductions in energy demand achieved by the energy efficiency and demand reduction programs. AB2021 additionally requires a report every three years that highlights cost-effective electric potential savings from energy efficiency and established annual targets for electricity energy efficiency and demand reduction over 10 years.

The legislative reports require both an on-going assessment of what is occurring within the programs along with a comparison of how much possible savings is left within the POU service territory. This report provides the third party independent evaluation of CPAU's 2010 electricity conservation programs.

Objectives

The goals of the EM&V effort at CPAU are to provide unbiased, objective and independent program evaluations by giving:

- Useful recommendations and feedback to improve CPAU programs.
- Assessment of conservation program effectiveness.
- Assessment of the quality of the program data for impact evaluation purposes.
- Increased level of confidence in conservation program results through transparent protocols.

Impact Evaluation Results

In FY 2010, there were 132 total projects with claimed electricity savings in the Right Lights and Commercial Advantage Programs. Nineteen of these projects are included in the impact evaluation sample and they represent just over 50% of the two programs *ex-ante* FY 2010 electricity savings. Some of the sites included multiple measures. Nine of the sampled sites included lighting measures, two pump VFDs, two chillers, two HVAC systems, an elevator, and two sites with refrigeration door gaskets.

The methodologies employed to measure and verify electricity savings attributed to these programs included the following activities:

1. Verified measure installation.
    a. Developed a sample for field verification activities.
    b. Conducted field verification activities and observations.
2. Reviewed applications and supporting documentation provided to the City of Palo Alto Utilities.
3. Developed adjusted measure savings values based on field activities, billing records, and data reviews.

Directly estimating net impacts was not part of the scope for this project. However, a review of net to gross ratio (NTGR) assessments conducted primarily for the investor owned utilities (IOUs) in California was conducted in order to provide CPAU possible alternative NTGR values to their current general value of 80%. These IOU studies relied on large sample populations and though the IOU programs differ in some ways from CPAU's programs, they provide evidence of alternative NTGR values that CPAU may want to consider.

Results for the nineteen sampled sites are provided in Table EX-1 and Table EX-2. Table EX-1 identifies the claimed and verified energy impacts, as well as realization rates, for the Custom Advantage Program. The overall energy measure realization rate for CAP is 75%.

The realization rates for sites 11 and 10 are especially low. For energy, the site 11 realization rate is only 4.1%. The claimed *ex-ante* savings is based on an error. The claimed savings were based on a previous program's incentive schedule, rather than calculated savings above the Title 24 baseline. Site 10 has an energy realization rate of 33.2%. The difference is in part due to the alternating nature of the pumps, which resulted in only half of typical usage for each individual pump.

Table EX-1. Custom Advantage Program Claimed *Ex-ante* and Verified *Ex-post* Gross Savings

	Claimed		Verified		Measure Realization Rate	
Project	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings
Site 1	186.0	828,360	186.0	828,360	100.0%	100.0%
Site 2	0.7	61,122	12.8	58,645	1828.6%	95.9%
Site 6	3.7	18,680	3.7	18,680	100.0%	100.0%
Site 8	25.9	176,648	25.9	176,648	100.0%	100.0%
Site 9	123.4	118,150	126.2	116,268	102.3%	98.4%
Site 10	0.0	45,180	0.0	15,017	NA	33.2%
Site 11	0.0	367,500	5.4	15,220	NA	4.1%
Site 12	0.0	97,858	44.0	97,858	NA	100.0%
Site 14	0.0	126,859	4.1	103,249	NA	81.4%
Site 15	0.0	8,800	0.0	8,800	NA	100.0%
Site 16	0.0	1,733	0.0	800	NA	46.2%
Site 17	0.0	146,975	6.7	69,000	NA	46.9%
Site 18	0.0	99,855	0.0	66,570	NA	66.7%
TOTAL	339.7	2,097,720	414.8	1,575,115	122.1%	75.1%

Table EX-2 identifies the claimed and verified energy impacts, as well as realization rates, for the Right Lights Program. The overall energy measure realization rate for Right Lights is 103.4%. The combined CAP and Right Lights Programs achieved an energy realization rate of 80%.

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Table EX-2. Right Lights Program Claimed *Ex-ante* and Verified *Ex-post* Gross Savings

	Claimed		Verified		Measure Realization Rate	
Project	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings
Site 3	3.8	47,288	2.7	30,566	71.1%	64.6%
Site 4	17.2	165,071	14.0	74,855	81.6%	45.3%
Site 5	38.8	306,233	79.1	448,898	203.9%	146.6%
Site 7	0.4	2,611	0.6	2,611	150.0%	100.0%
Site 13	20.7	103,986	19.3	89,594	93.2%	86.2%
Site 19	0.0	5,610	0.0	5610	NA	100.0%
TOTAL	80.9	630,799	115.7	652,134	143.1%	103.4%

FY 2010 *Ex-ante* Gross Energy Savings

Table 1 identifies CPAU's 2010 *ex-ante* gross electric program savings. As can be seen in the table, just over 50% of the *ex-ante* gross savings comes from the Commercial Advantage Program followed by the Commercial Right Lights Program at 34%. The remaining combined programs account for less than 15% of the savings.

Table 1. FY 2010 *Ex-ante* Gross Electricity Savings by Program

Program	Gross Annual *Ex-ante* Savings (kWh)	Gross Annual *Ex-ante* Peak Savings (kW)	Program Share as % of Total kWh Savings
RES- Smart Energy	626,145	528	10%
RES- REAP Low Inc	121,798	3,082	2%
COM- Right Lights	2,207,349	365	34%
COM-Com. Advantage	3,496,317	319	53%
COM-NRM	131,839	0	2%
COM-SCVWD	3,480	3	0%
TOTAL	**6,586,928**	**4,297**	**100%**

As shown in Table 2, about one-half of the non-residential *ex-ante* gross savings comes from lighting measures. Comprehensive projects, which combine many end-uses within one project, account for the next largest amount of *ex-ante* gross savings at 19 percent.

Table 2. FY 2010 *Ex-ante* Gross Electricity Savings by End-Use

Program Sector	Gross Annual *Ex-ante* Savings (kWh)	Gross Annual *Ex-ante* Peak Savings (kW)	Program Sector Share as % of Sector Total kWh Savings
Residential:			
Appliances	99,774	9	13%
HVAC	35,270	3,059	5%
Lighting	219,233	478	29%
Pool Pump	14,000	5	2%
Refrigeration	379,129	59	51%
Water Heating	537	0	0%
Residential Total	**747,942**	**3,610**	100%
Non-Residential:			
HVAC	461,803	43	8%
Lighting	2,853,737	555	49%
Refrigeration	935,041	79	16%
Comprehensive	1,514,924	0	26%
Other	73,480	10	1%
Non-Residential Total	**5,838,985**	**687**	100%
TOTAL	**6,586,928**	**4,297**	

Evaluation Priorities

Previous EM&V studies for CPAU have focused on the Commercial Right Lights and Commercial Advantage Programs. The FY 2010 EM&V study will again focus on these two programs, both for the reason of the high levels of *ex-ante* savings but also from the uncertainty of the *ex-ante* savings estimates caused by differing hours of operation in commercial buildings and the custom nature of many of the projects.

Impact Evaluation Plan

A useful construct for thinking about the range of efficiency measures offered by the CPAU is the International Performance Measurement and Verification Protocol (IPMVP). Table 3 presents a listing of the IPMVP protocols, the nature of the performance characteristics of the measures to which M&V options typically apply, and an overview of the data requirements to support each option. Our approach to selecting M&V strategies followed these guidelines.

Table 3. Overview of M&V Options

IPMVP M&V Option	Measure Performance Characteristics	Data Requirements
Option A: Engineering calculations based on spot or short-term measurements, and/or historical data. Deemed energy savings fall in this Option.	Constant performance	» Verified installation » Nameplate or stipulated performance parameters » Spot measurements » Run-time hour measurements
Option B: Engineering calculations using metered data.	Constant or variable performance	» Verified installation » Nameplate or stipulated performance parameters » End-use metered data
Option C: Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multi-variate regression analysis.	Variable performance	» Verified installation » Utility metered or end-use metered data » Engineering estimate of savings input to SAE model
Option D: Calibrated energy simulation/modeling; calibrated with hourly or monthly utility billing data and/or end-use metering	Variable performance	» Verified installation » Spot measurements, run-time hour monitoring, and/or end-use metering to prepare inputs to models » Utility billing records, end-use metering, or other indices to calibrate models

Sample Selection

As shown in Table 4, 51% of the total Commercial Advantage and Right Lights *ex-ante* gross savings are included in the sample. The shares among the end-uses are similar between the total population and the sampled population. The sampling methodology gives preference to larger projects, which is why there are differences in the ratios between the two populations.

Table 4. Commercial Advantage Program *Ex-ante* FY 2010 Electricity Savings

Measure	All Right Lights and Commercial Advantage Projects	End-Use as Percent of Program Totals	Sampled Right Lights and Commercial Advantage Projects	End-Use Sample as Percent of Sample Totals
HVAC & Shell	461,803	8%	50,656	2%
Lighting	2,829,938	50%	1,671,625	57%
Refrigeration	829,941	15%	16,143	1%
Comprehensive	1,514,924	27%	1,179,074	40%
Other	67,061	1%	0	0%
TOTAL	**5,703,667**		**2,917,498**	**51%**

Stratified Ratio Estimation

Stratified ratio estimation combines a stratified sample design with a ratio estimator. Both stratification and ratio estimation take advantage of supporting information available for each project in the population. In this case, the supporting information is *ex-ante* energy savings per project. The population of accounts has a very wide range of energy savings ranging from 577 kWh to 828,360 kWh. The population coefficient of variation of the energy savings is large. Simple random sampling is not considered the proper sampling approach.

By using the *ex-ante* energy savings per project as the stratification variable, the coefficient of variation in each stratum is reduced thereby improving the statistical precision. Moreover, the sampling fraction can be varied from stratum to stratum to further improve the statistical precision. In particular, a relatively small sample can be selected from the accounts with small energy savings, but the sample can be forced to include a higher proportion of the projects with larger levels of energy savings. In particular, the largest projects can be included in the sample with certainty. Three strata are used. As shown in Table 4, this methodology resulted just over 50% of the savings being included in the sample. Nineteen of the total 132 projects are included in the sample population. Based on the *ex-ante* estimates of savings, the sample represents statistical confidence of 90 percent +/- 15 percent.

The claimed savings are based on CPAU accepted savings for the type of project, such as deemed savings, engineering calculations and utility work papers. Evaluation IPMPV options "A" and "C" were used as the evaluation methods.

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Gross Impact Evaluation Results

The methodologies employed to measure and verify electricity savings attributed to the Commercial Advantage and Right Lights Programs included the following activities:

1. Verified measure installation.
    a. Developed a sample for field verification activities.
    b. Conducted field verification activities and observations.
2. Reviewed applications and supporting documentation provided to the City of Palo Alto Utilities.
3. Developed adjusted measure savings values based on field activities, billing records, and data reviews.

These activities are discussed in detail in the following sections.

Measure Installation Verification

The objectives of the verification activities were to complete site visits and collect key energy program performance metrics including:

1. Establishing the presence of energy efficient measures by comparing the number of installations observed with the number of installations recorded in the rebate application.
2. Providing input on the quality of installations observed – including whether or not they were operating correctly.
3. Where observed equipment did not match program reported installations, determine if retrofits/installations were ever present, and/or the reason that the installation plan changed.
4. Recording key facility performance data, such as daily schedules, seasonal variations in schedules, and control strategies.
5. Reviewing available literature and reports to determine savings expected from the installed equipment.
6. Comparing utility billing data to predicted savings to determine if more accurate savings could be calculated.

Installation Verification Sample

Nineteen of the projects that received rebates in FY 2010 were selected for on-site evaluation. Table 5 lists the 19 sites along with the measures installed and the *ex-ante* demand and energy savings. For privacy, the customer names are not given, but rather a site number assigned.

Table 5. Site Measures and *Ex-ante* Gross Savings

Location	Measure	kW	kWh
Site 1	Lighting	186	828,360
Site 2	Lighting	0.7	61,122
Site 3	Lighting	3.8	47,288
Site 4	Lighting	17.2	165,071
Site 5	Lighting	38.8	306,233
Site 6	Lighting	3.7	18,680
Site 7	Lighting	0.4	2,611
Site 8	Lighting	25.9	176,648
Site 9	Lighting & Pump VFDs	123.4	118,150
Site 10	Pump VFDs	0	45,180
Site 11	Chiller/HVAC	0	367,500
Site 12	Chiller/HVAC	0	97,858
Site 13	HVAC	20.7	103,986
Site 14	HVAC/elevators	0	126,859
Site 15	Gaskets	0	8,800
Site 16	Gaskets	0	1,733
Site 17	New Construction	0	146,975
Site 18	New Construction	0	99,855
Site 19	Vending Machine Controls	0	5,610
Total		**420.6**	**2,728,519**

In evaluating these projects, particular attention was paid to reviewing the program documents and supplementing them with field verifications. Most of the sites did not require on-site measurements, since the lighting and gasket measures have well established energy savings values. On-site measurements were used at site 9 and logged energy use was used as sites 8 and 17. Additionally, on-site measurements of cooling equipment during winter months would not yield useful result. Billing data was used at sites 11, 12, 13, 14 17 and 19 to calculate energy savings or to verify calculated savings. IPMVP Options A and C were used by reviewing engineering calculations , performing site interviews, performing short term metering, and reviewing utility bills . Deemed values were used in calculating savings for the project at sites 14, 15, 16 and 19.

Site Verification Activities

Field activities typically involved two components:

1. Evaluators coordinated with the utility to establish field activity dates and identify site level contacts.
2. While on-site, the evaluation team conducted an area-by-area, measure-by-measure audit, noting retrofit count, type, and operating conditions. Discussions of the installation details were also conducted at the site representative's convenience.

Field evaluation activities were conducted from December 6-10, 2010. At the time, it was anticipated that all expected installations were completed and finalized.

Installation Verification Results

Verification work, discussions with participants subsequent to field verification activities, and an analysis of the verified installations indicated that most of the equipment attributed to Commercial Advantage Program (CAP) and the Right Lights Program were installed as expected. However, there were some discrepancies in lighting fixture numbers and some of the savings were not necessarily accurately calculated or recorded.

Site 1

Site 1 is a large department store. The site retrofitted track lighting throughout three floors of sales area. They replaced 1755 parabolic 50W halogen lamps and fixtures with 20 watt parabolic ceramic metal halide fixtures and 39 watt directional ceramic metal halide lights. This project was incentivized through the Commercial Advantage Program.

The Navigant team visited the site and visually verified the new lights in place. It was found that 673 39 watt fixtures were installed compared to the 684 expected and 1082 20 watt lamps were in place instead of the 1071 expected. In all, the total lighting count matched the sites records, but 37 of the larger directional lights were in the place of smaller parabolic lights.

Site personnel indicated that the lights are on 84 hours per week. There are additional emergency lights throughout the building that are on for longer hours, but those were not included in the retrofit. Interviews with site personnel indicated that the baseline lights had been 50 watt parabolic halogens lamps. The Navigant team's calculation of the site's savings is 197,431 kWh annually.

The *ex-ante* savings had been based on the deemed savings measure of 39 watt metal halide fixtures with a baseline of 150 watt incandescent lamps with savings of 472 kWh each annually and demand savings 0.106 kW each. The *ex-ante* savings were 828,360 kWh annually based on these deemed values, as seen in Table 6. The ex-post installation verification of these deemed measures agree with the claimed savings.

Table 6. Site 1 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	186	828,360
Verified *ex-post* Calculated Savings	45	197,431
Verified *ex-post* Deemed Savings	186	828,360
Gross Realization Rate	100%	100%

Site 2

Site 2 is a water treatment facility. The site updated lighting throughout the facility with 535 lighting fixtures replaced throughout five buildings. This project was incentivized through the CAP and included both prescriptive measures and custom measures. The retrofit involved delamping existing four lamp T8 fixtures and installing specialty lamps such as high output, low output and very high output with reflectors. In some areas the facility changed T12 ballasts to T8 ballasts and replaced CFLs with LED lighting. Occupancy sensors were also installed in one of the buildings.

The Navigant team visited site 2 and visually verified the lighting retrofit. The project application included a detailed room-by-room audit of the lights, which was used to verify fixture counts throughout the site. The verification review found 32 lights more than included in the rebate application.

The project application lists the majority of the lighting retrofit as a custom electric measure, and some of the project as deemed measures with prescriptive savings. Since CPAU does not claim demand savings on custom electric projects the reported demand savings for more than 500 of the lights is zero and, as seen in Table 7, the claimed demand savings is very low. The pre-installation report provided with the project application lists a more realistic *ex-ante* demand savings of 13.237 kW, which is close to the *ex-post* calculated demand savings of 12.99 kW.

The calculated ex-post savings for site 2 is 54,903 kWh per year. Since some of the measures for this project were prescriptive measures, savings were also calculated using deemed values for those items. The deemed ex-ante savings was 58,645 kWh per year. The claimed *ex-ante* and deemed *ex-post* savings for annual kWh yield a realization of 95.9%.

Table 7. Site 2 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0.71	61,122
Verified *ex-post* Calculated Savings	12.99	54,903
Verified *ex-post* Deemed Savings	12.77	58,645
Gross Realization Rate	1,799%	95.9%

Site 3

Site 3 is a sports and recreation facility, including office, lounge, and kitchen areas. The facility performed a lighting retrofit and was incentivized under the Right Lights program. The implemented measures included a lighting retrofit, including replacement of outdoor, accent and task fixtures. Portions of the site not covered by this retrofit include the locker rooms and weight room.

The Contractor Work Order Agreement for this retrofit was a near perfect match to the 134 total lamps noted during the verification visit. However, according to staff interviews, in one of the administrative areas the lighting retrofit resulted in an unsatisfactory reduction in luminance level. Therefore, three 8 watt cold cathode lamps were subsequently replaced with larger, 15 watt models. The 8 watt lamps are in storage until another use for them is found. The remainder of the incentivized lamps and fixtures remain in place and functioning.

The total calculated connected load reduction for site 3 was 9.44 kW, but 71% of that load is used exclusively for night time sporting activities. Therefore, only the interior lighting demand reduction of 2.73 kW is reported in Table 8.

The disparity between *ex-post* and *ex-ante* savings is primarily attributable to adjustments in the hours of operation for the individual fixtures. This may be due to staff vigilance to turn lights off in unoccupied spaces, such as the lounge and kitchen. In addition, several of the retrofitted fixtures are used less than 2 hours per week (i.e. storage and mechanical rooms).

Table 8. Site 3 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	3.81	47,288
Verified *ex-post* Calculated Savings	2.73	30,566
Gross Realization Rate	71.7%	64.6%

Site 4

Site 4 is a large, multi-family, residential complex. Lighting measures were implemented throughout the common areas, including two underground parking garages, accent wall washers, pool area, and porch/patio lights. The project was part of the Right Lights program.

The verification team counted 10.5% more fixtures than noted in the implementation report; nearly all of this discrepancy is attributed to an additional recessed can lights located on porches and balconies. *Ex-ante* savings for the 158 porch lights at this site assumed the lights were operated by a photo cell and utilized an average of 4,380 hr/yr. However, these fixtures are individually switch operated. Therefore, Ex-post measure savings for CFLs installed in each dwelling unit's porch light are based on an average of 3.1 hours of use per day, or 1,132 hr/yr.[1]

Staff interview indicated that there were roughly 20 failures among the initially installed CFLs. Given that a significant portion of these occurred in a very difficult area to access, 12 of the installed CFLs were replaced with LEDs. LEDs were selected because of their life expectancy is expected to help save in long term maintenance costs.

According to the CPAU database of measure savings, the total connected load reduction for site 4 was 28.94 kW. The Navigant team calculated the total demand reduction was 29.01 kW, but 40% of this is tenant controlled porch lighting and another 10% is controlled by photocells. Therefore, 14.03 kW is reported in Table 9 as a more accurate representation of expected coincident peak demand reduction.

[1] *CFL Metering Study, Final Report*, prepared for the Investor Owned IOUs, prepared by KEMA Inc., February 25, 2005

Table 9. Site 4 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	17.21	165,071
Verified *ex-post* Calculated Savings	14.03	74,855
Gross Realization Rate	81.5%	45.3%

Site 5

Site 5 is a high-tech manufacturing facility including clean rooms and office space. The facility did a large lighting upgrade under the Right Lights Program, including retrofitting T12 fixtures to T8 fixtures and delamping existing T8 fixtures. Additionally, incandescent lamps were replaced with CFLs and LED emergency lighting was installed.

The Navigant team visited the site and visually verified that the lighting retrofit was installed. While it was found that the quantities and sizes of the lights matched those that were listed in the implementer's analysis, site personnel indicated that all the 4-foot T-8 lamps used the same 2-lamp low output ballasts, with some of these ballasts being delamped to accommodate a single lamp. The implementer's report lists a mixture of low output and high output ballasts. Site personnel also indicated that hours of operation in the baseline case were not correct, as some areas had been over-lit and ½ of the lights in clean room areas had previously been turned off at all times. These adjustments to the savings calculation result in a calculated *ex-post* savings of 147%.

Table 10. Site 5 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	38.79	306,233
Verified *ex-post* Calculated Savings	79.08	448,898
Gross Realization Rate	203.9%	146.6%

Site 6

Site 6 is a school. The site installed 200 new T8 lights and removed T12 lights in four classrooms and a restroom and was incentivized through the CAP.

The Navigant team visited the school and visually verified the installation of T8 lights. Hours of operation for those rooms were used to calculate *ex-post* savings, while *ex-ante* savings had been based on deemed savings for T12 to T8 replacement. Table 11 shows the calculated savings are 50.5% of the *ex-ante* savings. The difference is due to the low hours of use at the school compared to other building types that the deemed savings for linear fluorescent lamps are based.

Deemed savings were used to estimate the *ex-ante* savings. Verification of deemed savings values provides an ex-post savings of 100%.

Table 11. Site 6 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	3.68	18,680
Verified *ex-post* Calculated Savings	3.15	9,446
Verified *ex-post* Deemed Savings	3.68	18,680
Gross Realization Rate	100%	100%

Site 7

Site 7 is a small retail space. The primary measure implemented at this site was a retrofit of existing exit signs to newer LED models. A limited number of other lighting upgrades were also performed, including two linear fluorescent fixtures, as well as two screw-in lamps. The remainder of the site's linear fluorescent fixtures were also replaced recently, but were part of a separate project. The project was part of the Right Lights program.

An occupancy sensor was installed in the restroom as part of this retrofit, but the sensor failed shortly after installation and was replaced with a standard switch. The business owner believes that the sensor failure directly led to the destruction of the store's fax machine.

Table 12. Site 7 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0.42	2,611
Verified *ex-post* Calculated Savings	0.63	2,611
Gross Realization Rate	150%	100%

The owners of this business are also the primary sales staff. Therefore, actual hours of use for the CFLs placed in their office desk lamps is typically one hour per day. Hours of use for the bathroom lights, post removal of the occupancy sensor, was estimated to be 3 hours per workday, or 936 hr/yr.

Site 8

Site 8 consisted of lighting retrofits throughout 11 different schools. This project was incentivized through the CAP. While at various locations, these projects were incentivized as one project and for the purpose of verification are treated as a single project. Lighting changes at the schools consisted of 4 foot T12 lamps and fixtures changed to T8. Additionally, occupancy sensors were installed in 162 classrooms and LED exit signs replaced four CFL exit signs.

The Navigant team visited the six schools with the most extensive upgrades. At five of those schools, all new lights were found to be as listed in their documentation. At the sixth school, documentation was not available regarding the location of the retrofit lights, and the facility had retrofitted more lights since the project being evaluated, so significantly more occupancy sensors and T8 lights were found. Because of the verified and detailed documentation at the other schools, there is high confidence that all the lighting quantities for the sixth school as well as the un-visited schools are also correct.

The *ex-ante* savings for site 8 were based on deemed savings values of 41 kWh for T12 to T8 retrofits. This value is a legitimate claim in California, but does not reflect the low operational hours of schools. The calculated *ex-post* savings is based on 3,000 annual hours of operation for the schools, with an additional 30% reduction in hours due to the occupancy sensors. Since this was a prescriptive project, the deemed ex-post calculation is included as well. This provides a realization of 100%. Table 13 shows savings at site 8.

Table 13. Site 8 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	25.95	176,648
Verified *ex-post* Calculated Savings	26.66	164,060
Verified *ex-post* Deemed Savings	25.95	176,648
Gross Realization Rate	100%	100%

Site 9

Site 9 is an office and research facility for a high-tech company, the facility consists of multiple buildings including offices, scientific laboratories, food service areas and machining shops. The site performed two projects under the CAP, a lighting retrofit and a VFD and pump control project.

The site replaced 4-lamp T12 lighting fixtures with 2-lamp T8 fixtures in two large open office areas, several stairwells and hallways and three labs. The Navigant team visited site 9 and visually verified the lights and occupancy sensors were installed. In the office areas, stairwells and hallways all the expected lights and occupancy sensors were found to be installed and working, with the exception of 2 fixtures which had been delamped due to over-lighting in a sensitive area. The three labs could not be identified as there were more than three labs in the building specified and all had T8 lights. The Navigant team assumes that the labs were retrofitted as reported. Documentation provided with the report demonstrates that the *ex-ante* savings were based on occupancy studies and wattages for the specific lights installed and the Navigant team agrees with those results. As seen in Table 14, the lighting *ex-post* savings is very close to the *ex-ante* savings, the difference being only due to the delamped fixtures. Since the lights were incentivized as a custom electric project, not as prescriptive projects, an ex-post deemed calculation is not provided.

The site replaced the hot water pumps used for its boilers in three buildings and reprogrammed their operation. There are six boilers, two in each building, with several hot water pumps for each. Prior to this project each boiler had four or five constant speed pumps. These were replaced with one "primary" 1 or 1.5 HP pump and one "secondary" 5 HP pump with a VFD and controls.

Data-logs for the site for January and part of February 2011 provided operational data for the majority of the pumps, although the "primary" pumps in buildings 2 and 3 were not included in the logs. However, the "primary" pumps in building one never turned on according to the logged data, and the secondary pumps in all areas were operating. During the site visit the "primary" pump in building two lower west,

the only one in buildings 2 or 3 observed, were not operating. Based on this, it is assumed that the "primary" pumps, which are actually smaller than the "secondary" pumps, are not typically used, and no energy use is ascribed to them in this analysis. There was no dependence of pump operation on outdoor air temperature, and each secondary pump operated at a constant, though not full, speed during operational hours. The 5 HP secondary pumps in building one west and building two west operated continuously. The 5 HP secondary pump in building one east was shut down from Christmas to New Years and the unit in building two east had a few brief shutdowns. Both the 5 HP pumps in building three operated 14 hours a day, 5 days a week, excluding holidays. Operational hours for each pump were calculated using the assumption that this schedule applied year round. All pumps were assumed to be around 60% loaded, which is consistent with typical pump loading in similar situations.

The project report included logged data and spot measurements both before and after the installation of the new pumps and VFDs. Based on this, the original project baseline use of 117,400 kWh/year with a peak demand of 14.0 kW is considered reliable. Navigant estimated current pump use at 34,900 kWh/year and 4.7 kW. The energy use is slightly higher than the project report indicated and the peak power use is significantly lower. This is due to the pumps operating longer hours than originally planned, but at somewhat reduced power overall. The energy savings for this project was 84,300 kWh/year, a 98% realization rate, with peak demand reduction of 9.3 kW, 50% higher than expected.

Table 14. Site 9 *Ex-ante* and *Ex-post* Savings

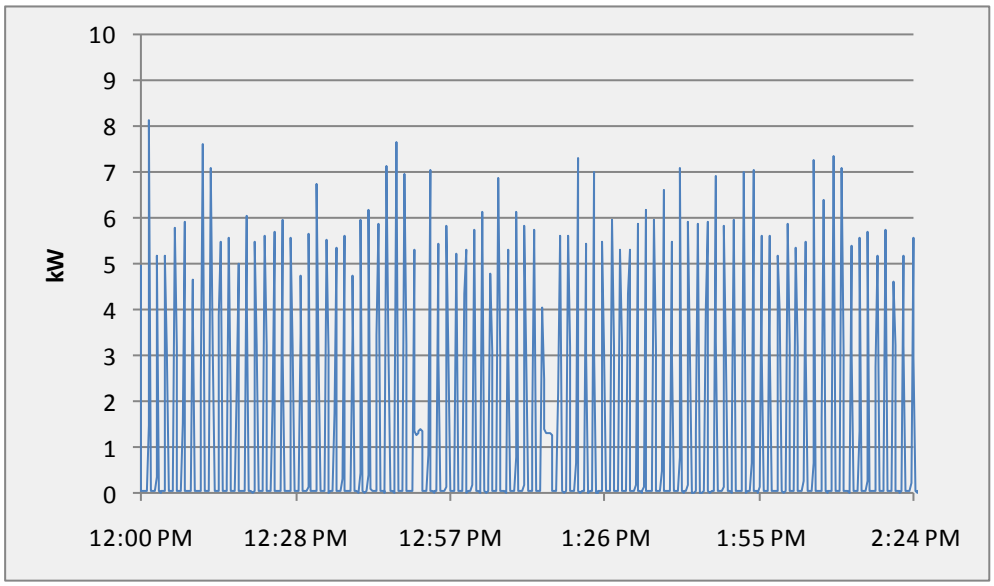
	kW Savings	Annual kWh Savings
Claimed *ex-ante* Lighting Savings	117.2	33,850
Claimed *ex-ante* Pump Savings	6.2	84,300
Verified *ex-post* Lighting Savings	116.9	33,768
Verified *ex-post* Pump Savings	9.3	82,500
Gross Realization Rate	102.3%	98.4%

Site 10

Site 10 is a parking garage built below the water table line. Two sump pump stations, each with two 15 HP pumps are located in the garage to prevent flooding in the parking area. Variable speed drives (VFDs) were installed on all four pumps. This project was incentivized through the CAP.

During the site visit, Navigant discussed the operation of the pumps and drives with site personnel. One of the east pumps was stuck operating at 43.5 Hz continuously due to sensor problems. Facility personnel indicated that this would be fixed soon, so the east pumps were used to model operation under normal circumstances for both areas. On-site observation and logging of the east pumps indicated typical peak operation varied, although typically only one pump was on most of the time. The second pump would cycle on as the first shut off so that the two were operating simultaneously only briefly, however this did produce the peak power seen during logging, which was greater than that of either pump alone. The Navigant team logged the pump operation for over two weeks at one station and eight days at the other. Operation did not vary significantly during this time. As shown in Figure 1 the pumps cycle on and off frequently to maintain water level. Overall the pumps were found to be off 57% of the time. It was assumed that this would be the case regardless of the use of VFDs.

Figure 1. Site 10 West Pumps Operation



Although it is frequently the case that sump pumps are not the best application for VFDs, since without them the pumps can simply operate at higher speeds for less of the time, in this case it appeared that the very narrow band allowed for water level would have resulted in not permitting reduced operational hours. Consequently, the base case was assumed to be one pump operating at full speed at all times when any pumps were found to be operating. Full speed power was estimated using the affinity law with a factor of 2.5 and the measured power for 43.5 Hz operation, since that was the only steady operation that allowed for measurement. This resulted in a single pump full speed power of 4.5 kW, indicating the pumps were significantly under loaded. Notably, this also indicates that the peak power observed in the logged data was for both pumps briefly operating simultaneously.

The actual calculated savings at the site were found to be substantially less than the claimed calculated savings. This is in part due to the alternating nature of the pumps, which resulted in only half of typical usage for each individual pump. However, the prescriptive values used for the VFD program are based upon savings for HVAC VFDs in Climate Zone 4, rather than for pumps and fans used for different purposes. Although this simplifies the program, it reduces the accuracy of savings estimates at individual sites. No demand savings were found because of the brief nature of the pump cycling and the peaks during which both pumps operate simultaneously.

Table 15. Site 10 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	45,180
Verified *ex-post* Calculated Savings	0	15,017
Gross Realization Rate	100%	33.2%

Site 11

Site 11 is an office building, with numerous independent tenants. A chiller had been installed as part of a facility upgrade. This project was incentivized through the CAP. The building had originally been constructed in 1969, and the HVAC system then consisted of a boiler and a chiller, both of which ran continuously to provide air for mixing to the appropriate temperature. The new chiller provides building cooling, and runs year round. It has a capacity of 175 tons and an IPLV efficiency of 0.392 kW/ton. The building is typically occupied from 6:00 AM until 8:30 PM on weekdays and between 9:00 AM and 5:00 PM on weekends.

Studies performed prior to installation of the new chiller provide baseline usage for the cooling system, as well as a Title 24 comparison. The calculated *ex-ante* savings, based on Title 24, in the report provided with the application lists as savings of 13,963 kWh. This savings is based on measured cooling requirements of 413,844 annual ton-hours and estimates chiller load is 15.2% of the building's energy consumption. As the building's actual energy use was 9% higher than estimated, the *ex-post* calculation was based on cooling requirements were increased to 451,100 ton hours for both the new system and the title 24 system. The calculated *ex-post* saving is 15,220 kWh.

Compared to the ex-ante savings in the pre-installation report, the site has a realization of 109%. However, as seen in Table 16, CPAU reported a much higher savings for site 11 and consequently the realization rate was only 4%. While the project study found a savings of 13,963 kWh, the utility's claimed savings for the site are 367,500 kWh. The project application was submitted during the transition

between the 2009 and 2010 CAP programs. This project was originally approved as a chiller measure, and rebated accordingly at $210/Ton, with a total incentive of $36,750. Later however, the project was entered into the utility's tracking system as a custom electric project, with an incentive rate of $0.10/kWh. The claimed ex-ante savings was adjusted to 367,500 kWh in order to reflect the incentive payment of $36,750.

Table 16. Site 11 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	367,500
Verified *ex-post* Calculated Savings	5.43	15,220
Gross Realization Rate	∞	4.1%

Site 12

Site 12 is a bio-technology company. The facility includes 2 buildings with high HVAC loads needs due to their air-quality needs. The facility uses 100% outside air at all times and uses a chiller set point of 65 degrees. This project was incentivized through the CAP.

The facility installed two new Turbocor 80 ton chillers with VFDs in place of one of 150 Ton Trane Chiller to cool air for one of the buildings. At the time of installation a detailed engineering report was completed.

The report was reviewed by the Navigant team and determined to be complete and it's assumptions valid. Since the retrofit, the building has been remodeled and the chiller load has increased. The chillers at the site were no longer sufficient to maintain the desired cooling and another 30 ton chiller has been added at the site and is running as the primary chiller with the two new Turbocor chillers running secondarily.

A review of the project's pre-instillation report yield that the previously existing Trane chiller would have also not been sufficient at the site and so the baseline is taken to be the previous chiller plus the new 30 ton chiller. Part load studies for the new and old chiller indicate that the savings are essentially the same as predicted and the *ex-ante* savings are taken to be correct.

Because of the significant expansion of the building, which included the installation of significant amounts of office equipment, medical and laboratory equipment as well as the increased HVAC needs, billing records were not of use in determining savings for the chiller project.

Table 17. Site 12 *Ex-ante* and *Ex-post* Savings

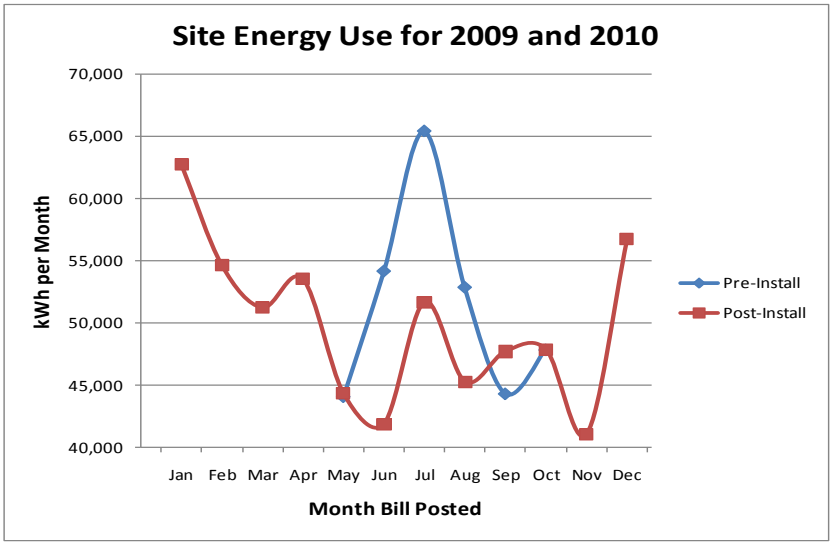
	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	97,858
Verified *ex-post* Calculated Savings	44	97,858
Gross Realization Rate	∞	100%

Site 13

Site 13 is a 141 room motel where an HVAC Energy Management System (EMS) was installed. The EMS uses occupancy sensors and a control unit to automatically cycle the packaged terminal air conditioner (PTAC) units off whenever the rooms are unoccupied. The implementer reported that a 109 tons of cooling capacity had been retrofitted with occupant based controls; however, the verification team noted 84 tons of PTAC capacity. The remainder of the property is serviced by split-AC units and EMS controls were not found in the rooms serviced by split systems. The project was part of the Right Lights program.

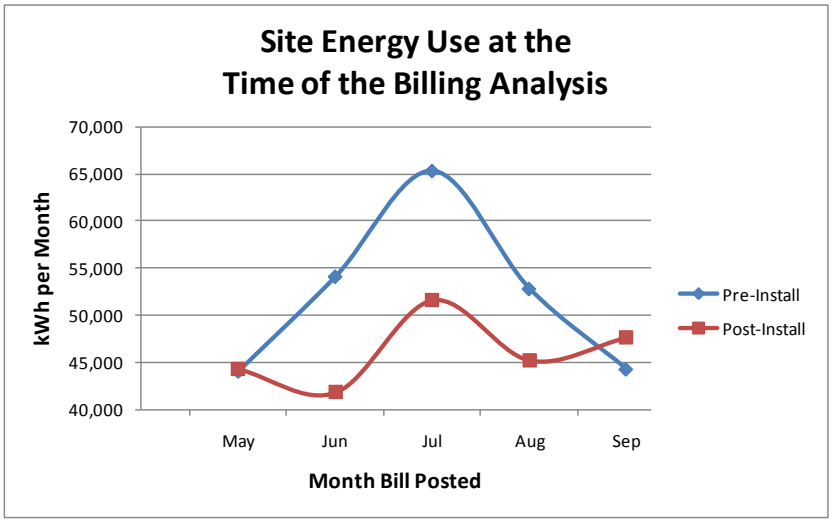
The *ex-post* annual energy savings shown in Table 19 are based on the available electric billing data from the site. Since a full year of pre/post billing data was not available for this analysis, the calculations are based on metered data that compares 2009 and 2010 cooling seasons, from May through September.

Figure 2. Billing Profile for Site 13



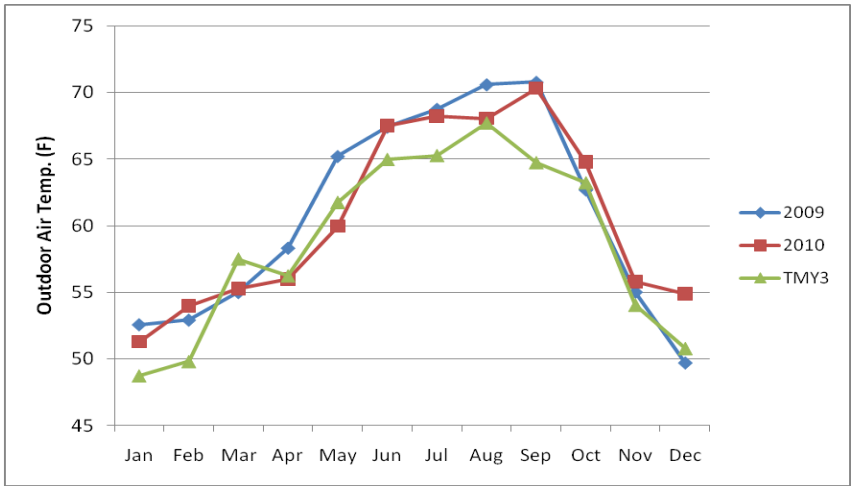
Note that the Nov.-Dec. portion of the Post-Install trend was transposed from those months in 2009.

Figure 3. Portion of Site 13 Billing Data Used for Pre/Post Comparison



In order to extrapolate the metered savings profile shown in Figure 3 out to a full year, site energy use was normalized based on the available occupancy and weather data, but this data was limited and did not provide a definitive trend.

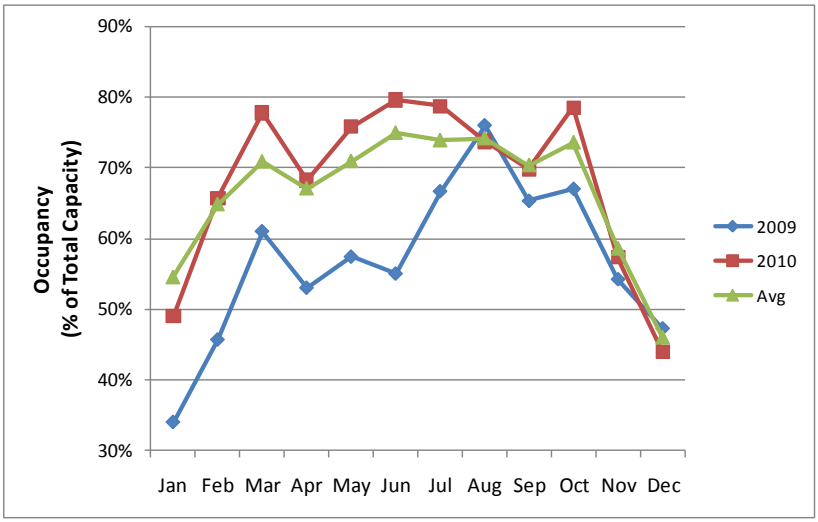
Figure 4. Outdoor Air Temp Profile and TMY3 Data for the San Jose Airport



The slightly cooler summer temperatures in 2010 relative to 2009 may push the billing analysis to over predict savings from this weather dependent measure. Furthermore, the temperature profiles for 2009 and 2010 will both lead to higher savings estimate than if the weather followed the profile set by a

Typical Meteorological Year (TMY), however as temperature trends have been rising, this is considered acceptable.

Figure 5. Occupancy Profile for Site 13



Counter to the impact of weather, the increase in occupancy rates seen between 2009 and 2010 push the billing analysis method to under predict savings, which should compensate in part for the weather trends. Therefore, the following assumptions were made in order to expand the savings noted from May through September, into an annual savings profile.

- Savings for January, February, and December were based on the average savings during the summer peak months of June, July, and August. This provides a winter peak savings of 19.5%
- Savings for March and November were based on the average savings for the entire 5 month billing sample. This average was 11.5%.
- Savings for the shoulder months of April and October were assumed to be zero. This assumption ignores potential fan energy savings, however it is supported by the available billing data.

This series of generalizations produces a winter savings profile that is comparable to, but slightly less than, the observed summer peak.

Coincident summer peak demand savings were calculated by multiplying the connected load by the average summer occupancy rate and a diversity factor. The diversity factor represents a run time of 12 minutes per hour, this agrees with the ratio between *ex-ante* savings and is considered to be reasonable for typical AC units in the absence of more definitive data.

Table 18. Factors Relevant to Calculating Peak Demand Reduction

Value	Name
103 kW	Connected PTAC Load
74%	Average Summer Occupancy
0.20	Diversity Factor

Table 19 shows the *ex-ante* and *ex-post* savings estimates.

Table 19. Site 13 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	20.71	103,986
Verified *ex-post* Calculated Savings	19.32	89,594
Gross Realization Rate	93.3%	82.7%

Site 14

Site 14 is a condominium building. The facility installed new air conditioning units in 2 common areas as well as their leasing office totaling 13 tons. This project was incentivized through the CAP. The engineering calculations provided with the application used to calculate their *ex-ante* savings list average occupancy in the areas to be 20 people, however 20 is the maximum occupancy of those areas. Interviews with site personnel indicate that the common areas are empty for much of the day and rarely have more than a few occupants; the office area has 2-3 occupants throughout the day. This decreased occupancy greatly reduces the load on the units from calculated. The Navigant team used deemed savings for 13 SEER unitary AC units, 207 kWh/annually per ton of cooling and demand savings of 0.314 kW per ton cooling.

The facility installed new motors and VVVF controls on their elevators. Elevators commonly use direct drive motors and require motor generators to convert from AC to DC poser. Older models, such as at Site 14 use nearly as much electricity when at idle as they do while running. The calculations provided with the incentive application provide *ex-ante* savings make reasonable assumptions about the elevator's use. The Navigant team agrees that these calculations are rigorous.

Table 20. Site 14 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* HVAC Savings	0	26,301
Claimed *ex-ante* Controls Savings	0	100,558
Verified *ex-post* HVAC Deemed Savings	4.082	2,691
Verified *ex-post* Controls Calculated Savings	0	100,558
Gross Realization Rate	∞	81.4%

Site 15

Site 15 is a deli. The facility replaced the door gaskets on 5 refrigerated display cases and walk in coolers, totaling 88 linear feet of door gaskets or glass and solid doors. This project was incentivized through the CAP.

The Navigant team visited site 15 and found all the expected gaskets. Refrigerator door gaskets have a deemed savings of 100 kWh annually per linear foot. This value was used for both the *ex-ante* and *ex-post* savings resulting in 100% realization.

Table 21. Site 15 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	8,800
Verified *ex-post* Deemed Savings	0	8,800
Gross Realization Rate	100%	100%

Site 16

Site 16 is a small café. The facility had two small under-counter refrigerators that were not functioning well. The site replaced the door gaskets on these units, totaling 17.33 linear feet of door gaskets. This project was incentivized through the CAP.

The Navigant team visited site 16 and found only one refrigerator, with 8 linear feet of door gasket. Site staff indicated that one of the refrigerators had continued to not function well and had been removed from the site. The staff expressed anger with the program implementer because they were encouraged to retrofit equipment that was broken. Table 22 shows a realization of less than 50% because one of the refrigerators was not at the site.

Table 22. Site 16 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	1,733
Verified *ex-post* Deemed Savings	0	800
Gross Realization Rate	100%	46.2%

Site 17

Site 17 is one floor of a multistory building. The floor was completely gutted and retrofitted. The project was classified as new construction under the CAP incentive program. The floor had a total area of 12,160 square feet. The incentive was calculated using a 2005 Title 24 baseline for an office building of that size. The floor contains offices and a computer closet with its own cooling.

The Navigant team visited the facility and discussed the design and implementation of the systems with facility personnel. All of the energy use for the floor is logged by an integrated building management system (BMS). Navigant was given one year of these hourly logs by facility personnel, and these were used to determine actual energy use. The observed energy use from the BMS was 110,367 kWh/year not including HVAC systems which are shared with other floors.

The project application provided for site 17 included a detailed EnergyPro 4.4 model as well as the Title 24 Certificate of Compliance. The EnergyPro 4.4 model, which assumed natural gas for both baseline building heat and all modeled water heat despite the building being all electric, predicted an energy savings of 12,352 kWh/year and 2,274 therms/year, including 452 therms for water heat. With a fuel conversion factor of 0.293 kWh/kBtu, this is equivalent to 78,980 kWh for an all electric facility. The

Energy Pro 4.4 model also provided a baseline of 135,658 kWh/year and 2,726 therms/year. This baseline is equivalent to 215,530 kWh/year for an all electric facility.

The design firm provided a Building Energy Performance Summary (BEPU report) at Navigant's request. This document detailed the baseline and proposed usage for each end-use category in kWh and therms. Navigant used this information to determine site 17's share of the heating and cooling loads provided by the overall building HVAC system. According to the BEPU report, the proposed systems would use 318 kWh for space heat, 46,478 kWh for cooling, and 5,844 kWh for fans annually.

Since the floor does not employ reheat of supply air, and Palo Alto is in Climate Zone 4, with relatively mild winters, the space heating estimate is considered reasonable for the 12,160 ft² occupied by the facility. Utility billing records show that the ten story building has electric usage peaking in the winter months, indicating that other floors are using a significant amount of heating through re-heat. The building's winter usage dropped by around 1,350 kWh/day on average between 2009 and 2010 and, although conditions in the rest of the building are unknown, this does indicate that the modeled values are realistic. Based on the EnergyPro model, BMS records of the computer air conditioner, and HVAC specifications for the building the floor requires around 30,000 kWh for cooling from the building's cooling load.

The BMS showed 110,367 kWh/year usage for all systems at site 17 aside from building HVAC. Adding 318 kWh for heat, 30,000 kWh for cooling, and 5,844 kWh for fans, the floor's usage would be 146,529 kWh/year. Utility records indicate an average usage of around 230,000 kWh/year for each floor of the building in 2010, demonstrating that site 17 is more efficient that the rest of the building.

Using the EnergyPro 4.4 model, the baseline usage is equivalent to 215,530 kWh/year. Based on this and current usage of 146,529 kWh/year, the verified savings was calculated to be 69,000 kWh/year, which is 46.9% of the claimed savings, as shown in Table 23. The low realization rate is due to an incorrect claimed value. The claimed savings based on the EnergyPro 4.4 outputs is 78,981 kWh/year, providing a realization rate of 87.4%. Differences between the predicted savings and the verified savings were partly due to the original model's assumption that the building used natural gas. Overall, lighting was much lower than either expected or permitted by Title 24.

While the energy model predicted savings of 78,980 kWh annually, the project application claimed a savings of 146,975 kWh annually. The claimed savings was based on the time dependent valuation (TDV) energy use (with a conversion factor of 0.293 kWh/kBtu) which is a time weighted performance quantity, not a direct measure of electricity use or energy savings. TDV is "the new method for valuing energy in the performance approach in the 2005 Building Energy Efficiency Standards. Under TDV the value of electricity differs depending on time-of-use (hourly, daily, seasonal), and the value of natural gas differs depending on season. TDV is based on the cost for utilities to provide the energy at different times."[2] There is no straightforward conversion between the TDV savings provided on a Title 24

[2] http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/tdv/index.html

Certificate of Compliance and electric savings. The TDV value includes both electric and gas savings, weighted together without any details provided in the summary as to how much savings came from each. In addition, the TDV weights energy use at different times by different amounts[3].

CPAU did not claim demand savings for this custom electric project. The *ex-post* demand savings were calculated based on logged maximums between 2:00 and 5:00 PM on the three weekdays surrounding the hottest recorded day in 2010 at the San Jose airport. The demand savings is 6.7 kW.

Table 23. Site 17 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	146,975
Verified *ex-post* Calculated Savings	6.7	69,000
Gross Realization Rate	∞	46.9%

Site 18

Site 18 is a new office building. The project was classified as new construction under the CAP and the application was filed under the Business New Construction Program. The floor had a total area of 11,256 square feet. The building is LEED certified. Energy conservation measures at the site include energy star heat pumps, and air conditioning units, daylighting and occupancy sensors on all lights.

The Navigant team visited the facility and discussed the design and implementation of the systems with facility personnel and reviewed the billing data for the site and the EnergyPro 4.4 documentation provided by the builder. The incentive was calculated using standard a 2005 Title 24 baseline for an office building of that size. The EnergyPro documentation makes acceptable assumptions and is believed to be correct. The billing data also provides evidence that energy consumption has been within the expectations of the EnergyPro report.

As a new construction project, the City of Palo Alto Utility rebated both the owner of the building and the design team for the project. The owner was incentivized at ten cents per kWh and the design team at five cents per kWh. This is within the program's parameters. The total rebate for the project is therefore calculated as $0.15/kWh times the projected annual savings of 66,570 kWh. However, within the utility's tracking system, energy savings are calculated based on the standard incentive rate of $0.10/kWh. This results in overstating the savings at site 18 by 50%, as seen in Table 24.

[3] http://www.energy.ca.gov/title24/2005standards/archive/rulemaking/documents/tdv/TDV_EXCEL_FILES.ZIP

Table 24. Site 18 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	99,855
Verified *ex-post* Calculated Savings	0	66,570
Gross Realization Rate	100%	66.7%

Site 19

Site 19 is a school. VendingMiser controllers on two vending machines, one refrigerated and one not refrigerated in cafeteria areas. VendingMisers are occupancy-based controls, which switch off power to vending machines during periods of no nearby occupancy. The project was part of the Right Lights program.

The Navigant team visited the school and visually verified that the VendingMisers were installed and working properly. Deemed savings of 4836 annual kWh for the refrigerated machine and 774 annual kWh for the non-refrigerated machine were used for both claimed and verified savings.

Table 25. Site 19 *Ex-ante* and *Ex-post* Savings

	kW Savings	Annual kWh Savings
Claimed *ex-ante* Savings	0	5,610
Verified *ex-post* Deemed Savings	0	5,610
Gross Realization Rate	100%	100%

Program Record Observations

The final program records of The City of Palo Alto Utilities were analyzed for accuracy and consistency, and to ensure that the underlying assumptions were reasonable. The key documents analyzed included the project applications provided to the program for each site and the available savings spreadsheets and reports.

Based on the review of program documents and on-site verification activities, the following conclusions were reached:

1. *Use of deemed savings for lighting measures.* Energy Savings for lighting retrofits that have different baseline technologies and operating schedules from the deemed measure assumptions should be calculated as custom savings.
2. *Use of custom electric measure in place of other prescriptive measures.* Of the 32 measures at 19 sites, 8 were listed as custom electric measures. Several of these, such as lighting as site 2, HVAC equipment at site 14 and the chiller at site 11 could have been listed by their product codes.
3. *Systematic error in calculating claimed savings at custom electric sites*. The utility's documentation for claimed savings for custom electric measures uses paid incentives to calculate energy savings. In most cases, this would not lead to errors, as the incentives are meant to be based on energy savings. However, at two of the sampled sites, Site 11 and Site 18, this lead to over estimation of energy savings due to higher than standard incentives.
4. *All custom electric measures are reported to have zero demand savings.* While some individual project applications list calculated *ex-ante* demand savings, all are reported as zero demand savings.
5. *New Construction energy use*. New construction applications should be required to base savings on the annual electric use calculated, not on the time dependent valuation energy use used for Title 24 compliance. (see site 17)
6. *Improper use of deemed savings values.* Savings for VFDs throughout the program are based on savings for HVAC VFDs in Climate Zone 4, rather than for pumps and fans used for different purposes. Although this simplifies the program, it reduces the accuracy of savings estimates at individual sites.

Gross Impact Evaluation Results

Table 26 provides for the Custom Advantage Program the *ex-ante* savings reported in the final installation review documents submitted for the Program and the verified *ex-post* gross savings. The overall energy measure realization rate for CAP is 73%.

Table 26. Custom Advantage Program Claimed *Ex-ante* and Verified *Ex-post* Gross Savings

	Claimed		Verified		Measure Realization Rate	
Project	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings
Site 1	186.0	828,360	186.0	828,360	100.0%	100.0%
Site 2	0.7	61,122	12.8	58,645	1828.6%	95.9%
Site 6	3.7	18,680	3.7	18,680	100.0%	100.0%
Site 8	25.9	176,648	25.9	176,648	100.0%	100.0%
Site 9	123.4	118,150	126.2	116,268	102.3%	98.4%
Site 10	0.0	45,180	0.0	15,017	NA	33.2%
Site 11	0.0	367,500	5.4	15,220	NA	4.1%
Site 12	0.0	97,858	44.0	97,858	NA	100.0%
Site 14	0.0	126,859	4.1	103,249	NA	81.4%
Site 15	0.0	8,800	0.0	8,800	NA	100.0%
Site 16	0.0	1,733	0.0	800	NA	46.2%
Site 17	0.0	146,975	6.7	69,000	NA	46.9%
Site 18	0.0	99,855	0.0	66,570	NA	66.7%
TOTAL	339.7	2,097,720	414.8	1,575,115	122.1%	75.1%

Table 26 provides for the Right Lights Program the *ex-ante* savings reported in the final installation review documents submitted for the Program and the verified *ex-post* gross savings. The overall energy measure realization rate for Right Light is 103.4%. The combined CAP and Right Lights Programs achieved an energy realization rate of 80%.

Table 27. Right Lights Program Claimed *Ex-ante* and Verified *Ex-post* Gross Savings

	Claimed		Verified		Measure Realization Rate	
Project	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings	kW Savings	Annual kWh Savings
Site 3	3.8	47,288	2.7	30,566	71.1%	64.6%
Site 4	17.2	165,071	14.0	74,855	81.6%	45.3%
Site 5	38.8	306,233	79.1	448,898	203.9%	146.6%
Site 7	0.4	2,611	0.6	2,611	150.0%	100.0%
Site 13	20.7	103,986	19.3	89,594	93.2%	86.2%
Site 19	0.0	5,610	0.0	5610	NA	100.0%
TOTAL	80.9	630,799	115.7	652,134	143.1%	103.4%

Net-to-Gross Assessment

Directly estimating net impacts was not part of the scope for this project. Rather, the approach to identifying possible net-to-gross values is to rely on the extensive number of net-to-gross assessments conducted primarily for the investor owned utilities (IOUs) in California. These IOU studies relied on large sample populations and though the IOU programs differ is some ways from CPAU's programs, they provide evidence of alternative NTGR values that CPAU may want to consider. Using these outside studies also allows CPAU to save valuable budgetary resources.

The on-line searchable database for the California Measurement Advisory Council (CALMAC) was used as the source for the studies included in this NTGR literature review. The *ex-post* estimates for NTGR are drawn from these sources when appropriate

Residential

The residential CPAU energy efficiency programs include the list of measures that follow. An *ex-ante* NTGR of 80% is used for each of these residential measures.

- Various Low Income Program measures
- Clothes washers
- Dishwashers
- Energy Star refrigerators
- Refrigerator recycling
- Pool pump
- Electric water heaters
- CFLs
- LED lamps
- Holiday LED lights
- Building shell insulation
- Central A/C

Recent low income program evaluations have not included assessment of NTGR. This is because, as noted in 2003 KEMA-EXENERGY low income program impact study[4] and accepted by the CPUC, net savings from the LIEE program are assumed to be equal to gross savings.

Three recently completed studies by Cadmus[5], Itron[6], and ADM[7] included NTGR evaluations for a number of residential measures. Included in the evaluation sample were participants from the California

[4]*Impact Evaluation of the 2001 Statewide Low-Income Energy Efficiency (LIEE) Program,* prepared for the California Investor Owned Utilities, prepared by KEMA-XENERGY Inc et.al., April 8, 2003

Investor Owned Utilities. Table 28 identifies the NTGR values estimated by measure for each of the three studies. The table also includes a possible alternative NTGR value for the measures. The alternative values are an average of the findings.

Table 28. Current and Possible Alternative NTGRs

Measure	Current *NTGR*	*CADMUS Study*	*ITRON Study*	*ADM Study*	Alternative *NTGR*
Clothes washers	80%	29% - 31%	81%	NA	56%
Dishwashers	80%	24%	41%	NA	32%
Refrigerator recycling	80%	51% - 58%	NA	50% - 66%	56%
Pool pump	80%	32%	69%	NA	50%
Electric water heaters	80%	NA	58%	NA	58%
Building shell insulation	80%	25% - 30%	70%	NA	49%
Central A/C	80%	NA	67%	NA	67%

A study conducted for the Northern California Power Agency[8] included evaluating Energy Star refrigerators. The estimated NTGR from this study for Energy Star refrigerators was 80%.

No studies could be found that included a NTGR assessment for holiday lights or LED lamps. Therefore, there is no basis to change the current estimate of 80% NTGR. Table 29 lists the possible alternative NTGR values for residential measures.

[5] *Residential Retrofit High Impact Measure Evaluation Report,* prepared for the California Public Utilities Commission Energy Division, prepared by Cadmus Group, Inc et.al., February 8, 2010

[6] *2004/2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation,* prepared for the California Investor Owned Utilities, prepared by Itron, Inc et.al., October 7, 2007

[7] *Evaluation Study of the 2004-05 Statewide Residential Appliance Recycling Program,* prepared for the California Public Utilities Commission Energy Division, prepared by ADM Associates, Inc., April, 2008

[8] *Measurement & Verification Load Impact Study for NCPA SB5X Miscellaneous Rebate Programs*, prepared for the Northern California Power Agency, prepared by Robert Mowris & Associates, June 25, 2005

Table 29. Current and Possible Alternative NTGR Values for Residential Measures

Residential Measures	Current *NTGR*	Alternative *NTGR*
Clothes Washers	80%	56%
Dishwashers	80%	32%
Energy Star Refrigerators	80%	80%
Refrigerator Recycling	80%	56%
Central A/C	80%	67%
Shell - Insulation	80%	49%
Water Heater - Electric	80%	58%
Pool Pump	80%	50%
CFLs (currently only low income)	80%	100%
LED Lamps	80%	80%
Holiday LED Lights	80%	80%
REAP	80%	100%

Non-Residential

A large number of measures are included within the non-residential sector. As with residential measures, an *ex-ante* NTGR of 80% is used for all non-residential measures.

Lighting

Below is a list of all the lighting measures for which there are claimed energy savings for FY 2010.

- CFLs - Screw-in
- CFLs - Modular
- Controls
- Occupancy Sensors
- T12 to T8
- T8
- De-Lamping
- Exit Sign
- HIDs

A good source for commercial sector lighting measure net-to-gross assessment is the 2010 report "Small Commercial Contract Group Direct Impact Evaluation Report".[9] This report presented the evaluation results for the 2006-2008 nonresidential energy efficiency high impact lighting measures (HIMs) and several non-HIM measures, both lighting and non-lighting. These measures were offered in programs implemented by Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), San Diego Gas and Electric (SDG&E) and third party implementers for the 2006-2008 program cycle.

The net-to-gross analyses are based on a self-report methodology that estimated four separate measurements of free ridership from different inquiry routes and then averaged the values to derive the final free ridership estimate at the measure level. The net-to-gross estimates often varied widely by utility within the same measure classification. No reasons were provided for the variance between the utilities. Below are the estimates of net-to-gross by measure classification by utility and an overall weighted average across the utilities.

- Interior screw-in CFL lighting:
  - PG&E - 59%
  - SCE – 61%
  - SDG&E – 85%
  - Weighted (by savings) average – 63%
- Linear fluorescent lighting:
  - PG&E - 73%
  - SCE – 79%
  - SDG&E – 87%
  - Weighted (by savings) average – 81%
- High bay lighting:
  - PG&E - 68%
  - SCE – 68%
  - SDG&E – 95%
  - Weighted (by savings) average – 74%

[9] *Small Commercial Contract Group Direct Impact Evaluation Report*, CALMAC Study ID: CPU0019:01, prepared for the California Public Utilities Commission Energy Division, prepared by Itron, Inc et. al., February 9, 2010

- Occupancy Sensors
  - PG&E - 68%
  - SCE - NA
  - SDG&E – 75%
  - Weighted (by savings) average – 72%

Finding studies that provide recent estimates of NTGR for de-lamping and HID fixtures were scarce. The above value for high bay lighting can be used as a proxy for HID fixtures. De-lamping was lumped into an indoor lighting category in a dated (February 1996) study by Quantum Consulting for PG&E's 1994 commercial lighting technology evaluation. In this evaluation report,[10] the NTGR for the indoor lighting measures was estimated to be 67%.

Another study that focused specifically on high bay lighting, estimated a similar net-to-gross factor of 69% compared to the Itron study findings that ranged from 68% to 95% with a weighted average of 74%. This 2010 report[11] was conducted by KEMA and Itron and is a market effects study of the PG&E, SCE, and SDG&E 2006-2008 energy efficiency programs on the commercial and industrial high bay lighting products.

No studies could be found that included a NTGR assessment modular CFLs or exit signs. Modular CFLs are a close relative to screw-in CFLs, but their higher cost and greater permanence likely result in a higher NTGR than screw-in CFLs. Therefore, for both exit signs and modular CFLs, there is no basis to change the current estimate of 80% NTGR. Table 30 lists the possible alternative NTGR values for non-residential lighting measures.

[10] *1994 Commercial Retrofit Program Evaluation of Lighting Technologies*, prepared for Pacific Gas & Electric Company, prepared by Quantum Consulting Inc., February, 1996

[11] *High Bay Lighting Market Effects Study*, prepared for the California Public Utilities Commission Energy Division, prepared by KEMA, Inc and Itron, Inc., June 18, 2010

Table 30. Current and Possible Alternative NTGR Values for Non-Residential Lighting

Non-Residential Lighting Measures	Current *NTGR*	Alternative *NTGR*
CFLs - Screw-in	80%	63%
CFLs - Modular	80%	80%
Controls	80%	72%
Occupancy Sensors	80%	72%
T12 to T8	80%	81%
T8	80%	81%
De-Lamping	80%	67%
Exit Sign	80%	80%
HIDs	80%	74%

Refrigeration Related Measures

The most probable source for refrigeration related NTGR values would be evaluations on the EnergySmart Grocer Program. A recent evaluation of this program was conducted in 2006 by PWP Inc.[12] However, in this evaluation, NTGR estimates were not made. Rather, the CPUC stipulated NTGR of 96% was used. This 96% NTGR value will be considered the *ex-post* NTGR value for refrigeration measures unless other studies are found with actual NTGR *ex-post* estimates. Below is a list of all the refrigeration related measures for which there are claimed energy savings for FY 2010.

- LED Lights for Coolers
- Auto Closures
- ASH
- Vending Controls
- Other Controls
- Door Gaskets
- Evap EC Motor

[12] *Final Evaluation, Monitoring, and Verification (EM&V) Report for the ENERGYSMART Grocer Program 2004-2005,* prepared for the California Investor Owned Utilities, prepared by PWP Inc., June 8, 2006

- » Solid Freezer Door
- » Cases
- » Strip Curtains

Net-to-gross estimates for the refrigeration gasket and strip curtain measures can be found in a 2010 study by ADM Associates, Inc.[13] The evaluations focused on two PG&E programs offered during 2006-2008 to its high tech and commercial customers and focused specifically on these two measures. The net-to-gross estimates are based on a telephone survey of program participants. The estimated NTGR for refrigeration door gaskets is 19%, and for strip curtains 40%.

Table 31 lists the possible alternative NTGR values for non-residential refrigeration related measures.

Table 31. Current and Possible Alternative NTGR Values for Non-Residential Refrigeration

Non-Residential Refrigeration Related Measures	Current *NTGR*	Alternative *NTGR*
LED Lights for Coolers	80%	96%
Refrig - Auto Closures	80%	96%
Refrig - ASH	80%	96%
Refrig - Vending Controls	80%	96%
Refrig - Other Controls	80%	96%
Refrig - Door Gaskets	80%	19%
Refrig - Evap EC Motor	80%	96%
Refrig - Solid Freezer Door	80%	96%
Refrig - Cases	80%	96%
Refrig - Strip Curtains	80%	40%

[13] *Commercial Facilities Contract Group 2006-2008 Direct Impact Evaluation, ,* CALMAC Study ID: CPU0016:01, prepared for the California Public Utilities Commission Energy Division, prepared by ADM Associates et.al., February 18, 2010

Other Non-Residential Measures

An array of additional non-residential measures is offered by CPAU. These include two measures that combine a package of measures. They are referred to as "Custom Electric", and "Custom New Construction". The full list of other measures is listed below.

- Custom Electric
- Custom New Construction
- Cooling - Condenser Coil
- Cooling - EMS
- VFD on HVAC Fan
- Window Film
- Commercial Clothes Washer
- PC Power Management

A study conducted for the Northern California Power Agency evaluated the non-residential custom electric incentive programs for several Northern California publically owned utilities.[14] This study utilized telephone surveys to evaluate net-to-gross ratios. The estimated NTGR for these Custom Electric Programs is 84%.

A 2008 evaluation study by RLW Analytics[15] included an NTGR assessment for non-residential new construction. This study utilized telephone surveys to evaluate net-to-gross ratios. The estimated NTGR for non-residential new construction is 76%.

A recently completed study by KEMA[16] evaluated HVAC High Impact measures. Though condenser coils, EMS, and VFD on HVAC motors are not specifically singled out, these types of measures are in this family of measures. As with the other studies, the net-to-gross estimates are based on a telephone survey. Included in the evaluation sample were participants from the three largest California IOUs. The results were very similar across the three utilities.

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[14] *Measurement & Verification Load Impact Study for NCPA SB5X Commercial and Industrial Custom Incentive Programs*, prepared for the Northern California Power Agency, prepared by Robert Mowris & Associates, June 25, 2005

[15] *An Evaluation of the 2004-2005 Savings by Design Program,* prepared for the California Investor Owned Utilities, prepared by RLW Analytics, October, 2008

[16] *Evaluation Measurement and Verification of the California Public Utilities Commission HVAC High Impact Measures and Specialized Commercial Contract Group Programs,* prepared for the California Public Utilities Commission Energy Division, prepared by the KEMA Inc et.al., February 10, 2010

- HVAC A/C Equipment:
  - PG&E - 94%
  - SCE – 96%
  - SDG&E – 94%
  - Weighted (by savings) average – 94%

A study conducted for the Northern California Power Agency[17] included evaluating the non-residential window film measure. As with the other studies, the net-to-gross ratio was developed using a telephone survey. The estimated NTGR for non-residential window film is 96%.

No studies were found that specifically targeted commercial clothes washers or PC power management. Therefore, for both of these measures, there is no basis to change the current estimate of 80% NTGR. Table 32 lists the possible alternative NTGR values for non-residential "Other" measures.

Table 32. Current and Possible Alternative NTGR Values for Non-Residential Other Measures

Non-Residential Other Measures	Current *NTGR*	Alternative *NTGR*
Custom Electric	80%	84%
Custom New Construction	80%	76%
Cooling - Condenser Coil	80%	94%
Cooling - EMS	80%	94%
VFD on HVAC Fan	80%	94%
Window Film	80%	96%
Commercial Clothes Washer	80%	80%
PC Power Management	80%	80%

[17] *Measurement & Verification Load Impact Study for NCPA SB5X Miscellaneous Rebate Programs*, prepared for the Northern California Power Agency, prepared by Robert Mowris & Associates, June 25, 2005

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Appendix A

Table A-1: Standard Occupancy Sensor Reductions by Area Type

Space Type	% Savings	Space Type	% Savings	Space Type	% Savings
Assembly	45	Industrial	45	Restroom	45
Break room	25	Kitchen	30	Retail	15
Classroom	30	Library	15	Stair	25
Computer Room	35	Lobby	25	Storage	45
Conference	35	Lodging (Guest Rooms)	45	Technical Area	35
Dinning	35	Open Office	15	Warehouses	45
Gymnasium	35	Private Office	30	Other	15
Hallway	25	Process	45	Parking Garage	15
Hospital Room	45	Public Assembly	35		

Source: 2008 NRR-DR Program Procedures Manual, Table 2-1