NAVIGANT

CITY OF PALO ALTO UTILITIES: IMPACT EVALUATION OF THE COMMERCIAL ADVANTAGE AND ENOVITY PROGRAMS

DRAFT

Prepared for:
City of Palo Alto

CITY of PALO ALTO

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1 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 and natural gas energy efficiency programs in both the residential and non-residential sectors. About 72% of the FY 2011 *ex-ante* electricity savings is from the non-residential sector. Of this 72%, just over 50% comes from the Right Lights Program, just over 30% from the Custom Advantage Program, and just under 20% from the Enovity Program. This report focuses on the 2011 non-residential sector, both for electricity and natural gas. However, the Right Lights Program, which received an impact evaluation in both 2009 and 2010, was not included. This decision was made because essentially all of the measures funded under Right Lights are prescriptive with measure installation verification being the primary focus for prescriptive measure EM&V efforts. The 2010 realization rate for the Right Lights Program will be used, along with the new realization rates for Custom Advantage and Enovity, will be used to estimate the full non-residential realization rate.

Under separate reports are an impact evaluation of the residential Home Energy Report Program and a process evaluation of the Residential Clothes Washer program. The largest residential program, the Residential Smart Energy Program, has received impact evaluations in 2009 and 2010 and with many of the program measures being prescriptive, the decision was made that only a process evaluation of the clothes washer portion of the program was needed.

1.1 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.

1.2 Objectives

The goals of the 2011 non-residential 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.

1.3 Impact Evaluation Results

In FY 2011, there were 41 total projects with claimed electricity savings in the Commercial Advantage Program (CAP) and Enovity Program. All five Enovity sites were included in the sample along with 14 CAP sites. All of the Enovity sites were included as they represented five of the top seven projects in terms of claimed energy savings from the 41 total projects. Measures included within the sampled sites were refrigeration, motors/VFDs, chillers, computer room cooling, cleanroom air handlers, economizers, temperature reset, and pressure reset.

A total of five projects in FY 2011 include natural gas savings. Of these five projects, four were included in the EM&V sample.

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.

Table EX-1 provides the individual commercial program electric realization rates and the resultant ex post program impacts. The Right Lights realization rate was estimated in the 2010 evaluation. The total commercial sector electric realization rate, combining all three programs, is 102%.

Table EX-1. 2011 Commercial Sector Electric Utilization Rates and *Ex Post* Impacts

Program	Total Ex Ante kWh	Realization Rate	Total Ex Post kWh
Commercial. Advantage	1,910,333	112%	2,132,381
Right Lights (2010 Realization Rate)	3,213,412	103%	3,322,668
Enovity	1,045,600	81%	845,478
Total	**6,169,345**	**102%**	**6,300,527**

Table EX-2 provides the individual natural gas sample site realization rates, the total realization rate for the combined sample, and the resultant ex post program impacts. The total commercial sector natural gas realization rate is 129%.

Table EX-2. Commercial Sector Natural Gas Realization rate and *Ex Post* Impacts

Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
Program Total	**14,809**	**19,093**	**129%**

Navigant offers the following, limited recommendations for program refinement:

- **Commercial Refrigeration:** Participant comments indicated dissatisfaction with the service or workmanship provided in two of the five surveyed commercial refrigeration gasket projects. CPAU has noted similar feedback from other customers and revamped its approach to this measure. Subsequently, commercial refrigeration gaskets are no longer offered through the Commercial Advantage Program. Instead, this measure is offered as part of the "Keep Your Cool" program. Keep Your Cool is a 3rd-party program sponsored by seventeen California utilities with a focus on refrigeration measures.

- **Commercial Refrigeration EE Measure Persistence:** The CAP gasket retrofits and other commercial refrigeration measures, as a whole, may underperform in terms of expected net lifetime impacts. To fully realize the lifetime savings from the CAP refrigeration incentives, CPAU should consider conducting a targeted survey of local grocers, convenience stores, and restaurants (participants and non-participants) to ascertain satisfaction with retrofits conducted through the program relative to similar projects undertaken by non-participants. The results of this survey would be particularly useful for confirming measure persistence.

- **Prescriptive HVAC:** One of the prescriptive HVAC measures installed at Site 14 did not meet Title 24 minimum requirements effective as of January 2010. Requirements for qualifying HVAC measures should be reviewed to ensure the latest standards are observed.

- **Custom Project Documentation:** Project documentation related to the type and nature of custom projects is typically comprehensive and well organized. However, documentation of the supporting algorithms, inputs, and/or assumptions used to establish as-built, claimed savings for some projects was found to be incomplete. Documentation of the full process used to justify claimed savings enables targeted updates to savings calculations. This assists with evaluation and allows for feedback that can improve future *ex ante* estimates.

2 FY 2011 *Ex-ante* Gross Energy Savings

Table 1 identifies CPAU's 2011 *ex-ante* gross electric and natural gas program savings for the non-residential sector. As can be seen in the table, about 29% of the total *ex-ante* gross savings is included in the sample population and if adjusted by removing the Right Lights Program, 60% of the total *ex-ante* gross savings is included in the sample population. For natural gas, about 93% of the total *ex-ante* gross savings is included in the sample population.

Table 1. FY 2011 *Ex-ante* Gross Electricity Savings by Program and Sample Population for the Non-Residential Sector

Program	Program Total Gross Annual *Ex-ante* Savings (kWh)	Sample Total Gross Annual *Ex-ante* Savings (kWh)	Sample Share as % of Program Total
Commercial. Advantage	1,910,333	714,740	37%
Right Lights	3,213,412	0	0%
Enovity	1,045,600	1,045,600	100%
Total	**6,169,345**	**1,760,340**	**29%**
Total w/o Right Lights	**2,955,933**	**1,760,340**	**60%**
	Therms	**Therms**	
Natural Gas	**14,809**	**13,776**	**93%**

The Enovity Program is new for 2011, which, along with the large estimates of savings per project, is the reason for receiving EM&V emphasis. Previous EM&V studies for CPAU have focused on the Commercial Right Lights and Commercial Advantage Programs. The Right Lights program, though large in savings, is composed of prescriptive measures. For prescriptive measures, the primary variable being evaluated is verification of installation. CPAU and Navigant staff felt that the previous two years of evaluating this program has sufficiently dealt with this narrow focus at this time. The Commercial Advantage program has also been part of the last two EM&V efforts. However, unlike Right Lights, the Commercial Advantage Program includes many complex, custom measures that should be evaluated each year.

3 Impact Evaluation

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 2 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 2. 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-variant 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

3.1 Sample Selection

As previous shown in Table 1, 60% of the total Commercial Advantage and Enovity Program *ex-ante* gross savings are included in the sample. Additionally, 93% of all the natural gas *ex-ante* gross savings

are included in the sample. The sampling methodology gives preference to larger projects but also insures that smaller projects are represented in the sample.

3.1.1 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 3,538 kWh to 960,000 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.

The initial sample draw included both CAP and Enovity sites. This was done to ensure that the sites with the greatest savings, regardless of whether they were CAP or Enovity sites, were included in the sample. Three energy savings strata were utilized with the sample, based on the *ex-ante* estimates of savings, represents statistical confidence of 90 percent +/- 10 percent.

In reviewing the sample draw, it was found that all of the Enovity sites were included in the sample. This provides a statistical confidence of 100 percent for the Enovity sites. To ensure that statistical confidence of 90 percent +/- 10 percent was being maintained for the CAP sites, the sample was drawn again, but now with the Enovity sites removed.

The natural gas sample was drawn as part of the overall CAP project sample. Three of the natural gas sampled sites were also sampled electric sites. The one gas only site was selected to bring the sample total to four of the total five natural gas sites. These four sampled sites represent 93% of the natural gas *ex ante* savings.

3.2 *Electric*

Savings for each site in the Commercial Advantage Program (CAP) sample are listed in Table 3 below.

Table 3. CAP Electric Savings

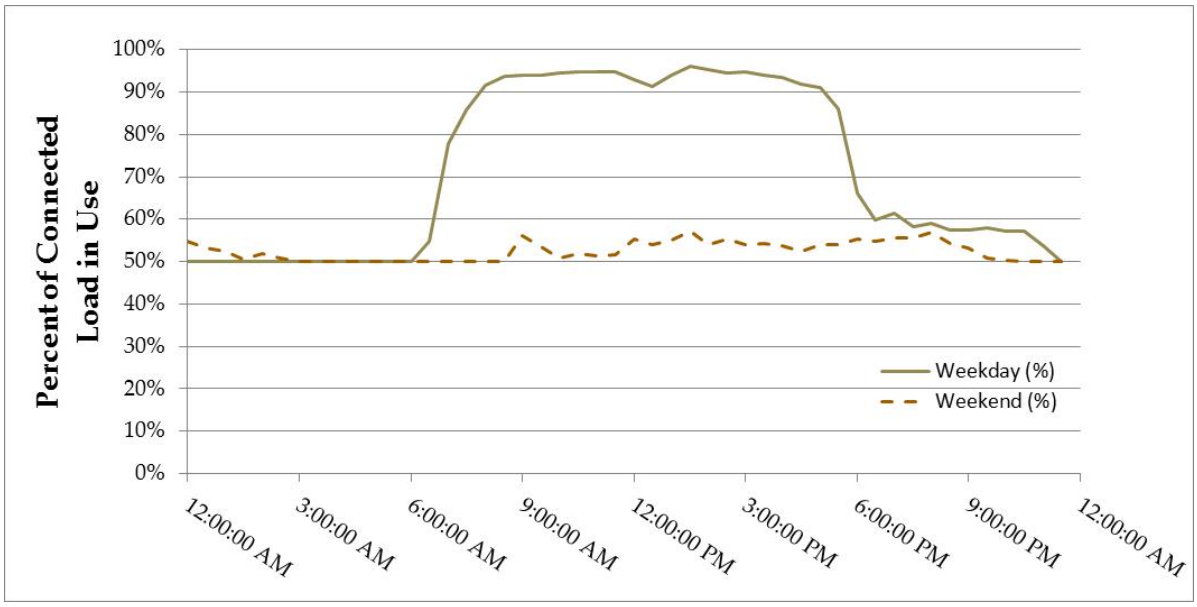
Site	Ex Ante kWh	Ex Post kWh	Realization Rate
1	16,415	12,924	79%
2	120,172	129,606	108%
3	5,301	5,730	108%
4	135,296	158,507	117%
5	3,388	3,744	111%
6	6,070	6,070	100%
7	3,260	3,260	100%
8	41,045	41,045	100%
9	14,790	14,790	100%
10	15,060	12,009	80%
11A	30,120	27,525	91%
11B	67,770	54,540	80%
12	960,000	TBD	TBD
13	68,707	115,491	168%
14	21,502	27,109	126%

3.2.1 Site 1

Site 1 is a mid-rise office tower. The energy efficient measures installed at Site 1 include occupancy sensors controlling 67 bi-level, linear fluorescent luminaries located in six stairwells. These fixtures are bi-level (two independently switched lamps) because egress and safety requirements necessitate that at least one of the two lamps remain in operation at all times.

Navigant's analysis of Site 1 included visual inspection of the lighting system and deployment of temporary HOBO data loggers to monitor general lighting operation trends. Primary data collection was conducted for a period of 4 weeks and the resulting log was consolidated in to two daily use profiles covering both weekday and weekend occupancy patterns.

Figure 1. Site 1 Daily Use Profile



The site specific daily use profiles shown in Figure 1 are combined with wattage information for the stairwell luminaries and extrapolated to calculate annual energy use. The lighting fixtures were replaced at the same time the occupancy sensors were installed. However, because this project's incentive was based solely on the additions of the occupancy sensors, baseline performance is calculated use the wattage of the new fixtures and assuming continuous operation for 8760 hours per year.

Ex ante savings for Site 1 is 16,415 kWh/yr; *ex post* savings are 13,411 kWh/yr, resulting in a gross realization rate of 82%. The downward shift in savings attributable to this project is primarily due to the bi-level switching arrangement. Hypothetically, the realization rate would have been 122% if the stairwell lighting system followed the same, verified use profile but were switched off completely when the space is unoccupied.

Table 4. Site 1 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Lighting Occupancy Sensors	16,415	12,924	79%

3.2.2 Site 2

Site 2 is a low-rise office and research campus. The energy efficient measures installed at Site 2 include 26 outdoor LED accent lighting lamp replacements and 72 LED fixtures used for general parking-lot illumination. The operation of these fixtures is controlled by a photocell.

Navigant's analysis of Site 2 included visual inspection of the retrofit lighting fixtures and an attempt to recover lighting trends from the site's building energy management system (EMS). Functional, recent lighting trends could not be obtained from the EMS system at this site. Therefore, lamp run time was estimated using a typical meteorological year (TMY)[1] data set and an assumed photocell on/off trigger point of 100 lux.

Wattage information for the superseded metal halide lamps and energy efficient LED replacements is used to calculate baseline and retrofit demand (kW) values. Annual kWh energy savings are determined using these demand values in conjunction with the TMY generated lamp run times mentioned above.

Ex ante savings for Site 2 are 120,172 kWh/yr; *ex post* savings are 129,606 kWh/yr, resulting in a gross realization rate of 108%. The increase in verified gross savings is attributed, in part, to differing baseline wattages. *Ex ante* savings appear to be based on the original lamps' rated wattages, whereas the *ex post* baseline wattages are from Appendix B of the Commercial Retrofit – Demand Response (CR-DR) manual. Additionally, *ex ante* savings assume lighting run times based on 12/day use assumption (4,380 hr/yr). Review of the typical daily solar patterns provide a suggested annual run time of 4,502 hours.

Table 5. Site 2 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Outdoor LED Lighting	120,172	129,606	108%

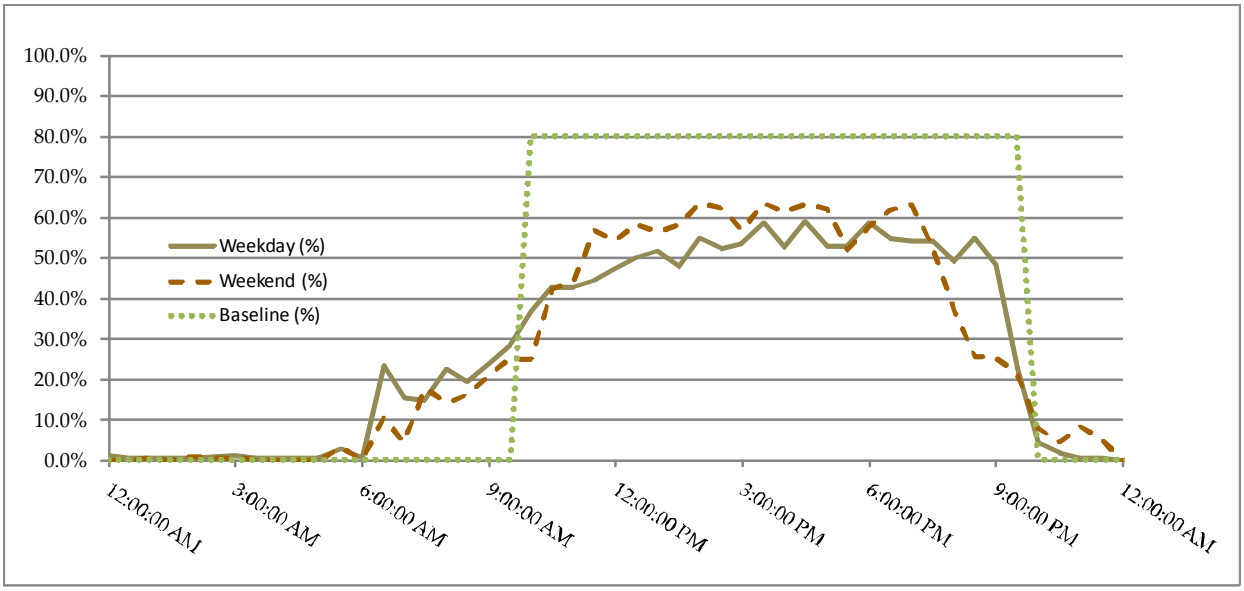
3.2.3 Site 3

Site 3 is a retail clothing store that installed 16 occupancy sensors in fitting rooms and storage areas to automate the on/off switching of lights dedicated to those spaces. The total connected lighting load associated with these spaces is 2.95 kW.

Navigant's evaluation of this project involved visual confirmation of sensor installation, assessment of the connected lighting load, and the deployment of temporary HOBO data loggers to monitor lamp switching behavior. Primary data collection was conducted for a period of 4 weeks and the resulting log was consolidated in to two daily use profiles covering both weekday and weekend occupancy patterns.

[1] TMY data sets are amalgamations of selected monthly climate measurements complied by the National Renewable Energy Lab (NREL). These regionally representative weather profiles are available from: www.nrel.gov.

Figure 2. Site 3 Daily Use Profile



The site specific daily use profiles shown in Figure 2 were combined with wattage information for the fitting room lighting clusters and extrapolated to calculate annual kWh energy use. Baseline energy use was calculated assuming the same fixtures were operated in conjunction with store occupancy, 10AM to 10PM daily, 4,380 hours per year. A lighting diversity factor[2] of 80% was applied to the occupied periods of the baseline load profile to account for some intermittent switching off of lights by staff and/or customers. The baseline for site 3 does not need to account for security lighting because those fixtures operate independently from the sensor controlled lighting loads.

Ex ante savings for Site 3 is 5,301 kWh/yr; *ex post* savings are 5,730 kWh/yr, resulting in a gross realization rate of 108%. This project's performance, better than deemed expectations, are attributed to the long daily run time applicable to the baseline and the elevated lighting power density typical of retail businesses and noted in these well-lit fitting rooms.

Table 6. Site 3 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Fitting Room Lighting Occupancy Sensors	5,301	5,730	108%

[2] Diversity factor is similar to a "coincident peak factor" or any other ratio that illustrates the portion of an end-use that is in use over a specified period. In the case of a coincident peak factor, this would reflect the specific time frame when a utility's peak use is expected. In the case of a general diversity factor, the multiplier reflects the portion of a load that is expected to be in use at any given point during the timeframe a space is typically occupied.

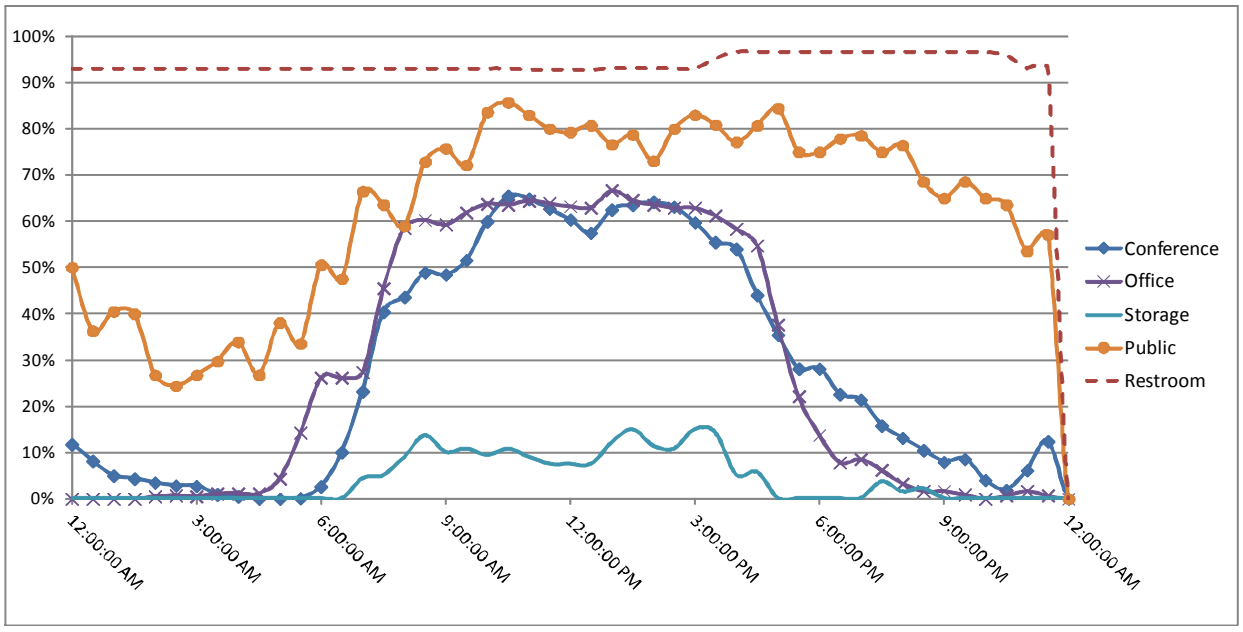
3.2.4 Site 4

Site 4 is a large healthcare facility that provides both in-patient and out-patient care. Lighting controls via occupancy sensors were installed in an extensive number of public, shared or lightly occupied spaces throughout the multi-building campus (e.g. in patient waiting rooms, restrooms, conference rooms, utility/mechanical closets, and employee lounge areas). An added component of this lighting system retrofit was the replacement of fixtures containing 900-T12 lamps; these fixtures were replaced with more efficient T8 luminaires.

Navigant's evaluation of the occupancy sensors involved visual confirmation of sensor installation, assessment of the connected lighting load, and the deployment of temporary HOBO data loggers to monitor lamp switching behavior. Navigant's evaluation of the lamp retrofit consisted of a visual inspection and count of the luminaires controlled by the occupancy sensors, as well as an inspection of lighting fixtures in a subset of adjoining rooms. This generalized overview approach was taken because the project's supporting documentation does not indicate which specific lamps were replaced from among Site 4's extensive lighting system. In no instance were T12 lamps noted at Site 4.

Primary data collection was conducted for a period of 4 weeks and the resulting trends were consolidated in to five pairs of daily use profiles covering both weekday and weekend occupancy patterns for each of the following primary space types: conference/employee lounge; office; storage/utility; public/waiting areas; and restrooms. Figure 3 shows the logged weekday load profiles.

Figure 3. Site 4 Logged Lighting Profiles, by Space Type



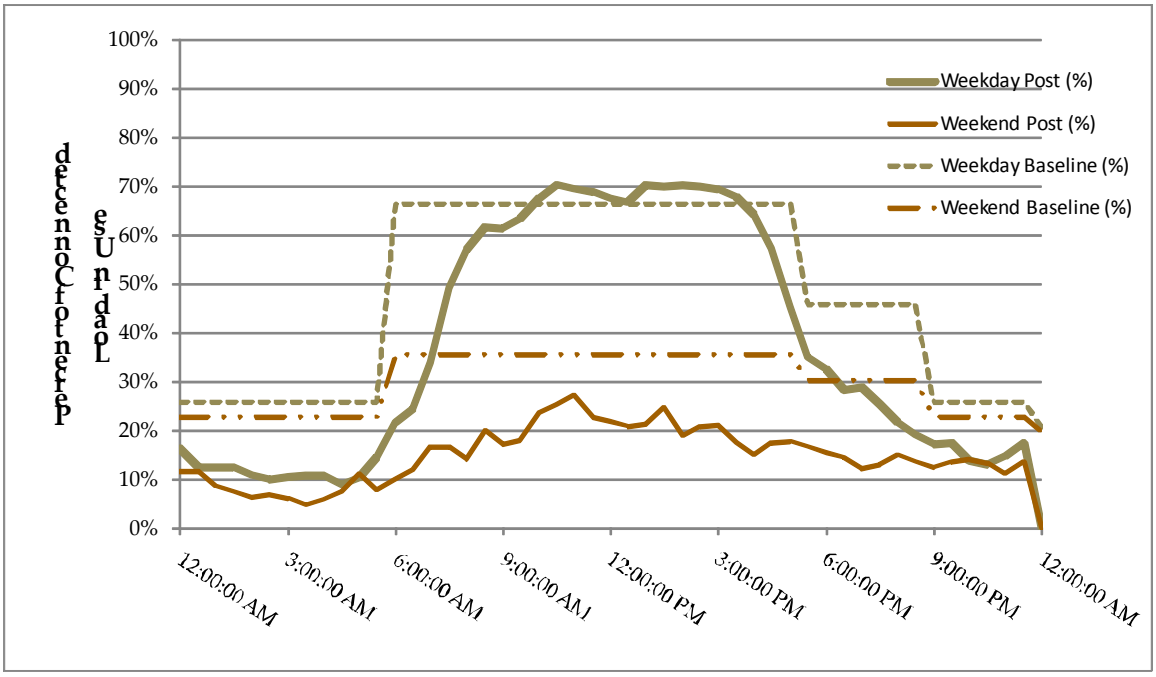
The lighting trends shown in Figure 3 were used to help inform the appropriate baseline assumptions for this site, provided in Table 7.

Table 7. Site 4 Baseline Daily Use Profile

		Conference	Office	Public	Restroom	Storage
Weekday	Occ. Start Time	6:00 AM	6:00 AM	12:00 AM	12:00 AM	6:00 AM
	Occ. Stop Time	9:00 PM	5:30 PM	11:59 PM	11:59 PM	9:00 PM
	Occupied % On	60%	90%	95%	95%	25%
	UnOcc % On	15%	10%	50%	90%	10%
Weekend	Occ. Start Time	6:00 AM	6:00 AM	12:00 AM	12:00 AM	12:00 AM
	Occ. Stop Time	9:00 PM	5:30 PM	11:59 PM	11:59 PM	11:59 PM
	Occupied % On	35%	30%	70%	90%	10%
	UnOcc % On	15%	10%	40%	90%	10%

Note that the percentages noted as "Occupied % on" in Table 7 reflect the diversity factor associated with the use of a given space type during the period contained by the stated start/stop times. Baseline energy use is calculated assuming the observed fixtures were operated with the diversity factors and on/off times noted in Table 7. The five space-specific daily use profiles were combined with associated load estimates for the given space type, see Figure 4, and extrapolated to calculate annual kWh energy use for the updated lighting system.

Figure 4. Daily Lighting Use Profiles for Site 4, Wattage Weighted



Final savings estimates for Site 4 are provided in Table 8.

Table 8. Site 4 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Occupancy Sensors	98,396	121,607	124%
Lamp Replacement	36,900	36,900	100%

3.2.5 Site 5

Site 5 is a food service establishment that replaced 85 linear feet of gasket on the doors of reach in coolers. Navigant's evaluation of the gasket replacement at this location consisted of a visual inspection of the gaskets, measurement of gasket length, temperature measurements of the case contents and surroundings, and an open ended customer satisfaction survey.

Total gasket length installed at site 5 was 10% greater than claimed. However, 20% of the gasket installed does not seal properly and the door opens with minimal resistance. The combination of these two adjustments results in 88.4% of the gasket length claimed as verified and fully functional.

It is not possible for Navigant to confirm the incremental shift in efficiency between the pre-existing, baseline gasket and the portion of gasket that was installed though the CAP program but not operating at peak potential. Therefore, given that the underperforming gasket is only 4.4% of the total gasket length reviewed as part of this evaluation sample, Navigant suggests that savings per unit length for this measure remain 100% of the deemed savings. This suggestion is reasonable as the result is well within the statistical precision of both the Navigant sample and the input assumptions used to determine the deemed savings for the measure.

Ex post savings for this site reflect verified gasket length and deemed saving per unit length and equal 3,744 kWh per year. The realization rate for Site 5 is provided in Table 9.

Table 9. Site 5 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Commercial Refrigeration	3,388	3,744	110%

3.2.6 Site 6

Site 6 is a liquor store that replaced 33.5 linear feet of gasket on the doors of reach in beverage coolers, added an auto closer to one of those cases, and added strip curtains to the door of their walk-in cold storage space.

Navigant's evaluation of the gasket replacement at site 6 consisted of: inspection of gaskets and auto-closer, measurement of gasket length, temperature measurements of the case contents and surroundings, and an open ended customer satisfaction survey.

The length of gasket installed and dimensions of the walk-in door match those claimed on the CAP application. Also, the auto-closer was found to be working properly. Thus *ex post* savings for site 6 are 100% of the deemed savings for these measures: 6,070 kWh per year. The realization rate for Site 6 is shown in Table 10.

Table 10. Site 6 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Commercial Refrigeration	6,070	6,070	100%

3.2.7 Site 7

Site 7 is a flower shop that replaced 74 linear feet of gasket on the doors of reach in display cases. Navigant's evaluation of the gasket replacement at site 7 consisted of: inspection of the gaskets, measurement of gasket length, temperature measurements of the case contents and surroundings, and an open ended customer satisfaction survey.

During Navigant's on-site review, the customer mentioned feeling that the installer did not do a good job and that some items from a subsequent project were still outstanding. The installer was described as "knowledgeable" but "unprofessional." The customer's belief is that the installer "didn't want to do the work properly." It is unclear if this is the same installer that worked at site 5.

Per Navigant's inspection, the length of gasket installed at site 7 matches the value claimed on the CAP application and the seal provided by the gaskets related to this project met expectation. Therefore, *ex post* savings for this site are 100% of the deemed savings for this measure: 3,260 kWh per year.

The realization rate for Site 7 is provided in Table 11.

Table 11. Site 7 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Commercial Refrigeration	3,260	3,260	100%

3.2.8 Site 8

Site 8 is a small food market that replaced 337 linear feet of gasket on the doors of reach in coolers and freezers. Site 8 also added a strip curtain to the door of their walk-in cold storage room and installed night covers along 177 linear feet of refrigerated display cases.

Navigant's evaluation of the refrigeration retrofits at site 8 consisted of: inspection of gasket condition, measurement of gasket length, inspection of the night covers and strip curtain, and an employee interview to confirm manual operation of the night covers.

The dimensions and condition of all equipment serviced at site 8 was found to be as expected with the exception of the walk in cold storage room. This space differs from standard walk-in coolers in several notable ways, including:

- The space is a repurposed storage room, not a conventional, metal-clad food service walk-in.
- Although not directly measured, the insulation that should be providing a thermal division between the storage room and ambient conditions is believed to be substandard.
- The entryway to the storage room has double swinging doors that poorly fit the opening they occupy; large gaps can be seen on all sides of the opening, even with the doors closed, Figure 5.
- Despite the addition of strip curtains, air infiltration into this cold storage room is expected to be greatly in excess of that experienced by industry standard walk-ins due to the poorly fitting doors and other details listed above.

Figure 5. Strip Curtains at Site 8

Navigant is confident that the strip curtains installed at Site 8 are having a more significant impact, reducing overall infiltration than typically expected for this measure. This leads to increased savings; however, the extended, seasonally relevant monitoring required to fully assess the impacts of strip curtains in such an atypical setting is beyond the scope of this evaluation effort.

Given that the length of gasket installed and dimensions of the walk-in door match those claimed on the CAP application, and the verification of employees related to consistent, daily use of the night covers, *ex*

post savings for site 8 are considered 100% of the deemed savings for these measures: 41,045 kWh per year.

The realization rate for Site 8 is provided in Table 12.

Table 12. Site 8 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Commercial Refrigeration	41,045	41,045	100%

3.2.9 Site 9

Site 9 is a 16,000 sqft, two story office building that installed window films to reduce passive solar heat gain. The total impacted window area for this project is 872 square feet.

Of the 872 sqft of window film installed: 73% is on glazing facing southwest, the primary aspect of concern for curbing peak demand; 23% is on the northwest aspect covering only half of the windows on that side of the building (the northwest aspect contributes significantly less towards overall solar heat gain); and the remainder, 4%, is on glazing oriented to the southeast, marginally useful for controlling building loads.

Navigant's evaluation of the window film project at site 9 involved physical measurement of the window area impacted, assessment of window orientation, and an analysis of recent electric billing history for the building. Although a billing analysis would have been preferred for assessing the impacts of this measure, a recent change over in occupancy has precluded that approach. Therefore, *ex post* savings for site 9 are based on the deemed savings per unit area for this measure and total 14,835 kWh/yr, indicating an overall reduction in site level energy use of 6%.

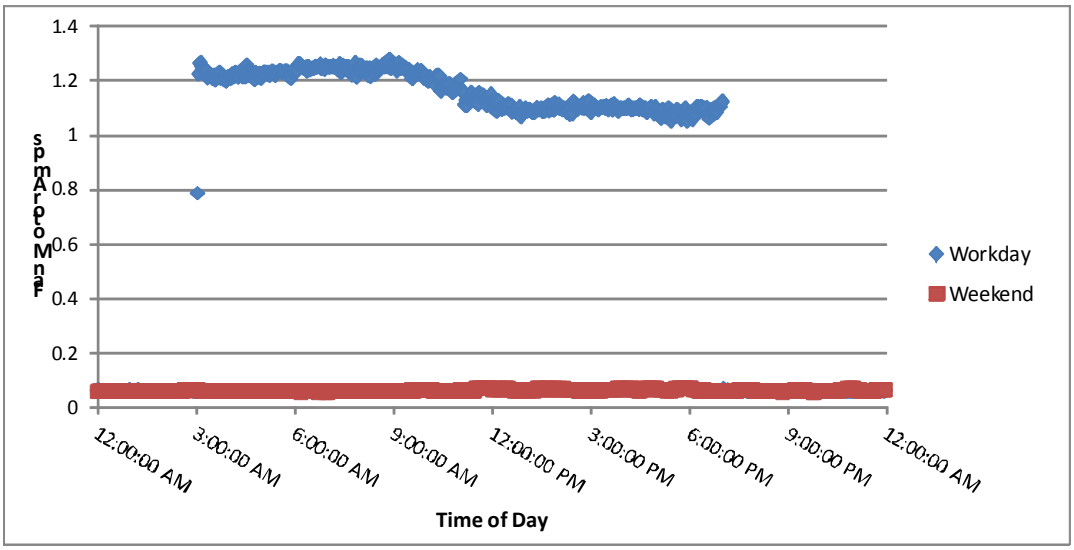
Table 13. Site 9 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Commercial Prescriptive HVAC	14,835	14,835	100%

3.2.10 Site 10

Site 10 is a research facility that installed a variable frequency drive (VFD) on a 20 HP supply air ventilation fan. Navigant evaluated this project through staff interviews, spot measurement of fan energy use and power factor, as well as short term monitoring current using a HOBO data logger. The HOBO data shows clear daily and weekly use patterns that are extrapolated to calculate annual energy consumption. Baseline energy use is determined by applying on/off switching patterns determined through the HOBO data analysis.

Figure 6. Site 10 Daily Use Profile of 20HP Fan Motor



Navigant's spot measurements and HOBO trends indicate that the supply fan associated with this project is significantly under-loaded; the fan is consistently operating below 60% of full speed. This under-loading is accounted for when backing out the motor's baseline power consumption via the fan affinity law[3].

Ex post savings for site 10 is 12,009 kWh/yr, with an associated realization rate of 80%. The variance between claimed and realized savings is due to the lack of night or weekend fan operation. The realization rate would be 95% if, under pre-retrofit conditions, this fan had been cycled on for at least 6 minutes per hour during off peak times.

Table 14. Site 10 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Commercial HVAC VFD	15,060	12,009	80%

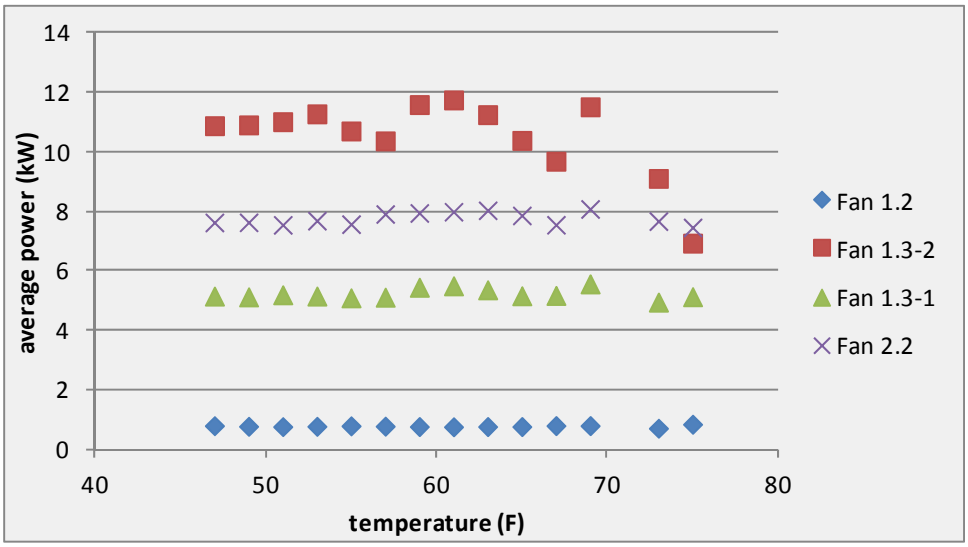
[3] Affinity law: $\left(\frac{n_1}{n_2}\right)^x = \left(\frac{p_1}{p_2}\right)$, where: n = speed; p = power; x ranges from 2 to 3 depending on conditions.

3.2.11 Site 11

Site 11 consists of two buildings containing primarily office areas. The facility installed variable frequency drives on four ventilation fans as two separate projects. Two of the fans were 25 HP units and two were 40 HP. The facility was typically occupied from 6:00 AM until 7:00 PM Monday through Friday, although occasional night and weekend use occurred as well. The *ex ante* savings were based on deemed savings for prescriptive installation of VFDs on HVAC fans.

After the VFD installation, the fans primarily operated around 45-50 Hz constantly when the building was occupied and were off during unoccupied times. As shown in Figure 7, only one of the larger fans showed any variation in operation with temperature, and that variation was minimal. The pairs of fans with similar sizing showed substantially different loading levels, resulting in the differences in observed power usage.

Figure 7. Site 11 Air Handling Fans – Occupied Times



Because of the limited evidence of temperature dependence for fan operation, the operational hours and average fan power were used to calculate savings. Because of the minimal dependence on outside air temperature, a straight average was used to determine savings. The baseline conditions assume airflow from the existing fans was regulated using dampers instead of VFDs and operation at full speed during occupied hours. Full load operation was estimated using spot measurements and the fan affinity law. The baseline systems were assumed to be shut off at the same times as the VFDs; allowing for occasional weekend usage, this results in 3,640 hours of use per year.

The resulting savings are shown in Table 15. Differences in fan loading result in the widely varied realization rates, but overall low realization rate is primarily due to short operational hours at the facility. Variations in the realization rates are primarily due to fan loading, which reduces both the baseline and retrofit energy use.

Table 15. Site 11 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Fan 1.2	30,120	26,759	89%
Fan 1.3-1	18,825	8,205	44%
Fan 1.3-2	18,825	19,321	103%
Fan 2.2	30,120	27,781	92%

3.2.12 Site 12

Site 12 is a water treatment plant, which installed new dissolved oxygen (DO) sensors and controls. The facility has four tanks, each with a single DO probe providing continuous feedback to the onsite monitoring systems. The facility's three blowers (numbered 1, 3, and 5) were previously controlled according to the lowest DO reading in any of the tanks. In addition, a minimum blower output limited how low the airflow could be set. Blower 5 is designed to handle the base load, with blowers 1 and 3 to provide additional flow. However, prior to this project, the facility did not have incremental control for blowers 1 and 3, so the facility used all three blowers at higher capacity than necessary. The DO level in individual tanks was frequently as high as 5.0 mg/l, when only 2.0 mg/l were expected be necessary, indicating significant overuse of the blowers.

Navigant reviewed the project file and found the assumptions to be reasonable. However, due to substantial delays in startup, this system was still being tuned as of the date of this report. Data from the facility showed the energy use dropping and DO levels around 2 mg/l in each tank by the beginning of February. After reaching these levels, the facility has continued tuning the system to maintain these levels while using fewer blowers. Data from the facility monitoring systems show blower 3 shut off since early February and blower 1 use slowly decreasing since that time. A steady drop in total blower power has been taking place since February 11, however the last data available for this report were gathered on February 15, so the final power use was not yet known.

Navigant estimated the baseline power use for the three blowers at 3,920,000 kWh/year, slightly higher than the 3,880,000 kWh/year estimated in the analysis provided prior to project implementation. The pre-installation analysis estimated that reducing average DO to 2.5 mg/l would reduce power use to 2,920,000 kWh/year. Navigant found that the current DO levels were closer to 2.1 mg/l, but that the facility had not yet optimized blower use to reduce power. As of February 15 energy use appeared to still be dropping, however if use that day were to become the final blower use, annual energy use could be expected to be 3,620,000 kWh/year, corresponding to annual savings of 300,000 kWh, a 31% realization rate. Based on the available data, Navigant believes the final system control setpoints will provide substantially higher savings, however it is not possible to accurately predict the final savings value.

Table 16. Site 12 Electric Savings as of February 15, 2012

Project	Ex Ante kWh	Ex Post kWh as of Last Available Data	Realization Rate as of Last Available Data
DO Controls	960,000	298,671	31%

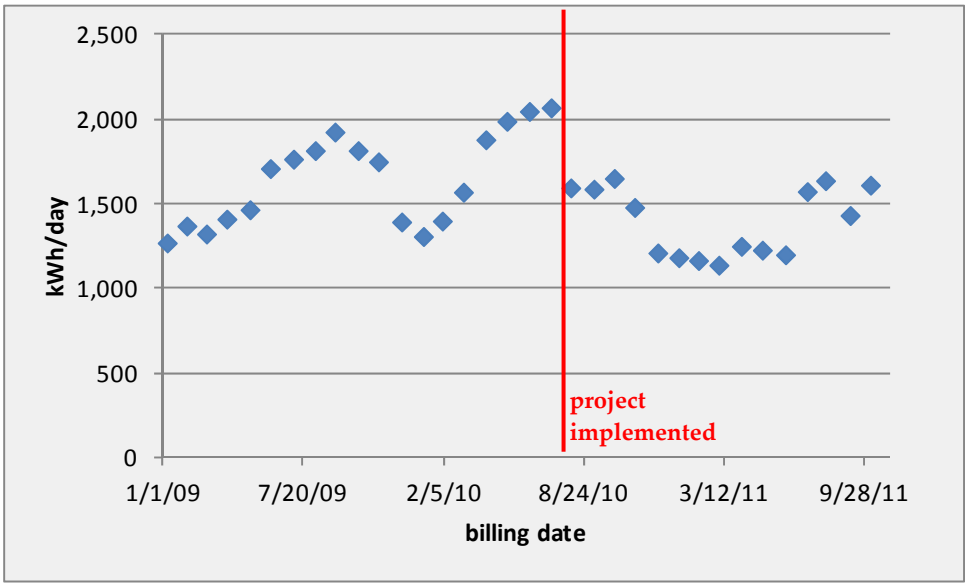
The savings shown in Table 16 are based on the most recent data available, but because this is expected to change as the controls are fully optimized this realization rate has not been included in the overall savings for FY 2011. Because this project is so far behind its original completion date, Navigant and the City of Palo Alto Utilities agree that its savings should be re-evaluated in the next program cycle as part of the FY 2012 impact evaluation.

3.2.13 Site 13

Site 13 is an office building which underwent recommissioning in the summer of 2010. This affected most of the building's major systems, including cooling, heating, airflow, hot water, static pressure set points, and economizer usage. The site claimed savings for both electric and gas; gas savings are discussed in section 3.4.1 below.

The building has not undergone any major occupancy or use changes since 2008, although the company is slowly adding staff. Since there were no changes in square footage or operations, Navigant used IPMVP Option C to calculate savings using billing data for both electric and gas. Figure 8 shows the electric usage for the site, which dropped noticeably at the time of the recommissioning in the summer of 2010. Figure 8 shows electric savings are most dramatic during summer months.

Figure 8. Site 13 Electric Usage



Using weather data for the nearby San Jose airport, Navigant created trends of daily electric usage as a function of average monthly temperature before and after the project. Typical annual savings are estimated by normalizing the temperature dependent consumption to typical meteorological year (TMY3) data for the same airport.

This normalization showed that the baseline configuration would have used 595,962 kWh in a typical year and the recommissioned system uses 480,471 kWh in a typical year. This results in annual savings of 115,491 kWh, 168% of the claimed value.

Table 17. Site 13 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Recommissioning	68,707	115,491	168%

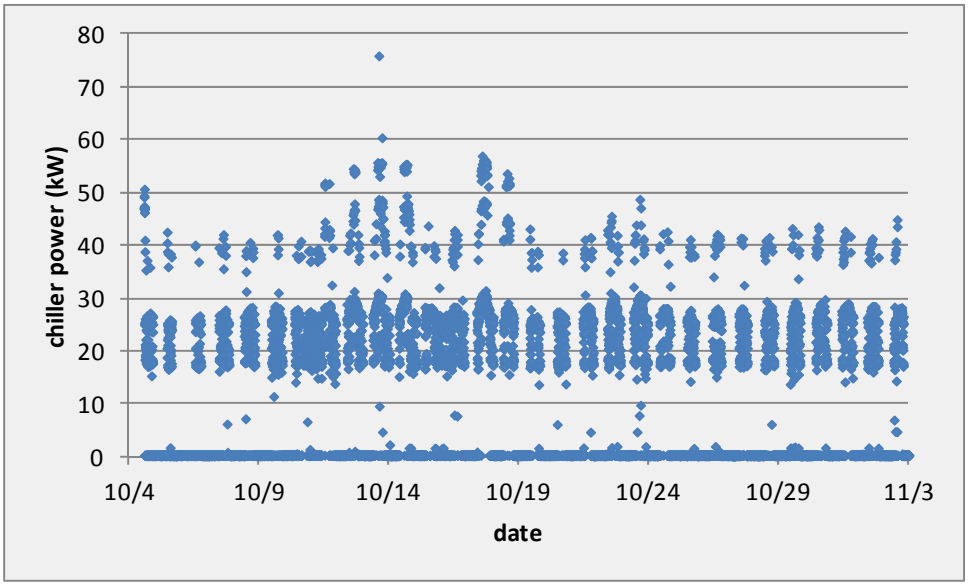
3.2.14 Site 14

Site 14 is an administrative building and medical clinic. The facility replaced both its 66.5 ton chiller and 7.5 ton air conditioner in prescriptive projects. Site 14 also claimed gas savings for a boiler replacement, which is discussed in section 3.4.2, below.

The new chiller had an IPLV (COP) of 3.9, as opposed to the Title 24 minimum of 3.05. However, the newly installed air conditioner had an EER of only 11, which is less than the Title 24 requirement of 11.2 for installations after January 2010.

Navigant visited the site, took spot measurements and logged current usage on both the chiller and air conditioner. Figure 9 shows the energy use for the chiller, which clearly varies with time of day. Navigant calculated chiller energy use over the range of observed temperatures, during times when the unit was in use, and normalized the usage to typical weather data (TMY3). The chiller showed an unusual use profile, increasing at temperatures above 75 °F, but also below 60 °F. It would take significantly more information to determine the reason for the low temperature increase in chiller usage, but it was assumed that the use profile would hold in the baseline case as well.

Figure 9. Site 14 Chiller Electric Usage



Based on logged data, the chiller would use 97,275 kWh annually, compared to 124,384 kWh for a Title 24 baseline chiller under the same conditions. The resulting savings are 27,109 kWh/year, 175% of the deemed savings claimed. No savings are credited to the air conditioner, since it does not meet the baseline efficiency standard.

Table 18. Site 14 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Chiller	15,494.5	27,109	175%
HVAC unit	6,007.5	0	0%

3.3 *Enovity*

Savings for each site in the Enovity Program sample are listed in Table 19 below.

Table 19. Enovity Savings

Site	Ex Ante kWh	Ex Post kWh	Realization Rate
15	123,400	53,070	43%
16A	164,700	121,960	74%
16B	459,300	381,308	83%
16C	203,200	144,613	71%
16D	218,400	244,309	112%

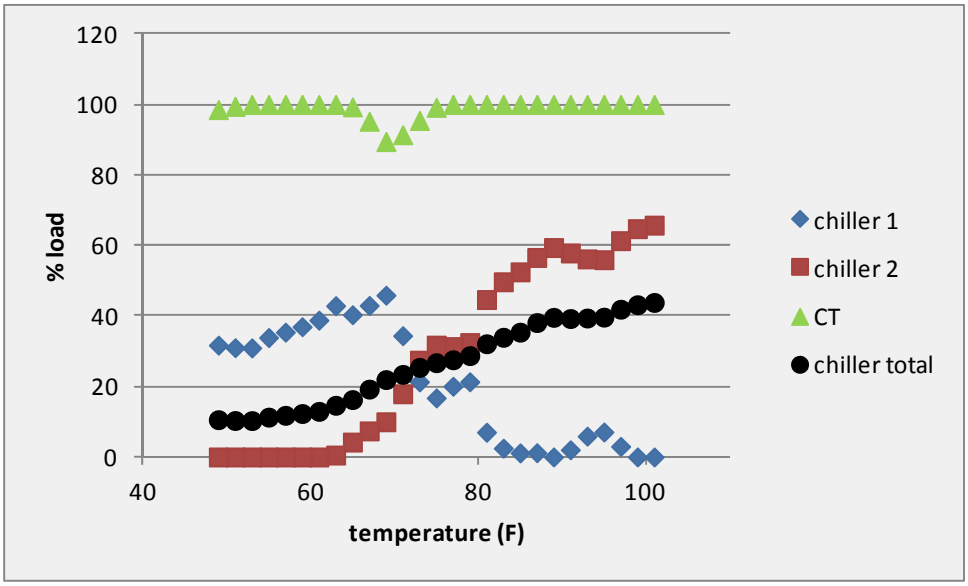
3.3.1 Site 15

Site 15 was a medical device manufacturing facility. The facility has 2 chillers: Chiller 1 is a 400 ton chiller which was installed for this project, replacing an older oversized less efficient 800 ton chiller. Chiller 1's cooling tower was replaced at the time of this project to accommodate the size reduction. Chiller 2 is an existing 800 ton centrifugal chiller which was not directly affected by this project.

A detailed study was performed prior to the project installation, followed by a detailed verification prior to issuing the incentive for the project. This evaluation, showed *ex ante* savings of 123,400 kWh/year for the project.

Navigant employed a combination of IPMVP Options A and B to evaluate the savings. Navigant took spot measurements to asses cooling tower and chiller energy use. Navigant also installed temporary current loggers on both pieces of equipment. In addition, the facility provided trend logs for both chillers and the cooling tower detailing operation for three months prior to the site visit. Navigant used the spot measurements to calibrate the facility trend logs, and to convert the logger measured current to power for the equipment. The facility's cooling operations are shown in Figure 10.

Figure 10. Site 15 Cooling Operation



The cooling tower operated at full capacity during most of the monitoring period, although it dropped slightly at both low and mid-range temperatures. This was consistent with facility staff comments suggesting that, post-retrofit, the cooling tower is operating at full capacity in order to supply the lowest water temperature possible to the chillers, thereby minimizing the overall system load.

The usage drop at the midrange of total system capacity coincides with the transition from the new 400 ton to the older 800 ton chiller at elevated outdoor air temperatures. The 800 ton unit (Chiller 2) becomes primary above around 75 °F, as shown in Figure 10. During the initial project verification, this use of Chiller 2 as primary at high temperatures did not appear to be the taking place. Consequently, the hours of operation for Chiller 1, are lower than observed when the incentive was issued.

Navigant assumes that the changes to operation schedules for the chillers would have occurred with a Title 24 baseline chiller as well. Based on a regression of weather dependent system performance, normalized to TMY3 data, Chiller 1 will use 349,148 kWh/year. Based on trend logs and Navigant's spot measurement, the full load cooling tower energy use is 20.55 kW and its total annual electricity use is 166,866 kWh/year.

Since both the cooling tower and chiller were very old, Title 24 is the baseline for the replacement of this equipment. The baseline chiller would have a COP of 6.10, or 0.576 kW/ton, compared to the new chiller at 0.5 kW/ton, for baseline usage of 402,218 kWh/year under the current conditions. The cooling tower meets, but does not exceed, Title 24 requirements and so no savings can be attributed to it.

The resulting savings of 53,070 kWh/year for this project is significantly less than the claimed savings of 123,400 kWh/year. The change results in substantially reduced savings for the project which has a realization rate of only 43%. The discrepancy is due to the reduced usage of Chiller 1 at high temperatures.

Table 20. Site 15 Electric Savings

Project	Ex Ante kWh	Ex Post kWh	Realization Rate
Chiller and cooling tower replacement	123,400	53,070	43%

3.3.2 Site 16

Site 16 is a large facility with test manufacturing, server rooms, and office areas. The site completed 17 projects which were filed on four separate incentive applications with CPAU. The projects are detailed in Table 21 at the end of this section.

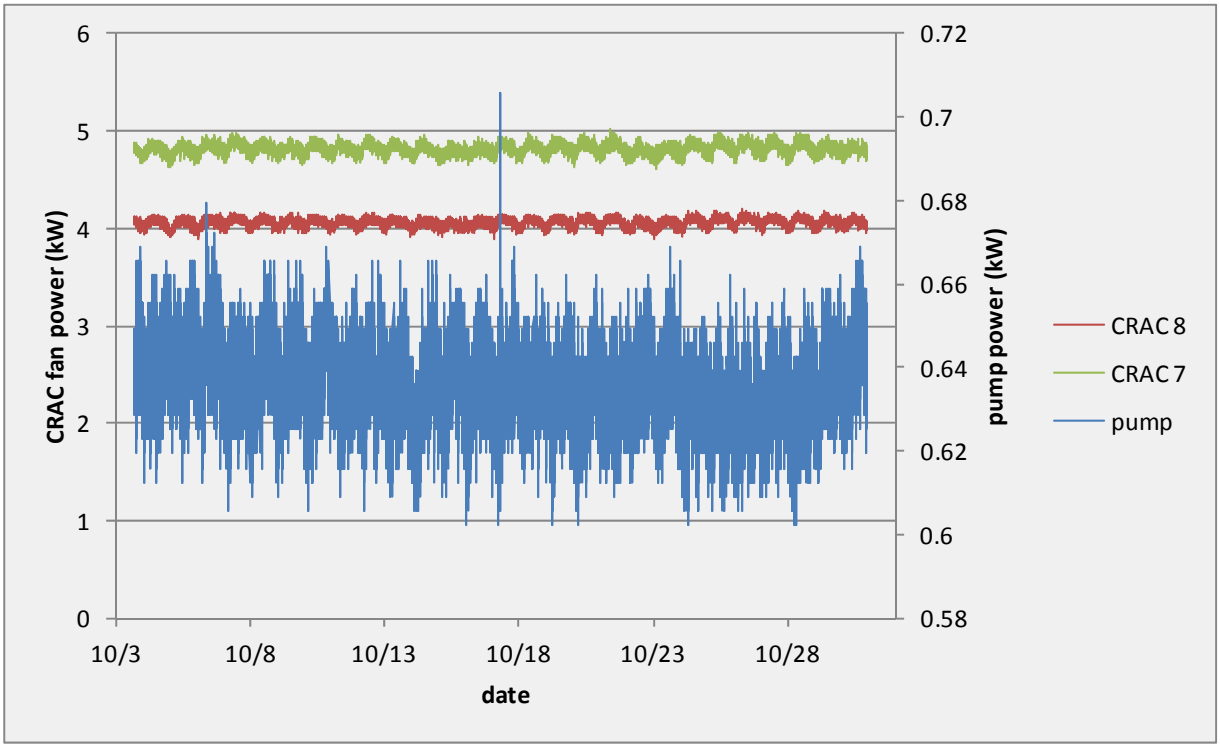
Project 16A

Project 16 A focused on computer room cooling and cleanroom air handlers. The project included:

- Upgrade of two computer room air conditioners (CRACs) and
- Removal of booster pumps from the chilled water loop in cleanrooms.

Navigant took spot measurements of the CRAC fans' power consumption; however since it was necessary to open the cabinet door in order to take the measurements, the fan usage measured was higher than it would be during normal operation. Navigant installed current loggers on both CRAC units and monitored their operation for four weeks. A single 5 HP booster pump with a VFD had been installed to support the CRACs, and its use was logged as well. The results are shown in Figure 11.

Figure 11. Site 16A CRACs



Navigant compared the total consumption of the CRAC fans and the new pump to the baseline provided in the project file, resulting in savings of 84,060 kWh/year, a 66% realization rate. The lower savings are the result of the fans being more heavily loaded than they were when the project was first installed. This is consistent with expectations as the computer room has added load since the installation.

The second project on this application is unrelated to the first. In the second project the facility removed six 1 HP booster pumps from the cleanroom air handlers. It was not possible for Navigant to independently confirm baseline energy consumption because the equipment was no longer in use. The project file provided measurements of the baseline consumption; Navigant accepts these as reasonable, resulting in *ex post* savings of 39,700 kWh/year and a 100% realization rate.

Project 16B

Project 16B included six measures. They were:

- lighting retrofit of 653 fixtures from T12 to T8;
- variable speed drives on 2 chilled water pump;
- addition of supply static pressure resets and VFDs on air handlers B1UW and B1UE;
- implementation of supply static pressure on reset air handler B1LW;
- economizer mode implementation on air handlers B1UW and B1UE;
- Implementation of operation schedules to shut off air handlers B1UE and B1UW during unoccupied periods.

The lighting retrofit portion of project 16B involved the replacement of 653 T12 fixtures with efficient T8 alternatives. The supporting documentation for this project does not provide a space by space breakdown of the areas impacted by the retrofit; therefore, Navigant staff interviewed facility staff and examined the lighting system throughout both buildings mentioned in the project description. Through this process it was determined that only a tiny portion of the lighting fixtures remain T12. The majority of the lighting system is located on the upper, day lit floor and is occupant controlled. The balance of the system is located on the lower level, below-grade and in near constant operation. The initial project proposal included the addition of occupancy sensors for a portion of the fixtures but that plan was not implemented.

Although this site has a computerized energy management system (EMS), facility staff was unable to provide operation trends related to specific zones known to have been part of the lighting retrofit. Therefore, Navigant's evaluation is based on observed lighting conditions, staff interview, and lighting trends collected via short term monitoring by the project implementer. Savings are calculated using CA deemed wattages for the pre-existing fixtures and a split in operating hours of 3,337 hours/yr (per implementer metering study) for 70% of the connected load and 8,760 hr/yr for the remaining fixtures. The extended hours are appropriate for the hallway and below grade mechanical spaces.

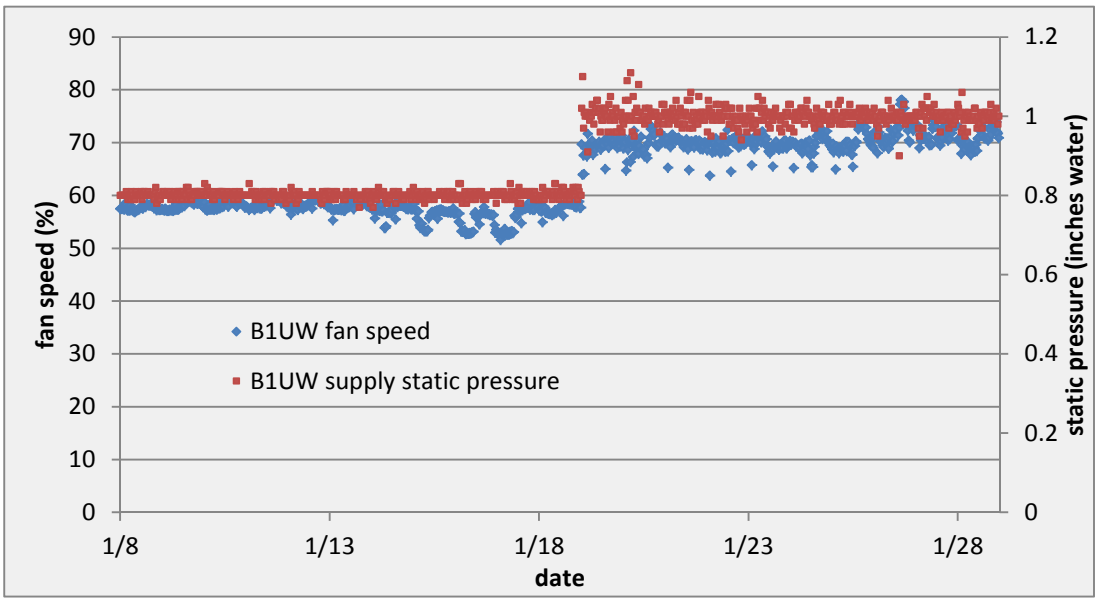
Verified savings for the lighting portion of project 16B is 120,587 kWh; providing a realization rate of 96% for this measure.

Project 16B also includes the installation of VFDs on two of the site's three chilled water pumps; both of the retrofit pumps are rated at 20 HP each. During the site visit, Navigant was unable to measure power consumption for these pumps as they were both off; only pump 3, which is a 25 HP constant speed unit, was operating. Chilled water pump 1 remained in bypass mode for the entire three weeks during which Navigant obtained trend logs from the facility. Chilled water pump 2 ran at 80% speed for 37.5% of the monitoring period, and was off for the remainder. Navigant used power data for pump 2 from the project file to estimate power use and baseline data for both pumps. In addition, based on the observed shutdown of pump 1 and typical maintenance schedules, Navigant estimated 10% downtime for the pumps in a typical year. This results in a realization rate of 90% for the measure.

As part of project 16B, the site adjusted static pressure set points for two air handlers, B1UE and B1UW, which serve the east and west portions of the upper level of the same building. Facility trend logs supplied by the site for both B1UE and B1UW show clear savings as the static pressure set point changes. Figure 12 shows the operation of fan B1UW and its static pressure set point over the logging period. Fan B1UW also showed speed changes as a function of outdoor air temperature, although this was not a strong effect. The speed of fan B1UE was relatively constant for each static pressure, without regard to temperature. During the monitoring period, the static pressure set point was 0.8 inches water for half the period and 1 inch water for the other half.

Fan B1UE showed similar, but not quite as clean, behavior as fan B1UW. Navigant accepted this as a typical breakdown and trended fan B1UW power usage as a function of outdoor temperature for both static pressures. Using TMY3 data, we normalized the usage to a typical year, and also calculated savings for fan B1LW based on average power at each static pressure. Navigant averaged the behavior at the two static pressures to obtain annual savings at 79% of the claimed value.

Figure 12. Site 16B B1UW Air Handler



As part of project 16B, the site implemented static pressure set point controls for air handler B1LW, which serves the west portions of the lower level of the same building as the other air handler changes. Facility trend logs show that the static pressure for fan B1LW stayed at a constant setting of 1.5 inches water during the logging period, which is higher than the typical reduced set point of 1.1 claimed in the project file. According to site personnel, air handler B1LW underwent fan replacements several months before Navigant's site visit, resulting in the 15 HP fan being replaced with a fan wall consisting of six 3 HP fans. It appears that the static pressure reset was also disabled at that time. Therefore, there are no longer any savings from this measure.

The economizers on air handlers B1UE and B1UW, which were enabled as part of project 16B, were both shown to be currently operating correctly according to facility trend logs. Prior to the project the economizers were not in use. The fan for air handler B1UE was operating for the entire logging period, but air handler B1UW was periodically turned off. Discussions with facility staff and examination of the trend logs indicate that this was most likely due to problems with the operating scheduling portion of this project, discussed in the paragraph below, which has now been disabled at colder outdoor air temperatures. Navigant was unable to obtain flow data for the fans, and therefore could not independently calculate energy savings from this measure. Based on a review of the project file, Navigant accepted the calculations used in the initial project evaluation. Since the economizers are still operating as planned, this project achieves a 100% realization rate.

Project 16B included introducing operating schedules to air handlers B1UE and B1UW. This was designed to reduce fan and heating energy use when the building is unoccupied at night and on weekends. The facility disabled the operating scheduling for B1UE and B1UW partway through the trending period. According to facility staff, the lack of reheat in the building caused problems when the

outdoor air temperature began getting below around 45 °F. Consequently, this measure is now disabled for around five months each year. Based on the trend data from the early part of the logging period normalized to TMY3 data excluding shutdown hours, Navigant estimated shutdown during the remaining months would still result in an 82% realization rate for the measure. In calculating this, Navigant accepted the project baseline usage for comparison to existing trend data.

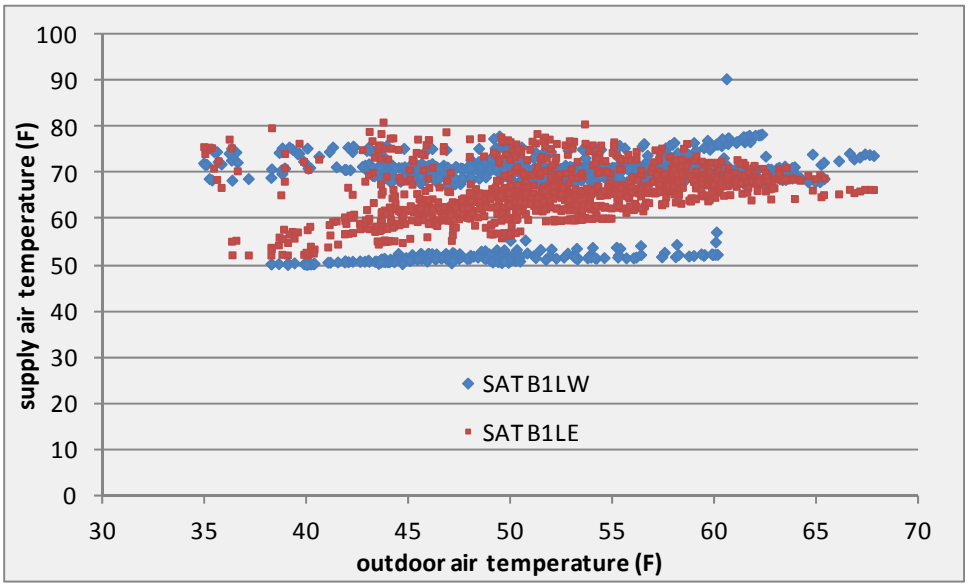
Project 16C

Project 16C consisted of four separate measures:

- supply temperature reset for air handlers B1LW and B1LE;
- increased chilled water temperature on chiller 3 from 42 °F to 44 °F;
- condenser water temperature reset on the cooling tower; and
- VFD installations on two condenser water pumps.

The supply air temperature for both B1LW and B1LE was modified to automatically adjust with outdoor air temperature in order to reduce cooling energy. Prior to the project the supply air temperature was set at 61 °F regardless of outdoor conditions. Based on trend data provided by the site, Figure 13 shows supply air temperature is a function of outdoor air temperature. As shown in the figure, B1LW also used a setback for times when the building was unoccupied. This operation was basically the same as that found at the time of the initial project verification. Since Navigant could not obtain adequate airflow details to estimate energy use directly, the measure savings were accepted based on a review of the project file, producing a realization rate of 100%.

Figure 13. Site 16C Supply Air Temperatures

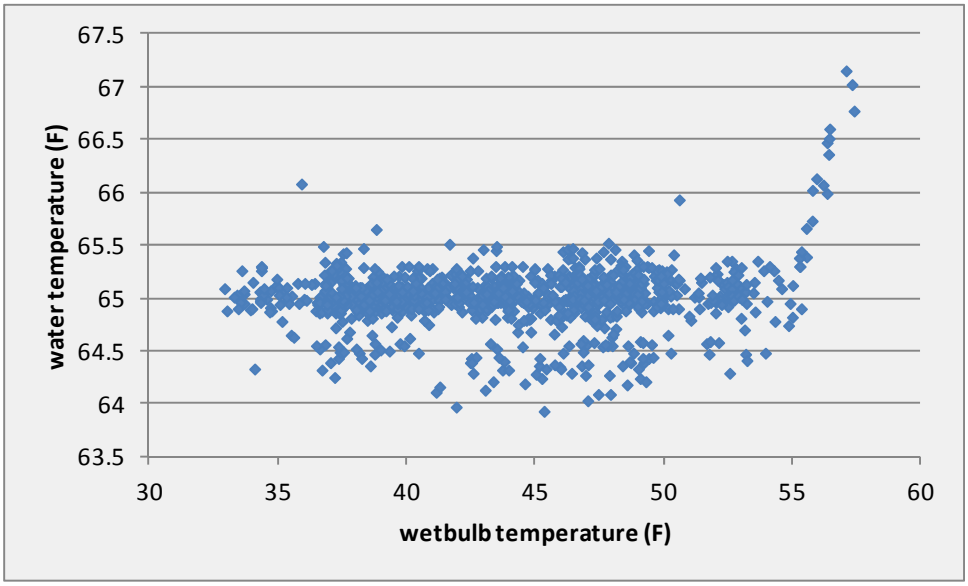


As part of project 16C, the chilled water temperature in chiller 3 was increased. Originally, chiller 3 employed a target temperature of 42 °F, which was used as the baseline temperature. The chilled water temperature on chiller 3 averaged 43.6 °F during the portion of the monitoring period for which it was

operating. This was slightly lower than original verification report showed at 44 °F, but still higher than the original target temperature of 43 °F. This results in slightly reduced savings and a realization rate of 80% on the project.

A cooling water reset was added to the cooling tower condenser as part of project 16C. The original system used a set point of 71 °F regardless of outside conditions. As shown in Figure 14 the cooling tower now uses a condenser temperature around 65 °F until it becomes too hot outside to maintain the low temperature. This is consistent with the verification report provided for the project. Without detailed facility operation details, which Navigant could not obtain, savings from this project cannot be accurately calculated. Consequently, the analysis provided in the project file was reviewed and accepted resulting in a realization rate of 100%.

Figure 14. Site Cooling Tower Temperature



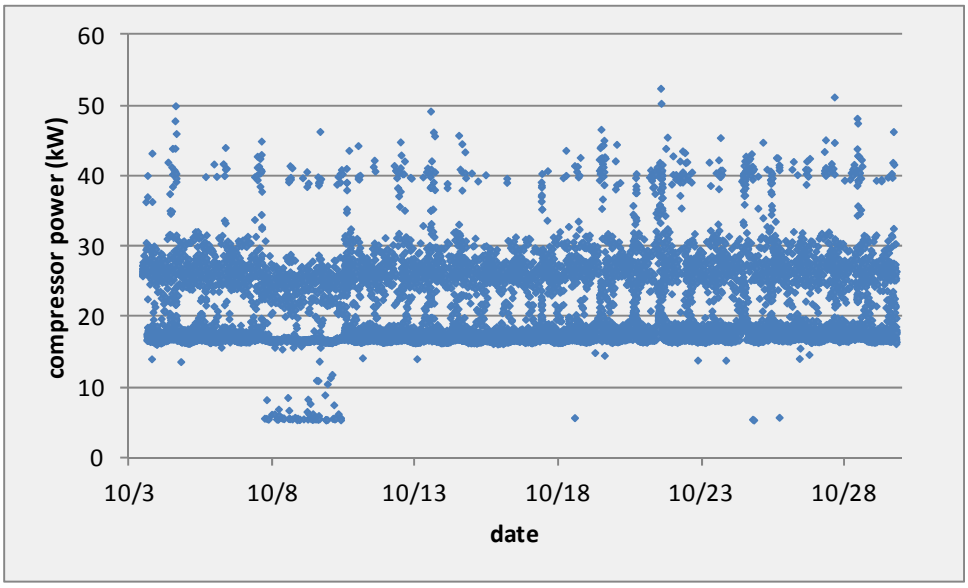
The final measure implemented in project 16 C was the addition of VFD controls to two condenser water pumps. During Navigant's site visit, it was found that condenser water pump 2 was off and condenser water pump 1 was operating at a constant 86.7% of full speed. Trend logs confirmed this operation. This is the same speed the pumps operated at prior to the project, indicating that the controls have been disabled. There are no savings for this measure.

Project 16 D included five separate efficiency measures:

- a new air compressor and dryer
- installation of a VFD on air handler B2UE
- implementation of economizers on air handlers B2LW and B2LE;
- duct static pressure reset on air handler B2LW;
- supply static pressure resets on air handlers B2LW and B2LE.

The facility replaced two Atlas Copco ZR55 air compressors with two ZR55 VSD model air compressors. At the same time, the facility replaced its refrigerated air dryer with a desiccant model. Navigant took spot measurements of power to the air compressors and dryer and monitored the compressor operation for four weeks. Since the two compressors are identical and run one at a time, Navigant only trended the operational unit, but the results are applicable to both compressors. The dryer operates at a constant 20 watts so there is no need to monitor its operation. Figure 15 shows the air compressor operation.

Figure 15. Site 16D Air Compressor



Navigant was unable to obtain CAGI (Compressed Air and Gas Institute) data for the new compressor, but estimated airflow from measured power based on available specifications, and used this to estimate baseline power use with CAGI data for the old compressor. The air compressor was operating at 124 psig during the site visit; Navigant used CAGI data for 131 psig for the baseline system and specifications for 125 psig for the new compressor. Based on this, project savings including both the compressor and dryer, are 122,025, a 103% realization rate.

As part of project 16D, the site installed a VFD on the supply fan for air handler B2UE. This project was similar to the VFD measure described in project 16B, although in a different building. Navigant was unable to obtain trend logs for the B2UE air handler fan. However, during the site visit, the fan was operating at 69% speed. Since the other six air handlers for which Navigant did obtain trend logs show minimal temperature dependence, this was accepted as typical operation. Navigant used the VFD power during the site visit to estimate full load power on the fan and calculate energy savings for the VFD. This results in savings of 68,291 kWh/year, a 95% realization rate for the project.

In another measure of project 16D, economizers were enabled on air handlers B2LW and B2LE, both serving the lower level of a single building. At the time of the site visit, the economizers were found to be operating correctly based on trend logs for the facility. As with B1UE and B1UW in project 16B,

Navigant could not obtain air flow for the system, so the analysis in the project file was reviewed and the savings were accepted for a 100% realization rate.

Project 16D also included the installation of a new duct static pressure sensor on air handler B2LW to allow the VFD to adjust to varying conditions. In a separate but related measure, air handlers B2LW and B2LE implemented supply static pressure resets. Navigant was unable to obtain power consumption for the B2LW fan during our site visit but its speed trends were available from the facility. Since the two air handlers are the same capacity, the power data for fan B2LE was used, along with the affinity law with an exponent of 2.5, to estimate power for both fans from their speed trend logs. Fan B2LW operated continuously and did not show any sign of using a static pressure reset, as the static pressure remained at 1.5 inches water for the entire trending period, indicating that the static pressure reset had been disabled. However, the VFD on fan B2LW was operating correctly, so all of the VFD savings on this fan were applied to the duct static pressure sensor. This resulted in temperature normalized annual savings of 35, 933 kWh, a 423% realization rate. The high realization rate is the result of the fan not having any shutdown hours and the high static pressure.

Fan B2LE was shut off during unoccupied hours, and static pressure reset operated correctly, so its savings were attributed to the static pressure reset. Fan B2LE did not exhibit temperature dependent behavior, so average power was used at each static pressure, assuming about half the time at each condition as with the other fans, to estimate savings of 1,860 kWh/year, a 47% realization rate due to no savings from fan B2LW.

Table 21. Site 16 Savings

Site 16 Projects	Ex Ante kWh	Ex Post kWh	Realization Rate
16A			
CRAC upgrade	126,800	84,060	66%
Remove booster pumps	37,900	37,900	100%
16B			
Lighting Retrofit	125,600	120,587	96%
VFDs on chilled water pumps	59,100	53,217	90%
Supply static pressure reset B1UE,B1UW	108,300	85,913	79%
Supply static pressure set point B1LW	26,300	0	0%
Economizer mode AHU B1UE,B1UW	12,500	12,500	100%
Operating schedule B1UE,B1UW	127,500	104,078	82%
16C			
Supply temp reset AHU B1LW,B1LE	4,900	4,900	100%
Raise chilled water temp	84,600	67,913	80%
Condenser water temp reset	71,800	71,800	100%
VFD on condenser water pump	41,900	0	0%
16D			
Air compressor and dryer	118,100	122,025	103%
VFD on AHU B2UE	71,600	68,291	95%
Economizer mode on AHU B2LW,B2LE	16,200	16,200	100%
Duct static pressure reset B2LW	8,500	35,933	423%
Supply static pressure reset B2LW,B2LE	4,000	1,860	47%

3.4 *Natural Gas*

The Palo Alto efficiency programs include gas as well as electric savings. Three of the sites included in Navigant's sample included both gas and electric savings. One additional site included only gas savings. Table 22 summarizes the gas projects evaluated here.

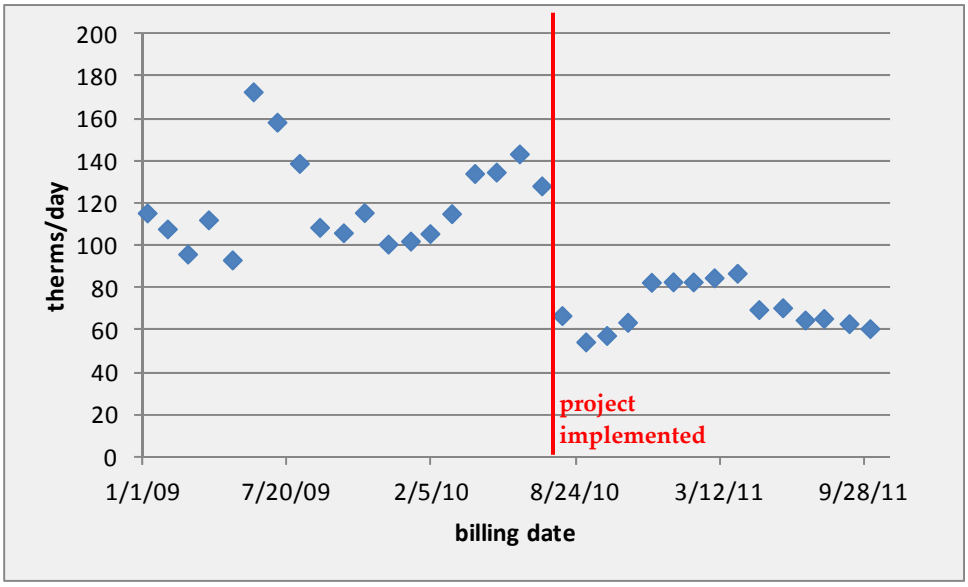
Table 22. Gas Savings

Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
13	12,819	16,612	130%
14	807.7	1,120	139%
16B	120	0	0%
17	29.2	29.2	100%

3.4.1 Site 13

The recommissioning of systems at site 13 included the air handlers, which affected both electric and gas usage for the site. Electric savings at the site are discussed in section 3.2.14 above. The building has not seen any major occupancy or use type changes since 2008, although the company is slowly adding staff. Since there were no changes in square footage or operations, Navigant considered the occupancy changes to be a minimal effect and used IPMVP Option C to calculate savings using billing data for both electric and gas.

Figure 16. Site 13 Gas Usage



As shown in Figure 16, gas usage for the site dropped substantially when the systems were recommissioned. Using weather data for the nearby San Jose airport, Navigant created trends of daily electric usage as a function of average monthly temperature before and after the project. We estimated typical annual savings by normalizing this to typical meteorological year (TMY3) data for the same airport.

Based on billing, weather, and TMY3 data, in a typical year the baseline system would have used 43,756 therms annually. The current systems would use only 27,144 therms in a typical year, resulting in 16,612 therms annual saving, 130% of the claimed value.

Table 23. Site 13 Gas Savings

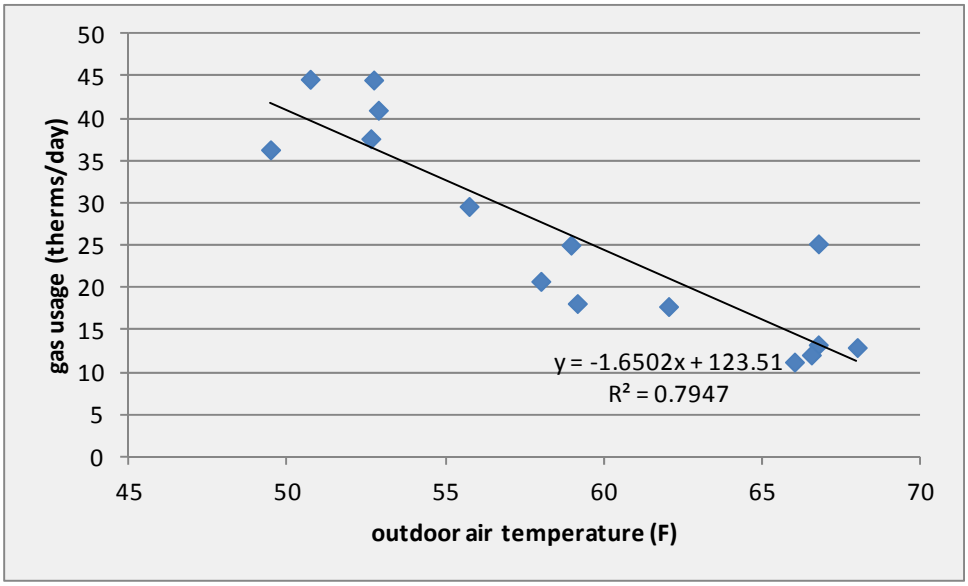
Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
13	12,819	16,612	130%

3.4.2 Site 14

Site 14 replaced an older boiler with a new, 85% efficient unit. Navigant was unable to confirm the boiler efficiency since there was no test port available. However, the specified boiler was installed and operating, so the manufacturer's list efficiency was accepted as correct. This site also performed a chiller replacement, discussed in section 3.2.14 above.

Because the original boiler was old, the Title 24 baseline of 80% efficiency was used for comparison. Navigant normalized gas usage from the average monthly temperature to the TMY3 data for the San Jose airport. As shown in Figure 17, the gas billing data correlated reasonably well with a linear trend relative to average monthly temperature. Using IPMVP Option C based only on monthly data can be difficult, since it is based on average monthly temperature while the actual boiler responds to real-time temperatures and time-based set-points. In some cases a better correlation can be obtained using heating degree days (HDD), but that was not the case in either this project or that at site 13.

Figure 17. Site 14 Gas Usage



The normalized gas usage was 17,920 therms annually. Adjusting the usage from the new 85% efficient boiler correlates to 19,040 therms for an 80% boiler. This results in 1,120 therms of savings, 139% of the deemed value claimed on the application.

Table 24. Site 14 Gas Savings

Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
14	807.7	1,120	139%

3.4.3 Site 16B

As discussed earlier, project 16B included schedule changes to shutdown of air handlers B1UE and B1UW during unoccupied hours. However, the planned shutdowns were disabled during winter months. This results in no gas savings from heating for the project, and a 0% realization rate.

Table 25. Site 16B Gas Savings

Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
16B	120	0	0%

3.4.4 Site 17

Site 17 is a 1,100 square foot combined retail, office and classroom space that received a new high efficiency gas furnace as part of a complete building retrofit. The new equipment is of the same type and capacity that would be used in a residential setting.

Navigant's evaluation of the furnace upgrade included an on-site review of the new equipment, thermostat set-points, occupancy profile, and building characteristics. Navigant also conducted a billing analysis on the building level gas use for site 17, but was unable to determine savings in this manner due to a lack of post-installation usage data. Total gas use at this site from system start up in March 2011 through the end of the available billing records in October 2011 was only slightly above 2 therms. The lack of use during this period is clearly due to the seasonality of gas heating in Palo Alto. Similarly a calibrated energy simulation, IPMV Option D, is not an option due to insufficient metered data. Due to the above mentioned constraints, no defensible justifications can be found for deviating from the claimed savings of 29.2 therms for this gas HVAC project. Table 26 presents this finding.

Table 26. Site 17 Gas Savings

Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
17	29.2	29.2	100%

4 Gross Impact Evaluation Results

4.1 CAP Gross Impact

An overview of the CAP gross electric impact evaluation findings for the sampled sites is provided in Table 27. The post installation data for site 12 is not as yet available, but will be added to the report when the post installation data is assessed. The overall CAP realization rate does not as yet include site 12. The overall realization rate for the CAP sample (not including site 12) is 112%.

Table 27. CAP Electric Savings

Site	Ex Ante kWh	Ex Post kWh	Realization Rate
1	16,415	12,924	79%
2	120,172	129,606	108%
3	5,301	5,730	108%
4	135,296	158,507	117%
5	3,388	3,744	111%
6	6,070	6,070	100%
7	3,260	3,260	100%
8	41,045	41,045	100%
9	14,790	14,790	100%
10	15,060	12,009	80%
11A	30,120	27,525	91%
11B	67,770	54,540	80%
12	960,000	TBD	TBD
13	68,707	115,491	168%
14	21,502	27,109	126%
Total (less Site 12)	**548,896**	**612,350**	**112%**

4.2 Enovity Gross Impact

An overview of the Enovity gross impact evaluation findings for the sampled sites is provided in Table 28. The overall Enovity realization rate is 81%.

Table 28. Enovity Electric Savings

Site	Ex Ante kWh	Ex Post kWh	Realization Rate
15	123,400	53,070	43%
16A	164,700	121,960	74%
16B	459,300	381,308	83%
16C	203,200	144,613	71%
16D	218,400	244,309	112%
Total	**1,169,000**	**945,260**	**81%**

4.3 CAP & Enovity Gross Impact by Measure Category

Electric savings for the CAP and Enovity sites sampled in the impact evaluation fall into four general categories, results by measure category are provided in Table 29:

- Lighting
- Prescriptive refrigeration
- Prescriptive motor/VFD
- Custom measures

Table 29. CAP & Enovity Realization Rates by Measure Category, Elec. Only

Category	*Ex ante* (kWh)	*Ex post* (kWh)	Realization Rate
Lighting	277,184	306,767	111%
Prescriptive Refrigeration	53,763	54,119	101%
Prescriptive Motor/VFD	112,950	94,074	83%
Custom, HVAC_Elec.	228,399	210,460	92%
Custom, Other [ENOVITY]	1,045,600	892,190	85%
Total (less Site 12)	**1,717,896**	**1,557,610**	**91%**

Lighting savings generally exceeded the *ex ante* estimates due to motion sensors having been installed in areas with extended baseline hours (twelve or more hours per day) and/or shutting off lights more than originally estimated.

The combined realization rate for prescriptive refrigeration measures installed at sites 5, 6, 7 and 8 is 101%. The total savings for these sites is slightly above the claimed savings because one of the sites installed 10% more gaskets than were initially claimed.

The prescriptive VFDs installed at Sites 10 and 11 had somewhat low realization rates due to their hours of use being lower than the typical values used for deemed savings for this type of installation.

Sites 12, 13, 15, and 16 all installed custom measures. The electric savings do not currently include Site 12, and since this project makes up over one-third of the *ex ante* savings for the sample, its addition is likely to affect the overall realization rate.

The recommissioning at Site 13 clearly achieved much higher savings than the *ex ante* estimates. This is largely due to the difficulty of estimating building wide savings from recommissioning. For this project, the initial estimates were conservative and the building operator has aggressively used the scheduling to save energy, resulting in a high realization rate.

The projects at sites 15 and 16 both underwent post-installation verification including as-installed estimates of energy savings. Navigant found these estimates to be thorough and believes that they were correct at the time of the verification. However, both sites saw significant changes in operation for some measures after initial installation. These were primarily related to operational changes resulting in reduced operational hours for some of the projects. Large industrial facilities, such as these two, frequently modify operations and this is not unusual. Some projects saw increased savings due to operational changes, but the overall savings have decreased since the installations.

Although these sites underwent detailed analyses prior to issuing incentives, the project files provided did not always include adequate details to determine the reasons for any discrepancies between estimated and verified savings. Navigant used the general descriptions and trend plots provided in the files to determine baselines, but more detailed assumption and analysis descriptions would have been very helpful. Navigant recommends that in the future detailed studies performed include in the project file complete descriptions of analysis methodology and any set points and assumptions used for the calculations.

4.4 Commercial Sector Electric Realization Rate

Table 30 provides the individual commercial program electric realization rates and the resultant ex post program impacts. The Right Lights realization rate was estimated in the 2010 evaluation. The total commercial sector electric realization rate, combining all three programs, is 102%.

Table 30. 2011 Commercial Sector Electric Utilization Rates and *Ex Post* Impacts

Program	Total Ex Ante kWh	Realization Rate	Total Ex Post kWh
Commercial. Advantage	1,910,333	112%	2,132,381
Right Lights (2010 Realization Rate)	3,213,412	103%	3,322,668
Enovity	1,045,600	81%	845,478
Total	**6,169,345**	**102%**	**6,300,527**

4.5 *Natural Gas Commercial Sector Realization Rate*

Table 31 provides the individual natural gas sample site realization rates, the total realization rate for the combined sample, and the resultant ex post program impacts. The total commercial sector natural gas realization rate is 129%.

Table 31. Commercial Sector Natural Gas Realization rates and *Ex Post* Impacts

Site	Ex Ante Therms	Ex Post Therms	Realization Rate (%)
13	12,819	16,612	130%
14	807.7	1,120	139%
16B	120	0	0%
17	29.2	29.2	100%
Sample Total	**13,776**	**17,761**	**129%**
Program Total	**14,809**	**19,093**	**129%**

The gas savings realization rate is primarily driven by Site 13, for which the recommissioning achieved high savings relative to the *ex ante* estimates. As with the electric portion of this project, this is largely due to the difficulty of estimating building wide savings from recommissioning since much of the savings depend on facility operators' use of scheduling and settings. For this project, the initial estimates were conservative and the building operator has aggressively used the scheduling to save energy, resulting in a high realization rate.

The boiler at Site 14 has seen heavier use than the deemed hours expected for this retrofit, also resulting in a high realization rate.

Site 16 has disabled the controls responsible for their gas savings due to operational problems. The building affected by the night and weekend fan shutoffs was experiencing operational problems during cold weather; therefore, ventilation and heating have been re-enabled.

5 Recommendations

The City of Palo Alto Utilities CAP and Enovity Program are performing very well with electric program realization rates of 112% and 81%, respectively and a natural gas program realization of 129%. The Right Lights program realization rate of 103% was estimated in the 2010 evaluation. When the three electric programs are combined, the overall electric realization rate is 102%.

Navigant offers the following, limited recommendations for program refinement:

5.1 Commercial Refrigeration

Participant comments related to two of the five surveyed commercial refrigeration gasket projects indicated that customers were dissatisfied with the either the service or workmanship provided. Navigant suggests that CPAU conduct a targeted survey of local grocers, convenience stores, and restaurants (participants and non-participants) to ascertain satisfaction with program implementers relative to other local gasket installers. The results of this survey would also be useful for confirming measure persistence.

5.2 Prescriptive HVAC

One of the prescriptive HVAC measures installed at Site 14 did not meet Title 24 minimum requirements effective as of January 2010. Requirements for qualifying HVAC measures should be reviewed to ensure the latest standards are observed.

5.3 Custom Project Documentation

Project documentation related to the type and nature of custom projects is typically comprehensive and well organized. However, documentation of the supporting algorithms, inputs, and/or assumptions used to establish as-built, claimed savings for some projects was found to be incomplete. Documentation of the full process used to justify claimed savings enables targeted updates to savings calculations. This assists with evaluation and allows for feedback that can improve future *ex ante* estimates.