LGP EVALUATION REPORT APPENDIX E:
UC/CSU PARTNERSHIP EVALUATION SITE REPORTS

a. Custom Linear Fluorescent Lighting
    i. PGE2036 - CSU Sonoma - Linear Fluorescent Lighting
    ii. SCE2530 - CSU San Bernardino - Linear Fluorescent Lighting
    iii. PGE2036 - UC Davis - Lighting Controls
    iv. PGE2036 - UC Davis - Lighting Controls
    v. SCE2530 - UC Irvine - Linear Fluorescent Lighting
    vi. SCE2530 - UC Irvine - Linear Fluorescent Lighting
    vii. SDGE3026 - UC San Diego - Linear Fluorescent Lighting
    viii. PGE2036 - UC San Francisco - Linear Fluorescent Lighting
    ix. PGE2036 - UC San Francisco - Linear Fluorescent Lighting
    x. PGE2036 - UC San Francisco - Linear Fluorescent Lighting
    xi. PGE2036 - UC Santa Cruz - Linear Fluorescent Lighting
b. Steam Traps
    i. PGE2036 - CSU Sacramento – MP/HP Steam Trap Replacement
    ii. PGE2036 - UC Berkeley – LP/HP Steam Trap Replacement
    iii. PGE2036 - UC Davis – LP/HP Steam Trap Replacement
    iv. SDGE3026 - CSU San Diego – LP/HP Steam Trap Replacement
c. PGE2036 - UC Davis - Replace Absorption Chillers with Centrifugal Chillers.
d. PGE2036 - UC Davis – Retrofit HVAC Supply and Exhaust Fans with VSDs
e. PGE2036 - UC San Francisco – Install VFDs on Supply and Exhaust Fan Motors
f. PGE2036 - UC San Francisco - Install New VFDs on HVAC Pumps and Fans
g. SCE2530 - CSU San Bernardino – Chiller Replacement
h. SCE2530 - UC Irvine - Upgrade HVAC Fans with Low Pressure Drop Filters
i. SCE2530 - UC Irvine - HVAC Centralized Demand Control Ventilation (CDCV).
j. SCE2530 - UC Irvine - HVAC Other (replace AHU fans 1 and 3)
k. SCE2530 - UC Irvine - PC Management Software
l. SCE2530 - UC Irvine - VAV Conversion
m. SCG3520 - UCLA - Fume Hood Controls
n. SDGE3026 - CSU San Diego - VFD - HVAC Fan
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LIGHTING MEASURES
CROSS-CAMPUS M&V PLAN
MAY 6, 2009

1. SUMMARY INFORMATION

1.1. Project Information

Utility Service Territory	PG&E, SCE, SDG&E, SCG
Program Numbers	PGE2036, SCE2530, SDGE3026, SCG3520
ADM Sample ID &Project ID	
Customer Name	
Site Name	
Site Address	
Site Type	University of California / California State University
Customer Business/Product	University of California / California State University

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

IOU REPRESENTATIVE

Name	David Hather	**Telephone**	
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Mike Yim

AUTHOR

Name	Mike Yim

Note: Measure information that has been obtained from project files is presented below using italicized text.

1.2. Schedule of M&V Activities and Reporting

Table 1. Schedule of M&V Activities and Reporting

Campus	Project Type	Schedule M&V	Begin On-Site M&V	End of Spring Session	Beginning of Summer Session	End of Summer Session	Beginning of Fall Session	Retrieve M&V Equipment	Analysis & Reporting
CSU San Bernardino	Campus Wide	4-May	20-May	15-Jun	24-Jun	3-Sep	25-Sep	24-Sep	1-Oct
CSU Sonoma	Campus Wide	4-May	28-May	21-May	1-Jun	24-Jul	26-Aug	5-Oct	7-Oct
UC Davis	Library	4-May	7-May	4-Jun	22-Jun	11-Sep	24-Sep	26-Oct	29-Oct
UC Irvine	Campus Wide	1-May	11-May	5-Jun	22-Jun	9-Sep	24-Sep	26-Oct	29-Oct
UC San Diego	Campus Wide	1-May	14-May	5-Jun	29-Jun	18-Sep	24-Sep	26-Oct	29-Oct
UC San Francisco	Parking Garage & Library	29-Apr	8-May	5-Jun	15-Jun	8-Sep	24-Sep	26-Oct	29-Oct
UC Santa Cruz	Campus Wide	4-May	18-May	5-Jun	22-Jun	28-Aug	23-Sep	26-Oct	29-Oct

1. MEASURE LIST AND SUMMARY DESCRIPTIONS

1.1. Projects Installed by Campus

Table 2. Projects Installed by Campus

Campus	Measure Name	Electric Energy Savings (kWh)
CSU Sonoma	Campus Wide Lighting Retrofits. T8, LED exit signs, HE HID lighting, CFLs, occupancy sensors	1,367,149
CSU San Bernardino	Campus Wide Lighting Retrofits. T8, LED exit signs, HE HID lighting, CFLs, occupancy sensors	1,411,805
UC Davis	Lighting shutoff override within library. Lighting occupancy sensors installed in library stacks (253)	638,789
UC Irvine	Upgrade existing stairwell lighting fixtures to bi-level T8s (395). Install Occupancy Controls on Lighting Fixtures (320)	421,812
UC San Diego	Campus Wide Lighting Retrofits. Retrofit lamps from T-12 to T-8 (27 Buildings)	7,443,115
UC San Francisco	Laurel Heights Garage - Replace lighting with more efficient T8 lamps and ballasts (362). Memorial Union - Replace HID with T8 fixtures (973). Main Library - Replace lighting with more efficient T8 Lamps and Ballasts (3,988)	944,533
UC Santa Cruz	Campus Wide Lighting Retrofits. Replace T8 32W Lamps in Rooms with 28W	165,945

1.2. Measures Included in Evaluation

The types of lighting measures considered in this M&V plan include both efficiency and control measures.

- Lighting efficiency measures reduce demand, but operating hours for fixtures may be the same pre- and post-retrofit. These measures include retrofitting existing fixtures, lamps and/or ballasts with more energy efficient alternatives.
- Lighting control measures for interior lighting reduce operating hours but may not reduce demand. These measures include occupancy sensors or daylighting controls that are installed *without* any changes to fixtures, lamps, or ballasts

1.3. M & V Approach Summary

The objectives of the proposed M&V approach are to:

1.) Define lighting load profiles by DEER prototype activity areas[1]
2.) Quantify the impacts of lighting replacement measures on annual gross energy and peak demand, while accounting for HVAC interactions among them.
3.) Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

These objectives will be met using IPMVP Options A & B, Retrofit Isolation. With IPMVP Option B, savings will be calculated using short term or continuous measurement, and savings will be determined by field post-measurements of the system(s) to which the measure(s) have been applied, separate from the energy use of the rest of the facility.

Whenever possible, information about the baseline lighting systems (quantities, types, lighting densities, operating characteristics, etc) will be collected[2]. Resources for this effort will include:

1.) Project application files
2.) Residual fixtures in non-retrofit areas
3.) Spare fixtures in storage
4.) Interviews with facility staff

1.4. M&V Approach

The EM&V methodology has been adapted from the Pre/Post Lighting Study protocols[3] but is restricted to project areas in the evaluation sample. Evaluation efforts will provide fidelity at the space and schedule type levels. More information on the space types included through this study, and their relationship to DEER is provided in section *C-1.3.3 Sampling Strategy*. For each specific project area in the evaluation sample, the following information will be collected:

1) Fixture Counts: Count unique fixtures to confirm[4]:
    a. Application reported fixture counts and installation quality

2) Fixture Wattage: Collect ballast/lamp specifications[5] and spot measure each unique fixture to determine:

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[1] Database for Energy Efficient Resources (http://www.energy.ca.gov/deer/)

[2] UC_CSU Form_Lighting Inventory V1.doc

[3] PrePost Lighting Study_data collection protocols_DRAFT_021909.doc

[4] UC_CSU Form_Site Info V1.doc

[5] UC_CSU Form_Fixture Details V1.doc

   a. Uncertainty in post-retrofit fixture wattage for various ballast/lamp configurations.
   b. Post-retrofit fixture wattage.

3) Operating Schedules: Identify and record unique operating schedules[6] within each specific (sample) area being evaluated to confirm:

   a. Annual self-reported space type operating schedules relative to interval metering findings.

The collected information will be used to determine the logger deployment strategy. We propose to:

1.) Whenever possible, panel metering will be used to support findings from the Lighting On/Off loggers. We propose the following criteria for panel metering activities:

   a. Panels must be safe and accessible to on-site staff
   b. Circuits may <u>only</u> feed retrofit fixtures on (1) Space Type and (1) Schedule ID.

2.) Install (2) DENT Lighting or CT On/Off Loggers on retrofit fixtures per unique Schedule ID in each specific (sample) area. Logged fixtures shall comprise at least 25% of retrofit fixture load[7] in the affected area to ensure we capture representative space operating characteristics.[8]

Evaluation staff will record detailed information the location and quantity of loggers deployed[9].

Evaluation staff proposes to install (2) Loggers per unique Schedule ID in order to compensate for a noted hardware failure in the logging equipment, namely:

1.) Noise in collected data from lamp flickering
2.) A de-synchronization of the internal clock

We recognize that this effort will require significant logistical planning and execution in order to coordinate evaluation activities with campus facilities management staff. On-site staff will document and report any complicating factors noted in the field (e.g. panel inaccessibility, fixture inaccessibility, inoperable fixtures, etc.).

[6] UC_CSU Form_Operating Details V1.doc
[7] UC_CSU Form_Lighting Inventory V1.doc
[8] LSS
[9] UC_CSU Form_Logger Installation V1.doc

2. MEASURE EVALUATIONS

Measure ID: 1
Measure Name: Lighting Efficiency and Control Measures

2.1. M&V Features for Measures

Features of the M&V for the lighting measures are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early Replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option A & B

Pre-installation Equipment and Operation

The types and quantities of pre-installation lighting fixtures for the different campus projects are reported in the attached Excel workbook[10]:

As-Built Equipment and Operation

Specifications for installed equipment are detailed in the attached workbook.

Seasonal Variability in Schedule and Production

The UC/CSU campuses generally follow a year-round schedule that includes summer sessions, with a mix of day, evening, and weekend classes. We will refine our understanding of campus specific schedules by reviewing the academic calendar. We will also use campus resources to confirm class schedules, custodial schedules, planned operating patterns, and class sizes. The collected information will be used to extrapolate results from short-term monitoring activities to annual operating hours by specific (sample) space type.

2.2. Algorithms for Estimating Savings

Algorithms Used by IOUs

Ex-ante savings for lighting retrofit measures were calculated using the following approach:

$$\text{Energy Savings (kWh)} = \Delta\,[\,\Sigma_i\,(\text{Qty} * \text{Fixture}_{kW} * \text{Hours})\,]$$

Where:

Qty: Quantity of Fixture_i

Fixture_{kW}: kW of Fixture_i
Hours: Annual Operating Hours of Fixture

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Demand Savings (kW) = Δ [Σ_i (Qty * $Fixture_{kW}$)]

Where:

Qty: Quantity of $Fixture_i$

$Fixture_{kW}$: kW of $Fixture_i$

Energy Savings Algorithms Used for Evaluation

Summit Blue proposes a similar approach to estimating the impacts lighting retrofit measures on annual gross energy and peak demand, while accounting for interactive effects:

Energy Savings (kWh) = Δ [Σ_i (Qty * $Fixture_{kW}$ * Hours * IF)]

Where:

Qty: Quantity of $Fixture_i$

$Fixture_{kW}$: kW of $Fixture_i$

Hours: Annual Operating Hours of $Fixture_i$

IF: Interaction Factor

Demand Savings (kW) = Δ [Σ_i (Qty * $Fixture_{kW}$)]

Where:

Qty: Quantity of $Fixture_i$

$Fixture_{kW}$: kW of $Fixture_i$

IF: Interaction Factor

Equation parameters will be developed through on-site verification and metering activities.

Peak Demand Algorithms Used in the Evaluation

The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

2.3. Data Collection

Site-Specific Data Required

The following information needed to assess the savings will be collected on-site[11]:

1.) Quantities and types of lighting fixtures, within each specified (sample) space.
2.) Operating hours for each specific (sample) space type.
3.) Power draw (kW) of unique fixtures for each specific (sample) space type.

Data Collection Method

In each sample space, all retrofit fixtures will verified by on-site staff. Unique fixtures will be identified by type, lamp count, ballast count, and corresponding manufacturer/model number information. Monitoring equipment will be installed to obtain comprehensive data on space type operating characteristics for the following time periods:

1.) (2) Weeks of the Spring Session
2.) The Entire Summer Session
3.) (4) Weeks of the Fall Session

Sampling Strategy

For monitoring hours of operation for the lighting where the efficiency or control measures have been installed, the sampling strategy is to select samples of spaces of different types of functional areas across campuses. For each campus, the spaces in which the lighting measures were implemented will be classified by functional use.

A taxonomy of functional uses for community colleges is provided by room use categories, as defined in the *Postsecondary Education Facilities Inventory and Classification Manual (FICM): 2006 Edition*[12] and as implemented by California community colleges in the space inventory data that they report.

The functional use areas where lighting efficiency or control measures were installed at the sample of community colleges being studied here are shown on the attached Excel workbook in the tab entitled "Usage Groups by Campus". The major functional use areas where lighting

[11] Contextual Data v3.doc

[12] U. S. Department of Education, National Center for Education Statistics, *Postsecondary Education Facilities Inventory and Classification Manual (FICM): 2006 Edition* (NCES 2006-160).

measures were installed are classrooms and offices. For three of the campuses, measures for exterior lighting were also installed.

The proposed sampling plan is to select a sample of areas, across campuses, within each major functional use category. Based on the data provided in the campuses' project applications, the major functional uses to be sampled will include the following:

- Classroom spaces
- Laboratory spaces
- Office spaces
- Dining/food service spaces

The sampling plan is premised on there being two estimates of operating hours for each area sampled within a functional use category: expected hours of use (as reported in the project applications) and the verified estimates of operating hours developed through the M&V monitoring. Essentially, these two sets of estimates allow developing a ratio from the data for the sampled sites that can be applied to adjust the expected hours as reported in the project applications.

The ratio to be estimated is given by the following formulation:

$$R = \frac{\bar{y}}{\bar{x}}$$

where R is the ratio of measured hours to reported hours for a functional use, $\bar{y}$ is the mean of measured hours of operation calculated from the sampled spaces within a functional use, and $\bar{x}$ is the reported (expected) hours of use for lighting in the sampled areas. For the estimation of this ratio, estimates of expected hours of operation are taken from the program tracking records are used as the auxiliary information.

For each functional use area, the sample size required to estimate the ratio with precision of ±10% at 90% confidence is determined from the following formula:

$$n = \left(\frac{1.645 ucv}{prec} \right)^2$$

Where n is the required sample size, *prec* is the desired precision (i.e., 10%) and *ucv* is given by

$$ucv = sqrt\ (cv_x{}^2 + cv_y{}^2 - 2\, r_{xy}\, cv_x\, cv_y\ )$$

Where

cv_x is the coefficient of variation for expected hours of operation;

cv_y is the coefficient of variation for measured hours of operation; and

r_{xy} is the correlation coefficient between x and y.

Thus, to determine n we need estimates of r, cv_x and cv_y. For planning purposes, we have taken such estimates from the *Express Efficiency Lighting Program Time of Use Study* that RLW Analytics prepared for SDG&E. This study provided a comparison of measured hours of lighting use to reported hours of use for 124 commercial facilities. The data from this study are summarized below:

Table 3. Comparison of Measured Hours of Lighting Use to Reported Hours of Use

Variable	Mean	Standard Deviation	Coefficient of Variation
Reported hours of lighting use	4,199	2,180	0.529
Measured hours of lighting use	4,098	2,121	0.518
Correlation coefficient: 0.793			

With these estimates of r, cv_x and cv_y, the required sample size for each functional use category is ≈ 31. We propose to sample a total of 160 areas across campuses for the four major functional uses. A total of 20 spaces will be sampled for each campus with interior lighting retrofits. To adequately reflect the distribution of space by use categories across college campuses, the campus-level sample will be developed as presented below:

Table 4. Use Category and Sample Spaces

Use Category	Sample Spaces
Classroom	9
Laboratory	3
Office	6
Dining / Food Service	2
Total	20

For each of the functional use areas, the allocation of sample points across campuses and campus buildings is accomplished using space inventory data obtained from the UC Office of the President (UCOP), which is a database of 60-million square feet of UC Campuses. Included in the database is detailed information for every room in every building on every campus. This detailed information includes functional use and assignable square feet for every room. (A space inventory for each campus is also maintained by the Facilities Planning, Maintenance and Operations department.)

The data contained in this database was combined into one database for all campuses, and rooms with lighting measures installed under the program will be randomly selected for the sample for each major functional use listed above.

2.4. Data Accuracy

All equipment used for monitoring is calibrated and tested before being installed.

2.5. Quality Assurance Procedures

All data are reviewed to resolve outliers, missing data, etc. Routine QA procedures are applied, including independent review of all field work by senior professionals.

2.6. Uncertainties

Uncertainties to be resolved for this study include the following:

- Operational schedules are campus-specific. Interviews with staff at the campuses are used to determine these schedules, which will be required in order to extrapolate the sampling period to an annual load profile.
- Baseline lighting totals need to be confirmed.
- Inspections are needed to confirm that the measures were installed and operating properly.

2.7. Methodology for UC-CSU Hours of Use Analysis for Lighting Logger Study

The logging sample consisted of 444 control points across seven campuses. Within each campus, loggers were deployed across multiple functional use areas. The sample was designed to collect data from a sufficient number of control points to allow for a reliable estimation of hours. The goal was ±10% precision at the 90% confidence level.

The sample focused on the areas at each campus where lighting and control retrofits were completed. Those areas included the major functional use areas proposed by the M&V as well as other areas identified in each of the campuses' program tracking data. A significant portion of retrofits were identified in areas described as common spaces. These common spaces included hallways, building lobbies, and other similar high-use areas. Other areas included in retrofit projects were library spaces (including book stack sections), stairwells (including areas controlled by bi-level lighting), parking garages, and storage areas. The M&V plan proposed including dining and food service spaces within the sample. However, the program tracking data indicated that only a small number of dining and food service spaces received retrofits. Field observations and review of the logger data for the dining areas sampled showed that these space types are operated similarly to common spaces. Therefore, this analysis combined dining and food service spaces into the common space type in order to achieve the precision goal.

The program tracking data indicated that projects included lighting retrofits, controls (i.e., occupancy sensor installations), and a combination of the two. 88% of the claimed savings involved lighting retrofits (e.g., replacing T12 lamps with more efficient T8 lamps). The claimed savings were derived from the resulting wattage reduction. 7% of claimed savings involved projects that installed both lighting retrofits and controls. The remaining 5% of claimed savings involved projects that installed only control. The majority of this 5% came from the projects completed at UC Davis.

Some campuses completed projects that only affect one space type. Additionally, these space types identified were unique to only one campus. For example, stairwells at UC Irvine were retrofitted with bi-level lighting and those spaces were logged. Therefore, the stairs space type and subsequent load shape is unique to UC Irvine. Similarly, the garage space type and load shape are unique to UC San Francisco. Table 5 shows the distribution of space types and the number control points logged at each of the seven campuses.

Table 5. Number of Sampled Control Points

	CSU San Bernardino	CSU Sonoma	UC Davis	UC Irvine	UC San Diego	UC San Francisco	UC Santa Cruz	TOTAL
Classroom	62	62			17		21	162
Common Area	10	14	6	4	4		5	43
Garage						3		3
Lab	20	10		12	6		16	64
Library			6			1		7
Office	58	46		10	8	6	17	145
Stair				11				11
Storage	4	4			1			9
TOTAL	154	136	12	37	36	10	59	444

Data Collection Method

Several onsite visits were conducted at each of the seven campuses in order to capture usage data for each of the space types associated with the retrofit projects identified in the program tracking databases. Data collection captured hours of operation and equipment measurement and verification after retrofit projects were completed. During deployment, logging equipment was installed to capture usage at the lamp level. During the deployment the space type, building, and campus were recorded along with the logger serial number. The logger was then launched (i.e., recording initiated) and its clock was confirmed to be the correct time before being secured in place. Next, the number and type of fixtures and lamps on the same control point as the logger were counted and recorded. Finally, the method of control (e.g., manual switch or occupancy sensor) was recorded. Approximately half of the monitored control points within the sample were controlled by occupancy sensors.

Spot measures were also taken to capture information about the various lamps, ballasts, and fixtures installed at each project. Equipment types, manufacturers, model numbers, and wattages were capture for each lamp and ballast. Installation details such as fixture type, lighting application, and ceiling height were noted. Finally, measures of voltage, current, wattage, and power factor were taken. This data was used to verify the installations claimed by each program tracking database.

Monitoring was conducted for the time periods specified by the initial M&V strategy described in section 0. Namely, for each campus, loggers monitored usage during the spring, summer, and fall sessions. Additionally, six day types were identified as having unique operating characteristics. These six day types are used to extrapolate the analysis, which only covers a portion of the year, to the entire year. The six day types are shown in Table 6.

Table 6. Day types Identified for Analysis

Day Type	Description
Weekday Full Session	Weekdays during the regular academic periods (e.g., fall/spring semesters).
Weekend Full Session	Weekends during the regular academic periods (e.g., fall/spring semesters)
Weekday Partial Session	Weekdays during summer and winter interim academic periods. Classes in session, but at reduced levels.
Weekend Partial Session	Weekends during summer and winter interim academic periods. Classes in session, but at reduced levels.
Weekday No Session	Weekdays between academic periods or during holidays.
Weekend No Session	Weekends between academic periods or during holidays.

Monitoring was conducted using a variety of logging equipment including Dent lighting loggers, Dent current transducer loggers, and HOBO current transducer loggers. Redundant loggers were also deployed to in order to reduce the potential for equipment failure and invalid data collection. Potential failures and mitigations are described in Table 7.

Table 7. Potential Logger Failure and Mitigation

Failure Mode	Mitigation
Logger stops recording/fails	Redundant logger
Logger detects other light sources	Logger sensitivity decreased and secured directly to T8 lamp(bulb)
Logger memory fills to capacity/stops recording	Interim inspections and data downloads
Lamp burns out/usage not recorded	Large sample size used
Logger removed by maintenance staff	Inform maintenance staff of study, mark each fixture included
Current transducer disconnects from source wire	Redundant lighting logger installed, or current transducer with mechanical latch deployed (HOBO CTs)

At the completion of the monitoring period the loggers were retrieved. The space type, building, and campus were confirmed. The retrieval date and time recorded, and the logger's clock was checked for any de-synchronization. Where possible, persons occupying the space were briefly surveyed to determine if any abnormal usage had occurred in the space monitored (e.g., lamps burned out or occupant away for extended periods). Finally, logger data was loaded onto computers for processing.

Raw data collected by loggers was also reviewed against quality control guidelines to determine if the actual usage conditions were accurately captured. For example, cycling between lights on and lights off (as recorded by the loggers) was reviewed to determine if flickering was taking place. For the quality control review, flickering was assumed to be when lights were turned on and off within a two minute period. These transitions were removed from the final data set except in cases where it could be determined that actual field use was being recorded. Actual field usage was verified through brief interviews with the building staff and maintenance teams. As an example, in these cases where data was included security personnel may have accessed a room for a brief period or storage and maintenance closet may only be accessed for short periods.

Raw data was also reviewed to determine if the loggers' internal clock had de-synchronized. This was important to determine so that the logged usage could be accurately assigned to one of the six day types defined for the study. Each logger's internal clock was inspected at the time of retrieval and the difference between its time and local time was recorded. The difference in time was applied to the logger data in order to re-synchronize the final data set. On average, the majority of loggers maintained accurate time and only a small sample de-synchronized by periods of less than one hour.

Raw data was also reviewed for any day types where a fixture appeared to be on or off for extended periods of time (e.g., multiple days). For these periods, actual field usage was verified through brief interviews with the building staff and maintenance teams whenever possible. These types of information were excluded from the final data set unless it could be determined that usage was being recorded accurately. For example, certain fixtures may be kept on 24 hours a day in some spaces. Some areas may not be accessed for several days because of holiday breaks or because they are storage areas with low usage rates. Finally, in a small number of instances loggers recorded long off periods because lamps burned out. These periods were excluded from the final data set.

Analysis Methodology

The analysis of the logger data was comprised of four major steps:

1. **Calculate average daily load shapes** by campus, functional use area, and day type across all campuses. The daily load shape is a set of twenty-four values, one for each hour of the day, that represent the equivalent percentage of each hour that all installed lighting wattage was on.
2. **Estimate annual hours of use** based on the average daily load shapes.
3. **Adjust the claimed savings** using the ratio of estimated annual hours of use to claimed hours of use.
4. **Manually review special cases,** like lighting controls, and make appropriate adjustments to the claimed savings based on logger data.

Each of these steps will be discussed in more detail below.

Calculate Average Daily Load Shapes. For each set of loggers deployed on a unique control point, data was averaged and load shapes were developed for each of the six day type periods. Findings were normalized so that any differences in the number of total days of monitoring would not affect the results. After normalizing the day type data in this way, average day type load curves were developed for each campus by space type and day type. Results for areas where only lighting controls were installed were kept separate since it is expected that the lighting control measures will have an effect on the normal hours of operation. This effect must be kept out of the estimation of average hours of use for the lighting retrofit measures.

Estimate Annual Hours of Use. Next, the daily load shapes are combined to total the annual hours of use for each space type within each campus space type.

The annual schedule of operations for each campus for the year 2009 is identified and each day is assigned to one of the six day types. The number of days of each day type is then used to determine a weighted-average load shape for the year. The resulting load shape totals the annual hours of operation for that particular control point.

The average annual hours of use are then calculated for each campus and space type by averaging the values for each control point. This was accomplished using three different weighting strategies. Three different weighting strategies were developed both to compare and understand the impacts of the different weights, and to offer options for future applications of this data:

1. A strategy with no weights in the creation of the average load shapes. Each control point contributed equally to the final result.

2. A strategy with weights based on the number of lamps associated with each control point. As a result, areas that had more lighting load contributed greater weight to the overall average load shape.

3. A strategy with weights based on the number of fixtures associated with each control point. This approach is similar to the second weighting strategy. Furthermore, this approach produced similar results.

After evaluating all three approaches, it was determined that lamp count weighting (strategy 2) provided the best application of the logger data to the claimed savings. Weighting averages captured the impacts on savings of large retrofit projects, and lamp count weighting provided more precision than fixture counting.

Adjust the Claimed Savings. The annual hours of use determined by the monitoring is compared to the project tracking data for each campus. Typically, each campus identified the previous and retrofit lighting conditions. Information included the total number of lamps change, the wattage changes of the lamps, the estimated operating hours, and the space type. The annual hours of use from the monitoring data is applied to the retrofit project details (i.e., the number of lamps replaced, the amount of wattage reduced, and whether or not occupancy sensors are installation) for the given campus and space type. Verified savings are then calculated and compared against the claimed savings.

Calculate Project Realization Rates. After the verified savings were calculated, realization rates were determined. These are the ratio of verified kWh savings to claimed kWh savings. Overall realization rate estimates were summarized both by space type and by IOU. The practice used for assigning the original estimates of hours of use may vary by IOU, and this could create considerable difference in the realization rate estimates. It is important to check for this possible systematic difference in the numbers.

Calculate Peak Demand Savings. Monitoring data was evaluated to find the average percentage of lights that were on during the peak period. The peak period is defined as 2:00 to 5:00 p.m. on the three hottest consecutive weekdays of the year for each of California's climate zones. Of the six day types identified, the peak times occurred during the weekday partial session day type for all seven campuses. The coincidence factor was multiplied by the claimed gross kW savings by campus and space type to determine the verified peak demand savings.

Statewide Load Profiles by Space Type

Statewide load profiles for classrooms, laboratories, offices, common spaces, and storage spaces were developed for the seven UC and CSU campuses. Loggers were also deployed in library spaces at UC Davis and UC San Francisco. Finally, garage spaces were logged at UC San Francisco.

The aggregate load profiles for classrooms, laboratories, offices, common spaces, and storage spaces for the UC and CSU school systems are present in Figure 1 through Figure 10. These load shapes are divided between weekdays and weekends.

Figure 1. Classroom Weekday Load Profile

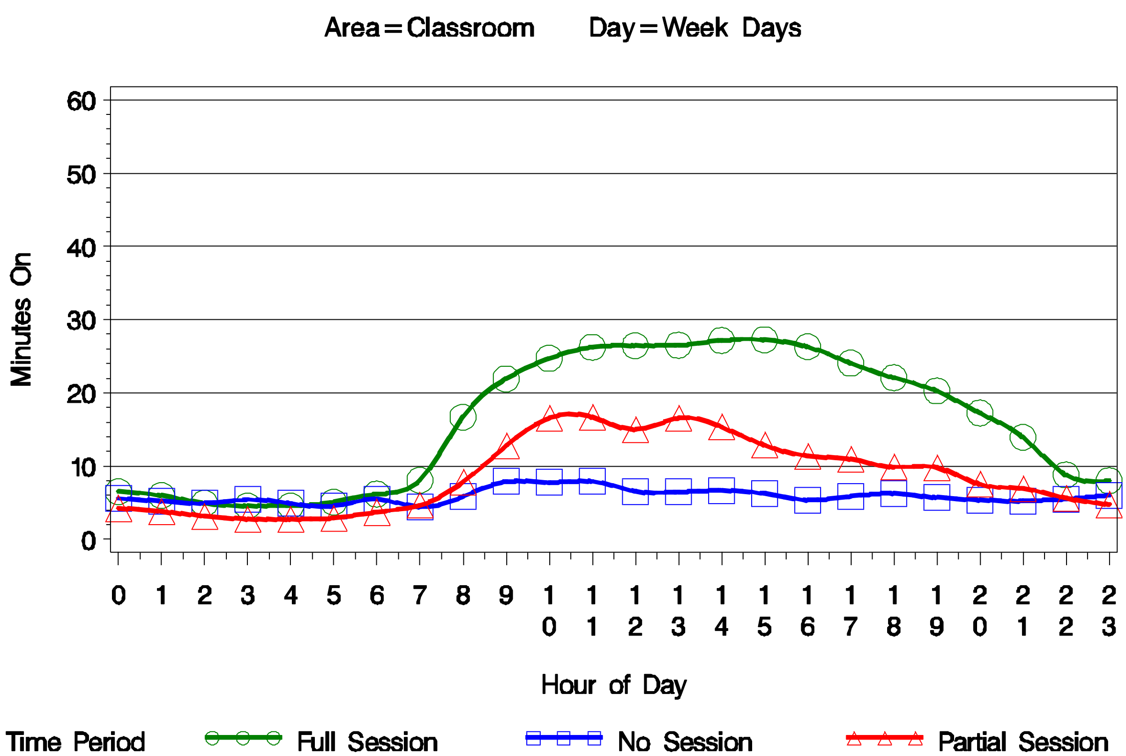


Figure 2. Classroom Weekend Load Profile

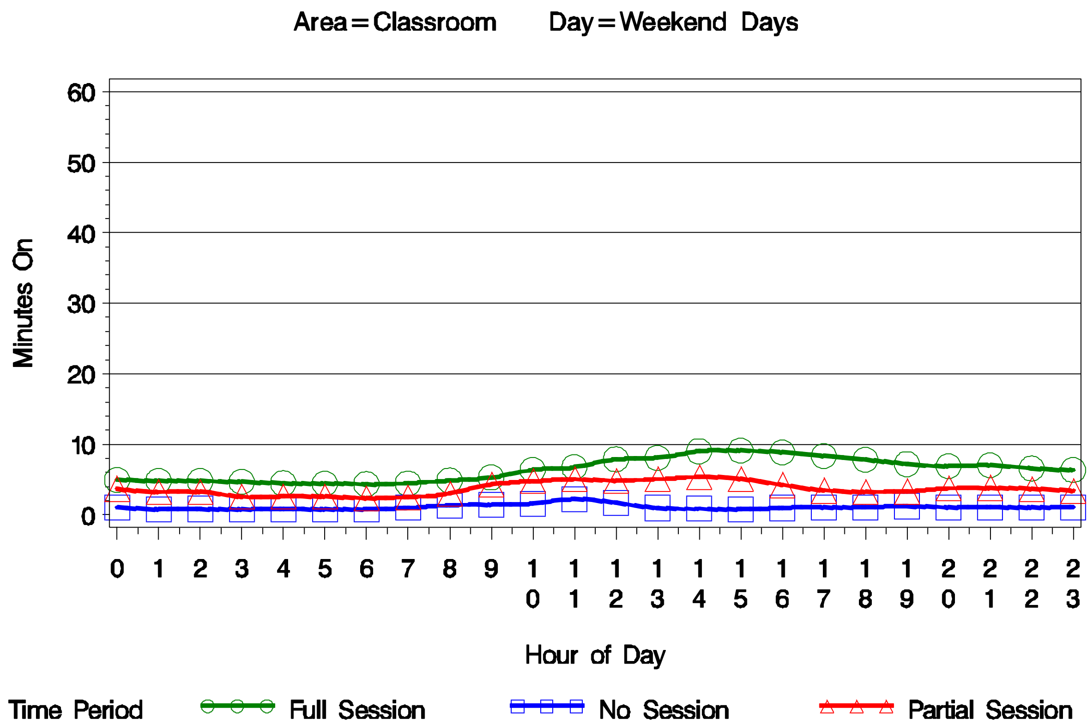


Figure 3. Laboratory Weekday Load Profile

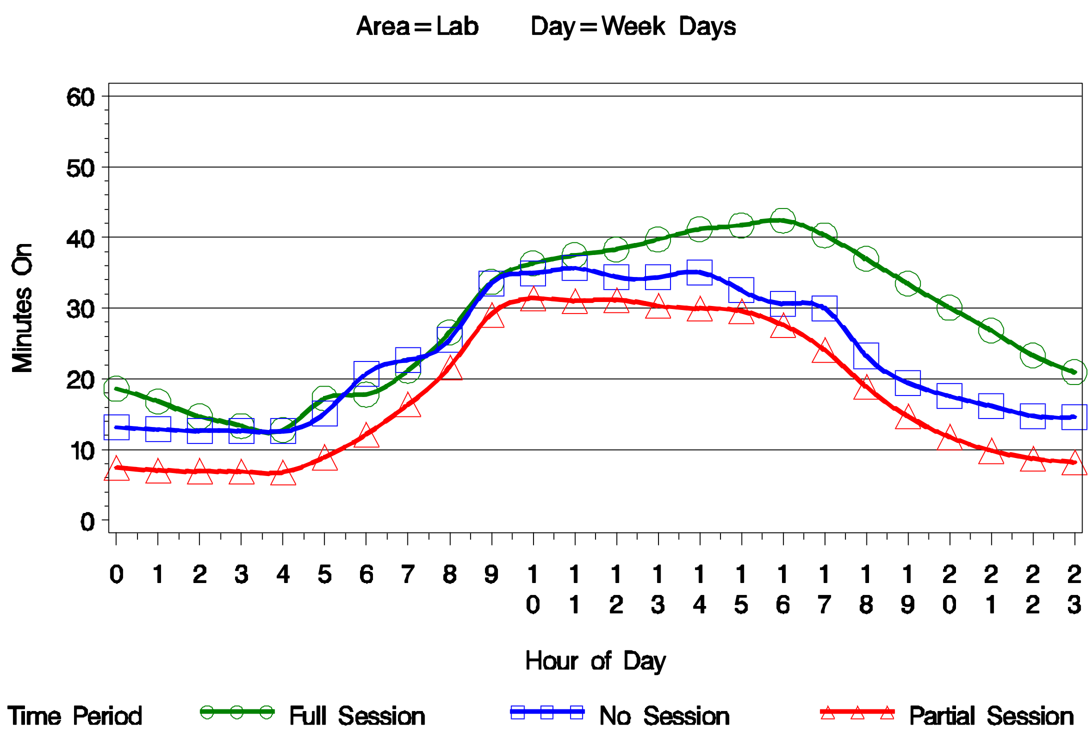


Figure 4. Laboratory Weekend Load Profile

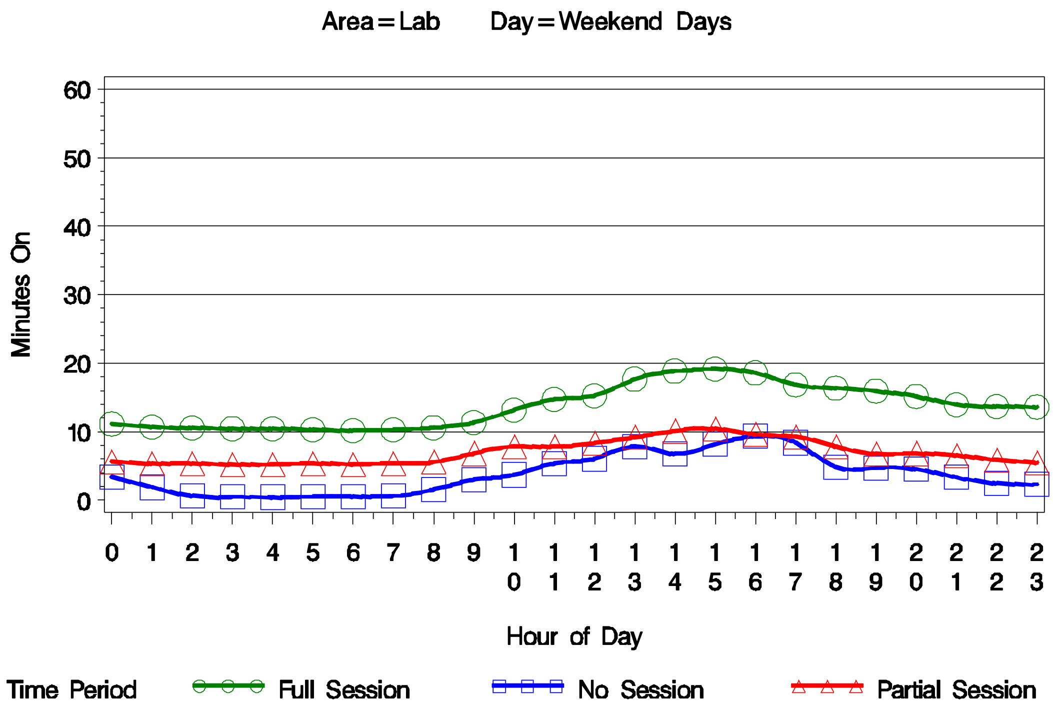


Figure 5. Office Weekday Load Profile

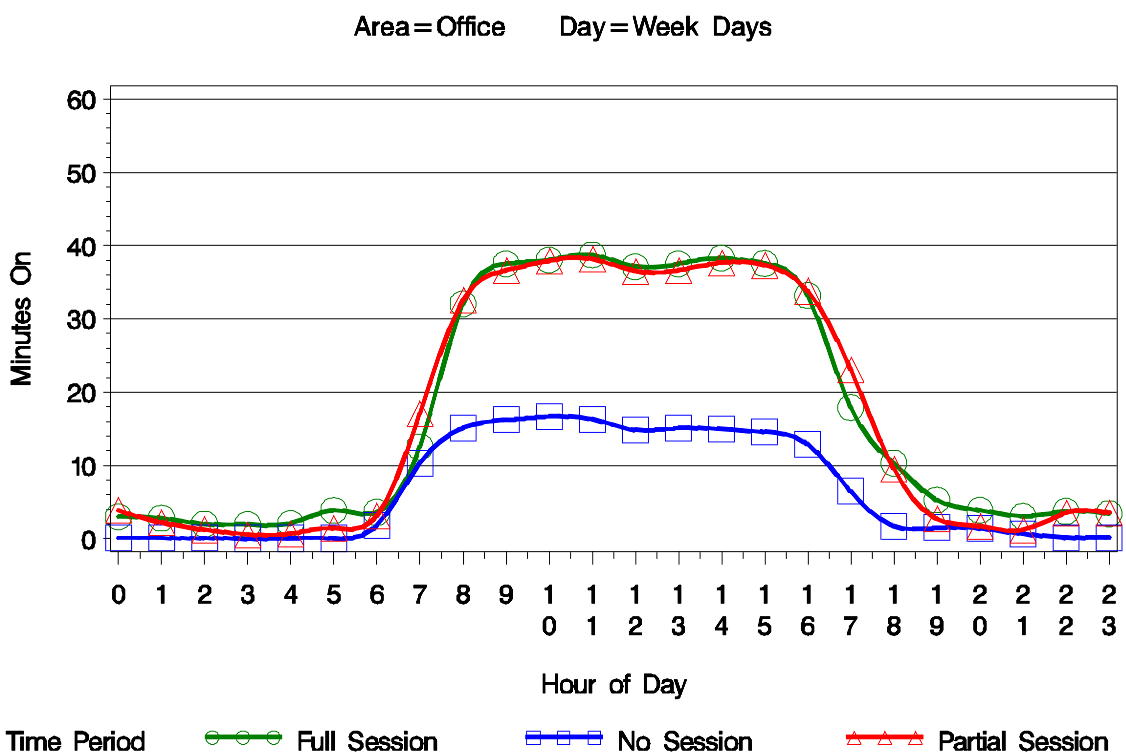


Figure 6. Office Weekend Load Profile

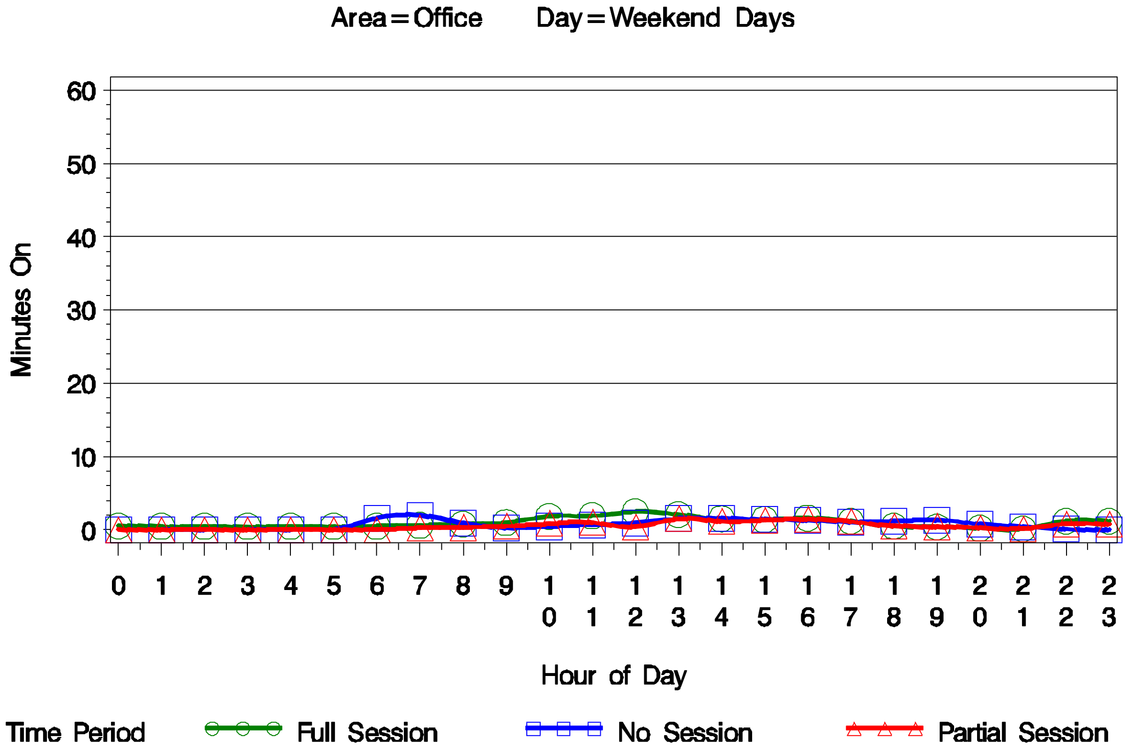


Figure 7. Common Space Weekday Load Profile

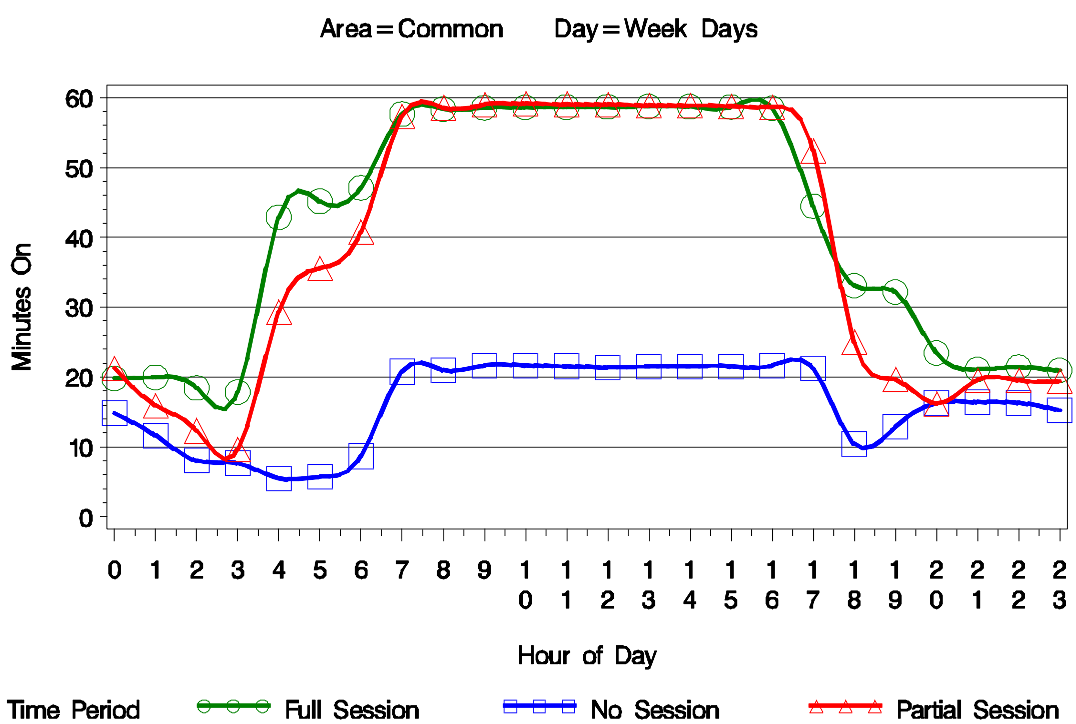


Figure 8. Common Space Weekend Load Profile

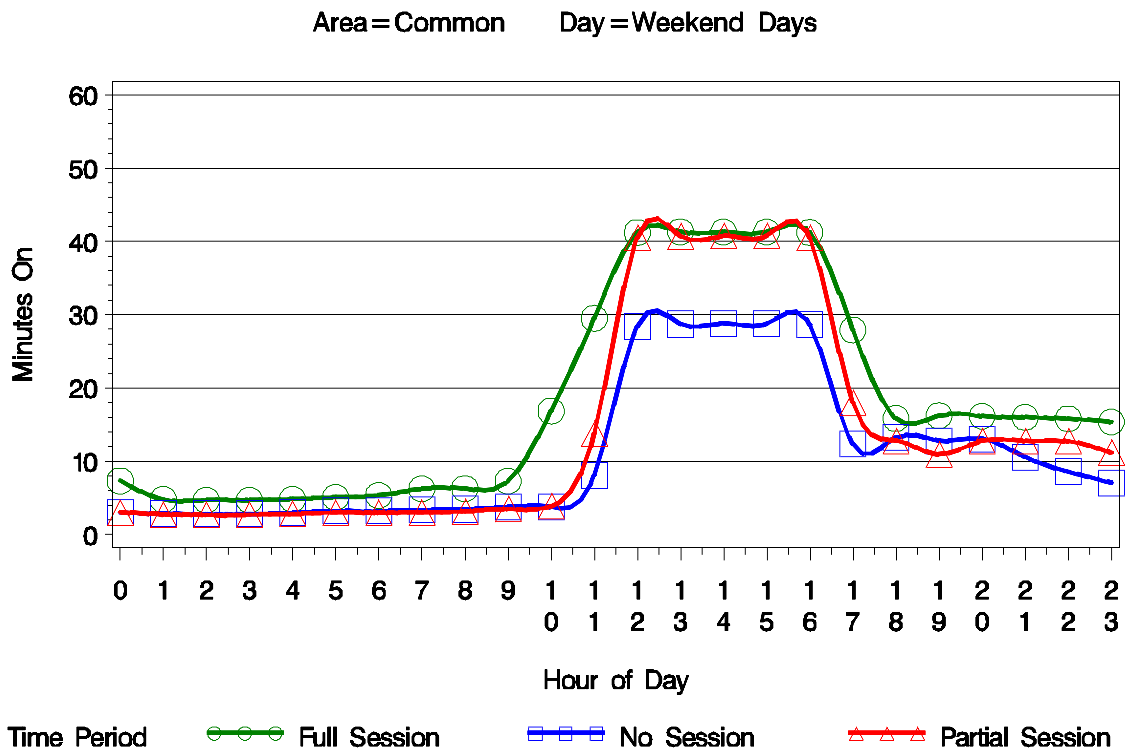


Figure 9. Storage Weekday Load Profile

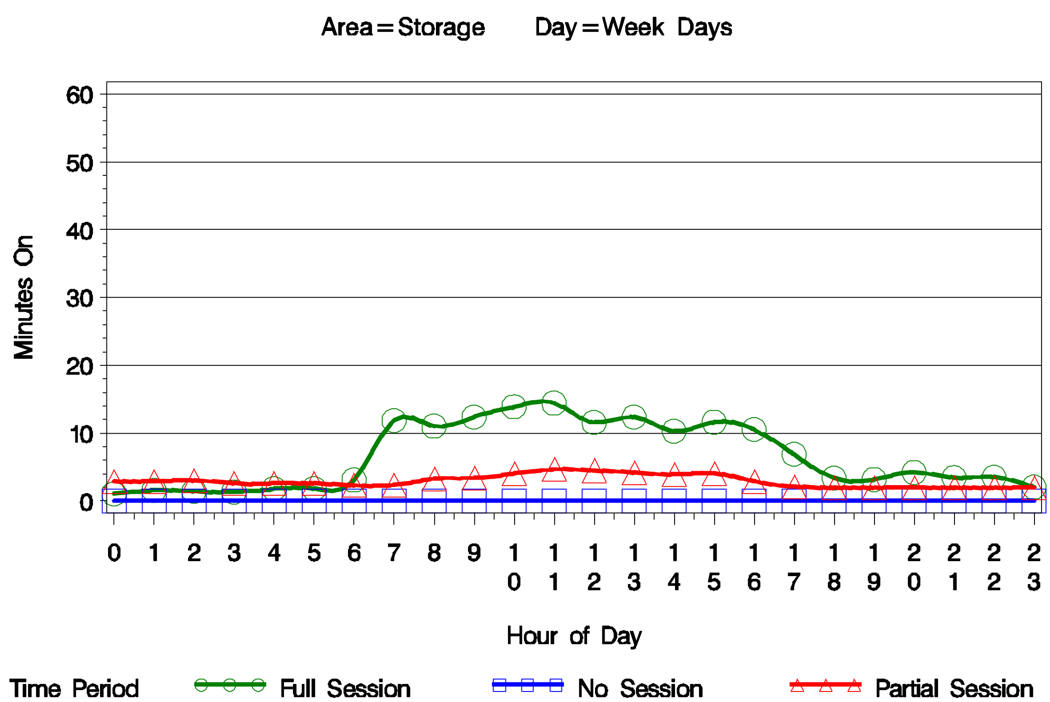
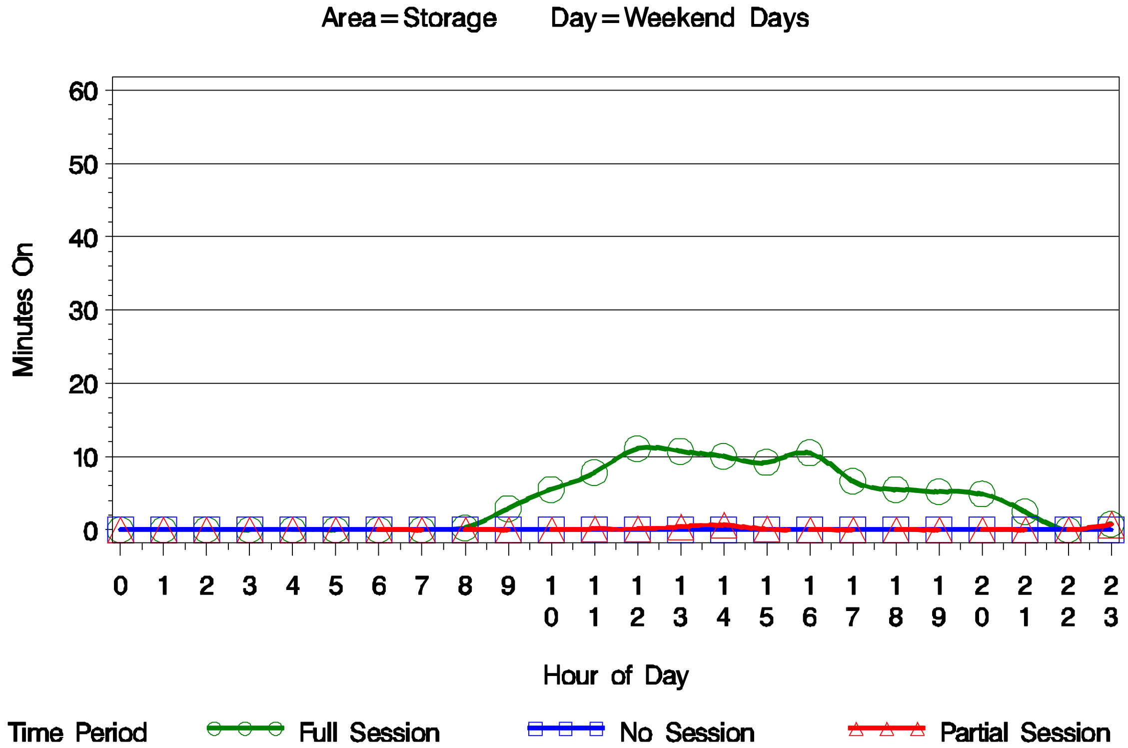


Figure 10. Storage Weekend Load Profile



These load profiles are intended to inform the prototype load profiles developed by DEER for classrooms, offices, laboratories, and dining/food service space types.

2.8. Campus Level Retrofit Project Realization Rates

Loggers were deployed amongst the seven UC and CSU campuses in order to quantify the impacts of lighting replacement measures on annual gross energy and peak demand savings while accounting for HVAC interactions among them. Lighting retrofits varied in type and quantity from campus to campus. The majority of the campuses included in the study completed retrofits across a variety of space types within several different buildings. Additionally, several campuses completed retrofits that included only one building or one specific space type. The following section includes the campus realization rates and an explanation of the discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

CSU Sonoma completed a campus wide lighting retrofit of various space types within several different buildings across their campus. CSU Sonoma's project tracking data provide the full level of detail for each retrofit completed. The annual hours determined from monitoring for each space type were lower on average than the ex-ante hours assumed for the retrofit case. This contributed to fewer kWh savings for retrofits where lighting loads (i.e., gross kW) were reduced. The lower hours also contributed to a lower peak demand savings estimate. CSU Sonoma reported that all lights were on during the peak demand period. As a result, the ex-ante peak demand savings equal the gross wattage reduction. However, monitoring data indicated that only a portion of the lights in each space type were on during the peak period. On average, only approximately 15 percent of the lights in each of the space types remained on. The value for the coincidence factor may be the result of the peak demand period occurring during the summer session. Through discussions with faculty and staff, the summer session (identified as the partial session in this analysis) has fewer classes offered and fewer students attending those classes. Additionally, faculty members are likely to be away during this period if they are not holding any classes.

Table 8. CSU Sonoma

Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
1,388,152	956,867	69%	329.0	85.0	26%

CSU San Bernardino completed a campus wide lighting retrofit of various space types within several different buildings across their campus. CSU San Bernardino's project tracking data provide the full level of detail for each retrofit completed. The annual hours determined from monitoring were similar to the ex-ante assumption. The peak demand savings differ because the verified data determined that fewer lights were kept on during the peak period than stated by the ex-ante assumptions. Similar to CSU Sonoma, CSU San Bernardino assumed that all lights were on during the peak demand period. However, the monitoring data and interviews with faculty and maintenance staff determined that fewer classes are held during the summer and fewer students occupy campus spaces. Monitoring data determined that for all the space types approximately 30 to 40 percent of lights were on during the peak demand period that occurred during the partial session time period at CSU San Bernardino.

Table 9. CSU San Bernardino

Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
1,411,805	1,395,660	99%	338.8	125.7	37%

UC Davis completed retrofit projects within the Shields Library building only. The first project installed occupancy sensors within the library stacks, and the second project installed a system to control the library's common areas with occupancy sensors from 12:00am to 6:00am. These projects did not include any fixture, lamp, or ballast retrofits and it was assumed that the total controlled wattage (i.e., gross kW) remained the same before and after installation.

The library stacks project installed occupancy sensors to control the light in the majority of the bookshelf rows within the library. Previously, lighting in these areas remained on whenever the library was open even though these stacks are accessed for a fraction of the time. Monitoring data verified savings higher than the ex-ante assumption. Additionally, the verified peak demand savings were significantly higher than the ex-ante assumptions. The ex-ante assumptions claimed a 20% reduction in operating hours during the peak period while the monitoring verified a 90% reduction. This difference resulted in the peak demand savings realization rate of 457%.

The main area lighting shut off only affected savings during the 12:00am to 6:00am time period. This project also had a realization rate higher than 1. A peak demand savings calculation did not apply to this project because these occupancy sensors do not operate when the peak demand period (i.e., 2:00pm to 5:00pm) occurs..

Table 10. UC Davis

Project	Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
Book Stacks	595,101	822,203	138%	23.2	106.0	457%
Nightly Main Area	43,688	66,052	151%	0.0	0.0	N/A

UC Irvine completed retrofits in stairwells as well as retrofits in three campus buildings. The stairwell retrofits included an upgrade to bi-level fixtures with occupancy sensors. Lighting in the stairwells prior to the retrofit remained on during an entire 24 hour period. The ex-ante estimates assumed that the lighting usage would decrease from 8,760 to 1,095 hours (while low wattage lighting operates for the remainder). The realization rate for the bi-level light project is below 1 because the monitoring data found that stairwells were occupied for longer periods than stated by the ex-ante assumptions. The peak demand savings are similar for the ex-ante and ex-post case because UC Irvine accounted for the load reduction resulting from occupancy sensor operation. The monitoring data determined that the stairwell lighting was on approximately 20% of the time during the peak demand period.

The retrofits in the three campus buildings included upgrades in lighting and occupancy sensor installations. The ex-ante assumptions were made at the building level and hours of operation for each space type were assumed to be the same. The realization rate for the building retrofits is 149% because the ex-ante reduction in operating hours, as a result of occupancy sensor installations, was lower than the hour reductions verified by the monitoring data. The peak demand savings realization rate is 373% because of a significant difference between the ex-ante and post-ante reported numbers. UC Irvine assumed that all lights were on in each of the space types of the three buildings during the peak demand period. However, monitoring data verified that the newly installed occupancy sensors reduced the number of lights on during the 2:00pm to 5:00pm period. Data indicated that only approximately 25% of lights remained on. This reduction was a result of the occupancy sensors as well as the peak period occurring during the partial session time period which occurs during the summer. Similar to other campuses, UC Irvine's summer session sees fewer classes and fewer students occupying campuses spaces than during the regular fall and spring semesters.

Table 11. UC Irvine

Project	Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
Bi-Level Stairwell Lighting	220,501	204,770	93%	18.7	18.1	97%
Building Retrofits	201,401	300,481	149%	16.3	60.7	373%

UC San Diego completed a campus wide lighting retrofit of various space types within several different buildings across their campus. UC San Diego assumed 8760 hours for all areas receiving retrofits. UC San Diego did not claim different operating hours for the different space types identified in this study. The realization rate is 39% because the logged operating hours for several of the space types identified were much lower than 24 hours per day. The peak demand realization rate for UC San Diego was also low because monitoring data determined that only a portion of the lights were on during the peak period. The low value is a result of the different in ex-ante operating hours and monitored hours. The ex-ante assumed that all lights were on while the monitoring determined that only approximately 25% of lights remained on during the peak period. Similar to other campuses, the peak period occurred during the summer session (partial session time period) when fewer students occupy campus spaces. Additionally, the documentation available for the analysis did not match the final reported ex-ante savings. It was not possible to verify why the final peak demand savings differed from the savings reported in the project tracking data. No documentation was available to confirm if any changes had occurred to the retrofit projects or the ex-ante assumptions and calculations.

Table 12. San Diego

Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
7,443,115	2,896,337	39%	2,233	229.6	10%

UC San Francisco completed retrofits in two garages and one library. The garage retrofits upgraded lighting to more efficiency T8 lamps. The ex-ante hours claimed for the MU garage is 8,760 hours. After brief discussions with facilities staff it was verified that the MU garage, which services a hospital, operates 24 hours a day for 7 days a week. Additionally, the monitoring data verified this claim. As a result, the realization rate for the MU garage is 100%.

The Laurel Heights garage is controlled by a timer to operate from 6:00am to 8:00pm. However, during the monitoring period the timer failed and the lights operated for the entire 24 hours period for a number of days. When the problem was discovered facilities staff manually controlled the lights. The ex-ante hours assumption for this garage is 4,175 hours. The resulting realization rate of 111% is attributed to the monitoring data recording 4,269 hours of operation per year. This increase in hours may have been a result of the failed timer.

For both UC San Francisco garages, the peak demand savings realization rates are 100%. The monitoring data verified the ex-ante claim that all lights remain on during the peak demand period.

The retrofits completed in the UC San Francisco library upgraded lighting to more efficient T8s and ballasts. These retrofits occurred in library stacks and in several offices. No occupancy sensors were installed and the ex-ante hours of operation claimed for this project is 4,500 hours for all spaces receiving retrofits. The realization rate is above 1 because the library's verified annual hours exceeded the claimed 4,500 hours. The peak demand savings realization rate is 59% because the monitoring data verified that only approximately half of the lights were on during the peak period while the ex-ante claimed that all lights were on. This lower coincidence factor can be attributed to the peak demand period occurring during the summer session (partial session time period) when there are fewer students occupying campus spaces.

Table 13. UC San Francisco

Project	Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
Garage MU	713,432	713,432	100%	81.4	81.4	100%
Garage Laurel Heights	32,690	36,245	111%	7.8	7.8	100%
Library	198,411	287,567	145%	45.7	26.8	59%

UC Santa Cruz completed a campus wide lighting retrofit of various space types within several different buildings across their campus. UC Santa Cruz assumed 18 hours of operation for halls and 12 hours of operation for all rooms receiving retrofits. UC Santa Cruz did not claim different operating hours for the different space types identified in this study. The realization rate is 47% because the logged operating hours for several of the space types identified were much lower than the ex-ante assumption of 12 hours per day (4,380 per year). The peak demand savings realization rate is 18% because the monitoring data verified that on average less than half of the buildings' lights were on during the peak period. The ex-ante peak demand savings claimed that 100% of lights were on. Similar to other campuses, the peak period occurred during the summer session at UC Santa Cruz. Typically during the summer session, fewer classes are offered to students and fewer students are present to occupy the various campus spaces. Additionally, a portion of the faculty and staff are likely be away from campus during the summer session.

Table 14. UC Santa Cruz

Ex-Ante Savings Estimate	Verified Savings	kWh Realization Rate	Peak Demand Savings Estimate	Verified Peak Demand Savings	Peak Demand Savings Realization Rate
165,945	78,701	47%	35	6.3	18%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

STEAM TRAP ENERGY SAVINGS STUDY – CSU - SACRAMENTO

November 4, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#
Company Name	California State University, Sacramento
Site Name	Central Plant and Campus-wide
Site Address	6007 J St, Sacramento, CA 95819
Site Type	University
Company Business/Product	University / Education

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[13]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Install new steam traps	Replace 8 defective steam traps.
M2	HVAC	Survey steam traps	Conduct survey of 154 existing steam traps.

2.2. Annual Measure Savings[1]

Table 15. Annual Measure Savings

Project Measure Number	Electric		Gas	Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input		
M1	-	-	4,120	-	100%

The *ex-ante* savings estimates were developed and submitted by the campus commissioned consultant, SteamEnergyPlus.[14] The initial application indicated 154 steam traps with the expected replacement of 8 units. The summary of the actual study included the survey and testing of 154 steam traps. Both low and high pressure traps were included in the survey. This system survey resulted in the repair or replacement of 8 steam traps, 8 of which were leaking.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

[13] Form B - Steam Traps Retrofit Application 2006-08 - 012507.xls

[14] UCB 2007 Steam Trap Survey.pdf

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation[15]

Program Measure Number	Equipment and Operation – Pre-installation
M1-M2	The CSU Sacramento steam system runs nearly continuously throughout the year, with short periods of down time due to maintenance and some sections closed seasonally. The savings estimates from the Workpaper assumed 7,752 hours of operation per year, less than actual campus operation. Therefore, this is expected to provide a conservative savings estimate. The steam traps were divided into low pressure (≤ 15 psig) and high pressure (>15 psig).

2.7. As-Built Equipment and Operation[16]

Measure characteristics for the steam system retrofits were drawn from the most recent project review file and documented savings calculations developed by SteamEnergyPlus.

Program Measure Number	Equipment and Operation – As-Built
M1	Project measures included the evaluation and replacement of high and low pressure steam traps on a campus-wide basis. The summary indicated there were 154 units located, and tested. There were 8 units needing repair. Of the leaking units, 2 were low pressure and 6 were high pressure. The detailed survey data includes annual steam loss estimates for each failed trap as well as estimated cost savings for each repair.

2.8. Seasonal Variability in Schedule and Production

A section of the CSU Sacramento steam system equipment operates continuously except for maintenance downtime. The heating and cooling loads for the facility vary mostly with the seasons and one section of the system is only turned on seasonally.

[15] Form B - Steam Traps Retrofit Application 2006-08 - 012507.xls

[16] UCB 2007 Steam Trap Survey.pdf

The best time to collect M&V data would be when the steam loads are active, i.e., winter for heating only loads, summer for absorption chiller loads, and year-round for CHP and laboratory loads. Consequently, fall or winter data collection is best. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort. Although the model assumes 7,752 hours of operation, the campus runs the system continuously, 8,760 hours per year. Details of the seasonal operation will be obtained from facility personnel.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the UC Berkeley Steam System Energy Savings Study project were developed by SteamEnergyPlus.[17] Their approach to estimating *ex-ante* savings is below.

Program Measure Number	Algorithm
M1	The Steam Trap Workpaper[18] was used to estimate medium/high pressure steam trap savings. The following baseline assumptions were made when estimating system *ex-ante* savings: • Low pressure steam traps have pressures ≤15 psig • Average low pressure steam trap inlet pressure of 11 psig • Average low pressure leak rate 6.9 lb/hr • Annual energy savings of 638 therms/yr for low pressure traps • Medium/High pressure steam traps have pressures >15 psig • Average medium/high pressure steam trap inlet pressure of 86 psig • Average medium/high pressure leak rate 27.2 lb/hr • Annual energy savings of 2,342 therms/yr for medium/high pressure traps Several surveys of steam traps were used by the Workpaper to provide sizes and conditions for steam traps. These values were used to calculate the estimated gross savings obtained by replacement of a failed open steam trap using two algorithms. Average values for savings listed above were then calculated in the Workpaper and have been used to estimate savings at the site. The first algorithm is the Napier Equation: Lbs Mass/Hr = $(\pi \times D^2/4 \times SP)/70$ Where: D = Orifice diameter in inches SP = Supply pressure in PSIG The second algorithm that was used is: Therm Savings = (M x LF x Hr x HV x CF) /(100 * BE) Where:

[17] UCB 2007 Steam Trap Survey Section 1.pdf

[18] 2K0700422 Att 1 SteamTrap Workpaper .doc

Program Measure Number	Algorithm
	M = Lbs Mass/Hr found via the Napier Equation LF = Leak Factor Corresponding the leak type, fully open leaks LF = 1, partial leaks, LF = .75 HR = Annual operational hours HV = Heat of Evaporation of steam at SP inBTU/lb CF = Condensate Factor, 0.6 BE = Boiler efficiency

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Options A and C will be used for evaluation purposes.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach in both the pre- and post-retrofit case involve end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M1	Energy savings attributed to the replacement of steam traps will be realized in a reduction of natural gas usage at the central plant. The proposed evaluation approach will seek to verify affected system components, including: • Use an ultrasonic leak detector to determine level of leaks, if any. Alternatively, measurement of temperature and/or pressure may be used to verify that steam traps are no longer leaking if ultrasonic measurement is not practical in some areas. If they are leaking, calculations of leakage amount will be performed using the algorithms outlined in section 3.1. The survey taken during the assessment included leak levels and these will be compared to conditions found during the site visit. • Comparison of pre- and post-installation steam usage if logs are available and of natural gas usage if savings are significant enough to be discernable. The evaluation team will also verify the following *ex-ante* input assumptions: • Temperature and pressure of repaired steam traps to determine that they have been repaired.

Evaluation Measure Number	Algorithm
	• Plant Operation: Central plant steam capacity and operating hours. These parameters will be confirmed through logs obtained from the University facilities office and discussions with facility personnel. • Steam Usage: Compare pre- and post-installation steam usage for affected areas. Overall, the evaluation will use the *ex-ante* algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by confirming that steam traps are no longer leaking or clogged and evaluating overall steam usage.

3.4. **Peak Demand Algorithms Used in the Evaluation**

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project for electric savings.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	1. **Use Ultrasonic Leak Detector** to assess leak level, if any, of repaired traps. 2. **Spot Measure Supply Pressure** at the steam traps being evaluated with hand-held Fluke PV-350 or equivalent where practical. Alternatively, use temperature to estimate pressure. 3. **Spot Measure Pipe Temperature** with Amprobe ACD-31P thermocouple or IR temperature probe. 4. **Collect Natural Gas Usage Data** from the University Facilities – Energy Management Office (if possible). 5. **Collect Building-Level Steam Consumption Data** from the University Facilities – Energy Management Office if available.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a sample of affected equipment. For low pressure steam traps, a 90% confidence level with 20% margin of error (90/20) would require a sample size of units. A 90/15 sample would include traps. Based on leak levels recorded during the initial survey, low pressure traps had leak levels above 10 and had leak levels of 10. The sample will include all of the traps which had leak levels above 10, and possibly some of the lower leak level units.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. **Uncertainties**

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1. Our ability to obtain adequate trend logs from the customer.
2. The percentage of natural gas usage saved by steam trap replacement.

4.6. **Data Products**

The following data products will be produced during the evaluation:

- Building steam use data
- Estimated gross savings (Therms)
- Site M&V report

4.7. **Data Reporting Formats**

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. **Building Characteristics Data**

Whenever possible, we will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Steam trap repair and replacement.
Steam Trap Repair and Replacement	• Supply Steam Temperature Set Points for Areas Affected by Measure (F) • Supply Steam Pressure Set Points for System Affected by Measure

System	Characteristics
	• Model and Size of Affected Steam Trap

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations during October 2009 and thus witnessed the system during the higher demand season. All steam traps had been replaced and appeared to be operating as expected.

It was found that model name and number on steam traps is not clearly legible and often not found on the devices.

5.2. Analysis

Orifice diameter for each of the steam traps was given on the initial ex ante survey and these values were used in the Napier equation for the majority of the traps.

5.3. M&V results

Results of our M&V analysis are shown in Table 16. Since the original study was utilized to access important factors in the savings algorithms including mass loss, the ex-post analysis is very similar to the ex-ante. The realization rate is greater than 95.6%, even after correcting operational hours to demonstrate seasonal usage on some traps.

Table 16. M&V Results

Project Measure Number	Project Measure	Ex ante Therms Savings	Ex post Therms Savings	Realization Rate
M2	High and Low Pressure Steam Traps	4,120	3,938	95.6%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

STEAM TRAP ENERGY SAVINGS STUDY – UC-BERKELEY

November 4, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#
Company Name	University of California – Berkeley
Site Name	Central Plant and Campus-wide
Site Address	2000 Carleton St., Berkeley, CA 94720
Site Type	University
Company Business/Product	University / Education

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ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

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More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[19]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Install new steam traps	Replace 160 defective steam traps.
M2	HVAC	Survey steam traps	Conduct survey of 1,218 existing steam traps.

2.2. Annual Measure Savings[1]

Table 17. Annual Measure Savings

Project Measure Number	Electric		Gas	Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input		
M1	-	-	82,810	-	100%

The *ex-ante* savings estimates were developed and submitted by the campus commissioned consultant, SteamEnergyPlus.[20] The initial application indicated 1,218 steam traps with the expected replacement of 160 units. The summary of the actual study included the survey and testing of 970 steam traps. Both low and high pressure traps were included in the survey. This system survey resulted in the repair or replacement of 111 steam traps, 46 of which were leaking. The remaining 65 were plugged or flooded, or exhibited rapid cycling and were not eligible for incentives under the program, although they were repaired as part of the assessment.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

[19] Form B - Steam Traps Retrofit Application 2006-08 - 012507.xls

[20] UCB 2007 Steam Trap Survey.pdf

2.5. **Sample Type**

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. **Pre-Installation Equipment and Operation**[21]

Program Measure Number	Equipment and Operation – Pre-installation
M1-M2	The UC Berkeley steam system runs continuously throughout the year, with short periods of down time due to maintenance. The savings estimates from the Workpaper assumed 7,752 hours of operation per year, less than actual campus operation. Therefore this is expected to provide a conservative savings estimate. The steam traps were divided into low pressure (≤ 15 psig) and high pressure (>15 psig). The plans estimated 1,218 steam traps on the campus and expected replacement of 160 units, without reference to operating pressure.

2.7. **As-Built Equipment and Operation**[22]

Measure characteristics for the steam system retrofits were drawn from the most recent project review file and documented savings calculations developed by SteamEnergyPlus.

Program Measure Number	Equipment and Operation – As-Built
M1	Project measures included the evaluation and replacement of high and low pressure steam traps on a campus-wide basis. The summary indicated there were 1,218 units located, and tested. There were 111 units needing repair, 46 of which were leaking. Of the leaking units, 20 were low pressure and 26 were high pressure. The detailed survey data includes annual steam loss estimates for each failed trap as well as estimated cost savings for each repair.

[21] Form B - Steam Traps Retrofit Application 2006-08 - 012507.xls

[22] UCB 2007 Steam Trap Survey.pdf

2.8. Seasonal Variability in Schedule and Production

The UC Berkeley steam system equipment operates continuously except for maintenance downtime. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a ‘9-month academic calendar’ are small given year-round classes and lab research at the University.

The best time to collect M&V data would be when the steam loads are active, i.e. winter for heating only loads, summer for absorption chiller loads and year-round for CHP and laboratory loads. Consequently, nearly any time of year would be suitable for collecting some data. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort. Although the model assumes 7,752 hours of operation, the campus runs the system continuously, 8,760 hours per year. Details of the seasonal operation will be obtained from facility personnel.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the UC Berkeley Steam System Energy Savings Study project were developed by SteamEnergyPlus.[23] Their approach to estimating *ex-ante* savings is below.

Program Measure Number	Algorithm
M1	The Steam Trap Workpaper[24] was used to estimate medium/high pressure steam trap savings. The following baseline assumptions were made when estimating system *ex-ante* savings: • Low pressure steam traps have pressures ≤15 psig • Average low pressure steam trap inlet pressure of 11 psig • Average low pressure leak rate 6.9 lb/hr • Annual energy savings of 638 therms/yr for low pressure traps • Medium/High pressure steam traps have pressures >15 psig • Average medium/high pressure steam trap inlet pressure of 86 psig • Average medium/high pressure leak rate 27.2 lb/hr • Annual energy savings of 2,342 therms/yr for medium/high pressure traps Several surveys of steam traps were used by the Workpaper to provide sizes and conditions for steam traps. These values were used to calculate the estimated gross savings obtained by replacement of a failed open steam trap using two algorithms. Average values for savings listed above were then calculated in the Workpaper and have been used to estimate savings at the site. The first algorithm is the Napier Equation: Lbs Mass/Hr = $(\pi \times D^2/4 \times SP)/70$ Where: D = Orifice diameter in inches SP = Supply pressure in PSIG The second algorithm that was used is: Therm Savings = (M x LF x Hr x HV x CF) /(100 * BE) Where:

[23] UCB 2007 Steam Trap Survey Section 1.pdf

[24] 2K0700422 Att 1 SteamTrap Workpaper .doc

Program Measure Number	Algorithm
	M = Lbs Mass/Hr found via the Napier Equation LF = Leak Factor Corresponding the leak type, fully open leaks LF = 1, partial leaks, LF = .75 HR = Annual operational hours HV = Heat of Evaporation of steam at SP inBTU/lb CF = Condensate Factor, 0.6 BE = Boiler efficiency

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Options A and C will be used for evaluation purposes.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach in both the pre- and post-retrofit case involve end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M1	Energy savings attributed to the replacement of steam traps will be realized in a reduction of natural gas usage at the central plant. The proposed evaluation approach will seek to verify affected system components, including: • Use an ultrasonic leak detector to determine level of leaks, if any. Alternatively, measurement of temperature and/or pressure may be used to verify that steam traps are no longer leaking if ultrasonic measurement is not practical in some areas. If they are leaking, calculations of leakage amount will be performed using the algorithms outlined in section 3.1. The survey taken during the assessment included leak levels and these will be compared to conditions found during the site visit. • Comparison of pre- and post-installation steam usage if logs are available and of natural gas usage if savings are significant enough to be discernable. The evaluation team will also verify the following *ex-ante* input assumptions: • Temperature and pressure of repaired steam traps to determine that they have been repaired.

Evaluation Measure Number	Algorithm
	• Plant Operation: Central plant steam capacity and operating hours. These parameters will be confirmed through logs obtained from the University facilities office and discussions with facility personnel. • Steam Usage: Compare pre- and post-installation steam usage for affected areas. Overall, the evaluation will use the *ex-ante* algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by confirming that steam traps are no longer leaking or clogged and evaluating overall steam usage.

3.4. **Peak Demand Algorithms Used in the Evaluation**

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project for electric savings.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**6. Use Ultrasonic Leak Detector** to assess leak level, if any, of repaired traps. **7. Spot Measure Supply Pressure** at the steam traps being evaluated with hand-held Fluke PV-350 or equivalent where practical. Alternatively use temperature to estimate pressure. **8. Spot Measure Pipe Temperature** with Amprobe ACD-31P thermocouple or IR temperature probe. **9. Collect Natural Gas Usage Data** from the University Facilities – Energy Management Office (if possible). **10. Collect Building-Level Steam Consumption Data** from the University Facilities – Energy Management Office if available.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	Based on leak levels recorded during the initial survey, low pressure traps had leak levels above 10 and had leak levels of 10. The sample will include all of the traps which had leak levels above 10, and possibly some of the lower leak level units.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1 Our ability to obtain adequate trend logs from the customer.

2 The percentage of natural gas usage saved by steam trap replacement.

4.6. Data Products

The following data products will be produced during the evaluation:

- Building steam use data
- Estimated gross savings (Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

Whenever possible, we will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Steam trap repair and replacement.
Steam Trap Repair and Replacement	• Supply Steam Temperature Set Points for Areas Affected by Measure (F) • Supply Steam Pressure Set Points for System Affected by Measure • Model and Size of Affected Steam Trap

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations during August 2009 and thus witnessed the system during the lower demand season. Summit Blue found that 6 of the steam traps were not operational as steam the steam system had shut down in those areas for building construction and maintenance, or due to seasonal use only. All steam traps had been replaced and appeared to be operating as expected.

It was found that model name and number on steam traps is not clearly legible and often not found on the devices.

5.2. Analysis

Due to the lack of model numbers on each of the sampled steam traps, we were not able to find accurate data on orifice diameter and were unable to use the Napier equation for the majority of the traps. Where possible, the equation was used. Otherwise, mass loss was assumed to be as indicated on the Master Log Report Survey written by PAN-Pacific Supply Co.

5.3. M&V results

Results of our M&V analysis are shown in Table 18. Since the original study was utilized to access important factors in the savings algorithms including mass loss, the ex-post analysis is very similar to the ex-ante. The realization rate is greater than 100%, even after correcting operational hours to demonstrate seasonal usage on some traps. The high realization is largely due to the low boiler efficiency. UC Berkley uses a co-generation system rather than a standard efficiency boiler, and therefore utilizes more natural gas in steam production than had been assumed in the SteamStar study.

Table 18.M&V Results

Project Measure Number	Project Measure	Ex ante Therms Savings	Ex post Therms Savings	Realization Rate
M2	High Pressure Steam Traps	82,810	113,703	137%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

STEAM TRAP ENERGY SAVINGS STUDY – UC-DAVIS

November 5, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#186
Company Name	University of California – Davis
Site Name	Central Plant and Campus-wide
Site Address	One Shields Ave., Davis, CA 95616
Site Type	University
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[25]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Survey HP steam traps	Conduct survey of 300 existing HP steam traps.
M2	HVAC	Install new HP steam traps	Install 45 HP steam traps for blocked or leak thru.
M3	HVAC	Survey of LP steam traps	Conduct survey of 3,000 existing LP steam traps.
M4	HVAC	Install new LP steam traps	Install 450 LP steam traps for blocked or leak thru.

2.2. Annual Measure Savings[26]

Table 19. Annual Measure Savings

Project Measure Number	Electric		Gas	Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input		
M2	-	-	131,588	-	27.6%
M4	-	-	227,849	-	72.4%

The *ex-ante* savings estimates were developed and submitted by the campus commissioned consultant, PAN-Pacific Supply Co.[27] The initial application indicated 3,300 steam traps with the expected replacement of 495 units. The summary of the actual study included the survey of 2,320 steam traps, 2,247 of which were tested for leakage or other repair requirements. Both low and high pressure traps were included in the survey. This system survey resulted in the repair or replacement of 560 steam traps, 308 of which were leaking. The remaining 252 were blocked or showed temperature losses and were not eligible for incentives under the program, although they were repaired as part of the assessment.

[25] Form B –UCD Steam Trap Retrofit 032807.xls

[26] Form B –UCD Steam Trap Retrofit 032807.xls

[27] Steam Trap Survey Letter.pdf

2.3. **Impact Type**

The impact type for all measures is *direct*.

2.4. **Baseline Type**

The baseline for all measures is *early replacement*.

2.5. **Sample Type**

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. **Pre-Installation Equipment and Operation**[28]

Program Measure Number	Equipment and Operation – Pre-installation
M1-M2	The UC Davis steam system runs continuously throughout the year, with short periods of down time due to maintenance. The savings estimates from the Workpaper assumed 7,752 hours of operation per year, less than actual campus operation. Therefore this is expected to provide a conservative savings estimate. The steam traps were divided into low pressure (≤ 15 psig) and high pressure (>15 psig). The plans estimated 3,300 steam traps on the campus and expected replacement of 45 high pressure and 450 low pressure units.

2.7. **As-Built Equipment and Operation**[29]

Measure characteristics for the steam system retrofits were drawn from the most recent project review file and documented savings calculations developed by PAN-Pacific Supply Co.

Program Measure Number	Equipment and Operation – As-Built
M1-M4	Project measures included the evaluation and replacement of high and low pressure steam traps on a campus-wide basis. The summary indicated there were 2,320 units located, 2,247 of which were tested. There were 560 units needing repair, 308 of which were leaking. Of the leaking units, 119 were low pressure and 189 were high pressure. The detailed survey data includes leak values for each trap as well as estimated cost savings for each repair. Although actual gas savings are not listed on a per trap basis, they can be calculated from the provided survey data.

[28] 2K0700422_UCD Steam Trap Retrofit PA Review (P59).xls

[29] Steam Trap Survey Summary Letter.pdf

2.8. Seasonal Variability in Schedule and Production

The UC Davis steam system equipment operates continuously except for maintenance downtime. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a '9-month academic calendar' are small given year-round classes and lab research at the University.

The best time to collect M&V data would be when the steam loads are active, i.e., winter for heating only loads, summer for reheat loads and year-round for CHP and laboratory loads. Consequently, nearly any time of year would be suitable for collecting some data, although the highest steam loads are during the winter months. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort. Although the model assumes 7,752 hours of operation, the campus runs the system continuously, 8,760 hours per year. Details of the seasonal operation will be obtained from facility personnel.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the UC Davis Steam System Energy Savings Study project were developed by PAN-PACIFIC SUPPLY CO.[30] Their approach to estimating *ex-ante* savings is below.

Program Measure Number	Algorithm
M2	The Steam Trap Workpaper[31] was used to estimate medium/high pressure steam trap savings. The following baseline assumptions were made when estimating system *ex-ante* savings: • Medium/High pressure steam traps have pressures >15 psig • Average medium/high pressure steam trap inlet pressure of 86 psig • Average medium/high pressure leak rate 27.2 lb/hr • Annual energy savings of 2,342 therms/yr for medium/high pressure traps Several surveys of steam traps were used by the Workpaper to provide sizes and conditions for steam traps. These values were used to calculate the estimated gross savings obtained by replacement of a failed open steam trap using two algorithms. Average values for savings listed above were then calculated in the Workpaper and have been used to estimate savings at the site. The first algorithm is the Napier Equation: Lbs Mass/Hr = $(\pi \times D^2/4 \times SP)/70$ Where: D = Orifice diameter in inches SP = Supply pressure in PSIG The second algorithm that was used is: Therm Savings = (M xLF x Hr x HV x CF) /(100 * BE) Where: M = Lbs Mass/Hr found via the Napier Equation LF = Leak Factor Corresponding the leak type, fully open leaks LF = 1, partial leaks, LF = .75 HR = Annual operational hours

[30] UC Davis Master Log Report 274 pages.pdf

[31] 2K0700422 Att 1 SteamTrap Workpaper .doc

Program Measure Number	Algorithm
	HV = Heat of Evaporation of steam at SP inBTU/lb CF = Condensate Factor, 0.6 BE = Boiler efficiency
M4	The Steam Trap Workpaper[32] was used to estimate low pressure steam trap savings. The following baseline assumptions were made when estimating system *ex-ante* savings: • Low pressure steam traps have pressures ≤15 psig • Average low pressure steam trap inlet pressure of 11 psig • Average low pressure leak rate 6.9 lb/hr • Annual energy savings of 638 therms/yr for low pressure traps The same methodology was used for low pressure as for medium/high pressure steam traps.

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Options A and C will be used for evaluation purposes.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach in both the pre- and post-retrofit case involve end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M2	Energy savings attributed to the replacement of steam traps will be realized in a reduction of natural gas usage at the central plant. The proposed evaluation approach will seek to verify affected system components, including: • Use an ultrasonic leak detector to determine level of leaks, if any. Alternatively, measurement of temperature and/or pressure may be used to verify that steam traps are no longer leaking if ultrasonic measurement is not practical in some areas. If they are leaking, calculations of leakage amount will be performed using the algorithms outlined in section 3.1. The survey taken during the assessment included leak levels and these will be compared to conditions found

[32] 2K0700422 Att 1 SteamTrap Workpaper .doc

Evaluation Measure Number	Algorithm
	during the site visit. • Comparison of pre- and post-installation steam usage if logs are available and of natural gas usage if savings are significant enough to be discernable. The evaluation team will also verify the following *ex-ante* input assumptions: • Temperature and pressure of repaired steam traps to determine that they have been repaired. • Plant Operation: Central plant steam capacity and operating hours. These parameters will be confirmed through logs obtained from the University facilities office and discussions with facility personnel. • Steam Usage: Compare pre- and post-installation steam usage for affected areas. Overall, the evaluation will use the *ex-ante* algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by confirming that steam traps are no longer leaking or clogged and evaluating overall steam usage.

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M2, M4	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM, during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M2, M4	11. **Use Ultrasonic Leak Detector** to assess leak level, if any, of repaired traps. 12. **Spot Measure Supply Pressure** at the steam traps being evaluated with hand-held Fluke PV-350 or equivalent where practical. Alternatively use temperature to estimate pressure. 13. **Spot Measure Pipe Temperature** with Amprobe ACD-31P thermocouple or IR temperature probe. 14. **Collect Natural Gas Usage Data** from the University Facilities – Energy Management Office (if possible). 15. **Collect Building-Level Steam Consumption Data** from the University Facilities – Energy Management Office if available.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M2	The evaluation will be based on a sample of affected equipment. For 189 high pressure steam traps, a 90% confidence level with 20% margin of error (90/20) would require a sample size of 16 units. A 90/15 sample would include 27 traps. Based on leak levels recorded during the initial survey, eight high pressure traps had leak levels of 11 and eight had leak levels of 12. An additional 17 had leak levels above 12. The sample will include all of the traps which had leak levels above 12, and possibly some of the lower leak level units.
M4	The evaluation will be based on a sample of affected equipment. For 119 low pressure steam traps, a 90% confidence level with 20% margin of error (90/20) would require a sample size of 15 units. A 90/15 sample would include 28 traps. Based on leak levels recorded during the initial survey, 16 low pressure traps had leak levels above 10 and four had leak levels of 10. The sample will include all of the traps which had leak levels above 10, and possibly some of the lower leak level units.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1. Our ability to obtain adequate trend logs from the customer.
2. The percentage of natural gas usage saved by steam trap replacement.

4.6. Data Products

The following data products will be produced during the evaluation:

- Building steam use data
- Estimated gross savings (Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

Whenever possible, we will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Steam trap repair and replacement.
Steam Trap Repair and	• Supply Steam Temperature Set Points for Areas

System	Characteristics
Replacement	Affected by Measure (F) • Supply Steam Pressure Set Points for System Affected by Measure • Model and Size of Affected Steam Trap

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations during August 2009 and thus witnessed the system during the lower demand season. Summit Blue found that three of the steam traps in the initial sample had been removed from the system, resulting in no savings for those traps. Otherwise, all steam traps had been replaced and appeared to be operating as expected.

It was found that model name and number on steam traps is not clearly legible and often not found on the devices.

5.2. Analysis

Due to the lack of model numbers on each of the sampled steam traps, we were not able to find accurate data on orifice diameter and were unable to use the Napier equation. Where possible, the equation was used. Otherwise, mass loss was assumed to be as indicated on the Master Log Report Survey written by PAN-Pacific Supply Co.

5.3. M&V results

Results of our M&V analysis are shown in Table 20. Realization rate is very close to 100% for both high and low pressure steam traps. Since the original study was utilized to access important factors in the savings algorithms, the ex-post analysis is very similar to the ex-ante.

Table 20. M&V Results

Project Measure Number	Project Measure	Ex ante Therms Savings	Ex post Therms Savings	Realization Rate
M2	High Pressure Steam Traps	131,588	131,567	97.5%
M4	Low Pressure Steam Traps	227,849	231,330	102%

Differences between the two figures are due to updated operational hours for the measures as several removed high pressure traps.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

STEAM TRAP ENERGY SAVINGS STUDY – SAN DIEGO STATE UNIVERSITY

November 4, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#101
Company Name	San Diego State University
Site Name	Central Plant and Campus-wide
Site Address	5500 Campanile Drive, San Diego, CA 92182
Site Type	University
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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IOU REPRESENTATIVE

Name		**Telephone**	
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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[33]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Survey HP steam traps	Conduct survey of 400 existing steam traps.
M2	HVAC	Install new LP steam traps	Install 15 LP steam traps for blocked or leak thru.
M3	HVAC	Install new HP steam traps	Install 25 HP steam traps for blocked or leak thru.

2.2. Annual Measure Savings[1]

Table 21. Annual Measure Savings

Project Measure Number	Electric		Gas	Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Total Therms Input		
M2			9,570		14%
M3	-	-	58,550	-	86%

The *ex-ante* savings estimates were developed and submitted by the campus commissioned consultant, Spirax Sarco, Inc. Energy Services.[34] The initial application indicated 400 steam traps with the expected replacement of 40 units, including both high and low pressure units. All of the replaced traps will be tested as part of this evaluation.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

[33] SDSU - STEAMTRAP - Replacement Application 2006-08 - 030207.xls

[34] Steam Trap Survey 2-2007.pdf

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation[35]

Program Measure Number	Equipment and Operation – Pre-installation
M1-M3	The SDSU steam system runs continuously throughout the year, with short periods of down time due to maintenance. The savings estimates assumed 7,752 hours of operation per year. The steam traps were divided into low pressure (≤ 15 psig) and medium or high pressure (>15 psig). The plans estimated 400 steam traps on the campus and expected replacement of 25 high pressure and 15 low pressure units.

2.7. As-Built Equipment and Operation[36]

Measure characteristics for the steam system retrofits were drawn from the most recent project review file and documented savings calculations developed by Spirax Sarco, Inc. Energy Services.

Program Measure Number	Equipment and Operation – As-Built
M1	Project measures involved the evaluation of high and low pressure steam traps on a campus-wide basis. The survey found one failed open, two failed closed, and eight cold low pressure steam traps as well as one cold high pressure steam trap. There were also 16 failed open, two 2 failed closed, and one cold steam trap located. Three steam traps were found to be disconnected or removed and 103 of the low pressure steam traps and 242 of the high pressure steam traps were found to be okay. A total of 379 steam traps were surveyed. Of these, a total of three low and 18 high pressure steam traps were found to be in need of replacement.
M2	Replace 3 failed low pressure steam traps.
M3	Replace 18 failed high pressure steam traps.

[35] SDSU - STEAMTRAP - Replacement Application 2006-08 - 030207.xls

[36] Steam Trap Survey 2-2007.pdf

2.8. Seasonal Variability in Schedule and Production

The SDSU steam system equipment operates continuously with short periods of downtime for maintenance. The Workpaper is based upon operation of 7,752 hours per year and has been used for savings estimates. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a '9-month academic calendar' are small given year-round classes and lab research at the University.

The best time to collect M&V data would be when the constant volume system is active. Consequently, nearly any time of year would be suitable for collecting data. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort. Although the model assumes 7,752 hours of operation, the campus runs the system continuously, 8,760 hours per year. Details of the seasonal operation will be obtained from facility personnel.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the Steinhaus Hall HVAC System Energy Savings Study project were developed by Spirax Sarco, Inc. Energy Services.[37] Their approach to estimating *ex-ante* savings is below.

<table>
<tr><th>Program Measure Number</th><th>Algorithm</th></tr>
<tr><td>M2</td><td>The Steam Trap Workpaper[38] was used to estimate medium/high pressure steam trap savings. The following baseline assumptions were made when estimating system ex-ante savings:

• Low pressure steam traps have pressures ≤15 psig
• Average low pressure steam trap inlet pressure of 11 psig
• Average low pressure leak rate 6.9 lb/hr
• Annual energy savings of 638 therms/yr for low pressure traps

Several surveys of steam traps were used by the Workpaper to provide sizes and conditions for steam traps. These values were used to calculate the estimated gross savings obtained by replacement of a failed open steam trap using two algorithms. Average values for savings listed above were then calculated in the Workpaper and have been used to estimate savings at the site.

The first algorithm is the Napier Equation:

Lbs Mass/Hr = $(\pi \times D^2/4 \times SP)/70$

Where:

D = Orifice diameter in inches

SP = Supply pressure in PSIG

The second algorithm that was used is:

Therm Savings = (M xLF x Hr x HV x CF) /(100 * BE)

Where:

M = Lbs Mass/Hr found via the Napier Equation

LF = Leak Factor Corresponding the leak type, fully open leaks LF = 1, partial leaks, LF = .75

HR = Annual operational hours</td></tr>
</table>

[37] Steam Trap Survey 2-2007.pdf

[38] SteamTrap Workpaper (11Dec06).doc

Program Measure Number	Algorithm
	HV = Heat of Evaporation of steam at SP inBTU/lb CF = Condensate Factor, 0.6 BE = Boiler efficiency
M3	The Steam Trap Workpaper[39] was used to estimate medium/high pressure steam trap savings. The following baseline assumptions were made when estimating system *ex-ante* savings: • Medium/High pressure steam traps have pressures >15 psig • Average medium/high pressure steam trap inlet pressure of 86 psig • Average medium/high pressure leak rate 27.2 lb/hr • Annual energy savings of 2,342 therms/yr for medium/high pressure traps The same methodology was used for medium/high pressure steam traps as for low pressure steam traps.

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Options A and C will be used for evaluation purposes.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach in both the post-retrofit case involves end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M2, M3	Energy savings attributed to the replacement of steam traps will be realized in a reduction of natural gas usage at the central plant. The proposed evaluation approach will seek to verify affected system components, including: • Use an ultrasonic leak detector to determine level of leaks, if any. Alternatively, measurement of temperature and/or pressure may be used to verify that steam traps are no longer leaking if ultrasonic measurement is not practical in some areas. If they are leaking, calculations of leakage amount will be performed using the algorithms outlined in section 3.1. The survey taken during the

39 SteamTrap Workpaper (11Dec06).doc

Evaluation Measure Number	Algorithm
	assessment included leak levels, and these will be compared to conditions found during the site visit. • Comparison of pre- and post-installation steam usage, if logs are available, and of natural gas usage, if savings are significant enough to be discernable. The evaluation team will also verify the following *ex-ante* input assumptions: • Steam temperature and pressure of repaired traps to determine that they have been repaired. This data along with pre-repair values will be used to estimate savings using equation 3.1. • Plant Operation: Central plant steam capacity and operating hours. These parameters will be confirmed through logs obtained from the University facilities office. • Steam Usage: Compare pre- and post-installation steam usage for affected areas. Overall, the evaluation will use the *ex-ante* algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by confirming that steam traps are no longer leaking or clogged and evaluating overall steam usage.

3.4. **Peak Demand Algorithms Used in the Evaluation**

Evaluation Measure Number	Algorithm
M2, M3	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM, during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project for any electric savings.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M2, M3	**16. Use Ultrasonic Leak Detector** to assess leak level, if any, of repaired traps. **17. Spot Measure Supply Pressure** with hand-held Fluke PV-350 or equivalent where practical. Alternatively use temperature measured at the trap or nearest gauge to calculate pressure. **18. Spot Measure Pipe Temperature** with Amprobe ACD-31P thermocouple or IR temperature probe. **19. Collect Natural Gas Usage Data** from the University Facilities – Energy Management Office (if possible) and from the Utility. **20. Collect Building-Level Steam Consumption Data** from the University Facilities – Energy Management Office if available.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M2, M3	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1 Our ability to obtain adequate data from the customer.

2 The percentage of natural gas usage saved by steam trap replacement. Pre-installation survey data includes estimated leakage values, but there is uncertainty in these values.

4.6. Data Products

The following data products will be produced during the evaluation:

- Building steam use data
- Estimated gross savings (Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

Whenever possible, we will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Steam trap repair and replacement.
Steam Trap Repair and Replacement	• Supply Steam Temperature Set Points for Areas Affected by Measure (F) • Supply Steam Pressure Set Points for System Affected by Measure • Model and Size of Affected Steam Trap

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations during August 2009, and thus witnessed the system during the lower demand season. Summit Blue found that several sections of the steam system were shut down due to building maintenance and seasonal use. Operational hours were adjusted accordingly. Also, two high pressure steam traps had become blocked and thus resulted in no savings. Otherwise, all steam traps had been replaced and appeared to be operating as expected.

5.2. Analysis

It was found that model name and number on steam traps is not clearly legible and often not found on the devices; however, the Spirax Barco STM survey listed each steam trap by model number as well as orifice diameter, so it was possible to use the Napier Equation to calculate mass loss.

5.3. M&V results

Results of our M&V analysis are shown in Table 22. Realization rate is high for both low pressure and high pressure steam traps, despite two failed high pressure steam traps and adjusted operational hours. The ex-ante calculations had been done by Spirax Barco STM. Spirax utilizes a modified Napier equation, $M = 24.4 \times D^2 \times (SP+14.7)$. This modified Napier equation yields a significantly different mass flow rate.

Table 22. M&V Results

Project Measure Number	Project Measure	Ex ante Therms Savings	Ex post Therms Savings	Realization Rate
M2	Low Pressure Steam Traps	9,570	12,985	135.7%
M3	High Pressure Steam Traps	58,550	73,382	125.0%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

CENTRAL PLANT – CHILLER REPLACEMENT (ELECTRIC CENTRIFUGAL FOR ABSORPTION)

October 27, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	TBD
Company Name	University of California – Davis
Site Name	Central Plant B
Site Address	University of California – Davis, Davis, CA
Site Type	Central Plant
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

Name	Joshua Morejohn	**Telephone**	
E-mail		**Title**	Project Manager

IOU REPRESENTATIVE

Name	David T. Hather	**Telephone**	
E-mail			

RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Roger Hill

AUTHOR

Name	Roger Hill

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for the 56 programs in this group.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrocommissioning measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for chillers, based on measurements and automation system logs.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

2. MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	Chilled Water	Chiller Replacement	Replace three (3) 1000-ton absorption chillers with two (2) 2500-ton centrifugal chillers. Replace associated primary chilled water (2) 75 HP and condenser water pumps (2) 100 HP.

2.2. Application Approved Annual Measure Savings[40]

Table 23. Annual Measure Savings

Project Measure Number	Electric		Gas	
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating
M1	-	-	1,246,278	0

This project is a replacement of three 1,000-ton absorption chillers (installed 1971 and 1975) with two 2,500 ton electric centrifugal chillers at the University of California, Davis, chilled water plant. The chilled water infrastructure consists of three plants with constant volume primary pumping tied into a single variable volume campus loop. Cooling load is shared among the three plants, so an estimate of changes requires examination of the whole system. Replacing the absorption machines will also affect primary loop pumping, condensing water pumping, and cooling tower fan operation. This project passes the "three-pronged" test for fuel switching.

Historically, the absorption machines were driven with waste heat from the campus' CHP plant or from waste heat from steam turbine-drive centrifugal chillers. As such, they achieved good resource efficiency. The power generation capability was decommissioned in 2006 and natural gas-fired boilers were used to drive the absorption cooling cycles.

The application approved savings estimates were submitted by Emcor Energy services.

2.3. Impact Type

The impact type for all measures is *direct*.

[40] Form B – UCD absorber to centrifugal central plant 2007a.xls, February 15, 2006.

2.4. **Baseline Type**

The baseline for all measures is *normal replacement*. The proposed chillers replace 3 machines that are more than 20 years old plus their additional capacity will be able to offset use of other machines that are more than 15 years old, i.e. they have less than 5 years remaining expected useful life. Furthermore interviews with facility staff indicated that the project of similar scope was planned within a couple years and the incentives served to “tip the scale.”

The baseline machines therefore would be Title 24 compliant electric machines for the operating conditions on the chilled water plant. In this case the minimally compliant Title 24 machines have an efficiency of 0.75 kW/ton. The chillers installed in this project have an efficiency of 0.65 kW/ton.

2.5. **Sample Type**

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. **Pre-Installation Equipment and Operation**

Characteristics of the replaced and mothballed equipment were drawn from the most recent project review file and documented savings calculations submitted by Taylor Engineering, LLC [41] and the 2003 Black & Veatch study cited in its appendix.

Program Measure Number	Equipment and Operation – Pre-Installation
M1	Chilled water plant B consisted of three 1000-ton absorption machines with a design temperature drop of 15°F. They were part of three chilled water plants that staged machines according to the loads on the campus. The system delta T was 15°F. Chiller staging and sequencing is manual.

<table>
<tr><th>Existing</th><th>Age</th><th>Plant</th><th>New/Proposed</th></tr>
<tr><td>3 x 1000 ton Absorption</td><td>1971
-
1975</td><td>B</td><td>2 x 2500 ton electric Centrifugal</td></tr>
<tr><td>2 x 1200 ton Absorption</td><td rowspan="2">1990</td><td rowspan="2">C</td><td rowspan="2">1 x 2550 ton electric Centrifugal (installed after Plant B renovations)</td></tr>
<tr><td>1 x 1350 ton Steam Turbine Centrifugal</td></tr>
</table>

[41] Cornish, Tracy, P.E., Taylor Engineering, LLC, UC – Davis CHCP Plant B Chiller Replacement Report, Alameda, CA, November 14, 2007.

2 x 1224 ton Absorption	1994	**D**	Mothballed
1 x 1309 ton Steam Turbine Centrifugal			
10,507 tons (de-rated capacity 7749 tons[42])		Total	7,550 tons

Chilled water monitoring data for the 2006 calendar year indicates maximum chilled water load is 7,100 tons and it exceeds 5,000 tons for only 219 hours per year for a total of 130,000 ton-hours above a 5000 ton threshold.

The Black & Veatch report details an overall COP = 0.62 for the existing steam-driven plant based on measured data. Measured chilled water pump, condenser water pump, and cooling tower performance are also detailed in the Black & Veatch report and cited in the Taylor engineering report.

2.7. As-Built Equipment and Operation

Measure characteristics for the installed chillers and primary chilled water pumps were drawn from the most recent project review file and documented savings calculations submitted by Taylor Engineering, LLC.[43]

Program Measure Number	Equipment and Operation – As-Built
M1	Chilled water Plant B now consists of two 2500-ton electric centrifugal machines with the following design parameters. Power 1623.9kW 0.65 kW/ton CHWS/R 39/59F CWS/R 83/98F CHW flow 2985 gpm 1.19 gpm/ton CW flow 4720 gpm 1.89 gpm/ton Plant B runs in conjunction a recently renovated Chilled Water Plant C (1 x 2550 ton electric centrifugal) to meet about 30% of the cooling loads on the campus. Chilled water thermal energy storage (TES) tanks and dedicated chillers have been installed between 2005 and 2008 provide the bulk of the remaining cooling. Exact sequence of chiller staging is not known from project documents. The post-installation 2008 data show the two new Plant B chillers supplant all steam driven CHCP Plant B, C & D chillers. The new chiller in Plant C (not part of this evaluation) provides peaking capacity, but mostly redundancy. IN the 2008 records which are the basis of this

[42] Black & Veatch, 2003.

[43] Cornish, Tracy, P.E., Taylor Engineering, LLC, UC – Davis CHCP Plant B Chiller Replacement Report, Alameda, CA, November 14, 2007.

Program Measure Number	Equipment and Operation – As-Built
	evaluation the Plant C electric chiller did not operate Based on the 2006 and 2008 calendar year data acquired for this evaluation, the TES system provides about 70% of the cooling required on campus. This ratio increased for 68% to 73% with the installation of the new electric chillers for this project, i.e. chilled water load shifted somewhat from the steam-drive plant to the electric-drive TES plant. Since the efficiency of the TES chillers might be assumed similar to the new Plant B chillers we assume all steam-driven chilled water production becomes electric load. The TES tanks are charged at night to reduce peak daytime loads. Therefore TES chiller loads are not coincident with system loads. In 2008 the new chillers in Plant B were the only machines in operation in the Central Chilled water plant. Steam-drive machines in Plants C and D never operated, according to site data.

2.8. Seasonal Variability in Schedule and Production

The UCD chilled water plant is a seasonal operation with peak loads occurring in the summer months. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a “nine-month academic calendar” are small given year-round classes and lab research at the Hall.

The best time to collect M&V data would be when chilled water system is active near capacity. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

3. ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the installed chillers were developed by Emcor Group, Inc. Their approach to estimating *ex-ante* savings is unknown. No supporting calculations have been received from the original application.

Subsequently, Taylor Engineering researched the chilled water system and developed eQuest simulations for the chilled water plant based on recorded loads from the plant reporting system. Chiller energy and cooling tower energy were estimated via eQuest for the existing system, a new gas system using the best economic gas technology (COP = 1.11) and the proposed electric-drive chilled water system. Taylor made many simplifying assumptions based on limited knowledge of how machines are staged and no data on the performance of individual machines as they functioned through the cooling season. Their assumptions are common-sense and based on sound engineering principles.

Evaluation Measure Number	Algorithm
M1	The project expected savings to be realized in two areas: 1. Natural gas savings will derive from reducing the use of steam-driven chillers, both turbine-drive centrifugal machines and absorption cycle chillers. 2. Electricity savings will derive from smaller (on a kW/ton basis) auxiliary services for chilled water pumping 20°F vs15°F water: reduced condenser pumping and cooling tower fan operation for machines with 5.0+ COP vs 0.62 COP absorbers and elimination of relatively small electric pumps within the absorption machines. The project expected energy increases in one area: 1. Electricity increases will derive from installation of electric drive machines to replace absorption machines.

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option A & B will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

Based on the reported conversion of the all three steam-driven chilled water plants to electric-drive machines, Summit Blue will address the energy impacts of the chilled water system excluding the TES system and loads.

The proposed evaluation approach in the post-retrofit case involves verification of installed equipment, analysis of chilled water production logs generated by the University Facilities – Energy Management Office (EMO) and spot measurements to calibrate consumption data in the production logs.

Evaluation Measure Number	Algorithm
M1	The proposed evaluation approach will seek to visually verify affected system components, including: 1. **Conversion of the absorption chillers and auxiliary equipment with centrifugal chillers and newly sized auxiliaries:** Visually confirm motor and VFD nameplate data, efficiency, etc. 2. Confirm that cooling towers are unchanged Overall, the evaluation will use production logs as the primary data for the analysis with supporting spot measurements. More specifically, we will calculate savings according to the following equations: Knowns: Annual hourly chilled water production for 2006 steam-driven plant plus TES. Annual hourly chilled water production for 2008 electric-drive plant plus TES. Run hours by month for each chiller. Reported measured overall steam driven chiller efficiency COP = 0.62 (source). Reported measured operating parameters and brake horsepower for original pumps. Reported measured operating parameters and brake horsepower for original cooling towers Eff_{CT} = 1.36 kW / MMBtu/h for the entire steam-driven plant and Eff_{CT} = 1.75 kW/MMBtu/h for Plant B towers. These towers are not changed and we assume the same performance post-installation. Design efficiency and performance parameters of proposed equipment. Spot measurements Pump kW – primary chilled water and condenser water pumps Chiller efficiency kW/ton based on equipment read-outs Chiller Gas consumption Gas MMBtu = (Annual ton-hours produced x 12000 / COP) / 1,000,000 Electric Chiller consumption Chiller kWh = Annual ton-hours produced x $kW/ton_{chiller}$ Auxiliary Equipment kWh CHWP kWh = Σ $Pump_i$ kW x $Pump_i$ Hours CWP kWh = Σ $Pump_i$ kW x $Pump_i$ Hours CT fan kWh = (Annual ton-hours produced x 12,000 x (1 + 1/COP)) x Eff_{boiler} / 1,000,000) x Eff_{CT} We will gather hourly chilled water production and chiller run-time data for one year pre-installation and one year post-installation to perform our estimates. Auxiliary equipment kW will be determined from spot measurements.

Evaluation Measure Number	Algorithm
	The evaluation team has engaged support from the UCD Program Manager and has begun trending to capture system operating characteristics during the peak demand period. The following parameters are being collected in 60-minute intervals for a period of two months: • Date/Time • Chiller run time • Plant entering and leaving chilled water temperature • Auxiliary pump status

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

4. DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	1. **Spot Measure Fan and Pump Power** with hand-held Fluke 43B at the motor control center and confirm power readings are consistent with campus EMCS logs. 2. **Collect Bin Temperature Data** from the local Department of Water Resources or the National Oceanic and Atmospheric Administration (NOAA) to correlate with historical consumption data. 3. **Collect chilled water plant Consumption Data** from the University Facilities – Energy Management Office.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED TECHNICAL ADVISORSEngineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

3 The ex ante savings algorithms.

2 Chiller staging and staging of the thermal storage system.

3 The accessibility to HVAC equipment we would spot-measure as part of the M&V effort.

4.6. Data Products

The following data products will be produced during the evaluation:

- Chilled water system characteristics data
- Time-series data for chilled water loads
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

Whenever possible, we will collect building characteristics[44] data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

[44] Contextual Data v3.doc

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model Number

4.9. **Supporting Data for this Plan**

All files referenced in this plan are attached.

5. MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations during August 2009 and thus witnessed the plant operating during peak conditions. For the most part the plant operated as described in the supporting project material and related in this M&V Plan. As expected, three new electric centrifugal machines were installed at the time of the verification visit – two 2500 ton machines in Plant B and one 2550 ton machine in Plant C. During the time of our visit the Plant C chiller and one Plant B chiller were operating. Measured and manufacturer data indicate the Plant C chiller is more efficient (about 0.52 kW/ton) than either of the Plant B chillers (0.67 kW/ton measured) that were part of this project. Using the Plant C machine as the lead and the Plant B machines as the lag machines would represent the most efficient staging of this equipment. The evaluation assumes the two Plant B chillers operated and not the Plant C chiller to be consistent with the plant configuration when the Plant B replacement application was made. Savings from installing and running the Plant C chiller would be attributed to that project during its M&V phase.

Steam Drive equipment in Plants B and C are removed and the Plant D equipment is ‘mothballed’.

Summit Blue received data as described and performed analysis according to section 3.3. Chilled water production records are shown below. Chiller (and subsequent primary chilled water and condenser water pump) run-time is not precise in the data. The hourly data calculate hourly chiller loads based on hourly average chilled water temperatures and pump flows. The logs also indicate whether the chillers (and associated pumps) operated in a given hour but not the actual runtime during that hour. Summit Blue assumed ½ hour operation during logged hours that transitioned from a machine being off to its being on and when it transitioned off. This adjustment had fairly minor consequences to the overall project savings since the bulk of the electric energy use is by the chillers that had comprehensive hourly ton-hour tabulations.

The project was initiated as an apparent early replacement project that claims natural gas savings. Subsequent interviews with the facilities manager lead the evaluation team to reclassify the project as normal replacement. The demolished machines were 23+ years old (expected useful life 20 years) and maintenance was becoming more of an issue. As a normal replacement project the site cannot claim gas savings, and electric savings is only possible to the extent that the new equipment exceeds the minimum requirements of Title 24 – chiller efficiency equal to 0.75 kW/ton for the design parameters.

5.2. Analysis

Table 24 presents the annual chilled water production for both the Chilled water and TES Plants for the year before and after measure implementation. Also shown is the ratio of campus chilled water supplied by each of the two sources on the campus chilled water loop.

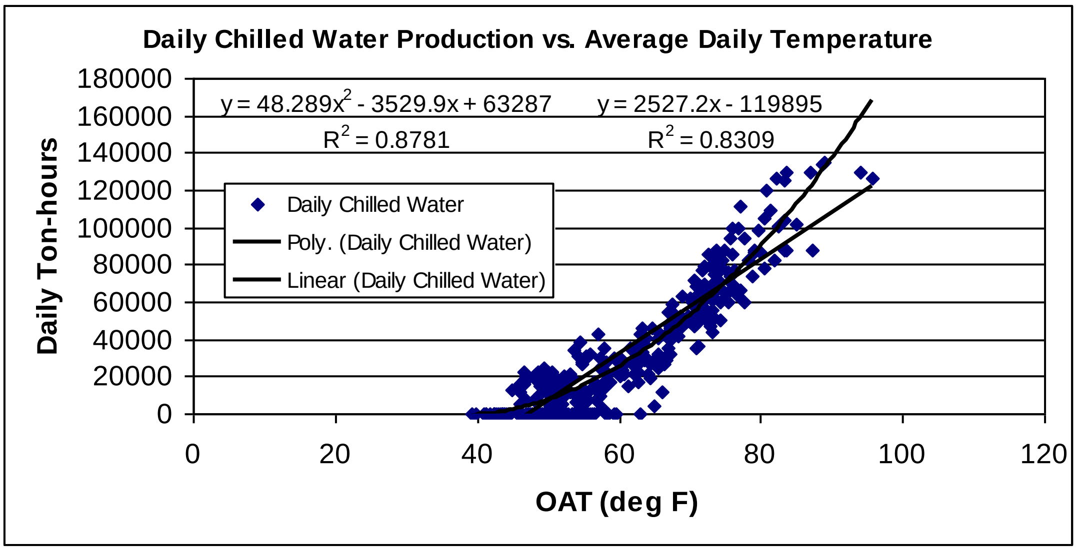
Table 24. Chilled Water Delivered by Thermal Storage and Chilled Water Plant

	Total Chilled Water Production	TES	Chilled water

	annual ton-hrs	Ton - hours	Ton-hrs
2006	35,267,566	24,574,012 (65%)	12,376,345 (35%)
2008	36,524,347	26,810,804 (73%)	9,713,543 (27%)

Daily chilled water production shows strong correlation with daily average temperature. The correlation coefficient for total chilled water delivered versus temperature is $R^2 = 0.90$. When the chilled water plant is considered without the TES system we get the data shown in Figure 11. Summit Blue considered both first and second-order correlations. The later prevents “negative” chilled water production below 47°F. Only slightly poorer correlation with this set of data reflects the variable utilization of the TES plant when temperatures were between 38 and 60°F. On some of these days, the TES carried the entire campus load and on other days operators used the chilled water plant to meet campus load.

Figure 11. 2006 Daily Chilled Water from Chiller Plant vs. Daily Average Temperature



Using the correlations and average daily temperatures from the CZ12 weather data set, Summit Blue estimated weather normalized annual chilled water production from the steam-drive plant equal to about 11,160,000 ton-hours for both correlations. These loads and the chiller efficiencies are used to derive normalized annual chiller energy for both the electric and steam-drive systems.

Chilled water logs were used to derive operating hours for constant flow pumps as described above. Measured pump power and pump data reported by Black & Veatch were used to calculate pump energy. Black & Veatch also reported cooling tower efficiencies, and these data were used to derive cooling tower energy for all steam-drive and electric drive plants alternatives. Total chilled water plant energy for each plant is the sum of chiller, pump and cooling tower energy.

Peak demand estimates are difficult to model since the thermal storage system operation is less predictable. Summit Blue analyzed actual post installation data from the campus supervisory control system as the best indication of how the total chilled water plant operates under peak conditions. Using the peak demand definition from the DEER Database, Summit Blue identified the hours in the 2008 calendar year that comprised the peak demand window. The average temperature in the 2008 data is only a fraction of a degree warmer than the average peak window temperature in the CZ12 weather set. Assuming that the difference in the chiller load is correspondingly small, Summit Blue determined the average cooling load on the Plant B chillers is 4685 tons during the peak hours. This load multiplied by chiller efficiency gives chiller demand savings. Minor demand savings also accrues from the auxiliary equipment.

5.3. M&V results

Results of our M&V analysis are shown in Table 25. In the table, we also show our estimate of a new high-efficiency gas plant that was considered as part of the “three-pronged” fuel-switching analysis. The methods used in the evaluation of the new gas plant were identical to the electric plant analysis. The Taylor Engineering report was the source of the gas plant efficiencies and pumping requirements.

The difference between the *ex ante* and *ex post* values appear to relate to the higher overall utilization of the plant chillers relative to the baseline assumed in the report used to derive *ex ante* savings.

Table 25. M&V Results

	Therms	Chiller kWh	Peak kW
Ex Ante Savings	1,246,278	0	0
Ex Post Savings	0	1,122,404	471
Realization Rate	0%	N/A	N/A

SITE M & V REPORT

UNIVERSITY OF CALIFORNIA – DAVIS

TUPPER HALL AHU VFD & FUME HOOD RETROFITS

1. SUMMARY INFORMATION

1.1. Facility Information

Tupper Hall is a building on the campus of the University of California- Davis (located in Davis, California). Several energy efficiency upgrades have been made in the last three years for several buildings within the retrocommisioning master plan work. This evaluation is related to the air flow reduction to the Air Handling Unit (AHUs) and Fume Hoods in the Tupper Hall.

1.2. Project Information

The proposed energy efficiency upgrades for Tupper Hall involved adding variable frequency drives (VFDs) to existing supply and exhaust fans in the air handling units (AHUs). However, the VFD installation was completed to the supply fans only under their phase I plan. The building pressure was also re-balanced after the supply fan VFDs were installed. None of the exhaust fans were retrofitted with VFDs and planned under another project under Phase II. The remaining work also included adding controls to tie the supply and exhaust air flows together.

Baseline Equipment/System: There are 17 AHU units with inlet guide vane controls in the Tupper Hall are part of this evaluation at the University of California-Davis.. The existing AHUs were verified as VAV systems with inlet vane control.

As-built Equipment/System: Only the supply fans in these AHUs were retrofitted with VFD drives to improve the energy performance. Further addition of VFDs to exhaust fans and to balance the building pressure by tying the supply and exhaust flow with fume hoods are not completed under Phase I and is not part of this analysis.

Utility Service Territory	PG&E
Program Being Evaluated	UC/CSU Partnership
ADM Sample ID &Project ID	PY2008
Customer Name	University of california Davis
Site Name	Tupper hall
Site Address	One shield Avenue, Davis, CA, 95616
Site Type	University Research Lab
Customer Business/Product	University

PRINCIPAL SITE CONTACT

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THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	Self Sponsored

ASSIGNED LEAD ENGINEER

Name	S.Thamilseran

AUTHOR

Name	S.Thamilseran

Note: The measure information that has been obtained from the project file is presented below using italicized text.

2. MEASURE LIST AND SUMMARY DESCRIPTIONS

2.1. Measures Installed in Project

Although there were plans to retrofit both supply and exhaust fans with VFDs and to tie the supply and exhaust flow rates to balance building pressure, only the supply fans were retrofitted during phase I in 2008 program year. After the supply fans were retrofitted the building pressure was re-balanced. Therefore, the scope of this M&V work reported here is limited to the evaluation of this part of the measure in Tupper hall at University of California Davis.

Program	Measure ID (ADM)[1]	Measure ID (IOU)	Measure Group	System	Measure Description
PY2008	1	-	HVAC	HVAC Fan VFD Retrofits	Supply Fan VFDs, Premium Efficiency Motors, Re-Balance

2.2. Annual Measure Savings Summary

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kW)	Electric Demand Savings (kWh)	Natural Gas Savings (therms)[1]	Incentive ($)	Total Annual Cost Savings ($)
1	0040	Supply Fan VFDs, Premium Efficiency Motors, Re-Balance	275.9	1,304,376	119,900	$457,772	
Total Savings:			275.9	1,304,376	119,900	$457,772	
Total Site Usage[2]:							
% Total Site Usage Saved[2]:							

Note 1: Taken from Approved savings as reported in the Project Agreement

2.3. Measures Included in the Evaluation

All of the measures listed above are included in ADM's evaluation of this project.

2.4. Information from Application Review

The final approved energy savings were based on an eQuest simulation performed by the project's reviewer because the reviewer felt that this project's savings could not be verified with standard engineering calculations. The eQuest model assumed an identical air flow reduction as that proposed in the submitted calculations. The eQuest model yielded higher electrical energy savings and lower natural gas energy savings.

2.5. M & V Approach Summary

The M&V approach for the measures at the site was to use enhanced rigor with IPMVP Option D, Calibrated Simulation. The simulation used field data obtained through a site survey as input. The simulation of as-built conditions was bench marked against the facility's latest 12-month calendar utility bills with as-built HVAC equipment characteristics used to determine as-built energy consumption.

For the HVAC Supply Fan VFD Retrofits, ADM gathered information about the physical and thermal characteristics of Tupper hall building. This data with appropriate building characteristics was used to prepare an eQuest building simulation. Since the proposed measure is associated with only one of the campus' buildings, only the associated building will be used for the simulation process. Table 3 summarizes ADM's M&V approach.

Table 26. M&V Approach

Measure ID (ADM)	Measure ID (IOU)	Measure Name	M&V Option Used*	Strata for Est. Savings	Summary of M&V Approach
1	-	Supply Fan VFDs, Premium Efficiency Motors, Re-Balance	D	Certainty[1]	See below

3. INDIVIDUAL MEASURE EVALUATION

MEASURE ID: 1

Supply Fan VFDs and premium efficiency motors

Variable Frequency Drives (VFDs) were installed on the supply fan motors in17 of Tupper Hall's air handling units (AHUs). Simultaneously, the supply fan motors were upgraded with 95% efficient premium efficiency motors and the building was pressure balanced with a reduced air flow rate.

The pre-installation inspection confirmed that there were17 axial-vane supply fans with inlet guide vane controls that are proposed to be retrofitted. These HVAC units will be retrofitted with VFDs, and drive motors will be retrofitted with premium efficiency motors.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	1	Supply Fan VFDs and premium efficiency motors	275.9	1,304,376	119,900	$457,772	

3.1. M&V Features

Features of the M&V for Measure 1 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Add VFDs and premium efficiency motors to Existing Baseline Equipment (Supply Fans)
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

The following is the sample of equipment listed in the *Pre-Installation Report* included in the project's documentation:

Table 27 Schedule of Sampled Supply and Exhaust Fans in Pre-Installation Report

Qty	Location	Power	Fan Type
2	Northwest Tower	7.5 hp, 3-phase, 475V/8.0A	Exhaust
2	Northwest Tower	10 hp, 3-phase, 475V/12.5A	Exhaust
2	Northwest Tower	3-phase, 475V/9.5A	Exhaust
2	Southeast Tower	7.5 hp, 3-phase, 475V/7.3 A	Exhaust
2	Southeast Tower	10 hp, 3-phase, 475V/13.5A	Exhaust
2	Southeast Tower	3-phase, 475V/9.0 A	Exhaust
1	2nd Floor Southeast Mechanical Room	25 hp, 3-phase, 475V/26.0 A	Vane-Axial Supply

1	4th Floor Northwest Mechanical Room	25 hp, 3-phase, 475V/26.0 A	Vane-Axial Supply

There were a total of 17 axial-vane supply fans, all of which modulated air-flow with inlet guide vanes. 16 of the supply fans were of the 25 hp type listed in table 5. However, one of the supply fans was only 5 hp. Though the system is a variable air volume system (VAV), the building houses many teaching and research laboratories – each of which require constant ventilation. Consequently, the laboratory zones function as constant air volume zone (CAV).

As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

VFDs and premium efficiency motors were installed on all 17 vane-axial supply fans. ADM verified that all of the supply fans were vane-axial during our onsite visit, and also obtained a copy of the re-balancing report. Each of the premium efficiency motors were 95% efficient. The building operation remained unchanged from the pre-existing condition, except for the re-balanced pressures. The overall building airflow rates were consequently reduced from the pre-existing building's operation.

Seasonal Variability in Schedule and Production

The campus follows a 3-quarters schedule plus 2 summer sessions, with a mix of day, evening, and weekend classes. The building has a mix of faculty offices, academic support areas, and laboratory spaces. We will refine this schedule information in discussion with facility staff, and will include items such as class schedules, custodial schedules, planned operating patterns, and class sizes in extrapolating short-term monitoring results to annual results. Since seasonal operating patterns are evident, class schedules, planned operating patterns, class sizes will be incorporated into the analysis to extrapolate the short-term monitored data and findings into an annual operation.

3.2. **Algorithms for Estimating Savings**

Algorithms Used by IOUs

Program Measure ID	Algorithm
1	Engineering Analysis

The IOU used the following algorithms by which they calculated the project's energy savings:

> Baseline kWh of equipment = *(HP of equipment) * (Load factor of motor obtained from measurement) * (baseline operational hours of equipment)*
>
> Current kWh of equipment = *(HP of equipment) * ∑ [(Load factor of motor obtained from measurement) * (current operational hours of equipment at particular load)]*
>
> Energy savings of equipment = *Baseline kWh of equipment - Current kWh of equipment.*

It should be noted however that the final approved energy savings were based on an eQuest model used by the original project reviewer. The results of the eQuest model were included with the project's documentation; however the model itself was not.

Energy Savings Algorithms Used in the Evaluation

Evaluation Measure ID	Algorithm
1	Engineering analysis

Estimates of the energy savings from use of VFDs were derived through a "post-only" analysis. This is done by estimating what energy use would have been for the motor application if the VFD (and premium efficiency motors) had not been installed.

For this study, the data collected were analyzed using an eQuest (DOE-2) Building Energy Use simulation that applies the IOU algorithms to calculate energy savings associated with this measure. For developing, conducting, and calibrating the simulations, the following types of data were considered as important to obtain:

1. Gather key architectural, lighting and HVAC drawings and related information from facility managers for Tupper Hall.
2. Interview facility managers about generic control and operational schedules and upgrades that might have changed from baseline to as-built periods.
3. Examine baseline and as-built control /reset schedules features for the measure impact areas.
4. Develop DOE-2 generic building input models that reflect the general proportional floor area of key building activity areas and use generic operational schedules drawn from typical schedules for the college activities. Attempt will be made to adjust/revise the class schedules based annual profile and operation for the class room or laboratory spaces. Faculty spaces may be occupied year round and may only need a minor adjustment in occupancy schedules.
5. Depending upon building features and mix of activity areas, we may develop separate the functional areas into representative zones within the buildings and prepare equivalent functional zones for the DOE-2 models.
6. Calibrate the models to post-retrofit data and then change all control options (kW/CFM to adjust the premium efficiency motors, fan retrofit or only inlet guide to SPEED control change) as parametric input for all the impacted supply fans to create the pre-retrofit operating scenario, to derive the energy savings impact. Both baseline and as-built operating flow rates will also be determined and input to the simulation.

Peak Demand Algorithms Used in the Evaluation

Evaluation Measure ID	Algorithm
1	See below

Pre and post load profiles for the three hottest consecutive weekdays as outlined in the California Evaluation Protocol will be compared to determine peak demand reduction.

3.3. **Data Collection**

Site-Specific Parameters

Evaluation Measure ID	Site-Specific Parameters
1	See below

Short term monitoring data is used to determine very critical assumptions in the savings algorithms that take hourly outdoor temperature into consideration. One such factor is the occupancy profile of the site. Here the only impact is the VFD drive changes the fan from baseline (in alternate scenario where fan type also needed to be changed):

1. Baseline: variable air volume system with inlet guide vane control fan running for the entire operating period.
2. Post: fan power and controls will match the necessary CFM flow needed to maintain the space to the required comfort levels.

Assuming the preexisting equipment were all VAV system with inlet guide vane controls in conjunction with the installation of VFDs, sufficient information was collected on operation control logic parameters to understand the current as-built AHU operations in each of the affected units. If any indication of the AHUs were set with minimum CFM levels that are not consistent with normal VAV operating conditions, specific minimum CFM parameters were collected for all AHUs and used in the simulation.

Data Collection Method

Evaluation Measure ID	Method for Collecting Site-Specific Parameters
1	See below text

Site information will be gathered using the Building Systems Form.

Data were first collected through telephone and in-person interviews with the staff of the site. A preliminary interview was conducted by telephone prior to visiting the site, in order to understand key baseline and as-built features that are not well-documented in the project file. The results of this preliminary interview were used to refine our approach to the on-site interviews and data collection process. The interview with site staff provided information on occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other “human factors” that are associated with energy use at the site. We will ask detailed questions about:

1. The extent and nature of non-incentive control upgrades, and related upgrades, that have been done in conjunction with the VFDs that had received IOU incentives.
2. Baseline AHU conditions, control logic and zone parameters for each building. We will verify our starting assumption that the baseline consisted of variable air volume air handling units with inlet guide vane control option.
3. As-built AHU conditions, control logic, and zone parameters for each building. For example, OAT, SAT, RAT, % OA, minimum air-flow setting on VAVs, etc.
4. Any atypical buildings or building features.
5. Availability of trend logs for developing time series data to help with model generation and calibration.

Documents and other records at the site were reviewed, including basic building plans and architectural drawings, plus information on HVAC systems and equipment, lighting and hot water systems from mechanical, electrical and plumbing plans

- Details include building orientation, square footage, number of floors, wall structure, wall insulation type and thickness, square footage of windows and their shading coefficient and type, roof structure, roof insulation type and thickness
- HVAC systems details include ratings, distribution system type and controls, and unit size
- Data on cooling tower, chiller, and boiler load profiles are gathered as well to properly account for the energy impact at the central plant level.

Visual inspections were made of control settings, lighting levels, inventory of end use appliances and equipment, ventilation rates, building occupancy level, and other parameters including set-point temperatures, operating schedules, etc.

Photographs of the site and of its electrical and mechanical systems were also taken during the on-site visit.

Sampling Strategy

Evaluation Measure ID	Sampling Strategy
1	See below

All relevant onsite HVAC systems for this measure were surveyed, including all fan motors greater than 5 hp within AHU's at Tupper Hall in which VFDs have been installed.

3.4. Data Accuracy

All equipment used for one-time monitoring was calibrated and tested before implementation.

3.5. Quality Assurance Procedures

All monitoring equipment was calibrated before use in the field. All data collected were reviewed to resolve outliers, missing data, etc.

MEASUREMENT AND VERIFICATION RESULTS

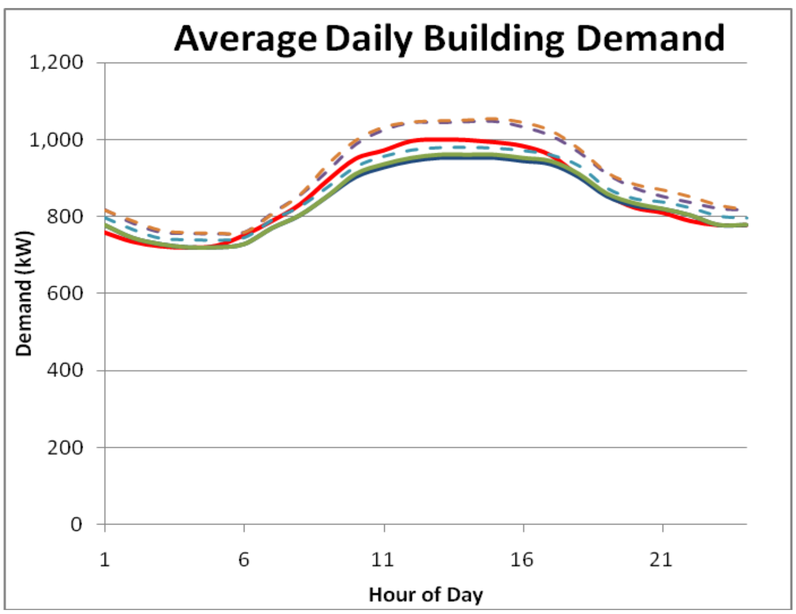
4.1. Analysis

The approved savings that were the basis for the IOU claimed savings were derived through eQuest model simulations. Documents provided as part of the program evaluation included a results summary from the eQuest simulation.

As part of the M&V effort, an eQuest model was formulated using the various data collected on the retrofitted building. Although VFDs were installed on the supply fans, the on-site inspection showed that the system type remained essentially constant volume. This is because the building is comprised mostly of laboratories, all of which require constant ventilation. Concurrently the measure includes a reduction in ventilation requirements for several of the laboratories (implemented during the building's rebalancing). Thus the VFDs provide cube law savings on the fans, while cooling, heating, and ventilation energy is saved in the reduction of ventilation requirements.

The IOU provided 15-minute interval data for the building, by which the eQuest model was calibrated. The following chart compared average daily demand profiles for three seasons. The dotted lines represent the metered interval data, while the solid lines represent the eQuest simulation. The three seasons being compared are summer, winter, and shoulder:[45]

Chart 1 Average Daily Building Demand for Three Seasons



[45] The Shoulder season is essentially Spring or Fall. The reason the two are combined into a single season is due to the fact that the HVAC system sees the same loads during both seasons. Thus the building's HVAC loads will behave identically in each season.

eQuest includes curves for axial-vane fans in its library. These curves were used to evaluate energy savings along with the flow reduction and premium efficiency motors.

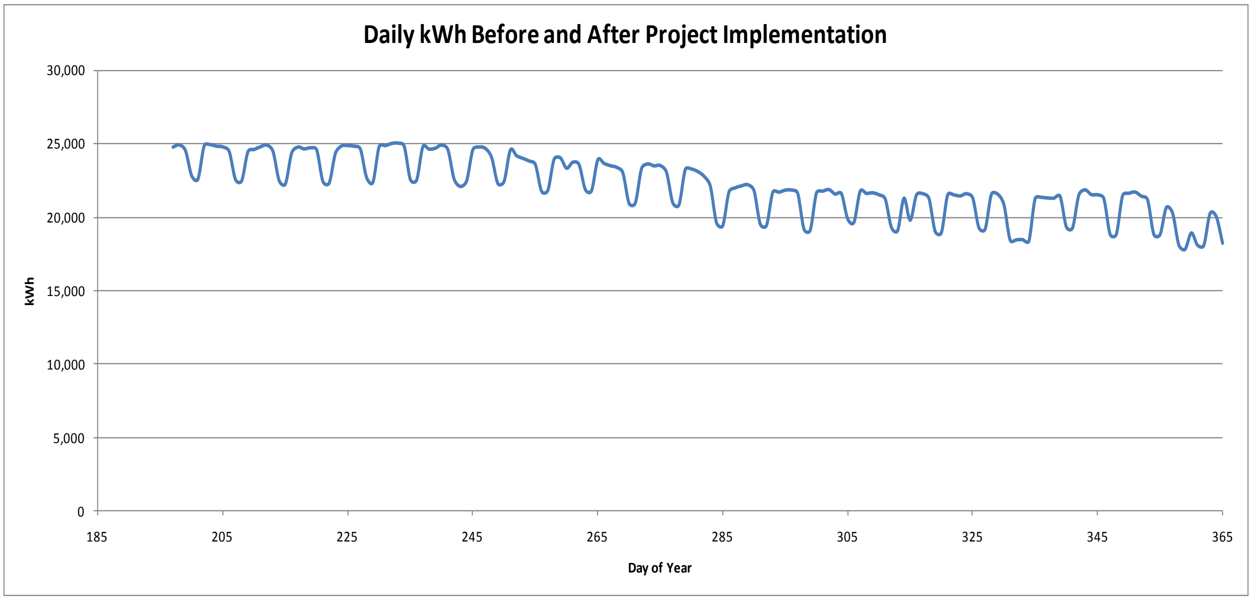
4.2. M&V Results

The results from the 8,760-hour eQuest simulations were used to calculate kWh, kW and therm savings relative to IOU claimed savings.

There is some uncertainty to the calculated kWh usage because of possible inaccuracies in capturing the performance of the central plants. Tupper Hall is supplied with chilled water from a central plant that serves many of the buildings on the campus. As such, in order to most accurately capture the cooling savings, the total load on the chilled water loop would need to be known. The increased demand reduction is most likely due to differences between the IOU assumed final flow rates and the actual as-built building flow rates. This kW reduction (along with the Therms savings) is reasonable due to the reduction in flow rate requirements.

A billing analysis was also performed to validate the energy savings predicted by the eQuest simulation. The following chart depicts daily energy use during the year in which this project was implemented. Note the obvious reduction in daily energy use at approximately day 250. Also note how the daily energy usage is unaffected by seasonality. This fact is also depicted in Chart 1, where each of the season's daily energy usage shares approximately the same profile.

Chart 2 Daily Energy Use Before and After Project Implementation



The difference in daily energy use before and after the retrofit was approximately 3,500 kWh per day, which, when extrapolated over the course of an entire year results in a savings of 1,274,618 kWh. Given the limited scope of available billing data, this corroborates the savings predicted by the eQuest model.

	Therms	kWh	Peak kW
Ex Ante Savings	119,000	1,304,376	275.9
Ex Post Savings	95,079	1,768,921	365.6
Realization Rate	79%	136%	129%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

DENTISTRY- INSTALL AND COMMISSION NEW VFDS

November 3, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#250
Company Name	University of California – San Francisco
Site Name	Dentistry – Install and Commission New VFDsS
Site Address	University of California - San Francisco, San Francisco, CA 94143
Site Type	Lab / Sciences
Company Business/Product	University / Education

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IOU REPRESENTATIVE

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
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ASSIGNED LEAD ENGINEER

Name	Roger Hill

AUTHOR

Name	Roger Hill

1. GOALS AND OBJECTIVES

This M&V Report is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for the 56 programs in this group.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrocommissioning measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for selected air handling units, based on measurements.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	CAV Systems	VFDs	VFDs installed supply and exhaust fan motors. AHU start and stop scheduling implemented to reduce energy consumption during occupied and unoccupied hours.

2.2. Application Approved Annual Measure Savings[46]

Table 28. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	917,852	71.7	-	137,713	-	100%

The dentistry building has nine constant air volume 100% outdoor air airhandlers, two exhaust fans and barometric pressure relief. Because of the moderate Bay Area climate, there is no cooling or terminal reheat. Heating only occurs at the air handlers.

This project converted the existing constant air volume HVAC system to variable air volume system at the Dentistry building located at the University of California, San Francisco. Variable frequency drives were installed on the supply and exhaust fan motors. Air handling unit start and stop scheduling was implemented to reduce energy consumption during occupied and unoccupied hours. A combination of interior and outdoor temperature control is now used to vary the amount of airflow supplied to the spaces based on the room temperature setpoint. The calculated approach was used to estimate the energy savings.

The application approved savings estimates were submitted ARUP Engineering.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *retrofit*.

[46] DENTISTRY__Application_2006-08_-_UCSF_HVAC_Dentistry.xls

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation[47]

Program Measure Number	Equipment and Operation – Pre-installation
M1	UCSF's Dentistry Building is a four-story building with two or three air handling units on each floor. The HVAC system is a constant volume system with 100% outside air. According to the Customer, the HVAC systems ran continuously year round. All the fans' motors were two speed motors locked in high speed. This project proposed to convert the existing constant volume system to Variable Air Volume (VAV) system by installing Variable Frequency Drives (VFDs) on all HVAC supply fans and two exhaust fans along with reducing the supply airflow and temperature based on space temperatures. The HVAC units were also proposed to be shut down during most unoccupied periods.

2.7. As-Built Equipment and Operation

Measure characteristics for the installed VFDs and temperature controls were drawn from the most recent project review file[48] and documented savings calculations submitted by ARUP Engineering.

Program Measure Number	Equipment and Operation – As-Built
M1	This project installed the following incentivized measures: 1. **Conversion of the constant volume air-handling units to a variable air volume system:** Install VFDs to control supply and exhaust fan motors based on demand.

[47] 2K0702159 UCSF HVAC (Dentistry Building) IR Review (P88).xls

[48] 2K0702159 UCSF HVAC (Dentistry Building) IR Review (P88).xls

Program Measure Number	Equipment and Operation – As-Built

VFD Motors	VFD Nameplate Data
Supply Fan 1-1: Motor - 20 hp, Efficiency - 93%	VFD - ABB ACH550-VCR-031A-4
Supply Fan 1-2: Motor - 7.5 hp, Efficiency - 91.7%	VFD - ABB ACH550-VCR-012A-4
Supply Fan 2-1: Motor - 20 hp, Efficiency - 93%	VFD - ABB ACH550-VCR-031A-4
Supply Fan 2-2: Motor - 7.5 hp, Efficiency - 91.7%	VFD - ABB ACH550-VCR-012A-4
Supply Fan 2-3: Motor - 10 hp, Efficiency - 91.7%	VFD - ABB ACH550-VCR-015A-4
Supply Fan 3-1: Motor - 25 hp, Efficiency - 91.7%	VFD - ABB ACH550-VCR-038A-4
Supply Fan 3-2: Motor - 7.5 hp, Efficiency - 91.7%	VFD - ABB ACH550-VCR-012A-4
Supply Fan 4-1: Motor - 15 hp, Efficiency - 92.4%	VFD - ABB ACH550-VCR-023A-4
Supply Fan 4-2: Motor - 15 hp, Efficiency - 92.4%	VFD - ABB ACH550-VCR-023A-4
Exhaust Fan - 1: Motor - 30 hp, Efficiency - 94.1%	VFD - ABB ACH550-VCR-045A-4
Exhaust Fan - 2: Motor - 30 hp, Efficiency - 94.1%	VFD - ABB ACH550-VCR-045A-4

2. **Implement AHU Start/Stop Scheduling:** A combination of interior and outdoor temperature control was used to vary the amount of airflow supplied to the spaces based on demand. This served to reduce energy consumption during both occupied and unoccupied periods.

2.8. Seasonal Variability in Schedule and Production

The UCSF Dentistry Building's HVAC equipment operates 8,760 hours per year. The heating and ventilation loads for the facility vary mostly with the seasons. Effects of a "9-month academic calendar" are small given year-round classes and clinic at the School of Dentistry.

The best time to collect M&V data would be when VAV system is active. Consequently, nearly any time of year would be suitable for collecting data. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the installed VFDs and start/stop controls were developed by ARUP Engineering. Their approach to estimating *ex-ante* savings are below.

Evaluation Measure Number	Algorithm
M1	The project expected savings to be realized in two areas: 1. Energy (kWh) savings from a reduction in fan motor energy use 2. Energy (kWh & Therms) savings from a reduction in heating energy use at the air handlers The following input assumptions were collected through discussions with campus facility staff: • Supply Air Temperature: 68 °F (Dry-bulb) • High Limit Air Flow Start: 76 °F (Dry-bulb) • High Limit Air Flow Stop: 80 °F (Dry-bulb) • Low Limit Air Flow Start: 68 °F (Dry-bulb) • Low Limit Air Flow Stop: 62 °F (Dry-bulb) • Heating Design DBT: 5 °F • Minimum System Air Flow: 50% • Control Static Pressure: 0 wg. • Heating Efficiency: 80% • Occupied Hours: 5:45 AM – 12:00 AM • Unoccupied Hours: 12:00 AM – 5:45 AM Savings were developed from supporting trend data provided by UCSF's Facilities Management Office using the following bin-temperature analysis approach: $\underline{Annual\ kWh\ Savings} = \Delta_{occupied}\sum(Hrs_t \times kW_{fan}) + \Delta_{unoccupied}\sum(Hrs_t \times kW_{fan})$ Hrs_t: Number of hours in temperature bin "t" kW_{fan}: Fan electric load in the pre- and post-installation case $\underline{Annual\ Therm\ Savings} = \Delta_{occupied}\sum(CFM_{supply} \times 1.08 \times T_t \times Hrs_t \div 100{,}000) + \Delta_{unoccupied}\sum(CFM_{supply} \times 1.08 \times T_t \times Hrs_t \div 100{,}000)$ CFM_{supply}: Supply Air CFM *1.08*: Conversion factor T_t: Temperature differential between supply air and OSA "t" Hrs_t: Number of hours in temperature bin "t" *100,000*: Conversion factor

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Options A & B will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in the post-retrofit case involves spot measurements to calibrate consumption data drawn from the University Facilities – Energy Management Office (EMO). The calibrated trend data will be used to estimate fan power relative to outdoor air temperature. Fan energy will be determined with bin hour analysis. Heating energy savings estimates will use the same algorithms as the IOU, but air volumes will be estimated using trend data rather than the assumptions of the IOU.

<table>
<tr><th>Evaluation Measure Number</th><th>Algorithm</th></tr>
<tr><td>M1</td><td>The proposed evaluation approach will seek to visually verify affected system components, including:

3. Conversion of the constant volume air-handling units to a variable air volume system: Visually confirm motor and VFD nameplate data, efficiency, etc.

4. Implement AHU Start/Stop Scheduling: Confirm occupied and unoccupied AHU operating characteristics through the campus EMS system.

5. Fan speed control sequence: Confirm and analyze the control sequence.

The evaluation team proposes to confirm, where possible, the following ex-ante assumptions:

• $Supply_{temp}/OSA_{temp}$: Temperature differential between supply and OSA temperatures. The evaluation team will use the Fluke 971 Relative Humidity & Temperature Meter to confirm temperature readings are consistent with campus EMCS logs.
• Fan Operation: Fan capacity and operating hours. These parameters will be confirmed through spot measurements of supply and exhaust fans and run-time data loggers. Results will be compared to EMCS readings to ensure consistency.

Overall, the evaluation will use verified trend data from the EMCS to develop regression equations between fan power and outdoor air temperature during occupied and unoccupied hours. Typical meteorological year data will be used to normalize annual energy use with the ex-ante algorithms as a basis for developing project level savings. The pre- and post-installation models will be more robust by including motor load and operating hours data from on-going trending and by expanding the model to include a bin hour temperature analysis.

More specifically, we will calculate savings according to the following equations:</td></tr>
</table>

Evaluation Measure Number	Algorithm
	<u>*Annual kWh Savings*</u> = $\Delta_{occupied}\sum(Hrs_t \times kW_{fan}) + \Delta_{unoccupied}\sum(Hrs_t \times kW_{fan})$ Hrs_t: Number of hours in temperature bin "t" kW_{fan}: Fan electric load in the pre- and post-installation case <u>*Annual Therm Savings*</u> = $\Delta_{occupied}\sum(CFM_{supply} \times 1.08 \times T_t \times Hrs_t \div 100{,}000) + \Delta_{unoccupied}\sum(CFM_{supply} \times 1.08 \times T_t \times Hrs_t \div 100{,}000)$ CFM_{supply}: Supply Air CFM estimated from trend data of the operating equipment *1.08*: Conversion factor T_t: Temperature differential between supply air and OSA "t" Hrs_t: Number of hours in temperature bin "t" *100,000*: Conversion factor <u>***The evaluation team has engaged support from the UCSF Program Manager and has begun trending to capture system operating characteristics during the peak demand period. The following parameters are being collected in 15-minute intervals for a period of two months:***</u> • Date/Time • VFD Speed on all Supply/Exhaust Fans • Supply Air Temperature • OSA Temperature • Power draw of all Supply/Exhaust Fans

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**4. Spot Measure Fan Power** with hand-held Fluke 43B at the motor control center and confirm power readings are consistent with campus EMCS logs. **5. Collect Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter and confirm temperature readings are consistent with campus EMCS logs. **6. Collect Bin Temperature Data** from the local Department of Water Resources or the National Oceanic and Atmospheric Administration (NOAA) to correlate with historical consumption data. **7. Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office. **8. Collect VFD Performance Characteristics** from the University Facilities – Energy Management Office.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical AdvisorsEngineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

4 The accessibility to HVAC equipment we would spot-measure as part of the M&V effort.

4.6. **Data Products**

The following data products will be produced during the evaluation:

- Building characteristics data
- Time-series data for electric and chilled water loads, and of air handler operating parameters
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. **Data Reporting Formats**

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. **Building Characteristics Data**

Whenever possible, we will collect building characteristics[49] data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

Table 29. Building Characteristics Data

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model

[49] Contextual Data v3.doc

System	Characteristics
	Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F) • Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.9. **Supporting Data for this Plan**

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations during August 2009 and thus witnessed the air handlers operating during typical summer conditions. Summit Blue verified that all equipment in the measure had been installed. For the most part, the airhandlers operated as described in the supporting project material and related in this M&V Report.

Implementation of the measure was completed in January 2009, but it took several months to tune the controls for the VFDs. Final settings were not established until mid-May 2009. Figure 12 below shows the time series of total exhaust and total supply fan power plotted with outdoor air temperature. Shown is total fan power – nine supply fans and two exhaust fans. Notable is the non-zero input power for all operation during un-occupied hours. This deviates from the measure assumptions. Un-occupied fan energy is not terribly high, but airflow is approximately 30% of design flow during un-occupied hours inducing more heating load in the winter than intended with this project.

Summit Blue also received trend data for fan speed for the fans in this project. Data collected after the VFDs controls were tuned showed anticipated correlation between fan speed and input power. Figure 13 shows the plot of average supply fan speed versus total supply fan power. Even at this aggregated level the speed and power map well against each other. Exhaust fan data each have strong correlation coefficients, R2 > 0.99.

Figure 12. May 2009 – August 2009 Fan Power and Outdoor Temperature

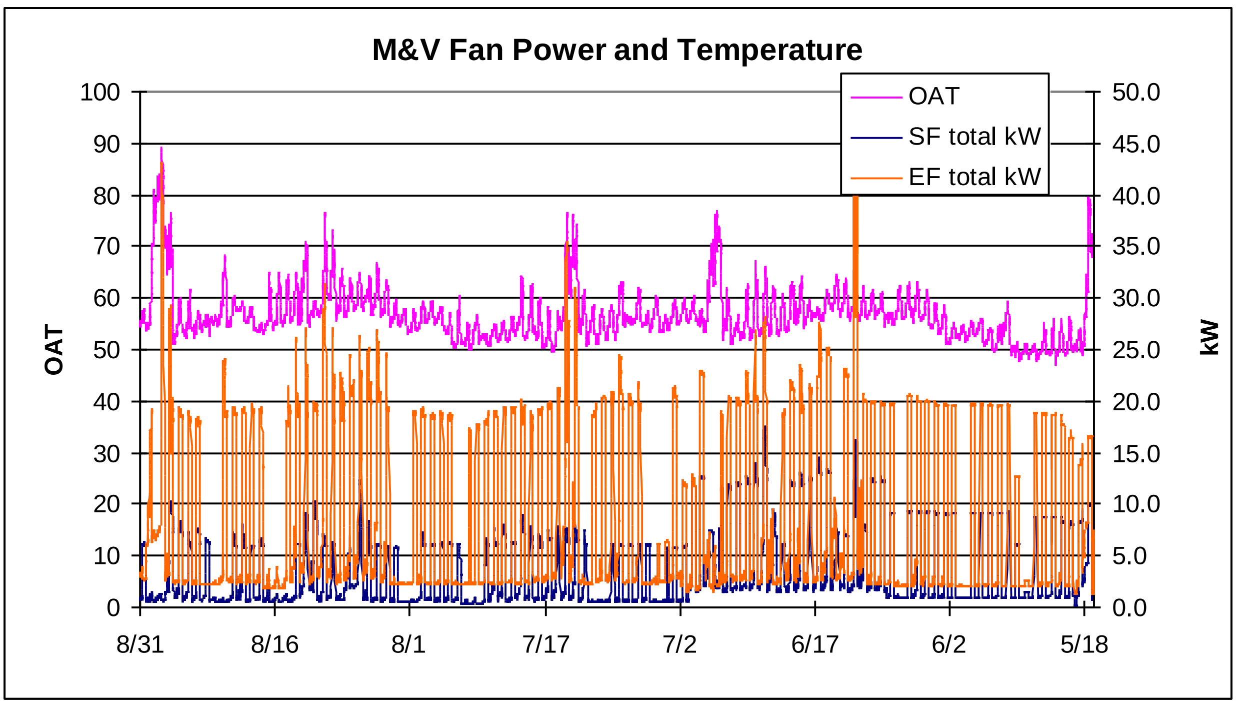
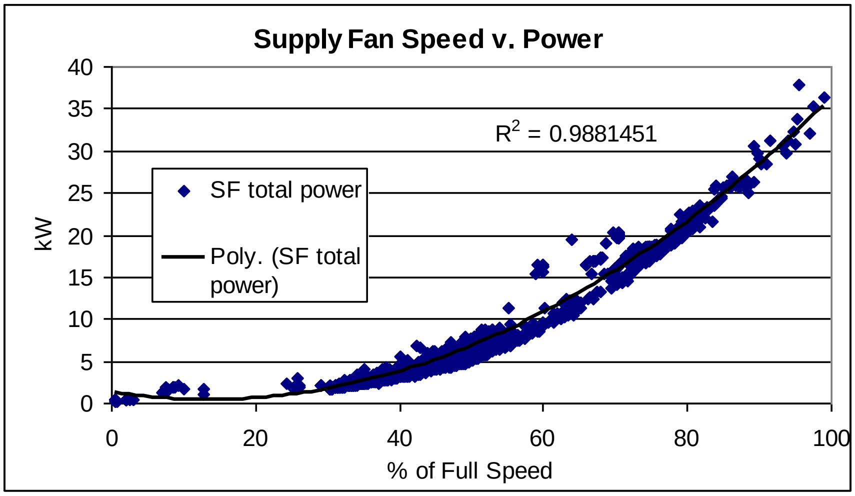


Figure 13. May 2009 – August 2009 Fan Power and Average Supply Fan Speed



Summit Blue measured fan power for accessible fans during our inspection. Table 0-1 summarizes these observations. Frequencies and total power are consistent both with trend data captured after the sequence of operations were stabilized in May 2009 and with data for the hours of our site inspections

Table 0-1 Fan Measurements

Fan ID	Nameplate HP	Measured kW	Observed Hz
1-1	20	6.3	44
1-2	7.5	1.65	42
2-1	20	1.65	34.5
2-2	7.5	1.2	37.4
2-3	10	1.80	37.5
3-1	25	1.36	32.8
3-2	7.5	1.22	36.7
4-1	15	2.11	36.6
4-2	15	NA	NA
EF1	30	10.6	44.2
EF2	30	10.82	43.5

5.2. Analysis

The data shown in Figure 14 and Figure 15 demonstrate there is not very much correlation with respect to outdoor air temperature. The anticipated increased volume (from the IOU calculations) when outdoor temperatures are between 62 and 80°F is not apparent in the data. Given the low correlation coefficients for these relationships, Summit Blue decided to revise the planned fan power estimation model. Rather than correlating fan power to temperature, we used average trended fan power during occupied and un-occupied hours as our post-implementation estimates.

Figure 14. Correlation between Supply Fan Power and Outdoor Air Temperature

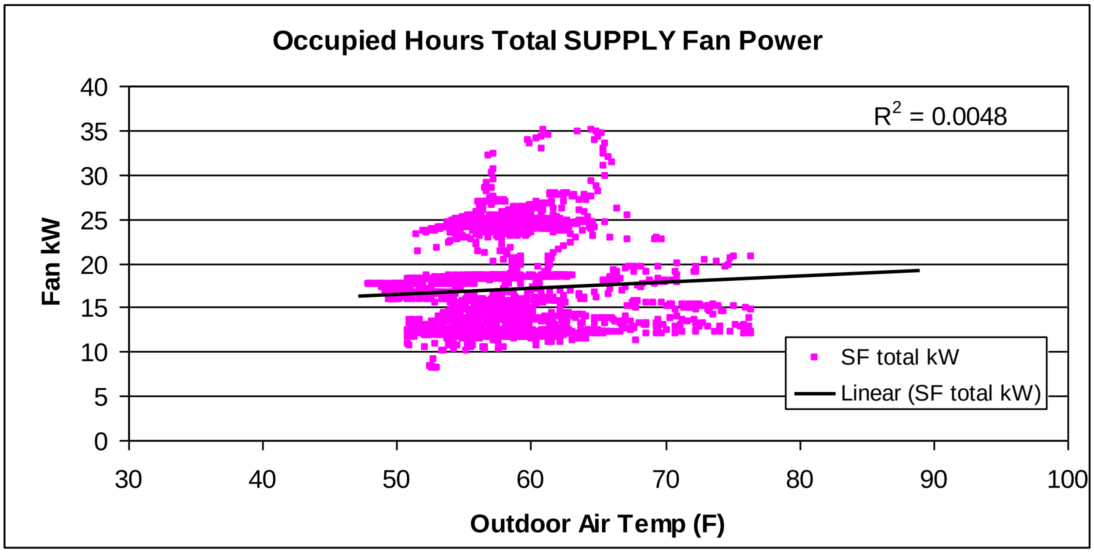
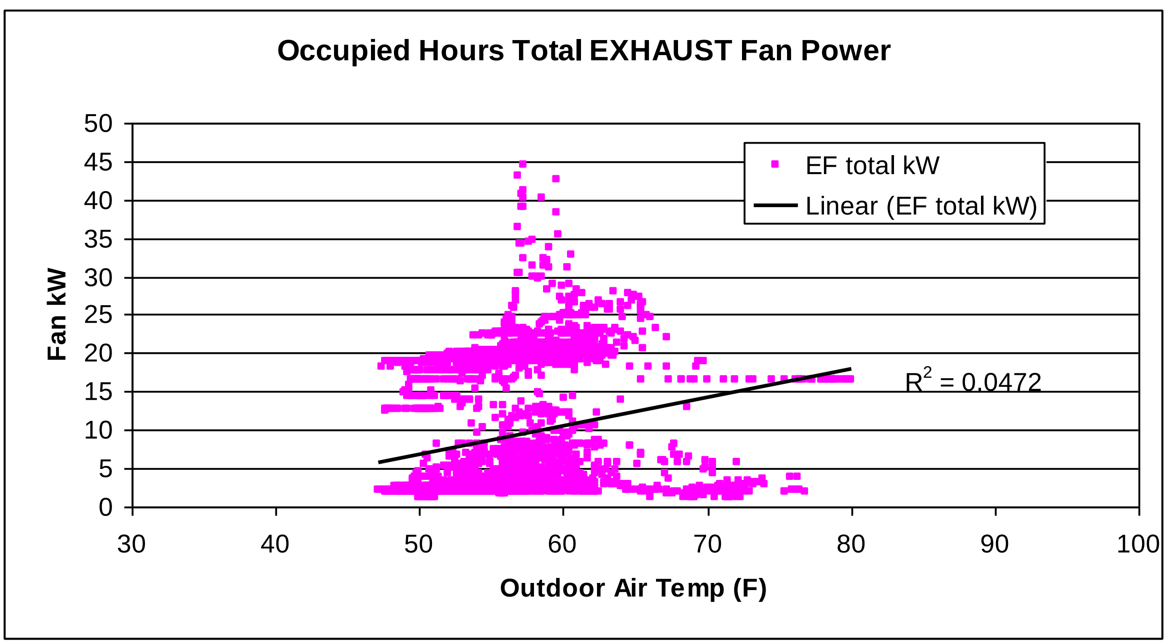


Figure 15. Correlation between Exhaust Fan Power and Outdoor Air Temperature



Analysis of the trend data gave cause to question the baseline assumptions in the *ex ante* estimates for savings. Site personnel report that only motors and VFDs were installed for the project and the fans were left, otherwise, as is. Given those conditions, Summit Blue would expect that when the fans run at full speed with the VFDs the motor power would be about the same as the pre-implementation power. (This estimate assumes that improved new motor efficiency and VFD losses approximately offset.) However when Summit Blue extrapolated the speed and power relationship for the supply fans to their full speed condition, we found total supply fan input power was substantially less that the value in the *ex ante* calculation – 40 kW and 91 kW, respectively.

Summit Blue could not substantiate the *ex ante* baseline and bases the evaluation savings on our M&V estimate of the baseline.

Gas savings is still estimated with the same algorithms used by the IOU. The IOU estimates, however, were based on the incorrect design CFM. Their estimate *adds* exhaust and supply CFM in their heating load calculation. This is an error because exhaust air is not heated, and only the supply air volume should be considered. Fan speed data and the fan affinity laws are used to determine that the average supply air volume during occupied hours is about 64% of design flow, and the average airflow during un-occupied hours is about 34% of design flow. Using these averages and typical temperatures from the California Climate Zone CZ03 data set, Summit Blue estimated annual heating energy for the baseline and the *ex post* savings.

5.3. **M&V results**

Results of our M&V analysis are shown in Table 30. *Ex post* electric savings estimates are considerably lower than the *ex ante* estimates. The dominant reason for the difference in the two estimates is the determination of the baseline. Summit Blue estimated total baseline fan power of 85.2 kW versus the *ex ante* estimate of 133 kW. Electric energy savings is correspondingly lower plus the additional factor of fans running more at night than anticipated with the IOU estimate.

Gas savings results show ex post savings comparable to ex ante estimates despite significant changes from the planned implementation. The higher-than-planned overall airflow during occupied and un-occupied hours increases natural gas consumption. However, the error in the *ex ante* estimate using the wrong airflow offsets the un-occupied hour use.

Table 2. Electric Savings and Realization Rates

		SF	EF	Hours	kW	kWh
Baseline	Ex Ante	58.8	46.9	8760	105.8	926,650
	M&V est	42.1	43.1	8760	85.2	746,198
ex post	occ	16.5	20.0	2890	36.6	105,635
	un-occ	3.8	4.9	5870	8.7	51,057
savings	Ex Ante				71.7	917,852
	M&V				48.6	589,506
Realization Rate					67.8%	64.2%

Table 3. Natural Gas Savings and Realization Rates

Natural Gas Savings (Therms)		Realization Rate
ex ante	*ex post*	
137,713	146,536	106.4%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

UC-SAN FRANCISCO – KALMANOVITZ LIBRARY

November 5, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#249
Company Name	University of California – San Francisco
Site Name	Kalmanovitz Library
Site Address	530 Parnassus Avenue, San Francisco, CA 94143
Site Type	Library
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

Name	Susan Simpson	**Telephone**	(415) 476-5391
E-mail	ssimpson@fm.ucsf.edu	**Title**	Project Manager

IOU REPRESENTATIVE

Name		**Telephone**	
E-mail			

RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[50]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	New VFDs, Start/Stop Controls	Install new variable frequency drives on pumps and fans in HVAC system. Implement optimal start-stop controls for the AHUs, cooling tower fan, and chilled water pumps.

2.2. Annual Measure Savings[1]

Table 4. Annual Measure Savings

Project Measure Number	Electric		Gas	Total Energy Savings (MMBtu)	% of Total Savings
	kWh/yr	Peak kW	Therms		
M1	1,044,617	25.6	107,206	-	100%

The *ex-ante* savings estimates were submitted as part of the Form B for this project. A more complete analysis was provided as part of the post-installation review.[51] Calculations were performed by the Campus commissioned consultant, ARUP. New VFDs were installed on the secondary chilled water pump, cooling fan motor, and supply and return air fans in AHUs 1 to 5. Start-stop controls were implemented for the AHUs, cooling tower fan, and secondary and primary chilled water pumps.

These system changes resulted in reduced fan and pump energy consumption. Additional savings are expected from reduced heating and cooling loads due to reduced outside air changes from the AHUs.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

[50] LIBRARY Application 2006-08 - UCSF HVAC Library.xls

[51] 2K0703150 Attachment 1 - IR Revised Energy Savings Calculations.pdf

2.5. **Sample Type**

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. **Pre-Installation Equipment and Operation**[3]

Program Measure Number	Equipment and Operation – Pre-installation
M1	The Kalmanovitz Library is a multi-story library building constructed in 1994. The Library's existing air-handling units and roof exhaust fans are very old (with the exception of the supply fans themselves) and inefficient and need to be replaced with new, and more efficient, equipment. It was observed that there were previously variable frequency drives on the pumps and fan motors. However, the VFDs were quite old and had been switched over to bypass mode such that the motors are ran at full speed. Discussions with the HVAC mechanic further confirmed that all the pumps and air handling units ran continuously.

2.7. **As-Built Equipment and Operation**[52]

Measure characteristics for the HVAC system retrofits were drawn from the most recent project review file by EMCOR and documented savings calculations developed by ARUP.

Program Measure Number	Equipment and Operation – As-Built
M1	New variable frequency drives (VFD) were installed on the supply and return fans of AHUs - 1 to 5. The secondary chilled water pump and condenser water pump also had variable frequency drives. VFDs were not installed on the cooling tower fan motor.

2.8. **Seasonal Variability in Schedule and Production**

The Kalmanovitz Library operates 8,760 hours per year. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a "9-month academic calendar" are small given year-round classes on the campus.

[52] 2K0703150 UCSF Kalmanovitz Library HVAC Retrofit IR Review.xls

The best time to collect M&V data would be when the variable frequency drives are active. Consequently, nearly any time of year would be suitable for collecting data. If available, historical trend logs will be reviewed through the M&V effort to confirm baseline assumptions.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the Kalmanovitz Library VFDs project were developed by ARUP.[53] The provided documentation did not provide algorithms, however, detailed savings results were included and their apparent approach to estimating savings is below.

Program Measure Number	Algorithm
M1	A bin-temperature analysis, supported by EMS trend data was used to develop savings estimates for the newly installed VFDs and controls: **<u>Replace VFD on Condenser Water Pump and Correct S/S:</u>** Under the base conditions, the CWP pump ran at full capacity in cooling mode, regardless of the cooling load. The baseline power draw was 50.9 kW. The replaced VFD, coupled with correct start/stop controls allowed pump operation to more closely match the cooling load profile and condenser water flow needs. VFD speed is fixed at 75%. The campus EMS trend data confirmed that the HVAC system is turned off from 12:15 am to 7:00 am on weekdays, Friday 12:15 am - Saturday 9:00 am, Saturday 8:30 pm - Sunday 9:00 am and Sunday 10:30 pm - Monday 6:00 am. $\underline{\textit{Annual kWh Savings}} = \Delta_{occupied}\sum(Hrs_t \times kW_{pump}) + \Delta_{unoccupied}\sum(Hrs_t \times kW_{pump})$ Hrs_t: Number of hours in temperature bin “t” kW_{pump}: pump electric load in the pre- and post-installation case **<u>Replace VFD on Secondary Chilled Water Pump and Correct S/S:</u>** Similar to the CWP, the Chilled Water Pump ran at full capacity in cooling mode, regardless of the actual cooling load. The baseline power draw was 10.6 kW. The replaced VFD, coupled with correct start/stop controls, allowed the chilled water pump to more closely match the cooling load profile and chilled water flow needs. VFD speed was not fixed and the campus EMS trend data was used to estimate pump power draw under various cooling loads. $\underline{\textit{Annual kWh Savings}} = \Delta_{occupied}\sum(Hrs_t \times kW_{pump}) + \Delta_{unoccupied}\sum(Hrs_t \times kW_{pump})$ Hrs_t: Number of hours in temperature bin “t”

[53] 2K0703150 Attachment 1 - IR Revised Energy Savings Calculations.pdf

Program Measure Number	Algorithm

kW_{pump}: pump electric load in the pre- and post-installation case

Primary Chilled Water Pump is On/Off Control

On/Off Control savings were calculated through "Chilled Water Profiles" which estimated the percent of time, in a particular temperature bin, that the primary chilled water pump was operating. Profiles were developed through campus EMS trend logs.

Annual kWh Savings $= \Delta_{occupied}\sum(Hrs_t \times kW_{pump} \times Chiller_{\%}) + \Delta_{unoccupied}\sum(Hrs_t \times kW_{pump} \times Chiller_{\%})$

Hrs_t: Number of hours in temperature bin "t"
kW_{pump}: Primary chiller pump electric load in the pre- and post-installation case
$Chiller_{\%}$: Primary pump chilled water profile in the pre- and post-installation case

Replace VFDs on AHUs 1-5 and Correct S/S

The following input assumptions were confirmed through the campus EMS system:

- Supply Air Temperature (W): 68 °F
- High Limit Air Flow Start: 60 °F
- High Limit Air Flow Stop: 72 °F
- Low Limit Air Flow Start: 65 °F
- Low Limit Air Flow Stop: 62 °F
- Supply Air Temperature (S): 52 °F

Under the baseline conditions, the fan speed varied depending on the specific outdoor air temperatures; however, no adjustments were made based on the occupancy status of the building. In the post-installation case, the AHUs were completely shut off when the building was unoccupied, resulting in heating and cooling savings. Fan power was measured in the pre- and post-installation case to develop savings based on Supply Air CFM.

Annual Fan kWh Savings $= \Delta_{occupied}\sum(Hrs_t \times kW_{fan}) + \Delta_{unoccupied}\sum(Hrs_t \times kW_{fan})$

Hrs_t: Number of hours in temperature bin "t"
kW_{fan}: Fan electric load in the pre- and post-installation case

Annual Cooling kWh Savings $= \Delta_{unoccupied}\sum(Hrs_t \times kW_{cooling})$

Hrs_t: Number of hours in temperature bin "t"

Program Measure Number	Algorithm
	$kW_{cooling}$: Cooling electric load under temperature case. <u>*Annual Therm Savings*</u> = $\Delta_{unoccupied}\sum(CFM_{supply}\ x\ 1.08\ x\ T_t\ x\ Hrs_t \div 100{,}000)$ CFM_{supply}: Supply Air CFM *1.08*: Conversion factor T_t: Temperature differential between supply air and mixed air "t" Hrs_t: Number of hours in temperature bin "t" *100,000*: Conversion factor **<u>Install VFD on Cooling Tower Fan</u>** This measure was not installed and the savings were adjusted accordingly.

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Options A and B will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in the post-retrofit case involves spot measurements to calibrate consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M1	The proposed evaluation approach will seek to visually verify affected system components and their proposed operating characteristics, including: • VFDs and start/stop controls on AHUs 1-5. • VFDs and start/stop controls on condenser water pump and secondary chilled water pump. • On/off controls on chilled water pump. • Absence of VFD on cooling tower fan. • Building occupancy rates and temperature set points used in the ex-ante savings calculations. The evaluation team will also verify the following *ex-ante* input assumptions: • $Supply_{temp}$ /$OSA_{heating}$/ $OSA_{cooling}$: Temperature differential between supply and OSA temperatures. The evaluation team will use the Fluke 971 Relative Humidity & Temperature Meter to confirm temperature readings are consistent with campus

Evaluation Measure Number	Algorithm
	EMCS logs. • Fan and Pump Capacity: Fan and pump power draw. These parameters will be confirmed through interval metering of all affected units in AHU 1 and 3. Findings will be used to correlate fan speed with power. VFD characteristics will collected/trended through the campus EMCS system to gather a more accurate view of fan performance. • Static Pressure of AHUs: Confirm post-installation static pressure with Fluke 922 Airflow Meter. The evaluation team will obtain operational characteristics and curves for the affected fans and pumps. This data will be used to correlate power consumption with VFD speed. Direct metering of electric consumption may also be combined with logged VFD operation to verify the power consumption at different operational speeds for both the pumps and AHUs. Overall, the evaluation will use the *ex-ante* and IOU algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by including on-going trending on performance parameters to calculate savings. A time series model will be developed using trending data along with EMS setpoints. ***The evaluation team has engaged support from the UCSF Program Manager and has begun trending to capture system operating characteristics during the peak demand period. The following parameters are being collected in 15-minute intervals for a period of two months:*** • Condenser Water Pump o Date/Time o OSA o Cooling Capacity (Tons) o Condenser Water Flow (GPM) o Condenser Water Pump kW o Condenser Water Pump VFD Speed o Condenser Water Supply Temperature o Condenser Water Supply Setpoint • Chilled Water Pump o Date/Time o OSA o Cooling Capacity (Tons) o Chilled Water Flow (GPM) o Chilled Water Pump kW o Chilled Water Pump VFD Speed o Chilled Water Supply Temperature o Chilled Water Supply Setpoint o Chilled Water Return Temperature • AHU Supply/Exhaust Fans o Date/Time

Evaluation Measure Number	Algorithm
	○ OSA ○ Supply Air Temperature ○ Supply Air Setpoint ○ Static Pressure ○ Static Pressure Setpoint ○ Fan kW ○ Fan VFD Speed ○ Fan CFM ○ Return Air Temperature ○ Hot Water Valve Operation ○ Chilled Water Valve Operation

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zones impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	9. **Spot Measure Fan and Pump Power** with hand-held Fluke 43B at the motor control center. 10. **Collect VFD, Fan, and Pump Performance Characteristics** from the University Facilities – Energy Management Office (if possible). 11. **Measure Static Pressure** for AHUs with Fluke 922 Airflow Meter. 12. **Collect Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter and confirm temperature readings are consistent with campus EMCS logs. 13. **Collect Time Series Temperature Data** from the campus or local Department of Water Resources or the National Oceanic and Atmospheric Administration (NOAA) to correlate with operation data. 14. **Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

5 The accessibility to HVAC equipment we would meter as part of the M&V effort.

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The following data products will be produced during the evaluation:

- Building characteristics data
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- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

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Whenever possible, we will collect building characteristics[54] data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

[54] Contextual Data v3.doc

System	Characteristics
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Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F) • Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations on August 24, 2009. For the most part, the library air handlers operated as described in the supporting project material and related in this M&V Plan. There were six air handler units, four of which were included through the project (AHUs 2-5). Although AHU 1 had VFD, it was not part of this project. Similarly, AHU 6 supplied the rare books collections and was also not included in the shutoff times. As expected, the air handlers and pumps in the library had VFDs installed and operating. During the Summit Blue visit, the pumps were not operating, nor was return fan. However, spot measurements of the remaining units were taken for comparison with baseline and logged data.

Summit Blue received data as described and performed analysis based on 2 °F temperature bins. Six months of data for the eight air handler fans and three pumps was provided including VFD speed and power. The power provided by the system did not match either onsite measurements or listed values on the calculations provided with the application and this was accounted for in calculations as discussed below.

5.2. Analysis

The calculations included with the application made a few assumptions which were different than those used in this analysis. Table 5 shows the differences in assumptions.

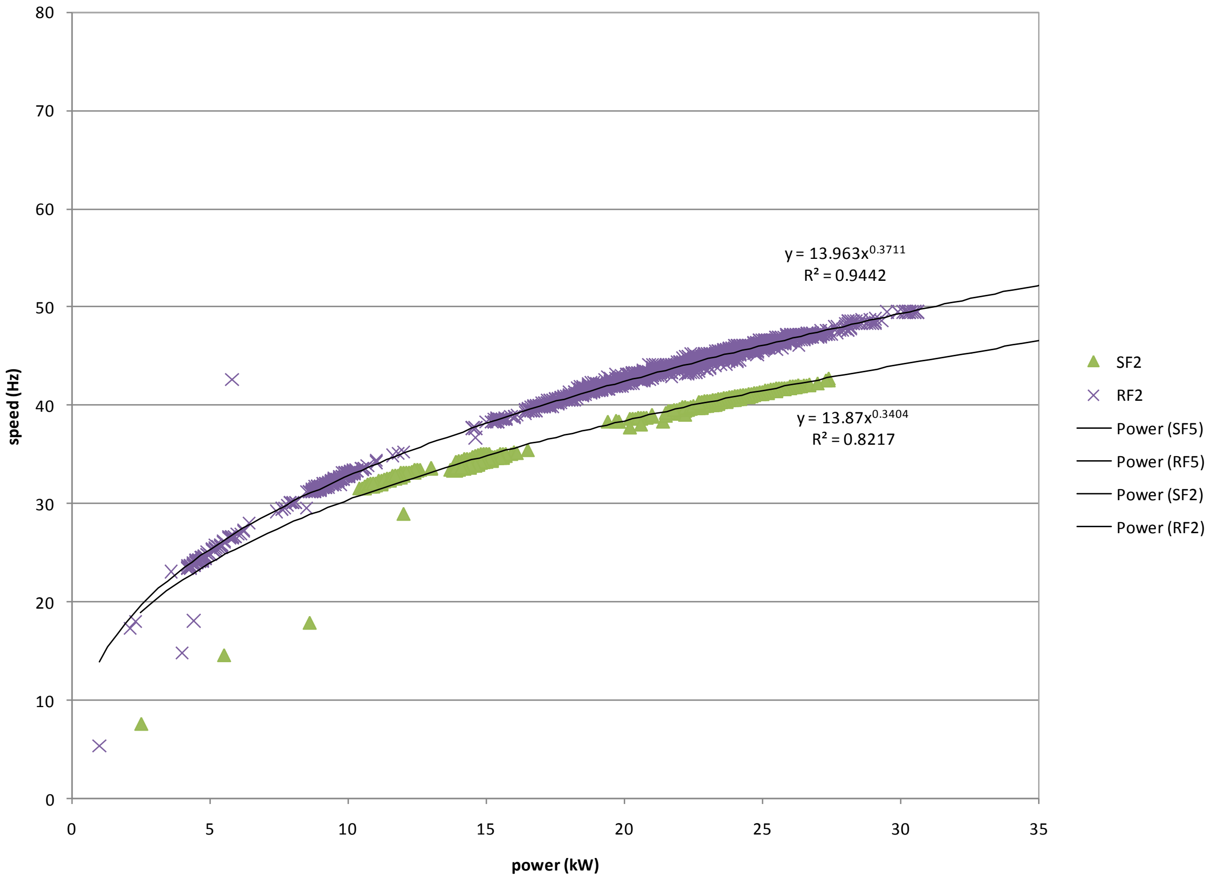
Table 5. Adjustments to Calculations

Variable	ARUP Report	Summit Blue Analysis
occupied hours	5855	5262
cooling temperature	52 °F	55 °F
supply air temperature	68 °F	varied 55-65 °F with area
chiller fuel	electric	gas

It is possible that the operational hours for the library had changed since the initial assessment; however, the other differences are more difficult to reconcile. Because of this, the ARUP baseline was adjusted to match the updated assumptions. The operational conditions for each temperature bin were kept as in the ARUP report. Additionally, the fan kW values reported by ARUP were found to be close to those measured during the site visit and were also accepted as correct for the baseline.

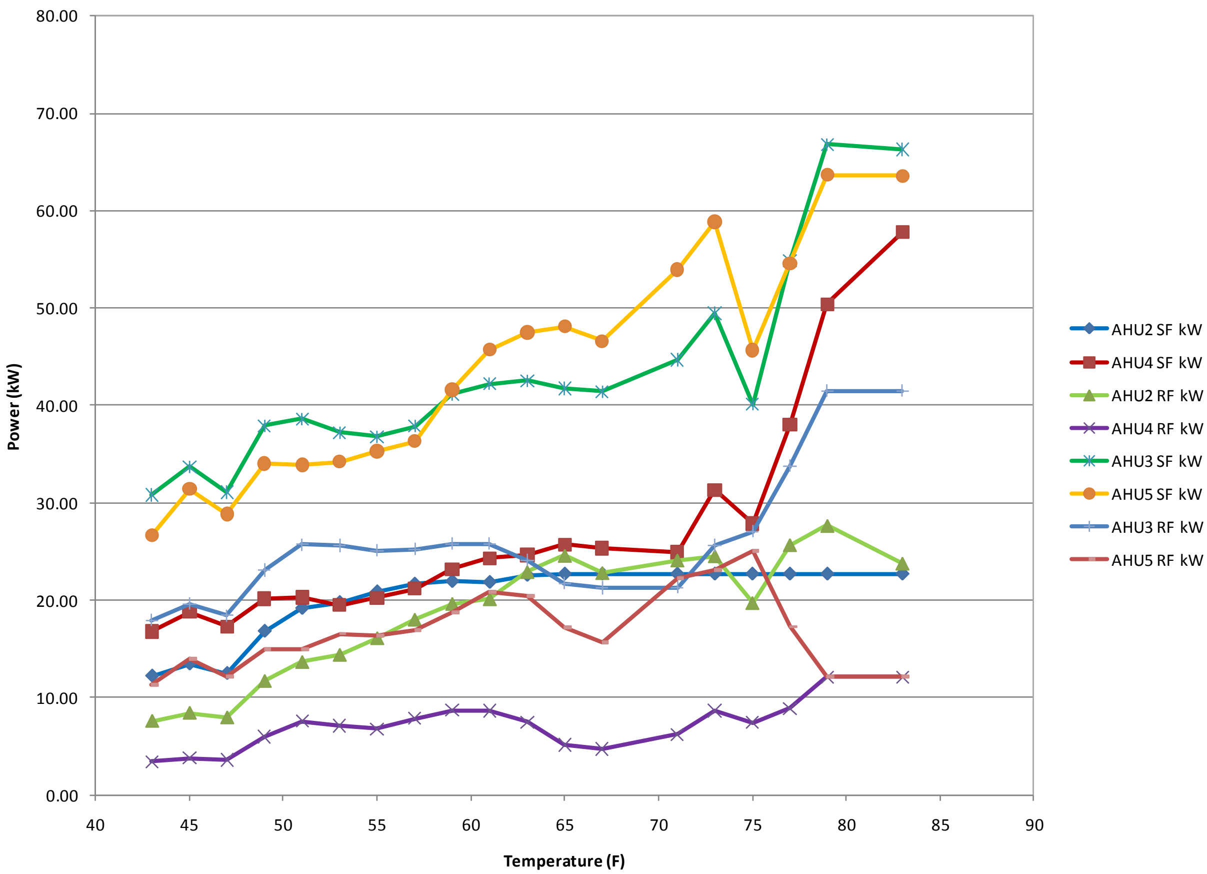
Figure 16 trends VFD speed as a function of kW reported by the data logs for air handler 2. As can be seen, the trend is clear and the exponents remain between 1/2.5 and 1/3, as predicted by the affinity law. Similar results were found for the other three air handlers. Because of this, it was assumed that the error in power was a scaling problem and a linear correction was made based on the spot measurements taken during the site visit. For the air handler that was not operating during the site visit, ARUPs reported powers were used to make the adjustments. Additionally, since the pump logs did not report power and they were not operating during the site visit, ARUP's power measurements were accepted for these calculations as well.

Figure 16. Speed as a Function of Reported kW for AHU 2



Normalized CZ data was used along with operational hours for the library to create temperature bins. Trends for each fan were created for both occupied and unoccupied conditions. Although only supply fan 2 showed the predicted clean asymptotic behavior, as shown in Figure 17, trends for the other fans were also found acceptable and were used to extrapolate the VFD operation under other temperature conditions.

Figure 17. Air Handler Fans Reported Power vs. Outdoor Temperature



The power reported by the system was used to create these trends and this was rescaled to match measured values in the predicted VFD behavior for each temperature. The relationship between power and VFD speed was used to calculate VFD power savings. Air volume was presumed to scale linearly with VFD speed with a maximum based on system specifications. Pump speed was not trended because the pumps reached maximum values at the extremes of available temperature and so that value was applied to lower or higher temperature bins as appropriate. Actual average speeds were used for pumps for the mid-range temperatures.

The HVAC savings were calculated using these data and the following formulae:

OA volume = SAV – RAV

MA temperature = (RAT x RAV + OAT x OAV)/SAV

MA enthalpy = (RA enthalpy x RAV + OA enthalpy x OAV)/SAV

Cooling BTUh = 1.08 x SAV x (MAT – 55) or BTUh=4.5 x SAV x (MA enthalpy - 22.55), as appropriate based on enthalpy conditions

Reheat BTUh = 4.5 x SAV x (enthalpy - 22.55), where the enthalpy varied depending upon the temperature set point

According to facility personnel the absorption chiller had an efficiency of 90% and was supplied by steam from the campus cogen plant which also reported a 90% efficiency. Based on this an estimated cooling efficiency of 80% was used for cooling and 90% was used for heating calculations.

5.3. **M&V results**

Results of the M&V analysis are shown in Table 6. The ARUP report was the source of the baseline conditions, although some adjustments were made to assumptions. Specifically, the post-installation reheat temperature was changed from 68 °F to 62 °F for AHUs 2 and 3, 57.4 F for AHU4, and 63.3 °F for AHU5 and the cooling temperature was changed from 52 °F to 55 °F based on information provided by the university. The baseline reheat was still taken to be 68 °F because of the greater air volume compared to the current case. The operational hours were adjusted slightly, the cooling was switched from electric to an adsorption chiller, and the peak supply air volume was corrected. The VFD speeds at given temperatures and motor power for the baseline were taken directly from the ARUP report.

The difference between the *ex ante* and *ex post* values is due to a combination of the changes in baseline airflow, temperatures, and cooling fuel. In addition, temperature logs provided with the application indicate that immediately after the retrofit, no reheat was being used, and that instead a cooling temperature of 65 °F was a simple economizer setting. However, based on current system settings this no longer appears to be the case, and mechanical cooling plus reheat is being used to dehumidify the air. This change in operating conditions has introduced additional significant changes from the *ex ante* savings provided with the application.

Table 6. M&V Results

	Therms	**AHU kWh**	**Pumps kWh**	**Peak kW**
Replace Non-operational VFDs and Economizer				
ex post Savings	126,932	1,044,584		62.2
ex ante Savings	107,206	1,044,617		25.6
Realization Rate	118%	100%		243%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

CENTRAL PLANT CHILLER #4 REPLACEMENT – CAL STATE SAN BERNARDINO

November 2, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#94
Company Name	Cal State San Bernardino
Site Name	Central Plant
Site Address	5500 University Parkway, San Bernardino, CA 92407
Site Type	Central Plant
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[55]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	New 1,200 Ton Chiller #4	Replace old 800 ton chiller with new, efficiency 1,200 ton chiller.

2.2. Annual Measure Savings[1]

Table 7. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	363,200	158	38,442	-	-	100%

The *ex-ante* savings estimates were developed and submitted as part of the Form B for this project.[1] This study included not only the replacement of chiller #4, but a complete expansion of the chilled water system to accommodate the new science building which requires approximately 1,100 tons of cooling. In addition to the replacement of chiller #4, the 500 ton chiller #3 was replaced with a 1,200 ton efficient chiller and a new 2,400 ton cooling tower was installed. Tertiary pumps, return blending, and loop completion were removed from the cooling system and replaced with VFD driven pumps, new piping, and controls. A second 1,080,000 gallon thermal energy storage (TES) tank was also added to the system, which had previously had only a single 1,080,000 gallon TES tank.

These system changes resulted in reduced chiller and pumping energy use as well as demand shifting because of the increased thermal storage.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

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[55] CSU SB Central Plant Retrofits rev1.xls

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation[56]

Program Measure Number	Equipment and Operation – Pre-installation
M1	The chilled water system is located at the central plant for Cal State San Bernardino, however, it serves numerous other buildings on the university campus. Prior to the installation of the new cooling equipment, the central plant had a load of approximately 1,100 tons less than currently and included a 500 ton chiller (#3) as well as the 800 ton chiller #4 evaluated here. A single 1,080,000 gallon tank was used for thermal storage. None of the pumps on the original system had VFDs and the piping included a tertiary loop. However, since this evaluation is only for the replacement of chiller #4, the base case will be the existing cooling system, including both TES tanks, the new chiller #3, the new cooling tower, all the VFDs, and the current piping scheme, but with the old 800 ton chiller #4. This may result in somewhat different savings for chiller #4 than when the system was treated as a whole, although the savings estimates did provide separate chiller values.

2.7. As-Built Equipment and Operation[2]

Measure characteristics for the HVAC system retrofits were drawn from the form B for this project.

Program Measure Number	Equipment and Operation – As-Built
M1	The only installed project measure for this evaluation was the replacement of the old 800 ton chiller #4 with a new, efficient 1,200 ton unit.

2.8. Seasonal Variability in Schedule and Production

Cal State San Bernardino's HVAC equipment operates 8,760 hours per year. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a "9-month academic calendar" are small given year-round classes and lab research on the campus.

[56] CSU SB Central Plant Retrofits rev1.xls

The best time to collect M&V data would be over an entire year, although the impact should be greatest during the summer months. Any available trend logs for chiller operation will be obtained from the campus facilities office; however, they indicated that due to problems with their EMS they had lost some of their historical data. Since the base case for this project will be the new system without the replacement of chiller #4, rather than the old system, this data is unlikely to be of any use in creating a baseline.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

The final approved energy savings were included in the Form B for this project;[57] however, the sheet including the detailed results did not provide formulas for the chiller replacement or TES tank addition. Consequently, the details of the approach to estimating *ex-ante* savings were not provided.

Program Measure Number	Algorithm
M1	This project was evaluated as five separate measures: chiller # 3 replacement, chiller #4 replacement, removal of tertiary pumps, eliminate blending and return loop completion, and new thermal energy storage tank. No details were provided on the calculation of savings due to the chiller replacement or TES tank addition.

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option A and B will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in involves end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO). Since the IOU was calculating savings for all measures involved in the plant expansion, and this evaluation is addressing only savings for chiller #4, the approach is significantly different.

Evaluation Measure Number	Algorithm
M1	Energy savings attributed to the replacement of chiller #4 will be realized as a reduction in total chiller energy use and a possible change in pumping energy use. However, since the loads on chillers #3 and #4 are linked it will be necessary to evaluate energy use of both units. The proposed evaluation approach will seek to visually verify affected system components, including: • Installation of the new 1,200 ton chillers #3 and #4 • Installation of the new 2,400 ton cooling tower • Presence and use of both 1,080,000 TES tanks • Operation of VFDs on pumps

[57] CSU SB Central Plant Retrofits rev1.xls

Evaluation Measure Number	Algorithm
	The evaluation team will also determine the following: • Supply and return water temperatures for the cooling tower. • Supply and return temperatures to the TES tanks. • Water flow rate from the TES tanks, if possible. • Pump operation, including hours and use of VFDs. • Schedules and set points for the cooling system and use of the TES. The evaluation will use the following approach: • Obtain trending for 15 minute operation of chillers #3 and #4 over as long a period of time as possible, up to one year. • Obtain data for hourly or daily average temperature and humidity for nearest available weather station to the campus over the period of time for which trending data is available, or use campus weather trending data if available. • Correlate average daily chiller loading to average daily outdoor air temperature and, if appropriate, wet bulb or humidity. Ideally for a thermal storage system, the “daily” average would actually be based on a “day” that began after the peak use hours as the temperature began to cool. If hourly average data is available, a “day” starting around 7 PM may be used; however, it may be necessary to use a standard day if hourly data is not practical. • Determine chiller use during peak periods. • Obtain chiller operation curves for both the current chillers and the old 800 ton chiller #4. • If chiller trending data is provided as power, use chiller data to determine loading. If loading data is available, this step may be skipped. • Use chiller data for the old 800 ton unit to determine energy use to cool an equivalent load. If the chiller does not have adequate capacity to handle the load, some load may be shifted to chiller #3 or hours of chiller operation may be extended. • If hours of chiller operation are extended, determine additional energy used for pumping, if any.

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zones impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**15. Spot Measure Chiller Power** with hand-held Fluke 43B or equivalent at the motor control center. **16. Trend Chiller Power** with Dent Instruments Elite Pro electric power loggers at the motor control center to measure true RMS kW of chiller at 15-minute intervals (if needed to confirm EMCS trending data). **17. Collect Chiller Performance Characteristics** from the University Facilities – Energy Management Office or manufacturer (if possible). **18. Spot Measure Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter or equivalent and confirm temperature readings are consistent with campus EMCS logs or BIN data if possible. **19. Collect Time Series Temperature Data** from the local Department of Water Resources or the National Oceanic and Atmospheric Administration (NOAA) to correlate with historical consumption data.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical AdvisorsEngineering Working Group.

4.4. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1 Our ability to obtain adequate trend logs from the customer.

2 The accessibility to HVAC equipment we would meter as part of the M&V effort.

4.5. Data Products

The following data products will be produced during the evaluation:

- Cooling system characteristics data
- Time-series data for electric and chilled water loads, including chiller kW, gpm, and water temperature
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.6. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.7. Building Characteristics Data

Whenever possible, we will collect building characteristics[58] data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type

[58] Contextual Data v3.doc

System	Characteristics
	• Monitored Packaged Unit or Chiller Make & Model Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F) • Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.8. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

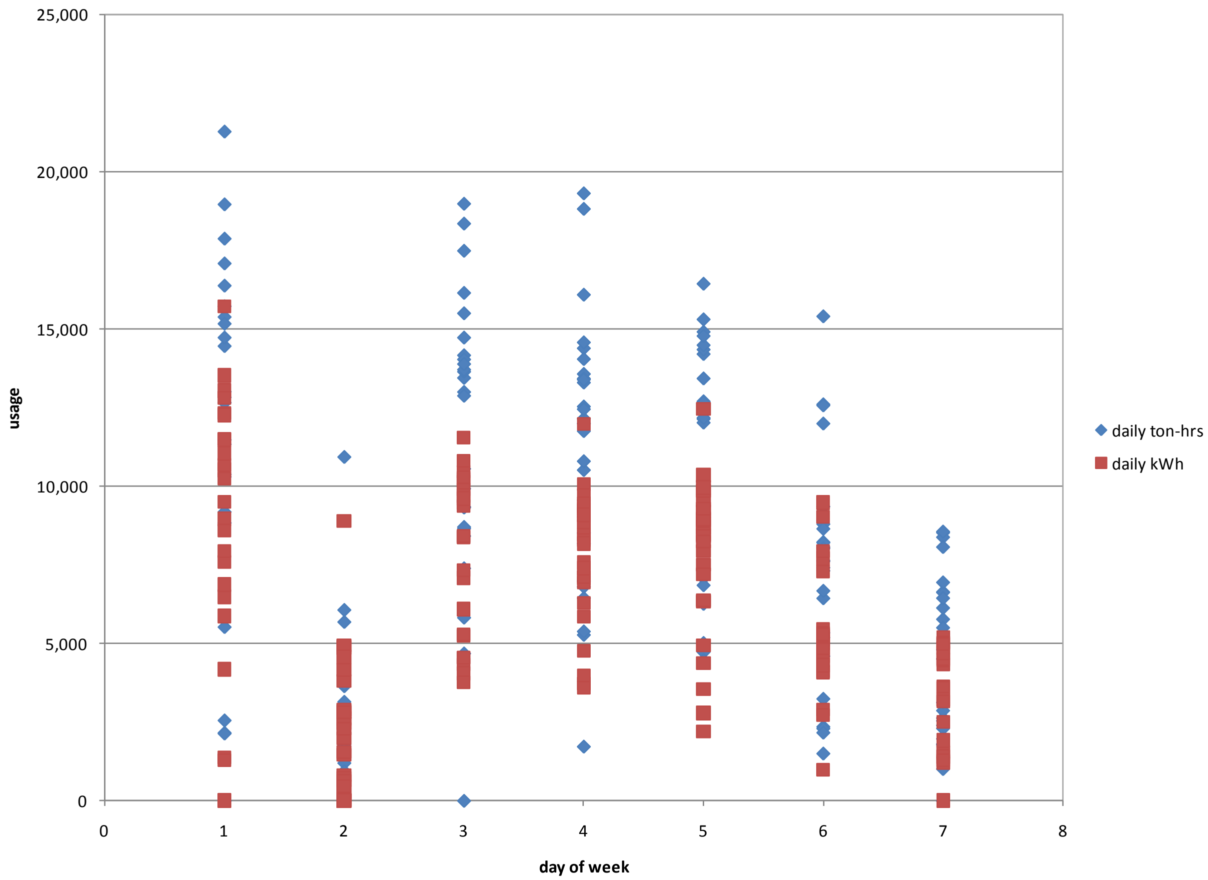
Summit Blue conducted on-site measurements and observations on August 27, 2009. In addition, operation logs were obtained from April through mid-September 2009. For the most part, the plant operated as described in the supporting project material and related in this M&V Plan. Two new 1,200 ton chillers and a second thermal energy storage tank had been installed and were storing chilled water during nighttime hours for use during the day. The old chillers 3 and 4 had been completely removed from the facility as expected. As described in section 2 of this report, only the replacement of chiller #4 is part of this evaluation, although the overall project was more extensive. Measured and manufacturer data indicate chiller #4 is operating at an efficiency of around 0.67 kW/ton, although it was designed for an efficiency of 0.591 kW/ton under planned operating conditions. Nevertheless, due to uncertainties in measurement of tons cooling, the manufacturer's efficiencies have been used for this analysis.

Summit Blue obtained efficiency data for both the old 800 ton chiller #4 and the two new 1,200 ton chillers. Efficiency data for the new chillers was obtained at both ARI and operating conditions from Trane. Both chillers 3 and 4 were designed to operate at 0.591 kW/ton with ARI efficiencies of 0.557 kW/ton and 0.553 kW/ton, respectively. The old chiller #4 had an ARI efficiency of 0.618 and 2005 Title 24 required a minimum ARI efficiency of 0.577, corresponding to a minimum COP of 6.1. The planned operating conditions for chiller #4 included an input temperature of 52 °F and an output temperature of 39 °F. Efficiencies for the old chiller and Title 24 were not available under these conditions.

5.2. Analysis

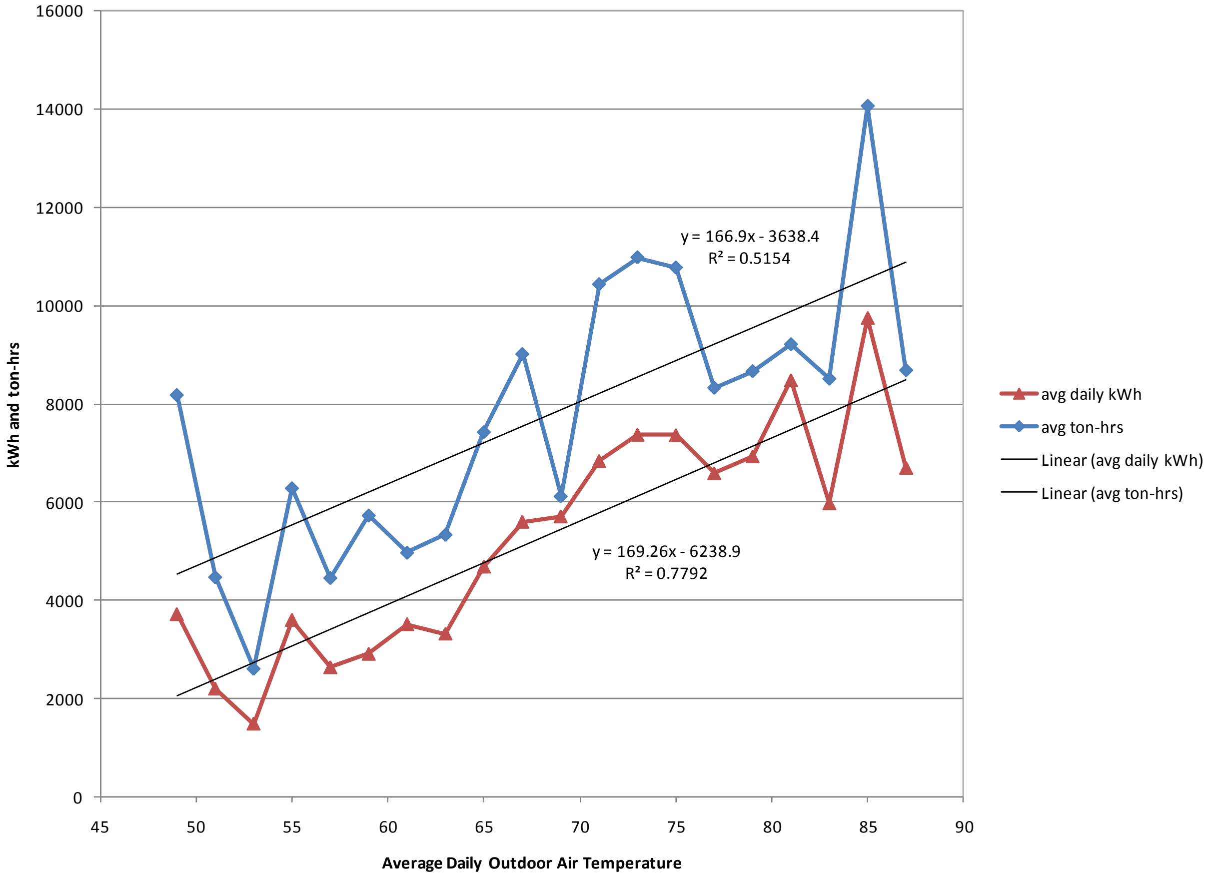
Daily kWh and ton-hrs for both chillers 3 and 4 were calculated from university data logs for the system. Because the TES system would begin operating for the night at 8PM or later, a "day" was defined for these calculations as starting and ending at 8PM. Campus outdoor air temperature logs were used to calculate average outdoor air temperature. Figure 18 shows the daily production and power usage of chiller #4. The only weekday during which any daytime usage was observed was on Sundays. From this data, it appears that the plant stores up extra chilled water on Sundays to reduce operation during the week. All days appeared to have significant hours of non-operation, even at night. Because of this it appears that the old 800 ton chiller would have had sufficient capacity to produce the current volume of chilled water.

Figure 18. Chilled Water Delivered by Thermal Storage and Chilled Water Plant



Average daily chilled water production shows a correlation with temperature, which was estimated as a linear trend. Data were placed in 2 °F temperature bins based on campus OAT and averaged prior to calculating the relationship. The results are shown in Figure 19.

Figure 19. Chiller Power and Output



Temperature bins for a year were calculated from temperature data for climate zone 10. These daily average temperatures were also based on a day from 8PM to 8PM. The trend for kWh/day was used to estimate daily energy usage for the current chiller over a typical year, using ARI efficiencies for the current chiller 4 and both the old chiller and a Title 24 equivalent.

5.3. **M&V results**

Results of the M&V analysis are shown in Table 36. The table shows the estimated energy savings for both the old chiller and a Title 24 compliant equivalent. Because of the evaluation of a single item from a more extensive project, it is difficult to directly compare the savings calculations. In fact the projected gas savings are from the replacement of chiller #3, which was a 500 ton absorption unit, even though they are credited to the replacement of chiller #4 in the application. It is also difficult to separate the two chiller replacements in the application since the electric savings are apparently attributed to both equally even though the two are very different baselines. Additionally, the use of ARI efficiencies to calculate savings may have affected the savings. However, since operating efficiencies were not available for either the old chiller or the Title 24 equivalent, it was not possible to use them for calculations at operating conditions. Summit Blue found that the old 800 Ton baseline chiller would have been able to accommodate the capacity during the non-peak hours. As such, peak demand savings are assumed to be 0.

Table 8. M&V Results

	Chiller kWh	Chiller kW	Chiller Therms
Old Chiller	1,811,087	0	0
Title 24 Chiller	1,689,637	0	0
New Chiller	1,620,601	0	0
Replace Chiller #4			
ex ante Savings	363,200	158	38,442
Early Replacement Savings	190,487	0	0
Early Replacement Realization Rate	53%	0%	0%
Normal Replacement Chiller Savings	69,036	0	0
Normal Replacement Realization Rate	19%	0%	0%

RESULTS REPORT

CAMPUSWIDE RETROFITS – HVAC, LOW PRESSURE DROP FILTER UPGRADE – UC-IRVINE

November 2, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	Retrofit Project #1 & 2
Company Name	University of California – Irvine
Site Name	
Site Address	201A Interim Office Building, Irvine, CA 92696-5444
Site Type	32 Campus Buildings
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Ryan Firestone

AUTHOR

Name	Ryan Firestone

GOALS AND OBJECTIVES

This project evaluation is part of the larger impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

This section describes the UC Irvine Low Pressure Drop (LPD) filter retrofit at the time of the evaluation plan development (March 2009). The following items are additional information and clarifications provided by the Campus Energy Manager since that time.

- All affected system are VAV systems regulated by VSDs – initially, the campus manager suggested that some of the units might be CAVs.
- Prior to the filter retrofit, AHUs had two sets of filters: an inexpensive *pre-filter* to screen out large particulate and a *final* filter to capture finer particulate.

2.1. Measures Included in the Evaluation[59,60]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Upgrade to Low Pressure Drop Filters	Replace existing HVAC fan filters with low pressure drop filters across various buildings

2,067 HVAC fan filters across 32 campus buildings in approximately 90 air handling units (AHUs) were replaced with low pressure drop filters. These filters reduce the supply fan horsepower necessary to provide a given air flow rate in the HVAC systems. During the development of this evaluation plan, the campus energy manager has not been on-site and is not certain of the specifications of all affected HVAC units; he stated that either:

1) All of the affected systems are VAV systems regulated by VSDs, and that the pressure drop reduction has resulted in lower fan speeds; or
2) Some of the affected systems are VAV systems regulated by VSDs and the rest are CAV systems for which the fan motors were resheaved after the filter switch.

As part of this measure, some of the filter housings had to be retrofitted to the standard 24” x 24” filter size of the new, low pressure drop filters.

Lighting measures and additional HVAC measures were also adopted at the site through the UC/CSU Partnership Program, and are the subject of separate M&V efforts.

[59] UCI_Campuswide_Bi-level_Lighting_and_Low_PD_Filter_Retrofit_-_RPCP_SCE.pdf

[60] UC-CSU-IOU_UCI_Retrofit__1Post_Installation__Review.doc

2.2. Annual Measure Savings[61]

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	3,092,757	386.7	-	-		100%

2.3. Impact Type

The impact type for this measure is *direct*.

2.4. Baseline Type

The baseline for this measure is *early replacement*.

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation

Program Measure Number	Equipment and Operation – Pre-installation
M1	This project affected 32 buildings on the UC Irvine Campus. The combined flow rate of air handling units in these buildings is 3,738,400 CFM, and these systems contain 2,067 air filters. These buildings encompass a variety of end user functions including science and engineering laboratories, lecture halls, and offices.

2.7. As-Built Equipment and Operation

Measure characteristics for the low pressure drop filters were drawn from the most recent project review files[62] and documented savings calculations.[63]

Program Measure Number	Equipment and Operation – As-Built
M1	This project was to replace the existing 2,067 filters with low pressure drop filters.

[61] UCI_Form_B_Campuswide_Retrofits.xls

[62] UC-CSU-IOU_UCI_Retrofit__1Post_Installation__Review.doc

[63] UCI_Form_B_Campuswide_Retrofits.xls

Program Measure Number	Equipment and Operation – As-Built
	No other changes were made to the equipment or equipment controls.

2.8. Seasonal Variability in Schedule and Production

According to the documented savings worksheet,[64] some of the HVAC equipment affected by this project operates 3,962 hours per year, the rest operates 8,760 hours per year. The variability in the heating and cooling schedule is presumed to be coincident with seasonal variability. The effects of a nine-month academic calendar are negligible due to year round classes and research.

M&V data collection would be effective at anytime in which the HVAC systems are active. When available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

[64] UCI_Form_B_Campuswide_Retrofits.xls

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

This section summarizes the final approved *ex-ante* savings calculations. Power and energy savings for this measure derive from reductions in supply fan load; there are no gas savings from this measure. The algorithm used to estimate supply fan load is:

$$Power = \frac{FlowRate \times \Delta P}{\eta_{fan}} \times Conversions$$

Where

- *Power* is the power (kW) consumed by the supply fans by pressure drop of ΔP
- *FlowRate* is the air flow rate (CFM) of the HVAC system
- ΔP is the pressure drop (inches WG) across the air filter
- η_{fan} is the efficiency (unitless) of the fan
- *Conversions* is the product of conversion factors necessary to convert the results into units of kW.

  i.e. $\dfrac{\left(\frac{kW}{HP} \times \frac{lb/ft^2}{inches\,WG}\right)}{\left(\frac{ft-lb/\min}{HP}\right)}$, which is approximately equal to 0.0001176, or 1/8507.

The reduction in power from the filter upgrade is then:

$$\Delta Power = Power_{pre} - Power_{post}$$

Where

- $\Delta Power$ is the reduction in power (kW) consumed by the supply fans to provide the specified flow rate of air across the air filter brought upon by the filter upgrade.
- $Power_{pre}$ is the power consumed by the supply fans to provide the specified flow rate of air across the old filters
- $Power_{post}$ is the power consumed by the supply fans to provide the specified flow rate of air across the new filters

Finally, the reduction in energy from the filter upgrade is the product of power reduction and hours of operation:

$$\Delta Energy = \Delta Power \times Hours$$

- *ΔEnergy* is the annual reduction in energy (kWh) consumed by the supply fans provide the specified flow rate of air across the air filter
- *Hours* is the number of hours per year that the HVAC system is in operation.

The ex-ante savings calculations assumed time-invariable values for the change in pressure drop (0.55 inches WG), the fan efficiencies (0.6) and the air flow rates (vary by building). Additionally, the fan motor efficiency is assumed to be 100%. The following table summarizes building specifications, parameter assumptions, and estimated savings used in the *ex ante* analysis.

	PARAMETER VALUES						SAVINGS		
Building	FlowRate (CFM)	ΔP_{pre} (inches WG)	ΔP_{post} (inches WG)	η_{fan}	Hours	Number of filters	HP	KW	KWH
				ZONE 1					
Berk/Alumni	27,000	1.10	0.55	0.6	3,962	15	3.90	2.91	11,527
Beckman Laser Inst.	33,200	1.10	0.55	0.6	3,962	26	4.80	3.58	14,174
Medical Sciences D. Cheney	25,200	1.10	0.55	0.6	8,700	14	3.64	2.72	23,624
Gillespie Neurosciences	109,200	1.10	0.55	0.6	8,700	64	15.77	11.77	102,371
Med. Surge II	90,000	1.10	0.55	0.6	8,700	50	13.00	9.70	84,372
Hewitt Hall	144,000	1.10	0.55	0.6	8,700	80	20.80	15.52	134,995
Irvine Hall	85,000	1.10	0.55	0.6	8,700	55	12.28	9.16	79,684
Med. Science A	21,600	1.10	0.55	0.6	8,700	12	3.12	2.33	20,249
Med. Science B	43,200	1.10	0.55	0.6	8,700	24	6.24	4.65	40,498
Sprague Hall	135,000	1.10	0.55	0.6	8,700	75	19.50	14.55	126,558
Tamkin Student Lecture	21,600	1.10	0.55	0.6	3,962	12	3.12	2.33	9,222
Sub -Total	***735,000***					***427***	***106.17***	***79.20***	***647,273***
ZONE 2				ZONE 2					
Bonnie Research Facility	32,400	1.10	0.55	0.6	8,700	15	4.68	3.49	30,374
Quershy Research Laboratory	31,500	1.10	0.55	0.6	8,700	15	4.55	3.39	29,530
Croul Hall	72,500	1.10	0.55	0.6	8,700	21	10.47	7.81	67,966
Reins Hall	349,200	1.10	0.55	0.6	8,700	214	50.44	37.63	327,362
Roland Hall	162,000	1.10	0.55	0.6	8,700	96	23.40	17.46	151,869
McGaugh Hall	444,600	1.10	0.55	0.6	8,700	247	64.22	47.91	416,796
Steinhaus Lecture Hall	126,000	1.10	0.55	0.6	8,700	70	18.20	13.58	118,120
Natural Science I	244,800	1.10	0.55	0.6	8,700	136	35.36	26.38	229,491
Natural Science II	176,400	1.10	0.55	0.6	8,700	98	25.48	19.01	165,369
Science Library	184,000	1.10	0.55	0.6	4,600	110	26.58	19.83	91,203
Sub -Total	***1,823,400***					***1022***	***263.38***	***196.48***	***1,628,081***
ZONE 3				ZONE 3					
Engineering Lab. Facility	72,000	1.10	0.55	0.6	8,700	40	10.40	7.76	67,497
Social Ecology II	66,600	1.10	0.55	0.6	3,962	37	9.62	7.18	28,433
Engineering Tower	216,000	1.10	0.55	0.6	3,962	123	31.20	23.27	92,215
California Institute For Telecom	230,400	1.10	0.55	0.6	8,700	128	33.28	24.83	215,992
Computer Science Engineering	28,000	1.10	0.55	0.6	3,962	16	4.04	3.02	11,954
Rockwell Engineering Center	43,200	1.10	0.55	0.6	3,962	28	6.24	4.65	18,443
Engineering Gateway	261,900	1.10	0.55	0.6	8,700	97	37.83	28.22	245,522
Humanities Instructional	53,100	1.10	0.55	0.6	3,952	33	7.67	5.72	22,612
Social Science B	50,400	1.10	0.55	0.6	3,952	28	7.28	5.43	21,463
Social Science Tower	108,000	1.10	0.55	0.6	3,952	60	15.60	11.64	45,991
ICS/Engineering Research Facility	50,400	1.10	0.55	0.6	8,700	28	7.28	5.43	47,248
Sub -Total	***1,180,000***					***618***	***170.44***	***127.15***	***817,370***

Estimated savings by zone and total savings estimated from this measure are summarized below:

	KW	KWH	Number of Filters
ZONE 1	79	647,273	427
ZONE 2	196	1,628,081	1022
ZONE 3	127	817,370	618
TOTAL SAVINGS	403	3,092,724	2067

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Option A & B will be used for evaluation efforts.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach involves end-use metering, spot measurements, collection of manufacturer and model information, verification of HVAC system flow rates and filter counts, and consumption data drawn from the University Facilities – Energy Management Office (EMO). The relatively large number of AHUs that must be examined to meet the 90/20 target relative precision called for in the Evaluation Protocols (~90 AHUs requires a sample size of 15) makes extensive testing at each AHU infeasible; the proposed evaluation strategies leverages EMS data and manufacturer specifications to the greatest extent possible.

The Campus Energy Manager noted that, while the site energy management system (EMS) is capable of capturing trend data for each HVAC system, historically, this data has not been collected. The system can store supply fan power (kW) and air flow rate (CFM). Additionally, maintenance staff maintain hand logs at the locations of the filters in which the pressure drop across the filters is noted. The Campus Energy Manager is not sure if any readings were taken prior to the filter upgrade. However, post-retrofit pressure drop trend data is available in this form.

For individual HVAC systems examined, two distinct possibilities exist: either the system is VAV, regulated by a VSD, or the system is CAV.

The power and energy savings will be calculated as in the *ex ante* savings calculations. However, given that the HVAC systems are variable air volume (VAV) systems, the air flow rates will not be assumed to be time invariable, but will rather be correlated to weather data. Fan efficiencies will be determined from fan curves provided by the site or, if unavailable on site, by manufacturer specifications. Motor efficiencies will be determined from motor nameplate information. A separate savings analysis will be conducted for each AHU inspected, and results will be extrapolated to the roughly 90 AHUs at the 32 buildings affected. Parameter values used in the calculations will be collected through the proposed M&V efforts, which are described in Section 0

3.4. **Peak Demand Algorithms Used in the Evaluation**

Peak demand will be determined by using the power equation stated in Section 3.1. The *ex ante* savings estimate assumed a constant air flow rate at all hours of operation, and therefore a time-invariable power savings. However, the HVAC systems affected by this measure are variable air volume (VAV) systems, and thus the flow rates will be dependent on the temperature conditioning requirements. A temperature sensitive air flow rate estimate is proposed for this verification.

The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for UC Irvine's climate zone (Climate Zone 8).

DATA COLLECTION

This section presents the data collection plan presented to and approved by the ED Technical Advisors in March 2009. Summit Blue was ultimately not able to collect the data that the Campus Energy Manager had confirmed was available. Section 0described the actual data collection process and the revised evaluation method, which was presented and approved by the ED Technical Advisors in September 2009.

4.1. Site-Specific Parameters and Data-Collection Methods

The following table summarizes the site-specific parameter data that will be collected, and the data collection methods.

Parameter	Data Collection Approach
-----Post-Retrofit	
Flow Rate (t)	Trend data collected from EMS system. Spot measure to calibrate EMS trend data. *Fluke 922 Airflow Meter Manometer*
ΔP	Average of manufacturer specifications for clean and loaded filter and manufacturer recommended pressure drop at which to replace filter. Spot measurement and review of trend data from paper logs for verification. *Fluke 922 Airflow Meter Manometer*
Static Pressure	Spot measurement. *Fluke 922 Airflow Meter Manometer*
η-fan (t)	Obtain fan curves from site, look up fan_efficiency as a function of static pressure and flow rate
η-motor	Obtain from motor nameplate data
Supply Fan Power (t)	Trend data collected from EMS system. Spot measure to calibrate EMS trend data. *Fluke 43B*
Fan Speed	Spot measure with strobe tachometer, along with power spot measurement to calibrate the power / CFM relationship observed from trend data.
Outdoor Air Temperature	Trend data collected from EMS system. Spot measure to calibrate EMS trend data. *Fluke 922 Airflow Meter Manometer*
-----Pre-Retrofit	
Flow Rate (t)	Verify that flow rates have not changed: **For VAV systems -** assume flow rate does not change **For CAV systems -** examine documentation of pre/post sheave sizes and resulting fan speed (rpm) change. From fan speed and static pressure estimate (see below), determine flow rate (from fan curves).
ΔP	Average of manufacturer specifications for clean and loaded filter and manufacturer recommended pressure drop at which to replace filter. Note that while it would be possible to replace new filters with old filters on site, the time required per AHU (~ 3 hours for system shut off, filter replacement, system stabilization, and filter re-replacement) is prohibitive.
Static Pressure	Compute: Static_Pressure_Pre = Static_Pressure_Post - ΔP_Post + ΔP_Pre
η-fan	Obtain from fan curves, as function of static pressure and flow rate
η-motor	Obtain from motor nameplate data
Supply Fan Power (t)	Compute from Power equation in section 3.1, using static pressure rather than ΔP and [η_{fan} (t)* η_{motor} (t)] rather than [η_{fan}]

Outdoor Air Temp and Relative Humidity	Trend data collected from EMS system. Spot measure to calibrate EMS trend data. *Fluke 922 Airflow Meter Manometer*

4.2. **Data Collection Procedure**

This approach suggests the following procedure:

Data Requests

The following data requests can be submitted prior to visiting the site:

1) EMS Trend Request – Request that flow rate, fan power, and outdoor air temperature be recorded for each AHU in the sample for two months, beginning in late July.
2) Pressure Drop Log Request – Request that pressure drop logs at filters be maintained during these two months.
3) Fan Curve and Motor Nameplate Data Collection – Request fan curves and motor nameplate data for supply fan. If this information is available digitally, collect on disk or via email. Otherwise, request mechanical drawings for building and photocopy relevant pages.
4) Identification of each AHU as VAV or CAV.
5) For CAV AHUs, request documentation of pre and post sheave size and/or resulting fan speed (rpm).
6) Pre and post filter specifications: manufacturer and model number.

Research

The following data can be obtained off-site:

1) Filter pressure drop: obtain manufacturer specified pressure drop (at rated conditions) and manufacturer recommended pressure drop at which to replace filter.

Onsite Data Collection

The following data will be collected onsite by spot measurement at each AHU in the sample:

1) Flow rate (CFM)
2) ΔP across low pressure drop filters (inches of water column)
3) Supply fan speed (rpm)
4) Supply fan power (kW)
5) Outside air temperature (°F)

4.3. **Data Analysis, Impact Estimation**

Upon completion of data collection, the following data analysis will be conducted:

1) Calibrate the following data to spot measurement (if necessary) and pressure drop hand logs:

   a. Post-retrofit filter pressure drop
   b. Fan CFM vs. power relationship (as observed from EMS data, calibrated to fan speed and power spot measurements)

2) Determine the relationship between outside air temperature and flow rate (by binning flow rate data points by outside air temperature).
3) Determine the relationship between flow rate and post-retrofit supply fan power.
4) For each of the range of flow rates observed, determine the hypothetical pre-retrofit supply fan power. Use the pre-retrofit estimate of static pressure, lookup the resulting fan efficiency (a function of static pressure and flow rate), and compute the fan power.
5) For each temperature bin, summarize the average CFM, the corresponding post-retrofit supply fan power, and the corresponding pre-retrofit supply fan power.
6) Use the supply fan power (pre- and post-retrofit) temperature bin data to estimate energy savings for a typical year of weather dat.

4.4. Sampling Strategy

We will follow the guidelines of the California Energy Efficiency Protocols, namely that *"the target relative precision is 90/20 for each measure selected for investigation. The sampling unit (measure, circuit, control point) shall be designated by the M&V plan. The initial assumption regarding the coefficient of variation for determining the sample size is 0.5".*

The sampling unit for this analysis will be one AHU. There are approximately 90 AHUs at the 32 buildings listed in Form B;[65] assuming a coefficient of variation of 0.5, the requisite 90/20 sample size is 15 AHUs. AHUs will be selected randomly from the full list of affected units. If on-site time is limited (due to site staff availability), we could select buildings randomly and sample *all* AHUs in each selected building (buildings have between one and five AHUs), up to a total of 15 AHUs. This would minimize the number of buildings that we would need to access, as well as the mechanical drawing sets (typically one per building) that we would need to access.

4.5. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

[65] We have requested the actual number from the site's Campus Energy Manager. Sample size may change slightly depending on the actual number of AHUs.

4.6. **Quality Assurance Procedures**

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.7. **Uncertainties**

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1. Our ability to obtain adequate trend logs from the customer.
2. The accessibility to HVAC equipment we would meter as part of the M&V effort.
3. Our dependence (most likely) on manufacturer specifications to determine the pressure drop across the old filters.

4.8. **Data Products**

The following data products will be produced during the evaluation:

- Building characteristics data
- Time-series data for air handler fan loads and operating parameters
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.9. **Data Reporting Formats**

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.10. **Building Characteristics Data**

We will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours

System	Characteristics
	• Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F) • Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.11. **Supporting Data for this Plan**

All files referenced in this plan are attached.

RESULTS

This section describes the site data collection and subsequent analysis, culminating in the impact estimate and realization rate.

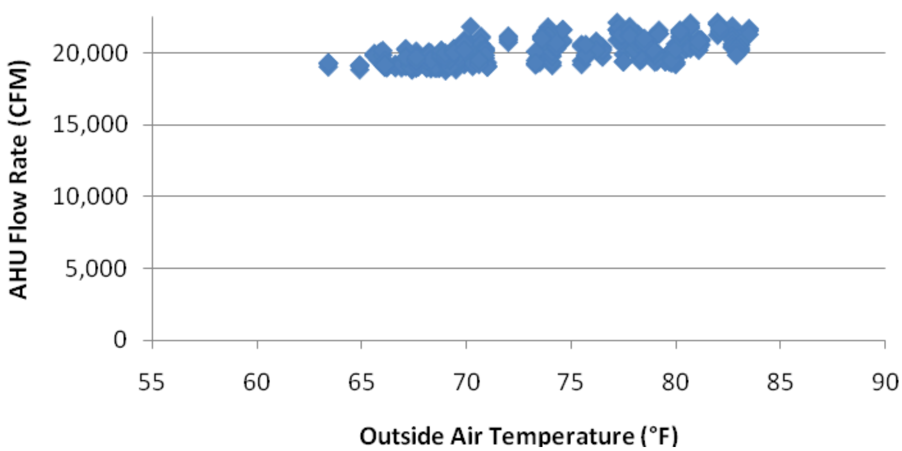
5.1. Data Collection

Despite assurances from the Campus Energy Manager that the initial evaluation plan were based on, data collection activities were hindered by incomplete access to EMS trend data and a lack of availability of the Campus Energy Manager; this impact evaluation included five projects at U.C. Irvine and the Campus Energy Manager simply did not have the time nor the support staff to collect all of the information requested for this evaluation.

5.2. Trend Data

The initial evaluation plan called for collection of trend data for several months. Ultimately, the site was only able to provide five to ten days (varied by AHU) of trend data from August, 2009. Trend data was available for 15 of the 90 AHUs, and trend data for seven of these 15 AHUs contained reasonable data for both the supply fan power (kW) and the air flow rate (CFM). Trend data was useful for deducing the hours of operation for each supply fan, as well as temperature / CFM relationships. Figure 20 illustrates the outside air temperature (OAT) to CFM relationship for one of the sites that the evaluation team received data for. Although trend data spanned a relatively short amount of time, a temperature span of 25°F and a clear relationship between the two variables were observed. The analysis workbook included with this report includes the data and graphs for all seven buildings.

Figure 20. Outside Air Temperature vs. Flow Rate for Croul Hall AHU 1, From EMS Data



5.3. **Onsite Data Collection**

The evaluation team was able to inspect 29 air handlers in seven buildings. The following data were collect

- **ΔP -** Pressure drop across filters was measured with the Fluke 922 Air Flow Meter Manometer. The Fluke 922 reads a differential pressure across two sensors, such that the area directly outside the air handler could be used as a reference pressure, and the pressure drop across filters could be taken as the difference in two successive pressure readings – one on either side of the filter bank. Readings of the *in situ* pressure drop gauges were also noted. Most of the *in situ* gauges were grossly oversized for the pressure drop range observed: gauges went up to 2, 5, or 10 inches water column, but filters are being replaced when the pressure drop reaches 1 inch.
- **Supply Fan Power** – supply fan power and VFD frequencies were read from VFDs and the time of reading was noted. For several VFDs, power readings with the Fluke 345 were conducted to confirm the VFD readings, all with satisfactory accuracy.
- **Outdoor air temperature** – This data was collected with the Fluke 922 Air Flow Meter Manometer and was in agreement with weather data collected from The California Irrigation Management Information System.[66]

The evaluators also collected the make and model information for the pre-retrofit pre-filters and final filters, and the post-retrofit LPD filters years (pre-filters are no longer used).

As-built specifications were provided for seven of the eight buildings inspected and included specifications for any HVAC retrofits and/or additions over time. These documents provided the following data for each AHU:

- Supply fan HP
- Current CFM and design CFM
- Design static pressure
- Number and size of filters
- Space type for AHU system (i.e., laboratory vs. office/classroom spaces).[67]

Additionally, the following filter replacement schedules were collected from the superintendent of plant operations and confirmed by inspection of filter pressure logs at the filter banks:

- **Pre-Retrofit**
  - Pre filters were replaced approximately every three to six months

[66] California Department of Water Resources, Office of Water Use Efficiency. http://wwwcimis.water.ca.gov

[67] Ventilation systems for laboratory spaces run 24/7 and must run at high flow rates (with outside air) regardless of space temperature conditioning needs, where as ventilation systems for non-laboratory spaces have much more variable flow rates and may not operate 24/7.

    - Final filters were replaced approximately every one year

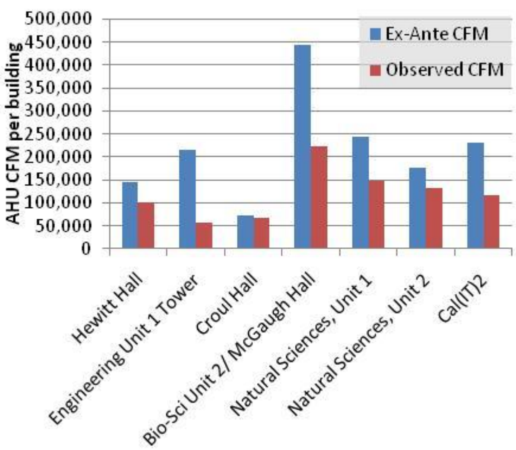
- **Post-Retrofit**
    - The new LPD filters are replaced approximately every 1.5 to 2 years, when the pressure drop observed across the filters approaches 1.0 inches water column.

The evaluators were not able to collect the following data that was required for the initial evaluation plan:

- **Flow Rate (t)** – In order to measure flow rate (CFM) accurately, a complete traverse of the duct is necessary, requiring a series of access points for instrumentation spanning a cross section of the duct. Test holes were not available for the AHUs inspected.
- **η-fan, η-motor** – Nameplate data for the fan and motor were unavailable. However, as-built documents for all systems observed were reviewed and AHU maximum flow rate (CFM) and supply fan motor rated power (HP) were provided, providing a single point on the fan power curve. ASHRAE recommendations were used for fan efficiency estimates[68] and Energy Policy Act 1992[69] motor efficiency standards were used for motor efficiency estimates.
- **Fan speed** – This data was not collected.

Discrepancies were found between building air handler characteristics assumed in the ex-ante savings and those that we observed. Most notable were over-statements of total air handler per building CFM (Figure 21) and hours of operation (Figure 22).

Figure 21. Comparison of ex-ante and observed total AHU CFM (annual average) per building



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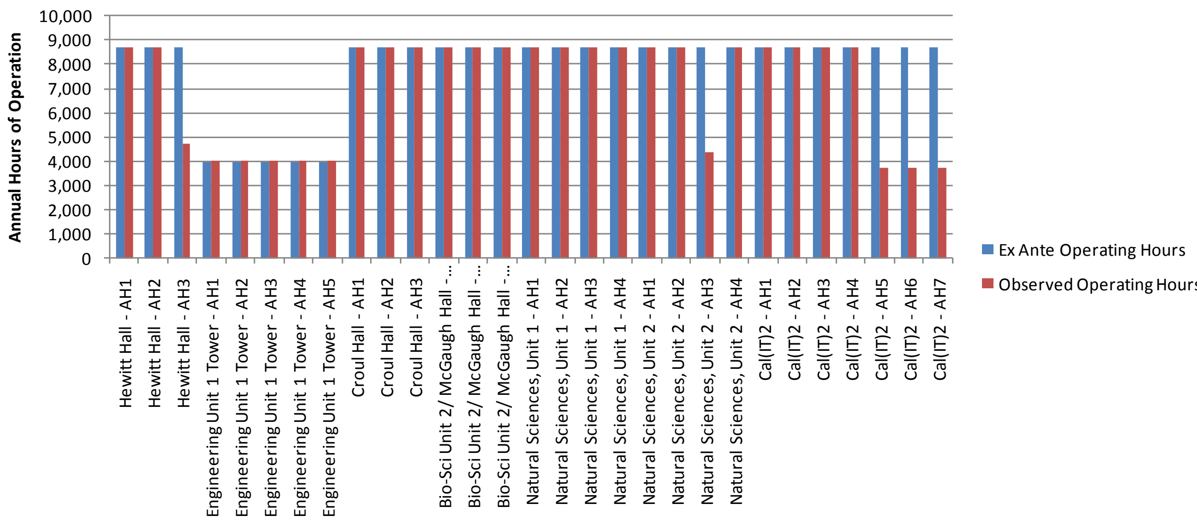
[68] *ASHRAE Pocket Guide for Air Conditioning, Heating, Ventilation, Refrigeration: Inch-Pound Edition*, American Society of Heating Refrigeration and Air Conditioning Engineers, June 2005. 45% for motors under 10 HP and 55% for motors larger than 10 HP were assumed. The assumption of constant fan efficiencies was deemed reasonable given the relatively small variation in CFM with temperature (i.e., all of the observed trend data of air handlers CFM was relatively constant).

[69] Energy Policy Act of 1992, United States Congress, 1992.

Figure 22. Comparison of ex-ante and observed annual AHU hours of operation



5.4. Impact Analysis

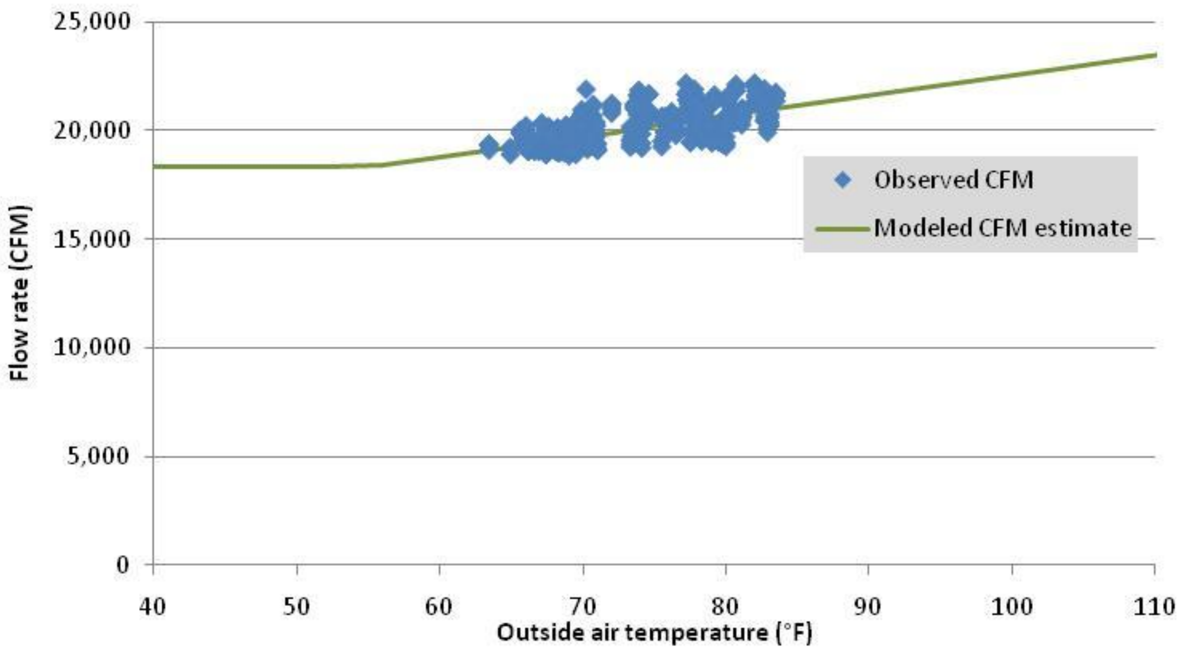
The collected data was discussed with the ED Technical Advisors in September 2009 and the following revisions to the initially proposed analysis were approved.

- **Analysis at the building level, not the air handler level** – because the ex-ante savings were at the building level and could not be disaggregated to individual air handlers, the sampling unit was changed from an air handler to a building.
- **Modeling of pressure drop across filters** – We had proposed to read longitudinal pressure drop from the hand logs. However, as discussed earlier, the actuators used to record pressure drop for the hand logs were neither precise enough nor thorough enough to use for analysis. Instead, we developed a model of filter pressure as a function of filter life and CFM in the air handler and calibrated it to observations from the hand logs and descriptions provided by the superintendent of plant operations.

The analysis then proceeded by the following steps:

1. **Year-round CFM estimate** – trend data was used to develop the OAT to CFM relationship for observed air handlers. The CFM to OAT relationship was assumed linear above a threshold OAT of 55 °F; below this threshold the CFM was assumed to be constant and equal to the linear curve fit at the threshold temperature. Figure 23 illustrates this process:

Figure 23. CFM to OAT curve fitting and assumptions



2. CFM estimates were then mapped to annual hours using annual hourly temperature data. From this mapping, the annual average CFM was computed. For air handlers that we did not have trend data for, the annual average CFM was assumed to be 82% of the design CFM stated in the building mechanical schedules: this was the average ratio of average CFM to design CFM observed from air handlers that we had trend data for.

3. The average annual pressure drop across the pre-retrofit and post-retrofit filters were then determined by using the following model:

$$dP = (C_1 + age^2) * C_2 * CFM^{1.8}$$

Where

- *dP* is the pressure drop across the filter, in inches of water column
- C_1 is a constant
- *age* is the portion of the filters rated lifetime that it has been in service for. For example, a filter that had been in service for half of its lifetime would have an age of 0.5.

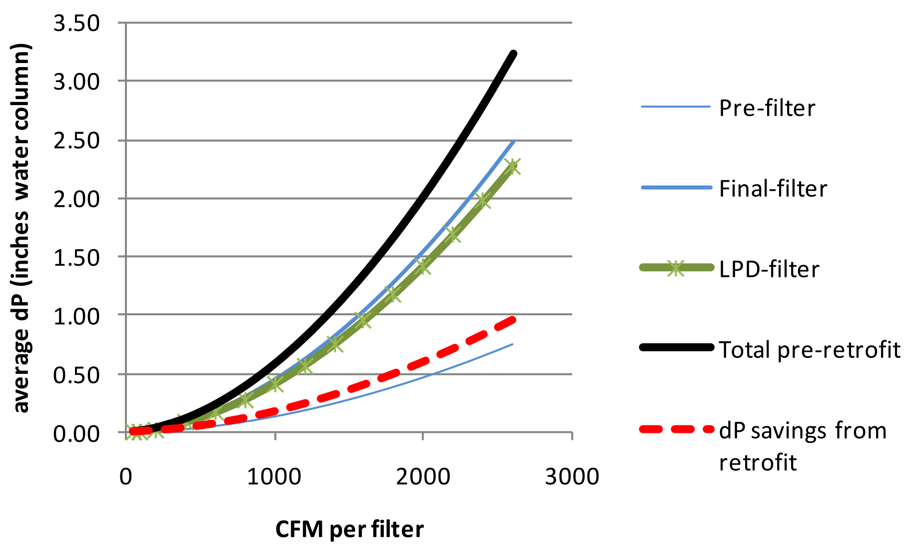
- the exponential relationship of *dP* to *age* was suggested in *HVAC: Systems and Components Handbook, Second Edition*[70]
- C_2 is a constant
- *CFM* is the flow rate *across each filter,* in cfm.
- The exponential relationship (1.8) of *CFM* to *dP* is that observed from manufacturer filter specifications for the filters observed at the site. This is slightly less than the theoretical value of 2.0 from the Bernoulli equation.

The constants C_1 and C_2 for each of the three filters of interest (pre-filter, final filter, and LPD filter) were solved for by using the manufacturers' specifications for *dP* at 2,000 CFM for filters at both the beginning and end of their lifetime as boundary conditions.

Finally, the equation above was integrated with respect to age for age ranging from 0 to 1 and divided by the duration of the integration (1) to determine the average dP over the lifetime of the filter, as a function of CFM.

The average *dP* over the lifetime of each of the three filters for a range of CFM are plotted in Figure 24.

Figure 24. CFM versus lifetime average dP



4. The average pressure drop as a function of CFM per filter determined above was used to assign an average pressure drop savings from the retrofit to each air handler in the sample. CFM per

[70] Niles Grimm and Robert Rosaler, *HVAC Systems and Components Handbook, Second Edition*. McGraw-Hill. 1990.

filter was determined by dividing the estimated annual average CFM by the number of filters specified in the mechanical schedules.

5. The power savings equation stated in Section 3.1was then used to compute the average annual power (kW) savings.
6. Annual energy savings (kWh) for each air handler were determined by multiplying the average annual power savings by the annual hours of operation of the air handler.
7. Coincident peak demand was determined by using the air handler design CFM, rather than the annual average, in the equations and procedures described above.
8. Savings were summed for each of the seven buildings in the sample. These results, along with the ex-ante savings and the implied realization rates are stated in Table 37.

Table 9. Realization rates are used to estimate project-wide energy and demand savings

Table 10

Table 10. Project level ex-ante and ex-post savings estimates

Savings	Ex-ante	Ex-post	Realization rate
Annual Energy (kWh)	3,092,757	729,415	24%
Coincident Peak Demand (kW)	403	129	32%

5.5. **Conclusions**

This ex-post analysis resulted in a realization rate of 0.24 for annual kWh savings, and a realization rate of 0.32 for coincident peak kW savings. The primary cause for an overstatement of ex-ante savings was the overstatement of air handler flow rates: ex-ante estimates assumed 1800 CFM per filter, on average, whereas the observed flow rate averaged just 1,016 CFM. Given that energy savings are proportional to the product of CFM and pressure drop reduction, and that the pressure drop reduction is proportional to CFM raised to the 1.8 power, energy savings are ultimately proportional to CFM raised to the 2.8 power. Additional overstatement of ex-ante savings resulted from overstating the hours of operation of some air handlers.

Realization rate estimates were less precise than the targeted 90/20 specified in the Protocols: at the 90% confidence level, ex-post precision was 32% for kWh savings and 31% for kW savings. This was due to: 1) less usable EMS trend data than site staff initially suggested, and 2) lack of ex-ante savings at the air handler level (only at the building level), resulting in a sample size of only *seven* buildings, rather than *29* air handlers.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

CROUL HALL HVAC SYSTEM ENERGY SAVINGS STUDY – UC-IRVINE

November 6, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#12
Company Name	University of California – Irvine
Site Name	Croul Hall
Site Address	Croul Hall, Irvine, CA 92697-3100
Site Type	Earth Systems Science
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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IOU REPRESENTATIVE

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[71]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Install Aircuity Air Monitoring and Control System	Reduce ACH air change rates in lab spaces when conditions permit using centralized demand control ventilation (CDCV).

2.2. Annual Measure Savings[72]

Table 11. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	117,399	-	-	9,443	-	100%

The *ex-ante* savings estimates were developed and submitted by Aircuity. No detailed study was available; however, summaries of this project were used to develop this site plan. These system changes resulted in reduced fan energy consumption, along with a reduced load on the heating and cooling systems.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

[71] FormB_UCI_Croul-Aircuity.xls

[72] Croul_Hall_Energy_Analysis_11-04-07.pdf

2.6. Pre-Installation Equipment and Operation[73]

Program Measure Number	Equipment and Operation – Pre-installation
M1	Croul Hall is a 3-story, 68,830 square-foot office and laboratory building constructed in 2003. The building has three floors including an atrium that is open to all three levels. The building occupancy consists primarily of laboratories and offices. Croul Hall's ventilation systems were originally designed for a constant six air changes per hour (ACH) in all laboratory areas regardless of occupancy or particulate levels.

2.7. As-Built Equipment and Operation[74]

Measure characteristics for the ventilation system retrofits were drawn from the project inspection and review file,[3] documented savings calculations,[4] and the presentation reviewing the project.[5]

Program Measure Number	Equipment and Operation – As-Built
M1	Installed project measures included the installation of Aircuity Centralized Demand Control Ventilation (CDCV) system to control air changes per hour (ACH) in 21 areas including 16 fume hoods in Croul Hall laboratories based on air contamination measurements.

2.8. Seasonal Variability in Schedule and Production

Croul Hall's HVAC equipment operates 8,760 hours per year. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a "9-month academic calendar" are small given year-round classes and lab research at the Hall.

M&V data could be collected at any time when the CDCV system is active. Consequently, nearly any time of year would be suitable for collecting data. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

[73] UCI_Retrofit__12_Post_Inspection_&_Review.doc

[74] Croul_Hall_Energy_Analysis_11-04-07.pdf

[5] UCI_Aircuity_Labs_21-2008Final.ppt

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

The provided documentation did not include algorithms used for estimating energy savings. However, some baseline assumptions were provided and we have approximated their likely savings approach based on HVAC systems evaluated elsewhere on the same campus. The presumed approach to estimating *ex-ante* savings is below.

<table>
<tr><th>Program Measure Number</th><th>Algorithm</th></tr>
<tr><td>M1</td><td>The following baseline assumptions were made when calculating system ex-ante savings:

• Base Air Changes per Hour of 6, in both occupied and unoccupied conditions.
• Design Fan Total Static Pressure of 5.0” water column (w.c.)
• Fan efficiency of 70% (Fan_{eff})
• Motor efficiency of 90% ($Motor_{eff}$)
• Average fume hood maximum airflow of 1,250 CFM
• Average fume hood minimum airflow of 290 CFM
• Average fume hood 70% open when unoccupied
• Average fume hood 30% open when occupied
• TVOC threshold of 1 PPM.
• Total square feet of 19,110 with average ceiling height of 9 feet.

At a minimum of 4 air-changes per hour based on actual air contamination levels, the ventilation rate at these times is assumed to be reduced by:

$\Delta CFM = [(Area \times Height) \times (ACH_{design} - ACH_{post})]/(60 \text{ minutes/hour}) = \underline{5,733}$

Where:
ACH_{design}: Design ACH for Laboratory i (6)
Area: Area of Laboratories in Sq. Ft. (19,110)
Height: Height of Laboratories in Ft. (9)
ACH_{post}: Post Project ACH in Affected Areas (4)

At other times the ACH may be increased to a maximum of 8. This results in increased CFM, calculated using the same formula. Trending data from the facility will be required to determine the number of hours at each rate post-installation.

Although not clearly specified in the project documentation, total static pressure for the ventilation fans may be calculated using system static pressures and airflow.

Although the provided documentation did not specify that Croul Hall used the University central plant for heating and cooling, this is assumed to be the case until more information can be obtained from the University Facilities office. Chiller/boiler plant energy use was assumed to be reduced due to the decrease in conditioned air flow demand to Croul Hall.</td></tr>
</table>

Program Measure Number	Algorithm
	The following system assumptions were provided with the savings estimates used to estimate kWh and Therm savings for this project, and will be verified during the field visit: • Cooling system COP of 4.7 • Heating efficiency of 80% • 200 CFM/Ton of cooling • 55 °F Supply Air Temperature • 40% RH for Supply Air • Reheat discharge temperature of 75 °F • Occupied cooling setpoint of 74 °F • Unoccupied cooling setpoint of 85 °F • Occupied heating setpoint of 70 °F • Unoccupied heating setpoint of 60 °F • No return air is used. It is presumed that standard calculations for cooling and heating savings were used based on the provided parameters.

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option B will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in both the pre- and post-retrofit case involve end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M1	Energy savings attributed to the reduction of ACH in unoccupied teaching laboratories will be realized in two areas: • A reduction in total supply and exhaust fan energy consumption due to reduced load. • A reduction in cooling/heating energy consumption due to the reduced conditioned air load to Croul Hall. The proposed evaluation approach will seek to visually verify affected system components, including:

Evaluation Measure Number	Algorithm
	• Installation and correct operation of CDCV system. • Operation of air contaminant sensors to identify pollutant concentration. The evaluation team will also verify the following *ex-ante* input assumptions: • $OSA_{heating}$/ $OSA_{cooling}$/ $Coil_{heating}$: Temperature differential between supply and OSA temperatures. The evaluation team will use the Fluke 971 Relative Humidity & Temperature Meter to confirm temperature readings are consistent with campus EMCS logs. • Fan Operation: Fan capacity and operating hours. These parameters will be confirmed through a combination of interval metering of a census of building fans and trend data logged by the CDCV system. Findings will be used to correlate fan speed with power. • Occupancy Schedules for Teaching Laboratories: The evaluation team will speak with facility staff and confirm annual occupancy periods for teaching laboratories. • Static Pressure: Confirm post-installation static pressure through the Campus EMCS system. A Fluke 922 Airflow Meter may be used to verify that EMCS readings are consistent with field findings. Overall, the evaluation will use the *ex-ante* algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by including on-going trending and by expanding the model to include a bin hour temperature analysis.

3.4. **Peak Demand Algorithms Used in the Evaluation**

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**20. Collect Building Design Information** including blueprints and relevant equipment specifications from the University Facilities office. Since this is a relatively new building, this information will most likely be available and accurate. **21. Spot Measure Fan Power** with hand-held Fluke 43B meter or equivalent. **22. Trend Fan Power** with Dent Instruments Elite Pro electric power or equivalent loggers at the motor control center to measure true RMS kW of fan motors at 15-minute intervals (if needed to confirm EMCS trending data). **23. Collect Fan Speed and Operation Characteristics** from the University Facilities – Energy Management Office (if possible). **24. Measure Static Pressure** across the fan with Fluke 922 Airflow Meter or equivalent. **25. Collect Outdoor Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter or equivalent and confirm temperature readings are consistent with campus EMCS logs. **26. Collect Bin Temperature Data** from the local Department of Water Resources or the National Oceanic and Atmospheric Administration (NOAA) to correlate with historical consumption data or use campus EMCS logs of temperature if available. **27. Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect. Equivalent meters may be substituted for the models listed above.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1. Our ability to obtain adequate trend logs from the customer.
2. The accessibility of HVAC equipment we would meter as part of the M&V effort.

4.6. Data Products

The following data products will be produced during the evaluation:

- Building characteristics data
- Time-series data for electric and heating loads, and of air handler operating parameters
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

Whenever possible, we will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type

System	Characteristics
	• Monitored Packaged Unit or Chiller Make & Model Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F) • Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations on August 27, 2009. The Croul Hall exhaust operated as described in the supporting project material and related in this M&V Plan. Air handlers 2 and 3 supplied the lab areas of the building and spot measurements of their supply fan operation were taken during the site visit. Facility schedules for the supply fans were used to obtain design conditions. The exhaust fans were constant speed and air was supplied through bypass ventilation when flow was reduced by the Aircuity system. This resulted in savings on the HVAC system and supply fans, but no reduction in exhaust fan operation.

The Aircuity system included detailed logging of airflow through each controlled area. These records were obtained for a one year period from September 2008 through August 2009. Although the supply fans were not generally monitored by the university, a year of power consumption data had been logged for them between the summers of 2008 and 2009 and this was used to estimate typical operation of the fans.

5.2. Analysis

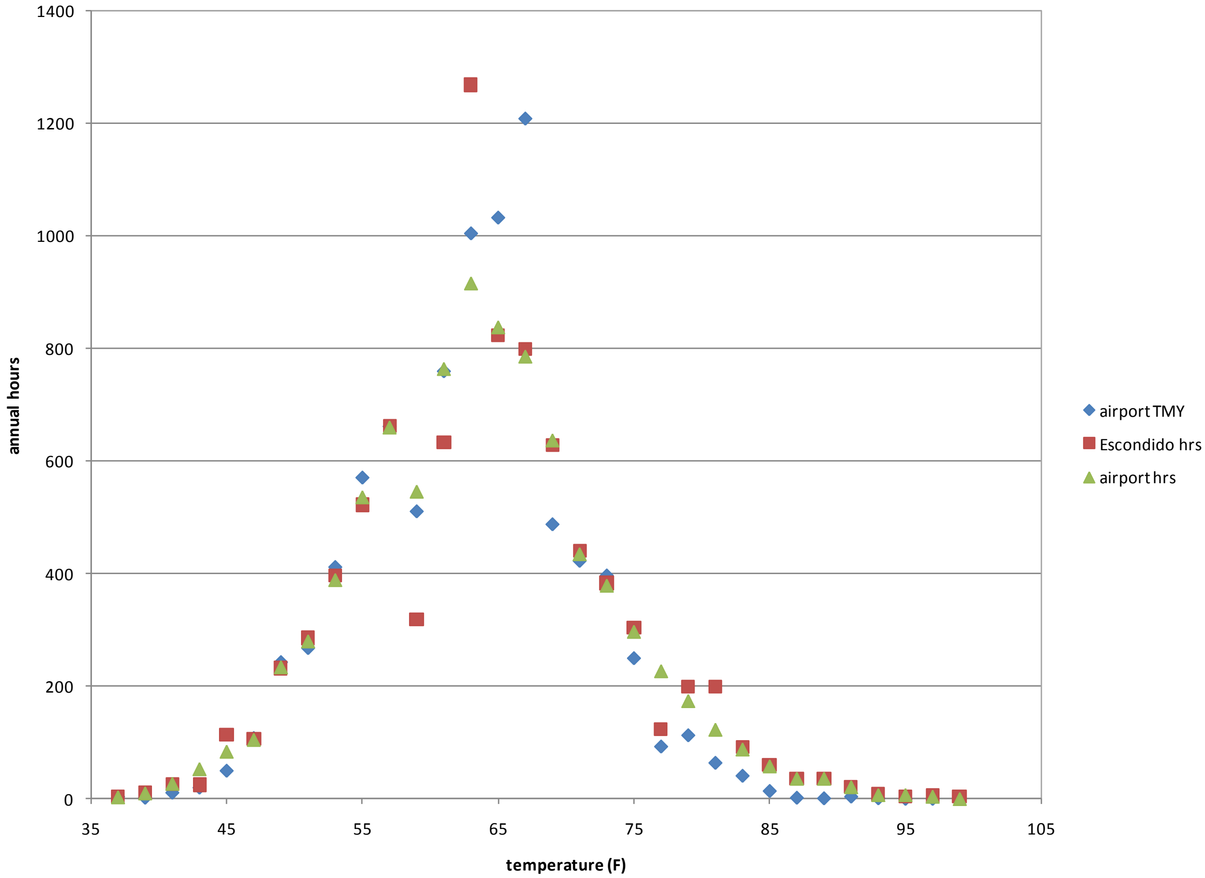
Table 41 presents the peak and average airflow for each of the Aircuity zones.

Table 12. Airflow

Sensor	Avg cfm	Max cfm	Min cfm
X_RM1212LSV111BFLOW	636	1009	461
X_RM1212LSV111CFLOW	926	1521	675
X_RM1212LSV111DFLOW	556	854	430
X_RM1212PHXMIJFLOW	436	1044	313
X_RM1222PHXMIJFLOW	854	1077	806
X_RM1226LSV110EFLOW	385	1190	315
X_RM1226LSV110FFLOW	384	519	334
X_RM1311LSV104CFLOW	660	1666	378
X_RM1311PHXMIJFLOW	721	2474	434
X_RM1313LSV105AFLOW	348	1087	307
X_RM1313PHXMIJFLOW	1757	1963	394
X_RM2212PHXMIJFLOW	1163	3872	989
X_RM2214LSV212FLOW	156	480	138
X_RM2214LSV213FLOW	156	322	138
X_RM2222PHXMIJFLOW	985	2368	919
X_RM2224LSV209BFLOW	348	1662	241
X_RM2224PHXMIJFLOW	646	1517	86
X_RM2311LSV202AFLOW	577	1688	332
X_RM2311PHXMIJFLOW	397	1290	290
X_RM2313LSV202CFLOW	180	513	151
X_RM2313LSV203BFLOW	364	1241	230
X_RM2313LSV203DFLOW	370	1055	341
X_RM2313PHXMIJFLOW	1009	1740	306
X_RMB228PHXMIJFLOW	1043	1575	505
X_RMB311PHXMIJFLOW	1081	2942	910
X_RMB321LSV030AFLOW	591	1654	385
X_RMB321LSV030BFLOW	1204	1677	400

Due to the high level of variability in operation of the areas controlled by the Aircuity system, it proved impractical to create reliable correlations between facility operation and airflow, regardless of what other parameters were considered. Since an entire year of data was available for the system, the actual outdoor air temperature for two weather stations was compared to the closest available TMY data. Figure 25 shows the comparison of hours in each two degree temperature range for the two stations during the data year and a typical meteorological year.

Figure 25. Sept 2008-Aug 2009 Year and TMY



The year for which the data was available, which consisted of August 2008 through July 2009 averaged around 1 degree hotter than the TMY data. Since the TMY data was not available at the campus itself this was considered a preferable variation to the variability that would be introduced by creating trends from the data and adjusting to TMY conditions since temperature dependence was weak. Therefore the actual flow data over one year was used to calculate energy savings.

Eight air changes per hour were taken to be the baseline, a total flow of 22,932 cfm. This was slightly less than the maximum observed airflow of 25,209 cfm but significantly more than the average observed airflow of 17,876 cfm. A reheat temperature of 68 °F was used during occupied hours, which were estimated to be Monday through Friday from 7:00 AM until 11:00 PM when the University was in session.

The trend data for supply fan operation showed that the two air handlers operated similarly. Since data for supply fan 2 was provided in cumulative kWh and data for supply fan 3 was provided in kW, the data for supply fan 3 was used to calculate airflow. Onsite spot measurements and fan design data were used to calculate airflow for measured operational power. This resulted in an affinity law with an exponent of 2.8. Hourly average fan power was used to calculate current and baseline airflow and baseline hourly power for the fans. A few missing hours of data were excluded from the total, but as these constituted about one day out of the year this should not have any significant effect on the savings, particularly since it is possible that the fans were actually shut off during this time.

Peak demand for climate zone 6 of 2:00-5:00 PM on July 9-11 was not usable for these data because in 2009 July 11th was a Saturday. Peak demand was therefore based upon operation from 2:00-5:00 PM on July 8-10.

5.3. **M&V results**

Results of our M&V analysis are shown in Table 42. It is difficult to determine the exact reason for the large discrepancy between *ex ante* and *ex post* savings because of the very different ways in which they were calculated. The *ex ante* savings were estimated based upon assumed air changes per hour, in much the same way as the *ex post* baseline. However, although the average airflow reductions appeared similar between the two calculations, and the provided information indicates that the same heating and cooling efficiencies were used in the *ex ante* calculations as Summit Blue obtained from university staff, the detailed *ex ante* calculations were not provided and the exact cause of the discrepancy could not be determined.

Table 13. M&V Results

	Heating Therms	Reheat Therms	AHU kWh	HVAC kWh	Peak kW
Baseline	6,823	7,529	111,964	51,805	47.6
With New VFDs	5,106	6,126	56,049	41,220	36.6
Install Aircuity Controls for Exhaust Fans					
ex post Savings	3,121		66,502		11.0
ex ante Savings	9,443		117,399		0.0
Realization Rate	33%		57%		N/A

MEASUREMENT AND VERIFICATION SITE REPORT

STEINHAUS HALL HVAC SYSTEM ENERGY SAVINGS STUDY – UC-IRVINE

November 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#3
Company Name	University of California – Irvine
Site Name	Steinhaus Hall
Site Address	201A Interim Office Building, Irvine, CA 92696-5444
Site Type	Boilogical Sciences
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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IOU REPRESENTATIVE

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E-mail	RHS@AESC-Inc.com		

RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Mike Yim

AUTHOR

Name	Mike Yim

1. GOALS AND OBJECTIVES

This M&V Site Report has been prepared as part of the impact evaluation of the UC/CSU/IOU Energy Partnership program conducted by the Local Government Partnership Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[75]

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Install Two-Position Dampers	Reduce Air Changes in Teaching Labs by installing dampers, controls, and occupancy sensors.

2.2. Annual Measure Savings[76]

Table 14. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	406,358	-	-	26,347	-	100%

The *ex-ante* savings estimates were developed and submitted by the campus commissioned consultant, Goss Engineering, Inc. (GEI)[77]. This study included the engineering assumptions and calculations used to realize three air changes per hour – the campus minimum standard – in unoccupied laboratory spaces. The measures installed included two-position dampers for the supply and exhaust air in teaching laboratories, as well as variable frequency drives for the existing fan motors. Occupancy sensors were also installed to reduce the number of air changes per hour when the laboratories are not occupied.

These system changes resulted in reduced fan energy consumption, along with a reduced load on the campus chiller and boiler systems.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

[75] UCI_Steinhaus_Hall_Air_Change_Retrofit_-_RPCP_-_SCE.pdf

[76] UC-CSU-IOU_UCI_Retrofit__3_Review_SCE.doc

[77] Steinhaus Study Final.pdf

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation[78]

Program Measure Number	Equipment and Operation – Pre-installation
M1	Steinhaus Hall is a 6-story, Type-1 construction, approximately 107,000 square-foot laboratory building constructed in 1965. The building has five floors plus a partially buried basement. The north side of the basement is accessible from the loading dock, a machine shop, and in a sub basement the main mechanical room. A screened mechanical enclosure formed by the fifth floor offices on the fifth floor (or low roof) houses the approximately 51 exhaust fans serving 27 fume hood and most of the required space exhaust. The building occupancy consists primarily of research laboratories, teaching laboratories, classrooms, and offices. The building also houses an animal vivarium on the basement level. The HVAC system is a dual-duct (a cold duct and hot duct) type constant air volume system. Two main air-handling units (AHU) located in the basement mechanical room serve the first floor to fifth floor and vivarium. The Machine Shop and other supporting areas are served by small ceiling suspended air-handling (fan-coil) units. Each fan supplies air through heating and cooling coils that receive hot water or chilled water from the campus Central Plant. Steinhaus Hall's ventilation systems were originally designed for 60 percent of outside-air (OSA) and 40 percent return-air (RA). Currently the systems provide 90 percent outside-air and 10 percent of return-air. The existing air-handling units and roof exhaust fans are very old (with the exception of the supply fans themselves) and inefficient and need to be replaced with new, and more efficient equipment.

2.7. As-Built Equipment and Operation[79]

Measure characteristics for the HVAC system retrofits were drawn from the most recent project review file and documented savings calculations developed by GEI.

[78] Steinhaus_Study_Final.pdf

[79] UC-CSU-IOU_UCI_Retrofit__3_Review_SCE.doc

Program Measure Number	Equipment and Operation – As-Built
M1	Installed project measures included the installation of two-position dampers for the supply and exhaust air fans in teaching laboratories, variable frequency drives for the existing fans, and the replacement of existing cooling coils and AHU casing. This retrofit allowed for a reduction in the number of air changes per hour when the laboratories were not occupied.

2.8. Seasonal Variability in Schedule and Production

Steinhaus Hall's HVAC equipment operates 8,760 hours per year. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a '9-month academic calendar' are small given year-round classes and lab research at the Hall.

The best time to collect M&V data would be when the constant volume system is active. Consequently, nearly any time of year would be suitable for collecting data. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the Steinhaus Hall HVAC System Energy Savings Study project were developed by GEI[80]. Their approach to estimating *ex-ante* savings are below.

Program Measure Number	Algorithm
M1	The following baseline assumptions were made when calculating system *ex-ante* savings: • Base Supply Air of 124,000 Cubic Feet per Minute (CFM) • Design Fan Total Static Pressure of 4.5" water column (w.c.) • Fan efficiency of 68% (Fan_{eff}) • Belt loss of 3% ($Belt_{loss}$) • Motor efficiency of 95% ($Motor_{eff}$) At a minimum of 3 air-changes per hour in unoccupied laboratories, the ventilation rate is assumed to be reduced by: $\Delta CFM = \sum_i [CFM_{i,design} - (Area_i \times Height_i \times ACH_{post})] = \underline{\mathit{27{,}163}}$ Where: $CFM_{i,design}$: Design CFM for Laboratory *i* $Area_i$: Area of Laboratory *i* in Sq. Ft. $Height_i$: Height of Laboratory *i* in Ft. ACH_{post}: Post Project ACH in Affected Labs (3) The total static pressure post project completion was calculated to be: $TSP_{post} = (TSP_{base} - TSP_{inlet}) \times (CFM_{post} \div CFM_{base})^2 + TSP_{inlet} = \underline{\mathit{3.15'' \ w.c.}}$ Where: TSP_{base}: Design Fan Total Static Pressure (4.5" w.c.) TSP_{inlet}: Static Pressure at Terminal Mixing Boxes / Dampers (1" w.c.) CFM_{post}: Post Project Supply Air CFM (96,837) CFM_{base}: Base Supply Air CFM (124,000)

[80] UC-CSU-IOU_UCI_Retrofit__3_Review_SCE.doc

Program Measure Number	Algorithm

The annual unoccupied periods for the affected teaching laboratories was assumed to be 7,200 hours. The overall fan savings attributed to reducing the ACH of unoccupied teaching laboratories was calculated to be:

$\Delta kWh_{fans} = (CFM_{base} \times TSP_{base} - CFM_{post} \times TSP_{post}) \div (6{,}356 \times Fan_{eff}) \times (1 + Belt_{loss}) \div Motor_{eff} \times 0.7457 \times Hrs =$ *340,011 kWh*

Chiller/boiler plant energy use was assumed to be reduced due to the decrease in conditioned air flow demand to Steinhaus Hall. The following system assumptions were used to estimate kWh and Therm savings for this project:

- 55 F Supply Air Temperature
- Average Annual OSA Cooling Temperature of 65.5 F[81] for 5,600 Hours During Unoccupied Teaching Lab Hours
- OSA Cooling Occurs Above 53 F to Account for 2 F Temperature Rise by Fan/Motor Heat
- Average Annual OSA Heating Temperature of 44 F for 1,600 Hours During Unoccupied Teaching Lab Hours
- 70% of Total Supply Air is Cooled by Cooling Coil
- 30% of Supply Air is Heated by Heating Coil

$\Delta kWh_{chiller} = 1.1 \times (CFM_{base} - CFM_{post}) \times (OSA_{cool} - OSA_{cooling}) \times 4 \div 3 \div 12{,}000 \times Chiller_{eff} \times Hrs \times 70\% =$ *123,955 kWh*

Where:

CFM_{base}: Base Supply Air CFM (124,000)
CFM_{post}: Post Project Supply Air CFM (96,837)
OSA_{cool}: Average annual OSA Cooling Temperature (65.5 F)
$OSA_{cooling}$: Temperature at which OSA is Cooled Accounting for Temperature Rise by Fan/Motor Heat (53 F)
$Chiller_{eff}$: Chiller Efficiency (0.55 kW/Ton)
Hrs: Average Annual OSA Cooling Hours During Unoccupied Teaching Lab Hours (5,600)

[81] Trace 700 Program

Program Measure Number	Algorithm
	$\Delta Therms_{boiler} = 1.1 \times (CFM_{base} - CFM_{post}) \times (Coil_{heating} – OSA_{heating}) \div 1{,}000 \div Boiler_{eff} \times Hours \div 100 \times 30\%$ = *26,347 Therms*[82] Where: CFM_{base}: Base Supply Air CFM (124,000) CFM_{post}: Post Project Supply Air CFM (96,837) $Coil_{heating}$: Temperature of Air Leaving Heating Coil (100 F) $OSA_{heating}$: Average Annual OSA Heating Temperature (44 F) $Boiler_{eff}$: Boiler Efficiency (80%) Hours: Average Annual OSA Heating Hours During Unoccupied Teaching Lab Hours (1,600)

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Option B will be used for evaluation purposes.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach in both the pre- and post-retrofit case involve end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO). According to the facility staff, the building is separately metered and EMCS system is capable of providing trend logs.

Evaluation Measure Number	Algorithm
M1	Energy savings attributed to the reduction of ACH in unoccupied teaching laboratories will be realized in two areas: • A reduction in total supply and exhaust fan energy consumption due to reduced load. • A reduction in chiller/boiler plant energy consumption due to the reduced conditioned air load to Steinhaus Hall. To evaluate these savings, energy analysis simulations were prepared using the eQuest (DOE 2) energy analysis model, using field verified data, EMCS trend log data, and information from any commissioning/TAB reports. The as-built building operation will

[82] A multiplication error was made in the *ex-ante* savings algorithm which resulted in higher than expected savings. The corrected savings estimate should be *10,039 Therms*

Evaluation Measure Number	Algorithm
	be benchmarked against the building metered data obtained from the facility along with field verified equipment operation and schedules. The class room schedules will then be set-back to reflect the baseline periods to assess the baseline operations. The energy savings for the measure will then be the drop of consumption from the baseline to as-built consumption..

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation used the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for Irvine for the period between 23rd September to 25 september 1991 as defined by the CPUC evaluation protocol for CEC climate zone 8

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**28. Spot Measure Fan Power** with hand-held Fluke 43B at the motor control center. **29. Trend Fan Power** with Dent Instruments Elite Pro electric power loggers at the motor control center to measure true RMS kW of fan motors at 15-minute intervals (if needed to confirm EMCS trending data). **30. Collect VFD Performance Characteristics** from the University Facilities – Energy Management Office (if possible). **31. Measure Static Pressure** with Fluke 922 Airflow Meter. **32. Collect Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter and confirm temperature readings are consistent with campus EMCS logs **33. Collect NOAA weather data for Irvine** from the National Climatic data Center (NCDC) web site ADM has obtained subscription for the weather station data and will use it to recompile the binary weather data to be used for calibrating the simulation with building level monitored data by the facility. **34. Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office. Also collect the zone occupancy level inputs and fractional flow rate registered by the EMCS for set period of time. **35.**

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Quality Assurance Procedures

The standard QA procedures in Appendix D of the *RCx Evaluation Handbook* were followed.

MEASUREMENT AND VERIFICATION RESULTS

An eQuest model was built based upon an onsite audit of the building and interviews with the facility staff. The model itself was calibrated to the building's metered energy use.

This site implemented a VFD on supply fan motors. Concurrently they installed a VAV box in several of their teaching Laboratories. This enabled reduction in the ventilation requirements for those zones during periods of non-occupancy. The rest of the distribution system remained a constant volume system. Thus the savings are constrained by the number of teaching laboratories on which VAV boxes were installed. Simulated and IOU reported savings compared as follows:

	Therms	**kWh**	**Peak kW**
Ex Ante Savings	26,347	406,358	0.0
Ex Post Savings	29,437	338,765	0.0
Realization Rate	112%	83%	N/A

The savings developed through the eQuest calculations are slightly less than the electric savings claimed in the IOU tracking database. The original calculations underlying the IOU reported savings were bin calculations. The difference in the M&V calculations compared to the approved energy savings could be due to differences in building assumed baseline operational parameters. The bin calculations make certain assumptions about chiller plant efficiency and run time, whereas the eQest simulation analysis has been calibrated to the building's hourly metered usage and determines chiller plant efficiency based upon current demand.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

COMPUTER MONITOR REPLACEMENT – UC-IRVINE

July 23rd, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	232
Company Name	University of California – Irvine
Site Name	Campus Wide
Site Address	201A Interim Office Building, Irvine, CA 92696-5444
Site Type	Campus Wide
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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ASSIGNED LEAD ENGINEER

Name	Mike Yim

AUTHOR

Name	Mike Yim

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	Computer Labs	LCD Monitors	Replace 1,000 CRT Monitors with LCD Monitors

The final installation report and subsequent SCE project work paper[83] revealed that only 470 of the projected CRT replacements took place through the project. This was later confirmed through on-site observations and a thorough review of customer invoices. The reduced installation count was accounted for in the annual measure savings estimates listed in Table 44 below:

2.2. Annual Measure Savings[84]

Table 15. Annual Measure Savings Estimates

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	19,740	1.41	-	-	-	100%

The *ex-ante* savings estimates were developed through the Energy Star Calculator.[85]

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

[83] WPSCREOE0001 0 - Residential LCD Monitors.doc

[84] FormC1_UCI.xls_PCPowerandLCDs.xls

[85] http://www.energystar.gov/

2.6. Pre-Installation Equipment and Operation[86]

Program Measure Number	Equipment and Operation – Pre-installation
M1	470 17" CRT monitors

2.7. As-Built Equipment and Operation[87]

Measure characteristics for the system retrofits were drawn from the most recent project review file and documented savings calculations developed by UCI.

Program Measure Number	Equipment and Operation – As-Built
M1	470 17" CRT monitors with 470 17" and 19" LCD monitors.

2.8. Seasonal Variability in Schedule and Production

The campus computer labs are operable throughout the entire year. Effects of a '9-month academic calendar' are small given year-round classes and computer lab activity. The best time to collect M&V data would be when the monitors are active. Consequently, nearly any time of year would be suitable for collecting data.

[86] FormC1_UCI.xls_PCPowerandLCDs.xls

[87] UC -CSU-IOU_UCI_Retrofit__11_Post_Install_Rpt.doc

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

The campus' approach to estimating *ex-ante* savings are provided below.

Program Measure Number	Algorithm[88]
M1	The annual energy use in each mode was calculated by multiplying the demand of each mode by the annual number of hours in each mode. The savings were calculated by subtracting the measure energy use from each base case energy use. This value was then multiplied by the base case market share percentages to determine the weighted energy savings for each type of monitor upgrade. Adding all of these together gives the weighted savings per monitor. Multiplying this value by the energy interactive effects yielded the total energy savings per monitor.

Ex-Ante Computer Monitor Savings Analysis Parameters

	Monitor Type	Annual Gross Electricity (kWh/yr) Active Mode	Annual Gross Electricity (kWh/yr) Sleep Mode	Annual Gross Electricity (kWh/yr) Off Mode	Total	Energy Savings (kWh/yr)	Base Case Market Share	Weighted Energy Savings (kWh/yr)
Base Case	CRT	208.0	6.7	1.9	217	154	1.8%	3
Base Case	Non-Energy Star LCD	108.3	4.7	3.7	117	54	39.2%	21
Base Case	Energy Star LCD – Tier 2	82.2	2.6	2.2	87	25	59.0%	15
Measure	Energy Star LCD – Tier 2 + 25%	58.1	2.3	1.9	62	0	-	0
Weighted Per Unit Savings								39
Energy Interactive Effects Factor								1.084
Tot./Unit Savings With Interactive Effects								42

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Options A and B will be used for the evaluation depending on equipment accessibility.

[88] UC-CSU-IOU_UCI_Retrofit__3_Review_SCE.doc

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in the post-retrofit case involves spot measurements to confirm power consumption and observations of computer power management settings to confirm *baseline* operating characteristics.

Evaluation Measure Number	Algorithm
M1	We propose to use spot measurements of monitor power and aggregated load shapes by weekday/weekend to evaluation project level savings. However, the Non-Residential Retrofit – Demand Response Procedures Manual[89] disqualifies technologies that are not permanently installed and can be easily removed (e.g., monitor operating settings). As such, Monitor operating characteristics will remain constant in the pre- and post-installation savings calculations. More specifically, the evaluation team intends to make the base and post-installation model more robust by spot measurements of monitor power and end-use metering of computer power management settings to confirm system operating characteristics. Load profiles of monitor operating characteristics will be developed using the aggregated energy consumption of the monitors in weekday and weekend hourly bins: **<u>Aggregated Monitor Operating Profile for Period *i*</u>** $\sum_i [(\text{Logger}_W) \div \sum(\text{Max}_W)]$ Where: Logger_W: Average Aggregated Logger Wattage in Period *i* Max_W: Maximum Aggregated Logger Wattage Project level savings will be calculated by accounting for the incremental wattage differences between the pre- and post-installation monitors: **<u>Aggregated Monitor Savings</u>** $\sum_s [N^*(\text{Monitor}_{pre,s} - \text{Monitor}_{post,s}) \text{ x } \text{Period}_s]$ Where: $\text{Monitor}_{pre,i}$: Aggregate Base Monitor Wattage in State *s* $\text{Monitor}_{post,s}$: Aggregate Retrofit Monitor Wattage in State *s* Period_s: Hours per Year that the Monitors are in State *s*

89 *2008 Nonresidential Retrofit - Demand Response (NRR-DR) Procedures Manual*, Pacific Gas and Electric Company, July 1st, 2008

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM, during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**36. Spot Measure Monitor Power** with the Watts Up Pro[90] and hand-held Fluke 345 with 50-wrap coil to minimize measurement error with small wattages. **37. Characterize Monitor Operating Characteristics** with the Watts Up Pro on a sample of retrofit monitors over a period of one month.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	Per the evaluation protocols,[91] the target relative precision is 90/20 at the monitor level. If the evaluation team can confirm that all monitors are of the same model, a smaller sample will be spot measured.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

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90 https://www.wattsupmeters.com/secure/products.php

91 *California Energy Efficiency Evaluation Protocols: Technical Methodological, and Reporting Requirements for Evaluation Professionals*, The TecMarket Works Team, April 2006.

4.5. **Uncertainties**

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1 Our ability to obtain access to the retrofit monitors.

4.6. **Data Products**

The following data products will be produced during the evaluation:

- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. **Data Reporting Formats**

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. **Building Characteristics Data**

Whenever possible, we will collect building characteristics[92] data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations.

4.9. **Supporting Data for this Plan**

All files referenced in this plan are attached.

[92] Contextual Data v3.doc

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurement and logging of retrofit monitors during September 2009. In-depth interviews with campus/project staff revealed that the project replacements were not limited to 17" LCD monitors. Rather, 17" CRT monitors were replaced with 17" – 19" LCD monitors. Project invoices and receipts were requested to develop an estimate of the distribution of monitors purchased. These receipts were also used to adjust the total number of monitors replaced through this project relative to *ex-ante* claims.

Per the, M&V plan, the target relative precision was 90/20 at the monitor spot measurement and end-use metering level. A total of 30 monitors were spot measured and metered for a period of one month using the Fluke 345 and Watts Up Pro data loggers. Spot measurements were taken during the "Active" and "Sleeping" modes for each monitor to support the calculation of energy and peak demand savings. A number of 17" CRT monitors were also identified and spot measured to confirm baseline assumptions.

The on-site spot measurements were calibrated against manufacturer data to ensure consistency in the analysis process.

5.2. Analysis

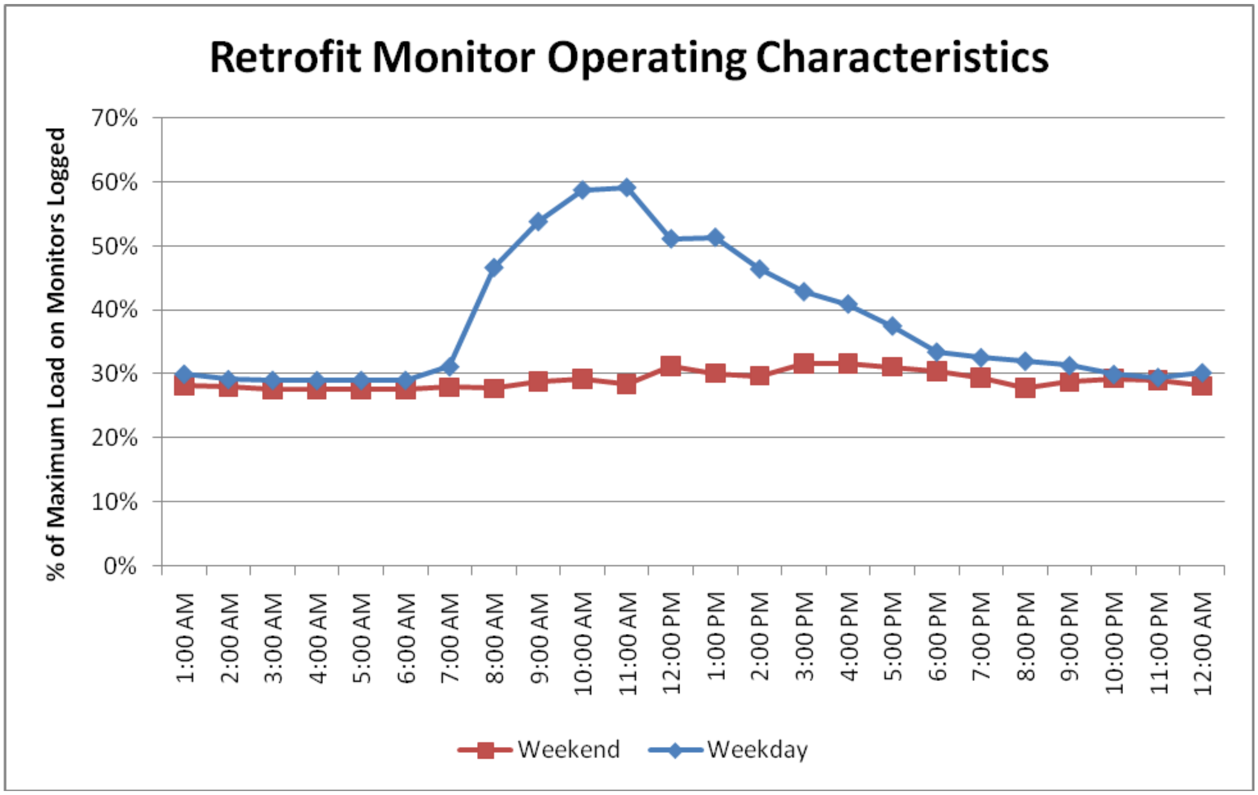
Spot measurements were compared against manufacturer power consumption ratings and deemed representative. Table 45 provides information consumption data on the monitors observed on-site:

Table 16. Retrofit Monitor Spot Measurements Readings

Model	Size (")	Active (W)	Sleep (W)
Dell 1708FPB	17	20	1
Dell 1907FPC	19	34	1
Samsung 943BX	19	34	1
Samsung 940BX	19	38	1
Dell 1908FPC	19	24	1
Dell 1707FPC	17	32	1

Logger data was compiled and used to develop hourly load shapes for the weekday and weekend bins. And because the retrofit monitors were generally installed in areas that were independent of the academic calendar (e.g., research laboratories and office space), it was not deemed necessary to disaggregate operating periods further. Figure 26 details the load profile developed through this analysis:

Figure 26. Retrofit Monitor Operating Characteristics



Per the *ex-ante* algorithm, savings were calculated as the difference in power consumption over a one year timeframe between the base and retrofit monitors.

5.3. **M&V results**

Results of the M&V analysis are shown in Table 47. The difference between the *ex-ante* and *ex-post* are attributed to the following factors:

1.) The *ex-ante* monitor savings analysis assumes a normal replacement baseline, while the project is classified as retrofit. This served to increase project realized savings:

"The energy savings is much larger if the retrofit case is included because the base case becomes the installed monitor base instead of the market share."[93]

2.) Monitor replacements were not limited to 17" LCDs. This served to increase the average retrofit monitor power consumption and reduced savings.

3.) The *ex-ante* monitor operating hour assumptions were smaller than the *ex-post* logger findings. This served to increase savings.

[93] WPSCREOE0001 0 - Residential LCD Monitors.doc

Table 17. UCI Monitor Retrofit Savings

Retrofit CRT with LCD Monitors			
	Therms	**kWh**	**Peak kW**
Ex-Ante Savings Assumptions	0	19,740	1.41
Ex-Post Verified Savings	0	77,189	10
Realization Rate	N/A	391%	709%

MEASUREMENT AND VERIFICATION SITE REPORT

MCGAUGH HALL – REPLACE FANS AND INSTALL VFDS – UC-IRVINE

November 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	SCE #4
Company Name	University of California – Irvine
Site Name	McGaugh Hall
Site Address	201A Interim Office Building, Irvine, CA 92696-5444
Site Type	Lab / Plant Sciences
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Mike Yim

AUTHOR

Name	Mike Yim

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for the 56 programs in this group.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrocommissioning measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for selected air handling units, based on measurements.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	CAV Systems	AHU Fan Replacements and VFDs	Replace six, belt-driven, vane axial fans with direct drive mixed flow fans in AHU 1 and 3. Install VFDs on replacement fans.

2.2. Annual Measure Savings[94]

Table 18. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	1,685,501	-	-	21,761	-	100%

This project involved the replacement six, belt-driven, vane axial fans with direct drive mixed flow fans in two air handling units in McGaugh Hall at the University of California, Irvine. Existing fan motors were also be equipped with variable frequency drives. Other measures included the removal of sound attenuators to decrease pressure drop through the duct, and the replacement of cooling coils, back draft dampers, and control valves. However, because these measures were considered maintenance/repair projects, savings due to the replacement of cooling coils, back draft dampers, and control valves were not included in the incentive calculations.

The accepted savings estimates were submitted by the campus commissioned consultant, Goss Engineering, Inc. (GEI).

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

[94] FormB_UCI_McGaughFans1.xls

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

2.6. Pre-Installation Equipment and Operation[95]

Program Measure Number	Equipment and Operation – Pre-installation
M1	McGaugh Hall is a 214,000 square-foot research laboratory building. This "B occupancy" building houses a vivarium, laboratories, and some offices. McGaugh Hall is served by three built-up, 100% outside air (OSA), draw-through AHUs: AHU-1, AHU-2, and AHU-3. AHU-2, which serves the vivarium, is presently being retrofitted as part of another project and is not part of this proposed scope of work. AHU-1 has three vane-axial fans for a combined airflow capacity of 120,000 Cubic Feet Per Minute (CFM) and AHU-3 also has three vane-axial fans at a combined capacity of 180,000 CFM. The existing HVAC system was designed and installed as a variable-air-volume (VAV) system, but in practice the fans operate more as a constant volume system. Building variable supply and exhaust air volume is designed to be achieved by adjusting the supply fan blade pitch and exhaust fan inlet vanes while the fans run at a constant speed. In short, the VAV Boxes modulate, while the fans do not and ride the curve. The existing built-up AHUs use vane-axial fans with variable pitch blades that require extensive periodic maintenance (weekly, monthly, quarterly, etc.), which can only be performed during a shutdown. As McGaugh Hall is a 24-hour-per-day, seven-days-per-week operating building, proper maintenance is problematic. The existing supply fans are noisy and sound traps were installed at the AHU inlets and outlets to attenuate the sound. The condensate drip pans and cooling coil frames are badly rusted. The condensate is currently flooding inside the AHU resulting in rusting at the AHU casing.

2.7. As-Built Equipment and Operation

Measure characteristics for the belt-driven, vane axial fans, direct drive mixed flow fans, and installed VFDs were drawn from the most recent project review file[96] and documented savings calculations submitted by GEI[97].

[95] Final_Report.doc

Program Measure Number	Equipment and Operation – As-Built
M1	This project installed the following incentivized measures: 3. **Replace Six Existing Belt-Driven Vane Axial Fans with New Direct-Drive Mixed Flow Fans:** The direct-drive mixed flow fans eliminate the permanent energy loss from belt drives. 4. **Add Variable Frequency Drive (VFD) Controls for the New Fans:** Installed VFDs reduces fan speed when less air is required. During a typical year, the fans are expected to operate at lower speeds to meet reduced demand loads. However, Summit Blue recognizes that the efficiency gain from the new direct-drive mixed flow fans may be offset to some degree by the efficiency loss from the VFD. We will investigate this relationship through the evaluation effort.

2.8. Seasonal Variability in Schedule and Production

McGaugh Hall's HVAC equipment operates 8,760 hours per year. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a "9-month academic calendar" are small given year-round classes and lab research at the Hall.

[96] UC-CSU-IOU_UCI_Retrofit__4_Review_SCE.doc

[97] McGaugh_Hall_Energy_Savings_Calculation.xls

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the direct-drive mixed flow fans and installed VFDs were developed by GEI. Their approach to estimating *ex-ante* savings are below.

Evaluation Measure Number	Algorithm
M1	The project expected savings to be realized in two areas: 3. Energy (kWh) savings from a reduction in fan motor energy use 4. Energy (kWh & Therms) savings from a reduction in chiller/boiler plant energy use The following baseline conditions were assumed were drawn from design specifications: to be the following: • 255,000 CFM average supply air • Peak total static pressure of 7” w.c., average total static pressure of 5.25” • Peak fan efficiency of 71% • Belt loss of 3% • Motor efficiency of 95% Summit Blue recognizes that the peak fan efficiency estimates may not include the impact loss of the vane-axial fans. As part of the evaluation effort, we will collect fan curve specification sheets on-site and verify/adjust the assumptions made. The *ex-ante* savings analysis also made the following assumptions regarding VFD operating schedules:

% of Operating Hours	% Capacity
5%	100%
10%	90%
15%	80%
20%	70%
50%	60%
Weighted Average Fan Operation	70%

Post-installation average total static pressure was calculated considering that average air flow is lower than rated capacity. The total static pressure at typical air flow was assumed to be 5.0”. The static pressure at the VAV box valve inlet was assumed to be constant at 1.0”.

Evaluation Measure Number	Algorithm

Average Total Static Pressure Post Installation = $TSP_{VAV} \times Fan_{op}^2 \times (TSP_{pre} - TSP_{VAV})$ = *3.0"*

Where:

TSP_{VAV}: Total Static Pressure at the VAV Box Valve Inlet (1.0")
Fan_{op}: Weighted Average Fan Operation with VFD (70%)
TSP_{pre}: Base Total Static Pressure at Typical Air Flow (5.0")

Overall fan energy use was calculated as a percentage of the energy use at baseline design conditions:

Average Post Installation Fan Power Consumption = $Fan_{op} \times (TSP_{post} \div TSP_{pre})$ = *42%*

Where:

TSP_{post} = Average Total Static Pressure Post Installation

These calculations were used to develop a set of design conditions for the post-retrofit system:

- 178,500 CFM average supply air (70% of baseline average CFM)
- Average total static pressure of 3.0"
- Peak fan efficiency of 68%
- Belt loss of 0% (due to conversion to direct drive)
- Motor efficiency of 95%
- Average fan power consumption of 42% (of baseline consumption)

Power use of the existing/proposed systems were calculated through the following equation:

$$\Delta\ kWh = CFM_{base} \times Pressure_{base} \div (6{,}356 \times Fan_{eff} \times Motor_{eff}) \times (1 + Belt_{loss}) \times 0.7457 \times Hrs_{base} \times (1 - Fan_{\%})$$

= *1,249,119 kWh*

Evaluation Measure Number	Algorithm

Where:

CFM_{base}: Base Cubic Feet Per Minute Air Flow under Design Conditions
$Pressure_{base}$: Design Fan Total Static Pressure (5.25")
Fan_{eff}: Fan Efficiency (71%)
$Motor_{eff}$: Motor Efficiency (95%)
Hrs_{base}: Hours of Fan Use in the Base Case (8,760)
$Fan_{\%}$ = Average Post Installation Fan Power Consumption (42%)

Chiller and boiler plant energy use was assumed to be reduced due to the decrease in conditioned air flow demand to McGaugh Hall. Savings were based on an average 30% decrease in cooling/heating loads. The following system assumptions were used to estimate kWh and Therm savings to this project:

- 55 F Supply Air Temperature
- Average annual OSA cooling temperature of 65.5 F[98] for 6,810 hours
- OSA cooling above 53 F to Account for 2 F Temperature Rise by Fan/Motor Heat
- Average annual OSA heating temperature of 44.4 F for 1,950 hours

$\Delta kWh_{chiller} = 1.1 \times \Delta CFM \times (OSA_{cool} - OSA_{cooling}) \times 4 \div 3 \div 12{,}000 \times Chiller_{eff} \times Hrs =$ *436,382 kWh*

Where:

ΔCFM: Cubic Feet Per Minute Air Flow under Design Conditions in the Pre/Post Case
OSA_{cool}: Average annual OSA Cooling Temperature (65.5 F)
$OSA_{cooling}$: Temperature at which OSA is Cooled Accounting for Temperature Rise by Fan/Motor Heat (53 F)
$Chiller_{eff}$: Chiller Efficiency (0.55 kW/Ton)
Hrs: Average Annual OSA Cooling Hours (6,810)

$\Delta Therms_{boiler} = 1.1 \times \Delta CFM \times (Supply_{temp} - OSA_{heating}) \div 1{,}000 \div Boiler_{eff} \times Hours \div 100 =$ *21,761 Therms*

[98] Trace 700 Program

Evaluation Measure Number	Algorithm
	Where: $Supply_{temp}$: Supply Air Temperature (55 F) $OSA_{heating}$: Average Annual OSA Heating Temperature (44.4 F) $Boiler_{eff}$: Boiler Efficiency (80%) Hours: Average Annual OSA Heating Hours (1,950)

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option D, Calibrated Simulation was used for the evaluation.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in both the pre- and post-retrofit case involved used simulation analysis with the eQuest model. According to the facility staff, the building is separately metered and EMCS system is capable of providing trend logs.

Evaluation Measure Number	Algorithm
M1	The proposed evaluation approach will seek to visually verify affected system components, including: • Replacement of six, belt-driven, vane axial fans with direct drive mixed flow centrifugal fans in AHU 1 and 3. • Installation of VFDs on as-built centrifugal fans. • Campus chiller/boiler systems and efficiencies through discussions with facility engineers. • Building occupancy rates, class schedules and temperature set points through discussions with facility staff • Trend log of Zone level occupancy input to the EMCS system, fractional flow adjustment as output by the EMS system. The evaluation used eQuest (DOE 2) simulations with adjustments to account for the system operating static pressure characteristics as a basis for developing project level savings. The baseline characteristics were modeled with the axial-vane fan option in eQuest and for as-built operation with VFD driven centrifugal fan characteristics. Option to include the additional pressure losses in baseline operation for the attenuators will be tested by adjusting the system static head loss in the input section. Else, the ventilation energy consumption will be recalculated to include the account for the power draw for the additional attenuators pressure losses. Field measurement and/or EMCS logs for the VAV system static pressure loss, minimum flow fraction, and zone level occupancy feedback to EMCS will provide better assessment of the necessary eQuest input parameters.

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation used the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for Irvine for the period between 23rd September to 25 september 1991 as defined by the CPUC evaluation protocol for CEC climate zone 8.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**38. Spot Measure Fan Power** with hand-held Fluke 43B at the motor control center. **39. Trend Fan Power** with Dent Instruments Elite Pro electric power loggers at the motor control center to measure true RMS kW of fan motors at 15-minute intervals (if needed to confirm EMCS trending data). **40. Collect Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter and confirm temperature readings are consistent with campus EMCS logs. **41. Measure Static Pressure** with Fluke 922 Airflow Meter. **42. Collect NOAA weather data for Irvine** from the National Climatic data Center (NCDC) web site ADM has obtained subscription for the weather station data and will use it to recompile the binary weather data to be used for calibrating the simulation with building level monitored data by the facility. **43. Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office. Also collect the zone occupancy level inputs and fractional flow rate registered by the EMCS. **44. Collect VFD Performance Characteristics** from the University Facilities – Energy Management Office.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation was based on a census of affected equipment.

4.3. Quality Assurance Procedures

The standard QA procedures in Appendix D of the *RCx Evaluation Handbook* were followed.

MEASUREMENT AND VERIFICATION RESULTS

This site implemented a VFD on supply fans serving laboratories. Concurrently the supply fan drives were switched from belt driven to direct drive. Because the removal of the sound attenuators was a repair, as opposed to an energy efficiency measure, their removal was not taken into account in the evaluation's savings. Despite the evaluations requests, facility billing data was never provided. Subsequently the eQuest model's calibration was constrained to a comparison between its energy usage and that of another building of the same functional type. Since no such building type is a part of the California End Use Survey (CEUS), the evaluation compared his model's annual kWh per square-foot to another building of the same type which was part of a different campus in a similar climate zone.

The eQuest model was built based upon an onsite audit of the building and interviews with the facility staff. Care was taken to represent the schedule as it changes across the academic calendar. Since this building is used primarily for research, its schedules are not as affected by the academic calendar as other buildings on the campus. The building's energy usage (per square foot) was calibrated to within 10% of that used by Tupper Hall on the UC Davis Campus.[99] Of particular importance to the savings are the fan curves and efficiencies used in the simulation. The evaluation used the curve titled "Vane Axial w Var Pitch FPLR" for the baseline fan curve and then the curve titled "Variable Speed Drive FPLR" for the as-built model. The fan mechanical efficiency was increased by 3% because of the transition from belt driven fans to direct drive fans. And finally, the static pressure remained the same as the pre-existing; namely 5.25 inches of water column. The calculated savings based on the results of the eQuest simulation analysis were compared to IOU claimed kWh savings.

Two factors led to the low realization rate. The first, and foremost, is that the IOU calculations assumed that there was a reduction in the building's airflow from 255,000 CFM to 178,500 CFM. However, during the evaluation's onsite visit it was confirmed that there was no reduction in the facility's airflow. The second factor leading to a low realization rate was that the IOU calculations included the effects of the sound attenuator removal. Since the attenuator removal is a repair, as opposed to an energy efficiency upgrade, the evaluation did not take into account its effects. The evaluation's final energy savings are presented below:

	Therms	**kWh**	**Peak kW**
Ex Ante Savings	21,761	1,685,501	0.0
Ex Post Savings	0	35,355	6.39
Realization Rate	0%	2%	N/A

[99] A building for which the evaluation had energy bills and was able to perform a detailed calibration at an hourly resolution.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

MSB FUME HOOD CONVERSION PROJECT – UC LOS ANGELES

December 30th, 2008

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	
Company Name	University of California – Los Angeles
Site Name	MSB
Site Address	731 Charles E. Young Drive South, Los Angeles, CA 90095-1526
Site Type	Lab / Plant Sciences
Company Business/Product	University / Education

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Name	Mike Yim

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Name	Mike Yim

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	Fume Hoods	Convert Fume Hoods to Adaptive Face Velocity (AFV) Using Zone Presence Sensors	Upgrade fume hood vent & controls. Install zone presence sensors on 220 fume hoods.

2.2. Annual Measure Savings[100]

Table 19. Annual Measure Savings

Project Measure Number	Electric		Gas		% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating	
M1				189,642	100%

The estimated savings were submitted by the campus project manager, Robert Striff, on May 29, 2007. Supporting calculations were developed by Twining Laboratories and submitted on May 30, 2007[101].

UCLA's central plant characteristics include:

- **Cogeneration:** All the campus steam and chilled water is provided by the central cogeneration plant. Chilled water is produced through absorption chillers, steam driven chillers and some minimal electric chiller capacity. About 80% of the campus electric is supplied by the cogeneration plant. Discussions with facility staff revealed that the cogeneration plant does not have the capacity to meet campus electric needs – power is continuously purchased.
- **Thermal energy storage:** The campus has a TES system, which is part of the central cogeneration plant. Most chilled water is provided by absorption or steam driven chiller equipment. The demand saving effect on this analysis is not relevant, since the small electric chiller in the cogeneration plant is powered by on-site produced electricity.

It should be noted that electric power is purchased through the Los Angeles Department of Water and Power[102] (LADWP). As such, purchased electric savings do not accrue to the program.

[100] Form_B_-_MSB_052907.xls

[101] MSB_Backup_Calcs.pdf

[102] http://www.ladwp.com/ladwp/homepage.jsp

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

2.5. Sample Type

This project came from the Comprehensive *UC/CSU Evaluation Sample*, and as such, was selected *after* the project was completed.

2.6. Pre-Installation Equipment and Operation

Program Measure Number	Equipment and Operation – Pre-installation
M1	UCLA's Medical Science Building (MSB) contains approximately 290 fume hoods – 60 of which are in empty rooms or under construction.[103] The average maximum CFM for existing fume hoods was assumed to be 1,250. An average of 1.1/26 fume hoods were assumed to be operating at any given time. Fume hood sashes were assumed to be left wide open. Base fume hoods were classified as bypass systems with constant stack velocity.

2.7. As-Built Equipment and Operation

Measure characteristics of UCLA's Fume Hood Conversion Project were drawn from the most recent application file[104] and the saving calculations submitted by Twining Laboratories.[105]

Program Measure Number	Equipment and Operation – As-Built
M1	This project converted a total of 220 fume hoods to AFV by installing zone presence sensors to control fume hood vent and controls. The project was completed in two phases: 1. 26 Fume Hoods Converted to AFV 2. 194 Fume Hoods Converted to AFV

[103] http://ehs.ucla.edu/Pub/Fall08_FumeHoodResults.pdf

[104] Form_B_-_MSB_052907.xls

[105] MSB_Backup_Calcs.pdf

2.8. Seasonal Variability in Schedule and Production

The Medical Science Building's HVAC equipment operates 8,760 hours per year. The heating and cooling loads for the facility vary mostly with the seasons. Effects of a '9-month academic calendar' are small given year-round classes and lab research at the Hall.

The best time to collect M&V data would be when the formerly constant volume system is active. Consequently, nearly any time of year would be suitable for collecting data.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the Fume Hood Conversion Project were developed by Twining Laboratories. The approach to estimating *ex-ante* savings are provided below.

The Medical Sciences Buildings is a 100% OSA terminal reheat system. Upon closer inspection of the project documentation files, it appears that supply fan savings are not claimed for this retrofit. Rather, the savings are derived from a reduction in exhaust fan power and the energy required to cool and reheat the discharge air.

Program Measure Number	Algorithm
M1	***Phase 1*** Average Fume Hood Maximum CFM: 1,250 CFM Average Fume Hoods in Use: 1.1 out of 26 Sash Position: Always Open Base CFM: 12,250 CFM × 26 Fume Hoods = 32,500 CFM Post-Project CFM: (1.1 Users × 1,250 CFM) + (24.9 Non-Users × 750 CFM) 20,050 CFM **Δ Therms = Σ_p [1.08 × ΔCFM × ΔT_p × Hrs_p] × 1.25 = *22,410 Therms*** Where: • 1.08: Conversion Factor • ΔCFM: Exhaust Air Flow Volume Differential Pre/Post Project Implementation (32,500/20,050) • ΔT_p: Temperature Differential Between OSA Temperature and Discharge Air Temperature and Between Discharge Air Temperature and Reheat Air Temperature in Seasonal Period "P" • Hrs_p: Hours in Seasonal Period "P" • 1.25: 25% Cogen Losses Due to Equipment Efficiency and Transmission Losses

Program Measure Number	Algorithm
	Phase 2 Average Fume Hood Maximum CFM: 1,250 CFM Average Fume Hoods in Use: 8.2 ((1.1 ÷ 26) × 194) Sash Position: Always Open Base CFM: 12,250 CFM × 194 Fume Hoods = 242,500 CFM Post-Project CFM: (8.2 Users × 1,250 CFM) + (185.8 Non-Users × 750 CFM) 149,600 CFM **Δ Therms = Σ_p [1.08 × ΔCFM × ΔT_p × Hrs_p] × 1.25 = *167,232 Therms/Yr*** Where: • 1.08: Conversion Factor • ΔCFM: Exhaust Air Flow Volume Differential Pre/Post Project Implementation (242,500/149,600) • ΔT_p: Temperature Differential Between OSA Temperature and Discharge Air Temperature and Between Discharge Air Temperature and Reheat Air Temperature in Seasonal Period "P" • Hrs_p: Hours in Seasonal Period "P" • 1.25: 25% Cogen Losses Due to Equipment Efficiency and Transmission Losses

Discussions with facility staff revealed that although the supply fans were equipped with VFDs prior to the fume hood AFV retrofit, the building operated as a Constant Volume system because the fume hoods were Constant Volume exhaust. In the post-installation case, exhaust fans are controlled by VFDs and follow the supply fans.

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option A & B will be used for project evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed project evaluation approach involves spot measurements to confirm and calibrate consumption data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm
M1	The proposed evaluation approach will seek to visually verify affected system components, including: • 220 fume hoods equipped with operable zone presence sensors • All affected supply and exhaust fan motors • Pre/post-installation fan operating characteristics Where possible, the evaluation team will also verify the following *ex-ante* input assumptions: • BHP: BHP per Fan (10.2) • Motor Efficiencies (unspecified in the ex-ante algorithms) • Fan & Motor Nameplate Data • Hrs: Hours of Fan Operation (8,760) • CFM: Fume Hood Air Flow Pre/Post Project Implementation • ΔT_s: Temperature Differential Between OSA Temperature and Discharge Air Temperature • ΔT_t: Temperature Differential Between Discharge Air Temperature and Reheat Air Temperature • Percentage of Fume Hoods in Use: 4.23% (1.1 ÷ 26) The evaluation team has engaged support from the UCLA Program Manager and has begun trending system operating characteristics to support the *ex-post* savings analysis. The following parameters are being collected in 15-minute intervals for a period of two months: • Supply and Exhaust Fan Power (kW) • Supply and Exhaust Fan Volts (V) • Supply and Exhaust Fan Current (A) • Supply and Exhaust Fan VFD Run Speed (%) • OSA Temperature • Discharge Air Temperature • Supply Air Temperature Set points • Discharge Static Pressure • Discharge Static Pressure Set points Overall, the evaluation will make the pre- and post-installation models more robust by including data from on-going trending and by incorporating a bin temperature analysis on fan operating characteristics. More specifically, the *ex-post* savings will be calculated using the following equation:

Evaluation Measure Number	Algorithm
	ΔTherms = Σ_{AHU}[1.08 × ΔCFM × $\lvert\Delta T_{OSA\text{-}DT}\rvert$ × Eff ÷ 100,000] + **Σ_{REHEAT}[1.08 × ΔCFM × $\Delta T_{RHT\text{-}DT}$ × Eff ÷ 100,000]** Where: • ΔCFM: Supply Air Flow Volume Differential Pre/Post Project Implementation • $\lvert\Delta T_{OSA\text{-}DT}\rvert$: Absolute Value of Temperature Differential Between OSA Air Temperature and Discharge Air Temperature • $\Delta T_{RHT\text{-}DT}$: Value of Temperature Differential Between Lab Reheat Air Temperature and Discharge Air Temperature • Eff: For Cooling: (1 ÷ Cooling Efficiency) and For Heating: (1 ÷ Heating Efficiency) • 100,000: Conversion Factor for Btu →Therms

3.4. **Peak Demand Algorithms Used in the Evaluation**

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM, during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	The following parameters will be verified on-site to ensure that campus EMS readings are consistent and accurate: **45. Spot Measure Fan Power** with hand-held Fluke 43B at the motor control center and confirm power readings are consistent with campus EMCS logs. **46. Collect Temperature Data** with Fluke 971 Relative Humidity & Temperature Meter and confirm temperature readings are consistent with campus EMCS logs. **47. Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office. **48. Collect Cogeneration Plant Data** from facility staff to confirm plant efficiencies. **49. Collect Fan Performance Characteristics** from the University Facilities – Energy Management Office. Test & balance reports, along with mechanical detail schedules, will be requested. **50. Deploy Power Loggers** on a census of affected supply and exhaust fans, over a one-month period, to calibrate against EMS trend data. **51. Deploy Temperature Loggers** in a sample of affected labs to characterize reheat air temperature.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The spot measurements and power loggers will be deployed on a census of affected equipment. Per the evaluation protocols,[106] the target relative precision will be 90/20 when deploying temperature loggers to evaluate lab reheat air temperatures.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

[106] *California Energy Efficiency Evaluation Protocols: Technical Methodological, and Reporting Requirements for Evaluation Professionals*, The TecMarket Works Team, April 2006.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1 The accessibility of affected equipment for M&V efforts.

4.6. Data Products

The following data products will be produced during the evaluation:

- Building characteristics data
- Time-series data of affected equipment
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

We will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F) • Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

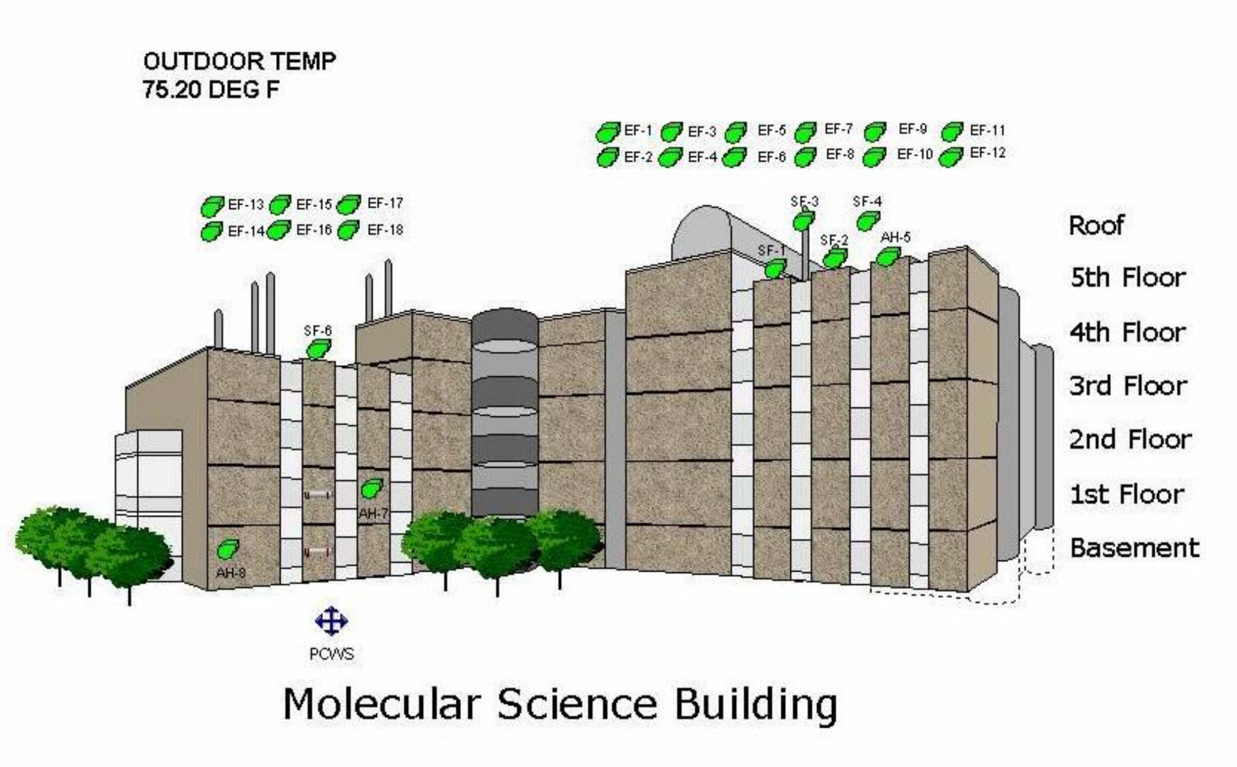
5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurement and logging of all affected supply and exhaust fans during September 2009. A visual verification of installed VFDs and AFV fume hoods was also completed during this process. In-depth interviews with facility staff were used to verify lab occupancy schedules and fume hood characteristics. Spot measurements were taken on all affected supply and exhaust fans. Dent Power loggers and HOBO current loggers were also deployed on all affected supply and exhaust fans for a period of one month. The collected data was compared against EMS trend data during the same time frame. While on-site, Summit Blue staff also deployed 10 temperature loggers within individual lab spaces to accurately quantify reheat terminal temperature.

The evaluation team also met with central plant staff and confirmed that approximately 80% of the campus electric load is supplied by the cogeneration plant and that power is continuously purchased. Campus heating and cooling loads are served by over 10 absorption and steam-driven chillers. The cogeneration plant staff was unable to disaggregate system loading patterns. As a proxy, design documents, process flow diagrams, and further discussion with plant staff were used to reliably estimate the average plant efficiency identified in the savings calculations.

Figure 27, below, provides a graphical representation of UCLA's Molecular Science Building. It should be noted that supply fans 1 through 4, along with exhaust fans 1 through 12, serve the fume hood retrofit spaces.

Figure 27. UCLA's Molecular Science Building and AHUs

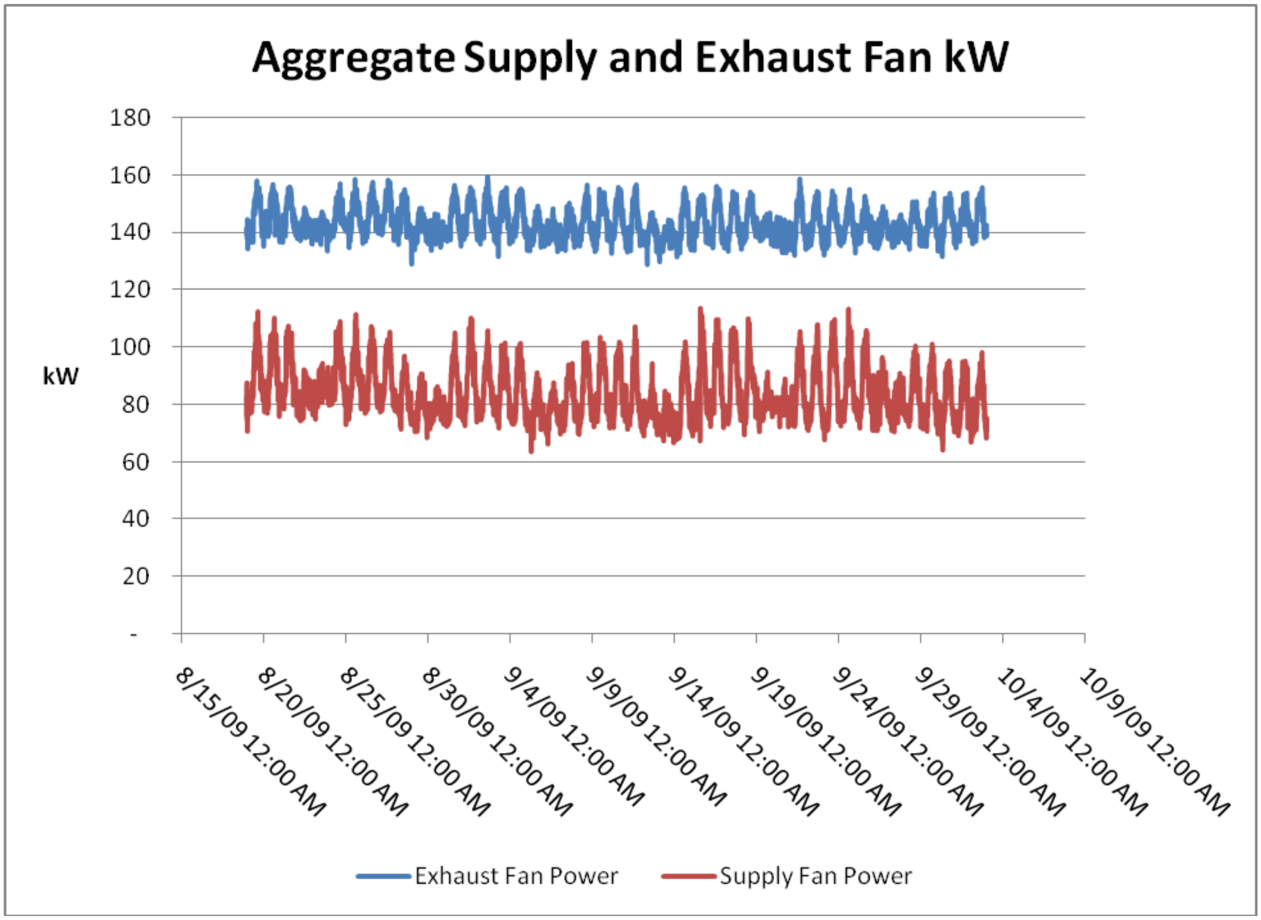


Evaluation staff visually confirmed the equipment schedules and building blue prints to verify that the EMS readings were consistent and maintained the mandated 6-8 ACH required of chemical labs. The documentation was also used to verify design CFM and supply/exhaust fan parameters (e.g., BHP, efficiency, FLA, etc.).

5.2. **Analysis**

EMS trend data collected over a two month period was calibrated against on-site spot measurements and logger findings. Overall, the EMS data was representative of the primary measurements taken and used to develop a bin model for annual savings using normalized Climate Zone data. Figure 28 provides a graphical representation of EMS trend data aggregated over the affected supply and exhaust fans:

Figure 28. EMS Trend Data on Affected Supply and Exhaust Fans



Aside from exhaust fans 1 and 3, the sensors that are used to control the exhaust fans do not appear to be functioning properly. In this case, the exhaust fans are running at high pressure and the VFDs are not reducing power consumption for a majority of the other exhaust fans.

Savings were calculated using the following equation:

$$\mathbf{\Delta Therms} = \Sigma_{AHU}[1.08 \times \Delta CFM \times |\Delta T_{OSA\text{-}DT}| \times Eff \div 100{,}000] + \Sigma_{REHEAT}[1.08 \times \Delta CFM \times \Delta T_{RHT\text{-}DT} \times Eff \div 100{,}000]$$

Where:

- ΔCFM: Supply Air Flow Volume Differential Pre/Post Project Implementation
- $|\Delta T_{OSA\text{-}DT}|$: Absolute Value of Temperature Differential Between OSA Air Temperature and Discharge Air Temperature
- $\Delta T_{RHT\text{-}DT}$: Value of Temperature Differential Between Lab Reheat Air Temperature and Discharge Air Temperature
- Eff: For Cooling: (1 ÷ Cooling Efficiency (55.6%)) and For Heating: (1 ÷ Heating Efficiency (82%))
- 100,000: Conversion Factor for Btu →Therms

5.3. **M&V results**

Results of the M&V analysis are shown in Table 50. The difference between the *ex-ante* and *ex-post* are attributed to the following factors:

4.) *Ex-post* weather data was normalized to the CA Climate Zone Data, which differed from the *ex-ante* temperature assumptions.

Table 20. UCLA Fume Hood Retrofit Savings

UCLA Fume Hood Retrofits			
	Therms	**kWh**	**Peak kW**
Ex-Ante Savings Assumptions	189,642	0	0
Ex-Post Verified Savings	156,281	0	0
Realization Rate	82%	N/A	N/A

MEASUREMENT AND VERIFICATION SITE REPORT

VARIABLE FREQUENCY DRIVES
SAN DIEGO STATE UNIVERSITY
STUDENT SERVICES WEST AND GATEWAY/KPBS

November 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#3
Company Name	San Diego State University
Site Name	Student Services West/KPBS/Gateway Building
Site Address	San Diego, California
Site Type	Campus
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

Name	Bill Lekas	**Telephone**	619-594-2801
E-mail	wlekas@mail.sdsu.educ	**Title**	Project Manager

1. GOALS AND OBJECTIVES

This M&V Site Report has been prepared as part of the impact evaluation of the UC/CSU/IOU Energy Partnership program conducted by the Local Government Partnership Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	HVAC	Upgrade fans to VSDs	Upgrade fans to VSDs and lock variable vanes open

2.2. Annual Measure Savings[107]

Table 21. Annual Measure Savings

Project Measure Number	Electric		Gas	Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms		
M1	179,804	7.0	25,848	-	100%

The *ex-ante* savings estimates were developed and submitted by the campus commissioned consultant, Cogent Energy, Inc.. Their study included the engineering assumptions and calculations used to assess the energy savings from the measure.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*.

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

[107] UC-CSU-IOU_UCI_Retrofit__3_Review_SCE.doc

2.6. Pre-Installation Equipment and Operation

Program Measure Number	Equipment and Operation – Pre-installation
M1	Student Services West is a 99,326 square feet, 3 story building built in 1992. The building houses various services for students including the office of the ombudsmen, office of financial aid and scholarships, student activities and campus life, and student affairs. The building is served by five VAV air-handling units and one single-zone CAV unit.

2.7. As-Built Equipment and Operation

Measure characteristics for the HVAC system retrofits were drawn from the most recent project review file and documented savings calculations developed by Cogent Energy.

Program Measure Number	Equipment and Operation – As-Built
M1	The inlet vanes on the air handling units for Student Services West were retrofit with variable speed drives

2.8. Seasonal Variability in Schedule and Production

The occupancy schedule for Student Services West is from 8:00 A.M. to 4:30 P.M.,Monday through Friday and reduced hours on the weekends. The airhandling systems are run 24 hours per day, seven days a week.

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

The final approved energy savings calculations for this project were developed by Cogent Energy. Their approach to estimating *ex-ante* savings are below.

Program Measure Number	Algorithm
M1	Cogent used an M&V methodology for this project that is similar to the "International Performance Measurement and Verification Protocol" (IPMVP) Calibrated Simulation Option D [1]. In this option, savings are determined by an energy use simulation model which is calibrated to metered data. Cogent considered the IPMVP Calibrated Simulation option best suited for energy use monitoring and verification at the Student Services West buildng because annual whole-building data for 2006-2007 was available to be used for model calibration. Energy usage data provided by SDSU was used to establish the energy baseline. For Student Services West electricity consumption was provided for the years of 2006-2007. The building was not meeting the minimum operational requirements and consequently the established baseline was adjusted to reflect modifications required to bring systems to compliance. Specifically the baseline was adjusted to account for the VAV terminal units that had an increase in the minimum airflow rate for ventilation requirements or to improve occupant comfort. To calculate post-installation energy use, Cogent prepared a spreadsheet model for all fifteen air handling units to simulate the energy usage of the buildings. Energy savings were calculated for the VFD retrofit project and subsequent VAV terminal unit calibration. Cogent noted that the models used estimate only the energy usage of the HVAC systems whereas the baseline usage represents the energy usage of the whole building. Thus, to calibrate the predicted HVAC usage to the baseline energy consumption, the lighting and miscellaneous building loads needed to be netted out of the baseline. Based on PG&E's Commercial Building Survey Report published in 1999, fan energy accounts for approximately 40% of the electrical consumption of a commercial building. The models could be calibrated to the baseline electrical consumption by assuming that the fan energy accounts for approximately 40% of the total baseline electrical consumption. To create the calibrated energy models, first the current minimum VAV turndown ratio as determined during the VAV terminal unit calibration was used as an input in the energy model. The models were then calibrated to the available energy baseline data. Since no chilled water or steam usage was available for Student Services West, only the electricity consumption could be calibrated. After calibrating the model to the baseline energy usage the next step was to calculate the savings for the VFD retrofit and VAV terminal unit calibration. During the VAV terminal unit calibration several of the terminal units had an increase in the minimum airflow rate in order to meet ventilation and cooling requirements, which will result in increased energy consumption. In order to account for this increased energy consumption, an adjusted baseline was established by running the model with an increase in the minimum airflow rate. The increased minimum flow rate was modified by adding only the terminal

Program Measure Number	Algorithm
	units that has an increase in the minimum airflow rate to the baseline condition. A model was then created to simulate the VFD retrofit and terminal unit calibration. In this model the fans are controlled by VFDs and the minimum airflow rate was calculated by subtracting only the terminal units that had decreases in the minimum airflow rate. The savings were then calculated by subtracting the retrofit energy consumption from the baseline energy consumption.

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option D will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in both the pre- and post-retrofit case involve end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO). According to the facility staff, the building is separately metered and EMCS system is capable of providing trend logs.

Evaluation Measure Number	Algorithm
M1	To evaluate savings, energy analysis simulations were prepared using the eQuest (DOE 2) energy analysis model, using field verified data and information from the MBCx report prepared by Cogent Energy. The as-built building operation was benchmarked against the building metered data obtained from the facility along with field verified equipment operation and schedules. The energy savings for the measure will be the drop of consumption from the baseline to as-built consumption..

3.4. Peak Demand Algorithms Used in the Evaluation

Evaluation Measure Number	Algorithm
M1	The evaluation used the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for Irvine for the period between 23rd September to 25 september 1991 as defined by the CPUC evaluation protocol for CEC climate zone 8

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**52. Collect Building and VFD Performance Characteristics** from the University Facilities – Energy Management Office (if possible). **53. Collect NOAA weather data for Irvine** from the National Climatic data Center (NCDC) web site ADM has obtained subscription for the weather station data and will use it to recompile the binary weather data to be used for calibrating the simulation with building level monitored data by the facility. **54. Collect Building-Level Consumption Data** from the University Facilities – Energy Management Office. Also collect the zone occupancy level inputs and fractional flow rate registered by the EMCS for set period of time.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Quality Assurance Procedures

The standard QA procedures in Appendix D of the *RCx Evaluation Handbook* were followed.

MEASUREMENT AND VERIFICATION RESULTS

An eQuest model was built based upon an onsite audit of the building and interviews with the facility staff. The model itself was calibrated to the building's metered energy use. VFDs were installed on supply fans whose flow was previously modulated by inlet guide vanes. Original inlet guide vane vanes had all broken such that the pre-existing system was functioning as a constant volume system. Because the measure equipment was used to replace broken down pre-existing equipment, the baseline type for this project became "Normal Replacement" and the savings were calculated assuming a working VAV baseline.

The eQuest model was built based upon data collected through an onsite audit of tge Student Services West building. The building is connected to a common central plant which serves the majority of the campuses buildings. The campus also has a co-generation plant which obfuscated the interval data such that the calibration relied predominately on CEUS data for any information lacking in the onsite survey.

Calculated savings compared to claimed savings were as follows:

	Therms	**kWh**	**Peak kW**
Ex Ante Savings	25,840	179,804	7.0
Ex Post Savings	0	82,786	14.5
Realization Rate	0%	46%	208%

The reason the savings are different is due to the change in baseline type. The IOU's original calculations assume as the baseline the broken inlet guide vane system. As such their savings reflect those garnered in converting a CAV system to a VAV system (Thus the reason they calculated a Therms savings). For the M&V calculations, it was assumed that the baseline was a working VAV system. The only change was the replacement of the inlet-guide vane system with a VFD on the supply fans. For such a measure one would not expect any Therms savings; and the electrical savings are predominately due to cube law savings.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

SERVER VIRTUALIZATION SYSTEM ENERGY SAVINGS STUDY – CSU-SAN MARCOS

August 31, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	#137
Company Name	California State University – San Marcos
Site Name	Campus Wide
Site Address	333 S.Twin Oaks Valley Rd.
Site Type	San Marcos, CA 92096
Company Business/Product	University / Education

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IOU REPRESENTATIVE

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RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Deborah Swarts

AUTHOR

Name	Deborah Swarts

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for UC/CSU Partnership Program.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrofit measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for installed measures and activities.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation[108]

Program Measure Number	System	Measure Name	Measure Description
M1	IT	Server Virtualization 55 to 8 servers	Reduce campus servers from 55 to 8.

2.2. Annual Measure Savings[1]

Table 22. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1	124,321	12.4	-	-	-	100%

The *ex-ante* savings estimates were developed and submitted in a calculation spreadsheet. No detailed study with metering data was available; however, the calculation spreadsheet was used to develop this site plan. These system changes resulted in reduced server consumption, along with a reduced load on the cooling systems.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *early replacement*. Project cost, EUL, and remaining life of old equipment will be addressed in the final report.

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

[108] Form_B_-_Retrofit_Application_2006-08_-_022406.xls

2.6. Pre-Installation Equipment and Operation[109]

Program Measure Number	Equipment and Operation – Pre-installation
M1	CSU San Marcos had 1 Sun Ultra Enterprise 2 servers and 54 Dell PowerEdge servers, including 13 PowerEdge 1650/1750, 15 PowerEdge 2650, 2 PowerEdge 2850, 1 PowerEdge 2900, 1 PowerEdge 2950, and 11 PowerEdge 1855 systems.

2.7. As-Built Equipment and Operation[3]

Measure characteristics for the server retrofits were drawn from the project calculation file[3] and documented savings calculations.[2]

Program Measure Number	Equipment and Operation – As-Built
M1	Installed 7 Dell PowerEdge 2950 III and one NetApp FAS2050 Filer (NAS storage) servers. These units provided the same calculation power as the 55 older units at significantly less power.

2.8. Seasonal Variability in Schedule and Production

Croul Hall's HVAC equipment operates 8,760 hours per year. The heating and cooling loads for the facilities vary mostly with the seasons. Effects of a "9-month academic calendar" are small given year-round use of the servers.

M&V data could be collected at any time when the servers are active. Consequently, nearly any time of year would be suitable for collecting data, unless downtime for maintenance is expected. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

[109] VirtualMachineIncentiveCalculationCSUSM041808.xls

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

The provided documentation included estimates of energy savings based on nameplate power and a derating factor. However, no measurements of system power appear to have been included in assumptions. The approach to estimating *ex-ante* savings and included assumptions are below.

Program Measure Number	Algorithm
M1	The following baseline assumptions were made when calculating system *ex-ante* savings: • A derating factor of 50% was used for all servers. • A unity power factor was used for all servers based on nameplate power (VA). • UPS efficiency of 86%. • Continuous operation 8,760 hours per year. • Cooling system efficiency of 1.22 kW/ton. • Power use is assumed to be roughly constant, regardless of time of day. Power savings are calculated as follows: Old Server kW = Σ(VA× PF × DF)/1,000 = 11.11 kW New Server kW = Σ(VA× PF × DF)/1,000 = 1.71 kW Where: VA: Nameplate Apparent Power for Server PF: Power Factor of Server DF: Derating Factor for Server Σ: Sum for All Servers Old Server Energy Use = $kW_{old} \times Eff_{UPS}$ × 8,760 hrs/yr = 113,167 kWh/yr New Server Energy Use = $kW_{new} \times Eff_{UPS}$ × 8,760 hrs/yr = 17,418 kWh/yr Server Energy Savings = Old Server Energy Use – New Server Energy Use = 95,749 Where: kW_{old}: Old Server kW kW_{new}: New Server kW Eff_{UPS}: UPS Efficiency Cooling Load = Server Energy Use (kWh/yr) × (3,413 Btu/kWh) / (12,000 tons/Btu) Cooling Savings = $(CL_{old} - CL_{new}) \times Eff_{cooling}$ = 33,224 kWh/yr

Program Measure Number	Algorithm
	Where: CL_{old}: Old Cooling Load CL_{new}: New Cooling Load $Eff_{cooling}$: Cooling System Efficiency (kW/ton) Total Energy Savings = Server Savings + Cooling Savings = 128,973 kWh/yr Peak Power Savings = Total Energy Savings / 8,760 hours = 14.7 kW

3.2. **Level of Rigor in Evaluation**

The rigor level is enhanced. IPMVP Options A and B will be used for evaluation purposes.

3.3. **Energy Savings Algorithms Used in the Evaluation**

The proposed evaluation approach in the post-retrofit case involves end-use metering, spot measurements, and consumption data drawn from the University Facilities – Energy Management Office (EMO), if it is available.

Evaluation Measure Number	Algorithm
M1	Energy savings attributed to the reduction of server power will be realized in two areas: • A reduction in total server energy consumption due to reduced load. • A reduction in cooling energy consumption due to the reduced conditioned air load. The proposed evaluation approach will seek to visually verify affected system components, including: • Installation and operation of the new servers. The evaluation team will also verify the following *ex-ante* input assumptions: • Server power consumption: The evaluation team will use the Fluke 43B or similar Power Meter to confirm power consumption of servers. • Cooling system efficiency and hours of operation: System efficiency and operational hours will be confirmed using data from the university facilities office. Metering of the cooling system may be used to supplement this data if practical. • Operation schedules for servers and building cooling: The evaluation team will speak with facility staff and confirm continuous operation of servers and building cooling.

Evaluation Measure Number	Algorithm
	• Power specifications of old and new servers: The evaluation team will obtain nameplate power data for both new and old servers. Spot measurements of available servers will be compared to derated power used in *ex-ante* calculations. Overall, the evaluation will use the *ex-ante* algorithms as a basis for developing project level savings. We intend to make the pre- and post-installation models more robust by including on-going trending and spot measurements to confirm assumptions.

3.4. **Peak Demand Algorithms Used in the Evaluation**

Evaluation Measure Number	Algorithm
M1	The evaluation will use the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for each of the four IOUs, for each for the 16 Title-24 climate zoned impacted by the individual project.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**55. Spot Measure Server Power** with hand-held Fluke 43B meter or equivalent. **56. Trend Server Power** with Dent Instruments Elite Pro electric power or equivalent loggers at the breaker to measure true RMS kW of servers at 15-minute intervals for at least three weeks (if needed to confirm EMCS trending data). **57. Collect Server and Building HVAC Characteristics** from the University Facilities – Energy Management Office (if possible) and confirm energy assumptions used in the *ex-ante* analysis. **58. Collect Building HVAC Trend Data** from the University Facilities – Energy Management Office (if possible). **59. Collect UPS Load Data** if available and determine if it can be used to determine re- and post-installation server loads. **60. Collect Bin Temperature Data** from the local Department of Water Resources or the National Oceanic and Atmospheric Administration (NOAA) to correlate with historical consumption data if economizers are used to shut off cooling systems.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect. Equivalent meters may be substituted for the models listed above.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on a census of affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. **Uncertainties**

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1. Our ability to obtain adequate trend logs from the customer.
2. The accessibility of equipment we would meter as part of the M&V effort.

4.6. **Data Products**

The following data products will be produced during the evaluation:

- Building characteristics data
- Time-series data for electric and heating loads, and of air handler operating parameters
- Estimated gross savings (kW, kWh, and Therms)
- Site M&V report

4.7. **Data Reporting Formats**

The data products will be provided in the following formats:

- Microsoft® Office Excel– Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. **Building Characteristics Data**

Whenever possible, we will collect building characteristics data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

Table 23. Building Characteristics Data

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy

System	Characteristics
	• Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model Number

4.9. Supporting Data for this Plan

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations on September 30, 2009. Spot measurements of server power for the older type of servers were taken where possible. In addition, Summit Blue visually verified the removal of the old units and the installation of the new server system. A spot measurement of power for the new server was taken and a current transformer and logger were installed on the system to monitor use for several weeks. Nameplate rated power consumptions were taken from the rebate calculations and checked against the units on site.

For two types of the old server, Dell PowerEdge 1750 and 2650, operating units were still installed on different systems. These spot measurements of power were taken with a Fluke 43B power quality meter.

5.2. Analysis

Table 54 presents the power for each type of server. Measured powers are compared to the derated powers, which were used in calculations for the application, where available. For the new unit, the instantaneous measurement taken while on site is compared to the logged power as well.

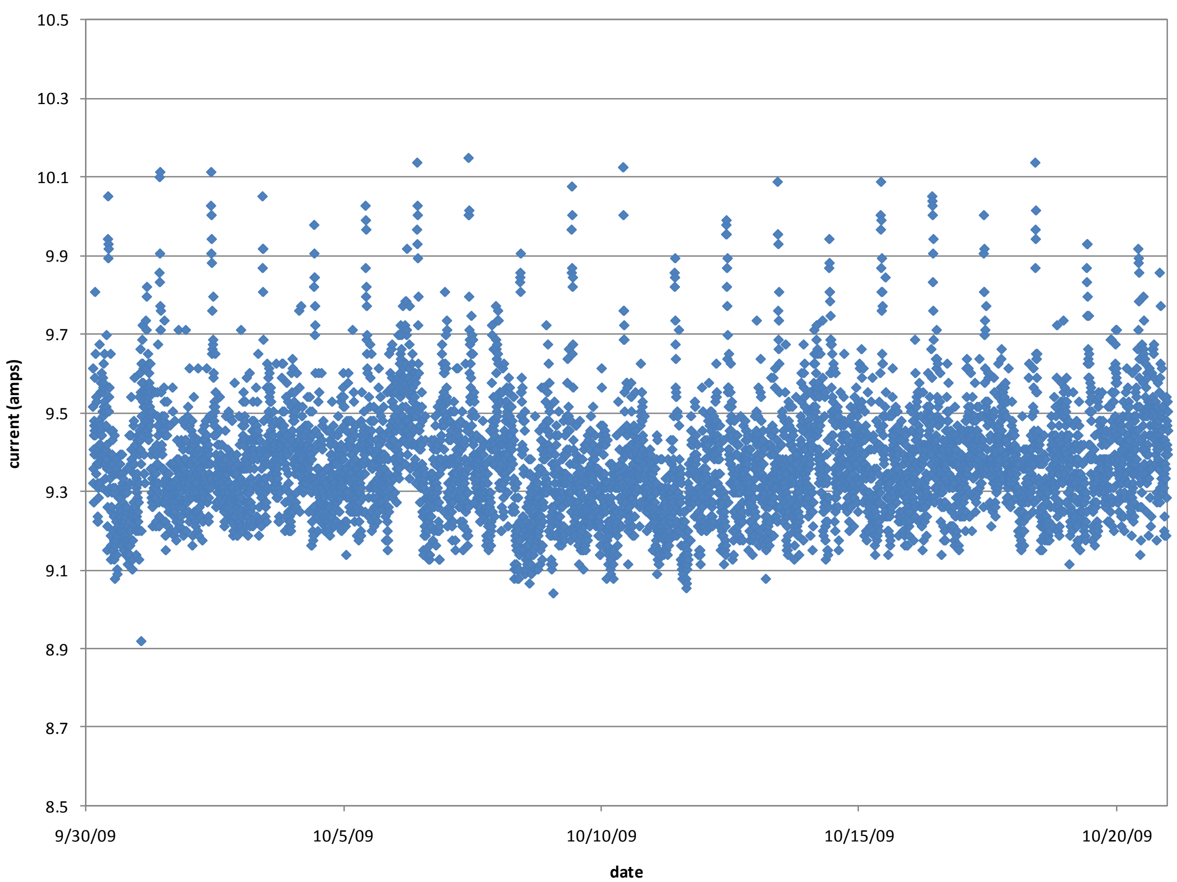
Table 24. Servers

	Server Type	Quantity	Nameplate Apparent Power (VA)	Derated Power (W)	Derated Total Power (W)	Measured Power (W) (if available)	% of Derated Power
old server system	Dell PowerEdge 1650/1750	13	400	200	2,600	one unit - 172	86%
	Dell PowerEdge 2650	15	500	250	3,750	one unit- 230	92%
	Dell PowerEdge 2850	2	400	200	400		
	Dell PowerEdge 2900	1	600	300	300		
	Dell PowerEdge 2950	12	360	180	2,160		
	Dell PowerEdge 1855	11	300	150	1,650		
	Sun Ulta Enterprise 2	1	500	250	250		
new units	Dell PowerEdge 2950 III	7	360	180	1,260	total - 1,970 (instantan-eous)/1,755 (logged)	115%/ 103%
	NetApp FAS2050 Filer	1	900	450	450		

The two old server types which were measured represent 57% of claimed baseline power. Both had power factors of 0.99 when measured, which compares well to the baseline assumption of power factors of 1 as required by IEC standards. The measurement of the new server showed a power factor of 0.91, contrary to this requirement. It is not clear if this is due to the filer or other factors, but a power factor of 0.91 was used to convert logged current to wattage. The server was operating on single phase 208 V power, which was measured at 206 V for use in calculating wattage from current. For the old servers which could not be measured, a factor of 90% of derated power was used to calculate baseline usage. This factor was used based on the measurements of the Dell PowerEdge 1750 and 2650 as compared to their derated powers. It should be noted however that, as seen for the new server, power usage varies with operation and this is not the exact power under operating conditions, which cannot be determined.

Figure 29 shows the results of the current monitoring of the new server system. The server power did not vary substantially with day of the week or time of day, except that a power spike was seen around 10:30 PM most nights. Since this spike was outside of peak hours, it was not included in demand savings calculations. There did not appear to be any other relationship between either time or day and power usage. Therefore the average power of 1,755 watts was used for calculating energy usage. This was 103% of the expected power usage.

Figure 29. Monitored New Server Current



An efficiency factor of 0.86 was added for the facility UPS and a cooling system efficiency of 0.6 kW/ton was used to calculate additional loads on both the baseline and the new server. This is significantly below the 1.22 kW/ton used for the ex-ante calculations.

5.3. M&V results

Results of our M&V analysis are shown in Table 55. In the table, we also show our estimate of a new high-efficiency server compared with the old servers. Overall, the ex-ante estimates for server power appear to have been fairly good, but the HVAC cooling efficiency is significantly better than that used.

Table 25. M&V Results

Existing Servers to Virtual Server		
ex post Savings	97,953	11.0
ex ante Savings	124,321	12.4
Realization Rate	79%	88%

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

INSTALL AND COMMISSION NEW BOILERS

November 3, 2009

SUMMARY INFORMATION

PROJECT

Program Being Evaluated	UC/CSU
Project ID	
Company Name	California State University – San Marcos
Site Name	Install and Commission New Boilers
Site Address	California State University - San Marcos, San Marcos, CA 92096
Site Type	Central Plant
Company Business/Product	University / Education

PRINCIPAL SITE CONTACT

Name	Ed Johnson	**Telephone**	760-644-7013
E-mail	ejohnson@csusm.edu	**Title**	Project Manager

IOU REPRESENTATIVE

Name		**Telephone**	
E-mail			

RETROCOMMISSIONING ENGINEER

Name		**Telephone**	
E-mail		**Company**	

ASSIGNED LEAD ENGINEER

Name	Mike Yim

AUTHOR

Name	Mike Yim

1. GOALS AND OBJECTIVES

This M&V Plan is part of the impact evaluation of the Local Government Partners Contract Group. The primary goal of the impact evaluation is to assess the net program-specific energy and demand impacts for the 56 programs in this group.

More specifically, the objectives of the impact evaluation are to:

- Determine the impacts of all retrocommissioning measures and activities on annual gross energy and peak demand, while accounting for interactions among them.
- Establish post-implementation performance profiles for selected air handling units, based on measurements.
- Account for the energy and peak-demand effects of spillover at this site, if applicable.
- Explain discrepancies between the results of this study and the ex-ante savings estimated by IOUs.

MEASURE DESCRIPTION

2.1. Measures Included in the Evaluation

Program Measure Number	System	Measure Name	Measure Description
M1	HHW	Boiler Replacement	Existing boilers removed. New energy efficient boilers with smaller capacity installed. Boiler sequencer controller installed.

2.2. Application Approved Annual Measure Savings[110]

Table 26. Annual Measure Savings

Project Measure Number	Electric		Gas		Total Energy Savings (MMBtu)	% of Total Savings
	kWh/Yr	Peak kW	Therms Input Cooling	Therms Input Heating		
M1			-	24,855	2,485.5	100%

The heating hot water system is used to provide domestic hot water on campus. The original boiler was oversized for summer usage and undersized for winter usage. As a result, in summer, the boiler was under-loaded and often idling, while in winter the boiler was running at capacity and a secondary large boiler was under-loaded and idling. Under-loading is an inefficient mode of operation. These boilers were removed and replaced with four smaller boilers which are more efficient. The new boilers are fitted with sequencing controllers to allow backups to come online when needed without running under-loaded.

The application approved savings estimates were submitted DMJM HARRIS.

2.3. Impact Type

The impact type for all measures is *direct*.

2.4. Baseline Type

The baseline for all measures is *retrofit*.

2.5. Sample Type

This project was drawn from the Comprehensive *UC/CSU Evaluation Sample* developed by ECONorthwest Consulting.

[110] Form B – Retrofit Application 2006-08 CSUSM Central Plant.xls

2.6. Pre-Installation Equipment and Operation[111]

Program Measure Number	Equipment and Operation – Pre-Installation
M1	The heating hot water system is used to provide domestic hot water on campus. The original boiler was oversized for summer usage and undersized for winter usage. As a result, in summer, the boiler was under-loaded and often idling, while in winter, the boiler was running at capacity and a secondary large boiler was under-loaded and idling. Under-loading is an inefficient mode of operation.

2.7. As-Built Equipment and Operation

Measure characteristics for the installed boilers were drawn from the most recent project review file[112] and documented savings calculations submitted by CSUSM.

Program Measure Number	Equipment and Operation – As-Built
M1	This project installed the following incentivized measures: 1. **Install 4 New boilers:** Four new 2.0 MMBB full-condensing boilers package boilers were installed in place. 2. **Install Dedicated boiler sequencing controller:** Sequencing controller provides control of boiler on-off timing to enable boiler operation at optimal loading.

2.8. Seasonal Variability in Schedule and Production

The CSUSM heating hot water system operates 8,760 hours per year. The heating loads for the facility vary mostly with the building population. The effects of a "9-month academic calendar" are significant as water use varies with campus usage.

The best time to collect M&V data would be when HHW system is active. Consequently, nearly any time of year would be suitable for collecting data. Where available, trend logs set up for the project and contractor verification work will be reviewed for the M&V effort.

[111] CSUSM_IGA_ECM_description.pdf

[112] CSUSM boiler savings for utility revew.xls

ALGORITHMS FOR ESTIMATING SAVINGS

3.1. Algorithms Used by IOUs

As noted earlier, the final approved energy savings calculations for the installed VFDs and start/stop controls were developed by Emcor Group, Inc. Their approach to estimating *ex-ante* savings are below.

Evaluation Measure Number	Algorithm
M1	The project expected savings to be realized in two areas: 5. Energy (Therms) savings from an increase in boiler efficiency 6. Energy (Therms) savings from boiler sequencing. The following input assumptions were collected through discussions with campus facility staff: • Baseline boiler efficiency is 83% above 65% load and 77% below 65% loads. • Retrofit boiler efficiency is 85% above 65% load, and 80% below 65% loads. Savings were developed from supporting trend data provided by CSUSM's Facilities Management Office using the following approach: <u>*Annual Therm Savings*</u> = $\Delta\sum(BHP \;\; x \;\; Hrs_l \, x \; 10 \, / \, Eff_l \, x \; 33.47)$ BHP_l: Boiler horsepower at loadn g *l* Eff_l :Efficiency at loadn g *l* in pre- and post-installation case Hrs_l: Number of hours at loadn g *l* 10: Conversion Factor, BTU to Therms 33.47: Conversion Factor, BHP to BTU

3.2. Level of Rigor in Evaluation

The rigor level is enhanced. IPMVP Option A & B will be used for evaluation purposes.

3.3. Energy Savings Algorithms Used in the Evaluation

The proposed evaluation approach in the post-retrofit case involves review of data drawn from the University Facilities – Energy Management Office (EMO).

Evaluation Measure Number	Algorithm

M1

The proposed evaluation approach will seek to visually verify affected system components, including:

6. **Installation of new boilers:** Visually confirm boiler nameplate data, efficiency, etc.

7. **Implement sequencing controller:** Visually confirm controller is present and operating.

8. **Control sequence:** Confirm and analyze the control sequence.

The evaluation team proposes to confirm, where possible, the following *ex-ante* assumptions:

- Boiler sequencing and operating hours. Controller sequencing data or other energy management logs (EMCS) will be reviewed to verify expected water heating load, hours, and sequencing.
- Gas consumption will be read from dedicated meters if such meters are present and billing data will be obtained from the utility.

Overall, the evaluation will use verified trend data from the EMCS to verify hot water demand during occupied and unoccupied hours. If EMCS data is unavailable, temperature probes and data loggers will be fitted to boiler outlet pipes. These will provide time-sensitive on-off data regarding boiler output, which will be used to verify sequencing.

More specifically, we will calculate savings according to the following equations:

$\underline{\text{Annual Therm Savings}} = \Delta\sum(BHP \; x \; Hrs_l \, x \; 10 \, / \, Eff_l \, x \; 33.47)$

BHP_l: Boiler horsepower at loadn g l
Eff_l :Efficiency at loadn g l in pre- and post-installation case
Hrs_l: Number of hours at loadn g l
10: Conversion Factor, BTU to Therms
33.47: Conversion Factor, BHP to BTU

The evaluation team will engage support from the CSUSM Program Manager and will capture system operating characteristics 24 hours per day. The following parameters will be collected at standard intervals for a period of two months:

- Date/Time
- BHP Range on all boilers
- Volume outside air

If gas usage is dominated by the boilers, billing analysis may be used as an alternative method of evaluating savings from this project.

3.4. Peak Demand Algorithms Used in the Evaluation

Not applicable on natural gas measure.

DATA COLLECTION

4.1. Site-Specific Parameters and Data-Collection Methods

Evaluation Measure Number	Site-Specific Parameters
M1	**61. Read Gas Meter** Visual read dedicated natural gas meter for boilers if such a meter is present. **62. Obtain Gas Usage Data** Obtain gas usage data from the utility. **63. Collect Site-Level Consumption Data** from the University Facilities – Energy Management Office. **64. Collect boiler gas and water flow data** from the University Facilities – Energy Management Office and through visual verification of the boiler nameplates.

We expect that observations made during the site visit will allow us to refine the proposed site-specific data to collect.

4.2. Sampling Strategy

Evaluation Measure Number	Sampling Strategy
M1	The evaluation will be based on all affected equipment.

4.3. Data Accuracy

Not applicable. Future plans may include quantitative analysis of uncertainty and data accuracy, as developed by the CPUC ED Technical Advisors Engineering Working Group.

4.4. Quality Assurance Procedures

We will follow the standard procedures in Appendix D of the *RCx Evaluation Handbook*.

4.5. Uncertainties

These factors, which are unknown as this plan is being written, may affect the M&V effort:

1. The existence of dedicated natural gas meters for the new boilers.
2. The availability of EMCS data regarding BHP loading and operational hours.

4.6. Data Products

The following data products will be produced during the evaluation:

- Estimated gross savings (Therms)
- Site M&V report

4.7. Data Reporting Formats

The data products will be provided in the following formats:

- Microsoft® Office Excel – Building characteristics data, time series data, and estimated gross savings
- Microsoft® Office Word – Site M&V report

4.8. Building Characteristics Data

Whenever possible, we will collect building characteristics[113] data that we expect to be useful for subsequent analyses, but not essential for M&V impact calculations. The following table lists these characteristics:

Table 27. Building Characteristics Data

System	Characteristics
All Project Sites	• Electricity/Natural Gas Meter Number(s) that Serve Equipment Affected by Installed Measures • Building Predominant Year of Construction
Commercial / Institutional Sites	• Observed Building Type by CEUS Category • Year Organization was Established at Site • Single or Multi-Site Business • Ownership Structure • General Business Hours • Total Building Floor Area Affected by Retrofit
Measure Types	• Summer Occupied Set Points (F) • Monitored System Type – Type of Coils in Supply Fan • Monitored System Supply Air Flow Control Strategy • Monitored System Outside Air Strategy • Monitored Compressor Type • Monitored Packaged Unit or Chiller Make & Model Number
Supply / Exhaust Air Fans	• Predominant Summer Supply Air Temperature Set Points for Areas Affected by Measure (F)

[113] Contextual Data v3.doc

System	Characteristics
	• Supply Air Temperature Control Scheme for System Affected by Measure • Supply Air Pressure Reset Control Scheme for System Affected by Measure • Monitored Fan Type • Monitored Fan Flow Control • Monitored Motor Nameplate HP, Volts, Amps, Efficiency, and Power Factor

4.9. **Supporting Data for this Plan**

All files referenced in this plan are attached.

MEASUREMENT AND VERIFICATION RESULTS

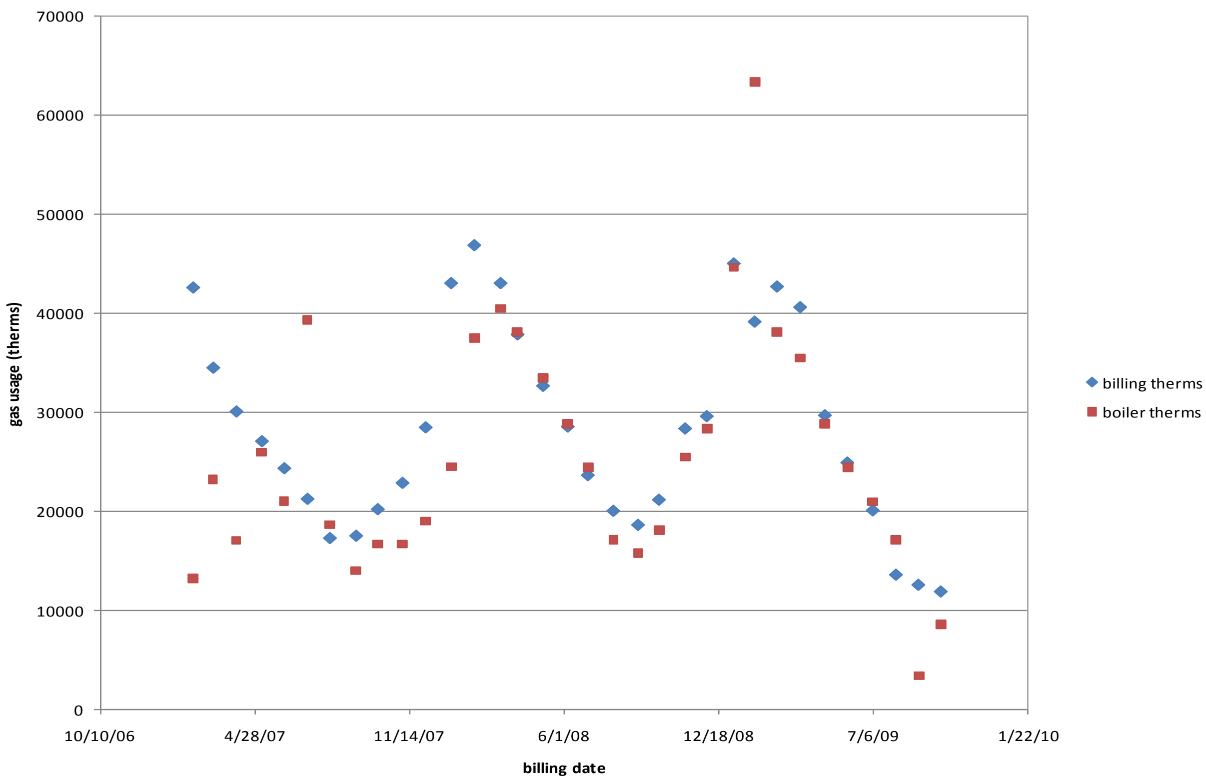
5.1. Site Observations and Data Collection

Summit Blue conducted on-site measurements and observations on September 30, 2009. In addition to checking the inlet and outlet temperatures of the boiler and confirming the installation, the available operation data was downloaded from the monitoring system. In addition, billing records for 2007-2009 were obtained from the utility. Boiler operation logs for the past several years were copied from the notebooks in the central plant for comparison to other data. Additionally, records for monthly boiler gas usage for 2007-2009 were obtained from the university.

5.2. Analysis

Figure 30 shows campus gas use and boiler gas use by month. It should be noted that the billing month, used for plotting, is not quite the same as the month used for boiler logs. Billing months begin around the 5th of the month for this meter whereas campus logs are kept on a calendar month basis. The dates on the chart are based on billing date and so are for the month prior to that labeled.

Figure 30. Gas Usage



It can be clearly seen that, especially in recent months, the boilers account for almost all of the metered gas usage. Although some discrepancies may be accounted for by the slight variation in billing and boiler months, there are two boiler therm values that are clearly impossible, in July 2007 and February 2009. It is likely that this is due to incorrect records on the boilers. Prior to the startup of the new boiler in March of 2009, the records appear to have been manually kept and may have errors. It is more likely that the boiler logs are in error, rather than the utility data, since the boiler data varies from the trend significantly.

Since boiler usage clearly makes up almost all of the metered gas usage and the older boiler logs were deemed unreliable, billing analysis was undertaken to determine savings due to new boiler system. According to campus personnel, the new, four-unit boiler system was started up in mid-March of 2009 and the old boilers have only operated briefly for testing since that time. The campus boiler logs agree with this, as no logs have been kept since that time for the old boilers, 1 and 3.

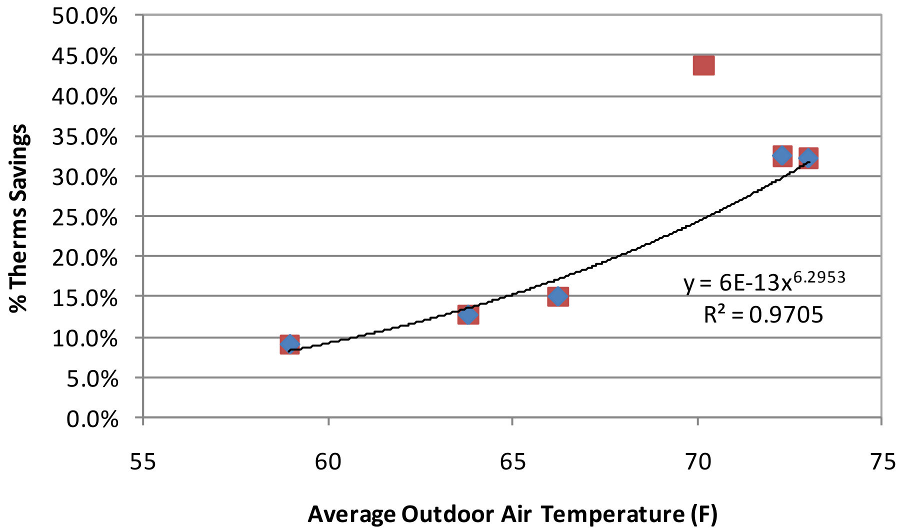
Billing data from the May 5, 2009 bill through the October 2, 2009 bill was normalized for daily gas usage and compared to billing data from May 5, 2008 through October 2, 2008. Temperature data for these billing months was similar so no normalization was performed for temperature variations. Table 58 shows the savings for each billing cycle. Percentage savings are relative to the 2008 bills.

Table 28. Billing Data

Bill Month	2008 Average OAT (F)	2009 Average OAT (F)	2008 Therms/ Day	2009 Therms/ Day	Monthly Therms Savings	% Savings
May	59.8	59.0	1089	990	2972	9.1%
June	62.6	63.8	921	804	3635	12.7%
July	70.1	66.2	788	670	3554	15.0%
August	71.4	73.0	656	438	6449	32.2%
September	72.5	72.3	601	405	6052	32.5%
October	69.9	70.2	705	397	9267	43.8%

Trending percentage savings as a function of boiler temperature did not prove practical due to the intermittent nature of the available data. Instead, savings were trended as a function of outdoor air temperature over the same period. There were extremely high savings in the most recent billing month of October 2009, and this was excluded from the trend as an outlier. Figure 31 shows the trend used to extrapolate savings for the rest of the year.

Figure 31. Gas Savings as a Function of Outdoor Air Temperature



Using the correlations and temperatures from the Escondido weather station, savings were estimated based on the billing year between April 2008 and March 2009, just before the new boiler system was started up. TMY data was not used because of the use of actual billing data and some variation can be expected in future years.

5.3. M&V results

Results of our M&V analysis are shown in Table 59. The realization rate is quite high and it is possible that this estimate is conservative as the extraordinary savings in the latest month were excluded from calculations. The increased savings may simply be an anomaly; however, it is also possible that the tuning that is ongoing at the university may be improving performance for increased savings.

Table 29. M&V Results

Replace Existing Boiler #2	
ex post Savings	42,482
ex ante Savings	24,855
Realization Rate	171%

LGP EVALUATION REPORT APPENDIX F: CALIFORNIA COMMUNITY COLLEGES PARTNERSHIP EVALUATION SUPPORT DOCUMENTS

a. CCC Net to Gross Net-to-Gross Methodology and Analysis

1 CCC NTG INTRODUCTION AND METHODS

As stated in the *Evaluation Framework*, reliable estimates of the energy and demand savings created by the Program need to be "net" of what would have occurred in the absence of the program. This Appendix summarizes the NTG efforts for the CCC Program and states the methods, data sources, questions and scoring algorithm, data analysis and results. Of the NTG levels of free-rider analysis, the CCC Program falls under the Standard – Very Large protocols, the most detailed of the three analysis protocols. While the calculation of the NTGR score is based on quantitative self-report data, multiple data sources, some of them qualitative, are integrated to produce an estimated NTG score. Two analysts reviewed the quantitative and qualitative data, following the Standard -Very Large NTG protocol.

1.1 Overview of the CCC LGP

The California Community Colleges is the largest higher education system in the nation. The system is comprised of 72 districts, 110 colleges and enrolls more than 2.9 million students. The Chancellor's Office operates under the direction of the state chancellor who is guided by the Board of Governors. The Chancellor's Office is charged with providing leadership, advocacy and support of the California Community Colleges. Serving as the administrative branch of the California Community College system, the Chancellor's Office is also responsible for allocating state funding to the colleges and districts.

Located in Sacramento, the Chancellor's Office includes the offices of the chancellor and vice chancellors who oversee the work of ten major divisions. These divisions include: College Finance and Facilities Planning. Both the Chancellor's Office and the Board of Governors were created by legislation passed in 1967.

California's Community Colleges have $18 billion in public bond funding to spend on improving its facilities. The funding will support retrofit and new construction projects over the next ten years. The CCC Partnership program was developed to incorporate energy efficiency efforts into these planned retrofit and new construction projects. It is set up similar to the UC/CSU Partnership with a management committee that includes the four participating utilities, the California Community College Chancellor's Office (CCCO), and the program administrator. Newcomb, Anderson, McCormick was selected to serve as the program administrator through a competitive bidding process similar to the one carried out for the UC/CSU program.

The program concept includes three major components—energy-efficiency retrofits, new construction assistance, and energy-efficiency education and training.

Each of the 110 community colleges is responsible for its own energy use. This partnership is modeled after the UC/CSU partnership. Unlike the UC/CSU systems in which all the campuses coordinate closely with central offices, California's community colleges have full autonomy over their campuses and facilities, with little to no central coordination.

As part of this study, the Summit Blue team interviewed four representatives from the CCC partnership team. Based on their insights, the CCC decision-making process at all the campuses follow this general approach: the project needs are determined and prioritized at the local campus or district level. The key decision-makers are the facility managers; however, there may be a campus or district-wide facility planning committee. The projects are then approved internally and are instituted based on the availability of the funding, campus needs, and priority.

Projects funded through the partnership are generally considered “lower priority” projects. These projects may be identified either by: the facility manager, the utility account representative, or a member of the LGP-outreach team from the Chancellor’s Office. Both the Chancellor’s office and the utility account representatives actively identify and encourage the CCCS to initiate energy efficiency projects on community college campuses. At times, the Chancellor’s office has even taken to some “arm twisting” to encourage the CCCs to identify and install energy efficiency projects through this program. The Chancellor’s office focuses on identifying projects that offer energy savings and then makes recommendations to the facilities committee at the CCC districts to get the approval and go-ahead. Then the projects are submitted to the utilities for their review process.

Since this partnership has been underway, the CCCs are now proactively involving the utility representatives in the project planning process. The utility representatives offer support with the project applications and paperwork. These projects are often part of a larger set of projects, which may be funded through local bond issues: 54 out of 72 districts have bonds for new construction and retrofit projects. The LGP projects are viewed as opportunities to incorporate energy efficiency into the project and take advantage of the program's focus and tie into the long-range plans.

Once the project is approved by the community college or college district, the utility then reviews the calculations to determine energy savings, payback, and the rebate amounts. The project scope is managed by the college and an engineering firm is hired to complete the project to meet the specific energy specifications. PG&E hires a separate engineering firm, Encor, to review the project energy savings calculations for each of its projects.

1.2 Vendor Role

The role of energy vendors including energy services companies (ESCOs) is fairly limited in the LGP program. According to the interviews with both the campus energy decision-makers and the members of the LGP Partnership Management Team, the vendors provide primarily technical assistance and guidance. However, they have little if no impact on the decision-making process.

Three of the CCCs indicated that the vendors played a role in helping them either identify potential LGP projects through energy audits. However, their role was primarily to identify the types of equipment that would operate best on these college campuses, and provide them with technical advice such as equipment specifications.

Another CCC energy decision-maker made it quite clear that the ESCOs are not involved in actually making equipment decisions. This is based, in part, on some bad experiences college campuses had with ESCOs “cherrypicking” projects that would benefit their firms more than their college campuses. Therefore, while the ESCOs may identify potential projects, the real drivers for these decisions are energy savings, the availability of the incentives, and the condition of the current infrastructure.

Another role that vendors provide is that of project management. Several ESCOs such as Southland, Kitchell, and Chevron Energy Services have long-standing relationships with particular college campuses. However, in talking with one of these vendors it became clear that these companies are viewed as construction project managers and have no role in the actual decision to implement specific energy projects on college campuses.

In the interviews, energy decision-makers were asked specifically about the role and importance that vendors played in the decision-making process. Where a vendor was rated as high in importance (i.e., giving a score of:"8", "9" or "10"), the team did ask for vendor contact information. The team tried contacting these vendors but only interviewed one mentioned by a respondent.

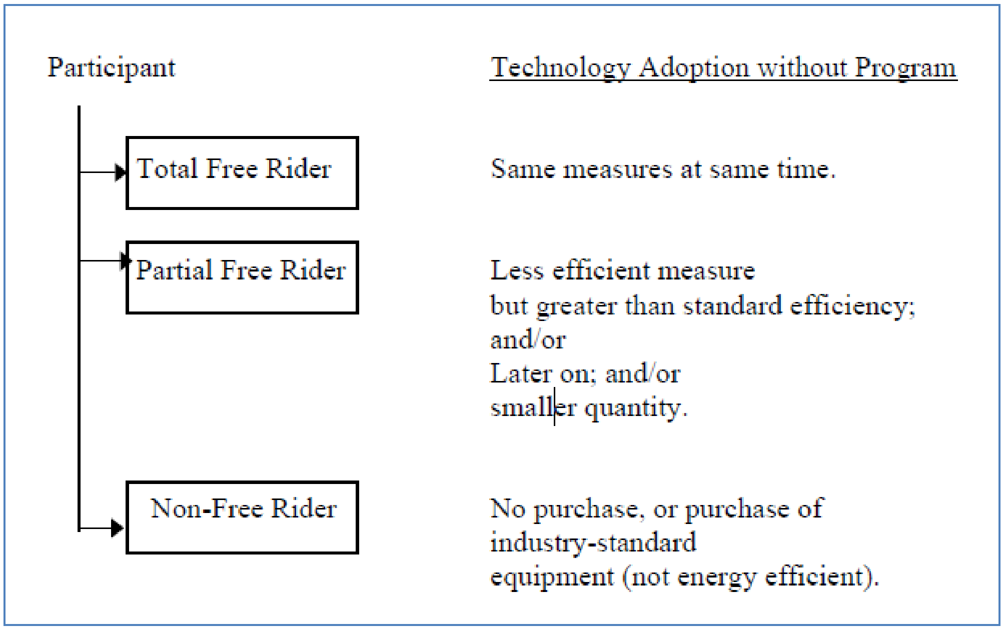
Overall, from these interviews it appears that while vendors are involved in implementing energy projects on these college campuses, they are not viewed as viable partners with the CCC community. Therefore, vendors do not play a role in free-ridership in these projects.

1.3 NTG Methods

As part of the evaluation of the 2006-08 energy efficiency programs, the Energy Division of the California Public Utilities Commission (CPUC) formed a nonresidential net-to-gross ratio working group to develop a standard methodological framework, including decision rules, for integrating in a systematic and consistent manner the findings from both quantitative and qualitative information in estimating net-to-gross ratios. The Large Non-Residential NTG Method described in this section was developed to address the unique needs of Large Non-Residential customer projects. This method relies exclusively on the Self-Report Approach (SRA) to estimate project and domain-level Net-to-Gross Ratios (NTGRs), since other available methods and research designs are generally not feasible for large nonresidential customer programs. Survey-based stated intentions, or "self-reports," is a method of estimating free-ridership by asking participants directly a series of questions on what they would have done in the absence of the program. This approach is designed to fully comply with the *California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (Protocols) and the *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches* (Guidelines). See Appendix H for guidance documents.

The method uses a 0 to 10 scoring system for key questions used to estimate the NTGR rather than using fixed categories that were assigned weights. It asks respondents to jointly consider and rate the importance of the many likely events or factors that may have influenced their energy efficiency decision making, rather than focusing narrowly on only their rating of the program's importance. This question structure more accurately reflects the complex nature of the real-world decision making and helps to ensure that all non-program influences are taken into account in assessing the unique contribution of the program as reflected in the NTGR. Figure 1 displays a continuum of Free-Ridership. A Total Free-rider (with a NTG ratio of 0), would have implemented the project at the same time even if they were not a participant in the Program. A Non-Free-Rider (with a NTG ratio of 1.0) would not have implemented the project without the Program. Partial Free-Riders might have installed a less-efficient measure, installed a smaller quantity, or implemented the project(s) at a later date.

Figure 1. Continuum of Free-Ridership



There are three levels of free-ridership analysis. The most detailed level of analysis, the **Standard – Very Large Project** NTGR, is applied to the largest and most complex projects (representing 10 to 20% of the total) with the greatest expected levels of gross savings[1] The **Standard** NTGR, involving a somewhat less detailed level of analysis, is applied to projects with moderately high levels of gross savings. The least detailed analysis, the **Basic** NTGR, is applied to remaining projects with smaller savings.

The CCC Program targets community college campuses that tend to have a unique and complex decision making environment, may be a large energy user, and implement custom retrofit and new construction capital investment projects. Therefore, the CCC Program falls under the Standard – Very Large protocol standards.

1.4 Case Study Methodology

The Net Impact Approach for the CCC/IOU Energy Efficiency Partnership evaluation was originally assigned a "Basic" level of rigor. However, the evaluation opted to apply a "Standard – Very Large" level of rigor to improve the quality of findings. This was triggered because the CCC Program targets community college campuses that tend to have a unique and complex decision making environment, may be a large energy user, and implement custom retrofit and new construction capital investment projects. Therefore, the CCC Program falls under the Standard – Very Large protocol standards. These protocols direct use of a case study methodology, as stated in the Guidelines:

"It is important to inquire about the decision-making process and the roles of those involved for those cases with relatively large savings and with multiple steps or decision-makers. If the customer has a multi-step process where there are go/no-go decisions made at each step, then this process should be considered when using the responses to estimate the firm's NTGR. There have been program evaluations

[1] Note that we do not refer to an Enhanced level of analysis, since this is defined by the Protocols to involve the application of two separate analysis approaches, such as billing analysis or discrete choice modeling.

whose estimates have been called into question when these factors were not considered, tested, and found to be important."

The CCC/IOU Energy Efficiency Partnership met these criteria in that decisions on energy efficiency investments were often made, or at least initiated, at a high level within large and complex organizations. This suggested a strong correlation and causal linkage between multiple projects, both on the same campus and, to some extent, across campuses.

As an example, program incentives may have influenced the Chancellor's Office to issue directives to the individual campuses to investigate opportunities for energy efficiency. Thus, the program influence (or, conversely, any free ridership) at the Chancellor's Office could come down to the individual campus decisions. In turn, decisions by the administrations of each different campus could influence or determine individual project decisions. Even if a project's site manager had not considered specific projects or measures prior to the program, free ridership identified at the higher levels of decision making would need to be estimated and integrated with free ridership rates for individual projects.

1.5 Survey Design and Implementation

The Standard – Very Large Survey was used to gather NTG information from site facility site managers and campus energy managers. Utility program manager discussion guides were similar to those developed by Itron for the PG&E/3rd Party Industrial, Southern California Industrial Program Evaluation. Utility program manager discussion guides and vendor and non-participant surveys were also patterned on those used in previous NTG evaluations involving large customer decision makers. Discussion guides for community college system representatives and committee members were largely based on the utility program manager discussion guide. Samples of the survey instruments are included in Appendix H.

Interviews and surveys were conducted by Summit Blue's professional executive interviewers. The interrelationships between the different levels of decision makers required experienced and knowledgeable personnel to conduct the interviews and that the same interviewers conduct the multiple surveys that were required at all levels of a project. Large customer surveys were designed to be administered via telephone using a CATI system to aid in data collection. Summit Blue staff resources were used to program the surveys online using Lime Survey, an open source programming tool. The more open-ended discussion guides for program managers and community college decision makers were input using Survey Monkey, another survey programming tool.

1.6 Data Sources

There are five sources of free-ridership information in this study. Each level of analysis relies on information from one or more of these sources. Table 1 shows the data sources that are used in each of the three levels of free-ridership analysis. Although more than one level of analysis may share the same source, the amount of information that is utilized in the analysis may vary. For example, all three levels of analysis obtain core question data from the Decision-Maker survey.

Table 1. Information Sources for Three Levels of NTGR Analysis

	Decision-Maker Survey Core Question	Decision-Maker Survey Supplemental Questions	Utility & Program Staff Interviews	Office of the Chancellor and District Staff Interviews	PIPs, Quarterly Reports and Web Sites
Basic NTGR	√		√		
Standard NTGR	√	√	√		
Standard NTGR - Very Large Projects	√	√	√	√	√

Decision-maker survey core questions, decision-maker survey supplemental questions, utility and program staff interviews and interviews with college district staff and representatives from the Community College Chancellor's Office were the sources for the CCC LGP Program NTGR calculation. Campus level decision-makers did not view vendors as a party in their decision making.

1.7 Minimizing Non-Response

To minimize non-response in the CCC surveys, the executive interviewer used several methods including:

- Sending out introductory emails advising potential respondents of survey intent and offering convenient interview times
- Calling and leaving messages at multiple times and days- every potential respondent was contacted up to 5 attempts or refused
- Calling supervisors of energy decision-makers to ensure follow-up by the proper individual
- Following up immediately with any survey respondents who did call back and scheduling interviews and their convenience
- Converting "hostile" respondents into full respondents by listening to their concerns before initiating the survey
- Using triangulation by asking utility staff and partnership team members to identify other potential respondents and then leveraging those connections in subsequent phone calls and emails.

The sample was managed closely and the status was reported during weekly meetings with the Summit Blue team.

For this survey, non-response is not an issue given that there were limited numbers of projects thatwere part of the CCC impact study sample. Every effort was made to contact all respondents on the list, but the entire original sample contained only 20 contact names. Four additional respondents were identified during the partnership interviews. There were a total of 10 interviews competed with energy decision-makers, which is a response rate of 42 percent.

1.8 NTGR Questions and Scoring Algorithm

The NTGR is calculated as an average of three scores. Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure.

1. A **Timing and Selection** score that reflects the influence of the **most important** of various program and program-related elements in the customer's decision to select the specific program measure at this time. Program influence through vendor recommendations could have been incorporated in this score, if a vendor role was very important. However, for all of these case studies, vendor recommendations in the actual decision to implement specific energy projects were not significant enough to warrant inclusion.

2. A **Program Influence** score that captures the perceived importance of the program (whether rebate, recommendation, training, or other program intervention) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents say they had already made their decision to install the specific program qualifying measure before they learned about the program.

3. A **No-Program** score that captures the likelihood of various actions the customer might have taken at this time, and in the future, if the program had not been available (the counterfactual). This score also accounts for deferred free-ridership by incorporating the likelihood that the customer would have installed program-qualifying measures at a later date if the program had not been available.

When there are multiple questions that feed into the scoring algorithm, as is the case for both the **Timing and Selection** and **No-Program** scores, the maximum score is always used. The rationale for using the maximum value is to capture the most important program element in the participant's decision making. Thus, each score is always based on the strongest influence indicated by the respondent. However, high scores that are inconsistent with other previous responses trigger consistency checks and can lead to follow-up questions to clarify and resolve the discrepancy.

For the Standard - Very Large Program algorithm, the missing score was excluded from the analysis based on advice provided by ITRON. For the CCC program, all of the situations where the missing score was excluded from the analysis were caused by missing data on the No Program score.

The self-reported core NTGR is simply the average of the Timing and Selection, Program Influence, and No-Program Scores, divided by 10 or the average of the Timing and Selection and Program Influence score divided by ten. The one exception to this is when the respondent indicates a 10 in 10 probability of installing the same equipment at the same time in the absence of the program, in which case the NTGR is based on the average of the Program Influence and No-Program scores only.

1.9 Data Analysis and Integration

The calculation of the Core NTGR is fairly mechanical and is based on the answers to the closed-ended questions. However, the reliance of the Standard NTGR – Very Large on more information from so many different sources requires more of a case study level of effort. The SRA Guidelines point out that a case study is one method of assessing both quantitative and qualitative data in estimating a NTGR. A case study is an organized presentation of all these data available about a particular customer site with respect to all relevant aspects of the decision to install the efficient equipment. In such cases where multiple interviews are conducted eliciting both quantitative and qualitative data and a variety of program documentation has been collected, all of this information is integrated into an internally consistent and coherent story that supports a specific NTGR.

Sometimes, *all* the quantitative and qualitative data clearly pointed in the same direction while, in others, the *preponderance* of the data pointed in the same direction. Other cases were more ambiguous. In all cases, in order to maximize reliability, it was essential that two analysts were involved in analyzing the data. Each person analyzed the data separately and then compared and discussed the results. Important insights emerged from the different ways in which two analysts looked at the same set of data. Ultimately, differences were resolved and a case made for a particular NTGR. Careful training of analysts in the systematic use of rules was essential to insure inter-rater reliability.[2]

Once the individual analysts completed their review, they discussed their respective findings and presented their respective rationales for any recommended changes to the Calculator-derived NTGR. The outcome of this discussion is the final NTGR for a specific project. In disputed cases, a third analyst is consulted to moderate the final NTGR score.

1.10 Weighting of NTGR Scores for Program NTG

The measure level adjusted NTGR scores for the campuses in the sample are weighted by the ex-ante measure savings to calculate the program level NTGR. The project level NTG ratio is weighted by the number of projects with kWh, kW and therm savings resulting in a slightly different NTG ratio for each savings measure. This analysis was conducted in Excel.

[2] Inter-rater reliability is the extent to which two or more individuals (coders or raters) agree. Inter-rater reliability addresses the consistency of the implementation of a rating system.

2 CCC NTG SUMMARY OF RESULTS

This section summarizes the NTG results for both the qualitative discussions and for the quantitative analysis.

CCC decision-makers at the campus or district level have come to rely on utility support when they participate in the program. Colleges make financial decisions independent of the Chancellor's Office and are responsible for their own energy use. However, the Chancellor's Office is a champion of the LGP program and has encouraged and, in some cases, pressured colleges to participate in the program. Utility representatives were assigned by the utilities to work with the decision-makers by helping them identify projects and complete the application. Generally, vendors and trade allies do not have an impact on college decision making for choosing energy efficient equipment.

A number of colleges recently acquired bond funding and, therefore, have plans for expanding or modifying their campuses. Unfortunately, only small or partial projects, non-priority projects, are proposed for LGP program participation. Generally, the building projects would last too long to quality for the LGP program.

2.1 Summary of CCC Qualitative NTG Results

Summit Blue conducted executive in-depth interviews with Utility Program Managers, CCC Campus System Representatives, and Vendors. These interviews are discussed in detail in "Section 3. CCC NTG Qualitative Summary." There was general agreement among those interviewed that there had been very little free-ridership in the 2007-2008 Program cycle.

From the interviews with Decision-Makers, there is a strong belief that free-ridership is not an issue for this program. These findings are based on the following:

- All CCCs have five year plans for campus improvements and many of them are in the midst of spending money from bond issues. The rebate is not a driver in this decision. In fact, one facilities manager reported that the project rebate was spent three-times over just trying to comply with the program's requirements and conditions.
- The projects selected for the program were not high priority or were not going to get completed without the program funding.
- Rather, the program funding identified and accelerated the completion of energy efficiency projects on CCC campuses and district buildings. These projects were accelerated between 12 to 18 months because of the rebate funding.
- The utility funding "makes the project more saleable to the facilities committee and it is great validation that the utility provides rebates." As one respondent said, "There is absolutely no free-ridership in this program- the incentives help to get these projects on the radar- otherwise they would be ignored."

2.2 Calculated and Analyst-Adjusted NTG Results

To meet the requirements of the Standard –Very Large CPUC evaluation standard, Summit Blue staff reviewed the Program Implementation Plans (PIPs), available quarterly reports and campus Web sites. An executive interviewer completed interviews with four utility representative, six campus representative and two vendors who were involved with the program but did not influence on-campus decision making. In addition, the executive interviewer surveyed decision-makers who participated in the LGP program. The sample of decision-makers was nested within the CCC Impact Sample. A census was attempted and ten completed decision-maker surveys with campus staff were completed.

Most of the utility, campus, district and vendor representatives interviewed believed there was no free-ridership in this program. However, survey results indicated a fairly high level of free-ridership among the community colleges. Two major changes were made to the program that increased campus participation. First, marketing and support for program was moved from the CCC Foundation to the Chancellor's office. Second, the utilities provided utility representative's support for community college and district staff to identify projects and encourage program participation.

The community college decision-makers who were previously selected for the on-site impact study were interviewed for this study. Decision-maker data was entered into the NTGR calculator to generate unadjusted NTGR scores. The unadjusted NTGR score is an average of the 'Timing and Selection', 'Program Influence' and 'No Program' scores. San Diego Community College and Saddleback Community College NTGR scores were calculated without the 'No Program' score because of missing data.

NTG ratios ranged from 0.44 at Butte College to 0.85 at San Diego Community College District. Then, two evaluators, one the executive interviewer, independently reviewed the NTGR scores and adjusted them based on the qualitative information gleaned from the in-depth interviewers with program staff, campus representatives and decision-makers during the survey. Next, the evaluators determined a collaborative adjustment. Adjustments were made to five of the ten scores, and overall NTG ratios were slightly increased from an un-weighted average of 0.79, to an un-weighted average of 0.85. In all cases, the 'Program Influence' score was adjusted to better reflect decision-maker comments, which increased the NTGR scores. Thus, free-ridership was deemed to be slightly lower than estimated in the calculator. Table 2 displays the results.

Table 2. Measure-Level NTG Ratios for CCC (Calculated and Adjusted)

ID	Community College/District	Measure	Calculated NTGR	Adjusted NTGR
23	San Diego Community College District	Lighting Retrofit	0.85	0.90
13	Kern Community College	Lighting Retrofit and occupancy sensors	0.80	0.80
15	Diablo Community College	Lighting Retrofit	0.67	0.67
47	Cabrillo College	Lighting	0.79	0.85
9	Saddleback Community College	Chiller Retrofit	0.70	0.70
46	Chabot College	Gas boilers	0.41	0.68
42	Cerritos Community College District	Central Plant Chillers	0.62	0.62
25	Victor Valley Community College	Central chiller plant	0.57	0.71

26	Yosemite College	Gas boiler retrofit	0.51	0.68
45	Butte College	Chillers	0.44	0.44

2.3 Spillover

A high level of spillover was found for the CCC program participants. When asked about spillover during the decision maker survey, 70% indicated they had installed energy efficiency measures outside of the program. CCC decision makers were not likely to install the additional equipment without the LGP program. The mean rating on this 0 to 10 likelihood question was 5.2. While few respondents rated the importance of the program on the 0 to 10 rating scale, decision-maker comments indicated that these additional measures would not have been replaced without the program. A few decision makers said they were not using the LGP program for large capital projects that were funded by their bond issues as the projects were too large to be completed within the timeframe of the program, but that they were planning to install energy efficient equipment. One decision maker was not participating in the program because his lighting projects were too small (ie: the hassle factor).

The results show that both inside and outside spillover has occurred as a result of the CCC LGP Program. Among the types of energy efficient equipment community colleges have implemented are:

- Additional upgrades to chiller plants
- VFD motors
- Cooling towers
- Built new buildings as part of bond issues but not part of LGP
- More lighting on different campuses
- Small lighting control projects
- Upgrade HVAC equipment
- Bond money designing LEED certified buildings

Detailed information on each measure, including the size, efficiency and quantity of the additional energy efficient equipment was not provided by survey respondents. While our results indicate that 70% of campuses had installed energy efficiency measures outside of the program, this is not sufficient information to apply across all projects impacting final Program savings estimates. In addition, CPUC directives require that participant spillover be measured and reported in the evaluation reports, but not included in the program accomplishments credited to the IOUs toward goal attainment. Therefore, Program Spillover percents are not estimated for Program impacts.

2.4 Program NTG

The population of campuses and projects from the impact sample was 27. Completed NTG decision-maker surveys were conducted on 10 projects at 10 universities. CCC campus decision makers were difficult to reach and keep on the telephone because of resource constraints. The decision was made to not attempt to complete the Net-to-Gross questions on multiple projects per decision-maker.

The adjusted NTG ratios for each project in the Program were then weighted based on the proportion of kWh, kW or therm savings they contributed to the total in the NTG sample to create a kWh, kW or therm savings-weighted Program NTG ratio. The NTG ratios for the CCC Program are presented in Table. 3, along with the coefficients of variation (CV), and levels of confidence and relative precision[3].

- The NTG ratio of 0.67 for kWh was based on 9 projects and had a confidence level and precision of 90/12.
- Similar levels were found for kW where 8 projects with an NTG estimate of 0.69 and a confidence level and precision score of 90/14 were found.
- The NTG Ratio for therms was 0.67, with 90/24 confidence and precision..

The precision levels for KWh and kW savings exced the original goal of 90/20. The precision for therm savings is little higher at 24%, where the ratio was estimated from just 5 project-level NTG ratios. These are the best achievable samples since a census of the impact sample was attempted for the NTG sample.

Table 3. Program NTG, Sampling, Confidence and Precision Results for CCC

Savings Type	NTG Sample Size	% Free Riders	NTGR % (1-%FR)	CV	Confidence	Precision
kWh	9	33%	67%	.20	90%	12%
kW	8	31%	69%	.21	90%	14%
Therms	5	33%	67%	.28	90%	24%

3 Calculations for relative precision applied T Values according to sample size at the 90% confidence level, and did not apply a finite population correction factor.

3 CCC NTG QUALITATIVE SUMMARIES

This section summarizes the results of in-depth interviews with Utility Program Managers, Campus System Representatives, and Vendors.

3.1 Summary of Interviews with Utility Program Managers

This document summarizes the interviews from six utility staff members including the program managers for each Investor-Owned Utility and account representatives who work directly with the California Community Colleges (CCC).

Program Description

The partnership offers incentives for retrofit and new construction projects, MBCx (Monitor-Base Commissioning), and educational training for the community colleges targeted to facilities staff. The CCC system includes 110 campuses, each of which is responsible for its own energy use. This partnership is modeled after the UC/CSU partnership. One of the issues with the CCC is that they have a lot of bond money, but they are not directing it at energy efficiency. So, the goal of the program was to have the CCCs include energy efficiency in their ongoing capital projects.

Program Implementation

All of the respondents said that the program implementation had changed during the first funding cycle. The major change was to provide more individual support to each CCC. However, this still proved to be challenging, as one respondent said, "We spent a lot of time herding cats."

The CCCS didn't know how to select projects or conduct the engineering calculations for energy efficiency savings; program staff was needed to provide additional support. Each utility added account representatives to provide the CCCs with the necessary technical support. These account representatives have ongoing relationships with 20 different CCCs. Their relationship with the community colleges differs from the traditional utility representative role by focusing on participation in the Local Government Partnership Program

> *"I handle the Bay Area segment and we assist the CCC in filing the applications and encouraging the projects to be more energy efficient."*
>
> *"We focus on both the sustainability side as well as the Energy Efficiency side, but not with the traditional Acct Reps who focus on reliability."*

Additional utility account representatives were assigned to address the fact that a lot of projects were never initiated during the first round of funding for the 2006-08 program cycle. PG&E followed the model created by SoCal Edison. This change has led to more projects being identified and implemented during the second program funding cycle.

Another major change at the college system was that program responsibility shifted from the CCC Foundation to the Chancellor's Office, who could more effectively influence the community colleges.

Program Outreach

The utility account representative jobs are to help influence participation in the program, create awareness, educate key stakeholders about the CCC/IOU program, and encourage the CCCs to do energy efficient renovations and new construction. The representatives identify project opportunities, potential audit sites, local engineering firms and consultants.

Project Decision-Making Process

Each district creates a unique decision-making structure. Decision-makers may be the Facility Directors and may have another title unrelated to energy use. The CCCs are not as organized as the UC system in terms of decision-makers.

The projects are selected by the CCCs or the districts. However, the applications have to be approved by the utility. All of the IOUs follow a similar approval process in which the application is reviewed, the calculations are verified by a third-party, and then tracked at various stages through the program administrator's database (Newcomb Anderson).

The utility representatives are generally not involved in the decision-making process, but rather identify potential projects and shepherd them through this process.

ESCOs play a minimal role at the community college campuses. In the first round of funding, many community colleges submitted previous ESCO proposals as projects. But the ESCOs calculated energy savings with different objectives and calculations that did not conform to the utility programs energy requirements. Therefore, these projects were rejected by the utilities. Some of the ESCOs involved include Kitchell, Trane and Compass Energy; Kitchell is very involved on one college campus (Solano) in implementing the LGP program.

Other vendors involved in these projects, in supporting roles, include lighting vendors and engineering firms. But the exact nature of their role is determined by the community colleges and the colleges are in control of decision making.

Types of Projects

The program has funded all types of projects ranging from lighting retrofits to new construction. The projects can span several years and are also an opportunity for college campuses to install new types of technologies such as EMS systems, bi-level lighting in stairwells, and LED parking lights. In the past, these projects would be more in the background and not viewed as high profile. With the program, the utility staff uses the rebates to "encourage the colleges to go the extra step and promote energy efficiency. We push projects that have not gotten off the ground by bringing in specialists like in lighting and push them to make more energy efficient decisions... but there is a still struggle to get them to replace T-12s."

Program Marketing

The program is marketed through peer-exchanges at industry conferences and events. The CCCS really like hearing what worked from their peers. Utility staff did not realize how powerful peer experiences could be with community colleges. Staff also works closely with the Chancellor's Office to encourage the colleges to submit projects. In fact, the Chancellor's Office does some "arm twisting" to encourage colleges to submit projects.

Non-Energy Benefits

The respondents also identified several other non-energy benefits from the program including:

- Awareness of Energy Efficiency (5 mentions)
- More Informed Target Market (4 mentions)
- Create partnerships (3 mentions)
- Reduced Environmental Impact (2 mentions)
- Increase Participation in Hard-to-Reach customers (3 mentions)
- Referrals to other Utility Programs (1 mention)
- Building Design Practices (1 mention)
- Increase Market Penetration (1 mention)

Other benefits cited by these respondents from the program included to promote more environmental sustainability and to develop "green projects."

Free-ridership

None of the utility staff believe that the Local Government Partnership program experiences a high level of free-ridership. In their view, the entire decision-making process discourages free-ridership as well.

> *"Free-ridership isn't even an issue for this program. The partnership is now included in the decision-making process from the very beginning; every new idea they have they contact us and we work with the design team. We are really entrenched now and there is definitely not any free-ridership. These projects are too hard otherwise."*
>
> *"If the CCCs were doing it on their own, they wouldn't need us."*
>
> *"The smaller projects just don't pay for themselves with the rebates and there is more competition among the CCCs to look green. I don't think there is much free-ridership... Other factors are driving these decisions."*

Program Impacts

The utility staff admitted that the program is still falling short of overall expectations in terms of energy and savings goals. The recent economic downturn may also be having a negative effect on the CCCs ability to finance new projects, which could help or hinder program participation.

However, they feel that the program changes will help them achieve their program goals during the second funding cycle.

> *"We got off to a rocky start but things are improving now."*
>
> *"During the first program cycle, we only achieved 82% of our savings but no we are not worried about reaching our goals. We are on track for this program cycle- we actually are ahead of expectations in 2009... Our goal for 2009-11 is to get 100% college participation; in the first funding cycle we only had 82% participation."*

> *"The budget constraints have made it harder to get some projects approved. A big issue is costing and the economy is becoming an issue; the CCCs are looking for creative ways to get funds since they are not getting money from the state and that makes them more motivated in terms of thinking about the future and helping them with sustainability goals."*

3.2 Summary of Interviews with Campus Representatives

Four respondents were interviewed using the Community College Campus Representative interview guide. These four respondents represented a good cross-section of the California Community College (CCC) key decision-makers including representatives from the Chancellor's office ,which serves all CCCs, and key facilities decision-makers representing large CCC districts and community colleges. One respondent was a former CCC facilities employee who now helps represent the Chancellor's office in promoting the program; he provided an additional perspective on how CCCs make capital project decisions.

Respondent Involvement with the CCC/IOU Program

Respondents have a broad range of responsibilities. Two are facilities directors who run large college campuses or entire campus districts. Two others represent the Chancellor's office and perform marketing and outreach to the CCCs. One has been involved with the CCC/LGP program since it began and the others have been involved for more than one and a half years.

Study respondents are also very involved in the decision-making process. The two campus representatives were the key decision-makers and were involved in getting CCC/IOU projects approved. The two representatives from the Chancellor's office were actively involved in promoting the program and helping to encourage CCCs to initiate energy efficiency projects on community college campuses.

The respondents from the Chancellor's office focus on identifying projects that offer energy savings and then make recommendations to the facilities committee at the CCC districts to get project approval. Then the projects are submitted to the utilities for their review process.

The program's marketing and outreach has increased substantially in the past few years through changes made in the program both by the utilities and the CCC system. At the CCC level, the Chancellor's office switched the marketing role from the CCC Foundation to directly within the Chancellor's office. This approach made it easier to invite key campus decision-makers to the table. The Chancellor's office also provided some "peer pressure" or "arm twisting" by helping CCCs and the CCC districts identify potential projects.

A second major changed, discussed more in the Program Representative Interviews, and was that each utility assigned specialized account representatives to work with these CCCs.

Decision-Making Process

The respondents indicated that the decision to proceed with projects under this program are made at the CCC or district level with the utility offering support with the project applications and paperwork. These projects are often part of a larger set of projects, which may be funded through local bond issues: 54 out of 72 districts have bonds for new construction and retrofit projects. The LGP projects are viewed as opportunities to incorporate energy efficiency into the project and take advantage of the program's focus and tie into the colleges long-range plans.

Project Process

Once the project is approved by the community college or college district, the utility reviews the calculations to determine energy savings, payback, and rebate amounts. The project scope is managed by the college and an engineering firm is hired to complete the project to meet the specific energy specifications. PG&E hires a separate engineering firm, Encor, to review the project energy savings calculations for each of its projects. However, ESCOs are not involved in these projects and are not viewed as viable partners with the CCC community.

Free-ridership

None of these respondents believes that free-ridership is an issue for this program. This is based on several key points:

- All CCCs have five year plans for campus improvements and many of them are in the midst of spending money from bond issues. The rebate is not a driver in this decision. In fact, one facilities manager reported that the project rebate was spent three-times over just trying to comply with the program's requirements and conditions. The projects selected for the program were not high priority or were not going to get completed without the program funding. Rather, the program funding identified and accelerated the completion of energy efficiency projects on CCC campuses and district buildings. These projects were accelerated between 12 to 18 months because of the rebate funding.

- The utility funding "makes the project more saleable to the facilities committee and it is great validation that the utility provides rebates."

As one respondent said, "There is absolutely no free-ridership in this program - the incentives help to get these projects on the radar - otherwise they would be ignored."

Areas for Program Improvement

Overall, the respondents were pleased with the program and the outreach efforts conducted by both the utilities and the Chancellor's office. However, there was some miscommunication at times with the campuses, which led to multiple data requests and created additional tension on overworked CCC staff. Another major issue was that the program funding cycle was not in-tune with the longer timeframes at the CCC level, which made it difficult to get large-scale projects through this program.

3.3 Summary of Interviews with Vendors

Two vendors who participated in the CCC/IOU LGP program (Encor and Kitchell) agreed to be interviewed. However, their roles were very different in terms of the support they provided the CCCs. Neither is involved in supporting colleges in their decision-making process.

Respondent Background

Encor conducts verification calculations for all PG&E partnership applications. They provide due diligence in reviewing the application to meet the requirement that a third-party vendor reviews the energy calculations for accuracy. Encor does not work on any specific project but conducts the verification of energy savings for both the UC/CSU and CCC programs. Verification of energy savings also ensures there is no double counting of energy savings from installing multiple projects on college campuses.

Kitchell provides on-site construction management support for several California Community Colleges including Solano Community College. However, they are not involved at all in the decision-making process.

Decision-Making Process

Neither vendor was involved in the decision-making process for the LGP projects. "The decision-making is made by the campus and the community colleges and one project is often tied into many others at these campuses."

Kitchell is not familiar with the program as they have not been directly involved. There has been a significant amount of staff turnover at Solano College; therefore, most of the current program staff has no experience with the projects installed during the 2006-08 timeframe.

Free-Ridership

"The partnership is super important in helping the community colleges make decisions on energy efficient improvements- every campus is different. CCCs don't have any much unity or resources to think about making the right changes for equipment improvements. I think a better gauge of free-ridership is to determine the age of the equipment that was replaced. But I do think the program does accelerate the installation of certain measures- like the Solano project has lots of VFDs installed and have a big wish list, but this is a good way to accelerate projects."

4 CCC NTG CALCULATOR

This section contains the NTG Calculator used to compute NTG ratios based on results from the Decision-Maker survey. As explained in the Introduction and Methods sections, these scores were then adjusted and weighted to compute the final NTG ratios.

The CCC LGP Program was evaluated using the case study method from the Standard Extra Large Customer protocol as developed by ITRON for use by all evaluators in the 2006-2008 program cycle. As explained in the standard language document for Large Non Residential Programs:

> "The Energy Division of the California Public Utilities Commission (CPUC) formed a nonresidential net-to-gross ratio working group that was composed of experienced evaluation professionals. The main purpose of this group was to develop a standard methodological framework, including decision rules, for integrating in a systematic and consistent manner the findings from both quantitative and qualitative information in estimating net-to-gross ratios."
>
> "The methodology described in this section was developed to address the unique needs of Large Nonresidential customer projects developed through energy efficiency programs offered by the four California investor-owned utilities and third-parties. This method relies exclusively on the Self-Report Approach (SRA) to estimate project and domain-level Net-to-Gross Ratios (NTGRs), since other available methods and research designs are generally not feasible for large nonresidential customer programs. This methodology provides a standard framework, including decision rules, for integrating findings from both quantitative and qualitative information in the calculation of the net-to-gross ratio in a systematic and consistent manner." [4]

To meet the requirements of the Standard –Very Large CPUC evaluation standard, Summit Blue staff reviewed the Program Implementation Plans (PIPs), available quarterly reports and campus Web sites. An executive interviewer completed interviews with four utility representative, six campus representatives and two vendors who were involved with the program but did not influence on-campus decision making. In addition, Summit Blue staff surveyed ten decision-makers who participated in the LGP program and who were previously selected for the on-site impact study. Decision-maker data was entered into the NTGR calculator to generate the calculated NTGR scores in the CCC NTG Calculator.

The calculated NTGR score is an average of the Timing and Selection, Program Influence and No Program scores. The survey questions and scores are presented in Table 4. One change was made to the algorithm to account for the following missed question: "When do you think you would have done this (installed the same energy efficient equipment)?" This question was collapsed with the following question on the number of months to installation of the same equipment. San Diego Community College and Saddleback Community College NTGR scores were calculated without the No Program score because of missing data. NTG ratios ranged from 0.44 at Butte College to 0.85 at San Diego Community College District.

[4] Large Nonresidential NTG Methods Language 110509, ITRON Consulting via email.

Table 4. Decision Maker NTG Scoring Worksheet

Scoring Category	Kern Community College	Diablo Community College	San Diego Community College District	Victor Valley Community College	Chabot College	Saddleback Community College	Cerritos Community College District	Butte College	Yosemite College	Cabrillo College
Timing and Selection Score	**10**	**10**	**10**	**10**	**9**	**10**	**8**	**6**	**10**	**10**
Please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.										
Age or condition of the facility ?	10		10	8	9	5	10	7	10	9
Availability of the program rebate	10		7	10	2	10	6		10	7
Information provided through program related feasibility study			9	8		7		5	10	
Information provided through program audit	6	10	9	8		7		5		
Information provided through other technical assistance provided through &PROGRAM	8	10	9	8		5		3		8
Recommendation from a vendor	1	10	10	8	9	8	10	2		6
VENDOR VMAX Score times Vendor Rec. score if Vendor Rec.>5	0	9	0	0	0	0	0	0	0	0
Previous experience with MEASURE	6	0	7	10	8	3	8	10		7
Previous experience with PROGRAM	0		8	10	1	3	9	7		
Information from UTILITY or program training course	6		10	5		5	8	6	10	7
Information from UTILITY or program marketing materials			10	7		3	8	5	10	7
A recommendation from an auditor or consulting engineer			10	8	9		8	2	10	6
Standard practice in your industry	0	10	10	10	8		5	9	10	6
Recommendation from PROGRAM staff	0	10	10	8	9		8	3	10	10

Scoring Category	Kern Community College	Diablo Community College	San Diego Community College District	Victor Valley Community College	Chabot College	Saddleback Community College	Cerritos Community College District	Butte College	Yosemite College	Cabrillo College
Endorsement or recommendation by UTILITY Account Rep	10		10	10			7	3		
Corporate policy or guidelines		10	10	10	8		7	9	10	6
Payback on the investment	10	8	10	10	9	10	10	8	10	8
Other, such as non-energy benefits	utility recommenda tion		now distict has a green policy in place so we have standard guidelines and business practice; more emphasis on renewables			we all like saving money			funded by state and being a good steward	
Importance of other factor	10							9		
Program Influence Score (reduced by half if learned after decision)	**10**	**5**	**8**	**2.5**	**4**	**4**	**5**	**1.5**	**2.5**	**5**
Did you first learn about the CCC Program BEFORE or AFTER you first began to think about implementing the measure ?	BEFORE	BEFORE	BEFORE	AFTER		AFTER	BEFORE	AFTER	AFTER	BEFORE
Did you learn about the program BEFORE or AFTER you decided to implement MEASURE?				AFTER	BEFOR E	AFTER		AFTER	AFTER	
The overall importance of the Program versus the most important of the non-program so that the two importance ratings total 10										
The overall importance of the CCC PROGRAM in your decision to implement MEASURE	10	5	8	5	4	8	5	3	5	5

Scoring Category	Kern Community College	Diablo Community College	San Diego Community College District	Victor Valley Community College	Chabot College	Saddleback Community College	Cerritos Community College District	Butte College	Yosemite College	Cabrillo College
The overall importance of other factors in your decision to implement MEASURE	0	5	3	5	9	2	5	7	8	5
No-Program Score	**4.00**	**5.00**	**10.00**	**7.14**	**7.43**	**10.00**	**5.71**	**5.71**	**7.14**	**8.57**
If the &PROGRAM had not been available, what is the likelihood that you would have installed exactly the same item/equipment	6	5	0	5	9	0	6	6	5	5
Number of months	48		24	24	36		18	18	24	36
NTGR SCORE =	**0.80**	**0.67**	**0.90**	**0.65**	**0.68**	**0.70**	**0.62**	**0.44**	**0.65**	**0.79**

5 CCC NTG CASE STUDIES

This section includes detailed Case Studies for the 10 different projects included in the Decision-Maker survey effort. Case Studies include background information on the campuses and projects, a description of each campus's decision-making process, an assessment of free-ridership (including results from the '2 Analyst' Assessment and the Collaborative Adjustment), and conclusions made for each project.

5.1 Butte College

Introduction

This case study documents the decision-making process Butte College used, based on interviews with the director of facilities, planning and management and more general insights from interviews with representatives from the LGP and the utility.

Campus Overview

Butte - Glenn Community College is a community college located in northern California between the towns of Chico, Oroville and Paradise. Butte College is a fully accredited two-year institution with educational facilities in Chico and Orland, and classes are offered in most of the District's communities. It was founded in 1968 and current has approximately 11,000 students enrolled and 1,100 employees.

The campus has a long-standing commitment to sustainability. It is located on a 928 wildlife refuge and has been recognized as a national leader in sustainability practices. The college has the largest solarized campus in the state as nearly 45% of the campus is energized with solar power. Butte College's goal is to become carbon neutral by 2015. It has 35 buildings on campus and a total of 630,000 square feet. (Source: http://www.butte.edu/)

Project Overview

Butte College could be described as an "early adopter," regarding energy efficiency programs. The college has a strong commitment to sustainable business practices, has developed a sustainable "green curriculum" and hosts sustainability conferences at its campus annually. Given the college's commitment to sustainability, the college did participate in a variety of energy efficiency projects as part of the LGP program. The college received $87,909 in incentives.

Butte College has installed energy efficiency measures including:

- Replace various size HVAC package units. Project was completed by 1/31/2008.
- Replace HVAC distribution and air handling systems (electric and gas). Project was completed by 1/31/2008.

- Replace chillers and install evaporative condensers. Project was completed by 1/31/2008.
- Lighting retrofit in the Library. Project was completed by 12/6/2008.

Description of Campus Decision-Making Process

Butte College has a strong commitment to sustainability practices on campus. They have a sustainability committee and incorporating sustainability goals is considered standard practice on this campus. They have invested in solar energy as part of their sustainability goals and have seen significant energy savings.

The facilities manager is the lead decision-maker for these projects; however, he also serves on the LGP Partnership and Management Team, so he was aware of the program and has submitted several projects for rebates. They use consultants such as Emcor and CEC to conduct the feasibility studies for these retrofits projects.

The facilities manager reported that it was a challenge to work with the utility, PG&E, and at times the process was disorganized. However, these projects were in the works already as part of the college's overall commitment to environmental sustainability. That situation has been improved with the assignment of program-focused utility representatives who know "you and your campus" and can work directly with the rebate process.

Another major factor in the decision to install these projects included shortened paybacks as a result of the rebates. Butte College uses both payback and life cycle costing to evaluate energy efficiency projects. The standard they apply depends on the project. They are currently considering a large LED lighting project.

Project Net to Gross Free-ridership Assessment

Deconstructing the low NTGR score of .44 tells an interesting story for Butte College. First, the program incentive was not rated as important in the 'Timing and Selection' score. The highest importance rating was provided by the decision-maker for Information from the utility or a program training course and that rating was a '6' on the '0' to '10' scale. 'Program Influence' was also rated quite low. First, the decision-maker rated the LGP Program a '3' compared to non-program factors. In addition, he reported that Butte College learned about the LGP Program after they decided to implement the occupancy sensors reducing the already low score of '3' in half to 1.5. The 'No Program' score result was a '6' based on a medium likelihood of installing the same chiller equipment without the program (score of '6') within 18 months.

According to the NTG calculator, this campus measure received a rating of 0.44, indicating it was a free-rider.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 agrees with this assessment based for the following reasons:

1. This campus had already made the decision to install energy efficient chiller as a way to achieve its sustainability goals.
2. The projects that received program rebates were already "in the works" and would have been completed without program funding. The rebate accelerated this decision by approximately 18 months.
3. The program was not the major factor in pursuing the chiller projects receiving an importance rating of '3' compared to other factors driving this decision.

4. The facilities manager reported learning about the qualifying measures and the program after already making the decision to install the new chiller.

Therefore, this chiller installation is a definite free-rider and the score of 0.44 is a fair assessment of the relative importance of the program compared to other factors.

Analyst 2 Analysis: Description and Justification of Analysis

The Butte Campus could be considered in the category of early adopter of energy efficiency and sustainability goals. For instance, they have received rebates on a lighting retrofit in the library, HVAC retrofits, hydronics (in-floor radiant heat), and they are in the process of changing out their transformer to achieve more energy savings in addition to the chiller project evaluated in this case study. They are also working on lighting upgrades inside and outside on other buildings and want to install energy efficient HVAC package units on three additional projects in the Life Science Building.

They have sustainability goals that are considered 'standard practice' on campus and have invested in a solar application that has been providing energy savings. They tend to have high free-ridership scores because they have planned projects that have flowed from the sustainability planning. Early adopters such as Butte College will generally have high levels of free-ridership and low NTGR scores because they represent what all the colleges and universities will be implementing as the program transforms the market. In our context, Butte College's low NTGR score for the chiller retrofit is regrettable; in the larger picture, when more campuses are acting like Butte College, there will be little need for the LGP Program in its current structure. There is no evidence to justify modifying the Butte College NTGR score of .44.

Collaborative Adjustments

Analyst 1 and Analyst 2 agreed that low NTGR score of .44 was justified by the situation at Butte College.

Summary Findings and Recommendations (Conclusions)

Early adopters can always be counted on to have a low NTGR score. They are far ahead of others in the planning for the adoption of energy efficient equipment and have sustainability goals that reduce the perceived influence of the incentive program. The positive aspect of the Butte College 'story' is that with more in-depth study the campus could be used as to market the program by highlighting the positive aspects of a high level of commitment to energy efficiency and sustainability goals.

5.2 Cabrillo College

Introduction

This case study documents the decision-making process for the Cabrillo college campus lighting project as well as more general insights from interviews with representatives from the LGP.

Campus Overview

Cabrillo College is a community college situated on the Monterey Bay in the county of Santa Cruz, California. It was established in 1959. It currently serves over 13,000 students. It is a fully accredited two-year college offering associate degrees and certificates in more than 70 fields of study. Classes can be attended at several locations including the main campus in Aptos; the Cabrillo College Watsonville Center in downtown Watsonville; and at several locations in downtown Santa Cruz. (Source: http://www.cabrillo.edu/)

Project Overview

Through its participation in the LGP program, Cabrillo College has installed a variety of energy efficiency measures including:

- Lighting retrofit (T8s). Project was completed by12/19/2008.
- DHW boilers replaced and energy efficient VSDs installed on the pool pumps for the swimming pool. Project was completed by 2/14/2008.
- Premium efficiency motor upgrade. Project was completed by 1/23/2009.
- Parking garage light retrofit and installation of occupancy sensors. Project was completed by: 12/19/2008.

These projects had about a five-year payback and the lighting retrofit and premium efficiency motor update projects were campus-wide. The college received $73,566 in incentives.

Description of Campus Decision-Making Process

The decisions at Cabrillo College are made in a “shared governance environment,” according to the facilities director. However, the outreach efforts from the Chancellor’s Office really helped Cabrillo College identify viable projects for this program. These projects were selected based on how they would help lower campus energy costs. The facilities director explained that he had bad experiences previously with “ESCOs cherry picking the low hanging fruit and that wasn’t in the best interest of the college.” So instead, these projects were selected because they offered excellent paybacks, and equipment that would be easily integrated with existing equipment on the campus. Moreover, the availability of the program rebate accelerated this lighting project three years.

The facilities director had learned about energy efficient technologies from PG&E prior to the launch of the LGP program. However, the availability of the program funding for these technologies made these installations including the lighting installation possible at this campus.

Cabrillo College has a payback requirement and also evaluates the lifecycle of the equipment before committing to a capital investment. Their payback requirement is about five years.

The rebate absolutely influenced their decision to install the energy efficient lighting. They did not have a campus policy on energy efficiency at the time of their participation in 2008, but have since adopted one.

Project Net to Gross Free-ridership Assessment

Cabrillo College received a NTGR score of .79 indicating it was a partial free-rider. This score was supported by a ‘Timing and Selection’ score of 10 based on the high importance of the recommendation from the program staff. However, the score was lowered because the importance of the program was rated a 5 compared to factors outside the program resulting in a 'Program Influence' score of 5. The decision-maker reported learning about the LGP Program before he began to think about installing the lighting. The 'No Program' score was '9'. The decision-maker only rated the likelihood of installing the same lighting equipment a '5' without the program. His timeframe for the lighting installation was within 3 years.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 believes this assessment based on an in-depth analysis of the interview findings from the energy decision-maker should be modified slightly.

1. The biggest factor in the decision to install the campus wide lighting retrofit was the recommendation from the program staff, receiving a '10' in importance rating.
2. The facilities manager was aware of the program even before the LGP program began, but the decision to install a new lighting was based on assistance from the utility staff as well as encouragement from the LGP staff at the CCC level. Therefore, it appears unlikely the college would have initiated this project on their own.
3. The decision to proceed was influenced by the rebate which accelerated the initiation of the lighting installation by three years.

The program certainly encouraged and even accelerated the installation of energy efficient lighting and other projects on this campus and, therefore, should be classified as a partial free-rider. However, the program importance was under-rated by the respondent given his other responses; a NTG rating of 0.83 would be more appropriate.

Analyst 2 Analysis: Description and Justification of Analysis

The LGP Program definitely influenced the decision-maker to overcome their concern about energy efficiency lighting retrofit programs based on their past experience. In addition, the decision-maker said the rebate was important in their decision to install the energy efficient lighting. However, he rated the importance of the program compared to other factors a '5'. Increasing this rating from '5' to '7' based on the decision-maker's comments about the importance of the LGP program increases the NTGR score from .79 to .85.

Collaborative Adjustments

Both analysts concluded the .79 NTGR rating should be increased slightly based on the perceived importance of the program in their decision to install energy efficient lighting. Changing the importance rating of the program form '.5' to '.7' increased the score to .85. This score was acceptable to both raters.

Summary Findings and Recommendations (Conclusions)

This adjustment can be attributed to the tendency of decision-makers to not think about the encouragement or, in some cases, pressure from the Chancellor's office as due to the LGP program. And, it is true that much depends on the historical political relationship between the Chancellor's office and the college. The bottom line for Cabrillo College is that they were influenced by the program incentive to install more lighting across their campus and that they were encouraged to do so by outreach from the Chancellor's Office.

5.3 Cerritos Community College District

Introduction

This case study documents the decision-making process for the central plant chiller plant retrofit on the Cerritos College campus as well as more general insights from interviews with representatives from the LGP.

Campus Overview

Cerritos College was established in 1955 and is located in Norwalk, California. It has 26,000 students and more than 1,000 employees. The campus has 35 buildings on 135 acres totaling 850,000 square feet.

Cerritos College serves as a comprehensive community college for southeastern Los Angeles County. Communities within the college's district include Artesia, Bellflower, Cerritos, Downey, Hawaiian Gardens, La Mirada, Norwalk, and portions of Bell Gardens, Lakewood, Long Beach, Santa Fe Springs and South Gate. Cerritos College offers degrees and certificates in more than 180 areas of study in nine divisions. Annually, more than 1,200 students successfully complete their course of studies, and enrollment currently averages nearly 23,000 students. (Source: http://www.cerritos.edu/).

Project Overview

As part of the LGP program, the Cabrillo College campus installed a new chiller plant. This was a comprehensive project requiring the removal of six existing chillers in buildings and then constructing a central plant with three new chillers to service the entire campus. The installation included digging trenching around each campus building and installing chilled water lines. The project was completed by 12/18/2008. Total incentives paid: $579,224. A few projects remain to be paid. The college is expecting to receive between $850,000 and $1 million in incentives, once all projects have been completed.

Other measures installed at Cabrillo College include:

- 18 hot water boilers were replaced. Project was completed by 12/31/2008.
- Lighting retrofit. Project was completed by 11/15/2008.
- 24 hood exhaust fan controls were added. Project was completed by 11/30/2008.
- PC network software was updated. Project was completed by 7/18/2008.
- CFL giveaway. Project was completed by 5/30/2008.
- Vending miser. Project was completed by 10/31/2008.

Description of Campus Decision-Making Process

The director of facilities learned about the LGP program through informational sessions and attending conferences. The decision to proceed with the installation of the new chiller was based on recommendations from the utility and CCC staff, the age of the current equipment and the energy savings associated with the new installation. However, the director of facilities was reluctant to proceed initially with this project.

"It is a real difficult project. I did this at another campus and it involves tearing up the campus. So we were going to have to do this project at some point, but the decision to proceed was concurrent with us finding out about the program funds. The availability of the funding really made us do it faster," he explained.

The project was approved by the Capital Outlay and Bond Committee. The project was not in the plan, but the payback and the energy savings made the technology attractive. They had an engineering firm evaluate the chiller technology. They were looking at substantial savings over time and rebates in the $800,000 to $1 million dollar range. The rebate definitely accelerated the timing of the project.

However; the project was in the works and would have been installed at some point based on the favorable payback and energy savings. The program was 'good timing' as they were going to retrofit this equipment soon. In addition, the project was recommended by the utility staff.

Project Net to Gross Free-ridership Assessment

The NTGR for Cerritos College is .62 indicating a partial free-rider. This decision-maker appears to be a tough rater. His highest 'Timing and Selection' score was '8' based on his answers to availability of the rebate, information provided through the feasibility study, information from utility or training course and the endorsement or recommendation by utility Account Rep. The 'Program Influence' score was rated a '5' by the decision-maker making it equally as important as other factors. The 'No Program' score was calculated as a '6'. The decision-maker was somewhat certain the he would have installed the same energy efficient chiller equipment with 18 months.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 disagrees with this assessment based on an in-depth analysis of the interview findings from the energy decision-maker. This rating should be adjusted higher to indicate it is a partial free-rider for the following reasons:

1. The facilities manager explained this chiller project was initiated based on a variety of reasons including energy savings, timing, and the availability of the rebates.
2. The rebates accelerated the project by 18 months, according to the facilities manager. This central plant chiller project was slated to be done eventually, but given the complicated nature of the project, the rebates helped to "accelerate the time-frame" according to the facilities manager.
3. While the program was not cited as a major influence on the decision, the recommendations from both the vendor and the program staff both received high importance ratings (i.e., :'10' and '8' respectively) suggesting that the program did play a role in the overall decision to install this chiller equipment.

Therefore, the NTG ratio should be adjusted upward slightly to better reflect the role that the program staff had in identifying and assisting with this central plant chiller project.

Analyst 2 Analysis: Description and Justification of Analysis

Cerritos College is in the midst of the five-year building expansion with at least one building under construction in 2008 and another building planned for 2009. In this situation, a low NTGR score is understandable. While the rebate was 'good timing' for the College and may have accelerated the central plant chiller installations, it is almost certain that this project was part of the five-year plan. Under these circumstances, there does not appear to be any reason to adjust the calculated NTGR score of .62.

Collaborative Adjustments

Analyst 1 and Analyst 2 disagreed slightly on how to interpret the NTGR score of .62 for the campus. Analyst 1 preferred to not adjust the calculation as the comments seemed to support the level of free-ridership. The NTGR score of .62 was not adjusted for the Cerritos Community College central plant chiller project.

Summary Findings and Recommendations (Conclusions)

When a community college is backed by the funding of a bond issue, the incentive is not large enough to do much more than move a planned project up in time or increase the scope of a planned or ongoing project. It seems that community colleges can be divided into two groups by their financial situation. Those with bond issues approved are by definition in a building mode and the incentives will be used for small projects or to influence the timing of project implementation. The LGP programs does not seem well-suited to be integrated with the larger building projects developed under the bond funding because of issues with length of the program cycle.

5.4 Chabot College

CHABOT
COLLEGE

Introduction

This case study documents the decision-making process for Chabot College, which is part of the Chabot-Las Positas Community College District. The findings from this case study are based on an in-depth interview with the project manager from Chabot College and insights from the utility partnership representative from this campus--the vice chancellor for facilities the Chabot College-Las Positas Community College District. Additional information was also provided in interviews with the utility representative assigned to this college campus and other representatives from the utility partnership management team.

Campus Overview

Chabot College is part of the Chabot-Las Positas Community College District was founded in 1961 and serves the San Francisco East Bay Area through its two colleges: Chabot College in Hayward and Las Positas College in Livermore. The district serves nearly 23,000 students and has more than 2,000 full time employees.

In March 2004, voters within the District's boundaries approved Measure B, the $498 million dollar Chabot-Las Positas Community College District capital improvement (construction) bond. This bond issue has funded significant retrofit and new construction projects at both college campuses.

Project Overview

Through the LGP program, the district retrofitted Chabot College with a new gas chiller plant. This project included installing piping for the entire campus to provide heating and cooling. This was an extensive project that affected every building on campus. The total price for this gas chiller installation and retrofit was $12 million; the college received a total of $750,000 in incentives.

To qualify for the program, the project had to be completed within a year- which escalated the cost by $3 to $4 million, according to the college officials.

Chabot College now has a “state of the art” gas fired chiller installed with the capacity to do both ice and thermal storage. This installation has led to significant energy savings. As the vice chancellor of facilities explained, “The project is hugely successful. We can heat and cool more efficiently and we know that it was "the right thing to do" from an environmental and occupant comfort perspective. There were so many good things that came out of it but we also had to trench the entire campus buildings and replace every line.”

Projects currently on hold as of mid 2008 at Chabot College include:

- Central plant – add high efficiency chiller
- Central plant – non-process boiler change/add (gas)
- EMS DDC – gas
- EMS DDC – HVAC controls
- EMS DDC – lighting controls

Description of Campus Decision-Making Process

Chabot Community College issued a major bond issue to renovate the campus and fund at least two new buildings. The boiler replacement was just one part of the larger building and retrofit initiative. The bond issue to build new buildings was the major driving factor for the campus-wide improvements and renovations but was not part of the LGP Program. Compared to the large amount of money available for investment through the bond issue, the LGP Program incentive was too small to be a driving factor in decision-making.

In fact, college district officials believe that this gas chiller project was installed due to pressure from the LGP partnership team. The vice chancellor was on the Partnership Management Team for three years and the CCC Chancellor’s Office wanted each member to install an energy efficiency project at their college. The vice chancellor of facilities said, “I don't think the Management Team or PG&E understood how big a project it was, but this was a major project at public facilities.”

Moreover, despite the complications of this project, the program required that the central plant gas chiller project follow the same timeframe as a simple lighting project.

"This was a three year project at least- with one year to design and two to build and we did it one year. The incentive wasn't worth it and we've burned the incentive three times over in trying to meet the project schedule set by PG&E," the vice chancellor said.

The district hired Southland Industries, a design-build firm, to prepare the scope of work and provide detailed specifications. However, the final decisions were made by the facilities office and the entire central plan chiller project was managed by campus personnel.

Energy savings was the major factor in the decision to install the chiller project, knowing that it had a relatively quick payback of four years. Other factors included the aging infrastructure on the campus and the district commitment to sustainability. While installing energy efficient boilers is not really standard practice at their campus, there is a sustainability program in place. They have made a sustainability commitment that all new buildings must meet the LEED silver or better standards.

As for the issue of free-ridership, the vice chancellor of facilities said that the program funding was not a primary driver for this decision. The LGP program funding accelerated this project. "We have lots of benefits from the project, but there is no free-ridership for this project at all," said the vice chancellor of facilities. The incentive did influence Chabot Community College to install the boilers sooner than they would have without the program.

Project Net to Gross Free-ridership Assessment

The NTGR score for Chabot Community College is quite low at .41 indicating a high level of partial free-ridership. This score can be traced to a low 'Program Influence' score and a low 'No Program' score. First, while the 'Timing and Selection' score is a '9' that is due to high ratings for recommendation from the program staff. The program rebate importance is rated a '2'. The 'Program Influence' score was a '1' indicating that other factors outside the program were more important than the program or the program incentive. For the 'No Program' score, the decision-maker indicated they would be very likely to install this same equipment within the next 12 months producing a "No Program' score of 1.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 ***strongly disagrees*** with this rating based on the additional information provided by the vice chancellor of facilities for this community college district. This net-to-gross ratio should be adjusted to 1.0 based on the following key findings:

1. The Vice Chancellor categorically stated this project was not a free-rider. He went on to explain that the incentive payment represented a small portion of the project cost, and this amount was spent three times over in trying to comply with the program requirements.

2. The project was selected for the LGP program due to pressure from the Chancellor's office. The project turned out to not be a good fit for the program and was much too ambitious to complete in the LGP's timeline.

3. The college has alternative funding available from its $438 million bond issue, therefore the incentive was not a driving factor in this decision. The energy decision-maker rated the importance of the incentive as a '2' in the decision-making process.

4. Although the energy decision-maker knew about the program before moving ahead with the project, this was because the vice chancellor was on the CCC partnership team.

Analyst 2 Analysis: Description and Justification of Analysis

Analyst 2 found support for *agreeing* with the calculating NTGR score. The decision-maker consistently said that the bond issue was the major driving force behind the new building construction and renovations. The boilers were aging and were due for replacement with or without the program. The energy efficient attributes of the new boilers were very attractive to the college. It seems very likely from the decision-maker's responses that the chiller equipment would have been replaced within a year without the program. In addition, Chabot Community College has a sustainability goal and the decision-maker serves on the committee and is very aware of this goal. All of this information available supports a low NTGR such that the estimated NTGR of .41 does not appear unreasonable.

Collaborative Adjustments

Analyst 1 strongly believed that the NTGR should be 1.0, while Analyst 2 believed the ratings for the central plant boiler installation supported the calculated NTGR rating of .41. The solution chosen was to bring in a third Analyst to mediate the disagreement between Analyst 1 and Analyst 2. He suggested that the number of months should be adjusted upward from 12 months to 36 months. The logic for this change was that if the project took the three years the Vice Chancellor believed it would have taken, and if the project was started one year later, it would be at least 36 months before any savings would begin to accrue to Chabot College. The change in months increased the NTGR from .41 to .58. Analyst 3 also pointed out that the Vice Chancellor, in rating the influence of the program a very low '1' compared to other factors, was not considering that the pressure that he was receiving from the Chancellors office and from the program champion within the Chancellor's office was due to the LGP program. Therefore, the 'Program Influence' score was increased from '1' to '4' to account for this factor. This change increased the NTGR from .58 to .68. Both Analyst 1 and Analyst 2 accepted this compromise as it was close to the simple average (.71) of the two original ratings of .41 and 1.00.

Summary Findings and Recommendations (Conclusions)

The Chabot College experience with the LGP Program during their central plant boiler project points to the problems that occur when political pressure from the utility and the Chancellor's Office leads to the implementation of a project that was too large and too disruptive for the time line of the program. The unrealistic three-year program cycle has been a recurrent theme throughout this study of University of California, California State University and California Community College Systems. Without a promise of continued funding or a more flexible program cycle, colleges and universities with larger projects such as this gas boiler retrofit will either choose to opt out of the program or will become disgruntled with the program and will reject further participation.

The Chabot College case study also illustrated the power of the case study method of analysis. While Analyst 1, who interviewed the decision-makers, and Analyst 2, who relied more on the NTGR calculation, originally provided very different views of the Chabot College NTGR score, Analyst 3 was able to provide a logical solution that provided an answer and a 'story' that satisfied all the analysts.

5.5 Diablo Valley College

DVC

Introduction

This case study documents the decision-making process for the LGP projects installed at the Diablo Valley College (DVC). The findings from this case study are based on in-depth interviews with the facility manager for the CCC district as well as interviews with the utility representative assigned to this college campus; and more general insights from interviews with representatives from the LGP.

Campus Overview

DVC serves more than 22,000 students. The college officially began in 1949 and was called East Contra Costa Junior College. The college moved to its Pleasant Hill site in 1952, in ten steel buildings acquired from the government for $45 each. It was renamed Diablo Valley College in 1958. The main campus is in Pleasant Hill, California while the San Ramon Valley Campus in Dougherty Valley opened in November 2006. DVC also has a center in downtown Walnut Creek.

DVC is part of the Contra Costa Community College District, one of the largest multi-college community college districts in California and serves approximately 62,000 students (Source: http://www.dvc.edu/index.htm).

There are more than 100 buildings on campus which represents about 1.5 million square feet. The college has more than 500 employees.

Project Overview

As part of the LCP program, the Contra Costa Community College district completed energy efficiency upgrades on its Diablo Valley College campus. The college received $125,339 in incentives.

Diablo Valley College's projects through the LGP program included a variety of measures which were completed by 10/24/2007:

- Lighting retrofit
- Network PC power management and CRT monitor upgrade
- Vending machine controllers
- Walk-in freezer controls

Description of Campus Decision-Making Process

The respondent was the chief facilities officer for the Contra Costa Community College District. However, he indicated that there had been a lot of staff turnover during the past few years, and therefore was not familiar with all of the projects instituted at these college campuses.

The decision-maker indicated that this particular lighting retrofit project was identified as part of a larger energy audit conducted by Chevron, an Energy Services Company (ESCO). This audit identified several other projects including a solar panel project, primary voltage upgrade and the installation of additional compressor-controllers in the heating, ventilation, and air conditioning (HVAC) systems.

The decision to complete these projects was based on a favorable Return on Investment (ROI) calculation. Without the program they would have installed standard rather than energy efficient lighting.

Currently, there is no formal policy in place directing the colleges in this district to install energy efficient lighting equipment.

Project Net to Gross Free-ridership Assessment

Calculator Results

The 'Timing and Selection' score is '10' based on the importance of the information provided through the feasibility study, the technical assistance provided by Chevron and support from their utility representative. The campus decision-maker gave a 'Program Influence' score of '5'. He said that other factors outside the program were as important as the influence of the program in their decision to install the energy efficient lighting. Using the substitute question for the action that would have been taken without the program, results in a No Program score of '5'. The NTGR ratio under these conditions is .67 which classifies this lighting project as a partial free-rider.

Analyst 1 Analysis: Description and Justification of Analysis

The assessment of this project as a partial free-rider is consistent with the findings from the decision-maker surveys. However, given that both the utility staff and the members from the CCC partnership pointed out that most CCCs have long-term plans for installations, this rating is appropriate. This analysis is based on the following:

1. The decision-maker said that this project was identified by a vendor rather than internally, suggesting that the campus was not considering lighting projects independently.

2. The project was "in the works" and the decision-maker knew about the program "before" he started working on the lighting project.

3. The decision-maker rated the importance of the program a '5,' suggesting that the program was not a primary driver in this decision.

In this case study, it appears that the decision to install the energy efficient lighting was driven more by other factors than the program and, therefore, this is an example of a partial free-rider.

Analyst 2 Analysis: Description and Justification of Analysis

The decision-maker did not elaborate on the details of the decision. He did not rate the rebate as important but gave high scores to the information from the audit and the technical assistance provided by the program. The decision-maker's emphasis on non-program influences such as Chevron led to a low program influence score. Incorporating the rating for the action that would have been taken in the absence of the measure also lowered the 'No Program' score. In addition, the decision-maker indicated they would have installed standard lighting without the program but also said that energy efficient lighting was their standard practice. Analyst 2 suggested accepting the NTGR rating of .67 for this program without adjustment.

Collaborative Adjustments

Both analysts agreed that the calculated score of .67 was a fair assessment of the NTGR estimate for Diablo College LGP program.

Summary Findings and Recommendations (Conclusions)

While the decision-maker at Diablo College was somewhat influence by the LGP program, many factors contributed to their somewhat low NTGR score. As energy efficient lighting becomes more likely to be considered 'standard practice' by campus decision-makers, NTGR scores for lighting programs can be expected to decrease across the program. Some decision-makers reported an incentive equal to one-half the cost of the lighting project. As the market moves and energy efficient lighting becomes standard practice in more campuses across the state– because of the LGP program and other environment factors - it may be advisable to decrease the lighting incentive.

5.6 Kern Community College District

Introduction

This case study documents the decision-making process for the LGP projects installed at the KCCD. The findings from this case study are based on in-depth interviews with the facility manager for the CCC district as well as interviews with the utility representative assigned to this college campus; and more general insights from interviews with representatives from the LGP.

Campus Overview

Kern Community College District (KCCD) serves communities over 24,800 square miles in parts of Kern, Tulare, Inyo, Mono, and San Bernardino counties through the programs of Bakersfield College, Cerro Coso College and Porterville College. It is governed by a locally elected Board of Trustees. KCCD is geographically one of the largest community college districts in the United States, serving 26,000 students. The Kern Community College District was established as a separate entity in 1968 but educational services have been provided to residents for many years: at Bakersfield College since 1913; at Porterville College since 1927; and in the Ridgecrest area since 1951 (Source: http://www.kccd.edu/Default.aspx).

There are a total of 35 buildings on these three campuses and the campuses have more than 500 employees.

Project Overview

Through the LGP program, Kern Community College District installed a variety of energy efficiency measures in three campuses. This was a $125,000 project that involved installing energy efficient lighting and occupancy sensors in all 35 buildings on campus. According to the energy manager, this entire project was managed by the utility representative from Pacific Gas & Electric (PG&E) in conjunction with the lighting vendor-Staples. The College received $5,054 in incentives thus far.

Projects at the Bakersfield College campus:

- Cool roofs on two buildings. Projects completed by 12/31/2008.

Projects in progress/currently on hold at the Bakersfield College Campus:

- Retrofits and upgrades, including: installation of occupancy sensors, installation of VSDs on AHUs, replace 50- and 100-ton chillers, replace T12 lighting with T8, Upgrade EMS systems-HVAC and Lighting.
- Campus-wide lighting upgrade.
- Vending machine controllers.
- Server virtualization.

Projects at the Cerro Coso Community College campus:

- CFL Giveaway. Project was completed by 5/30/2008.

Projects at the Porterville College campus:

- Vending miser. Project was completed by 11/30/2008.

Description of Campus Decision-Making Process

The project was a campus wide direct install lighting retrofit and occupancy sensor project performed by the lighting vendor. PG&E contacted the vendor directly and worked with the vendor during the project, which was based on the utility's recommendation. According to the energy manager, this entire project was managed by the utility representative from Pacific Gas & Electric (PG&E) in conjunction with the lighting vendor-Staples. As the facility manager said, "It was the utility recommendation. They identified the project and really helped us with it. We believed them. They have credibility."

The payback for this project was very short, less than four years with the program funding. However, this campus-wide retrofit "would have taken a lot longer without the program if we had done it building by building," according to the facility manager.

At the time of this project, the KCCD did not have any formal policies in place but do have a general policy encouraging energy efficient improvements. An energy efficiency policy is currently being developed by the district.

The facilities manager also reported that there was no spillover as a result of this project. Nothing additional has been installed except those projects funded through the partnership.

Project Net to Gross Free-ridership Assessment

Calculator Results:

The decision-maker reported the age or condition of the facility and the endorsement of the utility representative and the payback were very important in the 'Timing and Selection' score resulting in a score of 10. He learned about the program before he made the decision to install the campus wide lighting retrofit and rated the importance of the program a '10' in his decision to implement the project, resulting in a 'Program Influence score' of '10'. The decision-maker also indicated the projects would not have been done for about 10 years but the rating of '6' on what would have been done without the program resulted in a 'No Program' score of '4'. The final NTGR score was .80 indicating that this customer is a partial free-rider.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 agrees with this assessment for several reasons:

1. The facility manager said the project was identified and managed by the utility rather than initiated on its own.

2. The facility manager said that without the program the campus wide lighting project "would have taken a lot longer."

3. The **vendor** had absolutely no influence on the decision, with the respondent rating this '1' in importance, even though it was a direct install project.

4. The decision-maker rated the importance of the **program** a '10' meaning that was the key driver in the decision to install this lighting. While other factors were also important, the major reason for installing this campus wide lighting project was the LGP program.

Based on these findings as well as the additional insights from the utility and partnership representatives, this project is clearly not a free-rider and the rating of .80 should stand.

Analyst 2 Analysis: Description and Justification of Analysis

The decision-maker worked closely with their assigned utility representative to develop this campus wide lighting and occupancy sensor project. While the lighting would have been replaced eventually, the decision-maker reported it would have taken 10 years to implement the changes on an incremental basis. The decision-maker gave both the program rebate and the utility representative an importance rating of '10'. Therefore, Analyst 2 concludes there is no logical reason to reduce or increase the NTGR score of .80.

Collaborative Adjustments

Analyst 1 and Analyst 2 agreed that there were no logical reasons to modify the NTGR score of .8 for Kern Community College.

Summary Findings and Recommendations (Conclusions)

The utility representative is an important actor in the LGP Program, especially for community colleges. Some of them need a fair amount of support and encouragement to identify a qualifying project, choose a vendor and manage the project implementation. Vendors can also be instrumental in encouraging program participation and implementing the measures, although that was not the case here and is generally not the case for the CCC LGP Program.

5.7 Saddleback College

SADDLEBACK COLLEGE

Introduction

This case study documents the decision-making process for Saddleback College. The findings from this case study are based on in-depth interviews with the director of facilities, maintenance, and operation for the college, interviews with the utility representative assigned to this college campus and more general insights from interviews with representatives from the LGP.

Campus Overview

Saddleback College was established 1968 in Mission Viejo, California on 200 acres. It has approximately 1,200 full-time staff members and total enrollment is 43,000 students. It is part of the South Orange County Community College District which includes Saddleback College, Irvine Valley College, and the Advanced Technology & Education Park (ATEP). The college offers Associate Degrees and Certificates in over 75 fields.

Project Overview

For the LGP program, Saddleback College received $439,175 in incentives. The College has installed a variety of energy efficiency measures, including:

- Added a new 364 ton absorption chiller to its central plan and also installed heat recovery system to capture waste heat from cogeneration. Project was completed on 11/15/2008.
- Added VFDs to 25 AHU at various campus buildings. Project was completed on 11/15/2008.
- Central plant loop pumps – remove impellers on building pumps to reduce resistance. Project was completed on 11/15/2008.
- Piping modifications to allow cogeneration system to heat pool water and reduce gas consumption. Project was completed on 11/15/2008.
- VFDs on return fans. Project was completed on 12/9/2008.

Description of Campus Decision-Making Process

The facilities manager was the project lead for this chiller retrofit installation and was responsible for making the decision and managing the process. He also participated in the Partnership Management Committee for the program, so he was aware of this program.

The project was identified by an ESCO, Cal Power, who helped the college put the plan together to make these installations and improvements. However, the major reasons for pursuing this project were to realize the energy and financial savings from operating more efficient equipment.

"We all like saving money," the facilities manager said; the project had a payback of less than four years.

Project Net to Gross Free-ridership Assessment

The Saddleback Community College NTGR score was dependent on the 'Timing and Selection' score and the 'Program Influence' score. The 'No Program' score was not included in the calculation because of missing data. The 'Timing and Selection' score was rated a '10' based in the importance of the availability of the rebate. The 'Program Influence' score reduced the NTGR significantly. While the decision-maker gave the influence of the program a rating of '8' compared to other non- program factors, he also indicated the decision to implement the project was made before he heard about the LGP Program. This reduced the 'Program Influence' score by half to a rating of '4'. The NTGR result for Saddleback County Community College was .70 indicating it was a partial free-rider.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 agrees with this assessment based on an in-depth analysis of the interview findings from the energy decision-maker.

1. The decision-maker said the major drivers for this decision were the financial and energy savings as well as the short payback, suggesting that this decision was not purely based on receiving a rebate from the program.
2. The most important factors in the decision according to this respondent were the program rebate and the payback, each receiving an importance rating of "10."
3. The utility staff was active in assisting the college complete the necessary paperwork. However, the importance of the overall program in motivating this respondent to participate was not the major decision-point, with the respondent indicating that this program was not as important to his decision as other factors.
4. Overall, it appears that this program had some influence on this decision, but other factors were more important.

Therefore, this rating of .070 as a partial free-rider is appropriate.

Analyst 2 Analysis: Description and Justification of Analysis

The decision-maker at Saddleback County Community College was very clear that his campus is motivated by energy savings and program incentives such as those provided by the LGP Program. However, in this particular chiller retrofit project, the decision-maker had decided to install the new chiller before he knew about the program. Therefore, the program would have had limited impact on his decision to install the new chiller equipment; for instance, the new chiller may be more efficient that the chiller originally planned. It is not clear because of the missing data if Saddleback Community College would have installed the same energy efficient chiller or not. If this data were available, a case could be made for increasing or decreasing the score based on that information. Under the current circumstances, the .70 NTGR score should remain unadjusted for this project.

Collaborative Adjustments

Both analysts agreed that the program had some impact but that other factors were important in the decision to install the chiller and the .70 NTGR score should remain unadjusted.

Summary Findings and Recommendations (Conclusions)

Saddleback College illustrates the problem that causes many of the community colleges to be partial free-riders. Even though they may say the rebate and the payback were important and that the program was more important than other factors in their decision, the decision to implement the project was made before the decision-maker was aware of the program rebate. With slashed maintenance budgets and a sluggish economy (in 2008), it may be inevitable that many planned projects will be partially funded by with LGP dollars.

5.8 San Diego City College

Introduction

This case study summarizes the decision-making process used to implement a lighting retrofit at San Diego City College, one of three colleges that are part of the larger San Diego Community College District. The findings from this case study include an analysis of the key campus energy-decision-maker, the director of facilities.

Campus Overview

The San Diego Community College District serves approximately 100,000 students each semester through three two-year colleges and six Continuing Education campuses on three college campuses: San Diego City College, San Diego Mesa College, and San Diego Miramar College. San Diego City College is a public, two-year community college administered by the San Diego Community College District.

The San Diego Community College District is governed by its five-member, locally elected Board of Trustees and three student members. The District is in the midst of $1.5 billion in new construction and renovations at the three colleges and Continuing Education campuses throughout the city (Source: http://www.sdccd.edu/public/district/).

The San Diego Community College District operates approximately 167 buildings on its campuses totaling more than 2.4 million square feet. The college has more than 5,000 employees.

Project Overview

The San Diego Community College District participated in several projects with the Local Government Partnership during the 2006-08 funding cycle.

Projects completed (11/15/2007) at San Diego City College campus, receiving $120,097 in incentives:

- Install 3 New Turbocor Chillers (G Bldg Excluded)
- Exterior Lighting Controls
- Retrofit 2 existing Weul-McLain boilers with one new high efficiency P-K boiler
- Exterior Lighting Controls
- Mid City Bldg. Thermostat Management and EMS Upgrade
- Parking Garage Lighting Upgrade (MH150 to F28T8)

Project on hold:

- Lighting retrofits and occupancy censors

Projects completed at the San Diego Centers for Education and Technology campus, receiving $17,146 in incentives:

- Exterior Lighting Controls
- Replace grid welding system with new high efficiency welders.

Projects completed (11/15/2007) at San Diego Mesa College campus, receiving $87,240 in incentives:

- G-100 Chiller conversion to Turbocor
- L-100 Boiler Replacement
- LRC Chiller Conversion
- Exterior Lighting Controls

Projects completed (11/15/2007) at San Diego Miramar College campus, receiving $61,105 in incentives:

- Admin Bldg Chiller conversion to Turbocor.
- High Efficiency Motor Upgrades
- Replace old boiler with high efficiency.
- Exterior Lighting Controls.

Description of Campus Decision-Making Process

The San Diego College District has completed 10 to 15 projects as part of the Local Government Partnership since the beginning of the program cycle in 2006. The lighting retrofit project was done based on a recommendation from its Energy Service Company (ESCO). However, the District identified other projects including a high efficiency boiler installation.

The lighting project was considered a "no brainer" by the District was looking for ways to save energy. The incentive covered about half of the project cost and that was a major factor in the decision. With the incentive, the lighting project had a payback of two years and would not have been done at all. The facilities manager explained,

> "We are always having people coming and telling us to save energy; finally got to the point for lighting where it is a no brainer"

The boiler installation was part of the long-term plans for the District. The District would have to replace the boiler at some point because of safety issues. The boiler project was funded through a combination of the project incentives as well as "on-the-bill" financing which provides funding for up to 10 years.

Another factor which influenced the decision to install these measures included the District's new green energy policy which places more emphasis on renewable energy.

Project Net to Gross Free-ridership Assessment

The 'Timing and Selection' score was rated a '10' from information from a utility program training course, information from program marketing materials, a recommendation from program staff and endorsement or recommendation by utility program Account Representative. Although not included in the algorithm, the decision-maker for San Diego Community College also rated the importance of the vendor a '10'. Compared to other factors, the decision-maker provided a Program Influence score of '7'. He indicated that he would not have installed the same equipment without the program and said that he learned about the program before he decided to install the energy efficient lighting. A rating of '0' on this question gave him a "No Program' score of '10'. According to the Net-to-Gross Calculator, this project received a NTGR rating of 0.85, indicating this campus was a partial free-rider.

Analyst 1 Analysis: Description and Justification of Analysis

Based on the information provided by the key energy-decision-maker regarding the project details, this rating is appropriate. It is very unlikely this college district was a free-rider for the following reasons:

1. The lighting project ***would not*** have been completed without the program incentives, according to the energy decision-maker.
2. The District is focusing on larger projects as part of its overall bond issue and therefore these projects were lower priority and would not have been completed without this program.
3. The lighting project timing was accelerated by two years because of the program according to the energy decision-maker.
4. While there were other factors that may have played a role in the decision, these received a rating of only "3" in importance, while the program received an importance rating of "7."

Analyst 2 Analysis: Description and Justification of Analysis

The high NTGR score of .85 is certainly supported by the decision-maker's comments. Here is one case where it is clear the vendor was an important player in the decision-maker process. Without information from the vendor, it is impossible to know for certain that the vendor was promoting the program. However, it looks like the importance of the program was rated lower in the 'Program Influence' score because of the role the vendor played in the decision to install the energy efficient lighting. A change in importance rating from '7' to '8' would raise the NTGR score to .90. Therefore, because of the influence of the utility representative and his relationship with the vendor is facilitating the installation of the lighting, it is reasonable to increase the San Diego Community College score to .90.

Conclusion

The two analysts agreed that a high NTGR score was reasonable for San Diego Community College although for slightly different reasons and suggest a final NTGR of .90.

Summary Findings and Recommendations

For San Diego Community College, the Analysts recognized the importance of relationships between the community college, the utility representative assigned to the LGP Program and the vendors who serve and support community colleges. The assignment of utility representatives responsible for encouraging program participation and supporting colleges throughout their program participation has successfully increased program participation on many campuses. It was a mid-course change program change that was particularly successful with a group of customers many of whom did not previously enjoy a close relationship with a utility representative.

5.9 Victor Valley Community College District

Introduction

This case study documents the decision-making process for the Victor Valley Community (VVC) College District. The findings from this case study are based on in-depth interviews with the facility manager for the CCC district as well as interviews with the utility representative assigned to this college campus; and more general insights from interviews with representatives from the LGP.

Campus Overview

Victor Valley College serves approximately 10,000 students in the high desert region of southern California. In the past few years the college has undergone a growth spurt including the additions of a new library and resource center, a multifaceted science building adjoined by a high tech planetarium, a main gym, a construction technology complex, and a student activity and community conferencing center. The college offers Associate Degrees in 40 fields of study.

This district includes Victorville, Hesperia, Apple Valley, Phelan, and Adelanto. The 253-acre campus started construction in 1963 and was opened to students in 1965. There are approximately 1,000 full time staff members. The district operates 44 buildings with 380,000 square feet.

Project Overview

The VVC District completed several projects through the LGP. These projects included a campus-wide lighting retrofit and the upgrades of its cooling system and work on its mechanical systems. The campus replaced two cooling towers. Overall, the projects totaled more than $600,000 of which the college received 379,153 in incentives.

Specific measures installed at the Victor Valley College campus include:

- Add Buildings to Central Plant. Project completed by 6/26/2007.
- Demand Control Ventilation. Project completed by 6/26/2007.
- Retrofit T-8 to G4-T8. Project completed by 9/24/2007.
- Central Plant Upgrades. Project completed by 5/1/2008.

Description of Campus Decision-Making Process

Victor Valley College has an agreement with Chevron Energy Solutions in which the Energy Services Company (ESCO) will install a variety of energy efficient projects on campus. These projects include a complete upgrade of the Central Plant, a new energy management system, a new computerized irrigation system, and heating and ventilation improvements in several campus buildings. These projects also included mechanical upgrades and complete change-out of air distribution equipment, and lighting upgrades in every campus building.

The college hired Chevron Energy Solutions to implement specific projects but the energy decision-maker made the determination of what to pursue. According to the project manager, the LGP program encouraged the college to complete these efficiency projects. “We didn’t have the money without the program,” the decision-maker said. He added that the utility, Southern California Edison, worked closely with the college and helped them with the installation process.

The campus decision-maker said that while the retrofit and improvements to the central chiller plant would have been installed “eventually,” the college was able to install “lighting in more places” than originally planned. Payback was an important aspect of the decision making process and the payback for this lighting project was very favorable. He added, “We never would have done the entire campus” without the program but rather would have just made installations where it “made sense.”

Project Net to Gross Free-ridership Assessment

The Victor Valley decision-maker achieved a ‘Timing and Selection’ score of ‘10’ by scoring the importance of the program rebate and the recommendation of the utility representative a ‘10’. However, the ‘Program Influence’ score was ‘0’ because he rated the program as unimportant compared to other factors and indicated that he had heard about the program after the chiller project was planned. In addition, he was fairly certain he would have installed the same energy efficient equipment chiller within two years and had a ‘No Program’ score of ‘7’. The NTGR score was .57 indicating the project was a partial free-rider.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 disagrees with this assessment based on an in-depth analysis of the interview findings from the energy decision-maker.

1. The decision-maker said the program played a major role in the decision to complete the chiller project and this project would not have been completed without the program.
2. The decision-maker also indicated that the program accelerated this installation by 24 months.
3. He rated the availability of a rebate and the influence of a program representative both a rating of ‘10’.

4. However, the program was not the key driver in this decision, specifically because he did not think about this chiller project until after learning about the program.

Therefore, Analyst 1 believes that the net-to-gross ratio should be adjusted to .75 to more accurately reflect this project as *a partial free-rider*.

Analyst 2 Analysis: Description and Justification of Analysis

The decision-maker learned about the program after the central plant chiller project was planned. They qualify as a partial free-rider because they installed an energy efficient central plant chiller earlier than planned. In addition, the incentive was important in their decision making and the decision-maker worked closely with their utility representative to design the chiller project. Because of the importance of the rebate and the level of support of the utility program representative, a reallocation of the importance of the program and the incentive compared to other factors was changed from '0' for the program and '10' for other factors to a score of '5' for the program and '5' for other factors. This increased the NTGR from .57 to .65.

Collaborative Adjustments

The two analysts agreed that the NTGR should be increased but disagreed on how much the increase should be. Analyst 1 argued the NTGR should be increased to .75 and Analyst 2 argued the NTGR should be increased to .65. The two analysts agreed that the respondent may have misunderstood the question and that a change from '0' program influence to '5' program influence was justified. Therefore, they agreed to increase the NTGR from .57 to .65.

Summary Findings and Recommendations (Conclusions)

At Victor Valley Community College, the chiller project NTGR is firmly in the partial free-rider category (.65) even after the adjustment was made. The utility representative was an important influence at Victor Valley College. The importance of this program change – assigning more utility representatives to encourage program participation - cannot be under estimated as community college facilities staff are not trained to identify energy efficient projects and have neither the time nor inclination to oversee their implementation.

5.10 Yosemite Community College District

Introduction

This case study documents the decision-making process for Yosemite Community College District as well as more general insights from interviews with representatives from the LGP.

Campus Overview

Yosemite Community College District (YCCD) includes two colleges: (Modesto Junior College and Columbia College) and a Central Services unit. The District covers a 4,500 square mile area and serves a population of over 550,000, encompassing all of two counties (Stanislaus and Tuolumne) and parts of four others. Annual enrollment is 16,900 students and the district has 1,500 employees and an annual budget of $125 million (Source:http://www.yosemite.edu/externalaffairs/district.htm).

In November 2004, voters in the Yosemite Community College District approved a $326 million general obligation bond for the repair, upgrade and new construction of Modesto Junior College and Columbia College facilities and the expansion of college educational sites in Patterson, Oakdale, Turlock and Calaveras County.

Project Overview

YCCD has not yet completed any projects through the LGP program. This is mainly because the only eligible projects are for natural gas improvements, since the campus receives its electrical service from municipal providers. The campus is currently investigating installing a boiler and steam trap replacement at its Modesto Junior College campus. The project will replace the existing boiler on the Modesto Junior College's East Campus. The College District has not received any incentives yet.

Description of Campus Decision-Making Process

This college district was encouraged to apply for program funding from both PG&E and also from the LGP Partnership Management Team. He explained, "My boss told me to go find something and Dan Estrada (from the Chancellor's office) provided some encouragement."

The facilities manager made the decision to pursue the stream trap replacement gas project and has initiated the application with PG&E. A major factor driving this decision was the fact that utility expenses are paid out of the general fund, so any activity that helps reduce energy costs is "green lighted," according to the facilities manager.

The district worked with both an architectural and engineering firm to identify potential projects that would qualify for the program. However, the district does not have a formal policy in place regarding the energy efficiency installations but they are committed to meet Title 24 standards.

Project Net to Gross Free-ridership Assessment

The NTGR score for Yosemite College is .60 indicating they qualify as a partial free-rider. Their 'Timing and Selection' score is '10' based on the importance of the availability of the rebate, information provided by the feasibility program, information from the utility or a training program, information from utility training materials, and recommendation from program staff. However, the NTGR score was reduced significantly because of a 'Program Influence' score of 1. This low score occurred because the decision-maker rated the importance of the program a '2' on the 0 to 10 importance scale. He also indicated that he learned about the program after he had decided to implement the measure. His 'No Program' score was '7' based on a medium level of likelihood, a score of '5' that he would have installed the same technology within two years.

Analyst 1 Analysis: Description and Justification of Analysis

Analyst 1 disagrees with this assessment for the following reasons:

1. The district has been pressured to participate in this program from the utility staff and LCP outreach staff. The district would not have pursued the boiler and steam trap replacement project "on their own" without the program or the availability of project funding.
2. The types of eligible projects for this district are limited to gas measures, which make it more difficult to identify and initiate projects on their own. The program information and resources were the catalysts for trying to identify measures like the boiler and steam trap replacement project that would qualify for program funding.
3. The district has its own funding available, through its $326 million bond issue, and, therefore, is capable of funding many energy efficient initiatives on its own. However, the district has not yet developed a formalized process for identifying measures that exceed Title 24 measures, and are unlikely to do so without program guidance and funding.
4. The major drivers for the district's decision to participate in this program, based on the importance ratings in the NTG calculator are the: age of the current equipment, availability of the program rebate, information from the utility staff, and program outreach and marketing, all of which received a '10' in importance.

Therefore, the NTG ratio should be adjusted to at least .75, indicating this may be a partial but not complete free-rider.

Analyst 2 Analysis: Description and Justification of Analysis

This low NTGR score of .60 (and high free-rider score of .40) is justified because this decision-maker was basically told to find a project that would qualify Yosemite College to participate in the LGP Program. He was supported by the President of the College. The lack of importance that he placed on the LGP Program compared to other factors significantly reduced Yosemite College's NTGR score as did his admission that he heard about the program after he had decided to implement the project. The NTGR score of .60 appears to be justified by the factors leading to program participation for the boiler and steam trap replacement project.

Collaborative Adjustments

Analyst 1 and Analyst 2 disagreed on the interpretation of the NTGR data for Yosemite College. Analyst 1 argued for increasing the NTGR score from .60 to .75 to decrease the amount of free-ridership while Analyst 2 interpreted the NTGR ratings to justify the current rating of .60. The joint conclusion was to adjust the NRGR score because the college decision-makers appeared unqualified to identify program-qualifying gas measures on their own, especially less common measures such as the boiler and steam trap replacement project found in this case, without the aid of the utility or a vendor knowledgeable about the LGP program. Analyst 1 and Analyst 2 agreed to increase the 'Program Influence' score from a rating of '2' to a rating of '5' resulting in a final NTGR score of .65.

Summary Findings and Recommendations (Conclusions)

The Yosemite College experience with the LGP Program points to the problems that occur when political pressure from the utility and the Chancellor's Office leads to the implementation of a project that was too large and too disruptive for the time line of the program. The unrealistic three-year program cycle has been a recurrent theme throughout this study of University of California, California State University and

California Community College Systems. Without a promise of continued funding or a more flexible program cycle, colleges and universities with larger projects such as this boiler and steam trap replacement retrofit will either choose to opt out of the program or will become disgruntled with the program and will reject further participation.

LGP EVALUATION REPORT APPENDIX G:
CCC PARTNERSHIP EVALUATION SITE REPORTS

A. California Community Colleges Partnership Evaluation Site Reports
    a. Cross Campus Measurement of Lighting Run Hours
        i. PGE2018 - Diablo Valley College - Lighting Retrofit
        ii. PGE2018 - Evergreen Valley College - Occupancy Controls for Lighting and HVAC
        iii. PGE2018 - Laney College - Lighting Retrofit
        iv. PGE2018 - San Jose City College - Install Occupancy Sensors to Control Lights/HVAC
        v. SCE2526 - Monterey Park - Lighting Retrofit
        vi. SCE2526 - Victor Valley College - Retrofit T-8 to G4-T8
        vii. SDGE3001 – Mira Costa College - Lighting Retrofit
    b. SCE2526 - Cerritos College - Replace Existing Package Units with Central Plant
    c. SCE2526 - Fullerton College – Replace Campus Cooling Equipment with Central Plant
    d. SCE2526 - Long Beach City College – Liberal Arts College Central Plant Conversion
    e. SCE2526 - Long Beach City College - Pacific Coast College Central Plant Conversion
    f. SDGE3001 - Saddleback College - Add New Absorption Chiller to Central Plant
    g. SDGE3001 - San Diego Miramar College - Replace Boiler

CROSS-CAMPUS M&V REPORT FOR MEASUREMENT OF LIGHTING HOURS OF USE AT CCC CAMPUSES

NOVEMBER 2009

PART A: SUMMARY INFORMATION

A-1.1 Project Information

Utility Service Territory	PG&E, SCE, SDG&E, SoCalGas
Program Numbers	PGE2018-SCE2526-SDGE3001-SCG3518
ADM Sample ID &Project ID	
Customer Name	
Site Name	
Site Address	
Site Type	Community Colleges
Customer Business/Product	Community Colleges

This report describes the procedures used to gather data on operating hours for lighting at a sample of community colleges that participated in the CCC/IOU partnership programs of PG&E, SCE, SDG&E, and SoCal Gas

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.1 Measures Installed in Projects

The campuses with interior lighting projects where the lighting logging was conducted were the following:

Table 1. Campuses with Interior Lighting Projects

Campus	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Incentive ($)
Diablo Valley	Campus-wide Lighting Retrofit. This included the retrofit of over 7,800 fixtures plus the use of 96 WallSwitch sensors. Most of the savings (94%) were from the use of more energy efficient lighting lamps, ballasts and fixtures; the sensors accounted for just over 6% of the total savings from the lighting retrofit program.	770,793	256.0	$111,032.40
Evergreen	Lighting and HVAC Control (Electrical Savings) Occupancy sensors will be installed and interlocked with the HVAC and lighting in all the campus building. The LRC, Sequoia/Lecture Hall and LETC buildings have motion sensors already installed in all the rooms. About half of the rooms in the Cedro building have occupancy sensors previously installed.	1.209,994 (464,802 is lighting savings)	0	$181,499.10
Laney	T12 to Super T8 Retrofit	794,150	226.9	$119,112.50
Monterey Peninsula	Lighting. This lighting retrofit is campus-wide, with the majority of the upgrade being the replacement of 32W T8 lighting with 28W T8 lighting. The only buildings excepted from this are those that received a lighting retrofit in the last round of PG&E sponsored lighting retrofits.	513,328	208	$79,999.20
San Jose City	Install new occupancy sensors, interlock them to HVAC and lighting through EMS - Electricity Savings	851,925 (371,340 is lighting savings)	89.0 (includes both HVAC and lighting)	$127,788.75
Victor Valley	Campus Wide Lighting Upgrade.	1,377,354	271.6	$189,892.05
Mira Costa College	Replace inefficient T12, HID & incandescent lighting lamps / fixtures with new & more efficient lamps / fixtures at Oceanside Campus	334,362	50.5	$50,154.30

The campuses with exterior lighting control projects where the control settings were verified include the following:

Table 2. Campuses with Exterior Lighting Control Projects

Campus	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Incentive ($)
El Camino	Campus exterior lighting to EMS	1,010,998	92	$242,640
San Diego City	ExteriorLightingControls	88,791	13	$13,319
Santa Barbara	Lighting retrofit	365,230	59	$6,261

B-1.2 Measures Included in Evaluation

The types of lighting measures considered for this M&V effort included both efficiency and control measures.

- Lighting efficiency measures reduce demand, but operating hours for fixtures may be the same pre- and post-retrofit. These measures include retrofitting existing fixtures, lamps and/or ballasts with an identical number of more energy efficient fixtures, lamps and/or ballasts.
- Lighting control measures for lighting reduce operating hours but may not reduce demand. These measures include occupancy sensors or daylighting controls that are installed *without* any changes to fixtures, lamps, or ballasts

B-1.3 M & V Approach Summary

Savings for retrofit lighting measures were assessed using IPMVP Option A, Partially Measured Retrofit Isolation. Project files provided information on the existing and replacement lighting equipment (quantities, types, lighting densities, etc); this information was verified through site inspections. As discussed in Section 1.4, lighting loggers were used for collecting measured data on operating hours for lighting at different campuses and in different functional use areas. With this information, savings could be calculated as the difference in energy use between the baseline and upgraded lighting fixtures.

For exterior lighting control projects, control settings were confirmed during site inspections in order to verify ex ante estimates of energy savings.

PART C: MEASURE EVALUATIONS

C-1 Measure ID: 1
Measure Name: Lighting Efficiency and Control Measures

C-1.1 M&V Features for Measures

Features of the M&V for the lighting measures are as follows:

Impact Type:	Direct Impact
Baseline Type:	Normal replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option B

C-1.1.1 Pre-installation Equipment and Operation

The types and quantities of pre-installation lighting fixtures for the different campuses were reported by the different campuses.:

C-1.1.2 As-Built Equipment and Operation

Specifications for installed equipment are detailed in the data provided by the campuses.

C-1.1.3 Seasonal Variability in Schedule and Production

Community colleges generally follow a year-round schedule that includes summer sessions, with a mix of day, evening, and weekend classes. The schedule information was refined in discussion with staff from each college. Information was collected as appropriate for class schedules, custodial schedules, planned operating patterns, and class sizes.

C-1.2 Algorithms for Estimating Savings

C-1.2.1 Algorithms Used for Application to IOU

Expected energy savings from the lighting measures are calculated in the applications to the IOUs using engineering analyses.

The baseline period annual energy consumption is calculated as follows:

Base kWh = Σ ((Quantity of base Lighting) * (Fixture power of base lighting in kW) * (Operational hours))

Current kWh = Σ ((Quantity of current Lighting) * (Fixture power of current lighting in kW) * (Operational hours))

The energy savings are:

Energy savings, kWh = Baseline kWh - current kWh

C-1.2.2 Energy Savings Algorithms Used for Evaluation

For the evaluation, kWh savings are calculated using the following equation:

$$Savings = \sum Quantity_J * kW_j * Hrs_j - \sum Quantity_i * kW_i * Hrs_i$$

Note that 'j' indicates the pre condition, and 'i' indicates the post condition.

C-1.2.3 Peak Demand Algorithms Used in the Evaluation

The evaluation used the DEER defined peak definition period of 2:00 PM to 5:00 PM during the three consecutive weekday periods containing the weekday with the hottest temperature of the year for the various campus locations.

C-1.3 Data Collection

C-1.3.1 Site-Specific Data Required

The following information needed to assess the savings were collected.

1. Quantities and types of lighting fixtures, within each specified (sample) space.
2. Operating hours for each specific (sample) space type

C-1.3.2 Data Collection Method

In each sample space, all fixtures are counted. The fixtures will be indicated by type and number of bulbs. Monitoring equipment will be installed to obtain data on hours of operation for a period of two weeks in a sample of spaces.

C-1.3.3 Sampling Strategy

The sampling strategy outlined below pertains only to interior lighting projects.

For monitoring hours of operation for the lighting where the efficiency or control measures had been installed, the sampling strategy was to select samples of spaces of different types of functional areas across campuses. For each campus, the spaces in which the lighting measures were implemented were be classified by functional use.

A taxonomy of functional uses for community colleges is provided by room use categories, as defined in the *Postsecondary Education Facilities Inventory and Classification Manual (FICM): 2006 Edition*[1] and as implemented by California community colleges in the space inventory data that they report.

The functional use areas where lighting efficiency or control measures were installed at the sample of community colleges being studied here are shown on the attached Excel workbook in the tab entitled "Usage Groups by Campus". The major functional use areas where lighting measures were installed are classrooms and offices, laboratories, and food service areas..

[1] U. S. Department of Education, National Center for Education Statistics, *Postsecondary Education Facilities Inventory and Classification Manual (FICM): 2006 Edition* (NCES 2006-160).

The proposed sampling plan was to select a sample of areas, across campuses, within each major functional use category. Based on the data provided in the campuses' project applications, the major functional uses sampled included the following:

- Classroom spaces
- Office spaces
- Laboratory spaces
- Food service spaces

The sampling plan was premised on there being two estimates of operating hours for each area sampled within a functional use category: expected hours of use (as reported in the project applications) and the verified estimates of operating hours developed through the M&V monitoring. Essentially, these two sets of estimates allow developing a ratio from the data for the sampled sites that can be applied to adjust the expected hours as reported in the project applications.

The ratio to be estimated is given by the following formulation:

$$R = \frac{\bar{y}}{\bar{x}}$$

where R is the ratio of measured hours to reported hours for a functional use, $\bar{y}$ is the mean of measured hours of operation calculated from the sampled spaces within a functional use, and $\bar{x}$ is the reported (expected) hours of use for lighting in the sampled areas. For the estimation of this ratio, estimates of expected hours of operation are taken from the program tracking records are used as the auxiliary information.

For each functional use area, the sample size required to estimate the ratio with precision of ±10% at 90% confidence is determined from the following formula:

$$n = \left(\frac{1.645 ucv}{prec} \right)^2$$

where n is the required sample size, *prec* is the desired precision (i.e., 10%) and *ucv* is given by

$$ucv = \sqrt{(cv_X^2 + cv_X^2 - 2r_{xy} cv_x cv_y)}$$

where

cv_x is the coefficient of variation for expected hours of operation;

cv_y is the coefficient of variation for measured hours of operation; and

r_{xy} is the correlation coefficient between x and y.

Thus, to determine n initial estimates of r, cv_x and cv_y were needed. For planning purposes, such estimates were taken from the *Express Efficiency Lighting Program Time of Use Study* that RLW Analytics prepared for SDG&E. This study provided a comparison of measured hours of lighting use to reported hours of use for 124 commercial facilities. The data from this study are summarized in Table 3.

Table 3. Estimates of hours of use for commercial facilities

Variable	Mean	Standard Deviation	Coefficient of Variation
Reported hours of lighting use	4,199	2,180	0.529
Measured hours of lighting use	4,098	2,121	0.518
Correlation coefficient: 0.793			

With these estimates of r, cv_x and cv_y, the required sample size for each functional use category was ≈ 31. For planning purposes, n = 32 was used for each functional use area for which it was proposed to install lighting loggers.

For each of the functional use areas, the allocation of sample points across campuses and campus buildings was accomplished using space inventory data obtained from the Facilities Utilization, Space Inventory Options Net (FUSION), which is a database of 58-million square feet of California community college facilities. Included in the database is detailed information for every room in every building on every campus. This detailed information includes functional use and assignable square feet for every room. (A space inventory for each campus is also maintained by the Facilities Planning, Maintenance and Operations department.) These data from the various campuses were combined into one database for all campuses, and rooms were then be selected for the sample for each functional use.

Early results from lighting measurements made by other contract groups indicated that some of the newer loggers being supplied by a particular vendor were failing when installed in the field. Some of these loggers were also to be used for the CCC lighting measurements. To account for the possibility that some of these loggers might fail, the actual number of loggers installed was twice the number that sample size calculations indicated would be required. This ensured that the sample size requirements would be met even if an expected percentage of the loggers failed.

C-1.4 Data Accuracy

All equipment used for monitoring was calibrated and tested before being installed.

C-1.5 Quality Assurance Procedures

To guard against biases arising because of improper placement of the loggers, field staff were given a prescribed protocol for placing and installing the loggers within the spaces being monitored.

For lighting, usage patterns may vary from month to month. Sampling for only a short duration could therefore introduce a degree of error into the overall results. To reduce this type of error, the lighting loggers were left in place for a period of at least five months, covering spring, summer and fall sessions of the community colleges in the sample. Data were therefore collected that represented lighting usage for different periods of campus activity (e.g., in session, out of session).

All data collected with the loggers were reviewed to resolve outliers, missing data, etc. Routine QA procedures were applied, including independent review of all field work by senior professionals.

PART D: MEASUREMENT AND VERIFICATION RESULTS

D.1 Interior Lighting

To evaluate the savings from the different types of lighting measures, data were needed to verify the operating hours. These data were collected by installing lighting loggers for different types of spaces on seven campuses. These loggers were put in place beginning in May 2009 and removed beginning in September 2009. Data useable for determining operating hours for lighting were obtained from 320 loggers.

Error! Reference source not found. shows summary statistics on the hours of use measured with the 320 loggers when logger placement is classified by the type of functional space where the loggers were installed and by whether lighting controls were in place in the monitored spaces. (Relative precision is measured at 90% confidence level.)

Table 4. Statistics on Hours of Use When Logger Placement Is Classified by Type of Space and Whether Lighting is Controlled

Type of Space	Number of Loggers Installed	Average Hours of Use	Standard Deviation for Hours of Use	Relative Precision
Spaces Where Lighting Is Not Controlled				
Classrooms	55	2,096	1,093	11.6%
Food Service	11	5,631	2,740	24.1%
Laboratories	34	3,126	2,196	19.8%
Offices	80	2,237	1,322	10.9%
All Non-controlled	180	2,569	1,787	8.5%
Spaces Where Lighting Is Controlled				
Classrooms	63	1,539	597	8.0%
Food Service	7	5,041	3,135	38.7%
Laboratories	34	2,569	2,532	27.8%
Offices	36	2,099	2,267	29.6%
All Controlled	140	2,108	2,108	13.2%
All Spaces	320	2,367	2,367	7.4%

Table 5 shows the summary statistics on hours of use when logger placement is classified by the campuses where the loggers were installed and by whether lighting controls were in place in the monitored spaces.

Table 5. Statistics on Lighting Hours of Use When Logger Placement Is Classified by Campus and Whether Lighting Is Controlled

Campus	Number of Loggers Installed	Average Hours of Use	Standard Deviation for Hours of Use	Relative Precision
Spaces Where Lighting Is Not Controlled				
Diablo Valley	33	2,955	1,720	16.7%
Laney	35	2,881	1,951	18.8%
Mira Costa	53	1,777	1,169	14.9%
Monterey Park	27	2,558	1,707	21.1%
Victor Valley	32	3,151	2,187	20.2%
All Non-controlled	180	2,569	1,787	8.5%
Spaces Where Lighting Is Controlled				
Evergreen Valley	48	2,905	2,789	22.8%
San Jose City	70	1,536	1,040	13.3%
Victor Valley	22	2,189	1,781	28.5%
All Controlled	140	2,108	2,108	13.2%
All Spaces	320	2,367	2,367	7.4%

D.2 Exterior Lighting

During on-site inspections, control settings were confirmed in order to verify ex ante estimates of energy savings. The controls were operating as expected, and the respective methodologies for calculating ex ante savings were reviewed by ADM staff and deemed to be appropriate; therefore, the realization rate for these projects is 100%, and the ex post energy savings are presented above in Table 2.

M & V SITE REPORT

CERRITOS COMMUNITY COLLEGE –*CCC-DD-0035*

November 2009

PART A: SUMMARY INFORMATION

A-1.2 Project Information

Utility Service Territory	SCE & SCG
Program Being Evaluated	California Community Colleges Energy Efficiency Partnership Program
ADM Sample ID &Project ID	CCC-DD-0035
Customer Name	Cerritos Community College District
Site Name	Cerritos Community College
Site Address	11110 Alondra Blvd., Norwalk CA 90650
Site Type	Community College
Customer Business/Product	Community College

PRINCIPAL SITE CONTACT

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IOU REPRESENTATIVE

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THIRD-PARTY SPONSOR OR IMPLEMENTER

Name	Keith Valenzuela	**Telephone**	
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ASSIGNED LEAD ENGINEER

Name	S. Thamilseran

AUTHOR

Name	S. Thamilseran

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.4 Measures Included in the Evaluation

The original agreement for projects at Cerritos Community College includes several measures: (a) replace building load with central plant, (b) add lighting controls, (c) add hood exhaust fan controls, (d) lighting retrofit, and (e) boiler replacement. The measures with the most savings include retrofitting/replacing distributed boilers and replacing distributed chillers with a new central plant. These measures are the focus of this M&V activity. Three new chillers and eighteen new boilers are to be installed. The specific measures are as follows:

Measure ID[1] (ADM)	Measure ID (IOU)	Measure Group	System	Measure Description
1	6006	HVAC	HVAC	Add building load to central plant (Electrical Savings)
2	6127	Lighting	Lighting	Campus wide lighting retrofit
3	6008	Lighting Controls	Lighting	Add lighting controls
4	6128	HVAC	HVAC	Replace hot water boiler (Gas Savings)

Note 1: The ADM measure numbers are sequenced in descending order (highest to lowest) of estimated kWh or therm savings to emphasize that the evaluation level of effort should consider estimated savings of each measure.

Annual Savings Summary for Measures

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings[1] (kWh)	Electric Demand Savings[1] (kW)	Natural Gas Savings[1] (therms)	Incentive[1] ($)	Total Annual Cost Savings ($)
1	6006	Add building load to central plant (Electrical Savings)	1,651,101	642.3	0	$773,209.92	
2	6127	Campus wide lighting retrofit	918,052	229	0	$137,537.40	
3	6008	Add lighting controls	80,000	0	0	$12,000.00	
4	6128	Replace hot water boiler (Gas Savings)	0	0	20,752	$40,000.00	
Total Savings:			**2,649,153**	**820.5**	**20,752**	**$962,747.32**	
Total Site Usage:							
% Total Site Usage Saved:							

Note 1: Results from Project Application Review, 5/1/2006

B-1.5 M & V Approach Summary

THE M&V REPORT FOR CERRITOS COLLEGE FOCUSED ON MEASURES 1 AND 4 WHICH PERTAIN TO THE CAMPUS WIDE COOLING AND HEATING SYSTEM UPGRADES.

Measure ID (ADM)	Measure Name	M&V Option Used	Summary of M&V Approach
1	Add building load to central plant	D	D for Efficient HVAC Equipment
4	Replace hot water boiler	D	D for Efficient HVAC Equipment

B-1.2.1 Summary of M&V Approach for ADM Measures 1 and 4

ADM Measures 1 and 4 pertain to the Campus-wide Cooling and Heating Upgrade, with Measure 1 addressing electric savings and Measure 4 gas savings.

IPMVP Option D: Calibrated DOE-2 simulation was used to evaluate these measures based on data obtained from a site survey. The simulation of baseline conditions was bench marked against the CEUS's college end use profiles (as facility's utility bills were not available) with as-built HVAC equipment characteristics used to determine as-built energy consumption. In the baseline analysis, the HVAC equipment reflected the original conditions. Energy savings were computed as the difference between baseline energy consumption and as-built energy consumption.

PART C: INDIVIDUAL MEASURE EVALUATION

C-2 MEASURE ID: 1: ADD BUILDING LOAD TO CENTRAL PLANT (ELECTRICAL SAVINGS)

The Cerritos Community College campus has 41 buildings, 12 of which are involved with this measure (where the individual building cooling equipment were removed and the buildings are now connected to the central plant). The campus central plant was planned with four new (750-ton each) chillers and associated equipment. However, the post-installation verifies that only three chillers (two 1300 and one 485 ton) and associated equipment were installed.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	6006	ADD BUILDING LOAD TO CENTRAL PLANT (ELECTRICAL SAVINGS)	1,651,101	642.3	0	$773,209.92	-

C-2.1 M&V Features

Features of the M&V for Measure 1 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement**
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

**** Two of the baseline chillers, one 150-ton water-cooled chiller and one 125-ton air-cooled chiller had no remaining useful life. ADM used Title 24 efficiencies for these chillers.**

C-2.1.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

Keith Valenzuela of AESC and Lisa Hannaman of SCE met with Bob Riffle of Cerritos Community College on August 21, 2006 for a pre-inspection visit. Four of the twelve buildings that were part of the work were inspected. The following sampled sites were inspected and hours of operation were verified in a discussion with the representative from Cerritos Community College:

Administration Building: Carrier Chiller Model No. 19DK53122AC

Fine Arts Building: York Chiller Unit Model. YS BB BB S0 CFA

Learning Resource Center: Carrier Chiller Model No. 30HXC206R—640AA

Social Science Building: York Chiller Unit Model YSD CCAS 2-CJC

.The following are buildings that are part of the campus cooling consolidation effort.

Building #	Building Name	Year Built	Total OGSF	Estimated Load Tons	Actual Tons Installed	Tons Good for Reuse	New Tons Required	Comments/Remarks
1	ADMINISTRATION	1963	45,568	130	150	0	150	Chiller 14 yrs old w/ R-11
2	FINE ARTS	1963	40,224	125	150	150	0	Chiller 11 yrs old
3	INSTR SUPPORT CENTER	1960	2,640	8	0	0	0	Served from Burnight/Stud Ctr
5	WOODWORKING MANUFACTURING TECHNOLOGY	1959	25,443	102	80	0	80	Two 40 HP DX recip comp with high maintenance and failures
10	LEARNING RESOURCE CENTER	1961	94,170	269	260	260	0	Chillers installed 2002
17	STUDENT CENTER	1960	31,960	91	150	0	150	1987 R-11 Chiller, tied to Burnight
18	STUDENT ACTIVITY CENTER	1960	3,282	9	0	0	0	Served by Student Center
21	BURNIGHT CENTER	1965	45,513	130	150	0	150	Chiller 15 yrs old w/ R-11
22	SOCIAL SCIENCE	1968	61,462	176	225	225	0	Chiller installed 1996
25	BOOKSTORE	1974	22,037	63	60	0	0	Served by Burnight/Student Center
26	HEALTH SCIENCES	1976	45,939	153	125	0	125	Air cooled 15 years old
	Sub-total of associated Building(s)		418,238	1,256	1,350	635	655	
	Existing Building(s) on Campus		**655,844**	**2,103**	**3,085**			

From the Pre-Installation Inspection Report, 8/24/2006.

C-2.1.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

Distributed chillers and boilers in the various buildings described in the previous section were to be replaced by a central plant with three chillers (two 1300-ton and one 485 ton centravac three-stage single compressor type Carrier centrifugal chillers).

The project file did not provide information about the buildings on the Cerritos Community College campus, their sizes, or their dispositions. Information was also lacking about the central plant cooling operation. Documentation on the lighting project indicates that some of the other buildings have been cooled by package roof-top units. A preliminary conversation with the facility staff was therefore used to provide additional insight into the campus operation that could be relevant to planning the simulation analysis.

The central plant's equipment was inspected as part of a post-installation inspection by AESC, the results of which are described below:

Campus Central Plant:

Two (2) identical chillers (Trane CVHF1300) and one smaller chiller (Trane CVHF485)

Three (3) condenser water pump motors with VFD drives:

Baldor Spec Number: 42E105W798G1 HP: 50

Three (3) chilled water pump motors with VFD:

Baldor Model Number: 44E149W048G1 HP: 100

Six (6) cooling tower fans with VFD's were also verified.

The following buildings were all supplied chilled water by the central plant at the time of inspection: Student Center, Bookstore, Burnight Center, LRC, Physical Science, Science, Business Education, Administration, Social Science, Health Science, Woodworking, and Fine Arts..

C-2.1.3 Seasonal Variability in Schedule and Production

The campus follows a 2-semester schedule plus summer sessions, with a mix of day, evening, and weekend classes. There is a 2-week vacation in mid August and a 4-week vacation between mid-December and mid-January.

C-2.2 Algorithms for Estimating Savings

C-2.2.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
1	Engineering Analysis

S&K Engineers used eQuest modeling software to estimate baseline equipment energy consumption and proposed energy consumption in calculating energy savings. The models were first calibrated against actual usage to establish the baseline. Then the parameters of the proposed central plant consolidation were put into the models to calculate energy savings.

C-2.2.2 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	Engineering analysis

DOE-2 simulations with eQuest were similarly used for the evaluation of the project's energy savings. The baseline analysis assumes baseline chillers and associated pumping cool the 12 individual buildings. The as-built analysis considers the new central plant chillers provide cooling to the 12 buildings at the campus.

Baseline simulations:

For the baseline condition the M&V effort modeled 12 combined buildings with their respective chillers, or the entire campus with other buildings not-impacted by this measure. ADM used weighted kW/Ton efficiency value of chillers in our baseline analysis. The weighted average efficiency (kW/Ton) of chillers and packaged units are calculated to be 1.1**.** Two of the baseline chillers, one 150-ton water-cooled chiller and one 125-ton air-cooled chiller had no Remaining Useful Life. Hence, ADM used title#24 efficiencies for these chillers.

Monitoring As-built conditions:

The site parameters described in Section C-1.3.2 were collected, including HVAC system parameters and building activity areas. The same parameters were used for DOE-2 simulation model input.

As-built simulations:

For the as-built condition, data from a detailed site survey was used as input to the simulation. The separate buildings that are connected to the new central plant were combined into a single DOE-2 simulation. The weighted average chiller efficiency in as-built conditions is calculated to be 0.56**.**

The estimate of energy savings will be the difference between the baseline energy consumption and the as-built energy consumption.

C-2.2.3 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	See below

Peak Demand algorithm used by IOU:

S&K Engineers summarized eQUEST simulations and tabulated the peak loads by end-use. The details of the calculation are missing. Though not present, it was assumed that these baseline and as-built end-use peak loads were used toward the peak demand savings calculation. The baseline analysis assumes baseline chillers and associated pumping cool the 12 individual buildings. The as-built analysis considers the new central plant chillers as providing cooling for the twelve buildings involved in this measure.

Peak Demand algorithm used in the Evaluation:

The combined space cooling equipment energy consumption load profile provided by the eQuest simulation was matched against the CPUC stipulated 3-day period (September 23rd to September 25th for this site) for baseline and as-built cases to derive the peak demand savings for this measure.

C-2.3 Data Collection

HVAC data sheets (CP03) were used for data collection of the facility's economizer measure.

C-2.3.1 Site-Specific Parameters

Program Measure ID	Site-Specific Parameters
1	See below

On-site staff were interviewed to more precisely determine occupancy loads. Factors such as operating hours, class schedules, custodial schedules, and semester breaks were used to determine total savings from the lighting and HVAC control based on occupancy. Temperature settings (such as the deadband with occupancy and without occupancy) and schedule for environment management system (EMS) were checked.

C-2.3.2 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
1	See below text

Data were first collected through interviews with the staff of the site. These interviews provided information on the facility's functional areas, occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other "human factors" that are associated with energy use at the site.

Documents or records at the site were reviewed.

Photographs of the site and of its electrical and mechanical systems were taken during the on-site visit.

C-2.3.3 Sampling Strategy

Program Measure ID	Sampling Strategy
1	See below

Because all chiller systems are evaluated, no sampling strategy is required for this measure.

C-3 MEASURE ID: 4 – CAMPUS BOILER RETROFIT (GAS SAVINGS)

Measure 4 addresses gas savings for the Campus Boiler Retrofit (also referred to as Replace Hot-water Boiler). Fifteen hot water boilers were replaced with new high efficiency boilers. These range in size from 1.05 million Btu/hour to 1.95 million Btu/hour. All documents including the tracking system show the annual savings as 40,000 therms. One post-inspection form dated December 16, 2008 shows the annual savings as 13,879 therms. The validity of this document (because of a mismatch in project number referenced) may need to be verified before the measure savings can be revised. Based on the size of the equipment, the usage may be for domestic hot water use. If the usage is other than building space heating, we will use Option B to evaluate the savings based on equipment usage.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)[1]	Incentive ($)	Total Annual Cost Savings ($)
4	6128	Central Plant (Gas Savings)	0	0	40,000	$40,000.00	

C-3.1 M&V Features

Features of the M&V for Measure 4 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement***
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

*** All the baseline boilers have two plus years Remaining Useful Life and the baseline is Early Replacement.

C-3.1.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
4	See below

On Monday August 21, 2006 at 1:00 pm Keith Valenzuela of AESC and Lisa Hannaman of SCE met with Bob Riffle of Cerritos Community College for the pre-installation inspection of this measure. Three buildings were inspected and equipment nameplate data were noted, as shown below:

Administration Building: AJAX Boiler Model No. WGH-2000

Learning Resource Center: AJAX Boiler WG-1750 D

Business Education Building: AJAX Boiler Model No. WG-675 D.

C-3.1.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
3	See below text

Fifteen hot water boilers in individual buildings were replaced with new high efficiency boilers. The post-installation inspection verified eight buildings with the following nameplate data:

Boiler Installation Inspection:

Burnight Center:

RBI Model no: DB1950 Input: 1,950,000 Btu/hr Output: 1,657,500 Btu/hr

Learning Resource Center:

RBI Model no: DB1950 Input: 1,950,000 Btu/hr Output: 1,657,500 Btu/hr

Physical Science:

RBI Model no: DB1050 Input: 1,050,000 Btu/hr Output: 892,500 Btu/hr

Business Education:

RBI Model no: DB1050 Input: 1,050,000 Btu/hr Output: 892,500 Btu/hr

Administration:

RBI Model no: DB1950 Input: 1,950,000 Btu/hr Output: 1,657,500 Btu/hr

Social Science:

RBI Model no: DB1950 Input: 1,950,000 Btu/hr Output: 1,657,500 Btu/hr

Liberal Arts:

RBI Model no: DB1050 Input: 1,050,000 Btu/hr Output: 892,500 Btu/hr

Health Science:

RBI Model no: DB1050 Input: 1,050,000 Btu/hr Output: 892,500 Btu/hr

C-3.1.3 Seasonal Variability in Schedule and Production

Seasonal variability in schedule and production is the same as that described for Measure 1.

C-3.2 Algorithms for Estimating Savings

C-3.2.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
3	Engineering Calculations

Baseline therms = 260,000 therms

Note: No details were provided on the derivation of the consumption data.

Proposed therms: None provided. A single sum of 40,000 therms as savings is reported in the project documents.

Total Energy Savings, therms = 40,000 therms

C-3.2.2 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
3	Engineering analysis

ADM used the eQuest energy simulation model to estimate savings for space heating energy consumption.. Hot deck set points or reheat set points, domestic hot water usage and any hot water equipment schedules were collected and added to the simulation model as fixed usage by adjusting the DHW usage and schedules. ADM did not calibrate the gas usage with CEUS's end use data since eQuest model can not simulate the facility building's hot deck system properly. ADM used weighted average boiler efficiency in our analysis and the weighted average efficiency of baseline and as-built conditions are 70% and 85%, respectively.

In the final analysis, detailed information about usage patterns (class size, class schedule, etc) was accounted for in the as-built and baseline cases. Comparison of fuel usage between the two scenarios was derived from eQuest simulation runs to determine therm savings.

C-3.2.3 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
3	See below

Peak demand savings are not relevant for this measure.

C-3.3 Data Collection

ADM HVAC data sheets (CP03) were used to collect data for this measure.

C-3.3.1 Site-Specific Parameters

The following information was collected from site-specific data sources:

1. The specifications of boilers including burner and hot water pumps
2. Boiler and hot deck set points and controls
3. Operational hours of boilers
4. Building-level end-use descriptions
5. Any information about AHU reheat coil

C-3.3.2 Data Collection Method

The following data collection method was used to obtain data:

- Details of boilers, boiler burners, and hot water pumps werel be obtained from nameplate/ engineering drawings.
- The boiler set points were recorded from on-site survey observations and EMCS records
- Boiler control information was recorded from EMCS records/engineering drawings.
- The remaining data for the measure relating to the physical, thermal, and operational characteristics of the associated buildings was collected as described for measure 1.

C-3.3.3 Sampling Strategy

Program Measure ID	Sampling Strategy
2	See below

No sampling was necessary.

PART D: MEASURE AND VERIFICATION RESULTS

ADM employed an eQuest model to determine the energy savings of the project. ADM developed an eQuest model based on ex post baseline conditions calibrated to climate zone 8 CEUS colleges' electrical end use energy profiles. ADM calibrated the baseline eQuest model to be within 10% of the CEUS data. The details of electric usage calibration are presented in Figures 1 and 2.

ADM verified from eQuest model analysis that central plant project saves 963,371 kWh, and 213.25 peak kW. The project's realization rate of central plant is 39.87%.

ADM's eQuest analysis of boiler retrofit results 28,637 therms with a realization rate of 71.59%.

The variance between ex ante and ex post savings was mainly due to the following reasons:

- IOU analysis used eQuest defaults for analysis without calibrating the model either to the utility bills or CEUS end use profiles.
- IOU analysis energy consumption is half of the CEUS reported energy consumption for colleges in Climate Zone 8.

Figure 1: Comparison of Building and Simulation Demand

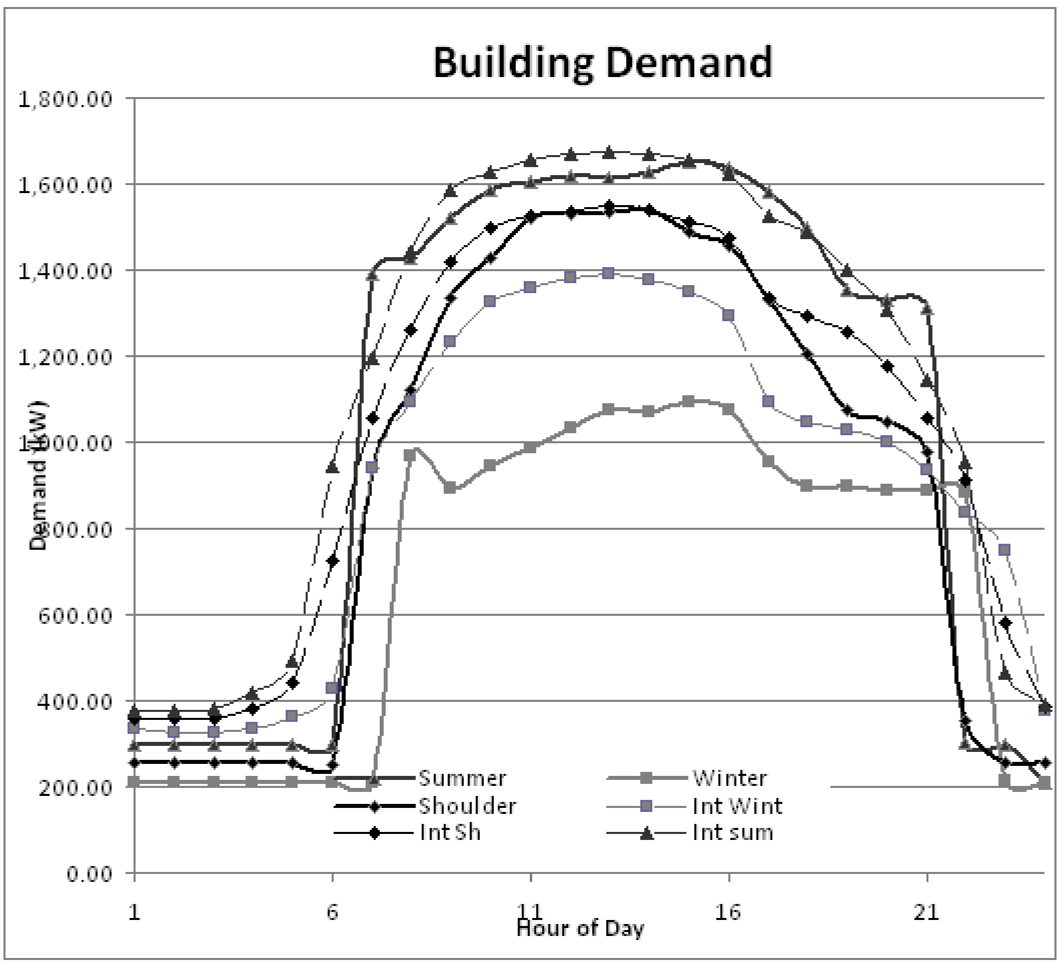
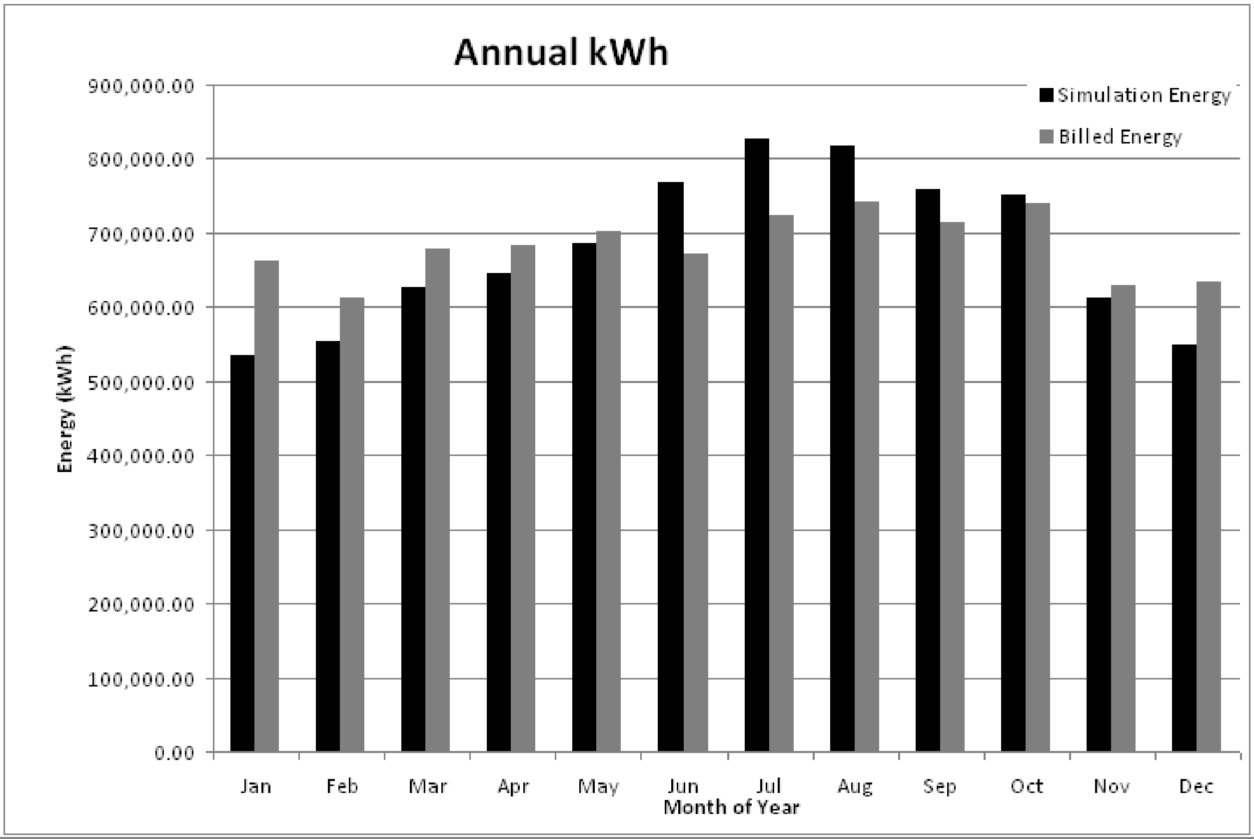


Figure 2: eQuest Monthly Consumption Versus Billing



M & V SITE REPORT

FULLERTON COMMUNITY COLLEGE – *CCC-DD-0015*
NORTH ORANGE COUNTY COMMUNITY COLLEGE DISTRICT
November 2009

PART A: SUMMARY INFORMATION

Facility Information: The Fullerton community college is part of the North Orange County Community College District. The facility has undergone campus-wide energy efficiency retrofits under three separate projects (Lighting upgrade, campus-wide central plant retrofit, and steam and condensate system upgrade). The campus energy upgrades were performed on 29 buildings in the Fullerton Community College under the evaluation period. These buildings range in size from 1,600 square feet of modular classrooms to approximately 152,000 square feet for Building 400. The primary functional uses of these buildings includes classrooms, offices, laboratories and support services. The buildings were built between 1973 and 1990.

Project Summary: The facility began as a centralized chilled water plant and was later expanded to four chilled water plants with an HVAC system upgrade. Objectives of the current project include:

1. Consolidating 14 individual chilled water plants into four chilled water plants with new chillers and associated equipment.
2. Replacing several package units with high efficiency HVAC package units or heat pumps.
3. Replacing existing motors and adding VFD to pumps and fans in Buildings 300, 1100 and 400.

A-1.3 PROJECT INFORMATION

Utility Service Territory	SCE
Program Being Evaluated	California Community Colleges Energy Efficiency Partnership Program
ADM Sample ID &Project ID	CCC-DD-0015
Customer Name	North Orange County Community College District
Site Name	Fullerton Community College
Site Address	1830 West Romneya Drive , Anaheim, CA
Site Type	Community College
Customer Business/Product	Community College

PRINCIPAL SITE CONTACT

Name	Ron Beeler	**Telephone**	(714) 808-4893
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IOU REPRESENTATIVE

Name	Michael B Lo	**Telephone**	626-302-3818 (fax)
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name	Keith Valenzuela	**Telephone**	760-931-2641 Ext. 124
E-mail	kvalenzuela@AESC-Inc.com	**Company**	AESC Inc.

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.6 Goals and Objectives

The primary goal of the impact evaluation is to assess the gross program-specific energy and demand impacts for the retrofits during the 2006 – 2008 program period. A secondary goal is to increase the quality, reliability and objectivity of the impact evaluation methodology employed.

The impact evaluation accomplished the following site-specific objectives that are relevant to the gross savings estimates addressed by this plan:

- Determine the impact of the sampled campus-wide chilled water plant and HVAC system upgrades measures on annual gross energy and peak demand savings; and
- Account for energy and peak demand effects of spillover, if applicable.

B-1.7 Measures Installed in Project

Two measures were installed at the Fullerton Community College facility during the 2006-2008 period that were relevant to the M&V effort.

- **Central Plant Chiller, Pumps and Cooling Tower Retrofits**: This measure consolidated individual chiller plants in 15 buildings (buildings 200, 300, 400, 500, 600, 700, 1000, 1100, 1300, 2000, 2100, and CE 232, and CE 233) into four new central chiller plants to located in the Mini plant, Buildings 1100 and 500, and the Wilshire plant. This measure also replaced package units in 14 buildings (Buildings 01, 100, 200, 232, 233, 1800, 1810, 1820, 900, 901, 1400, 2200, 3000, W-2, and mail room) with high efficiency units. The baseline and planned equipment list and associated building square footage are tabulated under the as-built and baseline equipment sections. The HVAC systems associated with buildings 200 and 1000 are not clearly described in the project supporting documents . Specifically, the (name of document) identifies Building 2100 as being covered by the Wilshire plant and separate package high efficiency heat pumps. Building 1000 is noted as covered by both the Mini Plant and the central plant in Building 1100. These points will be clarified during the site visit.
- The facility has also undergone steam system retrofits and associated EMS controls upgrade which provides gas savings (SCG project PY2008_0030). However, this project was completed in 2008 and comes under a separate project and consequently given in another pre-site M& V plan.
- A Campus-wide lighting retrofit: This measure involves (a) replacing T-12 lighting fixtures with T-8 lighting fixtures in all indoor spaces (class rooms, gymnasium, and support areas)and (b) replacing the Metal Halide fixtures with Pulse Start Metal Halide fixtures in all parking lot and campus outdoor lighting fixtures under another project.

Program	Measure ID (ADM)[1]	Measure ID (IOU)	Measure Group	System	Measure Description
SCE 2006	1	1	HVAC	HVAC	Central Plant for Entire Campus and High efficiency package units

Note 1: The original description/project application states the plan for a single centralized plant for the 14 buildings that are covered under four separate central plants.

Annual Measure Savings Summary

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kW)	Electric Demand Savings (kWh)	Natural Gas Savings (therms)[1]	Incentive ($)	Total Annual Cost Savings ($)
1	1	Campus-wide Central Plants and HE package Units	692.5	1,811,137	0	$423,793.92	
Total Savings:			692.5	1,811,137	0	$423,793.92	
Total Site Usage[2]:							
% Total Site Usage Saved[2]:							

Note 1: Results from Project P06-00039 and measure number 6053 invoice dated 09/19/2007

B-1.8 Measures Included in the Evaluation

Only one measure -- electric energy savings -- for this project was included in the evaluation.

B-1.9 Information from Application Review

The application for Fullerton Community College (under NOCCCD) was submitted by Keith Valenzuela of AESC Inc., with calculations and engineering details from ACCO Engineered systems. The project files include reports on the pre- and post- retrofit site visits performed by Keith Valenzuella accompanied by JohnWalton of ACCO Engineered Systems that cover the Mini plant, Wilshire plant, Building 500, Building 1100, Building 2100, Building 400, and Building 2000. However, there was no information on the project review and approval process in the project files.

The following items were noted as verified:

Building 400

Two McQuay Chillers: Style 061412001E, Model E2612382LA. These chillers are still in place but are not operating. This building's cooling load was added to the Campus Mini Plant

Building 1100

Two McQuay Chillers: Style E803434050, Model WSC063-DAABC. One chiller was operating. These chillers serve buildings 1100, 1300, 300 and 1000.

Two 15 HP chilled water supply pump motors with VFD.

WEG motor	Model 01518EP3E254T	HP 15	1760 RPM

Two 5 HP chilled water return pump motors with VFD.

WEG motor	Model 01518EP3E184T	HP 5	1745 RPM

Cooling Tower was seen on the roof of the building from the ground.

Building 500

One McQuay Chiller: Style E803434020, Model WDC050-BBBBA. The chiller was operating at the time of the inspection. The chiller serves the 500 building.

Two 20 HP chilled water supply pump motors

WEG motor Model 02018EP3E254T HP 20 1765 RPM

Two 7.5 HP chilled water supply pump motors

WEG motor Model 00718EP3E213T HP 7.5 1765 RPM

Wilshire Plant:

One McQuay Chiller: Style E803434010, Model WDC050-BBBBA. The chiller was operating at the time of the inspection. The chiller serves buildings 2000, W1, W2, 2100, and CE 233/232.

Four 10 HP chilled water pump motors

WEG motor Model 01018ET3E215T HP 10 1765 RPM

One Cooling Tower with VFD: Baltimore Aircoil Company Model Number: 15201

Mini-Plant:

Two McQuay Chillers: Style E803434040, Model WDC079-DCCCC. One chiller was operating at the time of the inspection. The plant serves buildings 700, 600, 1000, 400 and 200.

Two 40 HP chilled water supply pump motors with VFD

WEG motor HP 40 1775 RPM

Two 15 HP chilled water supply pump motors with VFD

WEG motor Model 01512EP3E284T HP 15 1180 RPM

Three Cooling Towers with VFD's:

Baltimore Aircoil Company Model Number: 15296 Serial Number: U066282201

Building 2100:

The inspection included verifying that air handlers were installed in the building. Two of the four air handlers which serve the building were inspected. Information for one of the units is presented below:

Magic Aire fan coil unit Model number: 180/240-BMW/BMX BLOWR SECT

The units use chilled water.

Building 2000:

The inspection included verifying that air handlers were installed in the building. Approximately 25 units are on the roof of the building. Information for one of the units is presented below:

Magic Aire fan coil unit

Model number: 024-BRW-6-C

The units use chilled water.

B-1.10 M & V Approach Summary

The M&V approach for the measures at the site used enhanced rigor with IPMVP Option D, Calibrated Simulation. Savings were calculated using whole building simulation covering the associated buildings with load profiles calibrated using short term or continuous measurement.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	M&V Option Used*	Strata for Est. Savings	Summary of M&V Approach
1	1	Central Plant Pumps and Cooling Tower Fan VFD Retrofits	D	Certainty[1]	See below

Note 1: Final savings were significantly different from the estimate in the project application. However, there is no supporting document available for detailing the savings estimate of the project application.

Under this approach, savings were determined through a DOE-2 Building Energy Use Simulation (using eQuest).

PART C: INDIVIDUAL MEASURE EVALUATION

1.1 MEASURE ID: 1 Central Plant for Entire Campus

Total number of measures for this site is: 3

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	1	Central Plant for Entire Campus	1,811,137	692.5	0	$423,793.92	

Four new central plant for the Campus: A campus wide cooling system upgrade including replacement of chillers, cooling towers, and heat pumps, as well as consolidating central plants in fifteen buildings plants into four new central plants was completed. As second part of the HVAC systems upgrade, the package units were replaced with high efficiency package systems in a second group of 15 buildings.

C-3.4 M&V Features

Features of the M&V for Measure 1 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

The facility's project baseline equipment had Remaining Useful Life ranging from 2 to 5 years. Hence, the baseline is Early Replacement. ADM used weighted average efficiency of equipment in our analysis.

C-3.4.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

Measure 1 includes following HVAC system upgrades

#	Building Description[1]	Measure Detail	Project Description	Existing kW	Existing Annual kWh
1	Bldg. 700 73,911 SF	220 ton Chiller and Tower replacement	Replace 220 ton chiller with new 0.6kW/Ton Chiller and cooling tower replacement	283.1	941,952
2	Bldg. 700 73,911 SF	220 ton cooling tower replacement	Replace cooling tower		
3	Bldg. 2000 39,084 SF	Replace ground source HP	Replace Ground source Heat Pumps with 125 Ton chiller with AH and CT	159.9	429,332
4	Bldg. 700 73,911 SF	Replace controls in duct work	Convert pneumatic controls to DDC and motor controlled actuators		
5	Bldg. 500 32,746 SF	88 ton chiller replacement	Replace 88 ton chiller and cooling tower (water)	130.9	300,857
6	Bldg. 1100 32,619 SF	250 ton chiller replacement	Replace 250 chiller with new 0.59 kW/ton chiller (cools bldgs 1100&1300)	303.0	792,936
7	Bldg. 1100	Install VFD 25 HP chilled	Install VFD on 25 hp chilled water pump (CW-1)		

	32,619 SF	water pump			62,208
8	Bldg. 400 151,171 SF	Replace two 225 ton chillers	Replace two 225 chillers with high eff units(these cool bldgs. 200,400,1100)	416.7	620,394
9	Bldg. 400 151,171 SF	VFD installed on three 25hp cold water pump	Add VFD to three 25 hp chiller water pumps CWP-1,2,P	-	119,628
10	Bldg. 400 151,171 SF	Replace Air handlers w/ eff handlers sized to new chillers w/ VFD	AH-3, AH-9, AH-10, AH- 13, AH 11, AH 4, AH-12	518.3	1,249,740
11	Bldg 1820 1600 SF Modular	Replace 5 ton package unit	Replace SEER 8 Five Ton with SEER 14 unit	9.5	18,919
12	Bldg 1810 1600 SF Modular	Replace 5 ton package unit	Replace SEER 8 Five Ton with SEER 14 unit	9.5	18,919
13	Bldg 01— 20,275 SF	Replace a two and other HVAC Chillers with a single 100 ton unit	replace 40 ton, 25 ton chillers and two package and eleven Split-system with a 100 ton High eff chiller	124.1	276,258
14	Building 100(W1) 12,000 SF	Replace 7 Heat pump total 30 tons	Replace old Heat pump with hi eff Heat Pumps	52.5	165,748
15	Bldg 1800 4784 SF	Replace 15 tons of Heat pumps	Replace five old Heat pump with hi eff Heat Pumps	27.0	97,580
16	Bldg W-2 20,000 SF	Replace Bldg'sW2 water source Heat pumps	Replace five old Heat pump with hi eff Heat Pumps	136.0	246,133
17	Bldg 2300 15,000 SF	Replace Heat pump package units	Replace seven HP with Hi eff units	84.7	259,453
18	Bldg 900/901 20,102 SF	Replace AC,Exh fan,VFD for compressor	Replace six EF 1-6, 29 tons AC	35.7	132,102
19	Bldg. 300 22,705 SF	Rpl SF-1 economizer, CHW-pump-1	replace economizer SF-1/ CHW-1 Booster pump 2hp	49.5	211,930
20	Bldg 1400 10,000 SF	Replace Four 4 ton carrier units	Replace four SEER 10.2 units with SEER 16 units	46.3	122,415
21	Bldg 2200 2414 SF	Replace 0ne 4 ton Heat pump and one 5 ton HP	Replace two SEER 9 units with SEER 16 units	18.7	36,656
22	Bldg.s 1200 98,249 sq.ft.	Replace AC 35.5 ton	From Recommendation date 11-18-2005	99.8	479,124
23	Bldg.s 233/232	Replace AC AC-1,2,3,4,5.	Replace. AC AC-1,2,3,4,5, for a total of 15 tons	35.1	146,619
24	Bldg. 2100	Replace AC-1,AC-2, Exh Fan 1-14, SF-1	Replace 10 tons of HP& 14 Ex Fans, CWP-2, SF-1 for a total of 17.5 HP	25.8	118,103
25	Bldg. 3000 Berkley Cen. 20,725 SF	VFD on CT-1, CWP-1, CHW-P-1, SF-1 ,2	RPL motors/add VFD to pumps & fans total of 33 HP, and replace AC-1,2= 5 tons total	18.3	78,478
26	Bldg.mail room Adaptive svcs	Replace AC-2	Replace 7.5 ton HP	27.3	90,326
27	Bldg.600	Replace AC	Replace 60 tons of AC and two cooling towers	95.0	372,581
28	Bldg.2100	Replace AC	20 tons	117.2	196,892

1. For MBCx Projects - Building Area (square feet) for HVAC projects to included conditioned space only.

C-3.4.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

#	Building Description[1]	Measure Detail	Project Description	Existing kW	Existing Annual kWh
1	Bldg. 700 73,911 SF	220 ton Chiller and Tower replacement	Replace 220 ton chiller with new 0.6kW/Ton Chiller and cooling tower replacement	192.0	670,339
2	Bldg. 700 73,911 SF	220 ton cooling tower replacement	Replace cooling tower		
3	Bldg. 2000 39,084 SF	Replace ground source HP	Replace Ground source Heat Pumps with 125 Ton chiller with AH and CT	76.9	221,609
4	Bldg. 700 73,911 SF	Replace controls in duct work	Convert pneumatic controls to DDC and motor controlled actuators		
5	Bldg. 500 32,746 SF	88 ton chiller replacement	Replace 88 ton chiller and cooling tower (water)	78.1	181,367
6	Bldg. 1100 32,619 SF	250 ton chiller replacement	Replace 250 chiller with new 0.59 kW/ton chiller (cools bldgs 1100&1300)	226.3	597,891
7	Bldg. 1100 32,619 SF	Install VFD 25 HP chilled water pump	Install VFD on 25 hp chilled water pump (CW-1)		32,472
8	Bldg. 400 151,171 SF	Replace two 225 ton chillers	Replace two 225 chillers with high eff units(these cool bldgs. 200,400,1100)	265.1	399,044
9	Bldg. 400 151,171 SF	VFD installed on three 25hp cold water pump	Add VFD to three 25 hp chiller water pumps CWP-1,2,P		58,200
10	Bldg. 400 151,171 SF	Replace Air handlers w/ eff handlers sized to new chillers w/ VFD	AH-3, AH-9, AH-10, AH- 13, AH 11, AH 4, AH-12	518.3	636,611
11	Bldg 1820 1600 SF Modular	Replace 5 ton package unit	Replace SEER 8 Five Ton with SEER 14 unit	6.0	12,326
12	Bldg 1810 1600 SF Modular	Replace 5 ton package unit	Replace SEER 8 Five Ton with SEER 14 unit	6.0	12,326
13	Bldg 01— 20,275 SF	Replace a two and other HVAC Chillers with a single 100 ton unit	replace 40 ton, 25 ton chillers and two package and eleven Split-system with a 100 ton High eff chiller	68.1	153,704
14	Building 100(W1) 12,000 SF	Replace 7 Heat pump total 30 tons	Replace old Heat pump with hi eff Heat Pumps	35.2	116,823
15	Bldg 1800 4784 SF	Replace 15 tons of Heat pumps	Replace five old Heat pump with hi eff Heat Pumps	17.4	64,301
16	Bldg W-2 20,000 SF	Replace Bldg'sW2 water source Heat pumps	Replace five old Heat pump with hi eff Heat Pumps	65.9	121,450
17	Bldg 2300 15,000 SF	Replace Heat pump package units	Replace seven HP with Hi eff units	52.0	167,563
18	Bldg 900/901 20,102 SF	Replace AC,Exh fan,VFD for compressor	Replace six EF 1-6, 29 tons AC	28.6	65,064
19	Bldg. 300 22,705 SF	Rpl SF-1 economizer, CHW-pump-1	replace economizer SF-1/ CHW-1 Booster pump 2hp	49.4	140905
20	Bldg 1400 10,000 SF	Replace Four 4 ton carrier units	Replace four SEER 10.2 units with SEER 16 units	30.3	95,695
21	Bldg 2200 2414 SF	Replace 0ne 4 ton Heat pump and one 5 ton HP	Replace two SEER 9 units with SEER 16 units	11.5	27,044
22	Bldg.s 1200 98,249 sq.ft.	Replace AC 35.5 ton	From Recommendation date 11-18-2005	15.9	334,484
23	Bldg.s 233/232	Replace AC AC-1,2,3,4,5.	Replace. AC AC-1,2,3,4,5, for a total of 15 tons	24.5	103,063
24	Bldg. 2100	Replace AC-1,AC-2, Exh Fan 1-14, SF-1	Replace 10 tons of HP& 14 Ex Fans, CWP-2, SF-1 for a total of 17.5 HP	17.1	81,334
25	Bldg. 3000 Berkley Cen. 20,725 SF	VFD on CT-1, CWP-1, CHW-P-1, SF-1 ,2	RPL motors/add VFD to pumps & fans total of 33 HP, and replace AC-1,2= 5 tons total	15.5	66,125
26	Bldg.mail room Adaptive svcs	Replace AC-2	Replace 7.5 ton HP	21.6	72,999
27	Bldg.600	Replace AC	Replace 60 tons of AC and two cooling towers	58.7	157,103
28	Bldg.2100	Replace AC	20 tons	67.7	115,927

Note 1. For MBCx Projects - Building Area (square feet) for HVAC projects included conditioned space only.

Note 2. Baseline and as-built equipment are described in the measure detail column. Wherever applicable, package systems were replaced with high-efficiency systems, while chillers and associated equipment were replaced with four central chiller plants.

C-3.4.3 Seasonable Variability in Schedule and Production

The campus follows a 2-semester schedule plus summer sessions, with a mix of day, evening, and weekend classes. There is a 2-week vacation in August and a 4-week vacation from the midle of December to the middle of January. This schedule information was refined in discussions with Fullerton Community College staff to include as appropriate items such as class schedules, custodial schedules, planned operating patterns, and class sizes in extending short-term monitoring results to annual results.

C-3.5 Algorithms for Estimating Savings

C-3.5.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
1	Engineering Analysis

The actual algorithms and calculation methods used were not in the documents provided. A list of building operating loads, expected measure impact on the buildings, and a summary of energy usage by building was provided as part of the project documents. ADM obtained information on building operational hours during the site visit.

C-3.5.2 Level of Rigor in Evaluation

The Level of Rigor that will be used in the evaluation is IPMVP Options D.

C-3.5.3 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	Engineering analysis

Energy Savings on HVAC:

ADM performed a savings analysis using the DOE-2 Building Energy Simulation Model via eQUEST. The site parameters described in Section C-1.3.1 were collected, including HVAC system parameters and building activity areas. The same parameters were used for DOE-2 simulation model input. ADM used the weighted average kW/Ton values of project equipment in our analysis.

ADM calibrated the ex-post baseline model using climate zone 8 CEUS’ electrical end use profiles as facility’s utility bills were not available. The calibration details were presented in Section D.

C-3.5.4 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
	See below

ADM used California Protocol guidelines for estimating peak demand impact at the enhanced rigor level, option D. The peak demand, as defined by the CPUC, is the average demand reduction between 2pm and 5 pm for three consecutive weekdays, one of which must contain the hottest temperature of the year. ADM used the three peak days selected for climate zone 8 (September 23rd to September 25th) based on California Evaluation Protocol guidelines.

C-3.6 Data Collection

ADM's prepared survey forms (CP03) were used to collect data for the facility's campus-wide HVAC retrofit measure.

C-3.6.1 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
1	See below text

ADM conducted on-site interviews with facility staff in order to more precisely determine occupancy loads. Information thus provided on such factors such as operating hours, class schedules, custodial schedules, and semester breaks were incorporated into the analysis of total savings for the HVAC measures. Temperature settings (e.g., deadband with occupancy and without occupancy) and the schedule for the Environment Management System (EMS) were checked.

Documents and records at the site were reviewed, including basic building plans and architectural drawings. These data also include information on HVAC systems and equipment, lighting and hot water systems from mechanical, electrical and plumbing plans, as described below:

- Building plan data include building orientation, square footage, number of floors, wall structure, wall insulation type and thickness, number of windows and their shading coefficient, roof structure, roof insulation type and thickness.
- Visual inspections were made of control settings, lighting levels, inventory of end use appliances and equipment, ventilation rates, building population, occupancy level, and other parameters including set-point temperatures, operating schedules, etc.
- HVAC system details include SEER/EER ratings, distribution system, and unit tonnage.
- Data on cooling tower, chiller, and boiler load profiles.

Photographs of the site and of its electrical and mechanical systems were also taken during the on-site visit.

C-3.6.2 Sampling Strategy

Program Measure ID	Sampling Strategy
1	See below

We surveyed all relevant HVAC systems onsite for this measure. No sampling was done.

PART D: MEASUREMENT AND VERIFICATION RESULTS

Electrical Projects Summary: The facility began as a centralized chilled water plant and was later expanded to four chilled water plants with an HVAC system upgrade. The current electrical upgrade project include following measures:

4. Consolidating 14 individual chilled water plants into four chilled water plants with new chillers and associated equipment.
5. Replacing several package units with high efficiency HVAC package units or heat pumps.
6. Replacing existing motors and adding VFD to pumps and fans in Buildings 300, 1100 and 400.

ADM employed an eQuest model to determine the energy savings of the electrical upgrades and also the EMCS system controls of natural gas upgrades. ADM developed an eQuest model based on ex post as-built conditions calibrated to climate zone 8 CEUS colleges' electric end use energy profiles. ADM calibrated the as-built eQuest model to be within 10% of the CEUS data. The details of electric usage calibration are presented in Figures 1 and 2.

ADM verified from analysis that electrical project upgrades save 791,404 kWh, and 334.71 peak kW. The project's realization rate of electrical project upgrades is 27.47%. The variance between ex ante and ex post savings was caused mainly due to the following reasons:

- IOU analysis used eQuest defaults for analysis without calibrating the model either to the utility bills or CEUS end use profiles.
- IOU analysis included Building 400 in its analysis but ADM site survey discovered that this building was not yet connected to the central part. ADM did not consider the Building 400 in our analysis.

Figure 1: Comparison of Building and Simulation Demand

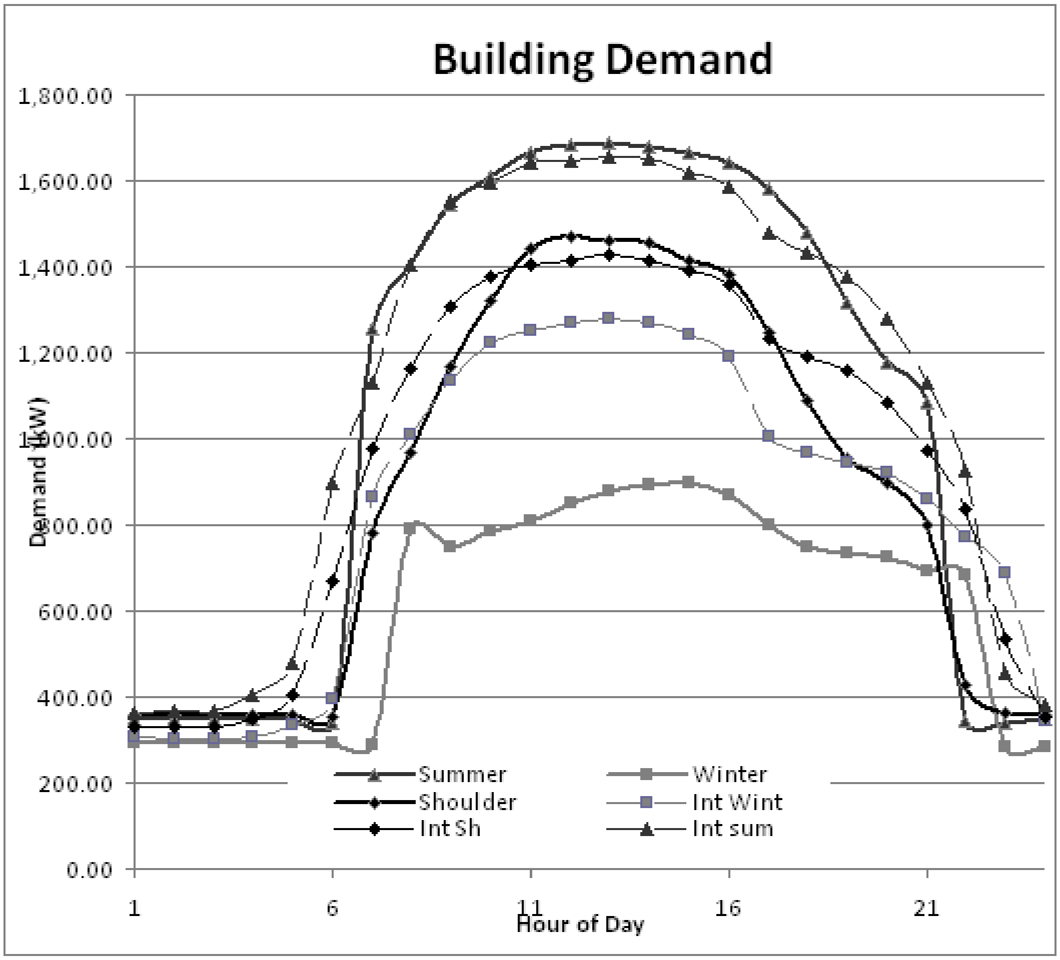
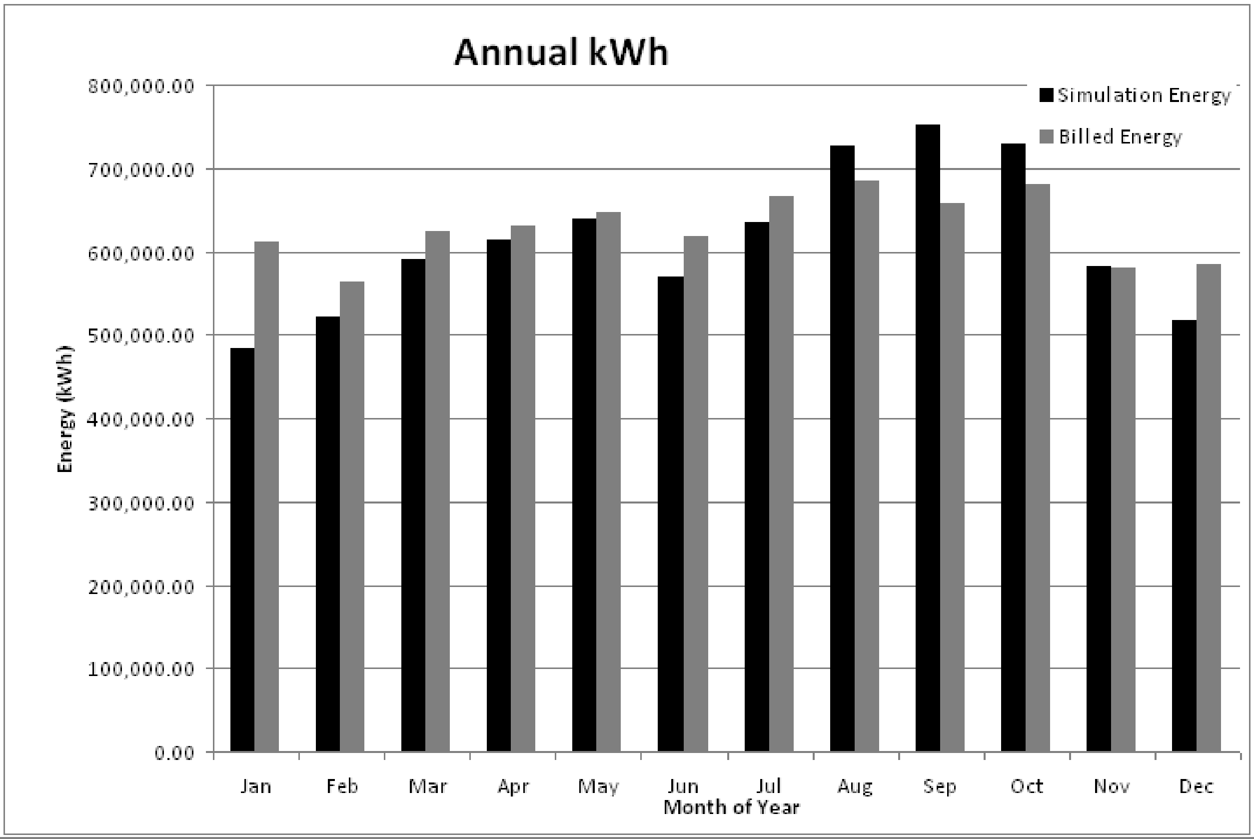


Figure 2: eQuest Monthly Consumption Versus Billing



SITE-SPECIFIC M & V REPORT

FULLERTON COMMUNITY COLLEGE – *PY2008-0030*
NORTH ORANGE COUNTY COMMUNITY COLLEGE DISTRICT

June 07, 2009

PART A: SUMMARY INFORMATION

Facility Information: The Fullerton community college is part of the North Orange County Community College District. The facility has undergone campus-wide energy efficiency retrofits under three separate projects (Lighting upgrade, campus-wide central plant retrofit, and steam and condensate system upgrade). There are 19 buildings that come under the Gas Savings measure. These buildings range in size from 22,705 square feet to approximately 152,000 square feet. The primary functional use of these buildings includes classrooms, offices, laboratories and support services. These buildings were built between 1973 and 1999.

Project Summary: The Steam and Condensate System Upgrade Project covers 19 buildings at Fullerton Community College. The project consists of three measures, as follows:

7. Faulty Steam Traps Replacement: This measure covers 10 buildings and associated tunnel areas and involves three types of steam traps (Drip, HX, HWST). Inlet pressures of 10-12 psi were replaced with Spirex-Sarco steam traps.
8. EMCS system controls: These controls were added to five buildings (#500, #600, #1100, #2000, and #2100) to perform a hot-deck reset and chilled water control.
9. Condensate return system: The existing system was upgraded to allow for condensate return and to reduce steam leakages in four buildings (#400, #700, #800, and #1200).

A-1.4 PROJECT INFORMATION

Utility Service Territory	SCG
Program Being Evaluated	California Community Colleges Energy Efficiency Partnership Program
ADM Sample ID &Project ID	PY2008-0030
Customer Name	North Orange County Community College District
Site Name	Fullerton Community College
Site Address	1830 West Romneya Drive , Anaheim, CA
Site Type	Community College
Customer Business/Product	Community College

PRINCIPAL SITE CONTACT

Name	Ron Beeler	**Telephone**	(714) 808-4893
E-mail	rbeeler@nocccd.edu	**Title**	Director of Facilities Planning and Construction

IOU REPRESENTATIVE

Name	Only a signature was found, no name anywhere	**Telephone**	
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	Self-sponsored by the facility

ASSIGNED LEAD ENGINEER

Name	S. Thamilseran

AUTHOR

Name	S. Thamilseran

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.11 Goals and Objectives

The primary goal of the impact evaluation is to assess the gross program-specific energy and demand impacts for the retrofits for the 2006 – 2008 program period. A secondary goal is to increase the quality, reliability and objectivity of the impact evaluation methodology employed.

The impact evaluation accomplished the following objectives:

- Determine the impact of the steam and condensate system upgrade on annual gross energy savings at this site.
- Account for any spillover effects at this site.

B-1.12 Measures Installed in Project

There are three measures that were installed at this facility during the 2006-2008 period, as described below.

- Steam and condensate system retrofits along with an associated EMS controls upgrade which provides gas savings (SCG project PY2008_0030).
- Central plant chiller, pumps and cooling tower retrofits which consolidate individual chiller plants in 15 buildings (buildings 200, 300, 400, 500, 600, 700, 1000, 1100, 1300, 2000, 2100, and CE 232, and CE 233) into four new central chiller plants located in the Mini plant, Buildings 1100 and 500, and the Wilshire plant. This measure will also replace package units in 14 buildings (Buildings 01, 100, 200, 232, 233, 1800, 1810, 1820, 900, 901, 1400, 2200, 3000, W-2, and mail room) with high efficiency units. Some buildings (300, 400, 500, 600, 700, 1000, and 1100) are impacted by both electric and gas energy savings measures. Project CCC-DD-0015 was performed for Southern California Edison and come under a separate M&V Plan. These combined measure impacts and the associated time frame will be clarified during the site visit. The impact of savings from EMS control of chilled water may be observed as a spillover effect measured by electrical energy savings.
- A campus-wide lighting retrofit that includes retrofitting all indoor spaces (class rooms, gymnasium, and support areas) replacing T-12 fixtures with T-8 fixtures and all parking lot and campus outdoor lighting fixtures (MH replaced with PSMH) under another project.

Program	Measure ID (ADM)[1]	Measure ID (IOU)	Measure Group	System	Measure Description
SCG PY2008	1	8.0030a	HVAC	Steam systems	Steam trap replacement
SCG PY2008	2	8.0030b	HVAC	Steam systems	Condensate system upgrade
SCG PY2008	3	8.0030c	HVAC	Steam systems	EMS Control upgrade

Annual Measure Savings Summary

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kW)	Electric Demand Savings (kWh)	Natural Gas Savings (therms)[1]	Incentive ($)	Total Annual Cost Savings ($)
1	8.0030a	Steam trap replacement (56 qty)	-	-	35,728	$53,592	
2	8.0030b	Condensate system upgrade	-	-	24,425	$38,138	
3	8.0030c	EMS Control upgrade	-	-	2,190	$ 9,255	
Total Savings:				-	62,343	$100,985	
Total Site Usage[2]:							
% Total Site Usage Saved[2]:							

B-1.13 Measures Included in the Evaluation

Only one measure (gas system energy savings) is included in the evaluation.

B-1.14 Information from Application Review

The application for Fullerton Community College (under NOCCCD) was submitted by Ron Beeler, Director of Facilities Planning and Construction, with calculations and engineering details provided by John Walton of ACCO Engineered Systems. No details on the project review or approval process are provided in the project files. There is also no information in the project files on pre- and post- retrofit site visits for these measures. However, the invoices for the 56 steam traps and a white paper on energy savings associated with steam trap are provided.

Following ADM's site visit, the M&V approach will be adjusted to simulate a sample of buildings on the Fullerton Community College campus.

B-1.15 M & V Approach Summary

Both the steam trap replacement and condensate return upgrade measures were evaluated using Option B while the EMCS control upgrade measure was evaluated using the Calibrated DOE-2 Simulation. The condensate return and steam trap upgrades savings depend upon system inlet pressure, pipe size, quality of leak, and type of trap. Consequently, the savings can be better evaluated by the Option B retrofit isolation approach. The impact of hot-deck reset and chilled water control changes in the EMS system will impact the gas savings for the five buildings. The Option D Calibrated Simulation approach was used for estimating savings for the EMS control upgrade.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	M&V Option Used*	Strata for Est. Savings	Summary of M&V Approach

1	8.0030a	Steam trap replacement (56 qty)	B	-	B for steam trap savings
2	8.0030b	Condensate system upgrade	B	-	B for efficient condensate return
3	8.0030c	EMS Control upgrade	D	-	D for HVAC control changes

PART C: INDIVIDUAL MEASURE EVALUATION FOR

1.2 MEASURE ID: 1

Steam Trap Replacement

Total number of measures for this site is: 3

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	8.0030a	Steam trap replacement (56 qty)	-	-	35,728	$53,592	

C-3.7 M&V Features

Features of the M&V for Measure 1 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Options B

The facility's project baseline steam traps had Remaining Useful Life ranging from 2 to 5 years. Hence, the baseline is Early Replacement.

C-3.7.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

Measure 1 replaces 56 steam traps as provided under C-1.1.2 for as-built equipment. Information on baseline equipment, quality of the trap leaks and operation were not provided.

C-3.7.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

The following 56 steam traps were replaced with Inverted bucket (IB) or Float & Thermostatic Traps (FT) type steam traps. The tabulation also provides the application point, type of application, approximate inlet pressure, and pipe size.

Location	Application	Steam	Pressure	Manufacturer	Type	Model	Size (inch)	Q'ty	Connection Type	Spirax sacrco Eq
Boiler Room	-	Drip	10~12	Spirax Sarco	IB	B1H	0.75	1	Straight thru	3/4" B1H-30
Boiler Room	-	HX	10~12	Hoffman	FT		2	1	Off set	2" FT14-4.5
1200	Gym	Drip	10~12	Warren-Webster	FT		0.75	1	Parallel	3/4" FT-30
1200	Gym	HWST	10~12		FT	1	1.25	2	Parallel	1 1/4" FT-30
1200	Gym	Drip	10~12	Armstrong	IB	881	0.75	1	Straight thru	3/4" B1H-30
1200	Gym	HX	10~12		FT	1	1.5	1	Parallel	1 1/2" FT-30
1200	Gym	Drip	10~12	Armstrong	IB	813-15	0.75	1	Straight thru	3/4" B1H-30
1200	Gym	Drip	10~12	Hoffman	FT	FT015H-5	1	2	Off set	1 1/4" FT-30
600	Bldg	HX	10~12	Armstrong	FT		2	1	Parallel	2" FT-30
600	Bldg	Drip	10~12	Armstrong	FT		2	1	Parallel	3/4" FT-30
600	Bldg	Drip	10~12	Hoffman	FT	FT015H-4	1	1	Parallel	1" FT-30
Tunnel	East West from Gym	Drip	10~12	Hoffman	FT	FT015-5	1	2	Off set	1" FT14HC-4.5
Tunnel	East West from Gym	Drip	10~12	Hoffman	FT	FT015-5	1	2	Off set	1" FT14HC-4.5
400	Bldg	Drip	10~12	Hoffman	FT		0.75	1	Parallel	3/4" FT-30
400	Bldg	Drip	10~12	Hoffman	FT	FT015H-3	0.75	1	Off set	3/4" FTI-30
400	Bldg	HX	10~12	Hoffman	FT		1.25	1	Off set	1 1/2" FT14-4.5
400	Bldg	HWST	10~12	Armstrong	IB	818	1	1	Straight thru	1" FT14HC-4.5
Tunnel	200 bldg	Drip	10~12	Armstrong	IB	811	1	1	Straight thru	1" B2-30
200	Bldg	Drip	10~12	Hoffman	FT	FT030H	1	1	Off set	1" FT14HC-4.5
200	Bldg	HX	10~12	Hoffman	FT	FT030H	1	1	Off set	1" FT14HC-4.5
Tunnel	NS of 900 bldg	Drip	10~12	Hoffman	FT	FT015H-5	1.25	1	Parallel	1 1/4" FT-30
Tunnel	East end of NS	Drip	10~12	Hoffman	FT	56FT15	1	1	Parallel	1" FT-30
Tunnel	East end of NS	Drip	10~12	Hoffman	FT	56FT15	1	1	Parallel	1" FT-30
Tunnel	exit cafeteria	Drip	10~12	Armstrong	FT		1.25	1	Off set	1" FT14HC-4.5
500	Bldg	HX	10~12	Hoffman	FT	FT015H-6	1.5	1	Off set	1 1/2" FT14-4.5
500	Bldg	HX	10~12	Hoffman	FT	FT015H-4	1	1	Off set	1" FT14HC-4.5
500	Bldg	Drip	10~12	Illinois	IB		1	1	Straight thru	1" FTI-30

500	Bldg	HWST	10~12	Illinois	IB		1	1	Straight thru	1" FTI-30
Tunnel	300 bldg	Drip	10~12	Armstrong	FT	FT15-5	1	1	Straight thru	1" FTI-30
300	Bldg	Drip	10~12	Warren-Webster	FT		1	1	Off set (2plane)	1" FT14HC-4.5
300	Bldg	Drip	10~12	Armstrong	FT	FT15-B5	1	1	Off set	1" FT14HC-4.5
300	Bldg	HX	10~12	Armstrong	FT	FT15	1	1	Off set	1" FT14HC-4.5
Tunnel	end of run 1000 bldg	Drip	10~12	Armstrong	FT		1.25	1	Parallel	1 1/4" FT-30
1000	Bldg	HX	10~12	Hoffman	FT	FT015H-5	1	1	Off set	1 1/2" FT14-4.5
1000	Bldg	HX	10~12	Illinois	IB		1.25	1	Straight thru	1 1/2" FT14-4.5
1000	Bldg	Drip	10~12	Illinois	IB		0.75	1	Straight thru	3/4" B1H-30
1100	Bldg	HX	10~12	Hoffman	FT	58FT-15	2	1	Parallel	2" FT-30
1100	Bldg	Drip	10~12	Hoffman	FT	53FT	0.75	1	Off set	3/4" B1H-30
1100	Bldg	DWH	10~12	Spirax Sarco	Thermostatic		0.75	2	Angle	3/4" FT-30
1100	Bldg	Drip	10~12	Armstrong	FT	FT15-B5	1	2	Off set	1" FT14HC-4.5
700	Bldg	HX	10~12	Armstrong	FT		2	1	Parallel	2" FT-30
700	Bldg	HX	10~12	Armstrong	IB	814	1	1	Straight thru	1 1/2" FT14-4.5
700	Bldg	HX	10~12	Dunham-Bush	FT		1.25	1	Parallel	1 1/4" FT-30
700	Bldg	Drip	10~12	Warren-Webster	FT		0.75	1	Parallel	3/4" FT-30
700	Bldg	HWST	10~12	Armstrong	FT		1	1	Parallel	1" FT-30
700	Bldg	Drip	10~12	Warren-Webster	FT		0.75	1	Parallel	3/4" FT-30
Cafeteria	-	HX	10~12	Hoffman	FT		1	1	Off set	1" FT14HC-4.5
Cafeteria	-	HX	10~12	Hoffman	FT		1.5	1	Off set	1 1/2" FT14-4.5
Cafeteria	-	HWST	10~12	Hoffman	FT		1.5	1	Off set	1 1/2" FT14-4.5

ADM did not consider the steam traps part of Building 400 (four traps) in our analysis since this building was not occupied as of our field visit.

C-3.7.3 Seasonal Variability in Schedule and Production

The campus follows a two-semester schedule plus summer sessions, with a mix of day, evening, and weekend classes. There is a two-week vacation in mid August and a four-week vacation from mid-December to mid-January. We will refine this schedule information in discussions with Fullerton Community College staff, and will include, as appropriate, items such as class schedules, custodial schedules, planned operating patterns, and class sizes in extending short-term monitoring results to annual results. Since seasonal operating patterns are present in the facility, information on seasonal variation (e.g., class schedules, planned operating patterns, and class sizes) was incorporated into the analysis to estimate annual savings.

C-3.8 Algorithms for Estimating Savings

C-3.8.1 Algorithms Used by IOUs

Program Measure ID	Algorithm

Program Measure ID	Algorithm
1	Engineering Analysis

The gas savings of steam traps were calculated as follows:

Energy savings, therms = (Number of steam traps) * (Average gas consumption of leaky trap per hour) * (Operational hours)

Though no detailed account of how the calculations were performed or how energy savings were estimated, a white paper (Steam Traps by Southern California Gas Company**) was provided as a support document.**

C-3.8.2 Level of Rigor in Evaluation

The level of rigor is IPMVP Option B. Building operating characteristics, a list of replaced steam traps, , inlet pressures and trap pipe sizes were collected on site. ADM could not obtain the baseline traps condition and their quality of performance for our survey efforts. The above collected data was used in a retrofit isolation approach.

C-3.8.3 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	Engineering analysis

Energy Savings on Steam traps:

ADM used the Steam Traps work paper published by Southern California Gas Company in our energy savings analysis as ADM could not obtain the details of baseline steam traps' faulty conditions during our site survey. Hence, ADM used the value of average gas consumption of leaky trap per hour mentioned in the white paper.

Energy savings, therms = (Number of steam traps) * (Average gas consumption of leaky trap per hour) * (Operational hours)

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C-3.8.4 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	Not applicable

This section is not applicable for the current measure as the measure resulted only gas savings.

C-3.9 Data Collection

CPA123 HVAC survey forms (CP03) will be used to collect data on the facility's steam trap replacement measure.

C-3.9.1 Site-Specific Parameters

Program Measure ID	Site-Specific Parameters
1	See below

ADM obtained the information of steam traps including number of traps replaced part of the project, line steam pressure, trap size, and operational hours and also verified the replaced steam traps in our survey. ADM interviewed the facility staff on-site and identified that steam system part of the project runs for 8,760 hours. Note that Building 400 steam traps were not considered in our analysis as this building was not occupied.

C-3.9.2 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
1	See below text

Documents and records were reviewed on site (e.g., maintenance schedules) to establish baseline equipment operations. . Trap characteristics, line size, line pressure and type of trap were verified through visual inspection.

C-3.9.3 Sampling Strategy

Program Measure ID	Sampling Strategy
1	See below

We conducted an onsite survey of all relevant steam traps listed for this measure. No sampling was done.

Measure ID: 2

CONDENSATE SYSTEM UPGRADE

Total number of measures for this site is: 3

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
2	8.0030b	Condensate system upgrade	-	-	24,425	$38,138	

C-3.1 M&V Features

Features of the M&V for Measure 2 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Options B

C-3.1.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
2	See below

ADM site survey discovered that the facility had fully functional condensate system in Buildings 700, 800, and 1200 before the project and did not perform any upgrades on this system part of the project.

ADM site visit also found that Building 400 was not occupied.

C-3.1.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
2	See below text

There were no changes in hanges in the steam condensate system from pre-project to as-built conditions.

C-3.1.3 Seasonable Variability in Schedule and Production

The seasonal variation was the same as that described under Measure 1.

C-3.2 Algorithms for Estimating Savings

C-3.2.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
2	Engineering Analysis

The energy savinsg due to this measure were calculated as follows:

Annual fuel savings=(1-flash steam fraction) * (Condensate load in lbs/hr) *Annual Operating hours * (Makeup water temperature rise in F)/ boiler efficiency

C-3.2.2 Level of Rigor in Evaluation

The level of rigor is IPMVP Options B. A list of building operating characteristics, replaced baseline systems, baseline conditions and quality of operation will be collected onsite along with verification of a given inlet pressures and pipe size. These will be used under the retrofit isolation approach.

C-3.2.3 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
2	Engineering analysis

Since facility did not perform any upgrades on steam condensate system described in the project file, ADM did not consider this measure in our analysis.

C-3.2.4 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
2	Not applicable

This section is not applicable for the current measure.

C-3.3 Data Collection

C-3.3.1 Site-Specific Parameters

Program Measure ID	Site-Specific Parameters
2	See below

ADM interviewed the facility staff and identified that measure 2 was not implemented. Hence, measure parameters were not collected.

C-3.3.2 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
2	See below text

ADM interviewed the facility staff and identified that measure 2 was not implemented. Hence, measure parameters were not collected.

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C-3.3.3 Sampling Strategy

Program Measure ID	Sampling Strategy
2	See below

We surveyed all relevant buildings associated with this measure. No sampling was done.

1.3 MEASURE ID: 3
EMS Control Upgrade

Total number of measures for this site is: 3

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
3	8.0030c	EMS Control upgrade	-	-	2,190	$ 9,255	

C-3.4 M&V Features

Features of the M&V for Measure 3 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Options D

C-3.4.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
3	See below

Measure 3 upgrades the EMS controls for five buildings (500, 600, 1100, 2000, and 2100). This measure will add a hot deck reset schedule to the existing EMS controls and add necessary chilled water controls adjustments as needed to reduce the chance of hot-call or cold-call type maintenance issues.

C-3.4.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
3	See below text

EMS controls were installed on the system equipment described in the previous section.

C-3.4.3 Seasonable Variability in Schedule and Production

The season variation for this measure was the same as that described under measure 1.

C-3.5 Algorithms for Estimating Savings

C-3.5.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
3	Engineering Analysis

IOU used eQuest model for its analysis. **The documents provide energy usage for the base case and for the two added control options in the form of eQUEST output. No additional details were available.**

C-3.5.2 Level of Rigor in Evaluation

The evaluation Level of Rigor is IPMVP Options D. Based on the field survey of the five impacted buildings a building prototype will be generated in DOE2 and used for evaluating the EMS control option changes.

C-3.5.3 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
3	Engineering analysis

Energy Savings on EMS Control Upgrade:

Based on site collected data and the characteristics of baseline and as-built equipment, a simulation was performed to estimate the measure savings.. Using the school calendar and building activity schedule, annual operation hours will also be assessed and input to the DOE 2 model.

C-3.5.4 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
3	Not applicable

This section was not applicable as measure 3 resulted only gas savings.

C-3.6 Data Collection

CPA123 HVAC survey forms (CP03) were used to collect data for the facility's EMS controls upgrade measure.

C-3.6.1 Site-Specific Parameters

Program Measure ID	Site-Specific Parameters
3	See below

The following information was collected from site-specific data sources:

1. The specifications of baseline and as-built EMS features and their control features
2. Specifications of chillers, chilled water pumps, cooling tower, boilers, and condensing water pumps
3. Chilled-water, hot-water and condensing water systems parameters and operational controls
4. Specifications of heating system including boilers
5. HVAC distribution system parameters and equipment including system type, zones, system schedules, and system resets, system supply and return fans, newly installed supply fan VFDs, and economizers
6. Measure condition area of the facility
7. Activity areas of the site, their associated lighting and equipment densities, and operational patterns.
8. Physical and thermal characteristics of the building including building orientation, Sq. footage, number of floors, wall structure, wall insulation type and thickness, number of windows and their shading coefficient, roof structure, roof insulation type and thickness

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C-3.6.2 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
3	See below text

The following methods was used to collect the data:

1. Specifications as well as their control features of pre- and post- **Energy Management Systems** were obtained from name plates, controls drawings, and interviews the facility staff.
2. Specifications of chillers, chilled water pumps, cooling towers, condensing water pump, condensing water pump VFD, and associated equipment were from name plates, engineering drawings, and interviews the facility staff.

3. The chilled water and condensing water flow parameters including temperatures were from on-site survey observations/measurements and the Energy Management Control System (EMCS) panel.
4. Specifications of HVAC distribution equipment was collected from name plate data and engineering drawings.
5. HVAC distribution system parameters and operational details were recorded from on-site survey observations/measurements, engineering drawings, and trend log of EMCS.
6. Boilers' specifications, load, operational hours, and controls were be obtained from nameplate, physical observations, and engineering drawings. .
7. Different functional areas of the facility and its associated lighting density and schedules weree obtained from visual inspections, and drawing layouts
8. Miscellaneous equipment density and schedules per functional area were obtained from visual inspections, and discussions with the facility personnel
9. Physical and thermal characteristics of the building were obtained from visual inspection, photographs, and architectural drawings
10. Trend profile and control parameters for the hot-deck and cold-deck set points, operating criteria were obtained from the EMS panel.

C-3.6.3 Sampling Strategy

Program Measure ID	Sampling Strategy
3	See below

ADM verified the installation of EMS control strategies in all the measure buildings described in the project file, . Hence, no sampling was done.

PART D: MEASUREMENT AND VERIFICATION RESULTS

The Steam and Condensate System Upgrade Project covers 19 buildings at Fullerton Community College. The natural gas project consists of following three measures:

1. Faulty Steam Traps Replacement: This measure covers 10 buildings and associated tunnel areas and involves three types of steam traps (Drip, HX, HWST). Inlet pressures of 10-12 psi were replaced with Spirex-Sarco steam traps.
2. Condensate return system: The existing system was upgraded to allow for condensate return and to reduce steam leakages in four buildings (#400, #700, #800, and #1200). ADM discovered from its site visit that facility had condensate Return System before the current project and did not do any changes in the system. Hence, ADM did not consider the "Condensate Return System" measure in our analysis.
3. EMCS system controls: These controls were added to five buildings (#500, #600, #1100, #2000, and #2100) to perform a hot-deck reset and chilled water control.

ADM employed engineering analysis for measure 1 and an eQuest model for measure 3 to determine the respective measure energy savings.

ADM's analysis of natural gas upgrades result 36,081 therms with a realization rate of 53.59%. The variance between ex ante and ex post savings was caused mainly due to the following reasons:

- IOU analysis included Building 400 in its analysis but ADM site survey discovered that this building was not yet connected to the central part. ADM did not consider the Building 400 in our analysis.
- Facility had condensate rerun system before the current project and nothing was done on this system during the current project period.

M & V SITE REPORT

LONG BEACH COMMUNITY COLLEGE – CCC-DD-0025

November 2009

PART A: SUMMARY INFORMATION

A-1.5 Project Information

Utility Service Territory	SCE
Program Being Evaluated	California Community Colleges Energy Efficiency Partnership Program
ADM Sample ID &Project ID	CCC-DD-0025
Customer Name	Long Beach Community College District
Site Name	Liberal Arts College
Site Address	Long Beach, CA 90808
Site Type	Community College
Customer Business/Product	Community College

PRINCIPAL SITE CONTACT

Name	Greg Floyd	**Telephone**	562-938-4069
E-mail	gfloyd@lbcc.edu	**Title**	Deputy Director of Facilities

IOU REPRESENTATIVE

Name		**Telephone**	
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	Self sponsored

Note: The measure information that has been obtained from the project file is presented below in this document using italicized text.

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.16 Measures Included in the Evaluation

The project covered under this period (2006 – 2008) under Long Beach Community College District includes two HVAC measures. Specifically, three new chillers were installed at the Pacific Coast College and Liberal Arts College sites to replace individual package units with new central chiller plants at Campus. The measures specified in the program period are as follows:

Measure ID[1] (ADM)	Measure ID (IOU)	Measure Group	System	Measure Description
1	6100	HVAC	HVAC	PCC Central Plant (Electrical Savings)
2	6101	HVAC	HVAC	LAC Central Plant (Electrical Savings)

This report describes the Liberal Arts College project analysis.

Annual Savings Summary for Measures

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings[1] (kWh)	Electric Demand Savings[1] (kW)	Natural Gas Savings[1] (therms)	Incentive[1] ($)	Total Annual Cost Savings ($)
1	6101	LAC Central Plant (Electrical Savings)	465,830	328.0	0	$894,385.31	
Total Savings:			**465,830**	**328.0**	**0**	**$894,385.31**	
Total Site Usage:							
% Total Site Usage Saved:							

Note 1: Results from CCC-DD-0025 agreement dated 5/04/2007

B-1.17 M & V Approach Summary

THIS M&V SITE REPORT PERTAINS TO THE MEASURE AT LONG BEACH COLLEGE – LIBRAL ARTS COLLEGE CAMPUS, AS SUMMARIZED BELOW.

Measure ID (ADM)	Measure Name	M&V Option Used	Summary of M&V Approach
1	LAC Central Plant (Electrical Savings)	D	D for Efficient HVAC Equipment

B-1.2.1 Summary of M&V Approach:

Measure 1 pertain to the central plant conversion at the Liberal Arts College campus and involve electricity savings.

IPMVP Option D: DOE-2 simulation was used to evaluate this measure based on site survey data.

PART C: INDIVIDUAL MEASURE EVALUATION

C-4 MEASURE ID: 1: LAC CENTRAL PLANT (ELECTRICAL SAVINGS)

Central Plant (Electrical Savings): The Liberal Arts College campus central plant was constructed with two Trane and 1 Multi-stack electric chillers to replace the individual cooling equipment at the campus's buildings.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	6101	LAC Central Plant (Electrical Savings)	465,830	328.0	0	$894,385.31	

C-4.1 M&V Features

Features of the M&V for Measure 1 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement*
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

* Sine the pre-project equipment had Remaining Useful Life ranging from 2 to 5 years, the baseline type was considered to be early replacement.

C-4.1.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

Keith Valenzuela of AESC met with Greg Floyd, Deputy Director of LBCC and Angel Alvarez of LBCCD Bond management Team on December 5, 2006. Buildings D, M and L in the LAC campus were inspected.

Building D:

Two Chillers

York Chiller 1: Model Number: YCAS0180EC46YFA

Serial Number: RKHM3840AA

York Chiller 2: Model Number: YCAS0180EC46YFA

Serial Number: RKHM3830AA

Building M:

Three Chillers

Carrier Chiller 1: Model Number: 30GTN040-EC520—

Serial Number: 1100F86099

Carrier Chiller 2: Model Number: 30GTN040-EC520—

Serial Number: 1100F86117

Trane Chiller 3: Model Number: RTAA1004XK01B300BFKN

Serial Number: U98M04612

Building L:

Two Chillers

Carrier Chiller: Model Number: 30 HP 100 D 600

Serial Number: U180338

Trane Chiller: Model Number: RTWA070AYE01D3D1W

Serial Number: U99K02905

Building T will be demolished to make room for the proposed central plant. The construction of the central plant has not been started at the Liberal Arts Campus.

C-4.1.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

According to Project File:

Distributed chillers and associated pumps and cooling units in Buildings D, M and L on campus were replaced by a central plant with three (two Trane CVHF570 & one Trane CVHE450) chillers. The project file did not provide information about the number of buildings on the Liberal Arts College campus, their sizes, or their dispositions. Based on the project information, it is considered as only these three building (D, M, and L) where individual cooling equipment are replaced with a new central plant for providing building cooling. Since the individual chillers are replaced by a central plant, no change in air-handling equipment or cooling coils is assumed.

The following equipment was noted during the post-inspection visit for Liberal Arts Campus (dated 12/17/2008):

Three (3) chillers were present

Two (2) identical chillers, Trane Model Number CVHF570

One (1) chiller, Trane Model Number CVHE450

Three (3) condenser water pump motors

Westinghouse Model Number: PDHO2504TE2N HP: 25

Three (3) chilled water pump motors with VFD’s

Westinghouse Model Number: PDHC5004TE2N HP: 50

The LRC building and South Quad Complex are tied to the central plant. According to Medhanie Ephrem of Long Beach Community College the central plant has been tested and chilled water has been run to the buildings but the buildings were not occupied until January 2009.

According to ADM survey:

The facility constructed a central plant for its eight buildings and it comprises three chillers, two Trane CVHF570 & one Trane CVHE450. ADM site visit discovered that only Building L (that had packaged units in the pre-project conditions) was connected to the Central Plant as of now.

C-4.1.3 Seasonal Variability in Schedule and Production

The campus follows a 2-semester schedule plus summer sessions, with a mix of day, evening, and weekend classes. There is a 2-week vacation in mid August and a 4-week vacation between mid-December and mid-January. This schedule information was refined in discussion with Long Beach Community College staff to include, as appropriate, items such as class schedules, custodial schedules, planned operating patterns, and class sizes in extending short-term monitoring results to annual results. Since seasonal operating patterns are evident, class schedules, planned operating patterns, class sizes were incorporated into the analysis to extrapolate the findings to annual operations.

C-4.2 Algorithms for Estimating Savings

C-4.2.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
1	Engineering Analysis

The baseline kWh is measured for both buildings combined. Long Beach CC EQuest Summary provides only baseline kW, therefore baseline kWh is used for this project.

Proposed kWh is also provided as summary for both building combined. Long Beach CC EQuest Summary provides only proposed kW, therefore, proposed kWh is used for this project.

Energy Savings, kWh = (Baseline kWh) – (Proposed kWh)

C-4.2.2 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	Engineering analysis

ADM performed a savings analysis using the DOE-2 Building Energy Simulation Model via eQUEST. The site parameters described in Section C-1.3.1 were collected, including HVAC system parameters and building activity areas. The same parameters were used for DOE-2 simulation model input. ADM used the weighted average kW/Ton values of project equipment in our analysis.

Since only one building, Building L is connected to the Central Plant as of now, ADM built the eQuest model based on the Building L’s description. ADM could not obtain the details of Building L’s baseline packaged units, facility distribution system, lighting and miscellaneous loads due to unresolved scheduling conflicts with the facility, ADM had to use project file information and our best engineering estimates for missing details.

ADM assumed that the campus buildings have Variable Air Volume (VAV) HVAC distribution system and used eQuest defaults for our analysis with pre-project and as-built space conditioning equipment specifications.

The baseline model consists of pre-project equipment while as-built model consists of as-built central plant equipment. The energy savings of the project were determined by subtracting as-built energy consumption from baseline energy consumption..

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C-4.2.3 Peak Demand Algorithms Used in the Evaluation

ADM used California Protocol guidelines for estimating peak demand impact at the enhanced rigor level, option D. The peak demand, as defined by the CPUC, is the average demand reduction between 2pm and 5 pm for three consecutive weekdays, one of which must contain the hottest temperature of the year. ADM used the three peak days selected for climate zone 6 (September 24th to September 26th) based on California Evaluation Protocol guidelines.

C-4.3 Data Collection

ADM HVAC data sheets (CP03) were used to collect data for the facility's Central Plant project. .

C-4.3.1 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
1	See below text

Data were first collected through interviews with the staff of the site. These interviews provide information on the two associated buildings' functional areas, occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other "human factors" that are associated with energy use at these buildings.
ADM site visit discovered that only one of the facility's fifteen buildings, Building L is connected to the Central Plant.

ADM obtained the details of Building LL's physical and thermal characteristics, schedules from survey observations, campus map, and campus calendar.

ADM could not obtain the details of Building L's baseline packaged units, facility distribution system, lighting and miscellaneous loads due to unresolved scheduling conflicts with the facility, ADM had to use project file information and our best estimates for missing details.

C-4.3.2 Sampling Strategy

Program Measure ID	Sampling Strategy
1	See below

Because only one building is connected to the Central Plant as of now, no sampling strategy was required for this measure..

PART D: MEASUREMENT AND VERIFICATION RESULTS

The Liberal Arts College campus project was to involve the replacement of individual campus buildings' cooling equipment with a central plant comprises two 570-ton and one 450-ton capacity Trane chillers. According to information obtained for this M&V effort, however, Building L was the only building connected to the Liberal Arts college central plant at the end of 2008.

According to IOU simulation files and project file information, Building L in Liberal Arts College had packaged units in the pre-project conditions. ADM built the eQuest model based on the Building L's description to determine the project energy savings.

The M&V analysis of electrical upgrades for the Liberal Arts College determined that project upgrades save 156,029 kWh, and 38 peak kW. The project's realization rate of electrical project upgrades is 4.8%.

The variance between ex ante and ex post savings was caused mainly due to the following reasons:

- Only one of the fifteen buildings was connected to Central Plant as of 2008.
- IOU analysis used inappropriate eQuest defaults in its analysis (for example constant speed Multizone HVAC distribution system in baseline conditions and variable speed VAV system in post-project conditions). In the M&V analysis, variable speed VAV system was specified for both baseline and post-project conditions.
- IOU analysis considered two buildings in its eQuest model and scaled the savings to the campus area.

M & V SITE REPORT

LONG BEACH COMMUNITY COLLEGE – CCC-DD-0025

November 2009

PART A: SUMMARY INFORMATION

A-1.6 Project Information

Utility Service Territory	SCE
Program Being Evaluated	California Community Colleges Energy Efficiency Partnership Program
ADM Sample ID &Project ID	CCC-DD-0025
Customer Name	Long Beach Community College District
Site Name	Pacific Coast College
Site Address	4901 E Carson Street, Long Beach, CA 90808
Site Type	Community College
Customer Business/Product	Community College

PRINCIPAL SITE CONTACT

Name	Greg Floyd	**Telephone**	562-938-4069
E-mail	gfloyd@lbcc.edu	**Title**	Deputy Director of Facilities

IOU REPRESENTATIVE

Name		**Telephone**	
E-mail			

THIRD-PARTY SPONSOR OR IMPLEMENTER

Name		**Telephone**	
E-mail		**Company**	Self sponsored

Note: The measure information that has been obtained from the project file is presented below in this document using italicized text.

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.18 Measures Included in the Evaluation

The project covered under this period (2006 – 2008) under Long Beach Community College District includes two HVAC measures. Specifically, three new chillers were installed at the Pacific Coast College and Liberal Arts College sites to replace individual package units with new central chiller plants at Campus. The measures specified in the program period are as follows:

Measure ID[1] (ADM)	Measure ID (IOU)	Measure Group	System	Measure Description
1	6100	HVAC	HVAC	PCC Central Plant (Electrical Savings)
2	6101	HVAC	HVAC	LAC Central Plant (Electrical Savings)

This report describes the Pacific Coast College project analysis.

<u>Annual Savings Summary for Measures</u>

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings[1] (kWh)	Electric Demand Savings[1] (kW)	Natural Gas Savings[1] (therms)	Incentive[1] ($)	Total Annual Cost Savings ($)
1	6100	PCC Central Plant (Electrical Savings)	1,592,970	686	0	$383,312.84	
Total Savings:			1,592,970	686	0	$383,312.84	
Total Site Usage:							
% Total Site Usage Saved:							

Note 1: Results from CCC-DD-0025 agreement dated 5/04/2007

B-1.19 M & V Approach Summary

THE M&V REPORT FOR LONG BEACH COLLEGE DISTRICT FOCUSED ON PCC CAMPUS CENTRAL PLANT UPGRADE.

Measure ID (ADM)	Measure Name	M&V Option Used	Summary of M&V Approach
1	PCC Central Plant (Electrical Savings)	D	D for Efficient HVAC Equipment

B-1.2.1 Summary of M&V Approach:

Measure 1 pertain to the central plant conversion at the Pacific Coast College campus and involve electricity savings.

IPMVP Option D: DOE-2 simulation was used to evaluate this measure based on site survey data.

PART C: INDIVIDUAL MEASURE EVALUATION

C-5 MEASURE ID: 1: PCC CENTRAL PLANT (ELECTRICAL SAVINGS)

Central Plant (Electrical Savings): Two Trane and one multistack electric chillers were installed in a central plant facility to replace the individual cooling equipment in Buildings on the Pacific Coast Campus.

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	6100	PCC Central Plant (Electrical Savings)	1,592,970	686	0	$383,312.84	

C-5.1 M&V Features

Features of the M&V for Measure 1 are as follows:

Impact Type:	Direct Impact
Baseline Type:	Early replacement*
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

* Sine the pre-project equipment had Remaining Useful Life ranging from 2 to 5 years, the baseline type was considered to be early replacement.

C-5.1.1 Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

Keith Valenzuela of AESC met with Greg Floyd, Deputy Director of LBCCD and Angel Alvarez of LBCCD Bond management Team on December 5, 2006. Both buildings AA and EE were inspected.

Building AA:

Two boilers: Crane Boiler Model: 16-402

Input 2,550,000 BTU/Hr Output 2,040,000 BTU/Hr

One chiller: Carrier Chiller Model: 30GTN045-EC520--

Serial number: 0400F75212

Building EE:

The roof of Building EE was inspected. Eighteen package units were noted as verified. The following nameplate information was recorded.

Carrier Heat Pump: Model: 50HJQ008---501--

Serial Number: 0496G30411

Carrier Heat Pump: Model: 50TJQ006---501GA

Serial Number: 3398G20073

Carrier Heat Pump: Model: 38AQ-016-C521

Serial Number: Could not locate

Lennox Condenser: Model Number: HP19-461-1P

Serial Number: 5189D15894

Lennox Condenser: Model Number: HP19-651-1P

Serial Number: 5189G19301

Trane Condenser: Model Number: TTA060A300B0

Serial Number: F42288681

York AC Unit: Model Number: D2PF042A06A

Serial Number: NKNM242940

C-5.1.2 As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

According to Project File:

Distributed chillers and roof-top package cooling units in Buildings AA & EE on campus will be replaced by a central plant with three (two Trane CVHE450 & one Multi-stack MS80T1H2W) chillers. The project file did not provide information about the number of buildings on the Long Beach campus, their sizes, or their dispositions. The project file also lacked information on the number of package units, their brand, changes in air-handling equipment or cooling coils or related heating equipment details. The Long Beach College website includes a PDF copy of its campus facilities master plan. Based on information in the existing project file, it appears that only Buildings AA and EE are involved in the replacement of cooling equipment.

According to ADM survey:

The facility constructed a central plant for its eight buildings and it comprises three chillers, two Trane CVHE450 & one Multi-stack MS80T1H2W. ADM site visit discovered that only Building LL(that had packaged units in the pre-project conditions) was connected to the Central Plant as of now.

C-5.1.3 Seasonable Variability in Schedule and Production

The campus follows a 2-semester schedule plus summer sessions, with a mix of day, evening, and weekend classes. There is a 2-week vacation in mid August and a 4-week vacation between mid-December and mid-January. We refined this schedule information in discussion with Long Beach Community College staff to include as appropriate items such as class schedules, custodial schedules, planned operating patterns, and class sizes.

C-5.2 Algorithms for Estimating Savings

C-5.2.1 Algorithms Used by IOUs

Program Measure ID	Algorithm
1	Engineering Analysis

Baseline kWh will be measured for both buildings combined. Long Beach CC EQuest Summary provides only baseline kW. Baseline kWh is used for this project.

Proposed kWh is also provided as a summary for both buildings combined. Long Beach CC EQuest Summary provides only proposed kW. Proposed kWh is used for this project.

Energy Savings, kWh = (Baseline kWh) – (Proposed kWh)

C-5.2.2 Energy Savings Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	Engineering analysis

ADM performed a savings analysis using the DOE-2 Building Energy Simulation Model via eQUEST. The site parameters described in Section C-1.3.1 were collected, including HVAC system parameters and building activity areas. The same parameters were used for DOE-2 simulation model input. ADM used the weighted average kW/Ton values of project equipment in our analysis.

Since only one building, Building LL is connected to the Central Plant as of now, ADM built the eQuest model based on the Building LL's description. ADM could not obtain the details of Building LL's baseline packaged units, facility distribution system, lighting and miscellaneous loads due to unresolved scheduling conflicts with the facility, ADM had to evaluate energy savings and demand impact relying solely on the project file information. ADM assumed that the campus buildings have Variable Air Volume (VAV) HVAC distribution system and used eQuest defaults for our analysis with pre-project and as-built space conditioning equipment specifications.

The baseline model consists of pre-project equipment while as-built model consists of as-built central plant equipment. The energy savings of the project were determined by subtracting as-built energy consumption from baseline energy consumption..

C-5.2.3 Peak Demand Algorithms Used in the Evaluation

Program Measure ID	Algorithm
1	See below

ADM used California Protocol guidelines for estimating peak demand impact at the enhanced rigor level, option D. The peak demand, as defined by the CPUC, is the average demand reduction between 2pm and 5 pm for three consecutive weekdays, one of which must contain the hottest temperature of the year. ADM used the three peak days selected for climate zone 6 (September 24th to September 26th) based on California Evaluation Protocol guidelines.

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C-5.3 Data Collection

ADM HVAC data sheets (CP03) were used to collect data for the facility's Central Plant project..

C-5.3.1 Data Collection Method

Program Measure ID	Method for Collecting Site-Specific Parameters
1	See below text

ADM site visit discovered that only one of the facility's nine buildings, Building LL is connected to the Central Plant.

ADM could not obtain the details of Building LL's baseline packaged units, facility distribution system, lighting and miscellaneous loads due to unresolved scheduling conflicts with the facility, ADM had to evaluate energy savings and demand impact relying solely on the project file information..

C-5.3.2 Sampling Strategy

Program Measure ID	Sampling Strategy
1	See below

Because only one building is connected to the Central Plant as of now, no sampling strategy was required for this measure.

PART D: MEASUREMENT AND VERIFICATION RESULTS

The Pacific Coast campus project was to involve the replacement of individual campus buildings' cooling equipment with a central plant that has two 450-ton Trane chillers and one Multi-stack chiller that consists of four 80-ton chillers. According to information obtained for this M&V effort, however, only one building. Building LL was connected to the Pacific Coast central plant at the end of 2008.

According to IOU simulation files and project file information, the building connected to the central plant had packaged units in the pre-project conditions. ADM built the eQuest model based on the Building LL's description to determine the project energy savings.

The M&V analysis of electrical upgrades for the Pacific Coast determined that project upgrades save 63,719 kWh, and 18 peak kW. The project's realization rate of electrical project upgrades is 4%.

The variance between ex ante and ex post savings was caused mainly due to the following reasons:

- Only one of the eight buildings was connected to Central Plant as of 2008.
- IOU analysis used inappropriate eQuest defaults in its analysis (for example constant speed Multizone HVAC distribution system in baseline conditions and variable speed VAV system in post-project conditions). In the M&V analysis, variable speed VAV system was specified for both baseline and post-project conditions.
- IOU analysis considered one buildings in its eQuest model and scaled the savings to the campus area.

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M&V SITE REPORT

SOUTH ORANGE COUNTY COMMUNITY COLLEGE DISTRICT

Saddleback College

November 2009

PART A : Summary Information

A-1.7 Facility Information

Saddleback Community College, which is located in Mission Viejo, California, is part of the South Orange County Community College District. The facility has undergone several energy efficiency upgrades in the last three years involving the installation of new absorption chillers and an EMS upgrade on HVAC system controls in four buildings (BGS, SSC, FA, and TAS) and the central plant.

A-1.8 Project Information

1.4 The energy efficiency upgrades are covered under three projects: PY2007_0025, PY2007_0026, and PY2008_0040. Since each of the procjects impact one another, ADM has included them together in this report. The following is a breif description of each of the projects:

PY2007_0025: The central plant's piping was modified such that a new absorption chiller could use the existing co-generation system's waste heat during the summer. Only electric savings are claimed within the scope of this project.

PY2007_0026: The hot water piping, serving the swimming pool, was modified in order to utilize waste heat from the campus' co-generation system – when extra heat was available. Since the project is covered by Southern California Gas Company (SCG), no electric savings are claimed within the scope of this project.

PY2008_0040: Variable Frequency Drives (VFDs) were added to 25 existing air handling units (AHUs) in four buildings. Simultaneously the existing Energy management System's (EMS) control logic was upgraded. Only electric savings are claimed within the scope of this project.

A-1.9 PROJECT INFORMATION

Utility Service Territory	SDG&E
Program Being Evaluated	California Community Colleges Energy Efficiency Partnership Program
ADM Sample ID &Project ID	PY2007_0025
Customer Name	South Orange County Community College District
Site Name	Saddleback College
Site Address	28000 Marguerite Parkway, Mission Viejo, CA, 92692
Site Type	Community College
Customer Business/Product	Community College

PRINCIPAL SITE CONTACT

Name	**JOHN OZUROVICH**	**Telephone**	**(949) 582 – 4880**
E-mail	jozurovich@saddleback.edu	**Title**	**DIRECTOR OF FACILITIES**

PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

B-1.20 Measures Installed in Project

The projects listed in the project information summary (section A-1.2) include one measure each. A list of each measure, its program, and measure type can be found in Table 1:

Table 6 Measures Evaluated in this Report

Program	Measure ID (ADM)[1]	Measure ID (IOU)	Measure Group	System	Measure Description
PY2007	1	0025	HVAC	Add/Change HVAC Equipment	New Absorption Chiller
PY2008	2	0040	HVAC	HVAC Fan VFD Retrofits	Install VFDs and Upgrade EMS
PY2007	3	0026	Gas	Campus Efficiency Upgrades	Piping modifications for pool heating efficiency

The savings found in the IOU Tracking database for each of the measures, along with their cooresponding incentives, are listed in Table 2:

Table 7 IOU Claimed Savings for Each Measure

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kW)	Electric Demand Savings (kWh)	Natural Gas Savings (therms)[1]	Incentive ($)
1	0025	New Absorption Chiller	216.3	1,162,794	0	$293,344
2	0040	Install VFDs and Upgrade EMS	24.4	130,986	0	$49,298
3	0026	Piping modifications for pool heating efficiency	0	0	34,717	$52,076
Total Savings:			240.7	1,293,780	34,717	$293,344

B-1.21 Measures Included in the Evaluation

Each of the measures listed in Table 1 (Section B-1.1) are included in this evaluation.

B-1.22 Information from Application Review

The following is information found in the documentation for each of the evaluated measures.

Evaluation Measure ID 1: New Absorption Chiller

The application for Saddleback College (SC) was reviewed by Jeff Silva of CalPwr Partners. The Project Application Review cited the following conclusions[2]:

[2] Report taken from South Orange CCDD Application Review

The application was approved as submitted. The final approved energy savings are based on the original savings and incentive calculation. The evaluation was using the approved SPC software using facility's input data of existing and proposed equipment capacities and efficiencies as stated in the "Pre-Installation" submittal.

Evaluation Measure ID 2: Install VFDs and Upgrade EMS

The application for Saddleback College (SC) was reviewed by Larry Nelson of CalPwr Partners. The Project Application Review cited the following conclusions[3]:

The application was approved as submitted. The final approved energy savings are based on the original savings and incentive calculations. The original evaluation was using the approved SPC software using facility's input data of existing and proposed equipment capacities and efficiencies as stated in the "Pre-Installation Inspection Forms".

Evaluation Measure ID 3: Piping Modifications for Pool Heating Efficiency

The project application was supported by an "Economic Feasibility Study of Efficiency Upgrades" performed by Hahn Engineering for California Power Partners (CalPwr) of Escondido, California. Dave Roberts of CalPwr is the on-site technician for the work and coordinates the project with the facility.

B-1.23 M & V Approach Summary

The M&V approach for the measures at the site was enhanced rigor with IPMVP Option D, Calibrated simulation. The simulation was performed with eQuest, using field data obtained through a site survey

Table 8 M&V Approach Summary

Measure ID (ADM)	Measure ID (IOU)	Measure Name	M&V Option Used*	Strata for Est. Savings	Summary of M&V Approach
1	0025	New Absorption Chiller	D	Certainty	See below
2	0040	Install VFDs and Upgrade EMS	D	Certainty	See below
3	0026	Piping modifications for pool heating efficiency	D	Certainty	See below

[3] Report taken from South Orange CCDD Application Review

PART C: MEASURE EVALUATION

The following section describes the approach ADM took in evaluating the measures in this report.

C-6 EVALUATION MEASURE ID 1: NEW ABSORPTION CHILLER

This M&V features for this measure are listed in Table 4 below:

Table 9 M&V Features for Evaluation Measure ID 1

Impact Type:	Direct Impact
Baseline Type:	Early Replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

This measure is described as follows in project's documentation:

> *Existing Cogeneration system (two 750 kW Waukesha gas engines producing HW). The waste heat is used for HW loop in the winter and exhausted to atm in the summer The existing pumps will be used to deliver the CHW, HHW to the loops. The GTF5 noncore gas that feeds the CoGen does not get charged the GAPS (public purchase) charge. The GN-10 gas does. This meter is a split rate meter (one meter with two rates). The TES system is in bad repair is not functioning at this time. The hours of summer time operation are 4120 hr annually (per Calpower). Proposed to install a new Absorber (BOARD BDH150) Chiller, (rated 496 tons at ___F CHWS). Proposed Abs Chiller will deliver 364 tons at ___F CHWS.*
>
> *All information supplied by Cal Power is correct and can be verified. Load profile is taken from SPC 2007 software for College at this weather location Electric chiller operated year around. The new absorption chiller will be operated exclusively off the summer time cogen wasted heat. Proposed absorber will supply 364 ton of chilled water. The equipment operational parameters are:*
>
> *Water Cooled Absorption Chiller - Single Effect efficiency COP=0.70 or 5.02 kW/ton per SPC 2007 (v1.1) Table C-4 page C-5.*
> *Water cooled electric chiller minimum efficiency COP = 6.10 or 0.577 kW/ton per SPC 2007 (v1.1) Table C-4 page C-5.*
> *."*

C-6.1 Pre-existing and As-Built Equipment

C-6.1.1 Pre-existing Equipment and Operation

The central plant had three electric chillers supplying the campus' chilled water loop. The chillers' information is listed in Table 5:

Table 10 Pre-Existing Chiller Information

Manufacturer	Model Number	Tons	kW/Ton
York	----------	600	N/A
Trane	----------	1000	N/A

C-6.1.2 As-Built Equipment and Operation

For this measure a new absorption chiller was installed in the central plant - to replace the summer time operation of the existing electric chillers. The electric chiller will be used as normal during the winter month operation, as the waste heat may not available for absorption cooling.

Table 11 As-Built Absorption Chiller Information

Manufacturer	Model Number	Tons	kW/Ton
Broad	BDH-150	364	5.2

C-6.2 Algorithms for Estimating Savings

C-6.2.1 Algorithms Used by IOUs

The IOU's original calculations for this measure were described in the project's documentation as follows:

> *"The submitted energy savings were calculated using the 2006 SPC Software, which is a correct approach. The reviewer revised the inputs to reflect field measurements and nameplate data gathered during the pre-installation inspection. Where applicable and/or available, all other inputs were reviewed and have been deemed reasonable."*
>
> *Once data is collected the following formulas are used to calculate kWh savings:*
>
> *Baseline kWh of equipment = (Baseline power for centrifugal chiller operation) * (baseline operational hours of equipment)*
>
> *Current kWh of equipment = (no Electric load for this portion of chiller operation (current operational hours of equipment at particular load)]*
>
> *Energy savings of equipment = Replaced kWh of the Baseline Chiller Operation"*[4]

C-6.2.2 Energy Savings Algorithms Used in the Evaluation

In order to calculate the energy savings for this measure ADM used eQuest energy model simulations.

C-6.2.3 Peak Demand Algorithms Used in the Evaluation

ADM used California Protocol guidelines for estimating peak demand impact at the enhanced rigor level, option D. The peak demand, as defined by the CPUC, is the average demand reduction between 2pm and 5 pm for three consecutive weekdays, one of which must contain the hottest temperature of the year.

C-6.3 Data Collection

Site information was gathered using the Building Systems Form.

Data were first collected through interviews with the staff of the site. The interview with site staff provided information on occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other "human factors" that are associated with energy use at the site. Documents or records for the site were also reviewed.

[4] 4 Taken From SCC Application Review File

C-6.3.1 Sampling Strategy

All three chillers at the central plant (with primary importance to the pre-existing baseline chiller that replaced) were addressed in the analysis, along with associated HVAC equipment in the buildings served by the central plant, and any existing trend data relating to the baseline operation from the EMS systems for this measure.

C-7 EVALUATION MEASURE ID 2: INSTALL VFDS AND UPGRADE EMS

This M&V features for this measure are listed in Table 4 below:

Table 12 M&V Features for Evaluation Measure ID 1

Impact Type:	Direct Impact
Baseline Type:	Early Replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

This measure involves the installation of Variable Frequency Drives (VFDs) on the HVAC supply and return fan motors on four *campus buildings (buildings Fine Arts, Tech & Applied Science, Business/General Studies, and Student Services Center)*. The pre-installation inspection by Jell Silva (conducted on 8/14/2007) confirmed that there are 25 supply and return fans with inlet guide vane controls that are proposed to be retrofitted. These HVAC units will be retrofitted with VFD’s, and controls will be added to the Existing Energy Management System (EMS) to perform the operation.

C-7.1 Pre-existing and As-Built Equipment

C-7.1.1 Pre-existing Equipment and Operation

The parameters for each of the pre-existing air handler units which were affected by this measure are listed in table 8 below:

Table 13 Pre-Existing Air Handling Unit Specifications

Bldg. No.	Tag #	Operational Hours	Pre-Existing Controls	VFD added	EMS control Upgraded
FA-100	AH-1 Supply	4432	*Inlet guide*	*Yes*	*Yes*
FA-100	AH-16 Supply	4432	*Inlet guide*	*Yes*	*Yes*
FA-200	AH-17 Supply	4432	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-1	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-2	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-3	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-4	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-5	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-6	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-7	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-8	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-9	3262	*Inlet guide*	*Yes*	*Yes*
BGS-	AH-10	3262	*Inlet guide*	*Yes*	*Yes*

BGS-	AH-11	3262	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-1 Supply	3702	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-2 Supply	3702	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-4 Supply	3702	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-5 Supply	3702	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-6 Supply	3702	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-7 Supply	3702	*Inlet guide*	*Yes*	*Yes*
SSC-	AH-8 Supply	3702	*Inlet guide*	*Yes*	*Yes*
TAS-	AH-1 Supply	4745	*Inlet guide*	*Yes*	*Yes*
TAS-	AH-1 Return	4745	*Inlet guide*	*Yes*	*Yes*
TAS-	AH-2 Supply	4745	*Inlet guide*	*Yes*	*Yes*
TAS-	AH-2 Return	4745	*Inlet guide*	*Yes*	*Yes*
	Average	*3763*			

C-7.1.2 As-Built Equipment and Operation

As-built equipment is essentially the same as baseline equipment. Changes made will include the addition of VFDs for supply and return fan motors. Also, the original systems were VAV systems with inlet guide vane controls that are being converted to VFD driven VAV systems by the installation of the drives on the fan motors. Thus, the AHU controls will have been upgraded to include new control logic, new zone parameters, zone-level return air temperature feedback to AHU systems, etc. Specifications for installed equipment are detailed in Table 1 where column 5 indicates the proposed control feature. It seems some data (i.e., FL Amps) are measured. Power factor and load are assumed, not measured. BHP and kW are calculated based on measured and assumed data.

C-7.2 Algorithms for Estimating Savings

C-7.2.1 Algorithms Used by IOUs

The IOU calculations used the following formulas, along with assumed hours of operation for each fan, in order to calculate this measure's energy savings:

*Baseline kWh of equipment = (HP of equipment) * (Load factor of motor obtained from measurement) * (baseline operational hours of equipment)*

*Current kWh of equipment = (HP of equipment) * ∑ [(Load factor of motor obtained from measurement) * (current operational hours of equipment at particular load)]*

Energy savings of equipment = Baseline kWh of equipment - Current kWh of equipment.

C-7.2.2 Energy Savings Algorithms Used in the Evaluation

Estimates of the energy savings from use of VFDs are derived through a "post-only" analysis. With this method, we:

1. Make one-time measurements of voltage, current, and power factor of the supply and return fan motors with VFD drives.
2. Use ACR loggers to conduct continuous measurements of amps over a period of time in order to obtain the data needed for operating schedules and power consumption. Based on one-time power

measurement and monitored data, this will be used to derive the operating schedule as well as the power consumption for each fan motor.

The data thus collected are then used in estimating what energy use would have been for the motor application if the VFD had not been installed.

For this study, the data will be analyzed using a DOE-2 Building Energy Use simulation for each of the four buildings on the campus that have received the VFDs. The simulations will apply the IOU algorithm to calculate energy savings associated with this measure. In developing, conducting, and calibrating the simulations, we will consider the following factors and take the following steps:

1. Gather key architectural, lighting and HVAC drawings and related information from facility managers.
2. Interview facility managers about generic control system and related upgrades that might impact the VFD operation.
3. Examine baseline and as-built control features for all campus buildings, plus exceptional characteristics for any special buildings..
4. Develop DOE-2 generic building input models that reflect the general proportional floor area of key building activity areas and use generic operational schedules drawn from typical schedules for community college activities.
5. Depending upon building features and mix of activity areas, we may develop separate DOE-2 models for each of the four buildings with VFDs, or we may combine these buildings into one simulation based on information collected during the field survey.
6. Calibrate the models to post-retrofit data and then change all control option from SPEED to INLET as parametric input for all the impacted supply and return fans to create the pre-retrofit operating scenario, to derive the energy savings impact.

C-7.2.3 Peak Demand Algorithms Used in the Evaluation

ADM used California Protocol guidelines for estimating peak demand impact at the enhanced rigor level, option D. The peak demand, as defined by the CPUC, is the average demand reduction between 2pm and 5 pm for three consecutive weekdays, one of which must contain the hottest temperature of the year.

C-7.3 Data Collection

Site information was gathered using the Building Systems Form. Data were first collected through interviews with the staff of the site. The interview with site staff provided information on occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other “human factors” that are associated with energy use at the site. Documents or records for the site were also reviewed.

C-7.3.1 Sampling Strategy

We will survey all relevant onsite HVAC systems for this measure, including all fan motors greater than 5 hp within AHU’s at each of the four buildings in which VFDs have been installed (See the list in Table 8).

C-8 EVALUATION MEASURE ID 3: PIPING MODIFICATIONS FOR POOL HEATING EFFICIENCY

This M&V features for this measure are listed in Table 9 below:

Table 14 M&V Features for Evaluation Measure ID 1

Impact Type:	Direct Impact
Baseline Type:	Early Replacement
Sample Type:	Post-only sampling
Level of Rigor	Enhanced, using IPMVP Option D

This measure involves re-piping the pool heating lines and adding flow control to the pool heating loop. The loop also allows the cogeneration system to heat the pool water to make use of the unused heat.

C-8.1 Pre-existing and As-Built Equipment

C-8.1.1 Pre-existing Equipment and Operation

Before this measure was implemented the pool was heated solely by the central plant's boilers.

C-8.1.2 As-Built Equipment and Operation

The project's documentation described the following with regard to the as-built operation of the campus' hot water loop:

> *The existing hot water heating loop ties into the existing hot water loop that travels through the cogenerator jackets for water heating. Photos are added to the document to show the addition of hot water loops, re-piped pool water loop. It was also noted that the existing pool and all the pool covers will be used as before the retrofit. The pools are about 30 feet x 65 feet (small pool) and 65 feet x 140 feet (large pool). The large pool is maintained at 80F while the small pool is maintained at 85F.*

ADM confirmed the loop operation described above during our on-site visit. It should also be noted that there is a great deal of seasonality in the use of the pool heating, requirements, evaporation losses, and solar heat gain. Savings from a pool heating bypass will also be affected by changes in ambient temperature.

C-8.2 Algorithms for Estimating Savings

C-8.2.1 Algorithms Used by IOUs

The IOU used engineering calculations based on assumed hours of operation and pool heating demand. Their calculations and assumptions are as follows:

Assumptions

Maximum Campus HVAC Demand = 9,660 MBTU/H

Maximum Pool Heating Demand = 5,500 MBTU/H

Average Pool Heating Demand = 4,125 MBTU/H

Maximum Cogen Heating Hot Water Output = 7,500 MBTU/H (3,750 MBTU/H per engine)

Hours/year that Campus does not Require Heating = 8,760 Hrs/Yr x 65% = 5,694 Hrs/Yr or 237.25 Days

<u>*Daily Co-gen System Output based upon Run-time and Load*</u>

7,500 MBTU/H for 8 hours per day = 60,000 MBTU
6,750 MBTU/H for 6 hours per day = 40,500 MBTU
5,250 MBTU/H for 5 hours per day = 26,250 MBTU
3,750 MBTU/H for 5 hours per day = 18,750 MBTU
Daily Cogen Heat Output = 145,500 MBTU
Amount of Heat Available to Heat Pool = 145,500 MBTU/Day x 237.25 Days = 34,519,875 MBTU

Amount of Heat Available to Heat Pool = 34,520 Therms

C-8.2.2 Energy Savings Algorithms Used in the Evaluation

The following equation will be used to calculate the heat loss for the swimming pool. Using this loss and the efficiency of the boiler, the gas savings will be determined.

$$Heat \quad Loss = U \bullet A \bullet \left(T_{pool} - T_{ambient}\right) \text{ in Btu/h}$$

where U is surface heat transfer coefficient = 10.5 Btu/h-ft^2 (°F) and A = pool surface area (ft^2). It should be noted that the calculations were done on an hour-by-hour basis, using ambient conditions and taking into account the maximum heat available from the co-generation plant.

C-8.2.3 Peak Demand Algorithms Used in the Evaluation

There were no demand savings for this measure.

C-8.3 Data Collection

Site information was gathered using the Building Systems Form. Data were first collected through interviews with the staff of the site. The interview with site staff provided information on occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other “human factors” that are associated with energy use at the site. Documents or records for the site were also reviewed.

C-8.3.1 Sampling Strategy

Since there is only one pool, sampling will not be necessary.

PART D: MEASUREMENT AND VERIFICATION RESULTS

There were three measures for this site under three separate M&V plans. The measures are as follows:

1) Install absorption chiller to use co-gen waste heat
2) Install VFDs on existing air handlers
3) Route waste heat from the co-gen to heat the swimming pools.

Since the facility's co-gen is used to generate the majority of the used electricity, the interval data that was available was only marginally helpful for energy model calibration. A description of each measure's results is listed below.

Evaluation Measure ID 1: New Absorption Chiller

In order to evaluate the savings from the installation of the absorption chiller, a generic model of the entire campus was formulated for eQuest simulation. This model was then calibrated using CEUS data and the description of the campus' central plant obtained from the site visit. For further description of the pre-existing and as built equipment please refer to sections C-1.1.1 and C-1.1.2. The CEUS data was used to provide power campus average power density and end-use schedule profiles. The campus uses its co-generation equipment for all of its electricity needs. The grid only supplements any demand that is beyond the co-generation plant's capacity. ADM's eQuest Model includes the co-generation plant and its operation. The eQuest model's monthly energy use reasonably matches the campus' metered data considering that ADM had only one year of monthly data with which to calibrate our baseline model.

Measure one was then simulated by adding an absorption chiller to the central plant which used waste heat from the simulated co-generation plant. This resulted in a gross savings of 492,110 kWh. However, since the facility only purchases a small percent of its electricity from SDG&E the available savings were dramatically less than the actual reduction in electrical energy. This fact applies to measure 2 as well. Consequently the final savings calculated were 180,661 kWh. In order to determine the final savings ADM exported the eQuest model's hourly energy use alongside the hourly energy produced by the co-generation plant. The difference between the two represented the amount of savings available for this measure.

Evaluation Measure ID 2: Install VFDs and Upgrade EMS

A similar approach as was used for evaluation measure 1 was used to determine savings for the second measure, except that this measure only applied to several buildings on campus which had been audited during a site visit. Since the energy bills applied to the entire campus, and due to the campus' co-generation plant, ADM was unable to calibrate our model to metered energy usage. Instead ADM used CEUS data from the appropriate building type and California weather zone for the buildings' lighting /internal loads schedules and power densities. This measure was simulated by adding VFDs to the pre-existing equipment. For further description of the pre-existing and as built equipment please refer to sections C-1.2.1 and C-1.2.2. The final savings for this measure were 202,553 kWh. In order to determine the final savings ADM exported the eQuest model's hourly energy use alongside the hourly energy supplemented by the grid after Evaluation Measure 1 is applied.[5] The difference between the two represented the amount of savings available for this measure.

Evaluation Measure ID 3: Piping Modifications for Pool Heating Efficiency

The savings for measure 3 were calculated in Excel, but informed by the model used for the analysis of measure 1. Since the amount of waste heat available from the co-gen plant is finite; the available savings for this measure were constrained by the hourly available waste heat after the absorption chiller. The final calculated savings for this measure were 27,991 Therms.

The following table summarizes the savings calculated for the measures through the M&V analysis and compares them to the claimed savings:

Table 15 Summary of Project Savings and Realization Rates

Summary of Meaures				
Measure	IOU Savings	Calculated Savings	Grid Savings	Realization Rate
Install Absorption Chiller	916,699 kWh	492,110 kWh	180,661 kWh	20%
VFDs on Air Handlers	205,407 kWh	202,553 kWh	57,548 kWh	28%
Pool heating	34,717 Therms	27,991 Therms	27,991 Therms	81%

The differences in M&V calculated savings versus the claimed savings are predominately due to the co-generation issue mentioned above. As can be seen in the table, before they are corrected for the grid, the M&V calculated savings for measure 2 are on par with the claimed savings. It seems that for measure 1 the IOU calculations assumed much more cooling demand than the simulation predicts. The peak demand savings are reported in Table 11 below:

Table 16 Project Peak Demand Savings and Realization Rates

ADM Measure ID	IOU Demand Reduction (kW)	ADM Demand Reduction (kW)	Realization Rate
1	45.9	7.78	17%
2	282.1	70.49	25%
3	---	---	---
Total	328.0	78.27	24%

[5] This is generated in the analysis of Evaluation Measure 1.

M & V SITE REPORT

SAN DIEGO COMMUNITY COLLEGE DISTRICT

MIRAMAR CAMPUS BOILER REPLACEMENT

SDG&E_PY2006_0002

November 2009

1. SUMMARY INFORMATION

1.1 Facility Information

The Miramar Campus is operated by San Diego Community College District. There are three projects planned for this campus: high efficiency motor upgrade (P3237003), chiller conversion to Turbocor compressor (P#237004), and high efficiency boiler replacement (P#237005). There is no supporting documentation on the number of buildings that are associated with these projects, operational schedules, functional types or the associated conditioned floor area.

1.2 Project Information

The project at the Miramar Campus involves replacing the old boiler with a new high efficiency boiler (in Building A-100)

Program Being Evaluated	California Community College Energy Efficiency Partnership
ADM Sample ID &Project ID	SDG&E_PY2006_0002
Customer Name	San Diego Community College District
Site Name	Miramar Campus
Site Address	1536 Frazee Rd, San Diego, CA 92108
Site Type	Community College
Customer Business/Product	School

PRINCIPAL SITE CONTACT

Name	Darell Rogers	**Telephone**	619-388-6422
E-mail	drogers@sdccd.edu	**Title**	Director facility Services

2. PART B: MEASURE LIST AND SUMMARY DESCRIPTIONS

2.1 Measures Included in the Evaluation

Program	Measure ID (ADM)[1]	Measure ID (IOU)	Measure Group	System	Measure Description
SG&E 2006	1	1	HVAC	HVAC	Miramar Motors, Boiler & Chiller Upgrades - (gas)

There are three projects planned for this campus: high efficiency motor upgrade (P3237003), chiller conversion to Turbocor compressor (P#237004), and high efficiency boiler replacement (P#237005). Based on the project agreement (dated January 09, 2007) the facility has upgraded their old boiler with a new Ajax WG0FD-1750 boiler. However, neither the motors nor the chiller upgrades have been completed. Supporting documentation is lacking on the number of buildings or central plant associated with these projects. Information on facility operating schedules is also not available.

One of the submittals includes a savings summary for the planned projects from SPC software. However, there is no reference to the version, input data or facility/equipment characteristics that were used for assessing these projects. The name of the reviewer or the IOU project engineer involved in the projects is also not provided.

Baseline Equipment: The brand of the old boiler in Building A-100 is not known. According to available documentation, the facility operates 365 days per year; the boiler is turned on between the hours of 7am and 10:30 pm Monday through Saturday; and the boiler is turned off on Sundays.

As-built Equipment: An Ajax boiler (Model WG0FD-1750) was installed and verified prior to the agreement dated 12/12/2006.

Since the facility has optimal start for the chillers, it is expected that the facility operation is controlled by an Energy management System and subsequently the boilers may also be controlled by the same EMS system. Energy savings in terms of both electricity and natural gas will be achieved from the boiler upgrade measure. However, electricity savings resulting from the boiler replacement is expected to be minimal and will not be analyzed. Only gas savings will be reported for this project.

There is no change in facility operating hours resulting from the implementation of this measure (i.e., from pre-project to post-project conditions).

2.2 Annual Measure Savings Summary

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	1	Miramar Motors, Boiler & Chiller Upgrades - (gas)	-	-	7,163	$7,163	
Total Savings:			-	-	7,163	$7,163	
Total Site Usage*:							
% Total Site Usage Saved*:							

*If available, includes all applicable fuels / commodities for project, such as: electric energy, electric demand, natural gas, fuel oil, coal, water, etc.

2.3 M & V Approach Summary

Measure ID	Measure Name	M&V Option Used*	Strata for Est. Savings	Summary of M&V Approach
1	Miramar Motors, Boiler & Chiller Upgrades - (gas)	D	1	See below

Option D: Calibrated Simulation[6] was used as the M&V approach, using the eQuest energy analysis model, supplemented by spreadsheet analyses with Excel..

[6] From Chapter 3 Basic Concepts and methodology, Section 3.4 Methods, *International Performance Measurement & Verification Protocol, Concepts and Options for Determining Energy and Water Savings, Volume 1,* Revised March 2002.

3. INDIVIDUAL MEASURE EVALUATION

Total number of measures for this site is: 1

Measure ID: 1

Measure Name: Miramar Campus BOILER Upgrade – Gas Savings

Measure ID (ADM)	Measure ID (IOU)	Measure Name	Electric Energy Savings (kWh)	Electric Demand Savings (kW)	Natural Gas Savings (therms)	Incentive ($)	Total Annual Cost Savings ($)
1	1	Miramar Motors, Boiler & Chiller Upgrades - (gas)	-	-	7,163	$7,163	

The project involves the installation of the following energy efficiency measures for San Diego Miramar Community College located in San Diego:

- Replace an Old boiler with a high efficiency boiler that is used for space heating hot water as part of the motors, boiler and chiller upgrade.

3.1 M&V Features

Impact Type

Impact Type is "**Direct impact.**"

Baseline Type

Baseline type is "**Normal Replacement.**"

Sample Type

Sample type is "**Post-only sampling design**"

Pre-installation Equipment and Operation

Program Measure ID	Equipment and Operation – Pre-installation
1	See below

No information about the pre-installation equipment is in the file. Only the boiler used for space heating purposes will be part of the analysis as HVAC equipment. However, the survey scope will expand to cover the buildings that are served by the hot water system.

Scope of Project

- *All the buildings that are served by the boiler will come under the scope of the field work.*
- *Type of boiler controls and changes if any*
- *Hot water system set-points and schedules*
- *Hot water system lockout (if any)*

As-Built Equipment and Operation

Program Measure ID	Equipment and Operation – As-Built
1	See below text

No information is available on type of boiler, efficiency, control strategy, any reset option, burner control strategy. ADM field staff collected these data as well as baseline operating characteristics by interviewing staff and visual inspection of the equipment.

Seasonal Variability in Schedule and Production

The annual operating hours used in IOU's estimated savings were not provided. No input summary for the SPC program was provided. We therefore refined schedule information in discussion with Miramar Community College staff, addressiing items such as class schedules, custodial schedules, planned operating patterns, and class sizes.

3.2 Algorithms for Estimating Savings

Algorithms Used by IOUs

Program Measure ID	Algorithm
1	Engineering Analysis, see below

A summary of SPC savings summary was provided without any documentation of actual input or output from the SPC software. Neither IOU reviewer information, nor any inspection information was provided.

"Level of Rigor in Evaluation

The evaluation Level of Rigor is IPMVP Option D.

Energy Savings Algorithms Used in the Evaluation

Evaluation Measure ID	Algorithm
1	See below

eQuest will be used to evaluate the project's energy savings. The baseline considers pre-retrofit hot water boiler (efficiency will be determined by information collected at the facility or from any prior monitoring if available) while as-built analysis considers the post-retrofit boiler equipment with current operational characteristics as obtained during the site visit.

The energy savings are the difference between baseline energy consumption and as-built energy consumption.

Peak Demand Algorithms Used in the Evaluation

Evaluation Measure ID	Algorithm
1	Not applicable

3.3 Data Collection

There was no sampling plan for facility's boiler system upgrade measure since it has only one boiler. ADM field staff collected physical and thermal characteristics of the buildings that are served (for space heating) by this boiler from discussions with the facility personnel as well as from observations during site visit and may bring changes into above mentioned sampling plan if necessary. ADM - HVAC forms (ADM-03) were used for data collection.

4. MEASUREMENT AND VERIFICATION RESULTS

This site had only one measure, which was the installation of a high efficiency boiler. However, the boiler is used to heat both the building and the pool. As such, calculations were performed using an Excel bin analysis which was informed by eQuest. The buildings were simulated based upon data collected during a site visit and billing data. Where information was lacking CEUS was used to supplement.

The hourly hot water loop loads were output from the eQuest simulation and added to the hourly calculated pool heating requirements. This was then divided by the difference in the boilers' efficiencies to get savings. The old boiler had an efficiency of 75% and the new boiler 85%.

The comparison between claimed and verified savings is as follows:

Savings Summary	
BTUAsBuilt	5,446,867,934
BTUPreExisting	6,207,256,904
BTUSavings	760,388,971
ThermsAsBuilt	54,469
ThermsPreExisting	62,073
ThermsSavings	7,604
Reported ThermsSavings	7,163
Realization Rate	1.06

LGP EVALUATION REPORT APPENDIX H:
NET-TO-GROSS INSTRUMENT SAMPLES AND GUIDANCE DOCUMENTS

a. UC/CSU/IOU and CCC/IOU Standard Decision Maker On-site Instrument
b. UC/CSU/IOU and CCC/IOU Program Managers Interview Guide
c. Participant Customer Survey for 2008 Palm Desert LG Program - RESIDENTIAL GUIDE
d. Participant Customer Survey for 2008 Palm Desert LG Program - COMMERCIAL GUIDE
e. Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches and the Algorithm for the Residential Consistent Free Ridership Method
f. Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers

UC/CSU/IOU and CCC/IOU Standard Decision Maker On-site Instrument

UC/CSU/IOU and CCC/IOU STANDARD DECISION MAKER ON-SITE INSTRUMENT

July 23, 2009

Identify Respondent

This is _________________ calling on behalf of the CPUC, [California Public Utilities Commission] from SUMMIT BLUE CONSULTING. THIS IS NOT A SALES CALL. May I please speak with <CAMPUS CONTACT> the person most knowledgeable about your campus's involvement in <CAMPUS>'s installation of <PROJECT DESCRIPTION> on approximately <COMPLETION DATE>?

Who would be the person most knowledgeable about your campus's involvement with the Local Government Partnership and with <DISTRICT/CAMPUS>'s project that involved the installation of <PROJECT DESCRIPTION> on approximately <COMPLETION DATE>?

Enter NEW CONTACT NAME and move on;

May I speak with him/her?

Yes, need to make an appointment,

No, but I will give you to the correct person

No (not available right now, set call back)

<PROGRAM> = (UC/CSU/IOU Program or CCC/IOU Program)

Introduction

We are interviewing representatives from universities that participated in the <PROGRAM> Partnership Program in 2008 to discuss the factors that may have influenced their decisions to participate in the program. We may have been chosen for a site visit to gather information on the measures installed.

Your input to this research is extremely important. We will not identify or attribute any of your comments directly to you or your campus (without your consent).

Before we start, may we record this interview?

C1. According to our records your campus participated in the UC/CSU/IOU (CCC) Partnership Program on <COMPLETION DATE> by installing <PROJECT DESCRIPTION>. Does this sound right?

1 Yes
2 No
88 Don’t know
99 Refused

Program Participation Module

P1. What MEASURES do you remember installing through this program? [Check all that apply. Do not read.]

Building Shell
Compressed Air
Cooking
HVAC
Indoor Lighting
Lighting
Motors
Office Equipment
Other
Other - Audit (NON-RES)
Other - Controls (NON-RES)
Other - Process (NON-RES)
Other - Whole Building (NON-RES)
Other (User Entered Text Description) (NON-RES)
Outdoor Lighting (NON-RES)
Process Cooling (NON-RES)
Process Heat (NON-RES)
Process Steam (NON-RES)
Pumps (NON-RES)
Refrigeration (NON-RES)
Space Cooling (NON-RES)
Water Heating (NON-RES)

P2. Did your campus also receive an AUDIT from <ELECTRIC UTILITY/GAS UTILITY>?

1 Yes
2 No
88 Don't know
99 Refused

P5. Did your campus received incentives from <ELECTRIC UTILITY/GAS UTILITY> for RETROCOMMISSIONING this building?

1 Yes
2 No
88 Don't know
99 Refused

P6. Did your organization receive PROGRAM TRAINING from <ELECTRIC UTILITY/GAS UTILITY>?

1 Yes

2 No
88 Don’t know
99 Refused

IF CUSTOMER RECEIVED AN INCENTIVE:

A1gg. What was the incentive amount that your organization received through the program?

77 RECORD VERBATIM
88 Refused
99 Don't know

P7. Our records show that your campus received <PAID INCENTIVE ELECTRIC/PAID INCENTIVE GAS> from the Partnership Program for the installation of this equipment. Does this sound correct?

1 Yes
2 No
88 Don’t know
99 Refused

IF P7 = 1, SKIP TO P9, ELSE ASK P8.

P8. IF AMOUNT IS NOT CORRECT OR AMOUNT NOT RECORDED: What was the incentive amount that your organization received through the Partnership Program?

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

P9. What was your role in the overall decision to install this energy efficient equipment in **this** building on the <campus> Campus?

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

P10. Did you serve on any campus or system level committees? Which ones?

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

P11. How did you work with the contractor/vendor to ensure the energy efficient equipment was installed as specified?

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

For the sake of expediency, during the balance of the study, we will be referring to the Local Government Partnership Program as the PROGRAM and we will be referring to the installation of <PROJECT DESCRIPTION> as the MEASURE.

I will repeat this from time to time during the interview as your organization may have installed more than one measure through more than one program.

I would like to get some information on the VENDORS, ESCOs or TRADE ALLIES that may have helped you with the implementation of this equipment. As part of this study, we MAY be conducting a separate interview with the vendors that worked with you on the implementation of this equipment. First let's talk about the company that installed the equipment.

PROGRAMMING NOTE: SET UP TO ALLOW FOR MULTIPLE VENDORS.

1. Can you provide us with the following information on the vendor that installed the equipment?

V1. VENDOR NAME_______________

V2. Phone number___________________________

V3. CONTACT name ________________________

V4. Cell phone number_______________________

V5. EMAIL ADDRESS ______________________

Make Sure To Get Contact Name

88 REFUSED

99 DON'T KNOW

V5.5 Did you use a DESIGN or CONSULTING Engineer?

1 Yes [Ask V6-V10]

2 No [Go to V10.5]

88 Don’t know [Go to V10.5]

99 Refused [Go to V10.5]

V6. May we have the name of the design or consulting engineer____________,

V7. Phone number________________________

V8. CONTACT name ______________________

V9. Cell phone number_____________________

V10. EMAIL ADDRESS ?___________________

V10.5 Did you use an Energy Service Provider (ESCO)?

1 Yes [Ask V11-V15]

2 No [GO TO F1]

88 Don’t know

99 Refused

V11. Can we have the Energy Service Provider’s name?
NAME_____________________

V12. Phone number ________________________________

V13. CONTACT name _______________________________

V14. Cell phone number______________________________

V15. EMAIL ADDRESS _____________________________

88 REFUSED

99 Refused

Thanks for helping us with this vendor information. *Now, I would like to ask some* questions about the implementation of the measures that you installed through the program.

Free Ridership

[REPEAT FOR EACH MEASURE FOR A MAXIMUM OF 3 MEASURES.]

F1. When did you first learn about <ELECTRICAL UTILITY/GAS UTILITY>'s Partnership Program? Was it BEFORE or AFTER you first began to THINK about implementing the <PROJECT DESCRIPTION>? *<MEASURE NAME> INSERTED FOR ADDITIONAL INFORMATION.*

1 Before [SKIP TO Q. F3]

2 After

88 REFUSED

99 DON'T KNOW

F2. Did you learn about <ELECTRICAL UTILITY/GAS UTILITY>'s Program: BEFORE or AFTER you DECIDED to implement the MEASURE(S) that was/were installed?

1 Before

2 After

88 REFUSED

99 DON'T KNOW

F3. Next, I’m going to ask you to rate the importance of the program as well as other factors that might have influenced your decision to implement this <PROJECT DESCRIPTION>. Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means extremely important, so that an importance rating of 8 shows twice as much influence as a rating of 4. Now using this scale please rate the importance of each of the following in your decision to implement the <PROJECT DESCRIPTION> at this time. Please rate the degree of importance of…

999 I did not receive this program component or service

0 NOT AT ALL IMPORTANT,2,3,4,5,6,7,8,9, 10 EXTREMELY IMPORTANT

88 REFUSED

99 DON'T KNOW

ROTATE F3A THRU F3P

A. The age or condition of the old equipment

B. Availability of the Partnership Program rebate

C. Information provided through the program related Feasibility study

C_1 TO C_3. What are the name, telephone number, and email address of the vendor that conducted the (feasibility study?)

D. Information provided through – The Facility or System Partnership Program AUDIT

E. Information provided through – the program related Technical Assistance

F. Recommendation from an equipment vendor that sold you the equipment and/or installed it?

G. Your previous experience with the equipment

H. Previous experience with this program or a similar program (NAME PROGRAM_________)

I. Information from a Partnership Program or other <ELECTRICAL UTILITY/GAS UTILITY> training course

J. Information from the <ELECTRICAL UTILITY/GAS UTILITY> Partnership Program's Marketing materials

K. Recommendation from a design or consulting engineer

L. Standard practice in your business/industry

M. Endorsement or recommendation by Program Staff or Program Vendor

N. Endorsement or recommendation by your <ELECTRIC UTILITY/GAS UTILITY> account rep

O. Corporate policy or guidelines

P. Payback on the investment

F3Q. Were there any other factors we haven't discussed that were influential in your decision to install this MEASURE?

1 Nothing else influential

77 Record verbatim

88 Refused

99 Don't know

F3QQ. Using the same zero to 10 scale, how would you rate the influence of this factor?

\# Record 0 to 10 score (_______)

88 Refused

F3A THRU F3P. [If score >7 FOR A THRU P, ASK:

F4. Why do you give it this rating?

77 OPEN\RECORD

88 REFUSED

99 DON'T KNOW

F5. Were there any other factors we haven't discussed that were influential in your decision to install this <SHORT PROJECT DESCRIPTION> project?

1 Nothing else influential

77 OPEN\RECORD

88 REFUSED

99 DON'T KNOW

F6. Using the same 0 to 10 scale, how would you rate the influence of this factor?

0 NOT AT ALL INFLUENTIAL 1, 2, 3,4,5,6,7,8,9, 10 EXTREMELY INFLUENTIAL

88 REFUSED

99 DON'T KNOW

For the sake of expediency, we are referring to the Partnership Program as the PROGRAM and we are referring to the installation of <PROJECT DESCRIPTION> as the MEASURE.

PB1: What financial calculations does your campus make before proceeding with installation of a <SHORT PROJECT DESCRIPTION> like this one?

77 OPEN\RECORD

88 REFUSED

99 DON'T KNOW

SKIP TO CP1 IF PAYBACK IS NOT MENTIONED IN PB1

PB2: What is the payback cut-off point your campus uses (in months) before deciding to proceed with an investment?

1. 0 to 6 months
2. 6 months to 1 year
3. 1 to 2 years
4. 2 to 3 years
5. 3 to 5 years
6. Over 5 years

88 REFUSED SKIP TO CP1

99 DON'T KNOW SKIP TO CP1

PB3: What was the payback calculation for this <SHORT PROJECT DESCRIPTION> (in months) with the rebate from the Partnership Program?

1. 0 to 6 months
2. 6 months to 1 year
3. 1 to 2 years
4. 2 to 3 years
5. 3 to 5 years
6. Over 5 years

88 REFUSED SKIP TO CP1

99 DON'T KNOW SKIP TO CP1

PB4: And what was the payback calculation for the <SHORT PROJECT DESCRIPTION> (in months) without the rebate from the Partnership Program?

1. 0 to 6 months

2. 6 months to 1 year
3. 1 to 2 years
4. 2 to 3 years
5. 3 to 5 years
6. Over 5 years

88 REFUSED SKIP TO CP1

99 DON'T KNOW SKIP TO CP1

Programming Criteria:

Four situations result:

1. The measure meets the payback criteria without the rebate (PB4 LE PB2) and importance of rebate is high (F3b GE 7), ASK PB5

2. The measure meets the payback criteria with the rebate (PB3 LE PB2) but the rebate is evaluated as not important (F3B LT 7), ASK PB6

3. The measure does not meet the payback criteria with the rebate (PB4 GT PB2) but the rebate is evaluated as important (F3B GE 7), ASK PB7

4. None of the above – skip to CP1

IF THE PAYBACK CRITERIA (PB2) IS GREATER THAT THE PAYBACK CALCULATION WITHOUT THE REBATE (PB4) …ASK PB5

PB5. Even without the rebate, the installation of this <SHORT PROJECT DESCRIPTION> met your campus's financial criteria. Would you have gone ahead with it even without the rebate?

1 Yes

2 No

88 Don't know

99 Refused

PB5A: IF NO: Why would you not have gone ahead with it even without the rebate?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

PB3 (PAYBACK WITH PROGRAM REBATE) IS LESS THAN PB2 (PAYBACK CRITERIA) AND F3B LT 7 (THE REBATE IS NOT IMPORTANT)

PB6: The rebate seemed to make the difference between meeting your financial criteria and not meeting them, but you are saying that the rebate didn't have much effect on your decision, why is that?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

IF PB4 (PAYBACK CRITERIA) IS GREATER THAN PB3 (PAYBACK WITH PROGRAM REBATE) AND IMPORTANCE OF REBATE IS MORE THAN 6 (F3b)

PGB7. The rebate didn't cause the installation of <SHORT PROJECT DESCRIPTION> to meet your campus's financial criteria, but you said that the rebate had an impact on the decision to install the <SHORT PROJECT DESCRIPTION>. Why did it have an impact?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

IF F3O > 5 (IMPORTANCE OF CORPORATE POLICY IS GREATER THAN 5), ASK CP1 THRU CP6 (CORPORATE POLICY SECTION)

Corporate Policy Section

CP1. Does your campus have a policy to reduce environmental emissions or energy use? Some examples would be to BUY GREEN or use sustainable approaches to business investments.

1 Yes

2 No

88 Don't know

99 Refused

CP2. What specific campus policy influenced your decision to adopt or install the <SHORT PROJECT DESCRIPTION>?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

CP3. Had that policy caused you to adopt the <SHORT PROJECT DESCRIPTION> at this building before participating in the Partnership Program?

1 Yes

2 No

88 Don't know

99 Refused

CP4. Had that policy caused you to adopt the <SHORT PROJECT DESCRIPTION> at other buildings on your campus before participating in the Partnership Program?

1 Yes

2 No

88 Don't know

99 Refused

CP5. Did you receive an incentive for a previous installation of this type of <SHORT PROJECT DESCRIPTION>?

1 Yes

2 No

88 Don't know

99 Refused

ASK CP5_AMT, CP5_TIME, CP5_PROG ONLY IF CP5 = 1 YES.

CP5_AMT What was the amount of the incentive received?

CP5_TIME What was the approximate timing of this incentive?

CP5_PROG What was the program name that provided this incentive?

For the sake of expediency, we are referring to the <PROGRAM> as the PROGRAM and we are referring to the installation of <MEASURE> as the MEASURE.

I will repeat this from time to time during the study as your organization may have installed more than one measure through more than one program.

IF CP3 = YES OR CP4 = YES ASK CP6

CP6 If I understand you correctly, you said that your campus's corporate policy has caused you to adopt a similar <SHORT PROJECT DESCRIPTION> previously at this campus. I want to make sure I fully understand how this university policy influenced your decision versus the Partnership Program. Can you please clarify that?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

Standard Practice Section

IF F3L (IMPORTANCE OF STANDARD PRACTICE IS GREATER THAN 5), ASK SP1 THRU SP5 (STANDARD PRACTICE SECTION).

SP1. Approximately, how long has this <SHORT PROJECT DESCRIPTION> been a standard practice at your campus?

Be sure to label answer IN MONTHS/YEARS, ETC.

SP2. Does your campus ever deviate from the standard practice?

1 Yes

2 No

88 Don’t know

99 Refused

IF SP2 = YES, ASK SP2_HOW.

SP2_HOW. Under what conditions does your campus deviate from your standard practice?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

SP3. How did this standard practice influence your decision to install the <SHORT PROJECT DESCRIPTION>?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

SP3A. Could you please rate the importance of the <PROGRAM>, versus this standard industry practice in influencing your decision to install <MEASURE>. Would you say the <PROGRAM> was much more important, somewhat more important, equally important, somewhat less important, or much less important than the standard practice?

1 Much more important
2 Somewhat more important
3 Equally important
4 Somewhat less important
5 Much less important
88 Don't know
99 Refused

SP4. What industry group or trade organization do you look to establish standard practice for your industry?

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

SP5. How does your campus receive information on updates in standard practice?

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

IF F3Q > 5 (IMPORTANCE OF OTHER FACTORS IS GREATER THAN 5), ASK QIN1 THRU QIN3 (INFLUENCE OF OTHER FACTORS SECTION)

Influence of Other Factors Section

QIN1. Who provided the most assistance in the design or specification of &MEASURE? [PROMPT AS NEEDED): Was it: the Designer, the Consultant, the Equipment Distributor, the Mfr Rep, the Installer, the Utility rep, or Internal staff?]

1. Designer
3. Consultant
3. Equipment distributor
4. Installer
5. &UTILITY account representative
6. &PROGRAM staff
77. Other: (Record VERBATIM)
88. REFUSED
99. DON'T KNOW

OIN2. Please describe the type of assistance that they provided.

77 OPEN\RECORD verbatim
88 REFUSED
99 DON'T KNOW

OIN3. Please state, in your own words, any other factors that influenced your decision to go ahead on this energy efficiency project.

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

Comparative Importance of Program

N4. Next, I would like you to rate the importance of the <PROGRAM> in your decision to implement this MEASURE as opposed to other factors that may have influenced your decision such as...(SCAN BELOW AND READ TO THEM THOSE

ITEMS WHERE THEY GAVE A RATING OF 8 or higher)

! <%N3A> Age or condition of old equipment,

! <%N3D> Equipment Vendor recommendation

! <%N3E> Previous experience with this measure

! <%N3F> Previous experience with this program

! <%N3I> Recommendation from a design or consulting engineer

! <%N3J> Standard practice in your business/industry

! <%N3M> Corporate policy or guidelines

! <%N3N> Payback on investment.

N5. If you were given 10 points to award in total, how many points would give to the importance of the program and how many points would you give to these other factors? How many of the ten points would you give to the importance of the PROGRAM in your decision?

Record 0 to 10 importance of program score (_______)

Record 0 to 10 importance of other factors score (_______)

________We want these two sets of numbers to equal 10.

88 Refused

99 Don't know

IF F3B IS GREATER THAN 7 & N5 IS GREATER THAN 7 AND LESS THAN 11, ASK N5A.

N5A. When you answered <F3B> for the question about the influence of the rebate, I would interpret that to mean that the rebate was quite important to your decision *to install this measure*. Then, when you answered <N5> for how likely you would be to *install the same equipment* without the rebate, it sounds like the rebate was not very important in your installation decision. I want to check to see if I am misunderstanding your answers or if the questions may have been unclear. Will you explain in your own words, the role the rebate played in your decision *to install this efficient equipment*?

77 OPEN\RECORD verbatim

88 REFUSED

99 DON'T KNOW

ADD. Would you like to change your score on the importance of the rebate that you provided earlier?

IF F3L (IMPORTANCE OF STANDARD PRACTICE QUESTION) IS GREATER THAN 7 ASK N5B.

N5b . In an earlier question, you rated the importance of Standard Practice in your industry very highly in your decision making. Could you please rate the importance of the <PROGRAM>, relative to this standard industry practice, in influencing your decision to install <MEASURE>. Would you say the PROGRAM was very important, somewhat important, or not at all important than Standard Practice?

1. Much more important
2. Somewhat more important
3. Equally important
4. Somewhat less important
5. Much less important

88. Don't know
99. Refused

N5c. Why do you say that? Record VERBATIM

88. Don't know
99. Refused

IF N5 IS GREATER THAN ZERO.

N9. You indicated in your response to a previous question that there was a <N5> in 10 likelihood that you would have *installed the same equipment* if the Partnership Program had not been available. When do you think you would have *installed this equipment?* Please express your answer in months.

N9A. *If respondent is having difficulty specifying answer in months:* Would it have been…

1. Within 6 months,
2. 6 months to 1 year later,
3. 1 to 2 years later,
4. 2 to 3 years later,
5. 3 to 4 years later OR
6. 4 or more years later

88. Don’t know
99. Refused

IF N9>=48 months OR N9a=response 6, THEN ASK N9b, ELSE ASK N6.

N9b. Why do you think it would have been 4 or more years later?

77 Record VERBATIM
88 Don't know
99 Refused

DEFERRED FREE RIDERSHIP FOLLOWUP

INTRO FOR BOTH TD1 and TD1a You said that there was an <N5> in 10 likelihood that you would have installed the same equipment about <&N9> months later (OR at the same time) if the PROGRAM had not been available. I'd like to ask a couple of questions to help us estimate at what point in the future you would definitely have installed new equipment. We understand that you can't know exactly when you would have done this, especially so far into the future. We're just trying to get a sense of how long you think the current equipment or process would have kept serving your company's needs before you had to or chose to replace it.

If N9 or N9a < 60 months, ask TD1, ELSE TD1A

TD1 So, again using a 0 to 10 scale, where 0 means not at all likely and 10 means extremely likely, what is the likelihood that you would have installed the same equipment within 60 months, or 5 years, if the program had not been available?

- # Record 0 to 10 score (_______)
- 88 Refused
- 99 Don't know

IF <10 ASK TD2, ELSE GO TO N5a

TD2 And what would you say is the likelihood that you would have installed the same equipment within 120 months, or 10 years, if the program had not been available?

- # Record 0 to 10 score (_______)
- 88 Refused
- 99 Don't know

If N9 or N9a > 60 months, ask TD1A

TD1A Now, using the same 0 to 10 scale, where 0 means not at all likely and 10 means extremely likely, what is the likelihood that you would have installed the same equipment within 120 months, or 10 years, if the program had not been available?

- # Record 0 to 10 score (_______)
- 88 Refused
- 99 Don't know

CONSISTENCY CHECK ON AGE

IF N3a>6 AND N9>=48 months OR N9a=response 6, THEN ASK N9BB. ELSE N6.

N9bb Earlier when asked about the influence of the age/condition of the old equipment on your decision to install this new equipment, you gave me a rating of <%N3A> out of ten. I would interpret this to mean that the age/condition was quite influential in your decision to install this new equipment when you did. Perhaps I have either recorded something incorrectly or maybe you could explain in your own words the role the age/condition of the existing equipment played in your decision to install this new energy-efficient equipment.

- 77 Record VERBATIM
- 88 Don't know
- 99 Refused

PARTIAL FREE RIDERSHIP

N6. Now I would like you to think one last time about what action you would have taken if the program had not been available. Supposing that you had not installed the program qualifying equipment, which of the following alternatives would you have been MOST likely to do?

- 1 Install fewer units
- 2 Install standard efficiency equipment or whatever required by code
- 3 install equipment more efficient than code but less efficient than what you installed through the program
- 4 repair/rewind or overhaul the existing equipment
- 5 do nothing (keep the existing equipment as is)
- 6 something else (specify what _____________)
- 88 Don't know

99 Refused

N6a How many fewer units would you have installed? (It is okay to take an answer such as ...HALF...or 10 percent fewer ... etc.)

77 RECORD VERBATIM

88 Refused

99 Refused

N6b Can you tell me what model or efficiency level you were considering as an alternative? (It is okay to take an answer such as … 10 percent more efficient than code or 10 percent less efficient than the program equipment)

77 RECORD VERBATIM

88 Don't know

99 Refused

N6c How long do you think the repaired/rewound/refurbished equipment would have lasted before requiring replacement?

77 RECORD VERBATIM

88 Don't know

99 Refused

Spillover Section

Identify how many additional energy efficient measures that were installed but did not receive an incentive.

SPILL1. Did you implement any additional energy efficiency measures at this campus since your participation in the 2006-2008 Program and before the end of 2008 that did not receive incentives through any utility or government program?

1 Yes

2 No

88 Don’t know

99 Refused

IF SPILL1 = YES ASK SPILL2

SPILL2_1 What was the FIRST measure that you implemented?

77 OPEN\RECORD FIRST measure

88 REFUSED

99 DON'T KNOW

IF SPILL2_1 = 77, ASK SPILL2_2.

SPILL2_2. What was the SECOND measure?

1 No Other

77 OPEN\RECORD SECOND measure

88 REFUSED

99 DON'T KNOW

IF SPILL2_2 = 77 ASK SPILL2_3.

SPILL2_3. What was the THIRD measure?

1 No Other

77 OPEN\RECORD THIRD measure

88 REFUSED

99 DON'T KNOW

Spillover Measure #1 to Measure #3 Section

Ask spillover section for a maximum of three measures (SPILL2_1, SPILL2_2, SPILL2_3.

I have a few questions about (<SPILL2_1>, <SPILL2_2>, <SPILL2_3>) that you installed. Ask this section for each measure implemented above.

MEAS1_1. I have a few questions about <SPILL2_1> that you installed. Was this measure part of a <ELECTRIC UTILITY/GAS UTILITY> program or any other utility or government energy efficiency incentive Program?

1 Yes

2 No

88 Don’t know

99 Refused

IF MEAS1_1= 2 - NO, 88 REFUSED OR 99 DON’T KNOW ASK MEAS1_2.

MEAS1_2a. Why are you not expecting a rebate for this measure?

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

MEAS1_2B. Why did you not install this measure through a utility program?

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

MEAS1_3. Please describe the SIZE, The EFFICIENCY and QUANTITY of this measure?

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

MEAS1_4. Was this measure specifically recommended by a Partnership Program related audit, report or program technical specialist?

1 Yes

2 No

88 Don’t know

99 Refused

IF MEAS1_4 = YES ASK MEAS1_5; IF MEAS1_4 =2, 88 OR 99 SKIP TO MEAS1_7.

MEAS1_5. How significant was your experience in the 2006-2008 Program in your decision to implement this measure, using a scale of 0 to 10, where 0 is not at all significant and 10 is extremely significant?

0 NOT AT ALL SIGNIFICANT 1, 2,3,4,5,6,7,8,9,10 EXTREMELY SIGNIFICANT

88 REFUSED

99 DON'T KNOW

IF MEAS1_5 IS BETWEEN 0 AND 10 ASK MEAS1_6.

MEAS1_6. Why do you give it this rating?

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

MEAS1_7. If you had not participated in the 2006-2008 Partnership Program, how likely is it that your campus would still have implemented this measure, using a 0 to 10 scale where 0 means you definitely WOULD NOT have implemented this measure and 10 means you definitely WOULD have implemented this measure?

0 DEFINITELY WOULD NOT HAVE 1,2,3,4,5,6,7,8,9 10 WOULD DEFINITELY IMPLEMENTED

88 REFUSED

99 DON'T KNOW

IF MEAS1_4 = NO, REFUSED, DON'T KNOW, ASK MEAS1_8.

MEAS1_8. How significant was your experience in the 2006-2008 Partnership Program in your decision to implement this measure that was not part of a program, using a 0 to 10 scale, where 0 is NOT AT ALL SIGNIFICANT and 10 is EXTREMELY SIGNIFICANT?

0 NOT AT ALL SIGNIFICANT 1,2,3,4,5,6,7,8,9,10 EXTREMELY SIGNIFICANT

88 REFUSED

99 DON'T KNOW

IF MEAS1_8 IS A VALID ANSWER ASK MEAS1_8WHY.

MEAS1_8WHY. Why do you give it this rating?

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

Outside Spillover – Other Facilities

CAFAC1. Now, thinking about other buildings on your campus, are you aware of any additional energy efficiency measures implemented since your participation in the 2006-2008 Partnership Program? These can include measures installed in or outside of a utility or government program.

1 Yes

2 No

88 Don't know

99 Refused

IF CAFAC1 = YES ASK CAFAC2_1.

CAFAC2_1. What was the FIRST measure that you implemented?

77 OPEN\RECORD FIRST measure VERBATIM
88 REFUSED
99 DON'T KNOW

IF CAFAC2_1 = VALID ANSWER, ASK CAFAC2_2.

CAFAC2_2. What was the SECOND measure?

1 No Other
77 OPEN\RECORD SECOND measure VERBATIM
88 REFUSED
99 DON'T KNOW

IF CAFAC2_2 = VALID ANSWER, ASK CAFAC2_3.

CAFAC2_3. What was the THIRD measure?

1 No Other
77 OPEN\RECORD THIRD measure VERBATIM
88 REFUSED
99 DON'T KNOW

Outside Spillover Measure #1 to Measure #3 Section

For each measure implemented above (CAFAC2_1, CAFAC2_2, CAFAC2_3).

MSURE1_1. I have a few questions about <CAFAC2_1> that you installed. Was this measure part of a Partnership Program or any other utility or government energy efficiency incentive Program?

1 Yes
2 No
88 Don’t know
99 Refused

IF MSURE1_1 NOT EQUAL TO YES ASK MSURE1_2.

MSURE1_2A. Why are you not expecting a rebate for this measure?

77 OPEN\RECORD VERBATIM
88 REFUSED
99 DON'T KNOW

MSURE1_2B. Why did you not install this measure through a utility program?

77 OPEN\RECORD VERBATIM
88 REFUSED
99 DON'T KNOW

MSURE1_3: Please describe the SIZE, The EFFICIENCY and QUANTITY of this measure.

77 OPEN\RECORD VERBATIM
88 REFUSED
99 DON'T KNOW

MSURE1_4. Was this measure specifically recommended by a Partnership Program related audit, report or program technical specialist?

1 Yes

2 No

88 Don't know

99 Refused

IF MSURE1_4 = YES ASK MSURE1_5. IF MSURE1_4 NE YES, SKIP TO MSURE1_8

MSURE1_5. How significant was your experience in the 2006-2008 Program in your decision to implement this Measure, using a scale of 0 to 10, where 0 is not at all significant and 10 is extremely significant?

0 NOT AT ALL SIGNIFICANT 1,2,3,4,5,6,7,8,9,10 EXTREMELY SIGNIFICANT

88 REFUSED

99 DON'T KNOW

IF MSURE1_5 IS A VALID ANSWER (1||11), ASK MSURE_6.

MSURE1_6. Why do you give it this rating?

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

MSURE1_7 If you had not participated in the 2006-2008 program, how likely is it that your campus would still have implemented this measure, using a 0 to 10 scale where 0 means you definitely WOULD NOT have implemented this measure and 10 means you definitely WOULD have implemented this measure?

0 DEFINITELY WOULD NOT HAVE 1,2,3,4,5,6,7,8,9,10 WOULD DEFINITELY IMPLEMENTED

88 REFUSED

99 DON'T KNOW

GO TO C2 IN FIRMOGRAPHICS

IF MSURE1_4 = NO, REFUSED, DON'T KNOW, ASK MSURE1_8.

MSURE1_8. How significant was your experience in the 2006-2008 program in your decision to implement this measure that was not part of a program, using a 0 to 10 scale, where 0 is NOT AT ALL SIGNIFICANT and 10 is EXTREMELY SIGNIFICANT?

0 NOT AT ALL SIGNIFICANT 1,2,3,4,5,6,7,8,9,10 EXTREMELY SIGNIFICANT

88 REFUSED

99 DON'T KNOW

IF MSURE1_8 = VALID ANSWER, ASK MSURE1_8WHY.

MSURE1_8WHY. Why do you give it this rating?

ASK OUTSIDE SPILLOVER MSURE #1 SECTION FOR MSURE #2 AND MSURE #3

Firmographics

And finally, I have a few questions about the characteristics of your business.

C2. Please describe the primary function of this building.

77 OPEN\RECORD VERBATIM

88 REFUSED

99 DON'T KNOW

C3: Please describe any changes made to this site since January 2007 that significantly impacted energy usage.

77 OPEN\RECORD VERBATIM
88 REFUSED
99 DON'T KNOW

C5: What is the total occupied floor area of this premise (excluding enclosed parking garage area)?

C6: How many buildings are on this campus?

C8. What year was this campus established at this location?

88 REFUSED
99 DON'T KNOW

C9. How many full-time equivalent employees work at this campus?

88 REFUSED
99 DON'T KNOW

Those are all the questions I have for you. On behalf of the CPUC, thank you very much for your time.
FirstName. For verification purposes only, may I please have your first name?
Gender. By observation only

1. Male,
2. Female

UC/CSU/IOU and CCC/IOU Program Managers Interview Guide

UC/CSU/IOU and CCC/IOU Program Managers Interview Guide (draft 2009-9-11)

Need program background information: latest quarterly report, PIP, monthly report, program theory, if available. (Portal or ACE?)

LEAD IN: My name is _______ and I work for Summit Blue Consulting. We have been hired by the CPUC to evaluate energy savings impacts from the 2006-2008 Energy Efficiency programs offered by California's investor owned utilities and third parties. Specifically, we have been hired to estimate savings from the (UC/CSU/CCC/PALM DESERT) Partnership Program. One of the first steps in our work is to interview program managers in order to develop as complete and accurate a picture of your program as we can. I am calling you to schedule this interview, which I expect will take approximately one hour to complete. I would also like for you to provide me with links, etc. to any program information so that I can review it thoroughly before our interview. My questions will then serve to confirm information that I have reviewed, to answer any questions that I may have based on what I have read, and to fill in any remaining gaps. What times would be convenient to do this interview during the next week? (Schedule a time.)

- Program Description
  - Could you please provide a fairly high level description of the Program. (4 - 6 sentences).
  - Was the program implemented as designed?
  - If no, what changes were made between the initial design and field implementation?
  - What caused these changes?

- Program Implementation Proposal (PIP)
  - We have a copy of the PIP (program implementation proposal -- concept paper). Did you follow the work plan as outlined in the PIP or have you or the implementer made changes in the program, such as changing the target audience, the mix of measures, or implementation procedures.?
    We may want to copy certain text from the PIP to refresh our memories of the details of the program.

- Program Theory
  - Can you briefly describe a program theory at a fairly high level (a few sentences)? We are interested in how the major intervention strategies and the major program delivery steps are believed to result in desired outcomes. In other words, how is your program designed to get the target audiences to reach the desired outcomes?
  - What barriers have you encountered?
  - How were these barriers overcome?
- Program Strategies
  - What are the main types of interventions (services/benefits) offered by the program to participating campuses?
  - How were the interventions marketed?

- Roles of Actors
  - What is your role in the (UC/CSU/CCC/PALM DESERT) Partnership Program?
  - What decisions are you responsible for?
  - How many organizations or groups/teams of people are involved in the Partnership? What role does each organization, group, or team play? What is their role in decision making?
  - Who else has a pivotal role in the decision making process: program implementer, on campus decision maker, campus administration, trade ally, ESCO, Teams, others.

- Marketing Approach
  - What types of marketing activities (strategies, tactics) are used to attract campuses to the program? Probe for all.
  - Who markets the program to the campuses?
  - What role do ESCO's play in marketing? Do they market the partnership program to the campuses?

- Market Actors/Delivery Support
  - What market actors (trade allies) are active in this program? For example:
      - Engineering firms
      - Specialized equipment suppliers (boiler firms, motor distributors)
      - Process experts
      - Lighting distributors, etc.
      - Designers/Architect/Engineers,
      - Energy Service Providers (ESCOs),
  - Are there others that market the program that we haven't identified?

- Non-Energy Performance Goals
  - Does the program have any non-energy performance goals such as the following?
    - MEC list:
      - Create Partnerships
      - Hard-to-reach Participation,
      - Commissioning Methods Changes,
      - Maintenance Method Changes,
      - More Informed Target Market,
      - Awareness of Energy Efficiency,
      - Building Design Practices,
      - Codes and standards changes,
      - Improved Indoor Air Quality,
      - Improved Occupant Comfort,
      - Market Penetration Increase,
      - Market Transformation,
      - Operations Methods Changes, Other,
      - Purchasing Methods Changes,
      - Reduced Environmental Impact,
      - Referrals to Other Programs,
      - Satisfaction Increase,

- (Target) Population Sectors
  - How do you define:
    - Program participants
    - Program Non-participants?

- Which types/sizes of projects are targeted by the program?
- Is there a minimum size level for participation?
- Who decides if the project qualifies for the program?
- What is the decision process?

- Program Performance vs. Goals
  - Next, I'd like you to comment on the program accomplishments to-date relative to goals. Based on the 4th quarter monthly report, the program is at READ SPENDING, KWH/KW/THERMS INSTALLED VS. GOALS. MENTION COMMITMENTS.
  - Also, according to the quarterly report narrative, you were (on target, ahead of expectations, falling short of expectations) relative to goals. Do the reported accomplishments to date and commitments provide an accurate picture of what the program had achieved by year end 2008?
  - Why did the program meet, exceed or fall short of its goals? Were there been any changes in the program or market that affected the program's ability to meet its goals? If so, how did they affect the program's performance in 2008?
  - Were there significant problems with the program's operation?
  - Have you received any feedback from customers on problems with the implementation of the Partnership program? (especially, if goals are not met) What problems have customers experienced during program implementation?
  - What changes would you have made to improve the program?

- **Minimization of Free Riders**
  Free ridership

  - To your knowledge, were there cases where people would have completed the same projects without the Partnership Program in about the same time frame? Do you think this led to higher or lower levels savings for the Partnership Program compared to programs marketed to other customer groups? What if anything did the Partnership program doing to minimize projects that would have been completed anyway?
  - Were there cases where projects associated with the Partnership Program stimulated additional projects that wouldn't have been done or would have been done much later?

Contact information

- Contact info – 3rd Party Program Managers or program implementation staff
- Can you provide contact information for the 3rd party implementation manager(s) if this role exists? Who else could I call to obtain this information?

- **In closing, do you have any questions you feel we should include in the any of the other interview guides?**
  - Implementation managers
  - Campus energy staff
  - University/college administrative staff
  - Team members

Closing: On behalf of the CPUC, I'd like to thank you for taking time out of your busy schedule to do this interview. This information will give us what we need to design the appropriate approach to evaluate savings from your program, and I thank you for providing it.

Participant Customer Survey for 2008 Palm Desert LG Program RESIDENTIAL GUIDE

Participant Customer Survey for 2008 Palm Desert LG Program RESIDENTIAL GUIDE

This survey document copy serves as a guide for the residential data results. Please refer to the document entitled "CPUC Palm Desert General Survey_9222009_COM GUIDE.doc" for guide to commercial data results.

Variable Definition: RESPNUM$ - This is a unique identifier for a participant/respondent. This variable can be found in each dataset and is always specific to the participant. This variable serves as a link between each dataset.

Residential Data Sets Accompanying Residential Guide

1) **Palm Desert Residential Non-measure Data_9212009.sav** – SPSS dataset that includes contact level variables introit to intro5; nspi to ap24_7 (ALL DATA OUTSIDE OF MEASURE LOOP). This also includes additional flags from sample, including respnum$ (unique respondent number), measure flags, incentive totals, program, etc. All recruit data has been removed from data.

2) **Palm Desert Residential Measure Loop Aggregate_9212009.sav** – SPSS dataset including variables w1chk to c3 (ALL DATA INSIDE MEASURE LOOP). This also includes respnum$ (unique respondent number), measure (see below), and measure flags.

   a. MEASURES: Each measure loop is assigned a measure flag (numbering from 1-9). All questions for that specific measure flag refer only to that specific measure. The data is arranged on a measure basis for the measure loop; therefore, respnum$ (respondent numbers) will repeat in this dataset, depending on the number of measures installed/rebated for a participant.

Flag Number	Corresponding Measure
1.00	CFL (CFL)
2.00	DUCT (Duct Repair)
3.00	HVACeq (HVAC equipment)
4.00	HVACer (HVAC early retirement)
5.00	HVACmt (HVAC maintenance)
6.00	Night (Night lights)
7.00	RCA (RCA)
8.00	Room (Room AC)
9.00	AudFlg (Audit)

3) **PalmRES_Open Ends.doc** – This document includes all open-end responses (Verbatim responses). The field "Respnum$" corresponds to those found in the SPSS files, though this file also includes responses from incomplete surveys. If an open-end response was recoded, the column "Recode To" shows which category a response was moved to.

4) **Field Definitions**

a. Respnum$ - Unique participant/respondent identifier.

b. Variable – This ties each response to a specific question.

c. RosterNum – A roster number is used to loop a series of questions for each given measure. This number is connected to a given measure, as seen in the table below.

i. For example, question FR11 is a rostered question. In the open end file, FR11 can be seen in the variable field. To determine which rostered measure the open end response is referring to, consult the RosterNum field. If the listed number is 1, then the open end response is tied to the CFL measures.

1. Please note that when comparing these open ends to the Measure Loop Aggregate, the roster numbers are not attached to the variable. For the measure loop, the RosterNum is the measure's flag number.

2. For the Non-Measure file, the RosterNum is tied to the variable. So, for example, NSP4 is a rostered question. This will look like: NSP4_1, indicating it is a roster.

RosterNum	Corresponding Measure
1	CFL (CFL)
2	DUCT (Duct Repair)
3	HVACeq (HVAC equipment)
4	HVACer (HVAC early retirement)
5	HVACmt (HVAC maintenance)
6	Night (Night lights)
7	RCA (RCA)
8	Room (Room AC)
9	AudFlg (Audit)

d. Select All Num – This indicates which option(s) a respondent chose for a question in which multiple answers are possible (Indicate all that apply/Select all that apply).

i. The specific answers are tied to the number in the Select All Num column. So, for example, if the column reads as "1,16", it means that the participant selected options one and 16.

ii. In the data files, these will appear as _X. In cases where rosters are used, the order is: VARIABLE_ROSTERNUM_SELECTALL; when rosters are not used, the order is: VARIABLE_SELECTALL.

DIALSCR Hello, my name is [interviewer name], and I'm calling on behalf of the California Public Utilities Commission regarding the Set to Save [Program] you participated in [YEAR]

May I speak with [named respondent]?

1 Yes
2 No [Attempt to Convert]

IntroI (Why are you conducting this study: Studies like this help the utility and its partners better understand customers' awareness of and interest in energy programs and services.)

(Timing: The length of this survey will vary depending on measures installed. Is this a good time for us to speak with you? IF NOT, SET UP CALL BACK APPOINTMENT OR OFFER TO LET THEM CALL US BACK AT 1-800-454-5070)

(Sales concern: I am not selling anything; we would simply like to learn about your awareness of services that can save energy, and your opinions about these services. Your responses will be kept confidential.

Intro1 According to our records, your organization participated in City of Palm Desert's [Program] in 2008. I was told that you are the person most knowledgeable about this program. Is this correct?

1 Yes
2 No
3 No one knows about the Set to Save Rebate/Direct Install Program

Intro2 Who would be the person at this location who is most knowledgeable about your [household/organization]'s participation in City of Palm Desert's [Program]?

1 Record Name, as &CONTACT
D Don't know
R Refused

Intro3 May I speak with him/her?

1 Yes
2 No (not available right now, set cb)

Intro4 Before we start, I would like to inform you that for quality control purposes, this call may be monitored by my supervisor.

Today we're conducting a very important study on the energy needs and perceptions of organizations like yours. We are interested in how organizations like yours think about and manage their energy consumption.

Your input will allow the California Public Utilities Commission to build and maintain better energy savings programs.

This is a fact-finding survey only, and responses will not be connected with your organization in any way.

SCREENER

Addr First, I'd like to ask you a few questions about your organization and facility. Our records show your firm is located at [ADDRESS] in [CITY]. Is that correct?

[CONTINUE IF ADDRESS REPORTED BY RESPONDENT IS SIMILAR ENOUGH]

1 Yes
2 No
D Don't know
R Refused

CORRECT May I have your correct address?

COMPARE Are these addresses similar or totally different?

Computer Address – [ADDRESS]
Corrected Address – [CORRECT]

1 Similar
2 Totally Different

WrgAddr We were attempting to reach the customer at &ADDRESS in &CITY and since that does not match your address, then we must have mis-dialed the telephone number. Those are all the questions that we have for you today, on behalf of the California Public Utilities Commission. Thank you for your time and cooperation.

Intro5 The questions in this survey will refer to your "FACILITY," which means ALL of the buildings and tenants serviced by &UTILITY under the following billing address: &SERV_ADDR. [INTERVIEWERS SHOULD RE-READ THIS STATEMENT AS NEEDED THROUGHOUT THE SURVEY TO REMIND THE RESPONDENTS]

CUSTOMER CHARACTERISTICS – COMMERCIAL ONLY
(RESIDENTIAL SKIPS TO W1CHK)

CC1i Now, I'd like to ask you questions regarding your facility.

CC1 How many square feet of heated or cooled floor area is your facility?
______ Square feet
888888 Don't know
999999 Refused

CC3 Would you say that the heated or cooled floor area is ...?

1 < 1,500 sqft
2 1,500 - 5,000 sqft
3 5,000 - 10,000 sqft
4 10,000 – 25,000 sqft
5 25,000 – 50,000 sqft
6 50,000 – 75,000 sqft
7 75,000 – 100,000 sqft
8 > 100,000 sqft
D Don't know
R Refused

CC3a Is your space heated using electricity or gas?

1 Electricity
2 Gas
3 Both electricity and gas
4 Propane
5 None
6 Other (Specify)
D Don't know
R Refused

CC4 Does your business own, lease or manage the facility?

1 Own
2 Lease/Rent
3 Manage
D Don't know
R Refused

ASK IF CC4 in (3, D, R)
CC5 Does your company pay the electric and/or gas utility bill?

1 Yes
2 No
D Don't know
R Refused
ASK IF CC4 = 2
CC5a Which of the following best describes how your business pays the electric and/or gas utility bill for your space at this facility? [READ LIST.]

1 You pay SCE directly
2 You pay a fee to your landlord that varies according to the size of the total utility bill
3 You pay a fixed fee to your landlord
4 You do not pay for electric and gas utilities
5 OTHER (Specify)
D Don't know
R Refused

CC8 In what year was the facility built?

____ Year
8888 Don’t know
9999 Don’t know

CC10 If don't know, would you say it was…

1 After 2000
2 In the 1990's
3 1980s
4 1970s
5 1960s
6 1950s
7 Before 1950
D Don’t know
R Refused

CC11 In what year was this facility last remodeled?

____ Year
6666 Never
8888 Don’t know
9999 Refused

ADDITIONAL FACILITY CHARACTERISTICS

FM050 What is the main business ACTIVITY at your facility?

1 Office
2 Retail (non-food)
3 College/University
4 School
5 Grocery Store
6 Restaurant
7 Health Care (other than Hospital)
8 Hospital
9 Hotel or Motel
10 Warehouse
11 Construction
12 Community Service/Church/Temple/ Municipality
13 Industrial Process/ Manufacturing/ Assembly
14 Condo Assoc./Apartment Mgr.
15 Other (Specify)
D Don’t know
R Refused

FM070 Approximately how many people are currently working at the facility, including individuals either full- or part-time (IF DON'T KNOW ASK FOR BEST GUESS)

____ Number of people
8888 Don't know
9999 Refused

ROLE OF CONTRACTORS – PROCESS SIDE

V1 Did you use a contractor to install the measures rebated through the 2008 [Program]?

1 Yes
2 No
D Don't know
R Refused

V5 Had you worked with this contractor before participating in the 2008 [Program]?

1 Yes
2 No
D Don't know
R Refused

V40 How important was the input from the contractor you worked with in deciding which specific equipment to install? Was it …

1 Very important
2 Somewhat important
3 Not at all important
4 They did not have any input.
D Don't know
R Refused

PROGRAM EFFECTS

PE1i Next we would like to ask you about your program experience.

PE1 Please rate these 4 factors on your decision to purchase rebated equipment as very, somewhat, or not at all influential. The first/next one is …

PE1A# The Set to Save rebate
PE1B# Contractor **IF V1 = 1**
PE1C# Your [UTILITY] representative
PE1D# Rising energy bills
PE1E# Global Warming
1 VERY Influential
2 SOMEWHAT Influential
3 NOT AT ALL Influential
D Don't know
R Refused

Warm-up Questions/Background Context

ALL RESPONDENT TYPES: RESIDENTIAL AND COMMERCIAL

RESIDENTIAL MEASURES: CFL, RCA, HVACer, HVACmt, HVACeq, DUCT, NIGHT, ROOM, AUDFLG

W1chk Just to confirm, did you receive a [measure] through the Set-to-Save [program] Program?

1 Yes, and I am the most knowledgeable about this measure
2 Yes, but I am not at all knowledgeable about this measure
3 No
D Don't Know
R Refused

W1i Please think back to the time when you were deciding to buy/install the energy efficient [**measure**], perhaps recalling things that occurred in your household shortly before and after [**installation_date]**. What factors motivated you to purchase energy saving [**measure**]? {DO NOT READ; INDICATE ALL THAT APPLY; ONCE THEY RESPONDENT HAS FINISHED, PROBE: Are there any other factors?}

1 Old equipment didn't work
2 Old equipment working poorly
3 The program incentive
4 The program technical assistance
5 Wanted to save energy
6 Wanted to reduce energy costs
7 The information provided by the Program
8 Past experience with this program
9 Because of past experience with another [**utility**] program
10 Recommendation from other utility program (Probe: What program? ______)
11 Recommendation of dealer/retailer
12 Recommendation of someone else (Probe: Who?___________)
13 Advertisement in newspaper (Probe: For what program? ___________)
14 Radio advertisement (Probe: For what program? _________)
15 Other (SPECIFY)
16 Environmental concerns
17 Global warming
18 Liked the appearance of the **[measure]** more than the old one
19 Keeping up with the latest trends and fashions
D Don't Know
R Refused

{SERIES REPEATED FOR UP TO THREE MEASURES}

{ASK W2a-W6 ONLY FOR INCREMENTAL EFFICIENCY REBATE MEASURES} (ROOM AC, POOL PUMP, POOL PUMP VSD, COOLING, CENTRAL AC ER, CENTRAL AC SUPER. HIGH PERFORMANCE, HVAC SYSTEM)

W2a Did you get this [**measure**] to replace [a/an] existing [**measure type**]?

1	Yes	{SKIP TO W3}
2	No	
D	Don't Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

W2b Did you get this [**measure**] because you wanted to add another/more [**measure**] to your [home/business]?

1	Yes	{SKIP TO FR1}
2	No	
D	Don't Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

W2c Is this [**measure type**] the first you have ever had in your [home/business]?

1	Yes	{SKIP TO FR1}
2	No	{SKIP TO FR1}
D	Don't Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

R W3 {IF MEASURE=LIGHTING or INDOOR_LT} What type of lighting did this replace? {DO NOT READ}

1	Incandescent
2	CFL
3	Other (SPECIFY)
D	Don't Know
R	Refused

W4 {IF MEASURE NOT LIGHTING} About how old was the [**measure**] you replaced? {READ CATEGORIES IF NEEDED}

1	Less than 5 years old
2.	5 to less than 10 years old
3	10 to less than 20 years old
4	20 years to less than 30 years old
5	30 or more years old
D	Don't Know
R	Refused

W5 Was the old [**measure**] working or not working?

1.	Working	
2.	Not working	{SKIP TO FR1}
D	Don't Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

W6 Was the old [**measure**] in good, fair, or poor working condition?

1 Good
2 Fair
3 Poor
D Don't Know
R Refused

DIRECT INSTALL MODULE
ASK FOR DIRECT INSTALL PARTICIPANTS FOR COMMERCIAL ONLY

Warm-up Questions/Background Context

DI1 I just want to confirm someone from [PROGRAM NAME/ORGANIZATION] came into your organization and installed [MEASURE] in [MONTH/YEAR]. Is this correct?

1 Yes
2 No
D Don't know
R Refused

DI2 [IF NO] What is incorrect? [Probe if necessary with below categories]
1 Do not recall someone coming to organization [SKIP TO NEXT SECTION]
2 Measures listed are incorrect
ASK AND RECORD: WHAT ARE THE CORRECT MEASURES?
3 Date is incorrect
4 Other [RECORD] [SKIP TO NEXT SECTION IF NECESSARY]

DI3 How did you hear about the program? [DO NOT READ; RECORD ALL THAT APPLY]

1 Another program (which program?)
2 Local government partnership activities
3 Water utility bill stuffing
4 Electric / gas utility bill stuffing
5 Water utility mailing
6 Electric / gas utility mailing
7 Community Sweeps
8 Community displays
9 Energy fairs
10 Word of mouth
11 Newspaper article
12 Technical assessment / audit
13 Other [RECORD]

ASK W2c ONLY FOR CFL
W2c Is this [MEASURE] the first you have ever had in your [home/business]?

1 Yes {SKIP TO FR1}
2 No {SKIP TO FR1}
D Don't know {SKIP TO FR1}
R Refused {SKIP TO FR1}

LI9i I'd like to ask you a few questions about the equipment that was removed and replaced when you installed the lighting.

LI9a What type of [measure] was removed and replaced when the energy efficient [measure] was installed through the [**Program**]?

1 High performance T8 (1" diameter bulbs)
2 T8 fluorescent fixtures (1" diameter bulbs)
3 T10 fluorescent fixtures
4 T12 Fixtures (1.5" diameter bulbs)
5 HID (High Density Discharge) Fixtures, Compact
6 Compact Fluorescent, Screw-in Modular
7 Compact Fluorescent, Hardwire
8 Incandescent
9 Exit Signs, Compact Fluorescent
10 Exit Signs, LED
11 Halogen
12 Install Reflectors
13 Electronic Ballast
14 Magnetic Ballast
15 Lighting Controls, Time Clock
16 Lighting Controls, Occupancy Sensor
17 Lighting Controls, Bypass/Delay Timers
18 Lighting Controls, Photocell
19 Other Fluorescent
20 Fat/Thick Tubes
21 Skinny/Thin Tubes
22 T5 Fixtures (5/8" diameter)
23 Did not replace anything - new equipment
24 Other (PLEASE SPECIFY)
25 Don't know/ Refused

ASK IF LI9a=5; else skip to LI9c

LI9b Were the HID lamps removed High Pressure Sodium, Metal Halide, Mercury Vapor or Incandescent?

1 High pressure sodium
2 Metal Halide
3 Mercury Vapor
4 Incandescent
D Don't know
R Refused

LI9c Approximately how old were the lights that were *removed* and replaced with [lighting **measure**]? Would you say...

1 Less than 5 years old
2 Between 5 and 10 years old
3 Between 10 and 15 years old
4 More than 15 years old
D Don't know
R Refused

Self Report Free-Ridership Survey

ALL RESPONDENT TYPES: RESIDENTIAL AND COMMERCIAL

RESIDENTIAL MEASURES: CFL, RCA, HVACer, HVACmt, HVACeq, DUCT, NIGHT, ROOM, AUDFLG

Free-Ridership Questions

FR1 Why did you participate in the **[Program]**?
[DO NOT READ, INDICATE ALL THAT APPLY]

1 Needed new [measure]
2 To save energy/have more efficiency
3 To save money
4 To help the environment/prevent global warming
5 To get better lighting/[measure]
6 Needed to dispose of old bulbs
7 Other (specify)

FR2 At the time that you first heard about the assistance from the Palm Desert **[Program]** for this **[Measure]**, had you…? {READ LIST}

1 Already been thinking about purchasing [measure]?
2 Already begun collecting information about [measure]?
3 Already selected the particular [measure] you were going to get?
4 Already decided to buy the [measure]**?**
5 Already installed the energy efficient [measure]?
6 [DON'T READ] Other: ___________
D Don't know
R Refused

FR3 So, the [measure] was installed before you learned about the assistance from **[Program]**?

1 Yes {SKIP TO FR5}
2 No
D Don't know
R Refused

FR4 Just to be sure I understand, did you have specific plans to install [measures] before learning about the [assistance] available through the **[Program]**?

1 Yes
2 No
D Don't know {SKIP TO FR4}
R Refused {SKIP TO FR4}

FR5 Did you have to make any changes to your existing plans in order to receive this [assistance] through the **[Program]**?

1 Yes
2 No
D Don't know
R Refused

FR6 What changes did you make?

1 [RECORD RESPONSE]
D Don't know
R Refused

If the [assistance] from the Palm Desert **[Program]** had not been available, would you have:

FR7a Purchased any [Measure]?

1 Yes
2 No {SKIP TO FR7D}
D Don't know
R Refused

FR7b Bought the [measure(s)] earlier than [you did/it was installed], or later?

1 Earlier
2 Same Time
3 Later
D Don't know
R Refused

FR7c How much [earlier/later] would you have bought the [measure]?

{RECORD RESPONSE} ______ Years {and/or} ______Months
D Don't know
R Refused

If QTY GT 1, ASK:

FR7d Without the program, would you have purchased the same quantity as you did? [Probe for more or less]

1 More
2 Same quantity
3 Less
D Don't know {SKIP TO FR8}
R Refused {SKIP TO FR4D}

FR7e How much **[more/less]** would you have bought?

______ [RECORD NUMBER]
88888 Don't know
99999 Refused

FR7f Would you have purchased the same energy efficient [lighting measure/measure]?

1 Yes
2 No
D Don't know
R Refused

FR7g If the [assistance] from the Palm Desert [Program] had not been available, would you have done anything else differently?

1 Yes
2 No {SKIP TO FR5}
D Don't know {SKIP TO FR5}
R Refused {SKIP TO FR5}

FR7h What would you have done differently?

1 [RECORD RESPONSE]
D Don't know
R Refused

FR8 On a 0 to 10 scale, with 0 being not at all likely and 10 being very likely, how likely is it that you would have bought [Measure] if you had not received any [assistance] from the program?

__ [RECORD RESPONSE (0-10)]
88 Don't know
99 Refused

ASK ONLY FOR LIGHTING MEASURES:

FR9 In total, how many efficient bulbs and/or fixtures did you receive through this program?

_____ [Record response]
88888 Don't know
99999 Refused

FR10 Of these, how many are currently installed?

_____ [Record response]
88888 Don't know
99999 Refused

FR11 [IF FR10<FR9] What happened to the [FR9-FR10] bulbs/fixtures that aren't currently installed?

1 [RECORD RESPONSE]
D Don't know
R Refused

FR12 Our records indicate you received about **[incentive]** from the Palm Desert [Program] either directly or at the time of purchase to offset the cost of the **[measure]**. Does this amount sound about right?

1 Yes {SKIP TO FR13}
2 No
D Don't know
R Refused

FR12a What would you estimate to be the actual amount?

[RECORD RESPONSE]________ {SET = NEW AMOUNT OF INCENTIVE}
D Don't know
R Refused

FR13 **I'm going to read several statements about how you came to choose your [measure]. On a scale of 0 to 10, where 0 is strongly disagree and 10 is strongly agree, how much do you agree with each statement?**

If I had not had any assistance from the program, I would have paid [the additional incentive amount] to buy the [Measure] on my own.

__ [Record Response (0-10)]
88 Don't know
99 Refused

FR14 There may have been several reasons for my purchase decision, but the assistance from the Palm Desert **Set to Save Rebate Program** was a critical factor in my decision to purchase the high efficiency/energy efficient product.

__ [Record Response (0-10)]
88 Don't know
99 **Refused**

FR15 I would have bought a(n) [measure] within 2 years of when I did even without the assistance from the Set-to-Save [Program] Program.

__ [Record Response (0-10)]
88 Don't know
99 **Refused**

CONSISTENCY CHECK & RESOLUTION

DEVELOPING PROGRAMMING TO TEST FOR INCONSISTENCIES BETWEEN RESPONSES IN THE FREE-RIDERSHIP BATTERY, C1 WILL TAKE PRECEDENCE OVER INCONSISTENT RESPONSES.

IF (FR7A or FR7F = 1) AND FR8 = 0,1 AND FR14 = 9,10 AND FR15 = 0,1;
IF (FR7A or FR7F = 2) AND FR8 = 9,10 AND FR14 = 0,1 AND FR15 = 9,10;
IF FR8 = 0,1 AND (FR7A or FR7F = 1) AND FR14 = 0,1 AND FR15 = 9,10;
IF FR8 = 9,10 AND (FR7A or FR7F = 2) AND FR14 = 9,10 AND FR15 = 0,1;
IF FR14 = 0,1 AND (FR7A or FR7F = 2) AND FR8 = 0,1 AND FR15 = 0,1;
IF FR14 = 9,10 AND (FR7A or FR7F = 1) AND FR8 = 9,10 AND FR15 = 9,10;
IF FR15 = 9,10 AND (FR7A or FR7F = 2) AND FR8 = 0,1 AND FR14 = 9,10;
IF FR15 = 0,1 AND (FR7A or FR7F = 1) AND FR8 = 9,10 AND FR14 = 0,1

Consistency Check & Resolution

{C1 will be asked only for those respondents who have a clear inconsistency between responses (i.e., all but one of the questions are at one end of the spectrum for free ridership while one question is at the other spectrum.) The question responses that will be used to trigger C1 are:

FR4A (efficiency enhancement measures) OR FR4D (incremental efficiency measures)
FR5
FR10
FR11

{IF FR4A/D = 1 AND FR5 = 0,1 AND FR10 = 9,10 AND FR11 = 0,1, ASK C1. INCONSISTENCY 1 = 'you would have purchased the [**measure**] without the program'}

{IF FR4A/D = 2 AND FR5 = 9,10 AND FR10 = 0,1 AND FR11 = 9,10, ASK C1. INCONSISTENCY 1 = 'you would not have purchased the [**measure**] without the program'}

{IF FR5 = 0,1 AND FR4A/D = 1 AND FR10 = 0,1 AND FR11 = 9,10, ASK C1. INCONSISTENCY 1 = 'you would likely <u>not</u> have purchased the [**measure**] without the program'}

{IF FR5 = 9,10 AND FR4A/D = 2 AND FR10 = 9,10 AND FR11 = 0,1, ASK C1. INCONSISTENCY 1 = 'you would likely have purchased the [**measure**] without the program'}

{IF FR10 = 0,1 AND FR4A/D = 2 AND FR5 = 0,1 AND FR11 = 0,1, ASK C1. INCONSISTENCY 1 = ‘the program was not a critical factor in your decision to purchase the high efficiency/energy efficient [**measure type**] without the program’}

{IF FR10 = 9,10 AND FR4A/D = 1 AND FR5 = 9,10 AND FR11 = 9,10, ASK C1. INCONSISTENCY 1 = ‘the program was a critical factor in your decision to purchase the high efficiency/energy efficient [**measure type**] without the program’}

{IF FR11 = 9,10 AND FR4A/D = 2 AND FR5 = 0,1 AND FR10 = 9,10, ASK C1. INCONSISTENCY 1 = ‘you would have bought the [**measure type**] within [**a year/2 years**] even without the program’}

{IF FR11 = 0,1 AND FR4A/D = 1 AND FR5 = 9,10 AND FR10 = 0,1, ASK C1. INCONSISTENCY 1 = ‘you would not have bought the [**measure type**] within [**a year/2 years**] even without the program’}

ASK C1A ONLY IF FREE RIDERSHIP QUESTIONS ARE INCONSISTENT.

C1a/1(J) Let me make sure I understand you. In your own words, could you please describe how the program influenced your decision to purchase and install your new [lighting measure/measure] at the time you did?

1 [Record Response]
D Don’t know
R Refused

End Loop –Repeat as necessary

PARTICIPANT - SPILLOVER

ALL RESPONDENT TYPES: RESIDENTIAL AND COMMERCIAL

Comment Thank you for discussing the new equipment that you installed through the **[Program].** Next, I would like to discuss any equipment you might have installed OUTSIDE the **[Program].**

LSP1 Since [received [assistance]] have you purchased and installed any energy efficient [lighting] on your own without any assistance from the [Program] or another utility program [READ THE FOLLOWING ONLY FOR SMALL COMMERCIAL: either at this facility or at other locations]?

1 Yes, only at this facility
2 Yes, only at other locations {SMALL COMMERCIAL ONLY}
3 Yes, at this facility and other locations {SMALL COMMERCIAL ONLY}
4 No {SKIP TO NSP1}
D Don’t know {SKIP TO NSP1}
R Refused {SKIP TO NSP1}

NSP1(J) Since [you received [assistance]] have you purchased and installed any OTHER energy efficient [equipment] on your own without any assistance from the [Program] or another utility program [READ THE FOLLOWING ONLY FOR SMALL COMMERCIAL: either at this facility or at other locations]?

1	Yes, only at this facility	
2	Yes, only at other locations {SMALL COMMERCIAL ONLY}	
3	Yes, at this facility and other locations {SMALL COMMERCIAL ONLY}	
4	No	{SKIP TO NSP1}
D	Don't know	{SKIP TO NSP1}
R	Refused	{SKIP TO NSP1}

NSP2 What type and quantity of high efficiency equipment did you install on your own? [PROBE TO GET EXACT TYPE AND QUANTITY AND LOCATION/BUIDLING IF SMALL COMMERCIAL]

INTERVIEWERS TYPE END TO EXIT OUT OF LOOP

Type 1: ____________	Quantity 1: ________	Location 1:____________
Type 2: ____________	Quantity 2: ________	Location 2:____________
Type 3: ____________	Quantity 3: ________	Location 3:____________
Type 4: ____________	Quantity 4: ________	Location 4:____________

NSP3 [ASK FOR EACH TYPE OF EQUIPMENT IN NSP2] How do you know that this equipment is high efficiency? [PROBE: WAS IT ENERGY STAR® RATED?]

Type 1: ____
Type 2: ____
Type 3: ____
Type 4: ____

IF LSP1 < 4; else skp AP9i

LSP2 What type of bulbs, fixtures, ballasts, or lighting controls were installed as part of this lighting retrofit? [SELECT ALL THAT APPLY, AFTER EACH RESPONSE, PROMPT WITH, "IS THAT ALL?"]

1 High performance T8 fluorescent fixtures (1" diameter bulbs)
2 T8 fluorescent fixtures (1" diameter bulbs)
3 T10 fluorescent fixtures
4 T12 Fixtures (1.5" diameter bulbs)
5 HID (High Density Discharge) Fixtures, Compact
6 Compact Fluorescent, Screw-in Modular
7 Compact Fluorescent, Hardwire
8 Incandescent
9 Exit Signs, Compact Fluorescent
10 Exit Signs, LED
11 Halogen
12 Install Reflectors
13 Electronic Ballast
14 Magnetic Ballast

15 Lighting Controls, Time Clock
16 Lighting Controls, Occupancy Sensor
17 Lighting Controls, Bypass/Delay Timers
18 Lighting Controls, Photocell
19 Other Fluorescent
20 Fat/Thick Tubes
21 Skinny/Thin Tubes
22 T5 Fixtures (5/8" diameter)
23 Other (PLEASE SPECIFY)
24 Don't know
25 Refused

Loop for first 3 mentioned L_MSP2 to LI23

L_MSP2/LSP2(J) How many high efficiency [measure/lighting] products did you buy on your own compared to what you got through the program [READ THE FOLLOWING ONLY FOR SMALL COMMERCIAL: at this facility and/or at another location]?

[PROBE FOR PERCENT OF PROGRAM EQUIPMENT. READ THE FOLLOWING IF NEEDED: For example, was it about one-fourth (25%) of what you installed through the program, one-half (50%) of what your installed through the program, the same amount as what you installed though the program (100%), twice as much as what you installed through the program (200%), or some other amount?"]

1 ___% at this facility
2 ___% at another facility {SMALL COMMERCIAL ONLY}
D Don't know
R Refused

I'm going to read a statement about this equipment that you purchased on your own. On a scale from 1-10, with 0 indicating that you strongly disagree, and 10 indicating that you strongly agree, please rate the following statement.

L_MSP4/LSP3(J) My experience with the 2008 SCE [Program] influenced my decision to install different types of high efficiency equipment on my own.

__ [Record Response (0-10)]
88 Don't know
99 Refused

L_MSP5/LSP4(J) Why did you purchase this equipment without the financial assistance available through the **[Program]**? [DO NOT READ; INDICATE ALL THAT APPLY]

1 Too much paperwork
2 Takes too long to get approval
3 No time to participate, needed equipment immediately
4 The program had ended
5 The equipment would not qualify {PROBE: Why not?}
6 The amount of the rebate wasn't important enough
7 Did not know the program was available
8 There was no program available
9 Other {SPECIFY}
D Don't know
R **Refused**

ASK IF LMSP2=5 ; ELSE SKIP TO LI19

LI17 Were the HID lamps you installed High Pressure Sodium, Metal Halide, Mercury Vapor or Incandescent?

1 High pressure sodium
2 Metal Halide
3 Mercury Vapor
4 Incandescent
D Don't know
R Refused

ASK ALL LIGHTING ADOPTERS

LI19 In what year did you install [INSERT FROM LSP2][PROBE FOR BEST GUESS]

1 2007
2 2008
3 2009
D Don't know
R Refused

LI20 And can you recall which month? [If you cannot get month, try to get the season.]

1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11 November
12 December
13 Fall

14 Winter
15 Spring
16 Summer
D Don't know
R Refused

Ask if LSP2 = 6

CFL_1a Where did you purchase the CFLS that were installed OUTSIDE the [**Program]**? [INDICATE ALL THAT APPLY]

1 Home Depot
2 Costco
3 Orchard Supply Hardware
4 ACE Hardware
5 Lowe's
6 Long's
7 SaveMart
8 K-Mart
9 Sam's Club
10 Smart & Final
11 Albertson's
12 Yardbirds Home Center
13 Fry's Electronics
14 True Value
15 CONTRACTOR INSTALLED
16 OTHER [Specify:]
17 Don't know
18 Refused

CFL_2 Did the CFL's have a sticker indicating a SCE instant rebate?

1 Yes
2 No
D Don't know
R Refused

CFL_QTY Approximately how many CFL bulbs have you purchased since January 2006?

_____ [Record Response]
88888 Don't know
99999 Refused

If CFL_QTY >0

CFL_3 Were all the CFLs installed or were some of them placed in storage for later use?

1 All installed
2 Some installed
3 Some in storage
4 All in storage
D Don't know
R Refused

IF CFL_3 = 2

CFL_4 What percentage of the CFLs was installed?

___% [Record Response]
888 Don't know
999 Refused

IF CFL_3 = 2 OR 3

CFL_5 Why were they put in storage?

1 [Record Response]
D Don't know
R **Refused**

IF CFL_3 = 1 OR 2 or 3

CFL24 When you allowed the **[Program]** to install CFLs, what kind of bulb did you replace? [ALLOW MULTIPLES]

1 Incandescent
2 CFLs
3 HID
4 Mercury vapor
5 Other [SPECIFY}
6 Don't know
7 Refused

Ask if CFL_2 not 1; ELSE SKIP TO L24

LI23 Did you receive a rebate for the purchase of the [INSERT FROM LSP2]?

1 Yes
2 No
D Don't know
R Refused

L24i Next I'd like to ask you a few questions about the equipment that was removed and replaced when you installed the [measures].

L24 What type of lighting was removed and replaced when you installed [INSERT FROM LSP2] without the utility program rebate?

1 High performance T8 (1" diameter bulbs)
2 T8 fluorescent fixtures (1" diameter bulbs)
3 T10 fluorescent fixtures
4 T12 Fixtures (1.5" diameter bulbs)
5 HID (High Density Discharge) Fixtures, Compact
6 Compact Fluorescent, Screw-in Modular
7 Compact Fluorescent, Hardwire
8 Incandescent
9 Exit Signs, Compact Fluorescent

10 Exit Signs, LED
11 Halogen
12 Install Reflectors
13 Electronic Ballast
14 Magnetic Ballast
15 Lighting Controls, Time Clock
16 Lighting Controls, Occupancy Sensor
17 Lighting Controls, Bypass/Delay Timers
18 Lighting Controls, Photocell
19 Other Fluorescent
20 Fat/Thick Tubes
21 Skinny/Thin Tubes
22 T5 Fixtures (5/8" diameter)
23 NOTHING, EQUIPMENT WAS ONLY ADDED, NOT REPLACED
24 Other (PLEASE SPECIFY)
25 Don't know/Refused

LI26 Approximately how old were the lights that were removed/replaced by the lighting equipment we just discussed? Would you say…

1 Less than 5 years old
2 Between 5 and 10 years old
3 Between 10 and 15 years old
4 More than 15 years old
D Don't know
R Refused

END LIGHTING MEASURE LOOP

Comment Please consider all of those purchases when answering these next questions.

ASK IF L_MSP1=1 or LI9=1 (for any Program Lighting Measure); ELSE SKIP TO NSP1

LI30 Considering all of the changes we just discussed, approximately what percentage of the facility's energy usage was affected by those changes?

___% [Record Response]
888 Don't know
999 Refused

End Module

PROGRAM AWARENESS

Next, I'd like to ask you about various energy efficiency programs and what influenced your program participation.

AP9 How did you **FIRST** learn about the Set to Save rebate? [DO NOT READ LIST, ACCEPT ONE NUMBER]

1 Utility provided advertising--radio, newspaper, trade journal, billboard, TV
2 Bill insert, newsletter, or other mailing from utility
3 Utility Website
4 Email from Utility
5 Other utility source (SPECIFY)
6 Local government, community or nonprofit meeting, event, workshop or training (SPECIFY)
7 Local government/community agency (SPECIFY)
8 Local government, community, or nonprofit advertising- radio, newspaper, trade journal, TV
9 School, classes, energy center (SPECIFY)
10 Building audit or assessment (SPECIFY)
11 Flex your Power TV or radio advertising
12 Other meeting, event or workshop training (SPECIFY)
13 Other advertising
14 Friend/Relative/Neighbor
15 Contractor
16 No other sources
17 Other (SPECIFY)
18 Don’t know
19 Don’t know

AP9a Did you hear about the Set to Save rebate through any other sources? [DO NOT READ LIST, ACCEPT MULTIPLES]

1 Utility provided advertising--radio, newspaper, trade journal, billboard, TV
2 Bill insert, newsletter, or other mailing from utility
3 Utility Website
4 Email from Utility
5 Other utility source (SPECIFY)
6 Local government, community or nonprofit meeting, event, workshop or training (SPECIFY)
7 Local government/community agency (SPECIFY)
8 Local government, community, or nonprofit advertising- radio, newspaper, trade journal, TV
9 School, classes, energy center (SPECIFY)
10 Building audit or assessment (SPECIFY)
11 Flex your Power TV or radio advertising
12 Other meeting, event or workshop training (SPECIFY)
13 Other advertising
14 Friend/Relative/Neighbor
15 Contractor
16 No other sources
17 Other (SPECIFY)

18 Don't know
19 Refused

IF AP9=6-13 or IF AP9a=6-13

AP9b You said that you received information from AP9/AP9a [insert all response between 6-13 for AP9 and AP9a] about the [Program]. How influential was this information on your decision to participate in the Set to Save Rebate/Direct Install Program on a scale of 1 to 5, where 1 is not at all influential and 5 is very influential.

__ [RECORD RESPONSE (1-5)]
88 Don't know
99 Refused

ASK IF AP9 NE 4

AP11 Did a utility representative talk to you about the [Program]?
1 Yes
2 No
D Don't know
R Refused

AP11a When did you first become aware of the City of Palm Desert Set to Save Rebate/Direct Install Program? Would you say…

1 Sometime during 2007
2 Sometime during or after 2008?
D Don't know
R Refused

PROGRAM AWARENESS - OTHER PROGRAMS

AP6a Aside from the Set to Save Rebate/Direct Install Program, are there programs or resources you are aware of that are designed to promote energy efficiency for businesses like yours? [IF YES] What types of programs can you recall? [RECORD ALL MENTIONS] [After each response prompt with "Can you recall any others?"]

1 NOT AWARE OF ANY
2 SPC / Standard Performance Contracting
3 20/20
4 Flex-your-Power
5 Distributor incentives
6 Upstream HVAC and Motors Program
7 Rebate (unspecified)
8 Nonresidential Audits or Energy Audits
9 Other programs (SPECIFY) ________
10 Don't know
11 Refused

ASK IF AP6a NE 3; ELSE SKIP TO LI1

AP20 Have you ever heard of the 20/20 Rebate Program? Each summer the governor of California promotes an energy conservation and efficiency program called the “20/20 Rebate program,” Businesses that saved 20% off their electricity bill in the summer months as compared to the previous year’s bill qualify for a 20% rebate on their bill.

1 Yes
2 No
D Don’t know
R Refused

AP22 Did any of your locations attempt to get the 20/20 rebate during any of the summers from 2005 through 2008?

1 Yes
2 No
D Don’t know
R Refused

AP23 During which summer(s) did you attempt the 20 percent reduction? [Multiples Allowed]

1 2005
2 2006
3 2007
4 2008
D Don’t know
R Refused

AP24 In which year(s) were you successful in reducing your electricity bill by 20%? [Multiples Allowed]

1 2005
2 2006
3 2007
4 2008
D Don’t know
R Refused

TO SCHEDULE ONSITE VERIFICATION - Note this section is not included in the companion datasets.

Introduction

I'm with PA Consulting Group, an independent research firm. We are working with the California Public Utilities Commission and Summit Blue to evaluate the Set to Save Direct Install Program and have you listed as a participant in [YEAR]. This program is an important component of the California Public Utilities Commission's ongoing efforts to save energy and reduce emissions affecting climate change.

In order to improve this program's performance, the CPUC would like to make an accurate measurement of the energy savings associated with energy efficiency equipment installed by collecting and analyzing information from selected customers. Your input to this research is extremely important. We expect the initial site visit to take about 3 hours and the return site visit to take an hour. The first visit would need to take place in the next 2 weeks. For your participation, you will receive $75 at the first site visit and $75 at the second visit.

If you agree to participate, Summit Blue Consulting, on behalf of the California Public Utilities Commission, will come to your business to install power and temperature logger devices on your air conditioner to record when it is in use and how well it is performing. Technicians will need to get access to the area where the furnace, air handler, or air conditioner is located. The loggers would be installed in an unobtrusive place and would be removed by us at the end of the research project which we expect will last less than 2 months.

(Note, the electric use data will be used strictly for the study of the Set to Save Direct Install Program and will not affect your electric service at all.)

TO SCHEDULE INSTALLATION OF HVAC LOGGERS

REC Are you interested in participating in this project?

1 Yes
2 No (Skip to End)
98 Don't know (Schedule a callback)
99 Refused (Skip to End)

(Your input to this research is extremely important. By receiving a rebate through the Set to Save Direct Install Program, you have agreed to allow verification of the installation of the equipment rebated through the program.)

PHONE1a What is the best number for the technician to reach you at to schedule an appointment within the next week?

_____________ **PHONE1a**

PHONE1aa Is that a home, work or cell phone number?

1 Home
2 Work
3 Cell

PHONE1b Is there an alternate number for the technician to reach you at to schedule an appointment within the next week?

1 Yes ____________ **PHONE1b**
2 No (Skip to Other)

PHONE1bb Is that a home, work or cell phone number?

1 Home
2 Work
3 Cell

OTHER Is there another person that the technician might speak with at your business, if you are not available?

1 Yes
2 No (Skip to Verify)

NAME2 May I please have their name for our records?

____________________ **NAME2**

PHONE2 May I also have the best phone number for the technician to reach them?

___________________ **PHONE2**

PHONE2aa Is that a home, work or cell phone number?

1 Home
2 Work
3 Cell

VERIFY For verification purposes only, may I please have your name?

_____________________ **NAME2**

END. Those are all the questions I have for today. (IF REC=1: A technician from Summit Blue will be in touch within the next 2 business days to schedule your onsite visit.) Thank you for your time and help in this important study.

Participant Customer Survey for 2008 Palm Desert LG Program COMMERCIAL GUIDE

Participant Customer Survey for 2008 Palm Desert LG Program COMMERCIAL GUIDE

This survey document copy serves as a guide for the commercial data results. Please refer to the document entitled "CPUC Palm Desert General Survey_9222009_RES GUIDE.doc" for guide to residential data results.

Variable Definition: RESPNUM$ - This is a unique identifier for a participant/respondent. This variable can be found in each dataset and is always specific to the participant. This variable serves as a link between each dataset.

Commercial Data Sets Accompanying Residential Guide

1) **Palm Desert Commercial Non-measure Data_9212009.sav** – SPSS dataset that includes contact level variables introit to intro5; nspi to ap24_7 (ALL DATA OUTSIDE OF MEASURE LOOP). This also includes additional flags from sample, including respnum$ (unique respondent number), measure flags, incentive totals, program, etc. All recruit data has been removed from data.

2) **Palm Desert Commercial Measure Loop Aggregate_9212009.sav** – SPSS dataset including variables w1chk to c3 (ALL DATA INSIDE MEASURE LOOP). This also includes respnum$ (unique respondent number), measure (see below), and measure flags.

    a. MEASURES: Each measure loop is assigned a measure flag (numbering from 1-9). All questions for that specific measure flag refer only to that specific measure. The data is arranged on a measure basis for the measure loop; therefore, respnum$ (respondent numbers) will repeat in this dataset, depending on the number of measures installed/rebated for a participant.

Flag Number	Corresponding Measure
1.00	RCA (RCA)
2.00	PC (PC Operation Systems)
3.00	AGP (Ag Pumps)
4.00	Door (Door Gaskets)
5.00	Exit (LED Exit Signs)
6.00	OccSens (Occupancy Sensors)
7.00	Strip (Strip Curtains)
8.00	LFL (LFLs)
9.00	CFL (CFLs)
10.00	Audflg (Audit Flag)

3) **PalmGEN_9242009_Commercial Open Ends.doc** – This document includes all open-end responses (Verbatim responses). The field "Respnum$" corresponds to those found in the SPSS files, though this file also includes responses from incomplete surveys. If an open-end response was recoded, the column "Recode To" shows which category a response was moved to.

4) **Field Definitions**

a. Respnum$ - Unique participant/respondent identifier.

b. Variable – This ties each response to a specific question.

c. RosterNum – A roster number is used to loop a series of questions for each given measure. This number is connected to a given measure, as seen in the table below.

i. For example, question FR11 is a rostered question. In the open end file, FR11 can be seen in the variable field. To determine which rostered measure the open end response is referring to, consult the RosterNum field. If the listed number is 9, then the open end response is tied to the CFL measures.

1. Please note that when comparing these open ends to the Measure Loop Aggregate, the roster numbers are not attached to the variable. For the measure loop, the RosterNum is the measure’s flag number.

2. For the Non-Measure file, the RosterNum is tied to the variable. So, for example, NSP4 is a rostered question. This will look like: NSP4_1, indicating it is a roster.

RosterNum	Corresponding Measure
1	RCA (RCA)
2	PC (PC Operation Systems)
3	AGP (Ag Pumps)
4	Door (Door Gaskets)
5	Exit (LED Exit Signs)
6	OccSens (Occupancy Sensors)
7	Strip (Strip Curtains)
8	LFL (LFLs)
9	CFL (CFLs)
10	Audflg (Audit Flag)

d. Select All Num – This indicates which option(s) a respondent chose for a question in which multiple answers are possible (Indicate all that apply/Select all that apply).

i. The specific answers are tied to the number in the Select All Num column. So, for example, if the column reads as “1,16”, it means that the participant selected options one and 16.

ii. In the data files, these will appear as _X. In cases where rosters are used, the order is: VARIABLE_ROSTERNUM_SELECTALL; when rosters are not used, the order is: VARIABLE_SELECTALL.

DIALSCR Hello, my name is [interviewer name], and I'm calling on behalf of the California Public Utilities Commission regarding the Set to Save [Program] you participated in [YEAR]

May I speak with [named respondent]?

1 Yes
2 No [Attempt to Convert]

IntroI (Why are you conducting this study: Studies like this help the utility and its partners better understand customers' awareness of and interest in energy programs and services.)

(Timing: The length of this survey will vary depending on measures installed. Is this a good time for us to speak with you? IF NOT, SET UP CALL BACK APPOINTMENT OR OFFER TO LET THEM CALL US BACK AT 1-800-454-5070)

(Sales concern: I am not selling anything; we would simply like to learn about your awareness of services that can save energy, and your opinions about these services. Your responses will be kept confidential.

Intro1 According to our records, your organization participated in City of Palm Desert's [Program] in 2008. I was told that you are the person most knowledgeable about this program. Is this correct?

1 Yes
2 No
3 No one knows about the Set to Save Rebate/Direct Install Program

Intro2 Who would be the person at this location who is most knowledgeable about your [household/organization]'s participation in City of Palm Desert's [Program]?

1 Record Name, as &CONTACT
D Don't know
R Refused

Intro3 May I speak with him/her?

1 Yes
2 No (not available right now, set cb)

Intro4 Before we start, I would like to inform you that for quality control purposes, this call may be monitored by my supervisor.

Today we're conducting a very important study on the energy needs and perceptions of organizations like yours. We are interested in how organizations like yours think about and manage their energy consumption.

Your input will allow the California Public Utilities Commission to build and maintain better energy savings programs.

This is a fact-finding survey only, and responses will not be connected with your organization in any way.

SCREENER

Addr First, I'd like to ask you a few questions about your organization and facility. Our records show your firm is located at [ADDRESS] in [CITY]. Is that correct?

[CONTINUE IF ADDRESS REPORTED BY RESPONDENT IS SIMILAR ENOUGH]

1 Yes
2 No
D Don’t know
R Refused

CORRECT May I have your correct address?

COMPARE Are these addresses similar or totally different?

Computer Address – [ADDRESS]
Corrected Address – [CORRECT]

1 Similar
2 Totally Different

WrgAddr We were attempting to reach the customer at &ADDRESS in &CITY and since that does not match your address, then we must have mis-dialed the telephone number. Those are all the questions that we have for you today, on behalf of the California Public Utilities Commission. Thank you for your time and cooperation.

Intro5 The questions in this survey will refer to your “FACILITY,” which means ALL of the buildings and tenants serviced by &UTILITY under the following billing address: &SERV_ADDR. [INTERVIEWERS SHOULD RE-READ THIS STATEMENT AS NEEDED THROUGHOUT THE SURVEY TO REMIND THE RESPONDENTS]

CUSTOMER CHARACTERISTICS – COMMERCIAL ONLY
(RESIDENTIAL SKIPS TO W1CHK)

CC1i Now, I'd like to ask you questions regarding your facility.

CC1 How many square feet of heated or cooled floor area is your facility?
______ Square feet
888888 Don’t know
999999 Refused

CC3 Would you say that the heated or cooled floor area is ...?

1 < 1,500 sqft
2 1,500 - 5,000 sqft

3 5,000 - 10,000 sqft
4 10,000 – 25,000 sqft
5 25,000 – 50,000 sqft
6 50,000 – 75,000 sqft
7 75,000 – 100,000 sqft
8 > 100,000 sqft
D Don't know
R Refused

CC3a Is your space heated using electricity or gas?

1 Electricity
2 Gas
3 Both electricity and gas
4 Propane
5 None
6 Other (Specify)
D Don't know
R Refused

CC4 Does your business own, lease or manage the facility?

1 Own
2 Lease/Rent
3 Manage
D Don't know
R Refused

ASK IF CC4 in (3, D, R)
CC5 Does your company pay the electric and/or gas utility bill?

1 Yes
2 No
D Don't know
R Refused

ASK IF CC4 = 2
CC5a Which of the following best describes how your business pays the electric and/or gas utility bill for your space at this facility? [READ LIST.]

1 You pay SCE directly
2 You pay a fee to your landlord that varies according to the size of the total utility bill
3 You pay a fixed fee to your landlord
4 You do not pay for electric and gas utilities
5 OTHER (Specify)
D Don't know
R Refused

CC8 In what year was the facility built?

____ Year
8888 Don’t know
9999 Don’t know

CC10 If don't know, would you say it was…

1 After 2000
2 In the 1990's
3 1980s
4 1970s
5 1960s
6 1950s
7 Before 1950
D Don’t know
R Refused

CC11 In what year was this facility last remodeled?

____ Year
6666 Never
8888 Don’t know
9999 Refused

ADDITIONAL FACILITY CHARACTERISTICS

FM050 What is the main business ACTIVITY at your facility?

1 Office
2 Retail (non-food)
3 College/University
4 School
5 Grocery Store
6 Restaurant
7 Health Care (other than Hospital)
8 Hospital
9 Hotel or Motel
10 Warehouse
11 Construction
12 Community Service/Church/Temple/ Municipality
13 Industrial Process/ Manufacturing/ Assembly
14 Condo Assoc./Apartment Mgr.
15 Other (Specify)
D Don’t know
R Refused

FM070 Approximately how many people are currently working at the facility, including individuals either full- or part-time (IF DON'T KNOW ASK FOR BEST GUESS)

____ Number of people
8888 Don't know
9999 Refused

ROLE OF CONTRACTORS – PROCESS SIDE

V1 Did you use a contractor to install the measures rebated through the 2008 [Program]?

1 Yes
2 No
D Don't know
R Refused

V5 Had you worked with this contractor before participating in the 2008 [Program]?

1 Yes
2 No
D Don't know
R Refused

V40 How important was the input from the contractor you worked with in deciding which specific equipment to install? Was it …

1 Very important
2 Somewhat important
3 Not at all important
4 They did not have any input.
D Don't know
R Refused

PROGRAM EFFECTS

PE1i Next we would like to ask you about your program experience.

PE1 Please rate these 4 factors on your decision to purchase rebated equipment as very, somewhat, or not at all influential. The first/next one is …

PE1A# The Set to Save rebate
PE1B# Contractor **IF V1 = 1**
PE1C# Your [UTILITY] representative
PE1D# Rising energy bills
PE1E# Global Warming
1 VERY Influential
2 SOMEWHAT Influential
3 NOT AT ALL Influential
D Don't know
R Refused

Warm-up Questions/Background Context

ALL RESPONDENT TYPES: RESIDENTIAL AND COMMERCIAL

RESIDENTIAL MEASURES: CFL, RCA, HVACer, HVACmt, HVACeq, DUCT, NIGHT, ROOM, AUDFLG

W1chk Just to confirm, did you receive a [measure] through the Set-to-Save [program] Program?

1 Yes, and I am the most knowledgeable about this measure
2 Yes, but I am not at all knowledgeable about this measure
3 No
D Don't Know
R Refused

W1i Please think back to the time when you were deciding to buy/install the energy efficient [**measure**], perhaps recalling things that occurred in your household shortly before and after [**installation_date]**. What factors motivated you to purchase energy saving [**measure**]? {DO NOT READ; INDICATE ALL THAT APPLY; ONCE THEY RESPONDENT HAS FINISHED, PROBE: Are there any other factors?}

1 Old equipment didn't work
2 Old equipment working poorly
3 The program incentive
4 The program technical assistance
5 Wanted to save energy
6 Wanted to reduce energy costs
7 The information provided by the Program
8 Past experience with this program
9 Because of past experience with another [**utility**] program
10 Recommendation from other utility program (Probe: What program? ______)
11 Recommendation of dealer/retailer
12 Recommendation of someone else (Probe: Who?___________)
13 Advertisement in newspaper (Probe: For what program? ___________)
14 Radio advertisement (Probe: For what program? _________)
15 Other (SPECIFY)
16 Environmental concerns
17 Global warming
18 Liked the appearance of the **[measure]** more than the old one
19 Keeping up with the latest trends and fashions
D Don't Know
R Refused

{SERIES REPEATED FOR UP TO THREE MEASURES}

{ASK W2a-W6 ONLY FOR INCREMENTAL EFFICIENCY REBATE MEASURES} (ROOM AC, POOL PUMP, POOL PUMP VSD, COOLING, CENTRAL AC ER, CENTRAL AC SUPER. HIGH PERFORMANCE, HVAC SYSTEM)

W2a Did you get this [**measure**] to replace [a/an] existing [**measure type**]?

1	Yes	{SKIP TO W3}
2	No	
D	Don’t Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

W2b Did you get this [**measure**] because you wanted to add another/more [**measure**] to your [home/business]?

1	Yes	{SKIP TO FR1}
2	No	
D	Don’t Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

W2c Is this [**measure type**] the first you have ever had in your [home/business]?

1	Yes	{SKIP TO FR1}
2	No	{SKIP TO FR1}
D	Don’t Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

R W3 {IF MEASURE=LIGHTING or INDOOR_LT} What type of lighting did this replace? {DO NOT READ}

1	Incandescent
2	CFL
3	Other (SPECIFY)
D	Don’t Know
R	Refused

W4 {IF MEASURE NOT LIGHTING} About how old was the [**measure**] you replaced? {READ CATEGORIES IF NEEDED}

1	Less than 5 years old
2.	5 to less than 10 years old
3	10 to less than 20 years old
4	20 years to less than 30 years old
5	30 or more years old
D	Don’t Know
R	Refused

W5 Was the old [**measure**] working or not working?

1.	Working	
2.	Not working	{SKIP TO FR1}
D	Don’t Know	{SKIP TO FR1}
R	Refused	{SKIP TO FR1}

W6 Was the old [**measure**] in good, fair, or poor working condition?

1 Good
2 Fair
3 Poor
D Don't Know
R Refused

DIRECT INSTALL MODULE
ASK FOR DIRECT INSTALL PARTICIPANTS FOR COMMERCIAL ONLY

Warm-up Questions/Background Context

DI1 I just want to confirm someone from [PROGRAM NAME/ORGANIZATION] came into your organization and installed [MEASURE] in [MONTH/YEAR]. Is this correct?

1 Yes
2 No
D Don't know
R Refused

DI2 [IF NO] What is incorrect? [Probe if necessary with below categories]
1 Do not recall someone coming to organization [SKIP TO NEXT SECTION]
2 Measures listed are incorrect
ASK AND RECORD: WHAT ARE THE CORRECT MEASURES?
3 Date is incorrect
4 Other [RECORD] [SKIP TO NEXT SECTION IF NECESSARY]

DI3 How did you hear about the program? [DO NOT READ; RECORD ALL THAT APPLY]

1 Another program (which program?)
2 Local government partnership activities
3 Water utility bill stuffing
4 Electric / gas utility bill stuffing
5 Water utility mailing
6 Electric / gas utility mailing
7 Community Sweeps
8 Community displays
9 Energy fairs
10 Word of mouth
11 Newspaper article
12 Technical assessment / audit
13 Other [RECORD]

ASK W2c ONLY FOR CFL
W2c Is this [MEASURE] the first you have ever had in your [home/business]?

1 Yes {SKIP TO FR1}
2 No {SKIP TO FR1}
D Don't know {SKIP TO FR1}
R Refused {SKIP TO FR1}

LI9i I'd like to ask you a few questions about the equipment that was removed and replaced when you installed the lighting.

LI9a What type of [measure] was removed and replaced when the energy efficient [measure] was installed through the [**Program**]?

1 High performance T8 (1" diameter bulbs)
2 T8 fluorescent fixtures (1" diameter bulbs)
3 T10 fluorescent fixtures
4 T12 Fixtures (1.5" diameter bulbs)
5 HID (High Density Discharge) Fixtures, Compact
6 Compact Fluorescent, Screw-in Modular
7 Compact Fluorescent, Hardwire
8 Incandescent
9 Exit Signs, Compact Fluorescent
10 Exit Signs, LED
11 Halogen
12 Install Reflectors
13 Electronic Ballast
14 Magnetic Ballast
15 Lighting Controls, Time Clock
16 Lighting Controls, Occupancy Sensor
17 Lighting Controls, Bypass/Delay Timers
18 Lighting Controls, Photocell
19 Other Fluorescent
20 Fat/Thick Tubes
21 Skinny/Thin Tubes
22 T5 Fixtures (5/8" diameter)
23 Did not replace anything - new equipment
24 Other (PLEASE SPECIFY)
25 Don't know/ Refused

ASK IF LI9a=5; else skip to LI9c

LI9b Were the HID lamps removed High Pressure Sodium, Metal Halide, Mercury Vapor or Incandescent?

1 High pressure sodium
2 Metal Halide
3 Mercury Vapor
4 Incandescent
D Don't know
R Refused

LI9c Approximately how old were the lights that were *removed* and replaced with [lighting **measure**]? Would you say...

1 Less than 5 years old
2 Between 5 and 10 years old
3 Between 10 and 15 years old
4 More than 15 years old
D Don't know
R Refused

Self Report Free-Ridership Survey

ALL RESPONDENT TYPES: RESIDENTIAL AND COMMERCIAL

RESIDENTIAL MEASURES: CFL, RCA, HVACer, HVACmt, HVACeq, DUCT, NIGHT, ROOM, AUDFLG

Free-Ridership Questions

FR1 Why did you participate in the **[Program]**?
[DO NOT READ, INDICATE ALL THAT APPLY]

1 Needed new [measure]
2 To save energy/have more efficiency
3 To save money
4 To help the environment/prevent global warming
5 To get better lighting/[measure]
6 Needed to dispose of old bulbs
7 Other (specify)

FR2 At the time that you first heard about the assistance from the Palm Desert **[Program]** for this **[Measure]**, had you…? {READ LIST}

1 Already been thinking about purchasing [measure]?
2 Already begun collecting information about [measure]?
3 Already selected the particular [measure] you were going to get?
4 Already decided to buy the [measure]**?**
5 Already installed the energy efficient [measure]?
6 [DON'T READ] Other: ___________
D Don't know
R Refused

FR3 So, the [measure] was installed before you learned about the assistance from **[Program]**?

1 Yes {SKIP TO FR5}
2 No
D Don't know
R Refused

FR4 Just to be sure I understand, did you have specific plans to install [measures] before learning about the [assistance] available through the **[Program]**?

1 Yes
2 No
D Don't know {SKIP TO FR4}
R Refused {SKIP TO FR4}

FR5 Did you have to make any changes to your existing plans in order to receive this [assistance] through the **[Program]**?

1 Yes
2 No
D Don't know
R Refused

FR6 What changes did you make?

1 [RECORD RESPONSE]
D Don't know
R Refused

If the [assistance] from the Palm Desert **[Program]** had not been available, would you have:

FR7a Purchased any [Measure]?

1 Yes
2 No {SKIP TO FR7D}
D Don't know
R Refused

FR7b Bought the [measure(s)] earlier than [you did/it was installed], or later?

1 Earlier
2 Same Time
3 Later
D Don't know
R Refused

FR7c How much [earlier/later] would you have bought the [measure]?

{RECORD RESPONSE} ______ Years {and/or} ______Months
D Don't know
R Refused

If QTY GT 1, ASK:

FR7d Without the program, would you have purchased the same quantity as you did? [Probe for more or less]

1 More
2 Same quantity
3 Less
D Don't know {SKIP TO FR8}
R Refused {SKIP TO FR4D}

FR7e How much **[more/less]** would you have bought?

______ [RECORD NUMBER]
88888 Don't know
99999 Refused

FR7f Would you have purchased the same energy efficient [lighting measure/measure]?

1 Yes
2 No
D Don't know
R Refused

FR7g If the [assistance] from the Palm Desert [Program] had not been available, would you have done anything else differently?

1 Yes
2 No {SKIP TO FR5}
D Don't know {SKIP TO FR5}
R Refused {SKIP TO FR5}

FR7h What would you have done differently?

1 [RECORD RESPONSE]
D Don't know
R Refused

FR8 On a 0 to 10 scale, with 0 being not at all likely and 10 being very likely, how likely is it that you would have bought [Measure] if you had not received any [assistance] from the program?

__ [RECORD RESPONSE (0-10)]
88 Don't know
99 Refused

ASK ONLY FOR LIGHTING MEASURES:

FR9 In total, how many efficient bulbs and/or fixtures did you receive through this program?

_____ [Record response]
88888 Don't know
99999 Refused

FR10 Of these, how many are currently installed?

_____ [Record response]
88888 Don't know
99999 Refused

FR11 [IF FR10<FR9] What happened to the [FR9-FR10] bulbs/fixtures that aren't currently installed?

1 [RECORD RESPONSE]
D Don't know
R Refused

FR12 Our records indicate you received about **[incentive]** from the Palm Desert [Program] either directly or at the time of purchase to offset the cost of the **[measure]**. Does this amount sound about right?

1 Yes {SKIP TO FR13}
2 No
D Don't know
R Refused

FR12a What would you estimate to be the actual amount?

[RECORD RESPONSE]_________ {SET = NEW AMOUNT OF INCENTIVE}
D Don't know
R Refused

FR13 **I'm going to read several statements about how you came to choose your [measure]. On a scale of 0 to 10, where 0 is strongly disagree and 10 is strongly agree, how much do you agree with each statement?**

If I had not had any assistance from the program, I would have paid [the additional incentive amount] to buy the [Measure] on my own.

__ [Record Response (0-10)]
88 Don't know
99 Refused

FR14 There may have been several reasons for my purchase decision, but the assistance from the Palm Desert **Set to Save Rebate Program** was a critical factor in my decision to purchase the high efficiency/energy efficient product.

__ [Record Response (0-10)]
88 Don't know
99 **Refused**

FR15 I would have bought a(n) [measure] within 2 years of when I did even without the assistance from the Set-to-Save [Program] Program.

__ [Record Response (0-10)]
88 Don't know
99 **Refused**

CONSISTENCY CHECK & RESOLUTION

DEVELOPING PROGRAMMING TO TEST FOR INCONSISTENCIES BETWEEN RESPONSES IN THE FREE-RIDERSHIP BATTERY, C1 WILL TAKE PRECEDENCE OVER INCONSISTENT RESPONSES.

IF (FR7A or FR7F = 1) AND FR8 = 0,1 AND FR14 = 9,10 AND FR15 = 0,1;
IF (FR7A or FR7F = 2) AND FR8 = 9,10 AND FR14 = 0,1 AND FR15 = 9,10;
IF FR8 = 0,1 AND (FR7A or FR7F = 1) AND FR14 = 0,1 AND FR15 = 9,10;
IF FR8 = 9,10 AND (FR7A or FR7F = 2) AND FR14 = 9,10 AND FR15 = 0,1;
IF FR14 = 0,1 AND (FR7A or FR7F = 2) AND FR8 = 0,1 AND FR15 = 0,1;
IF FR14 = 9,10 AND (FR7A or FR7F = 1) AND FR8 = 9,10 AND FR15 = 9,10;
IF FR15 = 9,10 AND (FR7A or FR7F = 2) AND FR8 = 0,1 AND FR14 = 9,10;
IF FR15 = 0,1 AND (FR7A or FR7F = 1) AND FR8 = 9,10 AND FR14 = 0,1

Consistency Check & Resolution

{C1 will be asked only for those respondents who have a clear inconsistency between responses (i.e., all but one of the questions are at one end of the spectrum for free ridership while one question is at the other spectrum.) The question responses that will be used to trigger C1 are:

FR4A (efficiency enhancement measures) OR FR4D (incremental efficiency measures)
FR5
FR10
FR11

{IF FR4A/D = 1 AND FR5 = 0,1 AND FR10 = 9,10 AND FR11 = 0,1, ASK C1. INCONSISTENCY 1 = 'you would have purchased the [**measure**] without the program'}

{IF FR4A/D = 2 AND FR5 = 9,10 AND FR10 = 0,1 AND FR11 = 9,10, ASK C1. INCONSISTENCY 1 = 'you would not have purchased the [**measure**] without the program'}

{IF FR5 = 0,1 AND FR4A/D = 1 AND FR10 = 0,1 AND FR11 = 9,10, ASK C1. INCONSISTENCY 1 = 'you would likely <u>not</u> have purchased the [**measure**] without the program'}

{IF FR5 = 9,10 AND FR4A/D = 2 AND FR10 = 9,10 AND FR11 = 0,1, ASK C1. INCONSISTENCY 1 = 'you would likely have purchased the [**measure**] without the program'}

{IF FR10 = 0,1 AND FR4A/D = 2 AND FR5 = 0,1 AND FR11 = 0,1, ASK C1. INCONSISTENCY 1 = 'the program was not a critical factor in your decision to purchase the high efficiency/energy efficient [**measure type**] without the program'}

{IF FR10 = 9,10 AND FR4A/D = 1 AND FR5 = 9,10 AND FR11 = 9,10, ASK C1. INCONSISTENCY 1 = 'the program was a critical factor in your decision to purchase the high efficiency/energy efficient [**measure type**] without the program'}

{IF FR11 = 9,10 AND FR4A/D = 2 AND FR5 = 0,1 AND FR10 = 9,10, ASK C1. INCONSISTENCY 1 = 'you would have bought the [**measure type**] within [**a year/2 years**] even without the program'}

{IF FR11 = 0,1 AND FR4A/D = 1 AND FR5 = 9,10 AND FR10 = 0,1, ASK C1. INCONSISTENCY 1 = 'you would <u>not</u> have bought the [**measure type**] within [**a year/2 years**] even without the program'}

ASK C1A ONLY IF FREE RIDERSHIP QUESTIONS ARE INCONSISTENT.

C1a/1(J) Let me make sure I understand you. In your own words, could you please describe how the program influenced your decision to purchase and install your new [lighting measure/measure] at the time you did?

1 [Record Response]
D Don't know
R Refused

End Loop –Repeat as necessary

PARTICIPANT - SPILLOVER
ALL RESPONDENT TYPES: RESIDENTIAL AND COMMERCIAL

Comment Thank you for discussing the new equipment that you installed through the **[Program].** Next, I would like to discuss any equipment you might have installed OUTSIDE the **[Program].**

LSP1 Since [received [assistance]] have you purchased and installed any energy efficient [lighting] on your own without any assistance from the [Program] or another utility program [READ THE FOLLOWING ONLY FOR SMALL COMMERCIAL: either at this facility or at other locations]?

1 Yes, only at this facility
2 Yes, only at other locations {SMALL COMMERCIAL ONLY}
3 Yes, at this facility and other locations {SMALL COMMERCIAL ONLY}
4 No {SKIP TO NSP1}
D Don't know {SKIP TO NSP1}
R Refused {SKIP TO NSP1}

NSP1(J) Since [you received [assistance]] have you purchased and installed any OTHER energy efficient [equipment] on your own without any assistance from the [Program] or another utility program [READ THE FOLLOWING ONLY FOR SMALL COMMERCIAL: either at this facility or at other locations]?

1 Yes, only at this facility
2 Yes, only at other locations {SMALL COMMERCIAL ONLY}
3 Yes, at this facility and other locations {SMALL COMMERCIAL ONLY}
4 No {SKIP TO NSP1}
D Don't know {SKIP TO NSP1}
R Refused {SKIP TO NSP1}

NSP2 What type and quantity of high efficiency equipment did you install on your own? [PROBE TO GET EXACT TYPE AND QUANTITY AND LOCATION/BUIDLING IF SMALL COMMERCIAL]
INTERVIEWERS TYPE END TO EXIT OUT OF LOOP

Type 1: ____________ Quantity 1: ________ Location 1:____________
Type 2: ____________ Quantity 2: ________ Location 2:____________
Type 3: ____________ Quantity 3: ________ Location 3:____________
Type 4: ____________ Quantity 4: ________ Location 4:____________

NSP3 [ASK FOR EACH TYPE OF EQUIPMENT IN NSP2] How do you know that this equipment is high efficiency? [PROBE: WAS IT ENERGY STAR® RATED?]

Type 1: ____
Type 2: ____
Type 3: ____
Type 4: ____

IF LSP1 < 4; else skp AP9i

LSP2 What type of bulbs, fixtures, ballasts, or lighting controls were installed as part of this lighting retrofit? [SELECT ALL THAT APPLY, AFTER EACH RESPONSE, PROMPT WITH, "IS THAT ALL?"]

1 High performance T8 fluorescent fixtures (1" diameter bulbs)
2 T8 fluorescent fixtures (1" diameter bulbs)
3 T10 fluorescent fixtures
4 T12 Fixtures (1.5" diameter bulbs)
5 HID (High Density Discharge) Fixtures, Compact
6 Compact Fluorescent, Screw-in Modular
7 Compact Fluorescent, Hardwire
8 Incandescent
9 Exit Signs, Compact Fluorescent
10 Exit Signs, LED
11 Halogen
12 Install Reflectors

13 Electronic Ballast
14 Magnetic Ballast
15 Lighting Controls, Time Clock
16 Lighting Controls, Occupancy Sensor
17 Lighting Controls, Bypass/Delay Timers
18 Lighting Controls, Photocell
19 Other Fluorescent
20 Fat/Thick Tubes
21 Skinny/Thin Tubes
22 T5 Fixtures (5/8" diameter)
23 Other (PLEASE SPECIFY)
24 Don't know
25 Refused

Loop for first 3 mentioned L_MSP2 to LI23

L_MSP2/LSP2(J) How many high efficiency [measure/lighting] products did you buy on your own compared to what you got through the program [READ THE FOLLOWING ONLY FOR SMALL COMMERCIAL: at this facility and/or at another location]?

[PROBE FOR PERCENT OF PROGRAM EQUIPMENT. READ THE FOLLOWING IF NEEDED: For example, was it about one-fourth (25%) of what you installed through the program, one-half (50%) of what your installed through the program, the same amount as what you installed though the program (100%), twice as much as what you installed through the program (200%), or some other amount?"]

1 ___% at this facility
2 ___% at another facility {SMALL COMMERCIAL ONLY}
D Don't know
R Refused

I'm going to read a statement about this equipment that you purchased on your own. On a scale from 1-10, with 0 indicating that you strongly disagree, and 10 indicating that you strongly agree, please rate the following statement.

L_MSP4/LSP3(J) My experience with the 2008 SCE [Program] influenced my decision to install different types of high efficiency equipment on my own.

__ [Record Response (0-10)]
88 Don't know
99 Refused

L_MSP5/LSP4(J) Why did you purchase this equipment without the financial assistance available through the **[Program]**? [DO NOT READ; INDICATE ALL THAT APPLY]

1 Too much paperwork
2 Takes too long to get approval
3 No time to participate, needed equipment immediately
4 The program had ended
5 The equipment would not qualify {PROBE: Why not?}
6 The amount of the rebate wasn't important enough

7 Did not know the program was available
8 There was no program available
9 Other {SPECIFY}
D Don't know
R **Refused**

ASK IF LMSP2=5 ; ELSE SKIP TO LI19

LI17 Were the HID lamps you installed High Pressure Sodium, Metal Halide, Mercury Vapor or Incandescent?

1 High pressure sodium
2 Metal Halide
3 Mercury Vapor
4 Incandescent
D Don't know
R Refused

ASK ALL LIGHTING ADOPTERS

LI19 In what year did you install [INSERT FROM LSP2][PROBE FOR BEST GUESS]

1 2007
2 2008
3 2009
D Don't know
R Refused

LI20 And can you recall which month? [If you cannot get month, try to get the season.]

1 January
2 February
3 March
4 April
5 May
6 June
7 July
8 August
9 September
10 October
11 November
12 December
13 Fall
14 Winter
15 Spring
16 Summer
D Don't know
R Refused

Ask if LSP2 = 6

CFL_1a Where did you purchase the CFLS that were installed OUTSIDE the [**Program]**? [INDICATE ALL THAT APPLY]

1 Home Depot
2 Costco
3 Orchard Supply Hardware
4 ACE Hardware
5 Lowe's
6 Long's
7 SaveMart
8 K-Mart
9 Sam's Club
10 Smart & Final
11 Albertson's
12 Yardbirds Home Center
13 Fry's Electronics
14 True Value
15 CONTRACTOR INSTALLED
16 OTHER [Specify:]
17 Don't know
18 Refused

CFL_2 Did the CFL's have a sticker indicating a SCE instant rebate?

1 Yes
2 No
D Don't know
R Refused

CFL_QTY Approximately how many CFL bulbs have you purchased since January 2006?

_____ [Record Response]
88888 Don't know
99999 Refused

If CFL_QTY >0

CFL_3 Were all the CFLs installed or were some of them placed in storage for later use?

1 All installed
2 Some installed
3 Some in storage
4 All in storage
D Don't know
R Refused

IF CFL_3 = 2

CFL_4 What percentage of the CFLs was installed?

___% [Record Response]
888 Don't know
999 Refused

IF CFL_3 = 2 OR 3

CFL_5 Why were they put in storage?

1 [Record Response]
D Don't know
R **Refused**

IF CFL_3 = 1 OR 2 or 3

CFL24 When you allowed the **[Program]** to install CFLs, what kind of bulb did you replace? [ALLOW MULTIPLES]

1 Incandescent
2 CFLs
3 HID
4 Mercury vapor
5 Other [SPECIFY}
6 Don't know
7 Refused

Ask if CFL_2 not 1; ELSE SKIP TO L24

LI23 Did you receive a rebate for the purchase of the [INSERT FROM LSP2]?

1 Yes
2 No
D Don't know
R Refused

L24i Next I'd like to ask you a few questions about the equipment that was removed and replaced when you installed the [measures].

L24 What type of lighting was removed and replaced when you installed [INSERT FROM LSP2] without the utility program rebate?

1 High performance T8 (1" diameter bulbs)
2 T8 fluorescent fixtures (1" diameter bulbs)
3 T10 fluorescent fixtures
4 T12 Fixtures (1.5" diameter bulbs)
5 HID (High Density Discharge) Fixtures, Compact
6 Compact Fluorescent, Screw-in Modular
7 Compact Fluorescent, Hardwire
8 Incandescent
9 Exit Signs, Compact Fluorescent
10 Exit Signs, LED
11 Halogen
12 Install Reflectors
13 Electronic Ballast
14 Magnetic Ballast
15 Lighting Controls, Time Clock
16 Lighting Controls, Occupancy Sensor

17 Lighting Controls, Bypass/Delay Timers
18 Lighting Controls, Photocell
19 Other Fluorescent
20 Fat/Thick Tubes
21 Skinny/Thin Tubes
22 T5 Fixtures (5/8" diameter)
23 NOTHING, EQUIPMENT WAS ONLY ADDED, NOT REPLACED
24 Other (PLEASE SPECIFY)
25 Don't know/Refused

LI26 Approximately how old were the lights that were removed/replaced by the lighting equipment we just discussed? Would you say…

1 Less than 5 years old
2 Between 5 and 10 years old
3 Between 10 and 15 years old
4 More than 15 years old
D Don't know
R Refused

END LIGHTING MEASURE LOOP

Comment Please consider all of those purchases when answering these next questions.

ASK IF L_MSP1=1 or LI9=1 (for any Program Lighting Measure); ELSE SKIP TO NSP1

LI30 Considering all of the changes we just discussed, approximately what percentage of the facility's energy usage was affected by those changes?

___% [Record Response]
888 Don't know
999 Refused

End Module

PROGRAM AWARENESS

Next, I'd like to ask you about various energy efficiency programs and what influenced your program participation.

AP9 How did you **FIRST** learn about the Set to Save rebate? [DO NOT READ LIST, ACCEPT ONE NUMBER]

1 Utility provided advertising--radio, newspaper, trade journal, billboard, TV
2 Bill insert, newsletter, or other mailing from utility
3 Utility Website
4 Email from Utility
5 Other utility source (SPECIFY)
6 Local government, community or nonprofit meeting, event, workshop or training (SPECIFY)
7 Local government/community agency (SPECIFY)

8 Local government, community, or nonprofit advertising- radio, newspaper, trade journal, TV
9 School, classes, energy center (SPECIFY)
10 Building audit or assessment (SPECIFY)
11 Flex your Power TV or radio advertising
12 Other meeting, event or workshop training (SPECIFY)
13 Other advertising
14 Friend/Relative/Neighbor
15 Contractor
16 No other sources
17 Other (SPECIFY)
18 Don't know
19 Don't know

AP9a Did you hear about the Set to Save rebate through any other sources? [DO NOT READ LIST, ACCEPT MULTIPLES]

1 Utility provided advertising--radio, newspaper, trade journal, billboard, TV
2 Bill insert, newsletter, or other mailing from utility
3 Utility Website
4 Email from Utility
5 Other utility source (SPECIFY)
6 Local government, community or nonprofit meeting, event, workshop or training (SPECIFY)
7 Local government/community agency (SPECIFY)
8 Local government, community, or nonprofit advertising- radio, newspaper, trade journal, TV
9 School, classes, energy center (SPECIFY)
10 Building audit or assessment (SPECIFY)
11 Flex your Power TV or radio advertising
12 Other meeting, event or workshop training (SPECIFY)
13 Other advertising
14 Friend/Relative/Neighbor
15 Contractor
16 No other sources
17 Other (SPECIFY)
18 Don't know
19 Refused

IF AP9=6-13 or IF AP9a=6-13

AP9b You said that you received information from AP9/AP9a [insert all response between 6-13 for AP9 and AP9a] about the [Program]. How influential was this information on your decision to participate in the Set to Save Rebate/Direct Install Program on a scale of 1 to 5, where 1 is not at all influential and 5 is very influential.

__ [RECORD RESPONSE (1-5)]
88 Don't know
99 Refused

ASK IF AP9 NE 4

AP11 Did a utility representative talk to you about the [Program]?

1 Yes
2 No
D Don't know
R Refused

AP11a When did you first become aware of the City of Palm Desert Set to Save Rebate/Direct Install Program? Would you say…

1 Sometime during 2007
2 Sometime during or after 2008?
D Don't know
R Refused

PROGRAM AWARENESS - OTHER PROGRAMS

AP6a Aside from the Set to Save Rebate/Direct Install Program, are there programs or resources you are aware of that are designed to promote energy efficiency for businesses like yours? [IF YES] What types of programs can you recall? [RECORD ALL MENTIONS] [After each response prompt with "Can you recall any others?"]

1 NOT AWARE OF ANY
2 SPC / Standard Performance Contracting
3 20/20
4 Flex-your-Power
5 Distributor incentives
6 Upstream HVAC and Motors Program
7 Rebate (unspecified)
8 Nonresidential Audits or Energy Audits
9 Other programs (SPECIFY) ________
10 Don't know
11 Refused

ASK IF AP6a NE 3; ELSE SKIP TO LI1

AP20 Have you ever heard of the 20/20 Rebate Program? Each summer the governor of California promotes an energy conservation and efficiency program called the "20/20 Rebate program," Businesses that saved 20% off their electricity bill in the summer months as compared to the previous year's bill qualify for a 20% rebate on their bill.

1 Yes
2 No
D Don't know
R Refused

AP22 Did any of your locations attempt to get the 20/20 rebate during any of the summers from 2005 through 2008?

1 Yes
2 No
D Don't know
R Refused

AP23 During which summer(s) did you attempt the 20 percent reduction? [Multiples Allowed]

1 2005
2 2006
3 2007
4 2008
D Don't know
R Refused

AP24 In which year(s) were you successful in reducing your electricity bill by 20%? [Multiples Allowed]

1 2005
2 2006
3 2007
4 2008
D Don't know
R Refused

TO SCHEDULE ONSITE VERIFICATION - Note this section is not included in the companion datasets.

Introduction

I'm with PA Consulting Group, an independent research firm. We are working with the California Public Utilities Commission and Summit Blue to evaluate the Set to Save Direct Install Program and have you listed as a participant in [YEAR]. This program is an important component of the California Public Utilities Commission's ongoing efforts to save energy and reduce emissions affecting climate change.

In order to improve this program's performance, the CPUC would like to make an accurate measurement of the energy savings associated with energy efficiency equipment installed by collecting and analyzing information from selected customers. Your input to this research is extremely important. We expect the initial site visit to take about 3 hours and the return site visit to take an hour. The first visit would need to take place in the next 2 weeks. For your participation, you will receive $75 at the first site visit and $75 at the second visit.

If you agree to participate, Summit Blue Consulting, on behalf of the California Public Utilities Commission, will come to your business to install power and temperature logger devices on your air conditioner to record when it is in use and how well it is performing. Technicians will need to get access to the area where the furnace, air handler, or air conditioner is located. The loggers would be installed in an unobtrusive place and would be removed by us at the end of the research project which we expect will last less than 2 months.

(Note, the electric use data will be used strictly for the study of the Set to Save Direct Install Program and will not affect your electric service at all.)

TO SCHEDULE INSTALLATION OF HVAC LOGGERS

REC Are you interested in participating in this project?

1 Yes
2 No (Skip to End)
98 Don't know (Schedule a callback)
99 Refused (Skip to End)

(Your input to this research is extremely important. By receiving a rebate through the Set to Save Direct Install Program, you have agreed to allow verification of the installation of the equipment rebated through the program.)

PHONE1a What is the best number for the technician to reach you at to schedule an appointment within the next week?

_____________ **PHONE1a**

PHONE1aa Is that a home, work or cell phone number?

1 Home
2 Work
3 Cell

PHONE1b Is there an alternate number for the technician to reach you at to schedule an appointment within the next week?

1 Yes ____________ **PHONE1b**
2 No (Skip to Other)

PHONE1bb Is that a home, work or cell phone number?

1 Home
2 Work
3 Cell

OTHER Is there another person that the technician might speak with at your business, if you are not available?

1 Yes
2 No (Skip to Verify)

NAME2 May I please have their name for our records?

_____________________ **NAME2**

PHONE2 May I also have the best phone number for the technician to reach them?

___________________ PHONE2

PHONE2aa Is that a home, work or cell phone number?

1 Home
2 Work
3 Cell

VERIFY For verification purposes only, may I please have your name?

_____________________ NAME2

END. Those are all the questions I have for today. (IF REC=1: A technician from Summit Blue will be in touch within the next 2 business days to schedule your onsite visit.) Thank you for your time and help in this important study.

Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches and the Algorithm for the Residential Consistent Free Ridership Method

Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches

October 15, 2007

Table of Contents

This document presents the “Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches.” These Guidelines were followed in the net-to-gross (NTG) assessments for the LGP Programs (Palm Desert, University of California/California State University, California Community Colleges, and Non-Resource).

1. Introduction

The California Public Utilities Commission (CPUC) recently adopted the *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (TecMarket Works, 2006) (referred to by the CPUC as the *Evaluator's Protocols*) for the measurement and evaluation (M&E) of energy efficiency (EE) programs. These guidelines focus on the critical elements of M&E such as impact evaluation, measurement and verification, process evaluation and sampling and uncertainty. These standards are understood to be minimal and are, in many cases, quite general.

A central objective of the California energy efficiency program evaluations is to identify that portion of the gross load impacts associated with a program-supported measure installation or behavior change that would not have been accomplished in the absence of the program. That portion is the net load impacts. In certain situations, the *Evaluator Protocols* allow for the use of the use of the self-report approach (SRA) to estimate the net-to-gross ratio (NTGR) for the basic and standard levels of impact evaluation rigor (see Table 3 of the *Evaluator's Protocols*). The SRA can also be used in the enhanced level of impact evaluation rigor if used in conjunction with a second approach such as participant and non-participant analysis of utility consumption data that addresses the issue of self-selection or econometric or discrete choice with participant and non-participant comparison that addresses the issue of self-selection. The SRA is a mixed methods approach that uses, to varying degrees, both quantitative and qualitative data and analysis to assess causality[1].

[1] There is wide agreement on the value of *both* qualitative and quantitative data in the evaluation of many kinds of programs. Moreover, it is inappropriate to cast either approach in an inferior position. The complexity of any decision regarding the purchase of efficient equipment can be daunting, especially in large organizations for which the savings are often among the largest. In such situations, the reliance on only quantitative data can miss some important elements of the decision. The collection and interpretation of qualitative data can be especially useful in broadening our understanding of a program's role in this decision.

However, while the Protocols allow for the use of the SRA, they are silent regarding basic methodological guidelines that are considered best practice.[2] The primary use of these SRA guidelines, which apply to assessing the influence of the program on both the direct impacts as well any participant spillover impacts, are to make sure that evaluators working under contract to the CPUC's Energy Division are adhering to these best practices.

Of course, while one could simply ask analysts to guarantee that they adhered to the methodological guidelines contained in standard textbooks, this may not be sufficiently reassuring either to the CPUC or other stakeholders. Thus, rather than simply trust analysts to follow the guidance contained in the standard methodological textbooks, the CPUC has chosen to develop the *Guidelines for Self-Report Methods for Estimating Net DSM Program Impacts* (GSR) (a summary of which has also been prepared) that requires analysts to address certain key issues rather than to require analysts to address these issues in a specific way. This is the sort of guidance that occupies a position somewhere between the minimal standards represented by the Protocols and the highly detailed guidelines contained in basic methodological texts.

It follows that the GSR must focus on those methodological issues on which there is general agreement regarding their importance within the social science and engineering communities. The GSR will also refer analysts to texts in which more detailed guidance can be found regarding all the issues addressed. Adherence to such guidelines still allows the results to be shaped by the interaction of the situation, the data and the analyst. It is this very interaction and the resulting plethora of legitimate methodological choices that prohibited the creation of a more detailed and prescriptive set of guidelines.

Earlier, the *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs (1998)* (1998 Protocols) provided quality control guidelines in Appendix J (*Quality Assurance Guidelines For Statistical, Engineering, and Self-Report Methods for Estimating DSM Program Impacts)* that addressed, among other methodological issues, the self-report method for estimating NTGRs. More recently, the *California Evaluation Framework* (TecMarket Works et al., 2004) also addressed many of the same issues associated with the self-report approach. This GSR attempts to draw upon both of these documents.

[2] These Protocols are also silent regarding methodological guidelines for conducting surveys in general. This is considered appropriate since there is general agreement (contained in numerous textbooks) regarding best methodological practices for designing and implementing surveys but relatively little agreement on what constitutes best methodological practices regarding the estimation of the NTGR using the SRA.

There are two features of these GSR that merit discussion. First, the issues addressed are issues that a variety of basic social science and engineering methodological texts also address. That is, there appears to be a consensus that these issues are important. Second, because some respondents may not be familiar with some of the issues addressed or the terms used, references have been provided that should provide reasonably clear explanations.

2. Issues Surrounding the Validity and Reliability of Self-Report Techniques

The SRA deviates from the standard approach to assessing causality, i.e., internal validity. The standard approach to assessing causality is to conduct an experiment or quasi-experiment[3] in which data are collected from both participants and nonparticipants with the data being subjected to a variety of statistical analyses (Shadish, Cook, and Campbell, 2002). In the early 1970s, many began to realize that such evaluation designs were not always desirable or possible (Weiss, 1972; Weiss and Rein, 1972). As a result, many evaluators began to explore alternatives that would allow them to generate causal conclusions (Guba, 1981, 1990; Cronbach, 1986). Such approaches as the modus operandi method (Scriven, 1976), intensive case studies (Yin 1994), theory-based evaluations (Chen, 1990; Rogers, et al., 2000), and mixed methods (Tashakkori and Teddlie, 1998) have been explored as alternative ways to generate causal conclusions. The SRA fits well with this tradition.

The SRA is useful in a variety of situations. For example, in some cases, the expected magnitude of the savings for a given program might not warrant the investment in an expensive evaluation design that could involve a billing analysis or a discrete choice analysis of both participants and nonparticipants. Or, key stakeholders might not want to wait for a billing analysis to be completed. Also, if the relationship of the savings to the normal monthly variation in energy use is too small, then a billing analysis should not even be attempted owing to a lack of statistical power. Finally, in some cases, it might not be possible to identify a group of customers to serve as a comparison group since they have been exposed through prior participation or are in some other ways contaminated. So, for budgetary, timing, statistical, and research design issues, the more traditional designs and analyses must sometimes be replaced with the SRA.

[3] In the literature, evaluations of energy efficiency and conservation programs that involve the use of a true experimental design are very rare.

More specifically, the SRA is a mixed method approach that involves asking one or more key participant decision-makers a series of structured and open-ended questions about whether they would have installed the same EE equipment in the absence of the program as well as questions that attempt to rule out rival explanations for the installation (Weiss, 1972; Scriven, 1976; Shadish, 1991; Wholey et al., 1994; Yin, 1994; Mohr, 1995). In the simplest case (e.g., residential customers), the SRA is based primarily on quantitative data while in more complex cases the SRA is strengthened by the inclusion of additional quantitative and qualitative data which can include, among others, in-depth, open-ended interviews, direct observation, and review of customer and program records [4]. Many evaluators believe that additional *qualitative* data regarding the economics of the customer's decision and the decision process itself can be very useful in supporting or modifying *quantitatively*-based results (Britan, 1978; Weiss and Rein, 1972; Patton, 1987; Tashakkori and Teddlie, 1998).

Having presented a very brief history of these alternatives approaches, we move on to discuss a number of special challenges associated with the SRA that merit mentioning.

One of the problems inherent in asking program participants if they would have installed the same equipment or adopted the same energy-saving practices without the program is that we are asking them to recall what has happened in the past. Worse than that is the fact that what we are really asking them to do is report on a hypothetical situation, what they would have done in the absence of the program. In many cases, the respondent may simply not know and/or cannot know what would have happened in the absence of the program. Even if the customer has some idea of what would have happened, there is, of necessity, uncertainty about it.

The situation just described is a circumstance ripe for invalid answers (low construct validity) and answers with low reliability, where reliability is defined as the likelihood that a respondent will give the same answer to the same question whenever or wherever it is asked. It is well known in the interview literature that the more factual and concrete the information the survey requests, the more accurate responses are likely to be. Where we are asking for motivations and processes in hypothetical situations that occurred one or two years ago, there is room for bias. Bias in responses is commonly thought to stem

[4] Of course, even in the simplest cases, an evaluator is free to supplement the analysis with additional quantitative and qualitative data such as interviews with architects and engineers involved in residential new construction or HVAC installers and a review of available market share data.

from three origins. First is the fact that some respondents may believe that claiming no impact for the program is likely to cause the program to cease, thus removing future financial opportunities from the respondent. Closely related to this is the possibility that the respondents may want to give an answer that they think will be pleasing to the interviewer. The direction of the first bias would be to increase the NTG ratio, and the second would have an unclear effect – up or down, depending on what the respondent thinks the interviewer wants to hear.

The second commonly recognized motivation for biased answers is that some people will like to portray themselves in a positive light; *e.g.*, they might like to think that they would have installed energy-efficient equipment without any incentive (the socially desirable response). This type of motivation could result in an artificially low net-to-gross ratio.

The third hypothesized source of bias involves an interaction between the positive perception of taking energy efficiency actions, the often observed difference between stated intentions and actual behaviors, and the fact that the counter-factual outcome can not be viewed, by the participant or outsiders. Using a series of survey questions to ask a participant about the actions they would have taken if there had been no program to derive a free-ridership estimate is referred to as the self-report approach (SRA). More specifically, this is asking the respondent to state their intentions with respect to purchasing the relevant equipment absent the program. Bias creeps in because people may intend many things that they do not eventually accomplish.

Beyond the fact that the situations of interest have occurred in the past and judgments about them involve hypothetical circumstances, they are often complex. No one set of questions can apply to all decision processes that result in a program-induced course of action. Some installations are simple, one-unit measures, while others involve many units, many different measures, and installations taking place over time. The decision to install may be made by one person or several people in a household, an individual serving as owner/operator of a small business, or, in the case of large commercial, industrial, or agricultural installations by multiple actors at multiple sites. Some measures may have been recommended by the utility for years before the actual installation took place, and others may have been recommended by consultants and/or vendors, making degree of utility influence difficult to establish. Finally, some efficiency projects may involve reconfiguration of systems rather than simple installations of energy-efficient equipment.

Another factor that can complicate the SRA is that, in certain situations, the estimated NTGR combines (more often implicitly than explicitly) the probability of a decision/action occurring and whether the *quantity* of the equipment installed would have been the same. This can complicate the interpretation of the responses and the way in which to combine these types of questions in order to estimate the NTGR.

This type of complexity and variation across sites requires thoughtful design of survey instruments. Following is a listing and discussion of the essential issues that should be considered by evaluators using SRA, together with some recommendations on reporting the strategies used to address each issue.

These should be regarded as recommendations for minimum acceptable standards for the use of the SRA to estimate net-to-gross ratios. Much of this chapter focuses on self-report methodologies for developing NTGRs for energy efficiency improvements in all sectors regardless of the size of the expected savings and the complexity of the decision making processes. However, in a given year, energy efficiency programs targeted for industrial facilities are likely to achieve a relatively small number of installations with the potential for extremely large energy savings at each site. Residential programs often have a large number of participants in a given year, but the energy savings at each home, and often for the entire residential sector, are small in comparison to savings at non-residential sites. Moreover, large industrial customers have more complex decision making processes than residential customers. As a result, evaluators are significantly less likely to conduct interviews with multiple actors at a single residence or to construct detailed case studies for each customer – methods that are discussed in detail in the following sections. *It may not be practical or necessary to employ the more complex techniques (e.g., multiple interviews at the same site, case-specific NTGR development) in all evaluations. Specifically, Sections 2.16 and 2.17 are probably more appropriate for customers with large savings and more complex decision making processes*. Of course, evaluators are free to apply the guidelines in these sections even to customers with smaller savings and relatively simple decision making processes.

2.1 Timing of the Interview

In order to minimize the problem of recall, SRA interviews should be conducted with the decision maker(s) as soon after the installation of equipment as possible (Stone et al., 2000).

2.2 Identifying the Correct Respondent

Recruitment procedures for participation in an interview involving self-reported net-to-gross ratios must address the issue of how the correct respondent(s) will be identified.

Complexities to be addressed include situations commonly encountered in large commercial and industrial facilities, such as:

1. Different actors have different and complementary pieces of information about the decision to install, e.g., the CEO, CFO, facilities manager, etc.;
2. Decisions are made in locations such as regional or national headquarters that are away from the installation site;
3. Significant capital decision-making power is lodged in commissions, committees, boards, or councils; and
4. There is a need for both a technical decision-maker and a financial decision-maker to be interviewed (and in these cases, how the responses are combined will be important).

An evaluation using self-report methods should employ and document rules and procedures to handle all of these situations in a way that assures that the person(s) with the authority and the knowledge to make the installation decision are interviewed.

2.3 Set-Up Questions

The decisions that the net-to-gross questions are addressing may have occurred from 1 month to as long as 24 months prior to the interview. Regardless of the magnitude of the savings or the complexity of the decision-making process, questions may be asked about the motivations for making the decisions that were made, as well as the sequence of events surrounding the decision. Sequence and timing are important elements in assessing motivation and program influence on it. Unfortunately, sequence and timing will be difficult for many respondents to recall. This makes it essential that the interviewer guide the respondent through a process of establishing benchmarks against which to remember the events of interest (Stone et al., 2000). Failure to do so could well result in, among other things, the respondent "telescoping" some events of interest to him into the period of interest to the evaluator. Set-up questions that set the mind of the respondent into the train of events that led to the installation, and that establish benchmarks, can minimize these problems. However, one should be careful to avoid wording the set-up questions in such a way so as to bias the response in the desired direction.

Set-up questions should be used at the beginning of the interview, but they can be useful in later stages as well. Respondents to self-report surveys frequently are individuals who participated in program decisions and, therefore, may tend to provide answers ex post that validate their position in those decisions. Such biased responses are more likely to occur when the information sought in questions is abstract, hypothetical, or based on future projections, and are less likely to occur when the information sought is concrete. To the extent that questions prone to bias can incorporate concrete elements, either by set-up questions or by follow-up probes, the results of the interview will be more persuasive.

An evaluation using self-report methods should employ and document a set of questions that adequately establish the set of mind of the respondent to the context and sequence of events that led to decision(s) to adopt a DSM measure or practice, including clearly identified benchmarks in the customer's decision-making process.

2.4 Use of Multiple Questions

Regardless of the magnitude of the savings or the complexity of the decision-making process, one should assume that using multiple questionnaire items (both quantitative and qualitative) to measure a construct such as free-ridership is preferable to using only one item since reliability is increased by the use of multiple items (Blalock, 1970; Crocker & Algina; 1986; Duncan, 1984).

2.5 Validity and Reliability

The validity and reliability of *each question* used in estimating the NTGR must be assessed (Lyberg, et al., 1997). In addition, the internal consistency (reliability) of multiple-item NTGR *scales* should not be assumed and should be tested. Testing the reliability of scales includes such techniques as split-half correlations, Kuder-Richardson, and Cronbach's alpha (Netemeyer, Bearden, and Sharma, 2003; Nunnally, 1978; Crocker & Algina, 1986; Cronbach, 1951; DeVellis, 1991). An evaluation using self-report methods should employ and document some or all of these tests or other suitable tests to evaluate reliability, including a description of why particular tests were used and others were considered inappropriate.

For those sites with relatively large savings and more complex decision-making processes, both quantitative and qualitative data may be collected from a variety of sources (*e.g.*, telephone interviews with the decision maker, telephone interviews with others at the site familiar with the decision to install the efficient equipment, paper and electronic program files, and on-site surveys). These data must eventually be integrated in order to produce a final NTGR.[5] Of course, it is essential that all such sites be evaluated consistently using the same instrument. However, in a situation involving both quantitative and qualitative data, interpretations of the data may vary from one evaluator to another, which means that, in effect, the measurement result may vary. Thus, the central issue here is one of reliability, which can be defined as obtaining consistent results over repeated measurements of the same items.

5 For a discussion of the use of qualitative data see Section 2.14.

To guard against such a threat at those sites with relatively large savings and more complex decision-making processes, the data for each site should be evaluated by more than one member of the evaluation team. Next, the resulting NTGRs for the projects should be compared, with the extent of agreement being a preliminary measure of the so-called inter-rater reliability. Any disagreements should be examined and resolved and all procedures for identifying and resolving inconsistencies should be thoroughly described and documented (Sax, 1974; Patton, 1987).

2.6 Consistency Checks

When multiple questionnaire items are used to calculate a free-ridership probability there is always the possibility of apparently contradictory answers. Contradictory answers indicate problems of validity and/or reliability (internal consistency). Occasional inconsistencies indicate either that the respondent has misunderstood one or more questions, or is answering according to an unanticipated logic.

Another potential problem with self-report methods is the possibility of answering the questions in a way that conforms to the perceived wishes of the interviewer, or that shows the respondent in a good light (consciously or unconsciously done). One of the ways of mitigating these tendencies is to ask one or more questions specifically to check the consistency and plausibility of the answers given to the core questions. Inconsistencies can highlight efforts to “shade” answers in socially desirable directions. While consistency checking won’t overcome a deliberate and well-thought-out effort to deceive, it will often help where the process is more subtle or where there is just some misunderstanding of a question.

An evaluation using self-report methods should employ a process for setting up checks for inconsistencies when developing the questionnaire items, and describe and document the methods chosen as well as the rationales for using or not using the techniques for mitigating inconsistencies. Before interviewing begins, one should establish rules to handle inconsistent responses. Such rules should be should be consistently applied to all respondents.

Based on past experience one should anticipate which questions are more likely to result in inconsistent responses (e.g., questions of what participants would have done in the absence of the program and reported importance of the program to their taking action could). For such questions, specific checks for inconsistencies along with interviewer instructions could be built into the questionnaire. Any, apparent inconsistencies can then be identified and, whenever possible, resolved before the interview is over. If the evaluator waits until the interview is over to consider these problems, there may be no chance to correct misunderstandings on the part of the respondent or to detect situations where the evaluator brought incomplete understanding to the crafting of questions. In some cases, the savings at stake may be sufficiently large to warrant a follow-up telephone call to resolve the inconsistency.

However, despite the best efforts of the interviewers, some inconsistencies may remain. When this occurs, evaluator could decide which of the two answers, in their judgment has less error, and discard the other. Or, one could weight the two inconsistent responses in a way that reflects the evaluator's estimate of the error associated with each, i.e., a larger weight could be assigned to the response that, in their judgment, contains less error.

However any inconsistencies are handled, rules for resolving inconsistencies should be established, to the extent feasible, *before* interviewing begins.[6] An evaluation plan using self-report methods should describe the approach to identifying and resolving apparent inconsistencies. The plan should include: 1) the key questions that will be used to check for consistency, 2) whether and how it will be determined that the identified inconsistencies are significant enough to indicate problems of validity and/or reliability (internal consistency), and 3) how the indicated problems will be mitigated. The final report should include: 1) a description of contradictory answers that were identified, 2) whether and how it was determined that the identified inconsistencies were significant enough to indicate problems of validity and/or reliability (internal consistency), and 3) how the indicated problems were mitigated.

However, the rules themselves have sometimes been found to produce biased results, eliminating these respondents (treating them as missing data) has at times been the selected course of action. Thus, whenever any of these methods are used, one must report the proportion of responses affected. One must also report the mean NTGR with and without these responses in order to assess the potential for bias.

2.7 Making the Questions Measure-Specific

It is important for evaluators to tailor the wording of central free-ridership questions to the specific technology or measure that is the subject of the question. It is not necessarily essential to incorporate the specific measure into the question, but some distinctions must be made if they would impact the understanding of the question and its potential answers. For instance, when the customer has installed equipment that is efficiency rated so that increments of efficiency are available to the purchaser, asking that respondent to indicate whether he would have installed the same equipment without the program could yield confusing and imprecise answers. The respondent will not necessarily know whether the evaluator means the exact same efficiency, or some other equipment at similar efficiency, or just some other equipment of the same general type. Some other possibilities are:

6 One might not always be able to anticipate all possible inconsistencies before interviewing begins. In such cases, rules for resolving such unanticipated inconsistencies should be established before the analysis begins.

1. Installations that involve removal more than addition or replacement (e.g., delamping or removal of a second refrigerator or freezer in a residence);
2. Installations that involve increases in productivity rather than direct energy load impacts;
3. Situations where the energy-efficiency aspect of the installation could be confused with a larger installation; and
4. Installation of equipment that will result in energy load impacts, but where the equipment itself is not inherently energy-efficient.

An evaluation using self-report methods should include and document an attempt to identify and mitigate problems associated with survey questions that are not measure-specific, and an explanation of whether and how those distinctions are important to the accuracy of the resulting estimate of free-ridership.

In large facilities or with decision-makers across multiple buildings or locations care must be taken to ensure that the specific pieces of equipment, or group of equipment/facility decisions, are properly identified. The interviewer and respondent need to be referring to the same things.

As part of survey development, an assessment needs to be made of whether there are important subsets within the participant pool that need to be handled differently. For example, any program that contains corporate decision-makers managing building/renovation of dozens of buildings per year requires some type of special treatment. In this case, a standard survey might ask about three randomly selected projects/buildings. Or, a case study type of interview could focus on the factors affecting their decisions in general, for what percentage of their buildings do they take certain actions, and what actions do they take in cases where no incentives are available (if a regional or national decision-making), etc. Such an approach might offer better information to apply to all the buildings they have in the program. The point is that without special attention and a customized survey instrument, such customers might find the interview too confusing and onerous.

2.8 Partial Free-ridership

Partial free-ridership can occur when, in the absence of the program, the participant would have installed something more efficient than the program-assumed baseline efficiency but not as efficient as the item actually installed as a result of the program. When there is a likelihood that this is occurring, an evaluation using self-report methods should include and document attempts to identify and quantify the effects of such situations on net savings. Partial free-ridership should be explored for those customers with large savings and complex decision making processes.

In such a situation, it is essential to develop appropriate and credible information to establish precisely the participant's alternative choice. The likelihood that the participant would really have chosen a higher efficiency option is directly related to their ability to clearly describe that option.

An evaluation using self-report methods should include and document attempts to identify and mitigate problems associated with partial free-ridership, when applicable.

2.9 Deferred Free-ridership

Deferred free riders are those customers who would, in the absence of the program, have installed exactly the same equipment that they installed through the utility DSM program, but the utility induced them to install the equipment earlier than they would have otherwise. That is, the utility *accelerated* the timing installation of the equipment. Because determining the extent of utility influence on the timing of the installation is a complex process, an evaluator should avoid relying on a single question asked of the key decision-maker. Rather, an evaluator should examine all available data and determine whether the preponderance of evidence supports the conclusion of deferred free-ridership.

The point at which the length of the deferral is interpreted as meaning no free-ridership needs to be explicitly developed in the evaluation plan and should be justified given the length of the measure life (the effective useful life or EUL) and the decision-making process of that type of customer.

Data from such sources as additional closed- and open-ended questions asked of the key decision-maker, information obtained from other people at the site familiar with the decision to install the efficient equipment, and information gathered from the program paper files should also be collected and analyzed. Rules for integrating the responses to closed- and open-ended questions should be established, to the extent feasible, before the analysis begins. Details regarding the establishment and use of such rules are provided in Section 2.14.

Unfortunately, evaluation budgets may only permit such data to be collected and analyzed for those customers with larger savings. For those customers with the smaller savings, the NTGR may be based only on the responses from close-ended questions obtained from the key decision-maker. In such cases, closed-ended questions regarding utility influence on both *what* was installed and *when* it was installed could be asked. These answers could be analyzed mechanically using an algorithm. However, to the extent that closed-ended questions are unable to capture fully the complexity of the decision-making process, any resulting conclusions regarding deferred free-ridership may be biased, with the direction of the bias unknown.

2.10 Scoring Algorithms

A consequence of using multiple questionnaire items to assess the probability of free-ridership (or its complement, the NTGR) is that decisions must be made about how to combine them. Do all items have equal weight or are some more important indicators than others? How are probabilities of free-ridership assigned to each response category? Answers to these questions can have a profound effect on the final NTGR estimate. These decisions are incorporated into the algorithm used to combine all pieces of information to form a final estimate of the NTGR. All such decisions must be described and justified by evaluators.

In some cases, each of the responses in the series of questions is assigned an ad hoc probability for the expected net savings. These estimates are then combined (additively or multiplicatively) into a participant estimate. The participant estimates are subsequently averaged (or weighted averaged given expected savings) to calculate the overall free-ridership estimate. The assignments of the probabilities are critical in the final outcome. At the same time, there is little evidence of what these should be and they are often assigned and justified given a logical argument. With this, however, a multiple number of different probability assignments have been shown to be justified and accepted by various evaluations and regulators. However, we recognize that this can make the comparability and reliability of survey-based estimates problematic.

Finally, evaluators must also conduct sensitivity analyses (e.g., changing weights, changing the questions used in estimating the NTGR, changing the probabilities assigned to different response categories, etc.) to assess the stability and possible bias of the estimated NTGR. A preponderance of evidence approach is always better than relying solely on a weighted algorithm and sophisticated weighting that is not transparent and logically conclusive should be avoided.

2.11 Handling Non-Responses and "Don't Knows"

In some cases, some customers selected for the evaluation sample refuse to be interviewed (unit nonresponse). In other cases, some customers do not complete an attempted interview, complete the interview but refuse to answer all of the questions, or provide a "don't know" response to some questions (item nonresponse). Insoluble contradictions fall into the latter category. Evaluators must explain in advance how they will address each type of problem.

Consider those who choose not to respond to the questionnaire or interview (unit nonresponse). Making no attempt to understand and correct for nonresponse in effect assumes that the non-respondents would have answered the questions at the mean. Thus, their net-to-gross ratios would assume the mean NTGR value. Because this might not always be a reasonable assumption, one should always assess the possibility of non-response bias. To assess the possibility of non-response bias, one should, at a minimum, using information available on the population, describe any differences between those who responded and those who didn't and attempt to explain whether any of these differences are likely to affect one's answers to the NTGR battery of questions. If non-response bias is suspected, one should, whenever possible, explore the possibility of correcting for non-response bias. When not possible, one should explain why not (e.g., timing or budget constraints) and provide one's best estimate of the magnitude of the bias.

When some respondents terminate the interview, complete the interview but refuse to answer all the questions, or who provide a "don't know" response to some questions (item nonresponse), decisions must be made as to whether one should treat such cases as missing data or whether one should employ some type of missing data imputation. For example, early methods to handle responses of "Don't Know," missing data, and inconsistent answers involved assuming a 35% or 50% free-ridership rate for these participants (as they might be less likely to have taken actions if they hadn't thought about it or made opposing reactions). These methods, however, were found to create a centrality tendency (the tendency to avoid extremely low scores or extremely high scores) in the overall free-ridership estimate, i.e., driving it towards 35% or 50%.

In all cases, one should always make a special effort to avoid "don't know" responses when conducting interviews. However, some survey methods and procedures have been used that do not allow a "don't know" response where that might be the best response a respondent can provide. Forcing a response can distort the respondent's answer and introduce bias. Such a possibility needs to be recognized and avoided to extent possible.

2.12 Weighting the NTGR

The Protocols require estimates of the NTGR at the program or program component levels (as determined by the CPUC). Of course, such an NTGR must take into account the size of the impacts at the customer or project level. Consider two large industrial sites with the following characteristics. The first involves a customer whose self-reported NTGR is .9 and whose estimated annual savings are 200,000 kWh. The second involves a customer whose self-reported NTGR is .15 and whose estimated savings are 1,000,000 kWh. One could calculate an unweighted NTGR across both customers of .53. Or, one could calculate a weighted NTGR of .28. Clearly, the latter calculation is the appropriate one.

2.13 Ruling Out Rival Hypotheses

An evaluator should attempt to rule out rival hypotheses regarding the reasons for installing the efficient equipment (Scriven, 1976). For example, to reduce the possibility of socially desirable responses, one could ask an *open-ended question* (i.e., a list of possible reasons is **not** read to the respondent) regarding other possible reasons for installing the efficient equipment. A listing by the interviewer of such reasons such as global warming, Flex Your Power, the price of electricity, concern for future generations, and the need for the US to reduce oil dependency might elicit socially desirable responses which would have the effect of artificially reducing the NTGR. The answers to such questions about other possible influences can be factored into the estimation of the NTGR.

In addition to obtaining the respondent's assess of other possible causes, the evaluator can independently assesses the evidence supporting any alternative hypotheses. For example, if there is a corporate policy regarding the purchase of efficient equipment, the evaluator should examine this document to verify its contents and the date on which this policy was established and also attempt to assess compliance with this policy. In addition, they could decide to interview industry experts to determine whether certain equipment has become standard practice in an industry. Or, they could review available market share data to determine whether a particular market for a specific technology has been transformed or is on its way to being transformed.

2.14 Precision of the Estimated NTGR

Most of the discussion thus far has been focused on the accuracy of the NTGR estimate and not the precision of the estimate. The calculation of the achieved relative precision of the NTGRs (for program-related measures and practices and non-program measures and practices) is usually straightforward, relying on the standard error and the level of confidence. For example, when estimating NTGRs in the residential sector, one typically interviews one decision maker in each household with the NTGR estimate based on multiple questions. In such a situation, one could report the mean, standard deviation, the standard error, and the relative precision of the NTGR based on the sample at the 90 percent levels of confidence.

However, in the nonresidential sector, things can get much more complicated since the NTGR at a given site can be based on such information as: 1) multiple interviews (end users as well as those upstream from the end user that might have been involved in the decision), 2) other more qualitative information such as standard purchasing policies that require a specific corporate rate of return or simple payback (*e.g.*, the rate of return for the investment in the energy efficiency measure can be calculated with and without the rebate to obtain another point estimate of the influence of the program), or 3) a vendor, involved in the installation of the efficient equipment, who might have been influenced by a utility training programs. In such a situation, a NTGR will be estimated that uses all of this information. However, one must recognize that the propagation of errors across multiple respondents and other sources of quantitative and qualitative data cannot adequately be reflected in the resulting standard error of NTGR estimate.

2.15 Pre-Testing Questionnaire

Of course, as with any survey, a pre-test should be conducted to reveal any problems such as ambiguous wording, faulty skip patterns, leading questions, faulty consistency checks, and incorrect sequencing of questions. Modifications should be made prior to the official launch of the survey.

2.16 The Incorporation of Additional Quantitative and Qualitative Data in Estimating the NTGR

When one chooses to complement a mixed methods (quantitative and qualitative) analysis of free-ridership with additional data, there are a few very basic concerns that one must keep in mind.

2.16.1 Data Collection

2.16.1.1 Use of Multiple Respondents

In situations with relatively large savings and more complex decision-making processes, one should use, to the extent possible, information from more than one person familiar with the decision to install the efficient equipment or adopt energy-conserving practices or procedures (Patten, 1987; Yin, 1994).

It is important to inquire about the decision-making process and the roles of those involved for those cases with relatively large savings and with multiple steps or decision-makers. If the customer has a multi-step process where there are go/no-go decisions made at each step, then this process should be considered when using the responses to estimate the firm's NTGR. There have been program evaluations whose estimates have been called into question when these factors were not considered, tested and found to be important. For example, a municipal program serving cities with financial issues where a department's facility engineer could say without bias that he definitely intended to install the same measure in the absence of the program and that he had requested that the city manager request the necessary funds from the City Council. However, one might discover that in the past the city manager, due to competing needs, only very rarely include the engineer's requests in his budget submitted to the to City Council. Similarly, there are cases where a facility engineer continues to recommend efficiency improvements but never manages to get management approval until the efficiency program provides the information in a way that meets the financial decision-makers needs in terms of information or independent verification or leverage by obtaining "free" funds.

These interviews might include interviews with third parties who were involved in the decision to install the energy efficient equipment. Currently, there is no standard method for capturing the influence of third parties on a customer's decision to purchase energy efficient equipment. Third parties who may have influence in this context include market actors such as store clerks, manufacturers (through promotional literature, demonstrations, and in-person marketing by sales staff), equipment distributors, installers, developers, engineers, energy consultants, and architects. Yet, these influences can be important and possibly more so in the continually changing environment with greater attention on global warming and more overlapping interventions. When one chooses to measure the effect of third parties, one should keep the following principles in mind: 1) the method chosen should be balanced. That is, the method should allow for the possibility that the third-party influence can increase or decrease the NTGR that is based on the customer's self report, 2) the rules for deciding which customers will be examined for potential third party influence should be balanced. That is, the pool of customers selected for such examination should not be biased towards ones for whom the evaluator believes the third-party influence will have the effect of influencing the NTGR in only one direction, 3) the plan for capturing third-party influence should be based on a well-conceived causal framework. The onus is on the evaluator to build a compelling case using a variety of quantitative and/or qualitative data for estimating a customer's NTGR

2.16.1.2 Other Site- and Market-Level Data

Information relevant to the purchase and installation decision can include:

1. Program paper files (correspondence between DSM program staff and the customer, evidence of economic feasibility studies conducted by the utility or the customer, correspondence among the customer staff, other competing capital investments planned by the customer)
2. Program electronic files (*e.g.*, program tracking system data, past program participation)
3. Interviews with other people at the site who are familiar with the program and the choice (*e.g.*, operations staff)
4. Open-ended questions on structured interviews with the key decision-maker and other staff who may have been involved with the decision.
5. Incremental costs of the equipment
6. Estimates of the equipment's market share

7. The diffusion (saturation) of the equipment in the market place

Where appropriate, for example, in the case of large-scale commercial and industrial sites, these data should be organized and analyzed in the form of a case study.

2.16.2 Establishing Rules for Data Integration

In cases where multiple interviews are conducted eliciting both quantitative and qualitative data and a variety of program documentation has been collected, one will need to integrate all of this information into an internally consistent and coherent story that supports a specific NTGR.

Before the analysis begins, one should establish, to the extent feasible, rules for the integration of the quantitative and qualitative data. These rules should be as specific as possible and be strictly adhered to throughout the analysis. Such rules might include instructions regarding when the NTGR based on the quantitative data should be overridden based on qualitative data, how much qualitative data is needed to override the NTGR based on quantitative data, how to handle contradictory information provided by more than one person at a given site, how to handle situations when there is no decision-maker interview, when there is no appropriate decision-maker interview, or when there is critical missing data on the questionnaire, and how to incorporate qualitative information on deferred free-ridership.

One must recognize that it is difficult to anticipate all the situations that one may encounter during the analysis. As a result, one may refine existing rules or even develop new ones during the initial phase of the analysis. One must also recognize that it is difficult to develop algorithms that effectively integrate the quantitative and qualitative data. It is therefore necessary to use judgment in deciding how much weight to give to the quantitative versus qualitative data and how to integrate the two. The methodology and estimates, however, must contain methods to support the validity of the integration methods through preponderance of evidence or other rules/procedures as discussed above.

2.16.3 Analysis

A case study is one method of assessing both quantitative and qualitative data in estimating a NTGR. A case study is an organized presentation of all these data available about a particular customer site with respect to all relevant aspects of the decision to install the efficient equipment. When a case study approach is used, the first step is to pull together the data relevant to each case and write a discrete, holistic report on it (the case study). In preparing the case study, redundancies are sorted out, and information is organized topically. *This information should be contained in the final report.*

The next step is to conduct a content analysis of the qualitative data. This involves identifying coherent and important examples, themes, and patterns in the data. The analyst looks for quotations or observations that go together and that are relevant to the *customer's decision to install the efficient equipment*. Guba (1978) calls this process of figuring out what goes together "convergence," *i.e.*, the extent to which the data hold together or dovetail in a meaningful way. Of course, the focus here is on evidence related to the degree of program influence in installing the efficient equipment. Identifying and ruling out rival explanations for the installation of the efficient equipment is a critical part of the analysis (Scriven, 1976).

Sometimes, *all* the quantitative and qualitative data will clearly point in the same direction while, in others, the *preponderance* of the data will point in the same direction. Other cases will be more ambiguous. In all cases, in order to maximize reliability, it is essential that more than one person be involved in analyzing the data. Each person must analyze the data separately and then compare and discuss the results. Important insights can emerge from the different ways in which two analysts look at the same set of data. Ultimately, differences must be resolved and a case made for a particular NTGR.

Finally, it must be recognized that there is no single right way to conduct qualitative data analysis:

> The analysis of qualitative data is a creative process. There are no formulas, as in statistics. It is a process demanding intellectual rigor and a great deal of hard, thoughtful work. Because different people manage their creativity, intellectual endeavors, and hard work in different ways, there is no one right way to go about organizing, analyzing, and interpreting qualitative data. (p. 146)

Ultimately, if the data are systematically collected and presented in a well-organized manner, and if the arguments are clearly presented, any independent reviewer can understand and judge the data and the logic underlying any NTGR. Equally important, any independent reviewers will have all the essential data to enable them to replicate the results, and if necessary, to derive their own estimates.

2.17 Qualified Interviewers

For the basic SRA in the residential and small commercial sectors, the technologies discussed during the interview are relatively straightforward (e.g., refrigerators, CFLS, T-

8 lamps, air conditioners). In such situations, using the trained interviewers working for companies that conduct telephone surveys is adequate. However, in more complicated situations such as industrial process and large commercial HVAC systems, the level of technical complexity is typically beyond the abilities of such interviewers. In such situations, engineers familiar with these more complicated technologies should be trained to collect the data by telephone or in person.

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Simple Res./Small Commercial Free-Ridership Algorithm, July 2009
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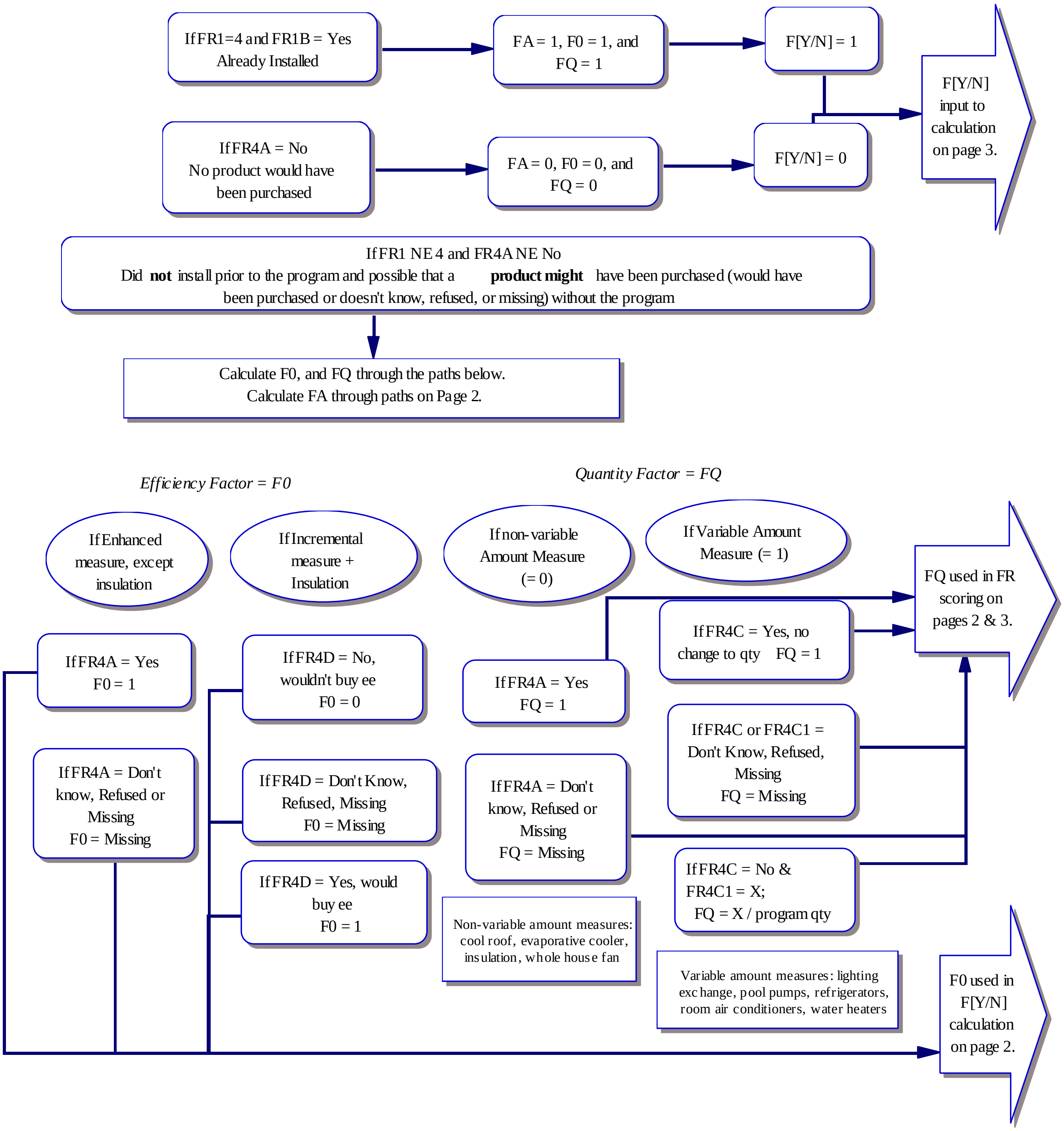

Simple Res./Small Commercial Free-Ridership Algorithm, July 2009
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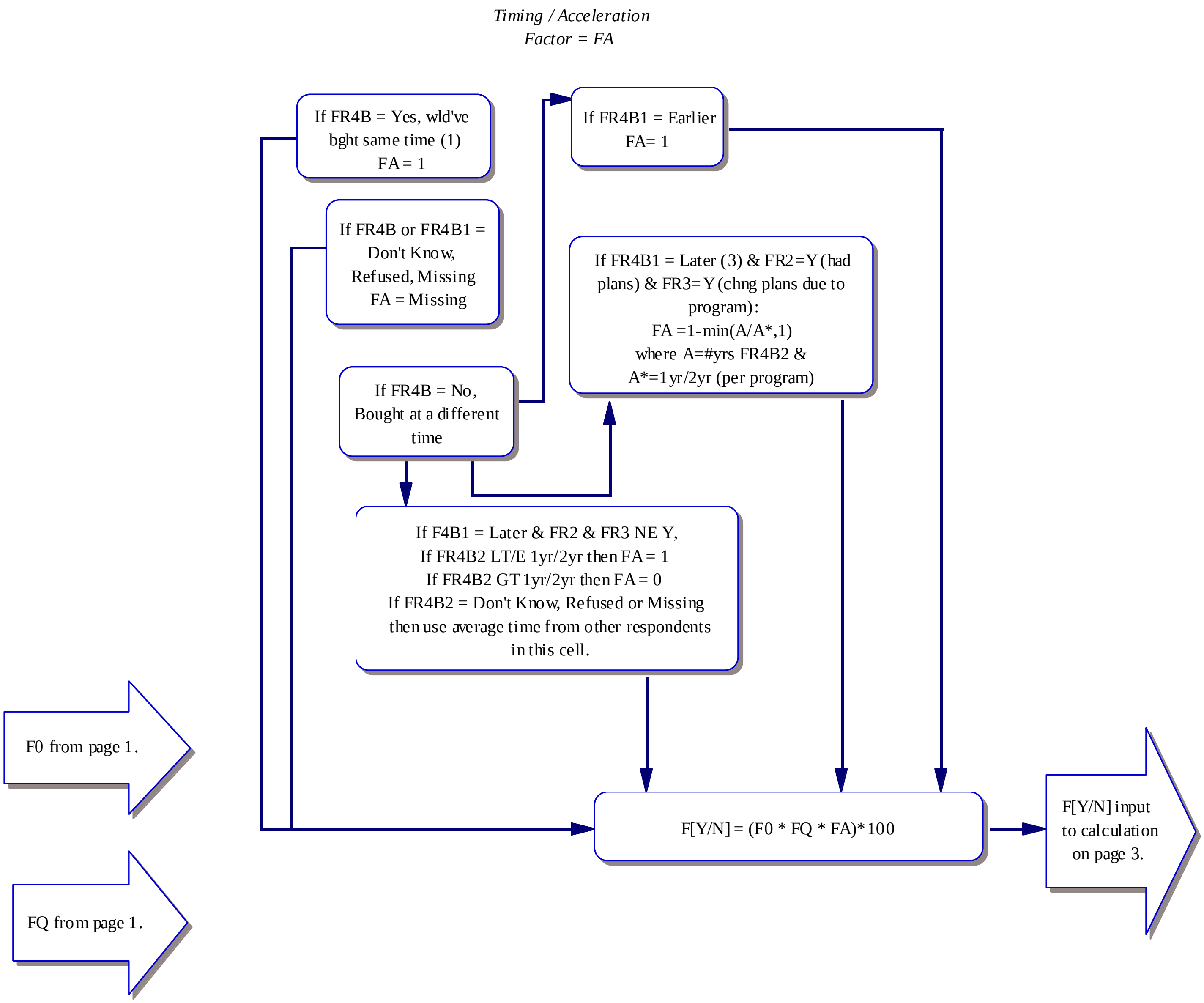

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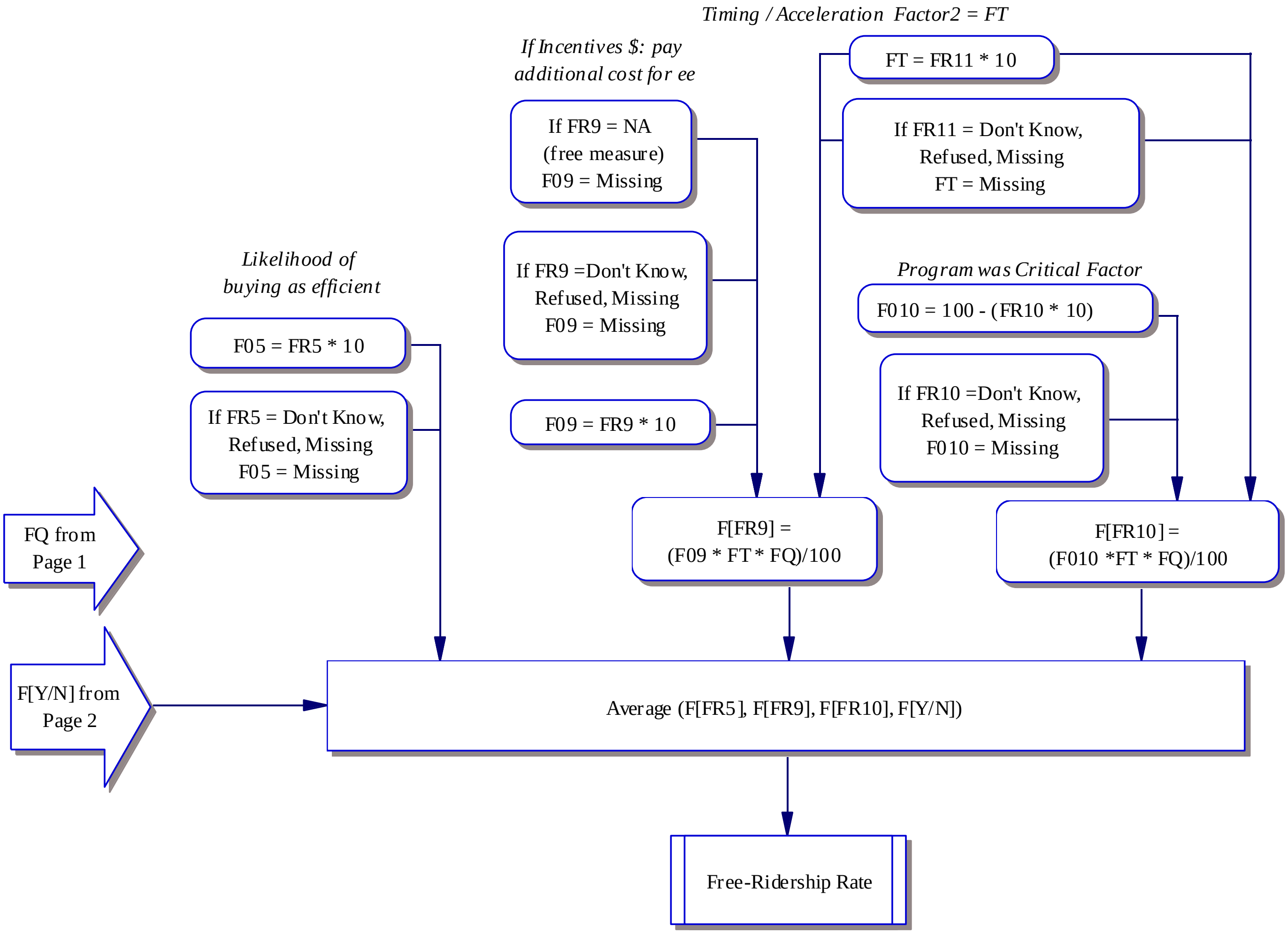

Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers

Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers

Prepared for the Energy Division, California Public Utilities Commission

By

The Nonresidential Net-To-Gross Ratio Working Group

February 9, 2009

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Acknowledgments

As part of the evaluation of the 2006-08 energy efficiency programs designed and implemented by the four investor-owned utilities (Pacific Gas & Electric Company, Southern California Edison Company, Southern California Gas Company, and San Diego Gas and Electric Company) and third parties, the Energy Division of the California Public Utilities Commission (CPUC) formed a nonresidential net-to-gross ratio working group that was composed of experienced evaluation professionals. The main purpose of this group was to develop a standard methodological framework, including decision rules, for integrating in a systematic and consistent manner the findings from both quantitative and qualitative information in estimating net-to-gross ratios. The working group, listed alphabetically, was composed of the following evaluation professionals:

- Michael Baker, SBW Consulting
- Ben Bronfman, Cadmus Group
- Fred Coito, KEMA
- Kevin Cooney, Summit Blue Consulting
- Scott Dimetrosky, Cadmus Group
- Donald Dohrmann, ADM Associates
- Tim Drew, Energy Division, CPUC
- Jennifer Fagan, Itron, Inc.
- Miriam Goldberg, KEMA
- Nick Hall, TecMarket Works
- Kay Hardy, Energy Division, CPUC
- Ken Keating
- Lori Megdal, Megdal & Associates
- Lisa Paulo, Energy Division, CPUC
- John Reed, Innovologie LLC
- Richard Ridge, Ridge & Associates
- Mike Rufo, Itron, Inc.
- Eric Swan, KEMA (formerly of RLW Analytics, Inc.)
- Christina Torok, Itron, Inc.
- Philippus Willems, PWP, Inc.

A public webinar was conducted to obtain feedback from the four investor-owned utilities and other interested stakeholders. The questionnaire was then pre-tested and, based on the pre-test results, finalized in November 2008.

1. Overview of the Large Nonresidential Free Ridership Approach

The methodology described in this section was developed to address the unique needs of Large Nonresidential customer projects developed through energy efficiency programs offered by the four California investor-owned utilities and third-parties. This method relies exclusively on the Self-Report Approach (SRA) to estimate project and program-level Net-to-Gross Ratios (NTGRs), since other available methods and research designs are generally not feasible for large nonresidential customer programs. This methodology provides a standard framework, including decision rules, for integrating findings from both quantitative and qualitative information in the calculation of the net-to-gross ratio in a systematic and consistent manner. This approach is designed to fully comply with the *California Energy Efficiency Evaluation: Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (Protocols) and the *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches* (Guidelines)**,** as demonstrated in Appendix D.

This approach preserves the most important elements of the approaches previously used to estimate the NTGRs in large nonresidential customer programs[7]. However, it also incorporates several enhancements that are designed to improve upon that approach, for example:

- The method introduces a 0 to 10 scoring system for key questions used to estimate the NTGR, rather than using fixed categories that were assigned weights (as was done previously).
- The method asks respondents to jointly consider and rate the importance of the many likely events or factors that may have influenced their energy efficiency decision making, rather than focusing narrowly on only their rating of the program's importance. This question structure more accurately reflects the complex nature of the real-world decision making and should help to ensure that all non-program influences are reflected in the NTGR assessment in addition to program influences.

It is important to note that the NTGR approach described in this document is a general framework, designed to address all large nonresidential programs. In order to implement this approach on a program-specific basis, it might need to be somewhat customized to reflect the unique nature of the individual programs.

[7] Such as, for example, the NTGR method used to evaluate NTGRs for the California Standard Performance Contracting Program.

2. Basis for SRA in Social Science Literature

The social sciences literature provides strong support for use of the methods used in the SRA to assess program influence. As the *Guidelines* notes,

> More specifically, the SRA is a mixed method approach that involves asking one or more key participant decision-makers a series of structured and open-ended questions about whether they would have installed the same EE equipment in the absence of the program as well as questions that attempt to rule out rival explanations for the installation (Weiss, 1972; Scriven, 1976; Shadish, 1991; Wholey et al., 1994; Yin, 1994; Mohr, 1995). In the simplest case (e.g., residential customers), the SRA is based primarily on quantitative data while in more complex cases the SRA is strengthened by the inclusion of additional quantitative and qualitative data which can include, among others, in-depth, open-ended interviews, direct observation, and review of program records. Many evaluators believe that additional qualitative data regarding the economics of the customer's decision and the decision process itself can be very useful in supporting or modifying quantitatively-based results (Britan, 1978; Weiss and Rein, 1972; Patton, 1987; Tashakkori and Teddlie, 1998).[8]

More details regarding the methodological underpinnings of this approach are in Ridge, Willems, and Fagan (2009). Appendix A provides an extensive listing of references in the social sciences literature regarding the methods employed in the SRA.

3. Free Ridership Analysis by Project Type

There are three levels of free-ridership analysis. The most detailed level of analysis, the **Standard – Very Large Project** NTGR, is applied to the largest and most complex projects (representing 10 to 20% of the total) with the greatest expected levels of gross savings. **Standard** NTG with a less detailed level of analysis is applied to projects associated with programs that have been assigned a Standard NTG rigor level. The least detailed analysis, the **Basic** NTGR, is applied to all remaining projects. Evaluators must exercise their own discretion as to what the appropriate thresholds should be for each of these three levels.

4. Sources of Information on Free Ridership

There are five sources of free-ridership information in this study. Each level of analysis relies on information from one or more of these sources. These sources are described below.

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[8] *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches*, October 15, 2007, pg. 3.

1. **Program Files**. As described in previous sections of this report, programs often maintain a paper file for each paid application. These can contain various pieces of information which are relevant to the analysis of free-ridership, such as letters written by the utility's customer representatives that document what the customer had planned to do in the absence of the rebate and explain the customer's motivation for implementing the efficiency measure. Information on the measure payback with and without the rebate may also be available.

2. **Decision-Maker Surveys**. When a site is recruited, one must also determine who was involved in the decision-making process which led to the implementation of measures under the program. They are asked to complete a Decision Maker survey. This survey obtains highly structured responses concerning the probability that the customer would have implemented the same measure in the absence of the program. First, participants are asked about the timing of their program awareness relative to their decision to purchase or implement the energy efficiency measure. Next, they are asked to rate the importance of the program versus non-program influences in their decision making. Third, they are asked to rate the significance of various factors and events that may have led to their decision to implement the energy efficiency measure at the time that they did. These include:

    - the age or condition of the equipment,
    - information from a feasibility study or facility audit
    - the availability of an incentive or endorsement through the program
    - a recommendation from an equipment supplier, auditor or consulting engineer
    - their previous experience with the program or measure,
    - information from a program-sponsored training course or marketing materials provided by the program
    - the measure being included as part of a major remodeling project
    - a recommendation from program staff, a program vendor, or a utility representative
    - a standard business practice
    - an internal business procedure or policy
    - stated concerns about global warming or the environment
    - a stated desire to achieve energy independence.

    In addition, the survey obtains a description of what the customer would have done in the absence of the program, beginning with whether the implementation was an early replacement action. If it was not, the decision maker is asked to provide a description of what equipment would have been implemented in the absence of the program, including both the efficiency level and quantities of these alternative measures. This is used to adjust the gross engineering savings estimate for partial free ridership, as discussed in Section 5.2.

This survey contains a core set of questions for **Basic** NTGR sites, and several supplemental questions for **Standard** NTGR sites (to help construct a "story" based on the information given). **Standard – Very Large Project** NTGR sites receive additional detailed probing on various aspects of the decision making and installation based on responses given to specific questions. For example, if the respondent indicates that a financial calculation entered highly into their decision, they are asked additional questions about their financial criteria for investments and their rationale for the current project in light of them. Similarly, if they respond that a corporate policy was a primary consideration in their decision, they are asked a series of questions about the specific policy that led to their adoption of the installed measure. If they indicate the installation was a standard practice, there are supplemental questions to understand the origin and evolution of that standard practice within their organization. These questions are intended to provide a deeper understanding of the decision making process and the likely level of program influence versus these internal policies and procedures.

3. **Vendor Surveys**. A Vendor Survey is completed for all **Standard** and **Standard- Very Large** NTGR sites that utilized vendors, and for **Basic** NTGR sites that indicate a high level of vendor influence in the decision to implement the energy efficient measure. For those sites that indicate the vendor was very influential in decision making, the vendor survey results enter directly into the NTGR scoring. The vendor survey findings are also be used to corroborate Decision Maker findings, particularly with respect to the vendor's specific role and degree of influence on the decision to implement the energy efficient measure. Vendors are queried on the program's significance in their decision to recommend the energy efficient measures, and on their likelihood to have recommended the same measure in the absence of the program. Generally, the vendors contacted as part of this study are contractors, design engineers, distributors, and installers.

4. **Utility and Program Staff Interviews**. For the Standard and Standard-Very Large NTGR analyses, interviews with utility staff and program staff are also conducted. These interviews are designed to gather information on the historical background of the customer's decision to install the efficient equipment, the role of the utility and program staff in this decision, and the name and contact information of vendors who were involved in the specification and installation of the equipment.

5. **Other information**. For **Standard – Very Large Project** NTGR sites, secondary research of other pertinent data sources is performed. For example, this could include a review of standard and best practices through industry associations, industry experts, and information from secondary sources (such as the U.S. Department of Energy's Industrial Technologies Program, Best Practices website URL, http://www1.eere.energy.gov/industry/bestpractices/). In addition, the Standard- Very Large NTGR analysis calls for interviews with other employees at the participant's firm, sometimes in other states, and equipment vendor experts from other states where the rebated equipment is being installed (some without rebates), to provide further input on standard practice within each company.

Table 1 below shows the data sources used in each of the three levels of free-ridership analysis. Although more than one level of analysis may share the same source, the amount of information that is utilized in the analysis may vary. For example, all three levels of analysis obtain data from the Decision Maker survey.

Table 1: Information Sources for Three Levels of NTGR Analysis

	Program File	Decision Maker Surveys	Vendor Surveys	Utility & Program Staff Interviews	Other Research Findings
Basic NTGR	√	√	√[1]		
Standard NTGR	√	√	√	√	
Standard NTGR – Very Large Projects	√	√	√	√	√

[1]Only performed for sites that indicate a high level of Vendor influence, based on a score of 6 or greater.

Appendix B provides the full battery of Decision Maker and Vendor survey questions along with notes, for each NTGR level, regarding which questions are asked (denoted by an "X"), and the intended uses of the information in the NTGR analysis. "CONTEXT" refers to providing additional detail on the circumstances surrounding the project, while "STORY" means the information is used to substantiate the rationale for the project and the emerging NTGR story. "TRIGGER" means that a score of 6 or greater triggers a further investigation in the case of Standard NTGR sites. A copy of the complete survey forms (with lead-in text and skip patterns) are contained in *Final Large Nonresidential NTGR Survey Instruments.XLS* that is available upon request.

5. NTGR Framework

The Self-Report-based Net-to-Gross analysis relies on responses to a series of survey questions that are designed to measure the influence of the program on the participant's decision to implement program-eligible energy efficiency measure(s). Based on these responses, a NTGR is derived based on responses to a set of "core" NTGR questions. The NTGR includes the effects of deferred free ridership (i.e., accelerated adoption).

5.1. NTGR Questions and Scoring Algorithm

A self-report NTGR is computed for all NTGR levels using the following approach. Adjustments may be made for **Standard – Very Large** NTGR sites, if the additional information that is collected is inconsistent with information provided through the Decision Maker survey.

The NTGR is calculated as an average of three scores. Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure.

1. A **Timing and Selection** score that reflects the influence of the **most important** of various program and program-related elements in the customer's decision to select the specific program measure at this time. Program influence through vendor recommendations is also incorporated in this score.

2. A **Program Influence** score that captures the perceived importance of the program (whether rebate, recommendation, training, or other program intervention) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents say they had already made their decision to install the specific program qualifying measure before they learned about the program.

3. A **No-Program** score that captures the likelihood of various actions the customer might have taken at this time and in the future if the program had not been available (the counterfactual). This score also accounts for deferred free ridership by incorporating the likelihood that the customer would have installed program-qualifying measures at a later date if the program had not been available.

When there are multiple questions that feed into the scoring algorithm, as is the case for both the **Timing and Selection** and **No-Program** scores, the maximum score is always used. The rationale for using the maximum value is to capture the most important element in the participant's decision making. Thus, each score is always based on the strongest influence indicated by the respondent. However, high scores that are inconsistent with other previous responses trigger consistency checks and can lead to follow-up questions to clarify and resolve the discrepancy.

The calculation of each of the above scores is discussed below. For each score, the associated questions are presented, and the computation of each score is described. For a detailed explanation of the scoring algorithm, including specific examples, see Appendix C.

5.1.1. Timing and Selection Score

For the Decision Maker, the questions asked are:

I'm going to ask you to rate the importance of the program as well as other factors that might influence your decision to implement [MEASURE.] Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.

Now, using this 0 to 10 rating scale, where 0 means "Not at all important" and 10 means "Very important," please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time.

- Availability of the PROGRAM rebate
- Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through PROGRAM
- Information from PROGRAM training course
- Information from other PROGRAM marketing materials
- Recommendation from a vendor/supplier (If a score of greater than 5 is given, a vendor interview is triggered)

For the Vendor, the questions asked (if the interview is triggered) are:

I'm going to ask you to rate the importance of the [PROGRAM] in influencing your decision to recommend [MEASURE] to [CUSTOMER] and other customers. Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.

1. Using this 0 to 10 scale where 0 is 'Not at all important" and 10 is "Very Important," how important was PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?

2. And using a 0 to 10 likelihood scale, where 0 denotes “not at all likely” and 10 denotes “very likely,” if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?
3. Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend MEASURE before you learned about the [PROGRAM]?
4. And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend MEASURE now that you have worked with the [PROGRAM]?
5. And, using the same 0 to 10 scale where 0 is “Not at all important” and 10 is “Very important”, how important in your recommendation were:
   a. Training seminars provided by UTILITY?
   b. Information provided by the UTILITY website?
   c. Your firm’s past participation in a rebate or audit program sponsored by UTILITY?

If the Vendor interview is triggered, a score is calculated that captures the highest degree of program influence on the vendor’s recommendation. This score (VMAX) is calculated as the MAXIMUM value of the following:

1. The response to question 1
2. 10 minus the response to question 2
3. The response to question 4 minus the response to question 3, divided by 10
4. The response to question 5a.
5. The response to question 5b.
6. The response to question 5c.

Note that vendors are asked an additional question regarding other ways that their recommendations regarding the measure might have been influenced. Their responses are not used in the direct calculation of the NTGR but are potentially useful in making adjustments to the core NTGR.

The Timing and Selection Score is calculated as:

The highest of the responses to the first four decision maker questions and, if the vendor interview has been triggered, the VMAX score multiplied by the score the decision makers assigned to the vendor recommendation.

5.1.2. Program Influence Score

The questions asked are:

1. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?

2. Now I'd like to ask you a last question about the importance of the program to your decision as opposed to other factors that may have influenced your decision. Again using the 0 to 10 rating scale we used earlier, where 0 means "Not at all important" and 10 means "Very important," please rate the overall importance of PROGRAM versus the most important of the other factors we just discussed in your decision to implement the specific MEASURE that was adopted or installed. This time I would like to ask you to have the two importance ratings -- the program importance and the non-program importance -- total 10.

The Program Influence score is calculated as:

The importance of the program, on the 0 to 10 scale, to question 2. This score is reduced by half if the respondent learned about the program after the decision had been made.

6.1.3. No-Program Score

The questions asked are:

1. Regarding the installation of this equipment, if the PROGRAM had not been available, using a likelihood scale from 0 to 10, where 0 is "Not at all likely" and 10 is "Extremely likely" how likely is it that you would have installed exactly the same item/equipment, using a 0 to 10 scale, where 0 is not at all likely and 10 is extremely likely?

2. Did you consider any alternatives to the [DESCRIBE MEASURE] [installed/removed] with the rebate from PROGRAM, which you would have implemented in the same time frame if the rebate had not been available?

3. If 2=YES, please describe the alternative which you most likely would have installed if the PROGRAM had not been available. Please be as specific as possible and include both efficiency level and quantities.

4. In the absence of the rebate from the PROGRAM, is it more likely that you would have done nothing or is it more likely that you would have installed the alternative that you just described?

5. IF 1>0. You indicated in your previous responses that there was an "***X"*** in 10 likelihood that you would have installed the same equipment if the PROGRAM had not been available. When do you think you would have installed this equipment? Please express your answer in months

a. _____ ____ within 6 months? (Deferred NTG Value=0)

b. _____ ____ 7 to 47 months later (Deferred NTG Value=(months-6)*.024)

c. _____ ____ 48 or more months later (Deferred NTG Value =1)

d. _____ ____ Never (Deferred NTG Value=1)

Note: The value 0.024 is 1 divided by 41 (41 is calculated as 47 – 6). This assumes that the deferred NTG value is a linear function beginning in month 7 through month 47, increasing 0.024 for each month of deferred installation.

The No-Program Score is calculated as:

10 minus (the likelihood of installing the same equipment multiplied by one minus the *deferred net-to-gross value* associated with the timing of that installation).

5.1.4. The Core NTGR

The self reported core NTGR is simply the average of the Program Influence, Timing and Selection, and No-Program Scores, divided by 10.

5.2. Accounting for Partial Free Ridership

What is referred to as partial free ridership is accounted for in the gross impact analysis and not in the NTGR calculation. That is, the NTGR as calculated above is applied to the adjusted gross impact estimate of savings, which takes into account the following:

- The energy use of the installed program-qualifying equipment relative to the appropriate market baseline – which may or may not be the same as the program baseline.
- The likelihood that, in the absence of the program, a customer would have installed equipment more efficient than the baseline but less efficient than program qualifying equipment. For example, if the customer reports that there is a 3-in-10 likelihood that they would have installed equipment that saves half as much energy over baseline as the program-qualifying equipment (as determined by engineering calculations), the gross impact would be reduced by 15% (.3 x .5). While the information needed to calculate this likelihood is derived from the results of the NTGR survey, the calculation is actually performed as part of the ***gross*** impact evaluation rather than in the NTGR analysis.
- Under the Partial Free Ridership framework, the gross impact evaluation requires estimates of energy usage associated with the following cases:
  - The existing equipment or program baseline

- The market baseline
- The alternate equipment considered by the customer
- The installed program qualifying equipment

Whether the gross impact estimate is adjusted is determined by:

1. Asking the customer if they considered alternatives to the program qualifying equipment;
2. If they respond that they did, determining the characteristics (e.g., size, number of units, efficiency) of that alternative equipment; and
3. Establishing whether the customer would have been more likely, in the absence of the program, to install this alternative equipment or to do nothing.

The partial free ridership adjustment is then calculated only if:

1. The customer considered alternatives to the program qualifying equipment, and
2. The customer says that in the absence of the program they would have been more likely to install this alternative equipment than to do nothing.

If they say they did not consider alternatives or if they would have been more likely to do nothing, no gross impact adjustment is calculated.

6. NTGR Interview Process

The NTGR surveys are conducted via telephone interviews. Highly-trained professionals with experience levels that are commensurate with the interview requirements should perform these interviews. Basic and Standard level interviews should be conducted by senior interviewers, who are highly experienced conducting telephone interviews of this type. Standard - Very Large interviews should be completed by professional consulting staff due to the complex nature of these projects and related decision making processes. More than likely, these will involve interviews of several entities involved in the project including the primary decision maker, vendor representatives, utility account executives, program staff and other decision influencers, as well as a review of market data to help establish an appropriate baseline.

All but the Standard -Very Large interviews should be conducted using computer-aided telephone interview (CATI) software. Use of a CATI approach has several advantages: (1) the surveys can be customized to reflect the unique characteristics of each program, and associated program descriptions, response categories, and skip patterns; (2) it drastically reduces inaccuracies associated with the more traditional paper and pencil method; and (3) the process of checking for inconsistent answers can be automated, with follow up prompts triggered when inconsistencies are found.

7. Data Integration Rules

In general, supplemental data from non-core NTGR questions collected through these surveys are used in the following ways:

- Vendor interview data are used at times **in the direct calculation of the NTGR** as described above and at other times to help provide context or to support a consistency check on customer-reported ratings.

- Qualitative information is used to alter core inputs only if contradictions are found between qualitative and quantitative information. Judgments will have to be made in deciding which information is more compelling when there are contradictions. Before scores are revised, at least two analysts independently review the supplemental data and determine whether and by how much a score should be changed. Each analyst should prepare a “case” citing the relevant data and why it supports revising or maintaining the NTGR calculation. The analysts then go over their cases together and come to an agreement on how to proceed. If they cannot agree, a knowledgeable third member of the evaluation team should be asked to review the findings and help resolve the issue.

- Responses are also be used to **construct a NTGR “story”** around the project. In general, the responses to the core NTGR questions are used to develop the free-ridership estimate for the project. These additional findings help to provide the context and rationale for the project, but are not be used in the direct calculation of the NTGR.

Findings from other non-core NTGR questions are also be used to **cross-check the consistency** of responses to core NTGR questions. When an inconsistency is found, it is presented to the Decision Maker respondent who is then be asked to explain and resolve it if they can. If they are not able to do so, their responses to the core NTGR question with the inconsistency may be overridden by the findings from these supplemental probes. These situations are handled on a case-by-case basis. Examples of the types of probes that are used to cross-check the consistency of responses regarding the importance of the program rebate are shown below:

> “When you answered “8” for the question about the influence of the rebate, I would interpret that to mean that the rebate was quite important to your decision to install; then, when you answered “8” for how likely you would be to install the same equipment without the rebate, it sounds like the rebate was not very important in your installation decision. I want to check to see if I am misunderstanding your answers or if the questions may have been unclear.”

If they volunteer a helpful answer at this point, respond by changing the appropriate answer. If not, follow up with something like:

> "Will you explain in your own words, the role the rebate played in your decision to install this efficient equipment?"

Alternatively,

> "Even without the rebate, this [describe item] met your company's financial criteria. Why wouldn't you have gone ahead with it even without the rebate?"
>
> "The rebate seemed to make the difference between meeting your financial criteria and not meeting them, but you are saying that the rebate didn't have much effect on your decision, why is that?"
>
> "The rebate didn't cause this [describe item] to meet your company's financial criteria, but you said that the rebate had an impact on the decision to [install/remove] the [describe item]. Why did it have an impact?"

8. Compliance with Self-Report Guidelines

The proposed NTGR framework fully complies with all of the CPUC/ED and the MECT's Guidelines for Estimating Net-to-Gross Ratios Using the Self-Report Approach, as demonstrated in Appendix D.

Appendix A

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Appendix B

Net-to-Gross Questions and Uses of Data by Level of NTGR Analysis

DECISION MAKER SURVEY

	Question Text	Basic	Standard	Standard – Very Large
	Introduction Hello, my name is ______ from COMPANY NAME and I am calling about your recent participation in PROGRAM NAME. Are you the person who was most involved with the decision to participate in the PROGRAM NAME? [IF YES, CONTINUE]. We are interviewing firms that participated in the PROGRAM NAME in 2006 and 2007 to discuss the factors that may have influenced your decision to participate in the program. The interview will take about 20 minutes. The questions on this survey pertain to work completed by your company at this current address, excluding other locations.			
	WARM-UP QUESTIONS			
A1	First, according to our records, you participated in PROGRAM NAME on (approximate date). [READ: Program Description. PROGRAM NAME promotes energy efficiency improvements in commercial/industrial facilities. The program offers (choose all that apply): energy audits to help identify applicable measures, feasibility studies to analyze the energy and cost savings of recommended measures, incentives to help cover a portion of the cost of implementing energy efficient measures, etc. Is that correct?	X	X	X
	Yes, No, DK, Refused			
A2	Next, I'd like to confirm the following information regarding the measures you implemented through the program: (READ: PROJECT DETAILS INCLUDING SERVICES RECEIVED, MEASURES INSTALLED, KEY DATES, PARTICIPATING VENDORS, ETC.) Does that sound right?	X	X	X
	Yes, No, DK, Refused			
A3	Why did you decide to implement MEASURE NAME? Were there any other reasons?	X	X	X
	a. Record VERBATIM			

	b. DK/Refused			
	NET-TO-GROSS BATTERY			
N1	When did you first learn about PROGRAM? Was it BEFORE or AFTER you first began to **think about implementing MEASURE**?	X	X	X
	a. Before (Skip to N3)			
	b. After			
	c. DK/Refused			
N2	Did you learn about PROGRAM BEFORE or AFTER you **decided to implement** the specific MEASURE that was eventually adopted or installed?	X	X	X
	a. Before			
	b. After			
	c. DK/Refused			
	READ: Program Description: *As I mentioned earlier, [PROGRAM NAME] promotes energy efficiency improvements in commercial/industrial facilities. The program offers (choose all that apply): energy audits to help identify applicable measures, feasibility studies to analyze the energy and cost savings of recommended measures, incentives to help cover a portion of the cost of implementing energy efficient measures, etc. I'm going to ask you to rate the importance of the program as well as other factors that might influence your decision to implement [MEASURE.) Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.*			
N3	Now, using this 0 to 10 rating scale, where 0 means "Not at all important" and 10 means "Very important," please rate the importance of each of the following in your decision to implement this specific [MEASURE] at this time. [CUSTOMIZE LIST OF FACTORS FOR PROGRAM BEFORE ASKING THEM TO SCORE THE FULL LIST. ROTATE PRESENTATION OF ITEMS. FOLLOW UP WITH "And is there anything else that I may have missed?" RECORD AS p. Other (SPECIFY)]			
	a. The age or condition of the old equipment	CONTEXT	STORY	TRIGGER
	b. Availability of the PROGRAM rebate	X	X	X

	c. Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through the PROGRAM (probe on when and by whom?)	X	X	X
	d. Recommendation from a vendor/supplier (If >5, Vendor interview triggered)	CONTEXT	TRIGGER	TRIGGER
	e. Previous experience with PROGRAM?	Information only.		
	f. Previous experience with this MEASURE?	CONTEXT	STORY	TRIGGER
	g. Information from PROGRAM training course?	X	X	X
	h. Information from other PROGRAM marketing materials?	X	X	X
	i. A recommendation from an auditor or consulting engineer	CONTEXT	STORY	TRIGGER
	j. Standard practice in our business/industry (IF >5, ask standard practice battery)	CONTEXT	STORY	TRIGGER
	k. Endorsement or recommendation by PROGRAM staff, PROGRAM vendor, or UTILITY representative	X	X	X
	l. Corporate policy or guidelines (If >5 ask Policy questions)	CONTEXT	STORY	TRIGGER
	m. Payback on the investment (If >5 ask payback battery)	CONTEXT	STORY	TRIGGER
	n. General concerns about the environment	CONTEXT	STORY	TRIGGER
	o. Specific concerns about global warming	CONTEXT	STORY	TRIGGER
	p. Specific concerns about achieving energy independence	CONTEXT	STORY	TRIGGER
	q. Other (SPECIFY)______________________________	CONTEXT	STORY	TRIGGER
N4	Now I'd like to ask you a last question about the importance of the program to your decision. Again using the 0 to 10 rating scale we used earlier, where 0 means “Not at all important” and 10 means “Very important,” please rate the overall importance of PROGRAM versus the other factors we just discussed in your decision to implement the specific MEASURE. I’d like you to give me a 0 to 10 score for the PROGRAM’s influence and a 0 to 10 score for the influence of the most important other factor so that the two scores total 10.	X	X	X
	a. ________rating of the importance of PROGRAM NAME			
	b. ________rating of the importance of Other Factors			
	Now I would like you to think about the action you would have taken with regard to the installation of this equipment PROGRAM had not been available.			

N5	Regarding the installation of this equipment if the PROGRAM had not been available, how likely is it that you would have installed exactly the same item/equipment, using a 0 to 10 likelihood scale, where 0 is not at all likely and 10 is extremely likely?	X	X	X
N6	Did you consider any alternatives to the [DESCRIBE MEASURE] [installed/removed] with the rebate from PROGRAM that you would have implemented in the same time frame if the rebate had not been available?	Used to adjust gross savings for partial free ridership.		
	Yes, No, DK, Refused			
N7	*IF YES:* Please describe the alternative equipment that you would most likely have installed if the PROGRAM had not been available. **Ask them to be as specific as possible and include both efficiency level and quantities. This will be used (with engineer input) to express the savings from the alternative equipment as a percentage of the gross savings from the program equipment.**	Used to adjust gross savings for partial free ridership.		
N8	In the absence of the rebate from the PROGRAM, is it more likely that you would have done nothing or is it more likely that you would have installed the alternative that you just described	Used to adjust gross savings for partial free ridership.		
	a. Would have installed the alternative described			
	b. Would have done nothing			
N9	*IF 6a>0.* You indicated in your previous responses that there was a X in 10 likelihood that you would have installed the same equipment if the PROGRAM had not been available.	X	X	X
	When do you think you would have installed this equipment? (Please answer in months)________			
	a. _____ ____ ..within 6 months? NTGR = 0			
	b. _____ ____.. 6 – 47 months later (NTGR=(months-6)*.024)			
	c. _____ ____ ..4 or more years later (NTGR=1)			
	g. _____ ____ ..Never (NTGR=1)			
	Additional Decision Maker Questions			
	PAYBACK BATTERY (If payback importance >5)			
N10	What financial calculations does your company make before proceeding with installation of a MEASURE like this one?			
N11	What is the cut-off point your company uses before deciding to proceed with the investment?			

N12	What was the result of the calculation for MEASURE: a) with the rebate? b) without the rebate?			
	INVESTIGATE INCONSISTENT RESPONSE			
N13	What competing investments, if any, were considered for the funds that were allocated to the adoption of MEASURE?			
N14	Why was MEASURE chosen over these other investments			
	CORPORATE POLICY BATTERY (If corporate policy importance >5)			
N15	Does your organization have a corporate environmental policy to reduce environmental emissions or energy use? Some examples would be to "buy green" or use sustainable approaches to business investments.			
N16	What specific corporate policy influenced your decision to adopt or install MEASURE?			
N17	Had that policy caused you to adopt the MEASURE at this facility before participating in this program?			
N18	Had that policy caused you to adopt the MEASURE at other facilities before participating in this program? When and where?			
N19	Did you receive an incentive for a previous [MEASURE]? If so, please describe.			
	STANDARD PRACTICE BATTERY (If standard practice importance >5)			
N20	How long has MEASURE been standard practice in your industry?			
N21	Does your company ever deviate from the standard practice? If yes, under what conditions?			
N22	How did this standard practice influence your decision to install the energy efficiency equipment			
N23	What industry group or trade organization do you look to establish standard practice for your industry?			
N24	How do you and other firms/facilities receive information on updates in standard practice?			
	OTHER INFLUENCES BATTERY			
N25	Who provided the most assistance in the design or specification of MEASURE? Designer or Consultant, Equipment Distributor or Mfr Rep, Installer, Utility rep, or Internal staff			

N26	Please describe the type of assistance that they provided.			
N27	Please state, in your own words, any other factors that influenced your decision to go ahead on this energy efficient equipment/project.			

VENDOR SURVEY

	Question Text	Basic	Standard	Standard Very Large
	Warm Up			
A1	The CUSTOMER indicates that you recommended the installation of [EFFICIENT MEASURE] at their facility at [CUSTOMER LOCATION] on [DATE]. Do you recall making this recommendation?	X	X	X
	a .Yes			
	b. No			
	c. DK (-8)			
	d. Refused (-9)			
	I'm going to ask you to rate the importance of the [PROGRAM] in influencing your decision to recommend [MEASURE] to [CUSTOMER] and other customers. Think of the degree of importance as being shown on a scale with equally spaced units from 0 to 10, where 0 means not at all important and 10 means very important, so that an importance rating of 8 shows twice as much influence as a rating of 4.			
V1	Using this 0 to 10 scale where 0 is ‘Not at all important” and 10 is “Very Important” , how important was PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?	X	X	X
V2	And using a 0 to 10 likelihood scale, where 0 denotes “not at all likely” and 10 denotes “very likely,” if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?	X	X	X
V3	Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend MEASURE before you learned about the [PROGRAM]?	X	X	X
V4	And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend MEASURE now that you have worked	X	X	X

	with the [PROGRAM]?			
V4a	In what other ways have your recommendations regarding MEASURE been influenced? [For each mention, ask: And using the same 0 to 10 scale, where 0 is "Not at all important" and 10 is "Very important", how important in influencing your recommendations. . . (INSERT FIRST MENTION, INSERT SECOND MENTION ETC.)]	X	X	X
V5	And, using the same 0 to 10 scale where 0 is "Not at all important" and 10 is "Very important", how important in your recommendation were			
	a. Training seminars provided by UTILITY?	X	X	X
	b. Information provided by the UTILITY website?	X	X	X
	c. Your firm's past participation in a rebate or audit program sponsored by UTILITY?	X	X	X
	Optional:			
V6	Approximately what percentage of your sales of MEASURE in UTILITY'S service territory are energy efficient models that qualify for incentives from the UTILITY program.			
V7	On a 0 percent to 100 percent scale, in what percent of sales situations do you encourage your customers in UTILITY territory to purchase program qualifying [MEASURES]?			
V8.	(IF LESS THAN 100) In what situations do you NOT encourage your customers to purchase energy efficient models if they qualify for a rebate? Why is that?			
V9	Of those installations of EQUIPMENT in UTILITY service territory that qualify for incentives, approximately what percentage do not receive the incentive?			
V10	Why do they not receive the incentive (open end?)			
V11	Do you also sell MEASURE in areas where customers do not have access to incentives for energy efficient models?			
V12	About what percent of your sales of MEASURE are represented by these areas where incentives are not available?			
V12a	IF AT LEAST 10%: And approximately what percentage of your sales of MEASURE in these areas are the energy efficient models that would qualify for incentives in UTILITY'S service territory?			
V13	Have you changed your stocking practices as a result of the UTILITY program? If yes, how?			

V14	Do you promote energy efficient models equally in areas with and without incentives?			

Appendix C

NTGR Scoring Algorithm and Example

The calculation of the self-report-based core NTGR is described below. The NTGR is calculated as an average of three scores representing responses to one or more questions about the decision to install a program measure.

1. A ***Timing and Selection*** score that captures the influence of the most important of various program and program-elated elements in influencing the customer to select the specific program measure at this time. Program influence through vendor recommendations is also captured in this score.

2. An overall ***Program Influence*** score that captures the perceived importance of the program (whether rebate, recommendation, or other information) in the decision to implement the specific measure that that was eventually adopted or installed. The overall program influence score is reduced by half if the respondent says they learned about the program only after they decided to install the program qualifying measure.

3. A ***No-Program*** score that captures the likelihood of various actions the customer might have taken at this time and in the future if the program had not been available. This score accounts for deferred free ridership by capturing the likelihood that the customer would have installed program qualifying measures at a later date if the program had not been available.

Calculation of each of the above scores is discussed below. For each score, the questions contributing to the calculation are presented, the calculation is described, and an example is provided.

Timing and Selection Score

For the decision maker, the questions asked are:

Using a 0 to 10 rating scale, where 0 means not at all important and 10 means very important, please rate the importance of each of the following in your decision to implement this specific measure at this time:

- Availability of the PROGRAM rebate
- Information provided through a recent feasibility study, energy audit or other types of technical assistance provided through the PROGRAM
- Information from PROGRAM training course
- Information from other PROGRAM marketing materials
- Recommendation from a vendor/supplier (If >5, a vendor interview is triggered)

For the vendor, the questions asked if the interview is triggered are:

1. On a 0 to 10 scale where 0 is Not at all important" and 10 is "Very important", how important was PROGRAM, including incentives as well as program services and information, in influencing your decision to recommend that CUSTOMER install the energy efficiency MEASURE at this time?
2. And using a 0 to 10 likelihood scale, where 0 denotes "Not at all likely" and 10 denotes "Extremely Likely," if the PROGRAM, including incentives as well as program services and information, had not been available, what is the likelihood that you would have recommended this specific energy efficiency MEASURE to CUSTOMER?
3. Now, using a 0 to 100 percent scale, in what percent of sales situations did you recommend this MEASURE before you learned about the PROGRAM?
4. And using the same 0 to 100 percent scale, in what percent of sales situations do you recommend this MEASURE now that you have worked with the PROGRAM?
5. And, using the same 0 to 10 scale where 0 is "Not at all important" and 10 is "Extremely Important", how important in your recommendation were:
   a. Training seminars provided by UTILITY?

   b. Information provided by the UTILITY website?

   c. Your firm's past participation in a rebate or audit program sponsored by UTILITY?

If the vendor interview is triggered, a score is calculated that captures the highest degree of program influence on the vendor's recommendation. This score (VMAX) is calculated as the MAXIMUM value of the following:

1. The response to question 1
2. 10 minus the response to question 2
3. The response to question 4 minus the response to question 3, divided by 10
4. The response to question 5 a.
5. The response to question 5b.

6. The response to question 5c.

The Timing and Selection Score is calculated as:

The highest of the responses to the first four decision maker questions and, if the vendor interview has been triggered, the VMAX score multiplied by the score the decision makers assigned to the vendor recommendation..

Example:

The decision maker provides responses of 5 for the importance of the rebate, 6 for an audit or feasibility study, 3 for training, 2 for other marketing materials, and 7 for the vendor recommendation, which means a vendor interview is triggered.

The vendor responses are 8 for the significance of the program, 5 for the likelihood of recommending the measure in the absence of the program, 40% for how often the measure was recommended before program awareness and 60% for how often it is recommended after program awareness, 3 for the importance of training, 2 for the importance of the website and 5 for the importance of previous participation. The VMAX score is the greatest of 8, (10-5), (60-40)/10, 3, 2 and 5. So VMAX is 8. This score is multiplied by the importance of the vendor recommendation, to which the decision maker assigned a 7, so the vendor score is 5.6.

The timing and selection score is the maximum of the four decision maker responses (5, 6, 3, and 2) and the vendor score (5.6). Even though the vendor interview was triggered, the vendor score is not as high as the 6 assigned to the importance of the audit or feasibility study, so the timing and selection score is 6.

Program Influence Score

The questions asked are:

1. Did you learn about PROGRAM BEFORE or AFTER you decided to implement the specific MEASURE that was eventually adopted or installed?

2. Again using the 0 to 10 rating scale we used earlier, where 0 means “Not at all important” and 10 means “Very important,” please rate the overall importance of PROGRAM versus the most important of the other factors we just discussed in your decision to implement the specific MEASURE that was adopted or installed. This time I would like to ask you to have the two importance ratings -- the program importance and the non-program importance -- total 10.

The program influence score is calculated as:

The program importance response, on the 0 to 10 scale, to question 2. This score is reduced by half if the respondent became aware of the program only after having decided to adopt the program qualifying measure.

Example:

The decision maker says they became aware of the program before deciding to implement the measure, and provides a response of 7 to question 2, which becomes the program influence score.

No-Program Score

The questions asked are:

1. Regarding the installation of this equipment if the PROGRAM had not been available, how likely is it that you would have installed exactly the same item/equipment, using a 0 to 10 likelihood scale, where 0 is not at all likely and 10 is extremely likely?

2. Did you consider any alternatives to the [DESCRIBE MEASURE] [installed/removed] with the rebate from PROGRAM that you would have implemented in the same time frame if the rebate had not been available?

3. If 2=YES Please describe the alternative equipment that you would most likely have installed if the PROGRAM had not been available. Please be as specific as possible and include both efficiency level and quantities.

4. In the absence of the rebate from the PROGRAM, is it more likely that you would have done nothing or is it more likely that you would have installed the alternative that you just described?

5. IF 1>0. You indicated in your previous responses that there was an ***"X"*** in 10 likelihood that you would have installed the same equipment if the PROGRAM had not been available. When do you think you would have installed this equipment? Please express your answer in months
   a. _____ ____ Within 6 months? (Deferred NTG Value=0)

   b. _____ ____ 7 to 47 months later (Deferred NTG Value=(months-6)*.024)

   c. _____ ____ 48 or more months later (Deferred NTG Value =1)

   d. _____ ____ Never (Deferred NTG Value=1)

Note: The value 0.024 is 1 divided by 41 (41 is calculated as 47 – 6). This assumes that the deferred NTG value is a linear function beginning in month 7 through month 47, increasing 0.024 for each month of deferred installation.

The No-Program Score is calculated as:

10 minus (the likelihood of installing the same equipment multiplied by one minus the deferred net-to-gross value associated with the timing of that installation).

Example

The respondent says there is a 4 in 10 likelihood that they would have installed the same equipment. In response to question 5, the decision maker says they would have installed the qualifying equipment 18 months later, which has a NTGR value of (18-6)*.024, or .29 associated with it.

The No-Program score is 10 minus (4*(1-.29)), which is 10 minus 4*.71 or 7.16.

Core NTG Ratio

The self reported NTGR ratio is simply the average of the Program Influence, Timing and Selection, and No-Program Scores, divided by 10.

Example

The NTGR is the average of 6, 8 and 7.2, or 7.1 divided by 10 = .71. This figure is then applied to adjusted gross savings to yield net savings.

Appendix D

Demonstration of Compliance with the CPUC/ED and MEC's Guidelines for Estimating Net-to-Gross Ratios Using the Self-Report Approach

1. Timing of the interview

To minimize problems of recall, every effort should be made to conduct the NTGR interview as close to project completion as possible.

2. Identifying the correct respondent

The survey form includes some initial probing on the respondent's role in the completed project, to confirm their involvement in the decision to implement the energy efficiency measures. In addition, both the utility or third party representative and any trade allies involved should be asked to confirm they are the correct contact. If multiple decision makers are identified, each one should be interviewed and the results pooled.

In the unfortunate circumstance where the key decision maker has left the company, that sample point should be discarded and replaced with a respondent from within the same stratum in the backup sample.

3. Set-up questions

The survey includes a series of warm-up questions that serve to remind the respondent about the circumstances and motivations surrounding the project, the project scope (including installed measures), incentives paid, and the project schedule. This information also helps to build the "story" to substantiate the NTGR responses given.

4. Use of multiple questions

The NTGR scoring algorithm relies on responses from several questions to determine the final NTGR score. The scoring is a function of:

- The timing of their program awareness relative to their decision to implement the installed measure
- The importance of program versus non-program influences in their decision making
- The importance of specific influences in the participant's general decision to implement the measure and that led them to implement the specific measure at the time they did rather than an alternative
- Without the program, the probability of alternative actions to implementing the selected measure

5. Validity and reliability

The proposed NTGR method is designed to produce valid and reliable NTGR results, based on the use of:

- *"Tried and true" question wording*. Many of the core questions used in NTGR scoring are substantially the same as those that have been used extensively in previous large C&I program evaluations, such as the last several rounds of evaluation for the California Standard Performance

Contracting Program. While the question construct is somewhat different from in the past, the wording used is essentially the same as has been used previously.

- *Information from supplemental questions and multiple data sources to corroborate and triangulate on the NTGR "story".* In addition to self-reported information, the NTGR findings for Standard and Standard – Very Large NTGR sites include responses to a number of supplemental questions surrounding the project (e.g., corporate policy, standard industry practice and payback), and the results from an interview with the vendor(s) involved in the project. These findings will be used to converge on a plausible estimate of the NTGR and to help tell the "story" behind the project and its context.
- *Multiple reviewers. Standard* **-** *Very Large customer projects are reviewed by two experienced analysts.* The two reviewers seek to develop a NTGR consensus on the project, and resolve any differences of opinion.
- *Identification and explicit consideration of alternate hypotheses.* Respondents are asked about the relative influence of a variety of program and non-program factors.

During the pre-test of the NTGR survey instrument, reliability tests should be conducted using the CATI software. Any problem areas detected should be corrected.

6. Consistency checks

Questions within the NTGR battery that are more likely to produce inconsistent responses have been flagged. These include questions regarding the program's reported importance in the decision to implement the specified measure, alternative actions in the program's absence, questions reporting the motivations for doing the project, as well as any closely related supplemental questions. The CATI software should be specifically programmed to flag any inconsistencies, and include follow-up prompts when they are found. Interviewers should be instructed how to administer these follow-up questions to resolve these inconsistencies. Interviewers should make every effort to resolve any inconsistencies before concluding the interview. Examples of the procedures for checking consistency of responses are provided in Section 3.

7. Making the Questions Measure-Specific

In general, most projects involve one type or class of measure. However, there are a few instances where the project consists of multiple types of measures, but usually, one measure predominates. In such cases, the interview should be conducted around the dominant measure with the greatest share of savings. If there are projects with multiple types of measures and no one measure class predominates, the NTGR sequence should be repeated for each significant measure class (e.g., once for lighting and once for process measures). At the beginning of each interview, there is a prompt with a description of the measure class that the questions pertain to so that it is clear in the minds of the respondent which measures they are being asked about.

8. Partial free-ridership

Questions N6, N7 and N8 are designed to collect the information necessary to adjust for any partial free-ridership. *However, this adjustment is be made to the* ***gross savings*** *estimates and not to the NTGR.*

9. Deferred free-ridership

Question N9 addresses deferred free ridership, and provides specific adjustment factors for each response category. The NTGR algorithm (See Section 5 and Appendix C) text fully explains the specifics of this adjustment.

10. Scoring algorithms

The methodology includes a specific algorithm for developing a NTGR based on responses received. The results of the 0 to 10 scoring are used to develop specific values for each question used to score the NTGR. A description of the scoring algorithm is provided in Section 5 and in Appendix C.

11. Handling unit and item non-response

Every effort should be made to discourage non-responses (i.e., refusals and terminates). For example, in California, the interviewer points out that the energy efficiency program requires the project to be evaluated as a condition of participation. Absent such a requirement, interviewers should stress such things as the importance of evaluation in improving program design and delivery. In some cases, incentives can be offered to respondents. In the event various strategies are not successful, the non-responding customer should be replaced by another customer within the same stratum. While efforts to minimize item non-response (“don’t knows” and “refusals”) should be made using a variety of available techniques, one should recognize that forcing a response can distort the respondent’s answer and introduce bias.

12. Weighting the NTGR

The mean NTGR for a given measure, end use or program should be weighted to take into account the size of the ex post gross impacts.

13. Ruling out rival hypotheses

The core NTGR questions, particularly question 4 of the Decision Maker survey, have been carefully constructed to try to rule out rival hypotheses. The method asks respondents to jointly consider and rate the importance of the many likely events or factors that may have influenced their energy efficiency decision making, rather than focusing narrowly on only their rating of the program’s importance. This question structure more accurately reflects the complex nature of the real-world decision making and should help to ensure that all non-program influences are reflected in the NTGR assessment in addition to program influences.

14. Precision of the NTGR

The calculation of the achieved relative precision of the NTGRs (for program-related measures and practices and non-program measures and practices) is expected to be straightforward. However, the inclusion of more complicated situations involving multiple participant and vendor interviews as well as the inclusion of additional qualitative information means that the NTGR standard errors may underestimate the uncertainty surrounding the NTGR estimate.

15. Pre-testing the questionnaire

The NTGR survey should be carefully and extensively pre-tested and adjusted in response to pre-test findings before it is fielded.

16. Incorporation of additional qualitative and quantitative data in estimating the NTGR (data collection, rules for data integration, analysis)

Specific rules have been established for data integration and these are described in Section 3.

17. Qualified interviewers

The NTGR surveys should be fielded by highly experienced interviewers. High level professional interviewers should be used for the largest and most complex projects, while less experienced professional interviewers should be used for smaller, simpler projects. A CATI approach should be used for all but the very largest and most complex projects.

APPENDIX I: RESPONSE TO PUBLIC COMMENTS ON DRAFT REPORT

Item #	Author	Subject
LGP01	**Carol Yin**	**Communication**
Question:		Regrettably, this evaluation process suffered from lack of open communication between the evaluators and the utilities. Several errors identified in these comments could have easily been corrected or avoided with more frequent communication. We hope that in the next evaluation cycle, the Energy Division (ED) would allow greater communication between the evaluation consultants and the utilities.
Answer:		All evaluation plans, as well as the evaluation reports, went through a public vetting period. We held workshops and solicited public comments, and the final plans incorporated responses and input from parties. In the next evaluation cycle, Energy Division will make every effort to further increase communication with stakeholders, within scheduling constraints as set by the Commission.
LGP02	**Carol Yin**	**Communication**
Comment:		Would the CPUC please explain why the research plan was changed in the 4th quarter of 2008, but the IOUs were not told until April of 2009? Please see the AEA's Guiding Principles for Evaluators, C. Integrity and Honesty, "3. Evaluators should record all changes made in the originally negotiated project plans, and the reasons why the changes were made. If those changes would significantly affect the scope and likely results of the evaluation, the evaluator should inform the client and other important stakeholders in a timely fashion (barring good reason to the contrary, before proceeding with further work) of the changes and their likely impact."
Response:		Energy Division notified parties once we were confident of the change we wanted to make. The process started in the fourth quarter of 2008 but was not complete until shortly before the April 2009 notification date. At that point we felt it was appropriate to inform the IOUs and other stakeholders.
LGP03	**Carol Yin**	**Communication**
Question:		What's the updated due date for the Strategic Plan support study?
Answer:		March 7, 2010
LGP04	**Carol Yin**	**Communication**
Comment:		Because of confusing and poorly communicated change from program evaluations to HIM evaluations, the difficulty in tracking which program measures were evaluated by what evaluation contract group, and the short time in which the IOUs were allowed to review this report, these comments do not represent the entirety of SCE's concerns with this study.
Response:		Comment noted.
LGP05	**Carol Yin**	**Communication**
Question:		Please give the non-technical reader some guideline as to how the calculated CVs should be interpreted. For example, according to Canada's national statistics agency, ACCEPTABLE estimates have a sample size of 30 and CV = 16.6%; MARGINAL estimates have sample sizes of 30 or more and CV between 16.6%and 33.3%, and UNACCEPTABLE estimates have sample sizes less than 30 _or_ CV > 33.3%.

Item #	Author	Subject
Answer:		Please see the attached document entitled "comAttach_1588_LGP_Response.docx", which provides a detailed explanation of the definition of CV as used in this report, which is consistent with standard practice and with the California Evaluation Protocols, and how it differs from the terminology used for CV in the Statistics Canada website referenced in the attachment provided with the question posted 1/7/2010.
LGP06	**Carol Yin**	**Communication**
Comment:		Attachment showing other organizations' guidelines for interpreting CV, suggesting that the estimates reported in this report may need to be accompanied by a caveat that these estimates are unreliable. If this is not the correct interpretation, the evaluators should explain how the non-technical reader is to interpret these results.
Response:		Please see the attached document entitled "comAttach_1588_LGP_Response.docx", which provides a detailed explanation of the definition of CV as used in this report, which is consistent with standard practice and with the California Evaluation Protocols, and how it differs from the terminology used for CV in the Statistics Canada website referenced in the attachment provided with the question posted 1/7/2010.
LGP07	**Carol Yin**	**Communication**
Question:		Should we apply those guidelines to the estimates in this study? The UC/CSU NTG estimates in this impact evaluation report were .23 for kWh, .12 (Acceptable) for kW, and .26 for Therms None of the NTGs for CCC would be Acceptable, with CVs at .20, .21, and .28 respectively. Palm Desert's savings estimate for Early Retirement has a CV of .7, which would be Unacceptable, and the report states clearly that the RCA Impact estimates were not acceptable. The RCA NTG estimates had CVs of .3 and .6, and Please explain to the reader, are those criteria also applicable to the data from this impact evaluation? If no, please explain why not.
Answer:		Please see the attached document entitled "comAttach_1588_LGP_Response.docx", which provides a detailed explanation of the definition of CV as used in this report, which is consistent with standard practice and with the California Evaluation Protocols, and how it differs from the terminology used for CV in the Statistics Canada website referenced in the attachment provided with the question posted 1/7/2010.
LGP08	**Carol Yin**	**Accuracy**
Question:		Did the evaluation team verify the figures they gathered from the proxy database maintained by NAM, with the Q4 2008 IOU Tracking Databases?

Item #	Author	Subject
Answer:		The figures gathered from the NAM database did not always align with the Q4 2008 IOU Tracking Databases. This was due to a number of factors (e.g. Re-adjusting project savings based on White paper Analyses that were not available on the NAM website). For the purpose of the final evaluation report, final project savings were aligned with the IOU Tracking Databases.However, there were three unique projects that were recorded as having been completed in the 2006-2008 program cycle, but did not make it into the IOU Tracking Databases 1.) PGE2036_2008_0111707 - All Zones - Nightly Main Area Lighting Shutoff with Override 2.) PGE2036_2008_0111708 - Book Stacks - Install Occupancy Sensors to Control Lighting 3.) PGE2036_2008_0054760 - Campus Wide Lighting Retrofits In these cases, savings values from the IOU Project Review Files were used in the calculation of project and program level realization rates.Collectively, these three projects accounted for 2,026,941 kWh savings and 352 kW savings, or 9.4% of kWh savings and 8.7 % of peak kW savings in the impact evaluation sample. These projects also had relatively high realization rates and their exclusion from the program realization rate calculations would reduce the PG&E kWh realization rate from 110% to 108%.
LGP09	**Carol Yin**	**Sampling**
Question:		This is unclear: Please provide more details about the two-stage cluster sampling. What were the clusters from which campuses were randomly drawn?
Answer:		The first stage "clusters" were the campuses themselves. The campuses represent a cluster of projects. This approach is discussed in Section 6.3.1 and Section 7.2.1 of the report.
LGP10	**Carol Yin**	**Sampling**
Question:		This is unclear: Please explain in the 2nd stage of the sampling; what criteria regarding "size of the actual project" was used?
Answer:		In the second stage, once campuses were selected, project-level ex ante savings were the "size of actual project" criteria used for ordering the projects for stratification. For example, for the PGE-kWh sample, the ex ante kWh savings of the individual projects were the "size" criteria.
LGP11	**Carol Yin**	**Compliance with SRA Guidelines**
Question:		The Self Report method also has its associated uncertainty. Please include a discussion of the problems commonly associated with self-report including the social desirability bias and poor recall of events.
Answer:		Responses to some of the criticisms of the SRA, including social desirability and recall, are included in the attached documents "CommercialSRA_Response" and "Res&SmallCommSRA_Response." Discussions of social desirability and recall biases were added to the main body of the report as well.
LGP12	**Carol Yin**	**Sampling**
Question:		Please provide the calculation details used to determine precision and confidence levels. For example, what weights did you use?
Answer:		Please see the attached document titled (UC_CSU - Precision Calculations.xlsx)

Item #	Author	Subject
LGP13	**Carol Yin**	**Accuracy**
Question:		Why were the same faulty loggers used in this study? When it was known from other studies that they had a high failure rate?
Answer:		Experience has confirmed that both HOBO and DENT loggers suffer from flicker issues, time de-synchronization, and premature failure (i.e., battery failure). In the absence of available and more cost-effective equipment, Summit Blue chose to simply deploy additional loggers to compensate for the failure rate.
LGP14	**Carol Yin**	**Compliance with SRA Guidelines**
Question:		Appendix D of Appendix H was supposed to be a Demonstration of compliance with the SRA Guidelines. However, most of the language used the future tense "should" and "will", as if it were extracted from a plan to comply, but not actually a report on compliance. Would the evaluators please review each issue described in the SRA Guidelines and demonstrate how exactly they with each of the SRA Guidelines in their respective surveys?
Answer:		This document in Appendix H presents the Guidelines themselves. An introductory paragraph was added to this document, specifying this and explaining that these Guidelines were followed in the NTG assessments. Discussions of specific issues of the Guidelines, such as addressing "Don't know" responses, are discussed in a separate response to comments.
LGP15	**Carol Yin**	**Compliance with SRA Guidelines**
Question:		2.1 Timing of interviews: For all the NTG interviews, please provide data on the time interval between the completion of each project and the date of NTG survey.
Answer:		Please see the attached file entitled "NTG Survey and Project Dates Palm, CCC, UCCSU.xlsx" for a detailed accounting of project dates and survey completions.
LGP16	**Carol Yin**	**Compliance with SRA Guidelines**
Question:		2.3 Set-Up Questions: Please provide data on whether Set-up questions were used, and what questions were specifically used to establish "benchmarks against which to remember the events of interest"?
Answer:		The following questions were used as set-up questions: **CCC and UC/CSU:** P1, P2, P5., P6., A1gg, P10. **Palm Desert**, W1, W2a, W2b, W2c, W4, W5
LGP17	**Carol Yin**	**Compliance with SRA Guidelines**
Question:		2.11 Handling Non-Responses and "Don't Knows": Please explain what plan was in place to deal with missing data, whatever the reason, and report on how that plan was carried out. Did you zero out the savings and included zero as the data point? Did you insert the sample mean? Did you use another method to impute missing data?
Answer:		There were no “Don’t know” responses for CCC and UC/CSU, given the nature of the large projects with significant impacts. “Don’t know” responses were omitted from the analysis for the Palm Desert program (10% of responses) and the Non-Resource programs (2% of responses for Audits) because of lack of information needed to conclude what NTG ratio to apply.

Item #	Author	Subject
LGP18	**Carol Yin**	**PDP Residential Survey**
Question:		"Please think back to the time when you were deciding to buy/install the energy efficient [measure], perhaps recalling things that occurred in your household shortly before and after [installation date]. What factors motivated you to purchase energy saving [measure]?" This is only a perfunctory attempt at a set-up question. Proper use of this memory jogging procedure requires that the interviewer pause and give the respondent time to recall a sequence of causal events that led up to the key event in question. This was mentioned in the SRA Guidelines. Asking respondents to "perhaps" recall "things that occurred in your household" is not specific enough, nor does it ameliorate concerns about memory. Please acknowledge that this survey did not comply with the Guideline to use Set-up Questions.
Answer:		See Section titled "Warm-Up Questions within the Free-Ridership Battery" in the attached document “Res&SmallCommSRA_Response.”
LGP19	**Carol Yin**	**Survey methodology**
Question:		Surveys indicate that in many instances, interviewers were instructed not to prompt the respondent's recall of installed measures ("Do Not Read"). When respondents were not prompted, were the evaluators able to compare the respondents' memories of the measures versus what was recorded by the program? If yes, on average, what percentage of the installed measures did the respondent recall?
Answer:		For Palm Desert, this does not apply as customers were asked if they installed a specific measure. For the UC/CSU and CCC, if the respondents had not been aware of the measures installed, the interviewer would prompt for recall and continue the interview. If the respondent was not at all aware (even after prompting) , the interview would have been terminated. However, this was not the case for these measures because of the large-scale nature of the projects and the respondent’s direct role in the decision-making process for these measures. Therefore, respondent recall was not an issue for this survey.
LGP20	**Carol Yin**	**Survey methodology**
Question:		When respondents were not prompted, and if neither the respondent nor the interviewer had a list of measures that the programs reported as being installed, did the evaluation team rely solely on the respondents' memories? If yes, the evaluation team needs to report that there was measurement bias: the construct validity of their instrument was not valid, as it was a measure of respondent memory rather than a measure verifying successful direct installation. Please reassure us.
Answer:		The NTG analysis brought in data on the measures and the sampling was conducted by measure. Therefore, the analysis did not rely on the respondent's memory for either the UC/CSU, CCC or Palm Desert programs.
LGP21	**Carol Yin**	**Survey methodology**
Question:		Words "energy efficient" and "energy efficiency" trigger social desirability bias. Why was it used repeatedly throughout the surveys? It would have been much better to just refer to the "new [measure] you purchased".

Item #	Author	Subject
Answer:		It was used repeatedly because, because among other things, we were attempting to ask about the motivations of the respondent when they purchased energy efficient equipment. Another commonly recognized motivation for biased answers is that some people will like to portray themselves in a positive light; e.g., they might like to think that they would have installed energy-efficient equipment without any incentive (the socially desirable response). This type of motivation could result in an artificially low net-to-gross ratio. The existence of the socially desirable response has been a perennial problem for survey researchers. Some critics appear to think that simply leveling this criticism is sufficiently damning. Unfortunately, they appear unwilling to acknowledge the various methods and techniques (Bradburn, Sudman, & Wansink 2004; Lyberg et al. 1997; Groves et al. 2004) that have been developed to address this potential source of bias and the extent to which these have been incorporated into the CA-SRA. For example, Bradburn, Sudman, and Wansink (2004), provide a checklist of 13 techniques for minimizing this bias including using data from knowledgeable informants (e.g., vendors, installers, etc.), attempting to validate the answers using other sources of information, using both closed and open questions. Another technique suggested by Bickman and Rog (2009) was to guarantee confidentiality. Another way of mitigating these tendencies is to ask one or more questions specifically to check the consistency and plausibility of the answers given to the core questions. Inconsistencies can highlight efforts to "shade" answers in socially desirable directions. While consistency checking won't overcome a deliberate and well-thought-out effort to deceive, it will often help where the process is more subtle or where there is just some misunderstanding of a question. These are among a number of techniques that have been incorporated into the CA-SRA. Of course, it is possible that a respondent might exaggerate the importance of the program because they want the program and its rebates to continue. Technically, this is not a case of the socially desirable response bias but does represent a type of biased response that should be mentioned. The same techniques used to reduce the socially desirable response bias can be used to mitigate this other type of bias. Bradburn, Norman, Seymour Sudman, and Brian Wansink. 2004. *Asking Questions: The Definitive Guide to Questionnaire Design- For Market Research, Political Polls, and Social and Health Questionnaires.* New York, NY: John Wiley & Sons. Lyberg, Lars, Paul Biemer, Martin Collins, Edith De Leeuw, Cathryn Dippo, Norbert Schwarz, and Dennis Trewin. 1997. *Survey measurement and process quality.* New York, NY: John Wiley & Sons. Groves, Robert M., Floyd J. Fowler, Jr., Mick P. Couper, James M. Lepkowski, Eleanor Singer, and Roger Tourangeau. 2004. *Survey methodology*. Hoboken, New Jersey: John Wiley & Sons. Bickman, Leonard and Debra J. Rog. 2009. *Applied Social Research Methods.* Los Angeles, CA: Sage Publications.
LGP22	**Carol Yin**	**Survey methodology**
Question:		It is unclear from the report and appendices: Did you send out the interview guides in advance of the interview with enough time for the respondent to gather supporting information? If yes, how much in advance?
Answer:		The respondents were not sent the guides in advance of the surveys unless the respondent requested so.

Item #	Author	Subject
LGP23	**Carol Yin**	**Survey methodology**
Question:		"Does your company ever deviate from the standard practice?" This question very strongly triggers the social desirability bias. Should not have use the word "deviate," should have used "adapt" or "modify". How many respondents admitted they deviated?
Answer:		Changing the terminology used here would not impact the NTG results since the question was only asked to one customer. Also, the response is not an input into the NTG algorithm anyway. In addition, the evaluation team used a variety of techniques mentioned in response to a previous comment to minimize the social desirability bias. However, the NTG evaluation team believes this is a valid concern of terminology and recommends the suggested adjustment to future surveys.
LGP24	**Carol Yin**	**Survey methodology**
Question:		"importance of the program versus this standard industry practice in influencing your decision to install". This question does not seem to be valid measure of the free ridership construct. The free ridership construct relates to actions that would have been taken in the absence of the program, the counterfactual. This question asks about actions under the influence of the program, which is the opposite of the counterfactual. Please explain this apparent discrepancy. What other questions were use to validate this construct, per the SRA Guidelines Section 2.4's direction to use multiple questions?
Answer:		In both the residential and nonresidential cases, we are attempting to determine the extent to which the program influenced a participant to install an energy efficient measure(s). One minus this score is interpreted as free-ridership. Some questions are designed to measure the counterfactual by asking the participant a number of questions about what they would have done in the absence of the program. Other questions attempt to get at the direct influence of the rebate and other forms of assistance on the decision to install efficient equipment. Still other questions attempt to establish the chronology of when the participant first heard about the program and their decision to install the efficient equipment. These three different types of questions are trying to measure three slightly different things with some being more difficult than others for the respondent to assess. For example, it is easier for the respondent to recall whether they found out about the availability of the rebate before or after they decided to buy the efficient equipment than it is to imagine what they would have done in the absence of the program or assess the influence of the rebate. Nevertheless, all three types of questions provide information about the influence of the program that decision makers should find both meaningful and useful. Also note that some of these questions are aimed at detecting false attributions to the program from customers who want to help the program or its representatives. This adds to the complexity of the algorithms, but how can it be overlooked if one is to make a good faith effort to circle around the “truth“?
LGP25	**Carol Yin**	**Survey methodology**

Item #	Author	Subject
Question:		Scales are not bounded, suggesting there may be a truncated range problem Zero means zero likelihood, but 10 means "extremely likely"? That is qualitatively very different from "definitely". Why did the scale not use "definitely"? People are used to reporting zero as zero and 10 as 100%. Changing the standard practice in scaling may result in underestimating influence of program. Did the evaluators pretest this scale for construct validity? The fact that the scale was not capped at the psychological maximum value poses serious threats to the ability to compare one person's response to another's. It's hard to misinterpret 100%, or "definitely," or "maximum possible," but it's very easy and likely for respondents to have differing internal definitions of what "extremely likely" means.
Answer:		See Sections titled "Theory and Practicality of Using Interval versus Ordinal Data" and "Anchoring and Scales" in attached document "Res&SmallCommSRA_Response."
LGP26	**Carol Yin**	**Survey methodology**
Question:		"Do not read…once the respondent has finished, probe" This is good, but the absence of this instruction in the other surveys indicates that the other surveys were measuring memory, not verifying program activity. Are we to assume that the absence of the instruction to probe means the interviewer was not allowed to prompt? This is extremely unclear throughout the surveys.
Answer:		The NTG effort for the Palm Desert Program used the standard small business and residential surveys. The NTG surveys for CCC and UC/CSU had numerous open-ended questions and follow-up questions. Specific direction in these surveys on prompting was not given because it was not needed given the style of these interviews, where the decision-makers were often eager to tell their story if they had the time.
LGP27	**Carol Yin**	**Survey methodology**
Question:		Was the interviewer allowed to prompt? Please clarify.
Answer:		Interviewers for the CCC and UC/CSU surveys were allowed to prompt.
LGP28	**Carol Yin**	**Survey methdology**
Question:		FR2: Why are all the options biased toward lowering increasing free ridership? Is this a two alternative forced-choice for each item, or was the respondent supposed to pick one? If latter, this is biased. What were the triangulating questions?
Answer:		Question FR2 does not stand on its own: it is the set-up question for FR3 and FR4, where it tries to confirm if the respondent is a 100% free rider.
LGP29	**Athena Besa**	**Overarching Comments**
Comment:		Please see attached document. In addition, SDG&E and SoCalGas support the attachment submitted by Carol Yin (SCE) labeled "Posted on behalf of Robert Brunn (SCE)".

Item #	Author	Subject
Response:		See attachment entitled " comAttach_1588_LGP_Response.docx"
LGP30	**PG&E Company**	**PG&E Comments - Corrected**
Comment:		Corrected PG&E's Comments on Draft Final Government Partnerships Programs Direct Impact Evaluation Report. Please disregard the attachment PG&E posted on January 6, 2010, as it contained an inadvertent error.
Response:		The document attached to the above question is simply a summary of all of the questions and comments presented in the "Report" and "Appendix" tabs in this worksheet, and therefore it is redundant. All responses to these questions are provided in these two worksheets and/or the accompanying attachments.
LGP31	**Carol Yin**	**Palm Desert**
Question:		For Greg Haney: Penalizing realization rates for units replaced subsequent to service can be questioned in the PD program results. The program's primary objective is early replacement however, making older units more efficient until such time has merit. Indeed, RCA services create a higher awareness to the customer of the need for greater efficiencies and thus can be a catalyst for unit replacement. Please explain why you are penalizing the Palm Desert Partnership for motivating greater awareness of deeper energy efficiency needs?
Answer:		In the case of a tuned-up unit being removed before it could be field-evaluated, the evaluator has the option of either performing an adjustment to the lifetime or an adjustment to the quantity of units installed (installation rate). In this case, the installation rate was adjusted. This is an important feature to track in programs with high penetrations (such as the Palm Desert Partnership). When a unit that has been tuned up the through program gets replaced a few months later, the repair effort does not directly create the savings that were deemed. The early replacement still receives full credit for savings. While the program tune-up may have played a strong role in getting the customer to participate in the early retirement portion of the program, the savings in that case accrue to the early retirement. This impact evaluation makes no claims about the marketing benefits of the tune-up program to other portions of the program. Only the savings impacts are being evaluated as part of this report.
LGP32	**Carol Yin**	**RCA**
Question:		For GH: RCA tests were performed 9 -12 months after the service was provided. It does not appear results were normalized or compared to typical RCA degradation found in older units over the same time frame as the sampling. Please clarify.

Item #	Author	Subject
Answer:		Either the lifetime or the installation rate can be adjusted when a unit does not stay in spec over a year. This evaluation did not perform a comprehensive analysis of the life of RCA measures, but focused instead on evaluating the rate at which repaired units were in spec at a nominal point in time after the repair. There are three main categories that repaired units can fall into. The first category includes units that are not repaired correctly and produce no savings as a result. These would test as being out of spec at the one year mark. The second category includes units that have an underlying problem (like a significant refrigerant leak) that is not repaired in conjunction with refrigerant charge adjustment and produce very little savings as a result, since the charge leaks out in a matter of weeks. These would test as being out of spec at the one year mark. The third category is units that need a one-time fix in refrigerant charge but have no other underlying problems. These units produce large savings. These units are likely to test in spec at the one year mark. Any unit that does not test in spec at the one year mark is likely not producing any large savings.
LGP33	**Carol Yin**	**Palm Desert**
Question:		For GH: Was data logged nomalized for weather? 2009 was a mild summer in Palm Desert
Answer:		All logged data was normalized for weather. Using an hourly energy simulation model, performance with the 2009 CIMIS weather data for La Quinta was adjusted to a typical meteorological year for climate zone 15.
LGP34	**Carol Yin**	**Palm Desert**
Question:		For GH: It is questioned whether the survey approach and questions were appropriate for this population where there has been such a focused and concerted marketing effort. Further, as is the nature of CZ15 residents, there is a natural increase of awareness of how one's cooling equipment impacts the energy bill. Free-ridership may appear higher in the Palm Desert program if the survey tool does not consider these factors. Please clarify.
Answer:		The survey effort intended to capture the impact of the concerted marketing effort. “Awareness of how one's cooling equipment impacts the energy bill" does not increase or introduce a bias in the measurement or calculation of free-ridership. In fact, being unaware can potentially lead to a false assumption that what they have or would have bought would have met the high efficiency criteria in survey questions. This means that the Palm Desert responses are less likely to contain a potential downward bias in reported free-ridership. The nature of the weather in CZ15 could "natural(ly) increase of awareness of how one's cooling equipment impacts the energy bill" and this would lead to higher sales of highly efficient cooling equipment and expectations for high actual free-ridership.
LGP35	**Carol Yin**	**Incorrect Ex Ante Savings**
Comment:		For Greg Haney: Slight difference in reported savings. SCE reports 23,618,934kWh and 6,865kW
Response:		There was an error in the report, where incorrect ex ante savings values were referenced. All ex ante savings values and applicable realization rates have been recalculated and updated in the report. While this has no impact on the ultimate verified ex post savings for the program (since an ex post UES will be used for the final savings estimates, not a realization rate), it does have a large impact on some key indicators of program performance (such as realization rates) that are included in the report. All of these indicators have been corrected accordingly.

Item #	Author	Subject
LGP36	**Carol Yin**	**UC/CSU and CCC**
Question:		Posted on behalf of Robert Brunn (SCE).
Answer:		NONE. This document was inadvertently posted to LGP. It is actually a MBCx document that will be addressed by the MBCx contract group (SBW).
LGP37	**PG&E Company**	**PGE Comments**
Comment:		PG&E's Comments on Draft Final Government Partnerships Programs Direct Impact Evaluation Report
Response:		Disregarded. This attachment is superseded by Attachment 1586.
LGP38	**PG&E Company**	**EUL/Realization Rate**
Question:		The gross realization rate methodology appears to use standard EUL measure assumptions to determine if a project is considered "early retirement" or a "normal replacement". Based on experience with campus personnel, the standard default EUL assumptions do not apply in the university/college sector with many measures being regularly used beyond the standard EUL timeframe. Did the evaluation team take into account how the university/college sector differs in their purchase decision making process from the de facto commercial sector? If not, could further analysis on better-suited EUL values be completed?
Answer:		In cases where there was uncertainty in a project's baseline classification, the evaluation team considered both the EUL and interview responses with campus staff regarding the nature of the replacement. Two key sources of information were used to confirm the baseline, with the following prioritization: 1.) Interviews with Campus staff and Project Representatives 2.) EUL The evaluation team also reviewed the NRR-DR Procedures Manual (2009 Nonresidential Retrofit - Demand Response (NRR-DR) Procedures Manual, Pacific Gas and Electric Company, November 18, 2009) and found the following eligibility requirements for fuel substitution and early retirement measures: "Fuel substitution (fuel switching) measures involve retrofit projects where all or a portion of the existing energy use is converted from one commodity to another, e.g., “electricity to natural gas.” Standard baselines are determined based on the applicable federal or state mandated energy performance (i.e. California’s Title 24, Federal Title 10, NEMA, EPACT, etc.). In the absence of government standards, current industry practices are used to establish baseline performance. Incentives are paid on the energy savings above and beyond the baseline standard... 1.4.7 Early Retirement Feature "This program feature is designed to accelerate the retirement of older, less efficient equipment with high efficiency replacements. Measures that are eligible for this feature are subject to an expanded definition of energy savings resulting in a larger incentive than would be possible using the traditional Calculated Approach. This approach can be applied to air conditioning units (packaged AC, heat pumps and chillers) and electrical motors with five or more years of remaining useful life"

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		Collectively, these resources were used to make an informed decision on each project's baseline classification.
LGP39	**PG&E Company**	**Evaluation Design**
Comment:		We believe the evaluators used an inappropriate application of an IPMVP protocol. Specifically we see two problems with the way IPMVP Option D was applied: 1) The protocol says you can use Option D when you have, at a minimum, either pre- or post- implementation energy data. You then use that data to calibrate a simulation to model and fill in the missing data. In some projects, the evaluators used Option D when they had neither pre- or post- energy data. 2) Because the evaluators didn't have the proper project energy data, they used CEUS (Commercial End-Use Survey) data from a similar building to calibrate the model. The protocol has no provision for this type of substitution. Using "similar building" average data is no way to calibrate a model for a specific situation."
Response:		For IMPMVP Option D, the simulation model must be calibrated so that it predicts an energy use and demand pattern that reasonably matches actual utility consumption and demand data from either the base year or a post-retrofit year. Interval energy use data, which were only available at the campus-wide level, could not be used to calibrate a simulation model for projects affecting only certain buildings of a campus. The protocol maintains that when pre- and post-installation energy data are not available, then isolation metering should be employed; however, this method was not practicable for several buildings of a campus. Instead, in these cases, the simulation model was calibrated using CEUS (Commercial End-Use Survey) data.
LGP40	**PG&E Company**	**HIM**
Question:		Will the Retrocommissioning and Government Partnership Programs reports eventually be combined into a single report? This report focused on retrofit projects and a separate evaluation was released focusing on retrocommmissioning. For SW Government Partnerships, these programs focus both on retrofit and retrocommissioning as a complete package in the overall program. When all is said and done, will the results from the two studies be grouped into a single report detailing realization rates and NTG number on all projects within the Government Partnerships? Will the HIM results reported in other contract groups for the partnership programs be provided in a combined total LGP program report?

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Answer:		The Retrocommissioning and Government Partnership Program reports will not be combined into a single report. The Energy Division staff report, through the Evaluation Reporting Tools, will combine all the results of the studies and produce program levels results by 4/15/10.
LGP41	**PG&E Company**	**NTG**
Comment:		Given that spillover was not included in the NTG analysis, the evaluated program net savings do not accurately record actual program net savings. Based on PG&E's Program influence and the collaboration of PG&E with the College campuses, these customers do not consider implementing a project without contacting PG&E, and participating in the program.
Response:		The policy is to not count spillover in 2006-2008. See Finding of Fact 27 of D. 05-04-051, "27. The speculative nature of any attempts to quantify spillover effects significantly reduces their applicability as an analytical tool at this time. Moreover, discounting the accounting of free-ridership through "spillover," as PG&E proposes, would make it particularly difficult to attribute indirect program benefits to education and information programs, without double-counting those benefits. "
LGP42	**PG&E Company**	**NTG**
Question:		In the CPUC webinar, evaluators confirmed that all NTG surveys were completed over the phone by expert interviews. However, program personnel also observed evaluation field staff (not trained NTG surveyors) asking NTG questions to university/college maintenance staff. Please provide documentation of actual phone surveys conducted.
Answer:		No questions given to customers by field staff were included in the NTG analysis. Some questions may have appeared to be NTG questions, but were not intended for the NTG effort. Dates of NTG phone surveys are provided in the attached file entitled "NTG Survey and Project Dates Palm, CCC, UCCSU.xlsx."
LGP43	**PG&E Company**	**NTG**
Question:		Could the summary NTG ratios be broken down by utility? While we understand that NTG precision was not attained for each utility, the webinar presentation indicated IOU experience influenced NTG. Obtaining IOU NTG results would provide greater information to improve program performance, even if the NTG ratios still are used on a statewide basis. How will the NTG numbers stated in the report be applied across the board. Will it be IOU to IOU or across the SW programs? What numbers will the evaluators be using?
Answer:		The Palm Desert Program evaluation covered just one utility. The NTG analyses for CCC and UC/CSU programs, which included multiple utilities, were not utility-specific evaluations, and therefore, NTG ratios are not broken down by utility. The program level NTG ratios by kW, kWh and therms will be applied. However, if PG&E is interested in better understanding the project by project NTG ratios, they can refer to response number 5 in the file entitled "1188_DR_PGE_ED-010_RESPONSE.3627.doc" provided in response to data request "PGE ED-010"
LGP44	**PG&E Company**	**NTG**
Question:		Please provide program titles/positions for each NTG survey respondent.
Answer:		Titles of survey respondents will not be released for confidentiality reasons.

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LGP45	**PG&E Company**	**NTG**
Question:		Given the NTG surveys were completed several months, and in some cases over a year, after the project was completed, how did the NTG results take into account the influence of that delay on survey responses?
Answer:		For the Palm Desert and Non-Resource programs, if a customer did not recall the measure, they were dropped from the analysis and thereby not 'penalized' for any length of time between project completion and survey effort. The CCC and UCCSU projects were large and respondents recalled all measures in question.
LGP46	**PG&E Company**	**NTG**
Question:		Please provide the dates when each NTG phone survey was completed.
Answer:		Please see the attached file entitled "NTG Survey and Project Dates Palm, CCC, UCCSU.xlsx" for a detailed accounting of project dates and survey completions.
LGP47	**PG&E Company**	**NTG**
Question:		Given the program influence in setting overall university system policies regarding energy efficiency, should the program receive spillover credit for projects completed due to these policies? Would this create a new baseline or attributed to Market Transformation?
Answer:		The policy is to not count spillover in 2006-2008. See Finding of Fact 27 of D. 05-04-051, "27. The speculative nature of any attempts to quantify spillover effects significantly reduces their applicability as an analytical tool at this time. Moreover, discounting the accounting of free-ridership through “spillover,” as PG&E proposes, would make it particularly difficult to attribute indirect program benefits to education and information programs, without double-counting those benefits. "
LGP48	**PG&E Company**	**NTG**
Question:		Please provide more detail on the NTG sampling results. From the detail given in the report, it appears that questions were not posed to the proper individuals or decision makers. If the right individuals were not addressed, the NTG will be flawed. Because that level of detail was not included in the report, more detail is being requested. Were the questions asked to the proper individuals in the sampling plan?
Answer:		Detail concerning the NTG survey efforts and sampling plans are included in Appendix D for UC/CSU and Appendix F for CCC. These appendices explain the “Standard – Very Large” protocol standards followed, and results of interviews with utility program managers, facility site managers, campus energy managers, and university system representatives and committee members. These interviews revealed the decision-making processes and decision-makers. The NTG sample target corresponded directly with the impact sample. However, NTG surveys were completed for a subset of the direct impact sample due to non-response. For UC/CSU, surveys were completed for eighteen projects, whereas for CCC, surveys were completed for ten projects.
LGP49	**PG&E Company**	**Project Values**
Comment:		Many issues related to NTG and realization rates could have been better refined and reported if evaluators and the IOU project managers had been more collaborative. We recommend that there be greater collaboration in future evaluations to minimize confusion regarding reported project savings values.

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Response:		We believe that any issues associated with NTG or realization rates have been fully addressed in responses to other comments.
LGP50	**PG&E Company**	**Report Values**
Question:		Using data resulting from data request PGE-ED_013, we have determined that evaluators used incorrect figures for Ex-Ante (Claimed) Net Savings for the CCC projects. In the CCC projects, the evaluator typically used the project application (PA) figures for the Ex Ante numbers. In most cases, the Ex Ante numbers that are used in the Impact Evaluation are overstated, thus reducing our realization rates. Could you please correct the Ex-Ante values accordingly?
Answer:		All calculations of realization rates for CCC were based on ex ante claimed savings as reported in IOU Filed Savings Claims. Consequently, calculated realization rates are not inflated. Project application values were included in first drafts of site reports, but are being replaced with IOU Filed Savings Claims values in final edited versions of site reports.
LGP51	**PG&E Company**	**Project Values**
Comment:		Reviewer used Project Application values that assumed completion of all 13 buildings submitted for implementation. The Reviewer did not take into account the actual number of projects completed. The original Project Application contained 13 buildings. Only 8 of those buildings were completed. This type of evaluation will result in inflated ex –anted numbers as well as flawed realization rates.
Response:		All calculations of realization rates for CCC were based on ex ante claimed savings as reported in IOU Filed Savings Claims. Consequently, calculated realization rates are not inflated. Project application values were included in first drafts of site reports, but are being replaced with IOU Filed Savings Claims values in final edited versions of site reports.
LGP52	**PG&E Company**	**Project Values**
Comment:		Reviewer used Project Application values which used the number submitted and not the actual projects completed. In practicing this methodology the realization rates are flawed and ex ante numbers are inflated.
Response:		All calculations of realization rates for CCC were based on ex ante claimed savings as reported in IOU Filed Savings Claims. Consequently, calculated realization rates are not inflated. Project application values were included in first drafts of site reports, but are being replaced with IOU Filed Savings Claims values in final edited versions of site reports.
LGP53	**PG&E Company**	**Non PY06-08 Savings**
Question:		How will the results of these 2006-08 impact evaluation reports be applied across the board to the Partnership Programs (retrofit and/or retrocommissioning)? Will the results be taken from a statewide perspective or will each IOU be given its own NTG and realization rate? How will savings be determined after PY2006-2008 for retrofit projects under the partnership program?
Answer:		The UC/CSU and CCC programs are unique partnerships in that they address only higher education campuses. Results from evaluation of these programs are not transferable to other partnership programs. Realization rates have been developed for each IOU, but the NTG value will be a statewide value. Determination of savings after PY2006-2008 for retrofit projects under the partnership program will be

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		decided when evaluation of PY2010-2012 programs is underway.
LGP54	**PG&E Company**	**Project Values**
Comment:		Reviewer used Project Application values that assumed completion of all 23 buildings submitted for implementation. The Reviewer did not take into account the actual number of projects completed. The original Project Application contained 23 buildings. Only 7 of those buildings were completed. This type of evaluation will result in inflated ex –ante numbers as well as flawed realization rates.
Response:		All calculations of realization rates for CCC were based on ex ante claimed savings as reported in IOU Filed Savings Claims. Consequently, calculated realization rates are not inflated. Project application values were included in first drafts of site reports, but are being replaced with IOU Filed Savings Claims values in final edited versions of site reports.
LGP55	**PG&E Company**	**Project Values**
Comment:		Original calculations for this project assessed 68F° for reheat temperature. However, the reviewer used 60F° for ex post savings calculations. It appears that the report used an assumption of 60F° because that is the industry standard. Since this project is located in San Francisco, this campus operates differently and operates on a standard of 68F°. It appears from reviewing the report that evaluators did not look at the hard data which PG&E believes would have affirmed the higher 68F° assumption justification. A reheat temperature for San Francisco of 68F° is appropriate. The evaluator's revision to 60F° is not warranted and results in a discrepancy in gas savings. The ex post savings calculations should be revised to incorporate the proper 68F° reheat temperature.
Response:		There was no data supplied that confirmed the ex ante reheat temperature. However, since a greater amount of air was being supplied than in the post-installation case, 68 ºF is a reasonable number.The evaluation team has contacted the project representative at UCSF who has confirmed that the library takes 55 ºF air (from outside, return, and cooling depending on the economizer operation and conditions) and supplies 62 ºF air on AHU2 and AHU3, 57.4 ºF air on AHU4, and 63.3 ºF air on AHU5. AHU1 does have a reheat temp of 66.4 ºF, but it was not included in the retrofit.As such, we have recalculated the ex-post savings, using a reheat temperature of 68 ºF in the pre-installation case and the values from the system logs in the post-installation case.The revised therm savings have increased from 70,489 to 126,932, yielding a realization rate of 118%.
LGP56	**PG&E Company**	**Project Tracking**
Comment:		The report states that the “lack of a properly maintained centralized database was responsible for a host of reporting and evaluating complications." This is curious, as a web based project database was employed throughout the program cycle. The database was used by program staff as well as the UC/CSU and CCC campuses to track and maintain project and program performance.. This database includes robust project detail that was continually maintained and updated by program staff and was used for detailed project tracking purposes as well as Management Team reporting. Access to this database was also provided to the reviewers for the M&V analysis.

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Response:		We found that the project database did not always contain comprehensive program data (e.g. project review files, white papers, etc.). Similarly, the project database was not consistent with the Q4 2008 IOU Standard Program Tracking Database.
LGP57	**PG&E Company**	**UC Davis - Absorption Chiller Replacement Project**
Question:		Based on discussions and documentation from the campus, it is clear that without the UC Davis – Absorption Chiller Replacement Project, the campus would not have replaced the chillers and would have continued to run the chillers for at least five more years. Can the measure baseline be revised to consider this documentation that the unique sector and project details vary from standard EUL assumptions?
Answer:		In cases where there was uncertainty in a project's baseline classification, the evaluation team considered both the EUL and interview responses with campus staff regarding the nature of the replacement. In the case of the UC Davis Centrifugal Chiller Retrofit, two key sources of information were used to confirm the baseline, with the following prioritization: 1.) Interviews with Campus staff and Project Representatives 2.) EUL The evaluation team also reviewed the NRR-DR Procedures Manual (2009 Nonresidential Retrofit - Demand Response (NRR-DR) Procedures Manual, Pacific Gas and Electric Company, November 18, 2009) and found the following eligibility requirements for fuel substitution and early retirement measures: "Fuel substitution (fuel switching) measures involve retrofit projects where all or a portion of the existing energy use is converted from one commodity to another, e.g., “electricity to natural gas.” Standard baselines are determined based on the applicable federal or state mandated energy performance (i.e. California’s Title 24, Federal Title 10, NEMA, EPACT, etc.). In the absence of government standards, current industry practices are used to establish baseline performance. Incentives are paid on the energy savings above and beyond the baseline standard... 1.4.7 Early Retirement Feature "This program feature is designed to accelerate the retirement of older, less efficient equipment with high efficiency replacements. Measures that are eligible for this feature are subject to an expanded definition of energy savings resulting in a larger incentive than would be possible using the traditional Calculated Approach. This approach can be applied to air conditioning units (packaged AC, heat pumps and chillers) and electrical motors with five or more years of remaining useful life" The IOU comments prompted the evaluation team to confirm our earlier discussions with the UC Davis Project Representative. During our conversation on 1/20/2010, he indicated that, in the absence of the program, they would have implemented the project on their own within five years, providing an indication that the project did not in fact have "five or more years of remaining useful life." Collectively, these resources were used to make an informed decision on each project's baseline classification.
LGP58	**PG&E Company**	**UC Davis - Absorption Chiller Replacement Project**
Question:		Regardless of measure baseline considerations, the UCD chilled water system (UC Davis – Absorption Chiller Replacement Project) uses less gas today than it did prior to Partnership involvement. Given this simple fact, isn't the zero therm savings for the measure incorrect?
Answer:		The baseline for normal replacement measures are defined to be the Title 24 equivalent of the technology installed. In this case, the Title 24 equivalent would be a centrifugal chiller, yielding no gas savings.

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LGP59	**PG&E Company**	**Logger Sampling Period**
Question:		For cross campus interior and lighting projects, loggers were put in place beginning in May 2009 and removed beginning in September 2009 when colleges are out of session or on limited schedules. Please provide detail on whether, and how, these data were modified to account for the higher lighting demands at other times of the year due to seasonality and greater facility use during the normal school year.
Answer:		The logging effort successfully captured operating characteristics for every academic session type (full, partial, and no-session periods). The findings from each session were extrapolated to each campus' unique academic calendar to estimate annual hours of use. It should be noted that a total of 444 lighting loggers were deployed across seven campuses over the span of five months. Within this time frame, the evaluation team captured, at a minimum, one month of lighting occupancy characteristics for each of the academic session types to inform the analysis.
LGP60	**PG&E Company**	**Therm Sampling**
Question:		The "UCD – Centrifugal Chiller Retrofit" project (under the UC/CSU Partnership program) accounted for half of the sample's therm savings. The report stated the project was incorrectly characterized as a retrofit in the project application, resulting in over the majority of therm savings for PG&E being discounted. We are concerned that, given this project's minimal therm savings and the fact that this project constituted a large amount of the UC/CSU sample, that it is not representative of the rest of the projects. Was there additional sampling conducted to determine if the project could be considered as representative of the rest of projects providing therm savings? Wouldn't it be more appropriate to put this project in its own strata?
Answer:		The UCD - Centrifugal Chiller Retrofit savings were classified in a unique stratum. Please see the attached document titled (UC_CSU - Precision Calculations.xlsx).
LGP61	**PG&E Company**	**Project Values**
Comment:		Original calculations for this project assessed 68F° for reheat temperature. However, the reviewer used 60F° for ex post savings calculations. It appears that the report used an assumption of 60F° because that is the industry standard. Since this project is located in San Francisco, this campus operates differently and operates on a standard of 68F°. It appears from reviewing the report that evaluators did not look at the hard data which PG&E believes would have affirmed the higher 68F° assumption justification. A reheat temperature for San Francisco of 68F° is appropriate. The evaluator's revision to 60F° is not warranted and results in a discrepancy in gas savings. The ex post savings calculations should be revised to incorporate the proper 68F° reheat temperature.

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Response:		There was no available data supplied that confirmed the ex ante reheat temperature. However, since a greater amount of air was being supplied than in the post-installation case, 68 ºF is considered to be a reasonable estimate and will be used in the analysis. The evaluation team has contacted the project representative at UCSF who has confirmed that the library takes 55 ºF air (from outside, return, and cooling depending on the economizer operation and conditions) and supplies 62 ºF air on AHU2 and AHU3, 57.4 ºF air on AHU4, and 63.3 ºF air on AHU5. AHU1 does have a reheat temp of 66.4 ºF, but it was not included in the retrofit. As such, we have recalculated the ex-post savings, using a reheat temperature of 68 ºF in the pre-installation case and the values from the system logs in the post-installation case. The revised therm savings have increased from 70,489 to 126,932, yielding a realization rate of 118%.
LGP62	**PG&E Company**	**Peak Savings**
Question:		Based on CPUC peak savings methodology, educational systems are to use the three hottest occupied days to determine the peak period. Shouldn't this peak definition be applied in the UC/CSU and CCC Partnership programs?
Answer:		The college campuses evaluated are active/occupied throughout the entire year, except for holidays. As such, the CPUC peak savings methodology is accurate.
LGP63	**PG&E Company**	**Lighting Loads**
Question:		In Figure 7 - Laboratory Weekday Load Profile - Why is the partial session lower than no session? How does this affect savings results for laboratory spaces?
Answer:		As expected, the occupancy characteristics of the laboratory space are relatively consistent, regardless of session type, because of year round academic research. The difference in operating characteristics between the no session and partial session period are very small and can be attributed to margin of error in the analysis.
LGP64	**PG&E Company**	**M&V Protocol**
Question:		Were the sample projects listed in the Table 1 monitored, per the M&V Plan?
Answer:		Yes, the projects listed in Table 1 were monitored, per the M&V Plan.
LGP65	**PG&E Company**	**NTG**
Comment:		Conclusions drawn from the comments captured during the interview do not appear to weigh heavily in the NTG methodology. Section 4 starting on page 20 describes the NTG evaluation protocol. This protocol seems to result in a bias toward low NTG by artificially "discounting" Program Influence scores by a factor of 50% if program participants stated that they had considered the energy efficiency projects before they heard about the Partnership program. As stated in the participant interviews, some campuses had considered energy projects resulting from earlier utility energy efficiency rebate programs and only made the final decision based on the enhanced rebates provided by the Partnership. Customers who learned about the benefits of energy efficiency from similar, but earlier utility programs should not be counted as free-riders. The NTG scoring should be corrected accordingly.

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Response:		The algorithm has been approved by the NTG Working Group. This is taken from Appendix F: "A Program Influence score that captures the perceived importance of the program (whether rebate, recommendation, training, or other program intervention) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to both the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents say they had already made their decision to install the specific program qualifying measure before they learned about the program." Therefore, even if the customer had decided to install the measure based on a previous recommendation, they would still be given some free-ridership if had made this decision to install before they learned about the Program.
LGP66	**PG&E Company**	**Report Values**
Question:		Please explain the discrepancies between values found in the body of the report and values pulled from the appendix calculations. For many projects in the CCC partnership evaluation, savings values in the Appendix do not match values reported in body of the report.
Answer:		All calculations of realization rates for CCC were based on ex ante claimed savings as reported in IOU Filed Savings Claims. The savings values and realization rates reported in the body of the report are based on the IOU Filed Savings Claims savings values. Project application values were included in first drafts of site reports, but are being replaced with IOU Filed Savings Claims values in final edited versions of site reports. Savings values will then be consistent between body of report and appendix.
LGP67	**PG&E Company**	**Project Values**
Question:		Appendix G indicates only 464,802 kWh claimed by PG&E for lighting related savings at CCC Evergreen Valley College – Occupancy Controls for Lighting, while the report and results state 1,209,994 kWh claimed. Does the reported value consist of a combination of other projects, not just lighting?
Answer:		Expected savings from lighting occupancy sensor savings equal 1,209,994 kWh. The notation in Appendix G has been corrected to reflect this.
LGP68	**PG&E Company**	**Project Values**
Question:		There was no documentation in Appendix G explaining or supporting how the reviewer calculated evaluated savings for CCC Diablo College, nor is there explanation of the discrepancies between claimed and verified savings. Please provide this information.
Answer:		Documentation and data used for calculating savings for CCC Diablo Valley College were provided in Excel file EEGADR_1188_CCC_RESPONSE.3628.xls, submitted in response to PG&E Data Request PGE-ED_010 of December 22, 2009.
LGP69	**PG&E Company**	**Project Values**
Question:		There was no documentation in appendix explaining or supporting how the reviewer calculated evaluated savings for CCC San Jose City College, nor is there explanation of the discrepancies between claimed and verified savings. Would you please provide this information?
Answer:		Documentation and data used for calculating savings for CCC Diablo Valley College were provided in Excel file EEGADR_1188_CCC_RESPONSE.3628.xls, submitted

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		in response to PG&E Data Request PGE-ED_010 of December 22, 2009.