Government Partnerships Programs Direct Impact Evaluation Report

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ABSTRACT

This report describes the evaluation activities related to the Local Government Partnerships (LGP) evaluation contract for the 2006-2008 program cycle. Originally, as defined in the research plan posted to Energy Division's Public Download Area on www.energydataweb.com/cpuc on May 10, 2008, the LGP evaluation was intended to cover 49 resource acquisition and seven non-resource programs operating during the 2006 – 2008 program cycle. During the 4th quarter of 2008, at the request of Energy Division, the LGP research team was directed to refocus their research on a number of evaluation activities consistent with ED's focus on High Impact Measures (HIMs). This report therefore summarizes the impact evaluation activities related to following subset of partnerships: the University of California, California State University (UC/CSU) Partnership Program, the California Community Colleges (CCC) Partnership Program, and the Palm Desert Partnership Program.

This report describes estimated gross realization rates and net-to-gross ratios for *retrofit* measures in the UC/CSU Partnership Program, which includes the following four programs: PG&E 2036, SCE 2530, SCG 3520, and SDG&E 3026. This report also describes estimated gross realization rates and net-to-gross ratios for the entire CCC Partnership Program, which includes the following programs: PG&E 2018, SCE 2526, SCG 3518, and SDG&E 3001. Finally, this report describes the evaluation activities related to Palm Desert Partnership Program SCE 2566. The measures evaluated in this program include: early retirement of residential air conditioners, refrigerant charge and airflow (RCA) adjustment for both residential and commercial refrigerators. Installation rates were estimated for residential and commercial RCA. Installation rates and unit energy savings were estimated for early retirement of residential air conditioners. Additionally, net-to-gross ratios were calculated for each of the three measure categories evaluated.

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4 EXECUTIVE SUMMARY

This report describes the evaluation activities related to the Local Government Partnerships (LGP) evaluation contract for the 2006-2008 program cycle. Originally, as defined in the research plan posted to Energy Division's Public Download Area on www.energydataweb.com/cpuc on May 10, 2008, the LGP evaluation was intended to cover 49 resource acquisition and seven non-resource programs operating during the 2006 – 2008 program cycle. During the 4th quarter of 2008, at the request of Energy Division, the LGP research team was directed to refocus their research on a number of evaluation activities consistent with ED's focus on High Impact Measures (HIMs). This report therefore summarizes the impact evaluation activities related to following subset of partnerships: the University of California, California State University (UC/CSU) Partnership Program, the California Community Colleges (CCC) Partnership Program, and the Palm Desert Partnership Program.

Results from Evaluation of UC/CSU Partnership Program.

This report provides results of an evaluation of the University of California/California State University (UC/CSU) Partnership program, which consists of PG&E 2036, SCE 2530, SDG&E 3026, and SCG3520. This evaluation focused on only the retrofit projects in these programs, as the retro-commissioning projects were evaluated separately as part of the statewide High Impact Measure (HIM) analysis conducted by SBW. Thus, all results presented herein for UC/CSU are specific only to retrofit projects. The results for gross realization rates, by IOU and fuel type, are provided below in Table 4-1.

Table 4-1. Evaluation Summary, UC/CSU Partnership[1]

Program	Fuel Type	*ex ante* Gross Savings	*ex post* Gross Savings	Gross Realization Rate
PGE2036	kW	3,940	4,571	116%
	kWh	29,361,194	32,297,313	110%
	Therms	3,128,902	1,846,052	59%
SCE2530	kW	2,904	1,103	38%
	kWh	21,277,596	12,128,230	57%
	Therms	342,276	N/A	N/A
SCG3520	Therms	627,613	389,120	62%
SDGE3026	kW	2,950	324	11%
	kWh	14,442,410	5,776,964	40%
	Therms	231,395	249,184	108%

In addition to estimating gross savings, this evaluation also included estimation of the net-to-gross (NTG) ratio for the entire UC/CSU partnership. The NTG ratio includes only the effect of free ridership and does not include the benefits of spillover, as directed by CPUC's Engineering Division (ED). Free-ridership and NTG ratios are provided below for the entire UC/CSU partnership and thus represent values that are applied to each IOU's program, as this program was jointly and collaboratively administered. NTG results are provided below.

[1] Retrofit Projects Only, Excludes Retro-Commissioning Projects

Table 4-2. Net-to-Gross (NTG) Results for UC/CSU Partnership

Savings Type	% Free Riders	NTGR % (1-%FR)
kWh	31%	69%
kW	25%	75%
Therms	28%	72%

Results from Evaluation of California Community Colleges (CCC) Partnership Program

This report provides results of an evaluation of the California Community Colleges (CCC) Partnership program, which consists of PG&E 2018, SCE 2526, SDG&E 3001, and SCG3518. The results for gross realization rates, by IOU and fuel type, are provided below in Table 4-3.

Table 4-3. Evaluation Summary, CCC Partnership

Program	Type of Savings	Total Gross Claimed Savings	Total *ex post* Gross Evaluated Savings	Gross Realization Rate
PG&E – 2018	kWh	10,616,600	8,351,277	79%
	kW	2,475	1,466	59%
	Therms	487,280	366,487	74%
SCE – 2526	kWh	24,551,989	15,267,383	62%
	kW	8,327	3,308	40%
SDG&E – 3001	kWh	4,832,953	1,983,307	41%
	kW	910	381	42%
	Therms	38,853	32,187	83%
SCG – 3518	Therms	355,075	275,681	78%

In addition to estimating gross savings, this evaluation also included estimation of the net-to-gross (NTG) ratio, which is provided below for the entire UC/CSU partnership, as this program was jointly and collaboratively administered.

Table 4-4. NTG Results for CCC Partnership Program

Savings Type	% Free Riders	NTGR % (1-%FR)
kWh	33%	67%
kW	31%	69%
Therms	33%	67%

Results from Evaluation of Palm Desert Partnership Program

The Palm Desert Partnership program consists of SCE 2566 and SCG 3543. However, since *ex ante* savings for SCG 3543 were very small, this evaluation focused on the SCE 2566 program and did not evaluate any projects in the SCG 3543 program. Evaluation of SCE 2566 further focused on estimation of realization rates for three key measures: early retirement of residential air conditioners, refrigerant charge and airflow for residential refrigerators, and refrigerant charge and airflow for commercial refrigerators.

Residential Early Retirement

The results of the modeling exercise showed the following verified gross unit savings for improvement from an early retirement of existing equipment and replacement with high efficiency equipment:

Table 4-5. *ex post* Unit Energy and Demand Savings and Tons/Unit[2]

Measure Category	Unit Energy Savings (kWh/ton)	Peak Demand Savings (kW/ton)	Tons Installed per Claimed Units
Early Retirement (Existing up to Code)	326	0.21	3.73
High Eff. Equip. (Code up to High Eff.)[3]	68	0.03	3.73
Total	394	0.24	3.73

These gross energy and demand savings and verified tons applied to the sample frame to derive the following realization rates.

Table 4-6. Derivation of Gross Savings Realization Rates[4]

	kWh	kW
ex ante Sample Gross Savings	34,946	22
ex post Sample Gross Savings	60,302	37
Gross Realization Rate[5]	173%	169%

Residential RCA

Table 4-7 summarizes the findings for the residential RCA verification analysis.

Table 4-7. Residential RCA Verification Rates

Sampled *ex ante* quantity (tons)	Sampled *ex post* quantity (tons)	Quantity-based Verification Rate
92.5	9	10%

[2] The savings database for Palm Desert contains numerous apparent errors in association with these measures. The quantity field is supposed to be tons, but it actually indicates the number of units installed in conjunction with the measure. Multiplying the claimed units times the claimed unit savings does not give the claimed savings. It appears that different constant deemed savings values were used instead. For this reason, a comparison between *ex ante* and *ex post* unit savings would create significant confusion, so it is being left out of this report.

[3] The savings in this row should only be applied to high efficiency equipment installations that happened in conjunction with an early retirement. The field sample provides sufficient precision at the total level, but not when disaggregated into the high efficiency equipment portion.

[4] The realization rate can be derived by multiplying the installation rate (Quantity of Tons Installed per Claimed Units) by the UES realization rate. Errors in the claimed number of units drive the high installation rate and high realization rate. The UES realization rates were actually lower (0.454 for kW and 0.462 for kWh).

[5] These gross realization rates are for illustrative purposes only. The verified tons per claimed unit and unit savings are used to calculate savings for this portion of the program.

The very low verification rate for residential refrigerant charge and airflow can be traced to problems in four different areas:

1. Refrigerant charging was not documented on the majority of units. An attempt was made to use a change in-refrigerant pressures on the installation forms as an indication that a charge was made.
2. Multiple units in the sample (3/22) had been replaced within a year of the program RCA visit.
3. Multiple units in the sample (2/22) had received significant repairs including a refrigerant charge adjustment within a year of the program RCA visit.
4. 75% of tons tested on site did not have proper charge, for a variety of reasons.

Commercial RCA

Table 4-8 summarizes the findings for the commercial RCA verification analysis. This low verification rate (4%) is the result of insufficient documentation of refrigerant charging having occurred and a low percentage of units passing having the correct refrigerant charge when tested on site.

Table 4-8. Commercial RCA Verification Rates

Sampled *ex ante* quantity (tons)	Sampled *ex post* quantity (tons)	Quantity-based Verification Rate
138.4	6	4%

In addition to the gross estimates for Palm Desert provided above, NTG ratios (net of free-ridership) were also estimated by measure category. Results of the NTG analysis are provided below in Table 4-9.

Table 4-9. Measure-Specific NTG Ratios for the Palm Desert Program

Measure	Residential	Commercial
RCA	0.76	0.70
Early Retirement (ER)	0.74	NA
Other Measures (excluding RCA and ER)	0.69	0.85

5 INTRODUCTION AND PURPOSE OF STUDY

The Government Partnerships Programs (LGP) Indirect and Direct Impact Evaluation project began in August 2007 was initially intended as an evaluation of 49 resource acquisition and seven non-resource programs operating during the 2006 – 2008 program cycle. During the 4th quarter of 2008, at the request of Energy Division, the LGP research team was directed to refocus their research on HIM evaluations and evaluations of the gross and net[6] savings for a limited number of partnership programs. Because the programs being evaluated also contain measures that were being evaluated by other contract groups as part of the HIM research effort, the LGP contract group is not reporting total *ex post* program level savings, but rather *ex post* savings and realization rates for only a select subset of measures. During the 1st and 2nd quarters of 2010, ED will be combining the results of this evaluation with other HIM research and evaluations in order to provide program level *ex post* savings values and realization rates. The programs evaluated and activities reported in this study include;

- **University of California, California State University (UC/CSU) Partnership;** Gross and net savings estimates for retrofit activity within the SDG&E, SCE, SCG, and PG&E service territories is reported. The UC/CSU program also had significant retro-commissioning activity completed during this program cycle that has been evaluated by the statewide retro-commissioning evaluation contract. The realization rate for the retro-commissioning activity will be reported separately by that contract group. During the 1st and 2nd quarters of 2010, ED will be combining the results of these 2 studies (retrofit and retro-commissioning), and additional HIM research, in order to provide program level *ex post* savings values and realization rate.
- **California Community Colleges (CCC) Partnership;** Gross and net savings estimates for retrofit activity completed within the SDG&E, SCE, SCG, and PG&E service territories are reported. The CCC program also had retro-commissioning activity and, similar to the UC/CSU partnership program, ED will be combining the results of this study with various other evaluation activities to provide program level *ex post* savings values and realization rate.
- **Palm Desert Partnership Pilot Program;** Gross and net savings estimates for early retirement (ER) of residential HVAC systems, and commercial and residential refrigerant charge adjustment (RCA) activity undertaken by the Palm Desert Partnership operating within the SCE and SCG service territories. These measures represented approximately 19% of reported program *ex ante* kWh savings, but represent special importance to Palm Desert because of the program is operating exclusively in climate zone 15, where these measures should provide significant savings, and also because these measures present a higher level of performance uncertainty. Other measures that make up a greater percentage of program *ex ante* savings, such as commercial CFL installations, are being reported through HIM research activity being undertaken by other contract groups. During the 1st and 2nd quarters of 2010, ED will be combining the results of this evaluation and these HIM studies to provide program level *ex post* savings values and realization rate. This study also provides a program level net-to-gross ratio.

The LGP contract also completed additional research which is being reported through other contract groups or as standalone reports. These research activities, discussed briefly in section 5.1 'Description of EM&V Activities and Results Contained in this Report', are being reported as follows;

[6] The net-to-gross (NTG) research includes only the effects of free ridership and does not include the benefits of spillover.

- Additional research completed under this contract for which research summaries have been provided in the appendix include;
    - High Impact Measure Evaluation Support
        - Linear Fluorescent Pre-post Metering
        - Residential Furnaces Post Metering
    - High Impact Measure Evaluation
        - Pre-rinse Spray Valves
- Additional research completed under this contract that will be submitted under separate report covers include;
    - Strategic Planning Support to help gain a better understanding of how local governments can be most effective at delivering substantial, comprehensive, and long-lived energy savings
    - An evaluation of non-resource activity undertaken by LGP programs to identify and measure indirect impacts that are the result of marketing and outreach, educational, and program referral activities (non-resource program activities)
    - A process evaluation of the SCE and SCG Palm Desert Partnership Pilot Program.

Section 5.1 provides a summary of the research activity referenced above.

5.1 Description of EM&V Activities and Results Contained in this Report

5.1.1 Evaluation of LGP Non-resource Activity

The evaluation of the LGP non-resource activity is intended to identify and measure indirect impacts that are the result of marketing and outreach, educational, and program referral activities (non-resource program activities). The Summit Blue team, along with PA Consulting, estimated the impacts from these Non-Resource programs. The team indentified and prioritized five types of non-resource activities:

1. Referrals (local government partnerships targeted specific customers or indirectly promoted to groups of customers the direct-install components of LGP, other energy efficiency programs offered by the utilities, third-party energy efficiency programs, and other local community initiatives to improve energy efficiency of local businesses and households)
2. Audits (energy assessments and audits)
3. Trainings (education through activities including print materials, centers, events)
4. Outreach (direct interactions with the public , information booths at local fairs, short training/information sessions)
5. Long-term/Strategy (these included efforts to affect codes and standards, capacity building efforts including building knowledge and awareness within government agencies)

Over 350 surveys of customers were completed (200 local businesses and 150 residential households). Results from the Non-Resource evaluation will be presented in a stand-alone report titled "*Effectiveness and Impacts for Non-Resource Activities by the CPUC Government Partnerships programs for the 2006-2008 Program Years*".

5.1.2 High Impact Measure Evaluation Support

Linear Fluorescent Pre-post Metering

Summit Blue was retained by Itron at the direction of the ED to conduct field M&V in support of Itron's evaluation of C&I linear fluorescents, high bay fixtures, and occupancy sensors. The major objectives of the field work include:

1. Conduct a pre-post lighting logger study to collect primary energy use data for C&I linear fluorescent fixtures, high bay fixtures, and occupancy sensors to support an estimate of mean lifetime avoided cost savings associated with installing each of these three HIMs, measured with a high level of confidence.
2. Collect contextual data about sites in the sample, including the equipment type, wattage, operating schedules, how prior equipment was used, an assessment of the likely wattage of prior equipment, and a freeridership assessment.
3. Collect primary energy use data to support development of hourly (8,760) load shapes for each HIM, for a number of key market segments, and for a number of space types within each market segment.

Results for the activities undertaken by the LGP evaluation team in support of the Linear Fluorescent Pre-post Metering project will be presented in Appendix A, HIM Research Support Summary.

Residential Furnaces Post Metering

Summit Blue was retained by Cadmus and RLW to conduct field M&V in support of Cadmus' evaluation of high-efficiency residential gas furnaces. The three major objectives of the field work include:

1. Collect primary data regarding therm usage of 90+ AFUE furnaces installed under CPUC programs.
2. Collect primary data regarding electricity usage of VSD blower motors installed under CPUC programs.
3. Collect contextual data about residences in the sample, including basic home information and cooling system data.

Results for the activities undertaken by the LGP evaluation team in support of Residential Furnaces Post Metering project will be presented in Appendix A, HIM Research Support Summary.

5.1.3 High Impact Measure Evaluation

Pre-rinse Spray Valves

Summit Blue reviewed the energy savings claims from low-flow pre-rinse spray valves (PRSV) and developed a measure and verification methodology to refine savings estimates on PRESV installation. The following issues were addressed in this methodology:

1. A review of previous studies on PRSV impacts to identify areas of refinement.
2. Possible areas of improvements in the past evaluations and the justification for the need of a new study.
3. An overview of the technical methodology that will be used to arrive at annual savings values.
4. An overview of the various site visits and activities that will be carried out in those site visits.

In the course of developing this methodology, Summit Blue reviewed PRSV savings claims in the 2006 – 2008 portfolio and concluded that PRSV claims exceeded 1% of IOU portfolio for only SCG. The team also reviewed the potential for PRSV savings based on plans submitted for the 2009 – 2011 portfolio and determined that only one program planned to install PRSVs. Based on this, it was decided not to pursue an *ex post* evaluation of 2006 – 2008 portfolio PRSV claims. Results for the activities undertaken by the LGP evaluation team in support of Pre-rinse Spray Valve HIM evaluation will be presented in Appendix A, HIM Research Support Summary.

5.1.4 **Strategic Planning Support**

In support of the California Energy Efficiency Strategic Plan (Rulemaking 06-04-010) the LGP conducted research on behalf of the CPUC to help gain a better understanding of how local governments can be most effective at delivering substantial, comprehensive, and long-lived energy savings through market transformation and sustainable system-change within local governmental organizations and communities. The research components included:

1. Identification of successful capacity building structures and operations.
2. Needs assessment for capacity building support.
3. Identification of barriers to building capacity in current approaches in the 2006-08 cycle's approach.

This study will also develop a comprehensive set of recommendations to the CPUC identifying how the capacity of the local governments can be developed. Results for the activities undertaken by the LGP evaluation team in support of the Strategic Plan will be presented in a stand-alone report to be delivered in March 2010.

5.1.5 **Program Evaluations**

A list of the program evaluations included in this report and the parameters estimated is described in Table 5-1.

Table 5-1. LGP Contract Group Program Specific Evaluations – Parameters Estimated

Evaluation Methods	Verification	Gross Savings	Net Savings	
	On-Site Audits, Spot Checks, Documentation Review and Analysis	Field Measurement and Calibrated Modeling	SRA Approach for Res. and Small Bus.	Large Non-Res NTG Method
Report Section	Parameters Estimated in this Report			
6. Evaluation of UC/CSU Partnership Program				
Custom HVAC, Excluding RCx (Statewide)	Realization Rate	Realization Rate		
Custom Lighting (Statewide)	Realization Rate	Operating Hours by Space Type		
Overall CCC Results, Excluding RCx (Cross-IOU)				NTG Ratio
IOU Level Results, Excluding RCx for each UC/CSU Program	Realization Rate	Realization Rate		
7. Evaluation of CCC Partnership Program				
Custom HVAC	Realization Rate	Realization Rate		
Custom Lighting	Realization Rate	Operating Hours by Space Type		
Overall CCC Results (Cross-IOU)				NTG Ratio
IOU Level Results for each CCC Program	Realization Rate	Realization Rate		
8. Evaluation of Palm Desert Partnership Program				
Residential Refrigerant Charge Adjustment	Verification Rate	Realization Rate	NTG Ratio	
Residential Early Retirement of A/C Units	Verification Rate	Unit Energy Savings, Realization Rate	NTG Ratio	
Commercial Refrigerant Charge Adjustment	Verification Rate	Realization Rate	NTG Ratio	
Program Level Results			NTG Ratio	
Residential Results (All measures)			NTG Ratio	
Commercial Results (All measures)			NTG Ratio	

5.2 Rationale for EM&V Activities

The rational for the evaluations of the UC/CSU and CCC programs included;

1. These 2 programs represent a discrete institutional market sector with several important attributes;
    a. Collectively they represent substantial statewide system loads
    b. The campuses included measures that have some performance uncertainty, and also occur with greater frequency than other sectors, such as a higher occurrence of central plants and distribution systems involving multiple buildings, steam trap retrofits, and retro-commissioning activity.
    c. This sector is represented in the DEER database and this evaluation provided an opportunity to refine assumptions in DEER, such as the campus space type definitions and lighting load shape assumptions.
2. Concerns had been expressed by the Energy Division technical advisors about the net-to-gross assumptions in program planning and this evaluation presented the opportunity to refine net-to-gross research on these programs.
3. The UC/CSU and CCC programs represented a significant portion of the 2006 – 2008 LGP programs portfolio. These programs accounted for approximately 29% of the total budget allocation, 30% of projected kW savings, and 52% of projected LGP portfolio therm savings.

The rational for the evaluations of the Palm Desert program included;

1. The Palm Desert program operates exclusively within climate zone 15 and the early retirement (ER) of residential HVAC systems, and commercial and residential refrigerant charge adjustment (RCA) measures installed by the program present a high level of performance uncertainty. This evaluation presented an opportunity to address this uncertainty and also contribute to the broader HIM research into these measures.
2. The Palm Desert program was designed as a pilot program, intended to implemented innovative measures and delivery strategies. This impact evaluation, coupled with the process evaluation referenced earlier, provides a platform to assess the innovative nature of the pilot program design and inform future decisions on program design and funding.

5.3 List of Programs Included in this Evaluation

An overview of the program evaluations included in this report is described in Table 5-2. The evaluation of these programs included a public review and comment period. Responses to public comments are provided in Appendix I and have also been incorporated in the body of this report when appropriate.

Table 5-2. Overview of Programs Included in the LGP Contract Group Evaluation

Programs Included in this Evaluation	Program Description	Key Program Elements
University of California, California State University Partnership: PGE 2036, SCE 2530, SCG 3520, SDGE 3026	The University of California, California State University (UC/CSU) Energy Efficiency Partnership is a statewide partnership among UC/CSU and the four IOUs (SCE, SDG, SCG, and PG&E).	The UC/CSU Partnership Program has a broad range of participating projects ranging from Total Air Balancing to Lighting Retrofits.
California Community Colleges Partnership: PGE 2018, SCE 2526, SCG 3518, SDGE 3001	CCC/IOU Energy Efficiency Partnership is a partnership among the California Community Colleges (CCC) and the four IOUs (SCE, SDG, SCG, and PG&E).	The CCC/IOU Partnership will include the implementation of retrofits, new construction, and retro-commissioning (RCx)/monitoring-based commissioning (MBCx) projects. The Partnership will also focus its efforts on training and education, which will leverage existing vocational education programs, while training faculty and staff on best practices, on energy-efficient technology implementation, and energy management.
Palm Desert Partnership: SCE 2566	This program is collaboration of the City of Palm Desert, The Energy Coalition, SCG and SCE.	This evaluation focuses on Residential Early Retirement and Residential/Commercial Refrigerant Charge and Airflow measures. Additionally, only the SCE portion of the program was evaluated due to low *ex ante* savings in the SCG program.

6 Evaluation of the UC/CSU/IOU Energy Efficiency Partnership Program

The University of California / California State University (UC/CSU) Energy Efficiency Partnership is a statewide non-residential program designed to achieve immediate, long-term peak energy and demand savings and establish a permanent framework for sustainable, comprehensive energy management programs. Through the 2006 – 2008 program cycle, the partnership continued to offer incentives for retrofit projects, Monitoring Based Commissioning (MBCx), and educational training for campus energy managers. The four participating IOUs included:

- Pacific Gas & Electric: PGE2036
- Southern California Edison: SCE2530
- San Diego Gas & Electric: SDGE3026
- Southern California Gas: SCG3520

Table 6-1 identifies the expected program achievements by IOU as stated in the individual Program Implementation Plans (PIP). Overall, the projected 2006-2008 program savings across all participating IOUs was 72,810,112 kWh, 18,233 kW, and 2,817,154 Therms, with an aggregate program budget of $32,367,189.

Table 6-1. Projected Achievements of the 2006 – 2008 UC/CSU/IOU Energy Efficiency Partnership Programs

Program ID	Project Partnership Budget	Projected kWh Savings	Projected kW Savings	Projected Therm Savings
PGE2036	$16,476,217	43,229,000	12,603	1,490,652
SCE2530	$6,830,972	17,440,000	3,670	0
SCG3520	$3,060,000	0	0	856,800
SDGE3026	$6,000,000	12,140,778	1,956	469,704

The participating IOUs implemented the partnership program with the goal of extending the reach and effectiveness of traditional utility programs by using the UC and CSU system communication and outreach channels to achieve broad penetration of energy efficiency services in the local campuses. The IOUs expected to engage the UC and CSU systems as strategic partners to help reach campus end-use customers through partnership activities and as channels for the IOUs' other energy efficiency and demand reduction programs.

6.1 Evaluation Objectives for the UC/CSU/IOU Energy Efficiency Partnership Program

The evaluation of the 2006-2008 UC/CSU/IOU Energy Efficiency Partnership Programs aimed to characterize program level savings, along with how effectively the programs functioned. Evaluation activities included:

- Determining the impacts of all ***retrofit projects***[7] on gross annual program energy and peak demand, while accounting for interactions among them.
- Establishing post-implementation performance profiles for program measures and activities.
- Accounting for the energy and peak-demand effects of free-ridership and spillover on program performance.
- Explaining discrepancies between the results of this study and the *ex ante* savings estimated by IOUs.

Per the California Energy Efficiency Evaluation Protocols,[8] the Protocol-Guided Direct evaluation approach was adopted for this study. The corresponding level of rigor for various evaluation components are identified in Table 6-2 below:

Table 6-2. Levels of Rigor for Evaluation of the 2006 – 2008 UC/CSU/IOU Energy Efficiency Partnership Programs

Program ID	Program Name	Level of M&V	Energy Rigor	kW Rigor	NTG Rigor
PGE2036	UC/CSU/IOU Energy Efficiency Partnership	Full Impact	Enhanced	Basic	Standard
SCE2530	UC-CSU-PG&E-SCE-SCG-SDG&E Partnership	Full Impact	Enhanced	Basic	Standard
SCG3520	UCP4-IOU/UC/CSU Partnership	Full Impact	Enhanced	N/A	Standard
SDGE3026	UCP-IOU/UC/CSU Partnership	Full Impact	Enhanced	Basic	Standard

Evaluation metrics and parameters reported through this study include:

- Gross program savings estimates and realizations rates, by fuel type (i.e., kWh, kW, and Therms), for retrofit projects.
- Statewide Net-to-Gross ratios for retrofit projects.
- Net program savings estimates and realizations rates, by fuel type, for retrofit projects.
- Lighting load shapes, by functional usage area, at the statewide level to inform future DEER updates of the "University" building profile.

The subsequent section provides additional information on the project and measure level evaluation methodologies used to support the calculation of these reporting elements.

[7] Per the Energy Division's directive, MBCx projects were evaluated through the Statewide Retro-Commissioning (RCx) Evaluation Contract Group.

[8] The TecMarket Works Team, California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, April, 2006.

6.2 Methodology and Specific Methods Used for Evaluation of UC/CSU Partnership Program

This section provides a detailed description of the evaluation methodologies used in the impact evaluation of the UC/CSU/IOU Energy Efficiency Partnership Programs. Additional information on project specific evaluation strategies and rationale is provided in Appendix E. Similarly, a more detailed discussion of the sampling methodology and expected/achieved precision levels is provided in Section 6.3. It should be noted that interactive effects were not considered in this evaluation. Further analysis will be conducted to apply factors for interactive effects based on the evaluation results and the method and results will be presented in the Energy Division report.

Table 6-3, below, provides a statistical overview of the projects included through the impact evaluation sample:

Table 6-3. Summary Statistics for the Revised UC/CSU/IOU Impact Evaluation Sample

Statistic	With Expected Demand Savings (kW)	With Expected Electrical Savings (kWh)	With Expected Gas Savings (Therms)
Number of Projects*	18	22	19
Mean Gross Savings Per Project	226	985,008	111,911
Total Gross Energy Savings**	4,067	21,670,166	2,462,032
Gross Savings as a Percentage of All Retrofit Projects	40%	32%	54%

*Total of 32 projects across all four IOUs, 9 of which had both expected electrical and gas savings.

**One Lighting project 34% of *ex ante* electrical savings in the impact evaluation sample. One HVAC project accounted for 50% of the *ex ante* Therm savings in the impact evaluation sample.

6.2.1 Gross Impact Analysis Methods

Methods Used in the M&V Activity

Due to the breadth of custom project applications, coupled with the broad geographic participant range, the impact evaluation of the 2006-2008 UC/CSU/IOU Energy Efficiency Partnership Programs required a host of unique considerations, including:

Custom Evaluation Approaches – This was relevant to the retrofit projects included through each program where it was difficult to establish baseline consumption, post-installation impacts, and/or interactive effects. Custom evaluation approaches were developed through project-specific M&V plans that addressed metering and spot measurement needs, reliable resources for project data, and the application of mathematically astute evaluation procedures.

Evaluation Scheduling and Protocols – Because each University campus had a unique academic calendar and limited time to support the impact evaluation effort, it was necessary to schedule M&V activities and reserve facilities management staff well in advance of the site visit. Moreover, a majority of campuses required that their electrician staff interact with the affected equipment, adding another level of complexity to the M&V planning process.

Summit Blue adhered to a systematic approach to make decisions about the selection of M&V methods. More specifically, the team followed the appropriate International Performance Measurement and Verification Protocol (IPMVP)[9] in the impact evaluation process.

Gross Impact Evaluation Protocols and Rigor Levels

The impact evaluation of the UC/CSU/IOU Energy Efficiency Partnership was designated as a Protocol Guided Direct (PGD) evaluation with an "Enhanced" level of rigor. As noted in the previous sections, our approach to selecting M&V strategies followed the guidelines provided in the California Energy Efficiency Evaluation Protocols, and Table 6-4 provides a mapping of the IPMVP Options onto the measure categories that were evaluated in the UC/CSU/IOU Energy Efficiency Partnership Programs:

Table 6-4. Overview of IPMVP Methodologies Used by Measure Category

Measure Category	IPMVP Option				M&V Data
	A	B	C	D	
Custom HVAC		✓	✓	✓	Spot measurements, interval metering, EMS trend data, and billing records
Custom Lighting	✓	✓			Spot measurements and run-time hour metering
Custom Other	✓	✓	✓		Spot measurements, interval metering, run-time hour metering, billing records, and outputs from diagnostic tools
Steam Traps	✓	✓			On-site measurements of input/output temperatures and assessment of leakage rates

On-site inspections of all projects in the impact evaluation sample served to support the IPMVP Option chosen and encompassed a range of activities, including:

- Simple verification of measure installations;
- Confirmation of measure counts, capacities, and efficiencies;
- Observation of system functionality;
- Collection of nameplate and performance data;
- Observation of control systems and schedules;
- Confirmation of baseline conditions (as possible); and
- Discussions with building operators regarding building construction features, occupancy schedules, and system characteristics.

[9] Efficiency Valuation Organization, International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume 1, April 2007.

Similarly, on-site measurements of affected equipment were used to inform the project level savings analyses and fell into the following three categories:

- **Spot Measurements** – Spot measurements are the first and simplest level of on-site performance measurement and include one-time instantaneous measurements of technology, system, or environmental parameters including temperature, volts, amperes, true power, power factor, light levels, and other performance variables. As a general guide, these measurements were used to provide a snap-shot of measure performance in the absence of seasonal effects or other influencing factors.
- **Run-Time Hour Metering** – Run-time hour monitoring represents the second level of performance measurement and is used to record operating profiles over a given time period. Run-time hour metering was particularly useful for estimating the long-term energy consumption of technologies which exhibited constant performance characteristics. As an example, this method was used extensively for assessing the operating hours of lighting systems and constant load motor retrofits. Monitoring was generally conducted with small, portable, simple-to-use monitors, which recorded data for multiple months.
- **Interval Metering** – Interval metering is the most sophisticated level of on-site performance measurement and involves real-time monitoring of measure level energy use over a given time period. This generally involved recording true energy use or “proxy” values, such as amperes, from which energy use was computed. Interval metering was generally used to assess post-installation performance and trends of HVAC retrofit measures. The collected data was calibrated against trending data provided by the campus facilities management offices and used to develop regression or simulation models capable of computing annual and seasonal measure impacts.

Data Collection and Savings Analysis Procedures for Lighting Measures

The lighting measures evaluated included both efficiency and control measures:

- **Lighting Efficiency Measures** – Lighting efficiency measures reduced demand while pre- and post-retrofit operating characteristics remained constant. These measures included the retrofit of existing fixtures, lamps, and/or ballasts with more efficient technologies.
- **Lighting Control Measures** – Lighting control measures for interior lighting reduced operating hours, and in some cases, peak demand. These measures included occupancy sensors or daylighting controls that were installed with or without any changes to fixtures, lamps, and/or ballasts.

Savings for lighting measures were assessed using IPMVP Options A and B. With IPMVP Option B, load shapes were developed using lighting loggers that were deployed for up to three months on retrofit fixtures. During this period, representative operating characteristics were captured for each of the six load shape day types shown in Table 6-5, below:

Table 6-5. Load Shape Day Types

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.

Lighting load shapes were also disaggregated by *primary* and *project specific* space types (See Table 6-6). The primary space types were metered when evaluating campus wide lighting retrofit projects. These projects accounted for a majority of the lighting savings claimed by the UC/CSU/IOU Energy Efficiency Partnership Programs. The rationale for identifying primary space types involved prioritizing the areas which, in aggregate, maximized the space type representation of the UC and CSU campuses. University Databases of Space Type Allocations were provided by the UC Office of the President and CSU Office of the Chancellor to support this process. Conversely, project specific space types were metered for projects that implemented lighting retrofits in unique areas of a University campus.

Table 6-6. Primary and Project Specific Space Types Metered

Primary Space Types	Project Specific Space Types
Classroom	Garage
Common Area	Library
Lab	Stairwell
Office	Storage

While on-site, spot measurements of voltage, current, wattage, and power factor were taken to capture information about the retrofit lamps, ballasts, and fixtures installed. Equipment types, manufacturer model numbers, and operating characteristics were recorded and compared against available project documentation to ensure consistency in the *ex ante* assumptions. Once the lighting loggers were retrieved, the lighting project savings analysis comprised the following five steps:

1. **Develop Average Daily Load Shapes** – Load shapes were developed for each of the six day type periods, for each set of loggers deployed on a unique control point. Findings were normalized so that any differences between the metering duration would not affect the results. Average day type load shapes were then combined for each campus by space type. Results for areas where only lighting controls were installed were kept separate since it was understood that the lighting control measures would have an effect on the normal hours of operation.

2. **Estimate Annual Hours of Use** – The daily load shapes, weighted by the number of lamps associated with each metered control point, were aggregated to calculate the annual hours of operation for each space type within a campus. As a result, areas with larger lighting loads contributed a commensurate weight to the annual hours of use.

3. **Adjust the Claimed Savings** – On-site M&V data was compared to the project tracking documentation for each project. Typically, each project identified the pre- and post-installation lighting assumptions used in the *ex ante* savings analysis. These assumptions included the total number of lamps retrofit, the incremental wattage difference between the base and retrofit fixtures, the estimated annual operating hours, and the space types where lighting retrofits were installed. Field measurements and metered annual hours of use were used to calculate the *ex post* savings for each lighting retrofit project in the impact evaluation sample.

4. **Calculate Peak Demand Savings** – The average daily load shapes by space type were used to develop coincidence factors during the peak period. 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 each of the four IOUs, for each of the 16 Title-24 climate zones affected by the individual project. Of the six day types identified, the peak period occurred during the weekday partial session day type for all seven campuses evaluated. Ex-post peak demand savings were compared against the *ex ante* claims to develop peak demand realization rates.

5. **Calculate Project Realization Rates** – Project level realization rates were calculated as the ratio of verified savings to claimed savings, by fuel type. In general, the *ex ante* project assumptions varied by IOU and contributed towards a majority of the variability in realization rates.

Appendix E provides additional information on the evaluation approach developed for lighting retrofit projects.

Data Collection and Savings Analysis Procedures for HVAC Measures

Energy savings for custom HVAC measures were verified through calculations using a site specific M&V approach. The specific evaluation approach chosen was dependent upon the following factors:

- Nature of the retrofit (e.g., constant vs. variable performance);
- Quality of project documentation;
- Availability of EMS trend data for the affected equipment;
- Whether or not measure energy consumption was large enough to be identified through billing records;
- Accessibility of retrofit measures for spot measurements and interval metering.

Project documentation and corresponding interviews with project representatives were used to develop an M&V plan that leveraged available data and proposed primary research activities required to accurately estimate savings. The M&V plan also addressed the unique nature of custom HVAC project components, including:

- IPMVP Option chosen;

- Identification of project variables and specification of *ex ante* assumptions;
- Identification of available and representative data resources;
- Specification of data collection approach (i.e., sampling, site inspection, and monitoring plan);
- Specification of savings calculation approach; and
- Identification and resolution of any other M&V issues.

In the absence of project-specific EMS trend data, IPMVP Option D – Calibrated Energy Simulation/Modeling, supported by spot measurements and/or interval metering, was used to reliably calculate *ex post* HVAC project savings estimates using eQuest (DOE-2) models.

While on-site, evaluation staff collected data that supported the development of bin and simulation models. In general, site level activities involved the following three processes:

1. **On-Site Verification** – While on-site, a visual verification of all custom HVAC retrofit measures to be evaluated was completed.
2. **Interviews with Project Representatives** – While on-site, interviews with project representatives were conducted to further inform the data collection parameters and to identify discrepancies in the project documentation files.
3. **Data Collection** – Primary data supporting the project specific evaluation approach was collected on-site. Data was collected using established forms with dedicated fields for spot measurements, building contextual data, etc. Whenever possible, EMS trend data on the affected equipment was requested to support the savings analysis.

Appendix E provides additional information on the evaluation approach developed for each custom HVAC project in the impact evaluation sample.

Data Collection and Savings Analysis Procedures for Other Measures

Other custom measures identified in the impact evaluation sample, included:

1. Steam Trap Retrofits
2. Server/Monitor Retrofits
3. Boiler Retrofits

Much like custom HVAC measures, the evaluation approach chosen for each project depended on:

- Nature of the retrofit (e.g., constant vs. variable performance);
- Quality of project documentation;
- Availability of EMS trend data for the affected equipment;
- Whether or not measure energy consumption was large enough to be identified through billing records;
- Accessibility of retrofit measures for spot measurements and interval metering.

The final evaluation approaches determined to provide the highest level of accuracy in *ex post* savings estimates, included:

1. **Steam Trap Retrofits** – Steam trap retrofits were evaluated using IPMVP Option B. Spot measurements of inlet/outlet temperatures and leakage rates were used to calculate *ex post* project savings.
2. **Boiler Retrofits** – Boiler retrofits were evaluated using IPMVP Option C – Utility Billing Analysis. Site-accessible performance logs and billing data were also used to estimate the reduction in energy consumption as a result of the boiler retrofits.
3. **Server/Monitor Retrofits** – Server/monitor retrofits were evaluated using IPMVP Option B. Power loggers were deployed over a month long interval to develop operating load shapes. This information was used in conjunction with spot measurements of a statistically valid number of base and retrofit equipment to calculate annual energy and peak demand savings.

Appendix E provides additional information on the evaluation approaches developed for each other custom measures in the impact evaluation sample.

Description of Baseline Sources

The baseline definitions used in the impact evaluation of the UC/CSU/IOU Energy Efficiency Partnership Programs differed between early and normal replacement projects. For early replacement measures, the baseline was defined as the existing equipment efficiency. However, the baseline for normal replacement measures was defined to be the Title 24 equivalent. Resources used to establish and validate baseline information, included:

1. Project information drawn from the UC/CSU/IOU Energy Efficiency Partnership website maintained by the program manager, Newcomb Anderson McCormick (NAM).[10]
2. Project invoices from the UC/CSU participant.
3. On-site verification and observation of remaining baseline equipment.
4. Interviews with site personnel familiar with the projects evaluated.
5. In the event that a project is classified as normal replacement savings may only be claimed to the extent that the replacement measure exceeds the minimum requirements of Title 24.

Peak Demand Savings Methodology

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 each of the four IOUs, for each of the 16 Title-24 climate zones affected by the individual project.

The Enhanced rigor level for the Gross/Peak Demand Impact Protocols required primary data from program participants. In general, this was developed through interval-metered data or time-of-use (TOU) consumption billing data, from field measurements, or from billing demand data.

Weather sensitive measures required regression or simulation models to be developed using primary data collected at the time of measurement (e.g., EMS or interval metering data). The models were then normalized to climate zone data and the 2008 DEER peak demand periods[11] were used to calculate measure level peak demand savings. For non-weather sensitive measures, climate zone data from the time

[10] Newcomb Anderson McCormick Energy Engineering and Consulting, http://www.newcomb.cc/
[11] California Public Utilities Commission, Summary of 2008 DEER Measure Energy Analysis Revisions, April 2009.

of measurement was used to calculate peak load reductions on the three consecutive hottest weekdays of the year from 2:00 PM to 5:00 PM.

6.2.2 Net Impact Analysis Methods

The Net-To-Gross (NTG) evaluation approach adopted by Summit Blue for the UC/CSU/IOU Energy Efficiency Partnership Programs are defined in "The Proposed Net-to-Gross Ratio Estimates Methods for Nonresidential Customers" developed by CPUC's Engineering Division (ED). This methodology was designed specifically to address the unique needs of large nonresidential customers using the standard level of rigor and complies with all CPUC/ED protocols. The document provides guidance on:

- A standard NTGR framework, including detailed directions on implementing the algorithm;
- Decision rules for integrating quantitative and qualitative information;
- Enhancements to the NTG methodology;
- References to SRA in social sciences literature; and
- An example applying the methodology.

A case study methodology was chosen because of the complex nature of a multi-tiered decision making process (see Appendix E for further detail). The design and content of the NTG surveys adhered to the guidelines of the Methodological Framework and, specifically, the Large Nonresidential NTG Survey Instrument template. Many of the questions were taken from the Standard – Very Large Customer survey that was pretested in mid-2008 by Itron for use in all 2006-2008 program evaluations and adapted to the unique requirements of the university college programs.

Interviews and surveys were conducted by Summit Blue's professional consulting staff. 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.

Further detail regarding the methods may be found in Appendix D. Survey instruments and guidance documents used in the analysis can be found in Appendix H.

6.3 Confidence and Precision of Key Findings for UC/CSU/IOU Energy Efficiency Partnership Programs

This section presents the targeted and achieved levels of confidence and precision for key evaluation findings and the methods used for these calculations. The approaches discussed are specific to the evaluation activities conducted by this contract group. Calculation of coefficients of variation (CV) and relative precision followed the methods specified in the California Evaluation Framework[12].

[12] The TecMarket Works Team, California Evaluation Framework: Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004. See page 320 for calculation of CV and page 322 for calculation of relative precision. See page 356 for a discussion of the stratified ratio estimation approach.

6.3.1 Confidence and Precision for the Gross Impact Evaluation

As noted in the previous section, the impact evaluation of the UC/CSU/IOU Energy Efficiency Partnership was designated as a Protocol Guided Direct (PGD) evaluation with an “Enhanced” level of rigor. The initial sample design adhered to the California Evaluation Framework[13] (CEF) and targeted a 90/10 level of confidence and precision at the statewide program and IOU levels.

In April 2009, the CPUC Energy Division chose to pursue a High-Impact Measure (HIMs) evaluation approach. This re-direction of evaluation focus required that resources for the overall Local Government Partnership Program Contract Group be re-allocated among different component efforts. More specifically, the confidence/precision targets for evaluation of the UC/CSU/IOU Partnership Program were relaxed from the original 90/10 requirement, to 90/20 (i.e., 20% precision at 90% confidence). The re-sampling effort was consistent with the original sample design. However, all projects that were currently being evaluated as part of the original sample were kept in the revised sample.

The impact evaluation sample design was based on using both the *ex ante* energy (kWh) and Therm savings as design variables. A sample frame was constructed using project information extracted from the UC/CSU/IOU Energy Efficiency Partnership website maintained by the program manager, Newcomb Anderson McCormick (NAM).[14] This external database was used as a proxy for the Q4 2008 IOU Tracking Databases, which were not available until March 2009.

A total of 328 projects were included in the sampling frame, representing three project classifications:

1. Completed – Projects that were identified to be paid and closed
2. In Process – Projects that were incomplete or in review by the IOUs
3. Planned[15] – Projects that were in the contract approval phase

Once the sample frame was established, the sampling plan for the evaluation of the UC/CSU/IOU Energy Efficiency Partnership programs involved the following steps:

1. Individual samples were drawn for each IOU-fuel type combination—resulting in six samples for the programs (i.e., three IOU and two fuel type permutations).
2. Each established sample had 90% confidence with 20% precision.
3. A cluster sampling (also known as two-stage sampling) approach was adopted to cost-effectively allocate M&V resources. In the first stage of this approach, campuses were randomly drawn based on total expected savings of all projects for the campus. Within the second stage, individual projects within the chosen campuses were selected for M&V. This minimized the total number of unique campuses needed to meet confidence and precision requirements.
4. It should be noted that in the first stage of the sampling process, the probability that a campus was selected was based on the total expected energy savings (in BTUs) of all participating projects for

[13] The TecMarket Works Team, The California Evaluation Framework, Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004

[14] Newcomb Anderson McCormick Energy Engineering and Consulting, http://www.newcomb.cc/

[15] There were total 588 projects in the database at the time the sample was drawn. However, projects listed as “Placeholder” in the *MeasureName* field, or as “Cancelled” or “On Hold” in the *Condition* field, were removed prior to development of the sample.

that campus. In the second stage, the probability that a project was selected for M&V activities was based on the size of the actual project.

In aggregate, a total of 32 projects were chosen to be evaluated, of which nine had both expected energy (kWh) and gas savings. The final relative precision for the estimates of realization rates by IOU and fuel type are shown in Table 6-77:

Table 6-7. Relative Precision for Estimated Gross Realization Rates

IOU	kWh Relative Precision	kW Relative Precision	Therm Relative Precision
PG&E	16%	42%	20%
SCE	42%	34%	N/A
SCG	N/A	N/A	50%
SDG&E	3%	15%	33%

A more detailed discussion of factors driving program precision estimates is provided in *Section 6.6.2 ex post Savings for UC/CSU/IOU Energy Efficiency Partnership Programs.*

6.3.2 Confidence and Precision for the Net Impact Evaluation

Five different surveys were conducted for this effort:

- Utility Program Managers
- University System Representatives and Partnership Committee Members
- University Campus Representatives
- Project level/Facility Managers (Decision-Maker)
- Vendors and ESCOs

All surveys except the Decision-Maker survey were used to obtain qualitative information. The Decision-Maker survey collected both qualitative and quantitative data. It was the primary instrument used to obtain the data needed for the NTG algorithm, which provides both a case study and program level NTG ratios.

The first step was to calculate individual measure level NTG ratios using a spreadsheet template. Next, a content analysis of the qualitative information gathered from university and market actors was used to identify supporting or contradictory information on the decision making process. Finally, the quantitative and qualitative information was analyzed and integrated to tell a NTG "story."

According to the California Guidelines, the achieved relative precision of the NTG ratios for the case study method is less straightforward than for other methods. Specifically, the use of multiple decision makers, the incorporation of other qualitative information, and the use of the market actor perspective combine to complicate the development of the relative precision estimate. The Guidelines state:

"When the NTGR is based on interviews with more than one person at a site, the propagation of errors should be taken into account in calculating the achieved relative precision. However, one must recognize the error bounds are probably underestimated due to the inclusion of the qualitative data."[16]

Precision was estimated and reported based on the sample of completed surveys and the sampling weights that those projects represented.

More specifically, there were 328 participating projects in the UC/CSU Program. The NTG sample was nested within the impact sample of 32 (an additional five steam trap projects were added to the impact evaluation sample to build on existing research). Assuming a mean of 0.8 and an *ex ante* CV of 0.50, completing 18 Decision-Maker surveys achieved a 90/20 level of confidence and precision. However, the actual CVs came in lower and the 90/20 goal was met for all fuel types:

- For kWh, the number of survey completes was 11 and the CV was 0.23, resulting in an achieved confidence/precision of 90/12.
- For kW, the number of survey completes was 8 and the CV was 0.12, resulting in an achieved confidence/precision of 90/8.
- For Therms, the number of survey completes was 13 and the CV was 0.26, resulting in an achieved confidence/precision of 90/13.

6.4 Validity and Reliability for EM&V of the UC/CSU/IOU Energy Efficiency Partnership Programs

There were several sources of uncertainty associated with estimating the impacts of the UC/CSU/IOU Energy Efficiency Partnership programs. Examples of such sources include:

- Sample selection bias
- Survey error (e.g., non-response bias)
- Physical measurement bias (e.g., meter bias, sensor placement, non-random selection of equipment or circuits to monitor)
- Engineering analysis error (e.g., baseline construction, engineering model bias, modeler bias)

Summit Blue remained cognizant of these issues throughout the evaluation process and adopted methods to reduce the uncertainty arising from these sources, thereby improving the validity and reliability of study findings.

6.4.1 Key Uncertainty Sources and Mitigation Methods

Reducing Uncertainty from Sample Selection Bias

The problem that selection bias creates for program evaluation has been long recognized. Although projects were chosen in the impact evaluation sample according to prescribed protocols, bias may have

[16] California Public Utilities Commission Energy Division and the Master Evaluation Contractor Team, Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches, October 15, 2007.

been introduced if the selected projects did not choose to participate in the evaluation effort. In an effort to minimize non-response bias, Summit Blue established and implemented the following recruitment protocols:

- Notify participants as early as possible in the evaluation process.
- Accurately characterize M&V activities and the duration of the evaluation process.
- Maintain brief and frequent communication with participants and inform them of any changes/additions to the evaluation effort.

The intent of these protocols was to give each participant ample time to prepare documentation and secure the appropriate resources to support the evaluation effort. Brief and frequent contact with each participant ensured the participant remained engaged.

In the event that a non-respondent was encountered, Summit Blue first identified the nature of the project (i.e., certainty vs. non-certainty). Non-response for non-certainty projects was addressed by oversampling projects within each of the original stratum. These “alternative” projects were substituted into the impact sample in the event that a project did not respond to evaluation requests. Non-response for certainty projects were generally addressed by choosing similar projects (i.e., measure technologies) with equivalent, or larger savings. Collectively, this effort ensured that precision levels were met within the overall impact evaluation sample.

Reducing Uncertainty from Survey Error

Uncertainty arising from survey error was applicable to the net savings estimation for the UC/CSU/IOU Energy Efficiency Partnership programs. The methods used to minimize non-response survey bias were similar to those developed in the previous section:

- As with the impact evaluation sample, campuses were chosen for the NTG sample through prescribed sampling plans. Nineteen Decision-Maker surveys were completed out of a census attempted. This response rate of 59% is considered high, with most decision makers at the selected campuses agreeing to participate in the interviews. Lack of response was addressed on a case-by-case basis. Because there were multiple players in most situations, it is unlikely that the loss of information from individual players introduced any bias. Actions taken to minimize non-response are explained in Appendix F.
- Construct validity was ensured through the use of standard survey and analysis methods that have been pretested with multiple types of customers and have produced reasonable NTG estimates in the past. In particular, the specific survey instrument developed for the UC/CSU/IOU Energy Efficiency Partnership Program NTG evaluation was customized by Summit Blue staff for the University decision makers from the Methodological Frameworks guidelines and, specifically, the Large Nonresidential NTG Survey Instrument template.

The NTG ratios of the UC/CSU/IOU Program may be compared with results from other studies using the case study method along with the results of the UC/CSU/IOU Energy Efficiency Partnership program impact evaluation.

Reducing Uncertainty from Physical Measurement Error

There is inevitably some error associated with all physical measurement. For the impact evaluation of the UC/CSU/IOU Energy Efficiency Partnership programs, a large measurement effort involved installing lighting/current/power loggers to determine the operating characteristics of baseline and retrofit technologies across a broad range of applications. Several steps were taken to minimize the uncertainty resulting from bias/error that may have been introduced in this process:

- 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 UC/CSU 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.
- To minimize measurement error from improper calibration of the lighting/current/power loggers, the field monitoring staff checked all loggers used in the field to ensure that they were properly calibrated prior to being deployed. Field staff was also trained to use consistent measurement intervals whenever possible, and to synchronize the logger deployment activities (e.g., time delay). This ensured that the data could be compared across a uniform time period.
- To minimize biases arising because of improper placement of the loggers, field staff was given a prescribed protocol for the placement and installation of loggers on circuits (e.g., CT placement) and fixtures (e.g., uniform distance from the lamps).
- Usage patterns for retrofit measures may vary from month-to-month. Sampling for 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 five months, capturing the full, partial, and no session periods of the custom lighting project campuses in the impact evaluation sample. Similarly, loggers deployed on retrofit HVAC equipment were left in place for a minimum of four weeks and supplemented with EMS data supplied by the University Facilities Management office. The logged data was used to calibrate the EMS data, which spanned multiple months or years. The extended logging intervals minimized the bias resulting from extrapolating results to different time periods.
- Poor quality data can also be a significant source of error and uncertainty. To minimize the potential impact of this problem, various quality assurance checks were applied to the logger results. This included consistent spot measurements that could be compared to both the EMS and logger data. Additionally, qualified analysts reviewed all logger files to ensure that the results were representative of the technology being investigated:
    - Lighting loggers were reviewed to identify inconsistencies in operating characteristics and/or extended periods of inactivity. If a particular file was deemed suspicious, the Evaluation Team followed up with field staff and campus program managers to ensure that the findings were reasonable. Inaccurate results were removed from the analysis.
    - Current/power loggers were reviewed to ensure that consumption was representative of the technology being investigated. Suspect operating characteristics were reviewed with field staff and the campus program managers to clarify usage pattern anomalies. As with the lighting loggers, inaccurate findings were removed from the analysis.

Reducing Uncertainty from Engineering Analysis Error

There are several types of bias in such engineering analysis that can induce errors and uncertainty into estimates of savings. In addition to having qualified peers review all project analysis findings, the following steps were taken to minimize uncertainty arising from engineering analysis error:

- Engineering model bias was reduced by using DOE-2, which is a well-known and widely used computer simulation model. Well-developed techniques and procedures for conducting engineering analyses with DOE-2 were used, coupled with rigorous internal reviews.

- Modeler bias was reduced by having the modeling and analysis performed by a team of engineers experienced in energy modeling within evaluation settings, and familiar with the application of DOE-2 analysis procedures.
- Algorithm/bin model bias was reduced by establishing data collection protocols that provided adequate information to the models and by reviewing all inputs into the models.

Reducing Uncertainty from Social Desirability Bias

There is an increasing 'Social Desirability' for actions related to energy efficiency. There is a great deal of focus and increased investment in energy efficiency due to the increasing concerns with climate change and the increasing knowledge of the role that energy use has on environmental impacts. A Social Desirability Bias may bias a NTG estimate downward if a respondent would like to portray themselves in a positive light; e.g., they want the interviewer and society to think they would have installed energy-efficient equipment without any incentive (the socially desirable response).

However, issues related to Social Desirability may bias a NTG estimate upward if:

- Energy efficiency investments would be made whether there are efficiency programs or not. This trend will continue as more individuals desire higher efficiency in order to support a group need to protect the environment.
- A respondent exaggerates the importance of a program because they want the program and its rebates to continue.

The existence of the socially desirable response has been a perennial problem for survey researchers. Critics (Peters & McRae, 2008[17]) 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[18]; Lyberg et al. 1997[19]; Groves et al. 2004[20]) 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, and using both closed and open questions. Another technique suggested by Bickman and Rog (2009)[21] was to guarantee confidentiality. Another way of mitigating these tendencies is to ask one or more questions specifically to check the consistency and

[17] Peters, Jane and Marjorie McRae. 2008. Free-Ridership Measurement If Out of Sync with Program Logic . . . or, We've Got the Structure Built, but What's Its Foundations? In the *Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings,* ACEEE.

[18] 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.

[19] 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.

[20] 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.

[21] Bickman, Leonard and Debra J. Rog. 2009. *Applied Social Research Methods.* Los Angeles, CA: Sage Publications.

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.

This literature was not widely known or distributed to the evaluation contractors (including the committees for the two consistent SRA methods) at the planning stages for the 2006-2008 evaluation. It could be useful for future evaluation planning efforts.

Also, it is not known how the other factors related to Social Desirability described above may impact estimates. While the standard survey does ask about a respondent's willingness to install efficient equipment without the program, no steps were taken to address any potential upward bias on NTG results from exaggeration of program importance.

Reducing Uncertainty from Recall Bias

Recall Bias may occur if there is a lag in time from program participation to survey response, and a respondent has a problem recalling program participation. A Recall Bias may bias a NTG estimate downward if a respondent indicates that the program had low importance only because they could not recall the program due to a lag in time. A Recall Bias may bias a NTG estimate upward if a survey is conducted very close to the receipt of an incentive, and a respondent overestimates the importance of the incentive on their purchase decision. In sum, Recall Bias does not have a known direction of bias on estimates. Evidence is lacking that recall issues actually create a known directional bias (in either direction). Where we are asking for motivations and processes in situations that occurred one or two years ago, there is room for bias but that does not provide an actual indicator or measurement of bias. Poor recall adds to the uncertainty of the information and, therefore, of the free-ridership estimate. However, uncertainty does not mean bias. Random error creates larger error bounds around an estimate.

One of the problems inherent in the CA-SRA is that we are asking customers to recall what has happened in the past. 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 situations that occurred one or two years ago, there is room for bias. In order to minimize the problem of recall, CA-SRA interviews should be conducted with the decision maker(s) as soon after the installation of equipment as possible (Stone et al. 2000[22]).

For the LGP Evaluation, the following occurred to minimize Recall Bias:

- Participant surveys were administered no more than 18 months after participation, and, in most cases, less than a year after participation.
- Introductory questions were administered to ensure that:
    - The respondent was indeed the one that made the participation decision (if not, the survey was terminated), and
    - The respondent remembered participating and remembered acquiring the measure.

[22] Stone, Arthur A., Jaylan S. Turkkan, Christine A. Bachrach, Jared B. Jobe, Howard S. Kurtzman, and Virginia S. Cain. 2000. *The science of the self-report: Implications for research and practice.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

6.4.2 Recommendations for Future M&V Activities

Most of the sources of bias and uncertainty discussed are documented and well-researched. As such, there are established and proven procedures for reducing uncertainty and errors associated with these sources. However, equipment failure is not formally addressed and may reduce the precision and confidence of evaluation findings. To compensate for the consistent nature of these failures, the team recommends developing an evaluation framework to identify failure rates by technology, and applying these failure rates to the expected equipment deployments required to achieve confidence and precision targets.

6.5 Detailed Findings for the UC/CSU/IOU Energy Efficiency Partnership Program

This section presents the detailed study findings from the EM&V for the UC/CSU/IOU Energy Efficiency Partnership programs. Results are reported for the evaluation of custom lighting, custom HVAC, and other custom projects implemented at the participating campuses. The discussion is focused on the results of the fieldwork as it pertains to the particular parameters that are most important in determining savings. Results are presented in four parts:

- Custom Lighting Measures
- Custom HVAC Measures
- Other Custom Measures
- Net-To-Gross Surveys and Analyses

It should be noted that this section has been developed solely to inform additional HIM analyses beyond the scope of the UC/CSU/IOU Energy Efficiency Partnership programs. The *Stratified Ratio Estimation* approach, consistent with the California Evaluation Framework, was used to calculate gross and net savings estimates and realization rates. The application of these findings to calculate program-level savings is discussed in more detail in *Section 6.6.3 Summary of ex post Results for the UC/CSU/IOU Energy Efficiency Partnership Programs.*

Table 6-8 provides the distribution of gross claimed savings, by measure category, within the impact evaluation sample:

Table 6-8. Measure Category Statistics for the Revised UC/CSU/IOU Impact Evaluation Sample

Statistic	HVAC	Lighting	Other
Number of Projects	12	11	9
Total Energy Savings (kWh)	9,111,864	12,414,240	144,061
Total Demand Savings (kW)	924.9	3,128.0	13.8
Total Therm Savings	1,922,580	0	539,452

6.5.1 Findings from EM&V for Lighting Measures

The lighting measures evaluated included both efficiency and control measures. As noted earlier:

- **Lighting Efficiency Measures** – Lighting efficiency measures reduced demand while pre- and post-retrofit operating characteristics remained constant. These measures included the retrofit of existing fixtures, lamps, and/or ballasts with more efficient technologies.
- **Lighting Control Measures** – Lighting control measures for interior lighting reduced operating hours, and in some cases, peak demand. These measures included occupancy sensors or daylighting controls that were installed with or without any changes to fixtures, lamps, and/or ballasts.

6.5.2 Hours of Lighting Use as Estimated with Lighting Logger Data

To evaluate the savings from custom lighting measures, primary research was needed to verify the *ex ante* input assumptions for each project. This level of information was collected through spot measurements of unique retrofit fixture voltage, current, wattage, and power factor. Equipment types, manufacturer model numbers, and operating characteristics were also recorded and compared against available project documentation. Finally, lighting loggers were installed on retrofit fixtures in primary and project specific space types across seven different campuses. The lighting loggers were put in place for five months and captured the full, partial, and no session periods of each campus. This information was then extrapolated to a full year based on each individual campuses academic calendar. Load shapes were subsequently developed and weighted based on the number of days within each session and further disaggregated by day type and space type. A total of 444 loggers were deployed and to support the custom lighting analysis.

Table 6-9 shows summary statistics for the hours of use measured by the 444 loggers where logger placement was classified by functional use area:

Table 6-9. Statewide Lighting Logger Characteristics

Space Type	Number of Loggers Installed	Average Annual Hours of Use	Standard Deviation for Hours of Use	Relative Precision
Classroom	162	1,655	802	6%
Common Area	43	4,630	2,945	16%
Lab	64	3,136	1,116	7%
Office	145	1,670	371	3%
Project Specific Space Types*	30	N/A	N/A	N/A

* Project specific space types were metered for projects that implemented lighting retrofits in unique areas of a University campus (i.e., Garage, Library, Stairwell, and Storage)

Similarly, Table 6-10 provides the summary statistics on hours of use when logger placement is classified by the campuses where the loggers were installed:

Table 6-10. Campus Level Lighting Logger Characteristics

Campus	Number of Loggers Installed	Average Hours of Use	Standard Deviation for Hours of Use	Relative Precision
CSU San Bernardino	154	2,229	1,396	8%
CSU Sonoma	136	2,411	648	4%
UC Davis	12	5,591	3,001	25%
UC Irvine	37	2,463	569	6%
UC San Diego	36	3,512	2,275	18%
UC San Francisco	10	7,340	7,065	37%
UC Santa Cruz	59	2,555	1,566	13%
TOTAL	444	4,227	2,611	5%

The decision of how many loggers to deploy on a particular campus/project was dependent upon a host of factors, including:

1.) The variability of operating characteristics within the affected space.

2.) The number of space types retrofit with new fixtures.

3.) The quality of project documentation.

6.5.3 Estimation of Realization Rates for Retrofit Lighting Measures

As noted in *Section 6.2.1 Gross Impact Analysis Methods,* savings for retrofit lighting measures were assessed using IPMVP Option B. With IPMVP Option B, load shapes were developed through the deployment of 444 lighting loggers over a five month period. Realization rates for retrofit lighting measures were calculated for the set of sample projects leveraging the load shapes from deployed loggers and the field-verified data on kW reductions resulting from fixture retrofits. The calculated realization rates for lighting retrofit measures are reported in Table 6-11 and are provided for informative purposes only:

Table 6-11. Lighting Project Energy (kWh) Realization Rates[23]

Project Description	IOU	*ex ante* kWh Savings	*ex post* kWh Savings	kWh Realization Rate
UCD – Library Main Lighting Shutoff	PG&E	43,688	66,052	151%
UCD – Library Occupancy Sensors	PG&E	595,101	822,203	138%
UCSF – LH Garage Lighting Retrofits	PG&E	32,690	36,245	111%
UCSF – MU Garage Lighting Retrofits	PG&E	713,432	713,432	100%
UCSF – Library Lighting Retrofits	PG&E	198,411	287,567	145%
CSU Sonoma – Campus Wide Retrofits	PG&E	1,388,152	956,867	69%
UCSC – Campus Wide Retrofits	PG&E	165,945	78,701	47%
CSU SB – Campus Wide Retrofits	SCE	1,411,805	1,395,660	99%
UCI – Bi-Level Lighting Stair Retrofits	SCE	220,501	204,770	93%
UCI – Campus Wide Retrofits	SCE	201,401	300,481	149%
UCSD – Campus Wide Retrofits	SDG&E	7,443,115	2,896,337	39%

Lighting project energy (kWh) realization rates were somewhat variable for the following reasons:

[23] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

1.) Individual projects often overestimated or underestimated base and retrofit fixture operating characteristics in the *ex ante* savings analysis.

   a. *Ex ante* fixture wattages were drawn from project files and manufacturer cut sheets. Ex-post fixture wattages were confirmed through spot measurements of unique fixtures installed at each campus. Overall, the evaluation found the *ex ante* and *ex post* fixture wattages to be fairly well aligned.

   b. *Ex ante* annual fixture operating hours were drawn from project file assumptions. Ex-post annual fixture operating hours were verified through the deployment of lighting loggers on a statistically significant number of fixtures across primary and project specific space types over a period of five months. It should be noted that the *ex ante* assumptions were rarely justified and were responsible for a majority of the deviation between *ex ante* and *ex post* savings estimates.

2.) Individual projects often inaccurately estimated the impact of occupancy sensors installed through project retrofits.

Lighting project realization rates for peak demand savings are provided in Table 6-12, below:

Table 6-12. Lighting Project Peak Demand (kW) Realization Rates[24]

Project Description	IOU	ex ante Peak kW Savings	ex post Peak kW Savings	Peak kW Realization Rate
UCD – Library Main Lighting Shutoff	PG&E	0.0	0.0	N/A
UCD – Library Occupancy Sensors	PG&E	23.2	106	457%
UCSF – LH Garage Lighting Retrofits	PG&E	7.8	8	100%
UCSF – MU Garage Lighting Retrofits	PG&E	81.4	81	100%
UCSF – Library Lighting Retrofits	PG&E	45.7	27	59%
CSU Sonoma – Campus Wide Retrofits	PG&E	329.0	85	26%
UCSC – Campus Wide Retrofits	PG&E	35	6	18%
CSU SB – Campus Wide Retrofits	SCE	338.8	126	37%
UCI – Bi-Level Lighting Stair Retrofits	SCE	18.7	18	97%
UCI – Campus Wide Retrofits	SCE	16.3	61	373%
UCSD – Campus Wide Retrofits	SDG&E	2,233.0	230	10%

Large variations in achieved demand reductions were generally attributed to the fact that:

1.) Many of the projects interpreted the peak load to be the total reduction in connected load. As less than 100% of the lights are generally operating during the peak period, this served to reduce savings estimates.

2.) In many cases where occupancy sensors were installed, the project applications did not properly, or accurately, account for the impact of reduced fixture loads during the peak period. This served to increase savings.

Table 6-13, below, provides a high level comparison of annual operating hours assumptions used in the *ex ante* savings estimates relative to *ex post* logger findings, by IOU:

[24] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

Table 6-13. *ex ante* vs. *ex post* Annual Operating Hours by IOU

Space Type	*ex ante* Assumptions			*ex post* Verified		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
Classroom	3,076	3,048	8,760	2,169	1,067	1,810
Common Area	6,321	4,885	8,760	5,772	4,898	3,835
Garage	7,355	N/A	N/A	7,585	N/A	N/A
Lab	3,257	4,962	8,760	2,303	3,541	3,596
Library	4,468	N/A	N/A	5,044	N/A	N/A
Office	3,013	2,082	8,760	1,912	1,403	1,590
Stairwell	N/A	1,095	N/A	N/A	2,595	N/A
Storage	2,498	1,567	8,760	1,561	317	158

Apart from the campus wide lighting retrofit in SDG&E's service territory, the *ex ante* annual operating hour assumptions by space type were fairly similar across IOUs. However, the *ex post* verified annual operating hours by space type were significantly more variable. This deviation was attributed to the following factors:

- Each campus had a unique distribution of full, partial, and no session periods throughout the logging duration.
- There was inherent variability in the annual operating hours for each space type metered. For example, a classroom that was metered may have been assigned more classes than other similar space types.

It should be noted that *ex post* verified annual operating hours for the labs and offices compare favorably to one another across IOUs because the effects of a '9-month academic calendar' are small given year-round administrative and lab research activities.

6.5.4 Findings from EM&V for HVAC Measures

The custom HVAC projects included through the impact evaluation sample ranged from building to plant-level system upgrades.

Engineering bin data analyses and simulations with the eQuest (DOE-2) energy simulation model were used to develop estimates of energy use for the HVAC projects chosen for evaluation. In general, bin models were developed when primary EMS data were available for the affected equipment. This process involved:

1.) Identifying the relevant parameters to trend through the EMS system for the affected equipment.

2.) Specifying the time intervals and duration of trend data requested.

3.) Scheduling on-site M&V activities with University Facilities Management staff to spot measure or interval meter the affected equipment. This information was used to calibrate or reconcile discrepancies in the EMS data.

4.) Developing a base and retrofit system bin models using campus specific parameters during the trending period. This model characterized the relationship between system energy consumption and weather data or occupancy characteristics of the affected buildings.

5.) Extrapolating the campus specific bin models to a full year using normalized DEER Climate Zone Data.

6.) Calculating the difference in energy consumption between the base and retrofit system bin models to develop *ex post* savings estimates and realization rates.

In the absence of EMS data, building contextual data was collected to generate robust simulation models capable of characterizing project savings. This process involved:

1) Collecting on-site data for the custom HVAC projects chosen for evaluation. This included building/central plant contextual data, spot measurements, interval metering data, and/or billing records.

2) Establishing eQuest models for each project using data collected on-site, as well as interval and billing data on energy use when available, or deemed necessary to mitigate uncertainty.

3) Calibrating eQuest models and defining the baseline energy use for each project. This included the use of billing records and on-site data, to inform the model's operational schedules and lighting/internal load power densities. In the event that meaningful billing records were unavailable, missing information was supplemented with California Commercial End-Use Survey (CEUS)[25] data for the appropriate climate zone. The resolution to which the energy models were calibrated (i.e., hourly vs. monthly) was dependent upon what data was available. In all cases, the models were calibrated such that their peak demand and annual energy usage were within 10% of the best available project resource.

4) Executing eQuest models to calculate *ex post* savings estimates and realization rates.

Appendix E provides additional detail on the custom HVAC evaluation approaches used to estimate savings for projects included through the impact evaluation sample.

The calculated HVAC project level energy (kWh) realization rates are provided in Table 6-14, below:

Table 6-14. HVAC Project Energy (kWh) Realization Rates[26]

Project Description	IOU	*ex ante* kWh Savings	*ex post* kWh Savings	kWh Realization Rate
UCD – Centrifugal Chiller Retrofit	PG&E	0	1,122,404	N/A
UCD – VFD Retrofits on Supply Fans	PG&E	1,304,376	1,768,921	136%
UCSF – VFD Retrofits on HVAC Fans	PG&E	917,852	589,506	64%
UCSF – VFD Retrofits on Pumps &	PG&E	1,044,617	1,044,584	100%

[25] Itron, Inc., California Commercial End-Use Survey, August 2006.

[26] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

HVAC Fans				
UCI – Upgrade to LPD Filters	SCE	3,092,757	729,415	24%
UCI – Install Two-Position Dampers	SCE	406,358	338,765	83%
UCI – VFD Retrofits on AHUs 1 & 3	SCE	1,685,501	35,355	2%
UCI – Centralized Demand Control Ventilation Retrofit	SCE	117,399	66,502	57%
CSU SB – Centrifugal Chiller Retrofit	SCE	363,200	190,487	52%
UCLA – Zone Presence Sensor Retrofits on Fume Hoods (Phase I)	SCG	0	0	N/A
UCLA – Zone Presence Sensor Retrofits on Fume Hoods (Phase II)	SCG	0	0	N/A
CSU SD – VSD Retrofits on HVAC Fans	SDG&E	179,804	82,706	46%

The low realization rates for custom HVAC projects (i.e., < 50%) were generally attributed to incorrect baseline assumptions. For example, the *CSU SD – VSD Retrofits on HVAC Fans* project was incorrectly assigned as a retrofit. On-site observations and interviews with project representatives revealed that the affected building was not meeting the minimum operational requirements. Consequently, the established baseline was adjusted to reflect modifications required to bring the HVAC system to compliance. This shift in the project baseline served to reduce realized savings.

Table 6-15 further details custom HVAC project peak demand savings for each project included through the impact evaluation sample.

Table 6-15. HVAC Project Peak Demand (kW) Realization Rates[27]

Project Description	IOU	*ex ante* Peak kW Savings	*ex post* Peak kW Savings	kW Realization Rate
UCD – Centrifugal Chiller Retrofit	PG&E	0.0	471	N/A
UCD – VFD Retrofits on Supply Fans	PG&E	275.9	357	129%
UCSF – VFD Retrofits on HVAC Fans	PG&E	71.7	49	68%
UCSF – VFD Retrofits on Pumps & HVAC Fans	PG&E	25.6	62	243%
UCI – Upgrade to LPD Filters	SCE	386.7	129	33%
UCI – Install Two-Position Dampers	SCE	0.0	0	N/A
UCI – VFD Retrofits on AHUs 1 & 3	SCE	0.0	6	N/A

[27] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

UCI – Centralized Demand Control Ventilation Retrofit	SCE	0.0	11	N/A
CSU SB – Centrifugal Chiller Retrofit	SCE	158.0	0	0%
UCLA – Zone Presence Sensor Retrofits on Fume Hoods (Phase I)	SCG	0.0	0	N/A
UCLA – Zone Presence Sensor Retrofits on Fume Hoods (Phase II)	SCG	0.0	0	N/A
CSU SD – VSD Retrofits on HVAC Fans	SDG&E	7.0	15	208%

In general, custom HVAC peak demand realization rates varied across projects for the following reasons:

1.) *Ex ante* system operating characteristics are generally difficult to predict and varied significantly from evaluation findings. *This was particularly true for the UCSF – VFD Retrofits on Pumps & HVAC Fans* project.

2.) In some cases, the peak demand savings period used in *ex ante* savings analysis differed from the impact evaluation (See *Section 6.2.1* Gross Impact Analysis Methods).

Table 6-16 provides the custom HVAC project Therm savings and realization rates:

Table 6-16. HVAC Project Therm Realization Rates[28]

Project Description	IOU	*ex ante* Therm Savings	*ex post* Therm Savings	Therm Realization Rate
UCD – Centrifugal Chiller Retrofit	PG&E	1,246,278	0	0%
UCD – VFD Retrofits on Supply Fans	PG&E	119,900	95,079	79%
UCSF – VFD Retrofits on HVAC Fans	PG&E	137,713	146,536	106%
UCSF – VFD Retrofits on Pumps & HVAC Fans	PG&E	107,206	126,932	118%
UCI – Upgrade to LPD Filters	SCE	0	0	N/A
UCI – Install Two-Position Dampers	SCE	26,347	29,437	112%
UCI – VFD Retrofits on AHUs 1 & 3	SCE	21,761	0	0%
UCI – Centralized Demand Control Ventilation Retrofit	SCE	9,443	3,121	33%
CSU SB – Centrifugal Chiller Retrofit	SCE	38,442	0	0%
UCLA – Zone Presence Sensor Retrofits on Fume Hoods (Phase I)	SCG	167,232	137,813	82%
UCLA – Zone Presence Sensor Retrofits on Fume Hoods (Phase II)	SCG	22,410	18,468	82%
CSU SD – VSD Retrofits on HVAC Fans	SDG&E	25,848	0	0%

Low Therm realization rates for custom HVAC projects (i.e., 0%) were generally attributed to incorrect baseline assignments. For example, the *UCD – Centrifugal Chiller Retrofit* project involved fuel switching and the normal replacement of absorption chillers. However, because the project was incorrectly characterized as a retrofit in the project application, gas savings were not realized. Instead, savings for the normal replacement centrifugal chillers were limited to the savings exceeding the Title 24 equivalent for the same fuel type. This project accounted for over 50% of the impact evaluation samples claimed gas savings.

6.5.5 Findings from EM&V for Other Custom Measures

Savings for other custom measures included through the UC/CSU/IOU Energy Efficiency Partnership programs were assessed using IPMVP Options A, B, and where data was available, Option C. Other custom measures identified in the impact evaluation sample, included:

[28] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

1. **Steam Trap Retrofits** – Steam trap retrofits were evaluated using IPMVP Option B. Spot measurements of inlet/outlet temperatures and leakage rates were used to calculate *ex post* project savings.
2. **Boiler Retrofits** – Boiler retrofits were evaluated using IPMVP Option C – Utility Billing Analysis. Site-accessible performance logs and billing data were also used to estimate the reduction in energy consumption as a result of the boiler retrofits.
3. **Server/Monitor Retrofits** – Server/monitor retrofits were evaluated using IPMVP Option B. Power loggers were deployed over a month long interval to develop operating load shapes. This information was used in conjunction with spot measurements of a statistically valid number of base and retrofit equipment to calculate annual energy and peak demand savings.

Table 6-177 provides the energy (kWh) savings and realization rates for other custom measures included through the impact evaluation sample:

Table 6-17. Other Project Energy (kWh) Realization Rates

Project	IOU	*ex ante* kWh Savings	*ex post* kWh Savings	kWh Realization Rate
UCB – Steam Trap Retrofits	PG&E	0	0	N/A
UCD – HP Steam Trap Retrofits	PG&E	0	0	N/A
UCD – LP Steam Trap Retrofits	PG&E	0	0	N/A
CSU Sacramento – Steam Trap Retrofits	PG&E	0	0	N/A
UCI – Monitor Retrofits	SCE	19,740	77,189	391%
CSU San Marcos – Server Retrofits	SDG&E	124,321	97,953	79%
CSU SD – HP Steam Trap Retrofits	SDG&E	0	0	N/A
CSU SD – LP Steam Trap Retrofits	SDG&E	0	0	N/A
CSU San Marcos – Boiler Retrofit	SDG&E	0	0	N/A

Table 6-18. Other Project Peak Demand (kW) Realization Rates

Project	IOU	*ex ante* Peak kW Savings	*ex post* Peak kW Savings	Peak kW Realization Rate
UCB – Steam Trap Retrofits	PG&E	0.0	0.0	N/A
UCD – HP Steam Trap Retrofits	PG&E	0.0	0.0	N/A
UCD – LP Steam Trap Retrofits	PG&E	0.0	0.0	N/A
CSU Sacramento – Steam Trap Retrofits	PG&E	0.0	0.0	N/A
UCI – Monitor Retrofits	SCE	1.4	10.1	391%
CSU San Marcos – Server Retrofits	SDG&E	12.4	11.0	79%
CSU SD – HP Steam Trap Retrofits	SDG&E	0.0	0.0	N/A
CSU SD – LP Steam Trap Retrofits	SDG&E	0.0	0.0	N/A
CSU San Marcos – Boiler Retrofit	SDG&E	0.0	0.0	N/A

The two projects yielding energy and demand savings within the other custom measure category involved monitor and server retrofits. The server replacement project yielded an acceptable realization rate. However he monitor retrofit project produced peak demand and energy realization rates of 391% because the *ex ante* savings analysis classified the project as a normal replacement. The evaluation team confirmed that the project was indeed a retrofit through interviews with project staff, resulting in justifiably higher savings estimates.

Table 6-19. Other Project Therm Realization Rates

Project	IOU	*ex ante* Therm Savings	*ex post* Therm Savings	Therm Realization Rate
UCB – Steam Trap Retrofits	PG&E	82,810	113,703	137%
UCD – HP Steam Trap Retrofits	PG&E	227,849	231,330	102%
UCD – LP Steam Trap Retrofits	PG&E	131,588	131,567	100%
CSU Sacramento – Steam Trap Retrofits	PG&E	4,120	3,930	96%
UCI – Monitor Retrofits	SCE	0	0	N/A
CSU San Marcos – Server Retrofits	SDG&E	0	0	N/A
CSU SD – HP Steam Trap Retrofits	SDG&E	58,660	73,519	125%
CSU SD – LP Steam Trap Retrofits	SDG&E	9,570	12,985	136%
CSU San Marcos – Boiler Retrofit	SDG&E	24,855	42,482	171%

A majority of the projects in the other custom measure category involved steam traps. The steam trap savings analysis was consistent with Steam Traps Work Paper for PY2006 - 2008[29] and yielded consistent savings across all projects.

A standalone boiler replacement project was verified using a combination of spot measurements, facility logs, and billing data over a three-year period. This project yielded a realization rate greater than 150% because the retrofit boilers greatly improved plant level efficiencies.

6.5.6 Findings from Net-to-Gross Surveys and Analysis

The UC-CSU LGP Program falls under the Standard – Very Large protocol standards and was evaluated using the Large Non-Residential NTG Method, which is a case study method and uses a survey developed by the NTG Working Group for use by all evaluators in the 2006-2008 program cycle. Summit Blue staff reviewed the Program Implementation Plans (PIPs), available quarterly reports, and campus websites. An executive interviewer completed interviews with nine utility representatives, four UC-CSU System staff (two from the UC Office of the President and two from the CSU Chancellor's Office), seven University or College representatives. The interviewer also completed 19 on-site campus decision-maker surveys (with Facility or Campus Energy Managers).

[29] Energy and Environment Analysis Inc. Steam Traps Work Paper for PY2006-2008, December 2006.

Ten University decision-makers were interviewed for this study. Decision-maker data were entered into the NTGR calculator to generate preliminary scores (see Appendix D). Key drivers in the calculator include:

- Timing and Selection Score
- Program Influence Score
- No Program Score

Further details on these scores and the calculator are described in Appendix D. NTG ratios ranged from 0.40 at UC Irvine to 1.0 at CSU San Marcos. Then, two evaluators, one of whom was the executive interviewer, independently reviewed the NTGR scores and adjusted them based on the qualitative information gleaned from in-depth interviews with program staff, campus representatives and decision-makers. Then, the evaluators determined a collaborative adjustment through discussion, as described in Appendix D.

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 UC/CSU Program are presented in Table 6-20.

Table 6-20. Program NTG Results for UC/CSU

Savings Type	% Free Riders	NTGR % (1-%FR)
kWh	31%	69%
kW	25%	75%
Therms	28%	72%

While no Spillover was indicated in the executive interviews with the UC and CSU campus-level decision-makers, the NTG ratios do not include impacts of Spillover. 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. See Appendix D for further information concerning Spillover for UC/CSU.

6.6 Program specific results for the UC/CSU/IOU Energy Efficiency Partnership Programs

This section presents program-level estimates of achieved savings for the UC/CSU/IOU Energy Efficiency Partnership Programs in each IOU service territory. Section 6.6.1 provides background information on the savings projected for the programs in the various Program Implementation Plans. Section 6.6.2 reports the savings claimed by each IOU in the 2006 – 2008 program cycle. Finally, Section 6.6.3 provides the results of the evaluation effort, detailing the savings achieved by the UC/CSU/IOU partnership programs in each IOU service territory.

6.6.1 Initial Projections of Savings for UC/CSU/IOU Energy Efficiency Partnership Programs

Table 6-211 identifies the expected program achievements by IOU as stated in the individual Program Implementation Plans (PIP). Overall, the projected 2006-2008 program savings across all participating IOUs was 72,810,112 kWh, 18,233 kW, and 2,817,154 Therms, with an aggregate program budget of $32,367,189.

It should be noted that the projected savings are inclusive of both MBCx and Retrofit projects. However, per the Energy Division's decision, this impact evaluation was limited to retrofit projects implemented through the UC/CSU/IOU Energy Efficiency Partnership Program. That is, all subsequent program and measure level realization rates are only applicable to *retrofit measures.*

Table 6-21. Projected Achievements of the 2006 – 2008 UC/CSU/IOU Partnership Programs

Program ID	Project Partnership Budget	Projected kWh Savings	Projected kW Savings	Projected Therm Savings
PGE2036	$16,476,217	43,229,000	12,603	1,490,652
SCE2530	$6,830,972	17,440,000	3,670	0
SCG3520	$3,060,000	0	0	856,800
SDGE3026	$6,000,000	12,140,778	1,956	469,704

6.6.2 *ex post* Savings for UC/CSU/IOU Energy Efficiency Partnership Programs

As noted in Section 6.5, the Stratified Ratio Estimation approach, consistent with the California Evaluation Framework, was used to calculate program level realization rates and relative precision estimates by fuel type. What follows is a discussion of each program's achievements, and the factors influencing the reported savings and precision results.

Table 6-22. PGE2036 *ex post* Gross Realization Rates and Relative Precision

PGE2036		
Fuel Type	**Realization Rate**	**Relative Precision**
kW	116%	42%
kWh	110%	16%
Therms	59%	20%

The impact evaluation sample contained 15 projects within the PGE2036 program. Of these, four were classified as custom HVAC projects, seven were classified as custom lighting projects, and four were classified as other custom projects.

Custom lighting projects had high realization rates because the participant campuses tended to underestimate lighting operating characteristics.

The other custom projects were restricted to steam trap retrofit projects, all of which had realization rates greater than 95%. This was attributed to the fact that the supporting documentation used to estimate savings was consistent across the *ex ante* and *ex post* savings analyses.

The custom HVAC projects exhibited significant variability because of the difficulty involved with accurately estimating HVAC system operating characteristics in the *ex ante* savings analysis. As an example, peak demand realization rates for custom HVAC projects ranged 64% to 243%. This contributed to the relative precision of the peak demand savings for the Program. A standalone Centrifugal Chiller Retrofit at UC Davis involved fuel switching and the normal replacement of absorption chillers. However, because the project was incorrectly characterized as a retrofit in the project application, gas savings were not realized. Instead, savings for the normal replacement centrifugal chillers were limited to the savings exceeding the Title 24 equivalent for the same fuel type. This project accounted for over 50% of the impact evaluation sample's claimed gas savings and is responsible for the program's 56% Therm realization rate. Conversely, this same project yielded significant peak demand (kW) and energy (kWh) savings that were anticipated, and contributed to the program realization rates that were greater than 100%.

Table 6-23. SCE2530 *ex post* Gross Realization Rates and Relative Precision

SCE2530		
Fuel Type	**Realization Rate**	**Relative Precision**
kW	38%	34%
kWh	57%	42%
Therms	N/A	N/A

The impact evaluation sample contained nine projects within the SCE2530 program. Of these, five were classified as custom HVAC projects, three were classified as custom lighting projects, and one was classified in the other custom category.

Overall, the custom lighting projects yielded relatively high realization rates with the exception of a campus wide retrofit at CSU San Bernardino, where the connected load reduction was inaccurately interpreted as the peak demand savings. This project had a 37% peak demand realization rate.

The other custom project evaluated in this program involved campus wide monitor retrofits at UC Irvine. This project produced peak demand and energy realization rates of 391% because the *ex ante* savings analysis classified the project as a normal replacement. However, the evaluation team confirmed that the project was indeed a retrofit, resulting in justifiably higher savings estimates.

The custom HVAC projects evaluated through this program yielded realization rates with significant variability. However, two projects that accounted for 64% of the energy savings claimed by SCE2530 projects in the impact evaluation sample produced realization rates of 24% and 2%, respectively. The first project involved an upgrade to low pressure drop filters at UC Irvine. An overstatement of air handler flow rates in the *ex ante* savings analysis was responsible for the low realization rate. The second project involved the replacement of six, belt-driven, vane axial fans with direct drive mixed flow fans in AHUs 1 and 3 at McGaugh Hall at UC Irvine. Existing fan motors were also be equipped with variable frequency drives. A thorough review of project documentation and interviews with campus staff revealed that savings were overstated because the *ex ante* savings analysis assumed a significant reduction in the building's airflow. The evaluation effort confirmed, however, that there was no reduction in the facility's airflow. Additionally, the *ex ante* savings analysis included the impacts of sound attenuator removal, which was incorrectly classified as an energy efficiency upgrade instead of a repair. As such, savings for this measure could not be claimed. These two custom HVAC project contributed significantly to the low energy and peak demand realization rates.

Table 6-24. SCG3520 *ex post* Gross Realization Rates and Relative Precision

SCG3520		
Fuel Type	**Realization Rate**	**Relative Precision**
kW	N/A	N/A
kWh	N/A	N/A
Therms	62%	50%

The impact evaluation sample contained four projects within the SCG3520 program, all of which involved custom HVAC retrofits. Therm realization rates varied between 82% and 112% for three of the four projects. However, the McGaugh Hall custom HVAC retrofit project, discussed above, yielded a 0% realization rate. This project was largely responsible for the low program realization rate and high relative precision estimates due to the variance introduced by a zero *ex post* savings value.

Table 6-25. SDGE3026 *ex post* Gross Realization Rates and Relative Precision

SDGE3026		
Fuel Type	**Realization Rate**	**Relative Precision**
kW	11%	15%
kWh	40%	3%
Therms	108%	33%

The impact evaluation sample contained seven projects within the SDGE3026 program. Of these, one was classified as a custom HVAC project, one was classified as a custom lighting project, and five were classified as other custom projects.

It should be noted that the standalone campus wide lighting retrofit at UC San Diego represented 96% of claimed energy savings, and 99% of claimed peak demand savings for SDGE3026 projects in the impact evaluation sample. The campus wide lighting retrofit also represented the project with the most energy savings in the 2006-2008 UC/CSU/IOU Energy Efficiency Partnership program cycle. Unfortunately, peak demand and energy realization rates for this project were 39% and 10% respectively. This was attributed to two factors:

1.) The campus incorrectly assumed that all retrofit fixtures operated 8,760 hours per year
2.) The campus incorrectly assumed that the connected load reduction from lighting fixture retrofits was equivalent to peak demand savings.

The four other custom measures yielded realization rates greater than 100% and represented a majority of claimed Therm savings for SDGE3026 projects in the impact evaluation sample.

The single custom HVAC project involved VSD retrofits on HVAC fans at CSU San Diego. This project yielded low realization rates because the project was incorrectly assigned as a retrofit. On-site observations and interviews with project representatives revealed that the affected building was not meeting the minimum operational requirements. Consequently, the established baseline was adjusted to reflect modifications required to bring the HVAC system to compliance. This shift in the project baseline served to reduce realized savings.

For comparative purposes, Table 6-26 provides a high level summary of *ex post* gross realization rates and relative precision estimates by IOU and fuel type.

Table 6-26. UC/CSU/IOU Energy Efficiency Partnership Programs *ex post* Gross Realization Rates and Relative Precision

Fuel Type	PGE2036		SCE2530		SCG3520		SDGE3026	
	Realization Rate	Relative Precision	Realization Rate	Relative Precision	Realization Rate	Relative Precision	Realizatio n Rate	Relative Precision
kW	116%	42%	38%	34%	N/A	N/A	11%	15%
kWh	110%	16%	57%	42%	N/A	N/A	40%	3%
Therms	59%	20%	N/A	N/A	62%	50%	108%	33%

6.6.3 Summary of *ex post* Results for the UC/CSU/IOU Energy Efficiency Partnership Programs

Table 6-27 compares the *ex post* gross kW, kWh, and Therm savings for the UC/CSU/IOU Energy Efficiency Partnership Programs to the *ex ante* gross estimates:

Table 6-27. Comparison of *ex ante* to *ex post* Gross Savings

Fuel Type	*ex ante Gross Savings*	*ex post Gross Savings*	Gross Realization Rate
PGE2036			
kW	3,940	4,571	116%
kWh	29,361,194	32,297,313	110%
Therms	3,128,902	1,846,052	59%
SCE2530			
kW	2,903	1,103	38%
kWh	21,277,596	12,128,230	57%
Therms	342,276	N/A	N/A
SCG3520			
Therms	627,613	389,120	62%
SDGE3026			
kW	2,950	324	11%
kWh	14,442,410	5,776,964	40%
Therms	231,395	249,906	108%

Table 6-28 compares the net evaluated kW, kWh, and Therm savings for the UC/CSU/IOU Energy Efficiency Partnership Programs to the *ex ante* net savings estimates:

Table 6-28. Comparison of *ex ante* to *ex post* Net Savings

Fuel Type	*ex ante* Net Savings	*ex post* Net Savings	Net Realization Rate
PGE2036			
kW	3,200	3,435	107%
kWh	24,025,555	22,218,706	92%
Therms	2,552,970	1,323,099	52%
SCE2530			
kW	2,323	829	35%
kWh	17,022,077	8,343,529	49%
Therms	273,821	N/A	N/A
SCG3520			
Therms	502,090	278,889	56%
SDGE3026			
kW	2,360	244	10%
kWh	11,553,928	3,974,221	34%
Therms	185,116	179,112	98%

6.7 Discussion of Findings and Recommendations for the UC/CSU/IOU Energy Efficiency Partnership Programs

The Summit Blue evaluation staff thoroughly documented the evaluation process in an effort to capture and assess program feedback based on discussions with participants, program data, auxiliary reports, and evaluation observations. This information has been used to develop recommendations that will improve future Program and impact evaluation cycles.

Recommendation 1: Standardize Participant Data Requirements

The accuracy of impact evaluation findings is limited by the availability and quality of relevant participant measure data. Throughout the evaluation, Summit Blue staff encountered numerous challenges in collecting supporting evaluation data from various participants due to:

1.) Lack of available project documentation and supporting savings methodologies, and

2.) Lack of participant support for the impact evaluation process.

As an example, multiple projects claimed savings for various custom HVAC measures but did not clearly delineate which measures the savings were attributed to. In an effort to improve the efficiency of future impact evaluations, Summit Blue recommends standardizing data requirements on project application forms to support M&V activities.

Similarly, to leverage the guidelines to their full potential, Summit Blue recommends future evaluation efforts closely monitor the quality of project level documentation provided to support the impact evaluation effort, along with the calculation of project level realization rates. Using this information, measure-specific guidelines may be developed and enforced when low realization rates intersect with High Impact Measures.

Recommendation 2: Ensure that Participant Campuses are Aware of M&V Activities as Early as Possible

As with most evaluations, Summit Blue faced challenges in recruiting participants to support the impact evaluation process – particularly the on-site verification activities. This is generally attributed to a number of factors, including:

1.) Lack of participant staff and/or resources during the evaluation time frame; and

2.) Lack of familiarity with the purpose of M&V activities. For example, Summit Blue staff assured a number of campuses that the results of the evaluation would not impact their incentive payments.

Summit Blue recommends informing Program participants of M&V activities and their value in future Program planning efforts as early as possible in the project cycle. This will help ensure that participants are receptive to, and supportive of, post-installation evaluation efforts. Moreover, it will encourage the participants to improve the quality of project documentation to support future evaluation activities.

Recommendation 3: Clearly Differentiate Between Gross and Peak Demand Savings

The differentiation between peak and gross demand savings on the project applications was not readily apparent. Moreover, the definition of the peak demand period was inconsistent with the DEER definition used for evaluation purposes. A majority of participants calculated peak demand savings as the reduction in total connected load. This misconception contributed significantly to the variability in peak demand realization rates.

In future program cycles, Summit Blue recommends the creation of two fields within the project application:

1.) Gross Demand Savings

2.) Peak Demand Savings

Similarly, defining consistent peak demand definitions in the application and evaluation phase will reduce the variability in project realization rates.

Recommendation 4: Improve Project Tracking Systems

The lack of a properly maintained centralized database was responsible for a host of reporting and evaluation complications, including:

1.) Multiple savings estimates for a single project

2.) Inconsistent naming conventions

Future program cycles would benefit significantly from more standardization and thoroughness in the tracking systems. More specifically, a robust database platform that adheres to standard design protocols and normalization would improve the accuracy of reported findings and reduce the amount of time required to identify *ex ante* and *ex post* savings assumptions.

Recommendation 5: Provide More Opportunities to Exchange Information and Expand T&E Participation

As noted within the 2004-2005 UC/CSU/IOU Energy Efficiency Partnership Evaluation,[30] despite of the many avenues for intra-program communication, it appears the lessons learned from individual projects are not shared among campus peers. Additional venues of communication between participant campuses would streamline the implementation process and improve the accuracy of project savings estimates.

[30] SBW Consulting, Inc., Impact and Process Evaluation Final Report for 2004 – 2005 UC/CSU/IOU Energy Efficiency Partnership, Mach 28, 2008

7 Evaluation of California Community Colleges (CCC) Partnership Program

The California Community Colleges/Investor Owned Utility Energy Efficiency Partnership (CCC Program) is a statewide program to achieve energy savings and peak demand reductions within California's Community Colleges system. The program is offered in the service territories of the four Investor Owned Utilities with the following EEGA program numbers:

Pacific Gas and Electric:	PGE2018
Southern California Edison:	SCE2526
San Diego Gas and Electric:	SDGE3001
Southern California Gas:	SCG3518

7.1 Evaluation Objectives for CCC Partnership Program

The parameters being examined in the evaluation of the CCC programs are the gross savings realization rates (at the IOU and fuel type level of aggregation) and net-to-gross ratios (at the statewide, cross-IOU, level of aggregation). The savings achieved for such measures have been evaluated using Protocol-Guided Direct evaluation approaches. The levels of rigor for various aspects of the evaluation are shown in Table 7-1. Gross savings are being evaluated with enhanced rigor. The net-to-gross evaluation accounts only for the effects of free-ridership in the net savings' estimates. The NTG analysis also examined spillover; however, the NTG ratios do not include impacts of spillover. 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.

Table 7-1. Levels of Rigor for Evaluation of California Community Colleges Programs

Program ID	Program Name	Level of M&V	Energy Rigor	kW Rigor	NTG Rigor
PGE2018	PGE CCC-IOU	Full Impact	Enhanced	Basic	Standard
SCE2526	SCE Community Colleges	Full Impact	Enhanced	Basic	Standard
SCG3518	SCG Community College	Full Impact	Enhanced	N/A	Standard
SDGE3001	SDGE Community College	Full Impact	Enhanced	Basic	Standard

7.2 Methodology and Specific Methods Used for Evaluation of CCC Programs

This section provides an overview of gross impact and net impact analysis methods. Additional details regarding these methods can be found in Appendix G (for gross methods), and Appendices F and H (for net methods). It should be noted that interactive effects were not considered in this evaluation. Further analysis will be conducted to apply factors for interactive effects based on the evaluation results and the method and results will be presented in the Energy Division report.

7.2.1 Gross Impact Analysis Methods

Sampling Plan

The sampling plan for evaluation of the Community College programs had the following features.

1. Individual samples are drawn for each IOU-fuel type combination—resulting in six samples for the programs (i.e., three IOUs and two fuel types equals six individual samples).
2. Confidence and precision levels within each combination are 90% confidence with 20% precision.
3. The sample design relied on cluster sampling (also known as two-stage sampling) methods, in which for the first stage, campuses are randomly drawn based on total expected savings of all projects for the campus; for the second stage, individual projects within the chosen campuses are chosen for M&V. This allowed M&V resources to be concentrated on fewer campuses, allowing for savings associated with less travel between campuses.
4. The sampling universe for each program was comprised of all projects from the original sample in which M&V work has not already begun.
5. In the first stage of the sampling process, the probability that a campus is selected is based on the total expected energy savings (in BTUs) of all projects scheduled for that campus. In the second stage, the probability that a project is selected is based on the size of the actual project.[31]

Table 7-2 shows summary statistics for the CCC sample. The projects selected through the two-stage sample process come from 14 campuses, out of a total of 76 campuses on which projects are being conducted.[32] A total of 33 projects were chosen, of which two have both expected electrical and gas savings.

[31] Because of this, care must be taken when extrapolating results from the M&V analysis to all projects within the sample universe.

[32] Note: 11 of the 14 campuses had ongoing M&V work and were deterministically selected for the revised sample.

Table 7-2. Summary Statistics for CCC Projects Selected in Resample

Statistic	With Expected Electrical Savings (kWh)	With Expected Gas Savings (Therms)
Number of Projects*	21	14
Mean Savings Per Project	1,066,484	38,418
Total Energy Savings	22,396,174	537,857
Energy Savings as a Percent of All Projects	38%	37%**

*Total of 33 projects, only 2 of which had both expected electrical and gas savings.

**Two projects on the Evergreen Valley College campus (and selected in the sample) account for 10% of total expected gas savings.

Review of Documentation

After the samples of projects were selected, documentation on the energy efficiency projects undertaken at these sites was requested from the different IOUs. For each site, the available documentation (e.g., audit reports, savings calculation work papers, etc.) for each rebated measure was reviewed, with particular attention given to the calculation procedures and documentation for savings estimates. Documentation that was reviewed for all sites selected for the sample included program forms, data bases, reports, billing system data, weather data, and any other potentially useful data. Each application was reviewed to see whether the following types of information had been provided:

Documentation for the equipment changed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information.

Documentation for the new equipment installed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information.

Information about the savings calculation methodology, including (1) what methodology was used, (2) specifications of assumptions and sources for these specifications, and (3) correctness of calculations.

Data Collection and Savings Analysis Procedures for Lighting Measures

The lighting measures evaluated included both efficiency and control measures. Savings for the three types of measures were assessed using IPMVP Option A, Retrofit Isolation. With IPMVP Option B, savings are calculated using short term or continuous measurement, and savings are 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. Short-term or continuous measurements are taken during the post-retrofit period.

The information needed to assess the savings from these lighting measures was as follows:

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

Analyzing the savings from such lighting measures required data for retrofitted fixtures on (1) wattages before and after retrofit, (2) hours of operation before and after the retrofit, and (3) number of fixtures affected by the measure. The documentation file was reviewed for these parameters. The fixture wattages as claimed in the documentation were verified against existing databases and industry sources based on the rated power of the original lamps. These claimed wattages were used for the purpose of calculations unless they deviated significantly from published databases or manufacturers' claims.

To obtain data on hours of operation for the lighting where the efficiency or control measures had been installed, samples of spaces of different types of functional areas were selected across campuses and lighting loggers were installed to collect data on hours of use.

For each campus with lighting measures in the evaluation sample, the spaces in which the lighting measures were implemented were 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[33] and as implemented by California community colleges in the space inventory data that they report. The major functional use areas where lighting measures were installed are classrooms and offices. For three of the campuses, measures for exterior lighting were also installed.

The sub-sampling plan for installing lighting loggers involved selecting 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 areas

The sub-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, having these two sets of estimates would allow developing a ratio from the data for the sampled sites that could be applied to adjust the expected hours as reported in the project applications.

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.

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

Data Collection and Savings Analysis Procedures for HVAC Measures

For sites with HVAC measures, energy savings were verified through calculations using a site-specific M&V approach. This approach involves (1) selecting a representative sample of projects that participated in the program; (2) determining the savings for each project, usually by using one or more of M&V Options defined in the IPMVP; and (3) applying the results of estimating the savings for the sample to the entire population in the project.

Information presented in the documentation for each sampled project with HVAC measures was used to develop a site-specific M&V plan. The M&V plan addressed the site-specific nature of the following elements:

- IPMVP Option chosen;
- Specification of approach to calculating savings;
- Identification of corresponding variables and specification of assumptions;
- Identification of data sources and / or collection techniques;
- Specification of data collection (i.e., sampling, site inspection, and monitoring plan), if required; and
- Identification and resolution of any other M&V issues.

For all of the projects with HVAC measures, IPMVP Option D was chosen. With this option, a Calibrated Simulation of energy use is made. For the analysis here, the eQuest (DOE-2) energy analysis model was used to prepare computer simulations of energy use before and after the HVAC measures were installed at a campus facility.

On-site visits were used to collect data that were used in making the simulation analysis. During an on-site visit, the field staff accomplished three major things.

- First, they verified the implementation status of all measures for which customers received incentives. They verified that the energy efficiency measures were indeed installed, that they were installed correctly, and that they still functioned properly.
- Second, they collected the physical data needed to analyze the energy savings that have been realized from the installed improvements and measures. Data were collected using a form that was prepared specifically for the project in question after an in-house review of the project file.
- Third, they interviewed the contact personnel at a facility to obtain additional information on the installed system to complement the data collected from other sources.

At some sites, monitoring was conducted to gather more information to inform the simulation analysis. Monitoring was conducted at sites where it was judged that the monitored data would be useful for further refinement and higher accuracy of savings calculations. Monitoring was not considered necessary for sites where project documentation allowed for sufficiently detailed calculations.

7.2.2 Net Impact Analysis Methods

The Net-To-Gross (NTG) evaluation approach for evaluation of the CCC partnership is consistent with that used for the evaluation of the UC/CSU partnership. An overview of this approach was provided in Section 6.2.2. Additional high-level discussion regarding the NTG methodology can be found in

Appendix F. Detail regarding the survey instruments and guidance documents used in this analysis can be found in Appendix H.

7.3 Precision and Confidence Intervals for the CCC Program

This section provides the targeted and achieved precision for both gross realization rates and net-to-gross ratios. Calculation of coefficients of variation (CV) and relative precision followed the methods specified in the California Evaluation Framework[34].

7.3.1 Confidence and Precision for the Gross Impact Evaluation

This section discusses the precision and confidence intervals for results obtained through the analysis and evaluation of the CCC Program.

The impact evaluation of the CCC Energy Efficiency Partnership was designated as a Protocol Guided Direct (PGD) evaluation with an "Enhanced" level of rigor. In preparing the corresponding sample design, the Summit Blue evaluation team adhered to the California Evaluation Framework[35] (CEF). The goal for the sample design was to meet the appropriate protocol precision/confidence targets at the statewide program and IOU levels. More specifically, the impact evaluation sample design was based on using both *ex ante* energy (kWh) and therm savings as design variables.

The sample design for the evaluation of the CCC programs was originally developed in August 2008. At that time, a sample frame was constructed using project information extracted from the CCC/IOU Energy Efficiency Partnership website maintained by the program manager, Newcomb Anderson McCormick (NAM).[36] This external database was used because the Q4 2008 IOU Tracking Databases were not available until March of 2009.

There were 240 projects contained on the sampling frame, representing three project classifications:

- Completed – Projects that were identified to be paid and closed
- In Process – Projects that were incomplete or in review by the IOUs
- Planned[37] – Projects that were in the contract approval phase

[34] The TecMarket Works Team, California Evaluation Framework: Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004. See page 320 for calculation of CV and page 322 for calculation of relative precision. See page 356 for a discussion of the stratified ratio estimation approach.

[35] The TecMarket Works Team, The California Evaluation Framework, Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004

[36] http://www.newcomb.cc/

[37] The database used to prepare the sample frame contained data on other projects. However, any projects listed as a "Placeholder" in the *MeasureName* field, or "Cancelled" or "On Hold" in the *Condition* field, were removed prior to development of the sample.

Table 7-3 provides summary statistics for the population of projects contained in the sample frame for the first sample design.

Table 7-3. Summary Statistics for Population of Projects for CCC Impact Evaluation

Statistic	Expected Electrical Savings (kWh)	Expected Gas Savings (Therms)
Number of Projects with Savings	213	67
Expected Savings per Project with Savings	288,463	23,473
Standard Deviation of Project Savings	478,651	29,372
Coefficient of Variation for Projects with Savings	1.6593	1.2513
Total Expected Energy Savings	61,442,669	1,572,723

The sample design was defined in terms of total sample size, number of certainty projects, and number of non-certainty strata. In practice, up to four non-certainty savings strata were defined for each IOU-fuel type permutation. Sample strata based on *ex ante* energy (kWh) and therm savings were defined by:

- Ordering the projects within the sample universe by respective energy savings.
- Specifying a set of certainty sites driven by projects representing a large portion of program savings.
- Dividing non-certainty projects quasi-equally among the strata.

Projects within the non-certainty (i.e., probability) strata were selected through random sampling.

The efficacy of different sample designs was evaluated by considering the precision with which total kWh and total therm savings could be estimated at the 90% confidence level, with 10% precision at both the statewide and IOU levels being the target. The original sample designs treated kWh savings and therm savings independently. In fact, however, some of the projects with kWh savings also had therm savings, and some of the projects with therm savings also had kWh savings. Thus, the samples selected independently to satisfy statewide requirements for precision/confidence would, when combined, provide sufficient sample points to also satisfy the precision/confidence requirements at the IOU/energy source level.

Shortly after field work began for projects selected for this original sample, the CPUC Energy Division chose to pursue an evaluation approach that focused more specifically on high-impact measures (HIMs). This re-direction of the evaluation effort required that resources for the overall Local Government Partnership Program Contract Group be re-allocated among component efforts. To economize on resources, the confidence/precision targets for evaluation of the CCC/IOU Partnership Program were relaxed from the 90/10 requirement specified in the Sampling Protocols presented in the CEF. The revised confidence/precision targets were 90/20 (i.e., 20% precision at 90% confidence).

A re-sampling effort therefore was undertaken that was consistent with the original sample design, but with adjustments to account for some field work having been completed for seven “legacy” projects on six campuses that had been chosen for the original sample. These legacy projects were retained for the final analysis sample. In addition, a subset of the projects chosen for the 90/10 sample was then chosen for the 90/20 sample. There were 40 projects selected for the final sample through this two-stage sampling process; these projects came from 20 campuses. Table 7-4 provides summary statistics for the projects in the final CCC/IOU Energy Efficiency Partnership impact evaluation sample. Because the final sample of projects exceeded the number required to achieve the 90/20 requirement, the precision expected from the overall sample was better than 20%.

Table 7-4. Summary Statistics for Final Sample for CCC Impact Evaluation

Statistic	With Expected Electrical Savings (kWh)	With Expected Gas Savings (Therms)
Number of Projects	26	16
Expected Savings per Project	992,821	42,280
Total Energy Savings	25,813,358	676,477
Energy Savings as a Percent of All Projects	42%	43%

Oversampling at the overall level allowed for acceptable precision within groups of projects classified either as “Custom HVAC” or “Custom Lighting”. In particular, Table 7-5 shows how the 26 projects with kWh savings in the final sample were distributed between “Custom HVAC” and “Custom Lighting” projects.

Table 7-5. Distribution between Custom HVAC and Custom Lighting Projects for Final Sample for CCC Impact Evaluation

Statistic	Custom HVAC Projects	Custom Lighting Projects
Number of Projects	9	17
Expected kWh Savings per Project	1,514,267	716,762
Total kWh Savings	13,628,400	12,184,958

The final relative precision for the estimates of realization rates by IOU are shown in Table 7-6.

Table 7-6. Relative Precision for Estimated Gross Realization Rates by IOU

	kWh Relative Precision	kW Relative Precision	Therm Relative Precision
PG&E	2%	15%	16%
SDG&E	38%	41%	11%
SCE	31%	18%	N/A
SCG	N/A	N/A	10%

7.3.2 Confidence and Precision for the Net Impact Evaluation

Five different surveys have been conducted for this effort:

Utility Program Managers

Partnership Committee Members

Campus Representatives

Project level/Facility Managers (Decision-Maker)

Vendors and ESCOs

All surveys except the Decision-Maker survey are used to obtain qualitative information and are provided for reference in Appendix H. The Decision-Maker survey collects both qualitative and quantitative data. It is the primary instrument used to obtain the data needed for the NTG algorithm, which will provide both a case study and program level NTG ratios.

The first step was to calculate individual measure level NTG ratios using an Excel worksheet, designed by Itron. Next, a content analysis of the qualitative information gathered from college and market actors will be used to identify supporting or contradictory information on the decision making process. Finally the quantitative and qualitative information will be analyzed and integrated to tell a NTG 'story'.

According to the Guidelines, the achieved relative precision of the NTG ratios for the case study method is less straightforward than for other methods. Specifically, the use of multiple decision-makers, the incorporation of other qualitative information and the use of the market actor perspective combine to complicate the development of the relative precision estimate. The Guidelines state: "When the NTGR is based on interviews with more than one person at a site, the propagation of errors should be taken into account in calculating the achieved relative precision. However, one must recognize the error bounds are probably underestimated due to the inclusion of the qualitative data".[38]

As stated, there were 240 participating projects in the CCC Program. The NTG sample was nested within the Impact sample. An executive interviewer was able to complete 10 Decision-Maker surveys out of a census attempted of 27. Assuming a mean of 0.8 and a CV of 0.50, completing 10 Decision-Maker surveys would achieve 90/20 level of confidence and precision. However, the actual CVs are lower, and the 90/20 goal was exceeded for kWh and kW (but not for therms, which had a sample size of just 5 projects):

- For kWh, the number of survey completes was 9 and the CV was 0.20, resulting in an achieved confidence/precision of 90/12.
- For kW, the number of survey completes was 8 and the CV was 0.21, resulting in an achieved confidence/precision of 90/14.
- For Therms, the number of survey completes was 5 and the CV was 0.28, resulting in an achieved confidence/precision of 90/24.

38 Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches, California Public Utilities Commission Energy Division and the Master Evaluation Contractor Team, October 15, 2007 p13.

Calculation of coefficients of variation (CV) and relative precision followed the methods specified in the California Evaluation Framework[39].

7.4 Validity and Reliability for EM&V of CCC Program

7.4.1 Key Uncertainty Sources and Mitigation Methods

There are several potential sources of uncertainty associated with estimating the impacts of the CCC programs. Examples of such sources include the following.

- Sample selection bias
- Physical measurement error (e.g., meter bias, sensor placement, non-random selection of equipment or circuits to monitor)
- Engineering analysis error (e.g., baseline construction, engineering model bias, modeler bias)
- Survey error (e.g., non-response bias)

The following discussion describes the steps taken to reduce the uncertainty arising from these sources and thereby increase the validity and reliability of key measurements for the evaluation of the CCC programs.

Reducing Uncertainty from Selection Bias. The problem that selection bias can create for program evaluation has been long recognized. Accordingly, explicit steps were taken to guard against selection bias. Although campuses were chosen for the evaluation according to prescribed sampling plans, bias could have been introduced if the campuses selected did not choose to participate in the evaluation effort. However, for the CCC impact evaluation work, response rates were high. All campuses in the sample agreed to participate in the evaluation effort.

However, there were some campuses where the project that was chosen for the sample was not ultimately implemented or would not being implemented in time for inclusion as a 2006-2008 claim. For each of these cases, a substitute measure project was chosen from among similar measure projects not originally sampled. The substituted project was one with similar kWh savings for the similar measure, thereby mitigating potential bias introduced through such substitution. This substitution was done to maintain the sample size at the targeted level as determined by the sample design while maintaining similar representation across measures.

Further discussion of sampling procedures, including discussion of procedures to reduce bias, is provided in Appendix G.

Reducing Uncertainty from Physical Measurement Error. There is some error associated with all physical measurement. For the CCC impact evaluation, the major measurement effort involved installing lighting loggers to determine hours of operation for lighting in different types of functional spaces. Several steps were taken to reduce errors for these lighting measurements.

[39] The TecMarket Works Team, California Evaluation Framework: Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004. See page 320 for calculation of CV and page 322 for calculation of relative precision. See page 356 for a discussion of the stratified ratio estimation approach.

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.

To minimize measurement error from improper calibration of the loggers, the field monitoring staff checked all loggers used in the field to ensure that they were properly calibrated prior to being installed. Field staff was also trained on proper procedures for installing the loggers in the field.

To guard against biases arising because of improper placement of the loggers, field staff was 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).

Poor quality data can be a significant source of error and uncertainty. To minimize the potential impact of this problem, various quality assurance checks were applied to the lighting logger data to ensure adequate quality for analysis.

Further discussion of the procedures for making lighting logger measurements is provided in Appendix G.

Reducing Uncertainty from Engineering Analysis Error. Besides lighting, the other major end use analyzed for the CCC impact evaluation was custom HVAC projects. Energy savings for such projects were analyzed using computer simulations developed with the DOE-2 energy analysis model. There are several types of bias in such engineering analysis that can induce errors and uncertainty into estimates of savings. Accordingly, various steps were taken to reduce these biases.

Engineering model bias was reduced by using DOE-2, which is a well-known and widely used computer simulation model. Well-developed techniques and procedures for conducting engineering analyses with DOE-2 were used, coupled with rigorous internal reviews.

Modeler bias was reduced by having the modeling and analysis performed by engineers who were experienced energy modelers within evaluation settings and who were familiar with applying DOE-2 analysis procedures.

Reducing Uncertainty in Net Savings Estimates Arising from Survey Error. For the net savings evaluation of the CCC program, the major source of uncertainty was likely to arise from survey non-response error. Accordingly, various steps were taken to ensure that non-response was minimized.

As with the impact evaluation sample, campuses were chosen for the NTG sample through prescribed sampling plans. 10 Decision-Maker surveys were completed out of a census attempted of 27 (for a response rate of 37%). Actions taken to minimize non-response are explained in Appendix F.

Construct validity was ensured through the use of standard survey and analysis methods that have been pretested with multiple types of customers and have produced reasonable NTG estimates in the past. In particular, the survey instrument for the CCC NTG evaluation was customized for the college decision makers from the NTGR survey instrument developed for the Large Commercial contract evaluation by the Summit Blue team. Similarly, the case study method developed for analyzing free ridership with large industrial and commercial customers was also adapted for the CCC NTG analysis.

External validity can be measured by comparing the NTG ratios of the CCC Program with results from other studies using the case study method and with the results of the UC/CSU Program Evaluation. However, there is a unique decision- making structure for the CCC system that needs to be considered in making such comparisons.

Reducing Uncertainty in Net-to-Gross Estimates from Social Desirability and Recall Biases. Issues related to Social Desirability and Recall biases are discussed in Section 6.4.1 Key Uncertainty Sources and Mitigation Methods. This section also discusses that while no steps were taken to respond to potential Social Desirability biases (which have unknown direction impact on NTG ratios), the following were taken to respond to potential Recall bias:

- Participant surveys were administered no more than 18 months after participation, and, in most cases, less than a year after participation.
- Introductory questions were administered to ensure that:
    - The respondent was indeed the one that made the participation decision (if not, the survey was terminated), and
    - The respondent remembered participating and remembered acquiring the measure.

7.4.2 Recommendations for Future M&V Activities

Most of the sources of bias and uncertainty discussed above are well known, and procedures are known for reducing error and uncertainty from these sources. However, there were difficulties (i.e., failures) experienced with the newer version lighting loggers, which were not fully anticipated. To compensate for a higher than usual rate of failure, the number of loggers actually installed was increased significantly; this effectively increased the cost of the monitoring effort. Accordingly, for future M&V work, it may be useful to establish a working group that could serve as a clearing house for the quality and reliability of equipment that will be used to take measurements.

7.5 Detailed Findings for California Community Colleges Program

This section presents the detailed study findings from the EM&V for the Community Colleges programs. Results are reported for the evaluation of custom lighting and custom HVAC projects undertaken at campuses. The discussion is focused on the results of the fieldwork as it pertains to the particular parameters that are most important in determining savings. The results are presented in three parts, first for lighting measures, second for HVAC measures, and third for net-to-gross surveys and analysis.

The findings presented in this section are based on analysis of the data collected for the sample of campuses and projects chosen for detailed analysis. The application of these findings to address program-level savings is discussed in Section 7.6.

7.5.1 Findings from EM&V for Lighting Measures

The types of lighting measures installed in community college projects included both retrofit (efficiency) and control measures.

Lighting retrofit (efficiency) measures were installed to reduce demand, but operating hours were the same pre- and post-retrofit. These types of measures included retrofitting existing fixtures, lamps and/or ballasts with an identical number of more energy efficient fixtures, lamps and/or ballasts.

Lighting control measures for interior lighting reduced operating hours but did not reduce demand. These measures include occupancy sensors or daylighting controls that are installed *without* any changes to fixtures, lamps, or ballasts

Lighting control measures for exterior lighting also reduced operating hours but did not reduce demand.

7.5.2 Hours of Lighting Use as Estimated with Lighting Logger Data

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.

Table 7-7 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.

Table 7-7. 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 7-8shows 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 7-8. Statistics on Lighting Hours of Use When Logger Placement Is Classified by Campus and Whether Lighting Is Controlled

Campus/Utility	Number of Loggers Installed	Average Hours of Use	Standard Deviation for Hours of Use	Relative Precision
Spaces Where Lighting Is Not Controlled				
Diablo Canyon (PG&E)	33	2,955	1,720	16.7%
Laney (PG&E)	35	2,881	1,951	18.8%
Mira Costa (SDG&E)	53	1,777	1,169	14.9%
Monterey Peninsula (PG&E)	27	2,558	1,707	21.1%
Victor Valley (SCE)	32	3,151	2,187	20.2%
All Non-controlled	180	2,569	1,787	8.5%
Spaces Where Lighting Is Controlled				
Evergreen Valley (PG&E)	48	2,905	2,789	22.8%
San Jose City (PG&E)	70	1,536	1,040	13.3%
Victor Valley (SCE)	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%

7.5.3 Estimation of Realization Rates for Retrofit Lighting Measures

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 7.4, 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.

Realization rates for retrofit lighting measures were calculated for the set of sample campuses, using the logger data for hours of use for lighting and the verified data on the kW reductions resulting from the retrofits.

The calculated realization rates for kWh savings for lighting retrofit measures are reported for the sample campuses in Table 7-9.

Table 7-9. Estimated kWh Realization Rates for Lighting Retrofit Measures, by Sampled Campus[40]

Campus / Utility	Claimed kWh Savings	Evaluated *ex post* kWh Savings	kWh Realization Rate
Diablo Canyon (PG&E)	770,793	736,247	95.5%
Laney (PG&E)	794,150	707,211	89.1%
Mira Costa (SDG&E)	334,362	163,199	48.8%
Monterey Peninsula (PG&E)	513,328	391,325	76.2%
Victor Valley (SCE)	1,103,261	750,340	68.0%

Realization rates for lighting retrofit measures were less than one for the sample campuses because measured hours of use for lighting that were used to determine evaluated kWh savings were generally less than the values for hours of use that were applied in developing the claimed savings estimates. These differences are shown in Table 7-10.

Table 7-10. Comparison of Average Hours of Use Used in Determining Claimed and Evaluated kWh Savings for Lighting Retrofit Measures, by Type of Space (Based on Data for Non-Controlled Spaces)

Type of Space	Average Hours of Use for Claimed kWh Savings	Average Hours of Use for Evaluated kWh Savings
Classrooms	3,461	2,096
Food Service	3,993	5,631
Laboratories	3,218	3,126
Offices	3,421	2,237
All Non-controlled	3,485	2,569

[40] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

7.5.4 Estimation of Realization Rates for Lighting Control Measures

Realization rates for kWh savings for lighting control measures were also calculated for the sample campuses where those types of measures had been installed. For lighting controls, hours of use differ of course before and after installation of the measures. In calculating the evaluated kWh savings, after-installation hours of use were determined from the logger data collected for controlled spaces. However, before-installation hours of use were determined using average hours of use by type of space collected for non-controlled spaces.

The calculated realization rates for lighting control measures are reported in 1.

Table 7-11. Estimated kWh Realization Rates for Lighting Control Measures (Occupancy Sensors), by Sampled Campus[41]

Campus	Claimed kWh Savings	Evaluated *ex post* kWh Savings	kWh Realization Rate
Evergreen Valley (PG&E	1,209,994	619,556	51.2%
San Jose City (PG&E)	851,925	839,541	98.5%
Victor Valley (SCE)	274,093	380,518	138.8%

7.5.5 Findings from EM&V for HVAC Measures

Analysis and estimation of gross kWh and therm savings for HVAC measures were based on data for a sample of campuses at which energy efficient HVAC measures had been implemented. The HVAC projects at the sample campuses all involved changes to the central plant (e.g., upgrades to chillers, installation of VFDs on fans and pumps, etc.).

Engineering analysis and simulations with the eQuest (DOE-2) energy simulation model were used to develop alternative estimates of energy use for the sampled sites where energy efficient HVAC measures had been installed. The major steps in the analysis were as follows:

1) Collect data on-site for the sample campuses where HVAC measures had been installed.
2) Calibrate eQuest model for each site, using data collected on-site as well as interval and billing data on energy use (where available).
3) Execute eQuest analysis to define baseline energy use for each site

[41] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

4) Execute eQuest model to determine savings from installing various energy efficiency measures at campus

5) Calculate energy savings as difference in energy use between baseline case and installed measures case

Realization rates for kWh and therm savings for HVAC measures were calculated from the results of the computer simulation analysis. The calculated realization rates for kWh savings for HVAC measures are reported in Table 7-12. The calculated realization rates for therm savings are reported in Table 7-12.

Table 7-12. Estimated kWh Realization Rates for HVAC Measures, by Sampled Campus[42]

Campus / Utility	Claimed kWh Savings	Evaluated kWh Savings	kWh Realization Rate
Cerritos (SCE)	1,651,101	660,440	39.9%
Fullerton (SCE)	1,811,137	489,007	27.0%
Long Beach – LAC (SCE)	403,000	156,029	38.7.0%
Long Beach-PCC (SCE)	62,830	63,719	101.4%
Saddleback (SDG&E)	1,293,780	331,305	25.6%

[42] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

Table 7-13. Estimated Therm Realization Rates for HVAC Measures, by Sampled Campus[43]

Campus / Utility	Claimed Therm Savings	Evaluated Therm Savings	Therm Realization Rate
Cerritos (SCG)	20,752	14,941	71.6%
Fullerton (SCG)	35,728	19,293	54.0%
Saddleback (SCG)	34,717	33,920	97.7%
San Diego-Miramar (SDG&E)	7,163	7,640	106.2%
Mira Costa (SDG&E)	14,446	10,401	72.0%
San Diego City (SDG&E)	3,639	2,911	80.0%

7.6 Program-Specific Results for CCC Programs

This section presents realization rates and the IOU and fuel-type level and statewide (i.e., across all CCC IOU programs) net-to-gross estimates for the CCC partnership program.

7.6.1 *Ex Post* Evaluated Savings for CCC Programs for 2006-2008 Program Period

The EM&V effort was directed at verifying the net kWh, kW and therm savings claimed for the CCC programs over the 2006-2008 program period. The *ex post* evaluated savings results developed through the EM&V work are presented and discussed in this section.

Realization rates and precision were estimated using the Stratified Ratio Estimator approach per the California Evaluation Framework. Summary statistics on the realization rates and precision of the *ex post* estimates of gross savings by IOU are shown in Table 7-14.

[43] The realization rates by project and measure category are provided for information only. The final realization rate that will be applied is the average realization rate at the IOU and fuel-type level of aggregation.

Table 7-14. Summary of Estimated Gross Realization Rates and Relative Precision, by IOU

	kWh RR	kWh Relative Precision	kW RR	kW Relative Precision	Therm RR	Therm Relative Precision
PG&E	79%	2%	59%	15%	74%	16%
SDG&E	41%	38%	42%	41%	83%	11%
SCE	62%	31%	40%	18%	N/A	N/A
SCG	N/A	N/A	N/A	N/A	78%	10%

Table 7-15 compares the gross claimed and *ex post* evaluated kWh, kW and therm savings for projects implemented through the CCC/IOU Energy Efficiency Partnership programs.

Table 7-15. Comparison of *ex ante* Claimed Gross Savings to *ex post* Gross Savings, by Utility Program and Type of Savings

Type of Savings	Total Gross Claimed Savings	Total *ex post* Gross Evaluated Savings	Gross Realization Rate
PG&E – 2018			
kWh	10,616,600	8,351,277	79%
kW	2,475	1,466	59%
Therms	487,280	366,487	74%
SCE – 2526			
kWh	24,551,989	15,267,383	62%
kW	8,327	3,308	40%
SDG&E – 3001			
kWh	4,832,953	1,983,307	41%
Kw	910	381	42%
Therms	38,853	32,187	83%
SCG – 3518			
Therms	355,075	275,681	78%

7.6.2 Findings from Net-to-Gross Surveys and Analysis

The CCC LGP Program falls under the Standard – Very Large protocol standards and was evaluated using the Large Non-Residential NTG Method, which is a case study method and uses a survey developed by the NTG Working Group for use by all evaluators in the 2006-2008 program cycle. 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 Summit Blue team surveyed ten decision-makers who participated in the LGP program.

Ten community college decision-makers were interviewed for this study. Decision-maker data were entered into the NTGR calculator to generate preliminary scores (see Appendix F). Key drivers in the calculator include:

- Timing and Selection Score
- Program Influence Score
- No Program Score.

Further details on these scores and the calculator are described in Appendix F. NTG ratios ranged from 0.44 at Butte College to 0.85 at San Diego Community College District. Then, two evaluators, one of whom was the executive interviewer, independently reviewed the NTGR scores and adjusted them based on the qualitative information gleaned from in-depth interviews with program staff, campus representatives and decision-makers. Then, the evaluators determined a collaborative adjustment through discussion, as described in Appendix F.

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 7-16.

Table 7-16. Program NTG Results for CCC

Savings Type	% Free Riders	NTGR % (1-%FR)
kWh	33%	67%
kW	31%	69%
Therms	33%	67%

7.7 Discussion of Findings and Recommendations

As shown by the comparative data in Table 7-15, the net *ex post* savings achieved through the CCC programs fell short both of the projected and the claimed savings. Net *ex post* savings fell below net claimed savings primarily because of (1) gross realization rates were less than 1 and (2) net-to-gross ratios were lower than the 0.8 value used by the IOUs to determine net savings.

The analysis indicated that while the realization rates for lighting measures were reasonably high (between 49% and 98% across the IOUs, with most in the higher range), the realization rates for HVAC measures were noticeably lower (most between 26% and 40%, with one exception). However, the HVAC measures analyzed were generally part of broader, campus-wide energy efficiency projects often involving changes to a campus's central plant. Such projects generally take some time to plan and often had not been fully completed by the end of the 2006-2008 program cycle. For example, a retrofit project may have been planned for central plant HVAC equipment that served several buildings, but only some of those buildings were being serviced during the evaluation period.

This observation is consistent with the information obtained in the process evaluations for the CCC programs, which showed that the planning cycle for large-scale energy efficiency projects at CCC campuses is such that the projects often are not designed and completed within a three-year period. Because of this, evaluation of the savings from the CCC programs that is restricted to examining savings planned and achieved within a three-year period may understate the savings that will finally be realized when the retrofit projects are fully completed. Also, the three-year period was also shown to be a deterrent to program participation, in cases where new construction or campus-wide retrofit programs would require longer periods of time.

The differences in gross and net realization rates across IOUs can also be attributed to differences in the mixes of lighting and HVAC projects. An IOU program with a greater percentage of lighting projects generally showed higher realization rates.

8 EVALUATION OF THE PALM DESERT PARTNERSHIP PROGRAM

8.1 Evaluation Objectives for Palm Desert Partnership Program

The Palm Desert Partnership program has aggressive goals of achieving a 30% reduction in energy consumption and peak demand in the City of Palm Desert within five years. The Partnership includes SCE, SCG, the City of Palm Desert, and the Energy Coalition, a non-profit base in Irvine. The program was funded as a pilot during the 2006-2008 funding period. The program had the following energy savings goals for 2006-2008:

- 26,866,000 kWh
- 9,442 kW[44]
- 703,371therms

The impact evaluation of the Palm Desert Partnership had two major objectives:

i. Evaluate the overall impacts of the Palm Desert programs, SCE2566 and SCG3543
    a. Develop overall program gross savings estimate using mixture of statewide HIM results and Palm Desert measure studies. Program level results will be provided separately as part of the overall Energy Division's Final Performance Basic Report, which will occur after all HIM studies have been completed.
    b. Complete program-level net-to-gross analysis to derive net savings

ii. Develop refined savings estimates for unique measures with significant impacts in the Palm Desert Program including:
    a. Commercial RCA
    b. Residential RCA
    c. Residential Early Retirement

A review of the E3 calculators and program tracking databases for SCE and SCG showed the following total 2006-2008 *ex ante* net savings estimates for SCE2566 and SCG3543:

23,618,934 kWh (SCE2566)

6,865 kW (SCE2566)

768 therms (SCG3543)

[44] Note that the 2006-2008 SCE Program Implementation Plan for Palm Desert lists 9,442 MW as the projected demand savings. This is obviously a typo.

The SCG3543 *ex ante* net savings are very small. As a result, a minimum of evaluation resources were expended looking at SCG3543, with no detailed impact evaluation for that portion of the program. It appears that almost all gas energy efficiency measures in Palm Desert were reported through other SCG programs.[45] The *ex ante* gross energy and demand savings for SCE2566 are broken out by measure and direct-install vs. not direct-install in the table below.

Table 8-1. Summary of SCE 2566 Savings

Res/ NonRes	DI/ NonDI	Measure	*ex ante* Gross kWh	*ex ante* Gross kW	% of kWh	% of kW
NonRes	DI	CFL[46]	5,244,179	798	17.8%	9.3%
		LFL[47]	2,938,386	487	10.0%	5.7%
		RCA[48]	2,141,566	533	7.3%	6.2%
		Strip Curtains	47,033	6	0.2%	0.1%
		Exit Sign	163,360	20	0.6%	0.2%
		Occ Sensor	188,604	-	0.6%	0.0%
		Com Whole Bldg	110,542	34	0.4%	0.4%
		Door Gaskets	38,469	2	0.1%	0.0%
		Other	2,779	2	0.0%	0.0%
NonRes	NonDI	CFL	5,587,310	439	18.9%	5.1%
		Ag Pumping	1,642,392	71	5.6%	0.8%
		PC Operation	357,361	0	1.2%	0.0%
		Door Gaskets	25,800	1	0.1%	0.0%
		Exit Sign	88,882	11	0.3%	0.1%
		Other	79,170	39	0.3%	0.5%

[45] This means that the money spent on marketing and administering SCG3543 in Palm Desert was really being spent in support of the SCG core programs operating in this area.

[46] Compact fluorescent lamps

[47] Linear fluorescent lamps

[48] Air conditioner refrigerant charge adjustment

Res/ NonRes	DI/ NonDI	Measure	*ex ante* Gross kWh	*ex ante* Gross kW	% of kWh	% of kW
		LFL	4,698	2	0.0%	0.0%
Res	DI	CFL	2,902,304	180	9.8%	2.1%
		Res Audits	1,418,844	305	4.8%	3.6%
		RCA	4,000,439	2,731	13.5%	31.8%
		Pool Pumps	342,102	78	1.2%	0.9%
		Night Light	95,289	-	0.3%	0.0%
		Other	36,358	-	0.1%	0.0%
Res	NonDI	HVAC ER	561,910	294	1.9%	3.4%
		Res Audits	306,705	66	1.0%	0.8%
		Pool Pumps	350,612	80	1.2%	0.9%
		HVAC Equip[49]	111,420	139	0.4%	1.6%
		HVAC Maint	474,253	387	1.6%	4.5%
		Duct Repair	151,281	163	0.5%	1.9%
		Other	104,872	1,710[50]	0.4%	19.9%
		Room AC	6,751	3	0.0%	0.0%

The measures making up more than 5% of kWh or kW savings were considered for detailed evaluation in Palm Desert. However, in cases such as Linear Fluorescents (LFLs) and Compact Fluorescents (CFLs), it was deemed that statewide HIM results for these prescriptive measures would provide a more accurate estimation of realization rate. Commercial Refrigerant Charge and Airflow (RCA), Residential RCA, and Residential HVAC Early Retirements were *ultimately* selected for detailed investigation in Palm Desert because of a combination of their uniqueness within the state of California and their comparatively large portion or the Palm Desert program savings. The investigation of Residential HVAC Early Retirements also allowed results for HVAC Equipment to be generated, since 75% of HVAC equipment installations

[49] 75% of claimed HVAC equipment replacement savings came when a unit was installed in conjunction with an early retirement and could be considered part of an early retirement.

[50] This demand savings number is representative of a mistake in the program deemed savings estimates. A units error was apparently made in transcribing the referenced DEER savings values for window films, so the deemed savings estimates are 100 times what they should be.

in Palm Desert happened in conjunction with an early retirement. These four measures comprise 23.1% of total energy savings and 43.1% of total demand savings claimed in the Palm Desert partnership program. HIM results and other secondary sources were used to derive *ex post* gross savings for the rest of the measures in SCE2566. Primary research was conducted to derive program-level net-to-gross estimates.

The following parameters were examined as part of the Palm Desert program impact evaluation:

- Residential RCA
    - Installation quantity
    - Post-installation refrigerant charge, airflow, efficiency, and capacity
- Commercial RCA
    - Installation quantity
    - Post-installation refrigerant charge, airflow, efficiency, and capacity
    - Post-installation energy consumption and capacity delivered during cooling season
- Residential Early Retirement
    - Installation quantity
    - Post-installation refrigerant charge, airflow, efficiency, and capacity
    - Post-installation energy consumption and capacity delivered during cooling season
    - Pre-installation nameplate efficiency and capacity
    - Gross energy and demand savings
    - Measure-level net-to-gross
    - Net energy and demand savings

The primary free ridership evaluation goals for the Palm Desert Local Government Partnership resource acquisition programs were to:

- Account for the effects of free-ridership in the net savings' estimates
- Measure and report levels of spillover.

Extra sampling was conducted on commercial RCA, residential RCA, and residential HVAC early retirements because they were identified as measures of particular interest by the MECT.

Program NTG ratios were estimated, for both kWh and kW savings. Also, Program level ratios were estimated by Sector (Residential and Commercial). In addition, NTG ratios were estimated for 2 measures of particular interest in Palm Desert:

- Early Retirement: Residential
- RCA: Residential and Commercial

8.2 Methodology and Specific Methods Used for Palm Desert Partnership Program

The impact evaluation of the Palm Desert program included a net-to-gross research effort and a detailed measure-level evaluation. Three measures were selected for primary data collection in Palm Desert, as described in the Evaluation Objectives section:

a. Commercial RCA

b. Residential RCA

c. Residential Early Retirement

These three measures were identified by the program evaluation team and Energy Division technical advisors as unique measures/measure implementations with significant savings in Palm Desert. These three measures were all also statewide High Impact Measures (HIM's). As a result, other contract groups, notably Small Commercial and Specialized Commercial, have developed evaluation methodologies for these three measures. The detailed field data collection and analysis methodologies developed primarily by the other contract groups for each measure can be found in Appendices C. A summary of the field data collection and analysis of each measure and how they were adapted for Palm Desert are found in the following pages. It should be noted that interactive effects were not considered in this evaluation. Further analysis will be conducted to apply factors for interactive effects based on the evaluation results and the method and results will be presented in the Energy Division report.

8.2.1 Commercial RCA

The commercial RCA HIM field data collection methodology involved pre-post data collection on individual commercial air conditioning systems receiving the measure. In Palm Desert, the evaluation team attempted to work with Energy Controls and Concepts (ECC), the direct installer of commercial RCA in Palm Desert, to schedule pre-post logging of equipment. Unfortunately, ECC indicated that their commercial RCA direct installations had diminished in number to the point where they did not expect to complete more than 15 installations over the course of the summer. In light of this information, the evaluation team determined it would not be cost-effective to perform pre-post logging of commercial RCA in Palm Desert, as the results of the pre-post study would not likely be statistically significant. Twenty sites were selected from a sample stratified by the quantity of *ex ante* savings. Commercial buildings were logged post-installation for 40-50 days, with loggers being placed in August or early September and pulled in September or October.

Field Data Collection Methodology

The HIM field data collection protocol developed by KEMA (see Appendix A) involved conducting pre-post data collection. In Palm Desert, post-only logging was completed instead. No refrigerant-side measurements were logged, because there was no pre-installation to log. The data logging was focused on deriving an estimate of the system loads, while spot measurements were collected for verification purposes. As a result, the KEMA protocol was simplified to collect the following post-installation information:

- Data logging for 40 days minimum

- Supply air temperature and humidity (90 sec interval)
- Mixed air[51] temperature and humidity (90 sec interval)
- Outdoor temperature at condenser (90 sec interval)
- Outdoor unit power consumption (90 sec interval)
- Indoor temperature and humidity at thermostat (5 min interval)

- Spot measurements
  - Supply air temperature and humidity
  - Mixed air temperature and humidity
  - Outdoor unit power consumption
  - Indoor unit power consumption (if applicable)
  - Return airflow
  - Refrigerant charge measurements
    - Evaporator pressure
    - Condenser pressure
    - Suction line temperature
    - Liquid line temperature
    - Temperature of air entering condenser
- Building characteristics
  - Thermostat settings
  - Envelope component areas and constructions
  - Building operating hours
- Unit characteristics
  - Manufacturer
  - Model number
  - Size (lookup)
  - Efficiency (lookup)

Analysis Methodology

The analysis of field data involved three major steps:

1. Creation of a seasonal cooling load shape based on power consumption and capacity of equipment.
2. Estimation of post-installation in-situ efficiency.
3. Derivation of an installation rate based on the spot measurements and unit characteristics compared to the database and the baseline observed in the statewide commercial RCA study.

The load on each air conditioner was calculated using the spot measurement of airflow and the change in the enthalpy of the airstream, using the temperature and humidity of the mixed and supply air, for each logged time step. This measured load shape for the logged period was then extrapolated to a full seasonal load shape using an aggregate eQuest hourly energy simulation model calibrated to logged AC end use consumption.

Post-installation in-situ efficiency was derived as a function of outdoor temperature only, using the power consumption and calculated capacity.

[51] Mixed air temperature and humidity were taken near the coil, after return and outdoor air have had some time to mix. The sensor was placed to try to capture the most-mixed portion of the plenum, between the return and outdoor air.

The installation rate was derived using the updated field quantity compared to the tracking database, and the measured in-situ efficiency vs. the pre and post in-situ efficiencies observed in the statewide sample. Data about the amount of refrigerant charge added or change in airflow was frequently unavailable. As a result, the evaluation team used a significant change in refrigerant pressures recorded on the installation form as a proxy for a significant change in refrigerant charge having been made in order to estimate an installation rate. This installation rate was combined with on-site verification of correct charge and unit operation to derive an overall verification rate. See Appendix A for more details.

8.2.2 Residential RCA

The residential RCA HIM field data collection methodology involved pre-post data collection on individual residential air conditioning systems receiving the measure. The statewide HIM study included data collection from sites in climate zone 15. As a result, both the typical load and efficiency improvement in climate zone 15 were calculated by KEMA as part of the statewide HIM study data. Therefore, this data did not need to be collected as part of the Palm Desert evaluation. The data collection in Palm Desert focused on calculating a verification rate.

Field Data Collection Methodology

KEMA conducted pre-post RCA analysis in climate zone 15, as noted above. The KEMA data collection protocol can be found in Appendix A. Post-only installation verification was conducted in Palm Desert. The HIM field data collection protocol was simplified to collect only the following spot measurements and building characteristics:

- Spot measurements
  - Supply air temperature and humidity
  - Return air temperature and humidity
  - Outdoor unit power consumption
  - Indoor unit power consumption (if applicable)
  - Return airflow
  - Refrigerant charge measurements
    - Evaporator pressure
    - Condenser pressure
    - Suction line temperature
    - Liquid line temperature
    - Temperature of air entering condenser
- Building characteristics
  - Thermostat settings
  - Envelope component areas and constructions
  - Vacation duration and thermostat settings
- Unit characteristics
  - Manufacturer
  - Model number
  - Size (lookup)
  - Efficiency (lookup)
- Lifetime data (for units that have been replaced since work was completed)
  - Date RCA work was performed
  - Date new unit was installed

Equipment was tested at 20 sites, randomly selected from the program tracking database.

Analysis Methodology

The analysis of the field data involved three major steps:

1. Analyze program installation forms to determine if a significant change in refrigerant charge occurred. This gives an installation rate
2. Verify on-site that the unit is still in use and did not receive significant repair including refrigerant charge after the initial installation
3. Verify on-site that the unit has the correct refrigerant charge.
4. Calculate the overall verification rate as the fraction of claimed tons passing all three of the above criteria.

Data about the amount of refrigerant charge added or change in airflow was frequently unavailable on installation forms. As a result, the evaluation team calculated an installation rate using a significant change in refrigerant pressures recorded on the installation form as a proxy for a significant change in the refrigerant charge having been made. This data was combined with on-site verification of the unit's present condition and refrigerant charge to derive an overall verification rate. See Appendix C for more details

8.2.3 Residential Early Retirement

The residential early retirement HIM field data collection methodology involved post-only data collection on individual residential air conditioning systems receiving the measure. The statewide HIM study included limited data collection from sites in climate zone 15. The results of this study should be applied to climate zone 15, since the statewide HIM effort did not address climate zone 15.

Field Data Collection Methodology

The HIM field data collection protocol collected the following information:

- Data logging for 40 days minimum
  - Supply air temperature and humidity (90 sec interval)
  - Return air temperature and humidity (90 sec interval)
  - Outdoor temperature at condenser (90 sec interval)
  - Outdoor unit power consumption (90 sec interval)
  - Indoor temperature and humidity at thermostat (5 min interval)
- Spot measurements
  - Supply air temperature and humidity
  - Return air temperature and humidity
  - Outdoor unit power consumption
  - Indoor unit power consumption (if applicable)
  - Return airflow
  - Refrigerant charge measurements
    - Evaporator pressure
    - Condenser pressure
    - Suction line temperature
    - Liquid line temperature
    - Temperature of air entering condenser
- Building characteristics
  - Thermostat settings

    - Envelope component areas and constructions
    - Vacation duration and thermostat settings
- Unit characteristics
    - Manufacturer
    - Model number
    - Size (lookup)
    - Efficiency (lookup)
- Lifetime data
    - Manufacturer and model number of sample of replaced equipment

Equipment was logged at 34 sites, randomly selected from the program tracking database.

Analysis Methodology

A summary of the analysis methodology is outlined below. The analysis methodology follows the same basic approach as that used by Cadmus and KEMA in their analysis, but the detailed realization of the analysis differs in the tools used, because the Palm Desert data included a high frequency of special cases and Cadmus and KEMA chose to simplify their analysis in the interest of time. Details of this analysis are available in Appendix C. The analysis of the field data involved six major steps:

1. Estimation of post-installation in-situ efficiency.
2. Derivation of a seasonal cooling load shape for residential early retirement participants.
3. Estimation of pre-installation in-situ efficiency based on results from statewide RCA study and data on vintage and nameplate efficiency of baseline equipment.
4. Derivation of an installation rate based on the spot measurements and unit characteristics compared to the database.
5. Adjustment of lifetime based on vintage of retired equipment and creation of lifetime curve from available data and secondary literature review. See Appendix C.
6. Estimate of measure-level net-to-gross from net-to-gross survey results.
7. Adjustment of results by calculation of a billing normalization factor comparing sampled sites to the population.

The load on each air conditioner for each logged time step was calculated using the spot measurement of airflow and the change in the enthalpy of the airstream, using the temperature and humidity of the return and supply air. This measured load shape for the logged period was then extrapolated to a full seasonal load shape using an eQuest hourly building simulation model calibrated to measured AC energy consumption and actual local weather data.

Post-installation in-situ efficiency was derived as a function of outdoor temperature using the power consumption and calculated capacity.

Pre-installation in-situ efficiency was estimated based on the vintage and nameplate efficiency of equipment replaced according to the SCE inspection reports.

The installation rate was derived based on the quantity of equipment discovered on site, compared to the quantity listed in the program tracking database.

Lifetime was adjusted based on the vintage of units replaced according to the SCE inspections. A lifetime frequency curve was derived from a set of secondary literature resources, which can predict the remaining useful life of equipment of a given vintage.

Billing analysis was used to compare estimated cooling energy consumption in the sample to the overall participant population. This was done to compensate for bias in sample recruitment as a result of seasonal residents leaving for the summer. Further details of the analysis can be found in Appendix C.

8.2.4 Net-to-Gross

Customers were asked a series of self-report free ridership questions to estimate free ridership for each program. The Summit Blue team adopted the question structure and syntax adopted as part of the larger Net-to-gross (NTG) subcommittees that worked to develop a consistent residential and business sector methodology.

The Palm Desert Program is marketed to residential and commercial customers. Therefore, this program is evaluated using the more common Self Report Approach (SRA) methodology for Residential and Small Business Customers. Details of the methodology can be found in Appendix C.

8.2.5 Sampling Methodology

The specific sampling results are explained in more detail in Section 8.3. Impact sample sizes were determined using a 90/20 precision target for each impact study, with secondary sources and energy division technical advisors used for sampling estimates of coefficient of variation. Where there was large variation in the size of savings claimed at each site (commercial RCA), the sample was stratified into three groups.

8.3 Precision and Confidence Intervals for the Palm Desert Program

The Palm Desert program was initially selected to receive a protocol-guided direct evaluation because of high interest in this pilot program on the part of CPUC staff. After the overall statewide evaluation shifted to the high impact measure evaluation framework, there was still a desire to focus on key elements of the Palm Desert partnership program. As a result, three measures of interest found in Palm Desert were selected for additional impact analysis field work, with goals of achieving 90/20 confidence and precision for each of these measures at the program level. In addition, resources were devoted to developing a program-level net-to-gross (NTG) estimate according to the California Evaluation Framework guidelines. The intention of these decisions was to achieve a high level of confidence and precision in the Palm Desert program net impact estimate, while adding as much as possible to the collective knowledge of savings from HVAC measures in hot dry climates. Calculation of coefficients of variation (CV) and relative precision followed the methods specified in the California Evaluation Framework[52].

[52] The TecMarket Works Team, California Evaluation Framework: Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004. See page 320 for calculation of CV and page 322 for calculation of relative precision.

This section states the precision and confidence intervals obtained in the Palm Desert analysis. Intervals are first described for the Impact Sampling and then for the NTG Sampling.

8.3.1 Impact Sampling

Early Retirement Impact (Residential)

There were 610 participating residential customers of the "Central AC Early Retirement (Tier 1 & 2 Adder)" Program. The data reveal a mean of gross savings of 921 kWh. Assuming a CV of 0.70, a sample size of 34 was targeted to achieve a 90/20 level of confidence and precision. The final usable sample size of 28, combined with an achieved CV of 0.7 resulted in an achieved confidence and precision of 90/27. There was no stratification of the Early Retirement Impact sample.

RCA Impact (Commercial)

The 427 total items with Commercial RCA (with Measure title "HVAC DIAGNOSTICS AND REPAIR BY THE UNIT OF THE TON") reveal a gross savings mean of 5,015 kWh. Assuming a CV of 0.50, a sample size of 20 was targeted to achieve a 90/20 level of confidence and precision. The actual results showed a much lower savings result than expected, which was up against the zero bound. As a result, the relative precision is low and the absolute precision is skewed. The mean result is a 4% verification rate, with a 90% confidence interval ranging from 2% to 10%[53].

Stratification was done by savings, each contributing to 33% of total savings:

The first stratum is composed of one participant.

The second stratum is composed of 18 participants.

The third stratum is composed of 212 participants.

The team attempted to recruit all participants in the first and second strata and then to recruit participants as needed from the third stratum to obtain a total of 20. However, because of difficulties in recruitment in the first and second strata, sample was shifted as necessary to the third strata. As a result, three logger installs were made in the first stratum, four in the second, and 13 in the third, still maintaining a total of 20.

RCA Impact (Residential)

There are 1,703 total items with Residential RCA (with 3 Measure titles "SINGLE FAMILY CENTRAL AC MAINT," "MULTI FAMILY CENTRAL AC MAINT," and "MOBILE HOME CENTRAL AC MAINT"). The data reveal a mean gross savings of 2349 kWh. Assuming a CV of 0.50, a sample size of 20 was targeted to achieve a 90/20 level of confidence and precision. There was no stratification, as verification is independent of building type since there is expected to be little variation among single-family, multi-family and mobile homes in this analysis. The actual results showed a much lower savings result than expected, which was up against the zero bound. As a result, the relative precision is low and

[53] The confidence interval and mean quoted here use pieces of equipment as the sampling premise and Monte Carlo analysis assuming a lognormal distribution to determine relative precision, which is then used to calculate the absolute precision range.

the absolute precision is skewed. The mean result is a 10% verification rate, with a 90% confidence interval ranging from 3% to 21%[54]. Additional details may be found in Appendix C.

8.3.2 NTG Sampling

The NTG sample for the Palm Desert LGP Program was designed to meet the CPUC protocols[55] and guidelines[56] for residential and small commercial customers. NTG ratios were estimated for two measures of particular interest in Palm Desert: Early Retirement/HVAC and RCA. Then, composite NTG ratios were estimated for the group of remaining measures in each sector.

Early Retirement/HVAC NTG

For this analysis, a target number of survey completes of 64 was planned and 69 were achieved. All Early Retirement customers also had one of the following 3 measures installed:

- Central AC Tier 1
- Central AC Tier 2
- Central AC Super High Performance

Therefore, results for all of these measures were considered together to obtain a NTG result, since just one decision was made. With an actual CV of 0.4, a confidence and precision of 90/13 was achieved. The Early Retirement NTG sample was not stratified by savings.

RCA NTG (Commercial)

There are 427 total items within the Commercial RCA measure (with Measure title "HVAC DIAGNOSTICS AND REPAIR BY THE UNIT OF THE TON"). Sorting the data by contact reveals 231 unique contacts (since a sample of unique contacts are needed for the NTG survey). Fifty of these unique Commercial RCA contacts were targeted to be among the 150 for the Commercial component of the Program NTG analysis, and just 19 were attained. For the NTG analysis, stratification by savings would not add precision because savings are prescriptive and are constant per unit installed. The final sample size of 19 however had a very low standard deviation resulting in a CV of 0.2. The achieved confidence and precision is 90/11.

RCA NTG (Residential)

There are 1,703 total items with Residential RCA (with Measure titles "SINGLE FAMILY CENTRAL AC MAINT," "MULTI FAMILY CENTRAL AC MAINT," and "MOBILE HOME CENTRAL AC MAINT"). Fifty of these unique Residential RCA contacts were targeted to be among the 150 for the

[54] The confidence interval and mean quoted here use pieces of equipment as the sampling premise and Monte Carlo analysis assuming a lognormal distribution to determine relative precision, which is then used to calculate the absolute precision range.

[55] California Energy Efficiency Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals, Prepared for the California Public Utilities Commission by the TecMarket Works Team, April 2006

[56] The TecMarket Works Team, California Evaluation Framework: Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004.

Residential component of the Program NTG analysis, and 38 were attained. The final sample size of 38, combined with an achieved CV of 0.4 , resulted in an achieved confidence and precision of 90/14.

8.3.3 Summary

In summary, out of a total of 18,641 projects, 74 projects were targeted and evaluated for the impact sample, and 256 survey completes were achieved out of a targeted 364 for the NTG sample. Table 8-2 summarizes sampling targets and completes, and displays stratification. Table 8-3 displays the results and achieved confidence and precision.

Table 8-2. Summary of Palm Desert Sampling

SAMPLE	Overall Population	*ex ante* Savings (Mean kWh)	Stratification	NTG Targeted	On-sites Targeted	NTG Completed	On-sites Completed
Total	18,641			364	74	256	74
Commercial Customers	2,336			150	20	93	20
Other than RCA	1,909		By measure	100		74	0
RCA Commercial	427	5,015	By savings	50	20	19	20
Residential Customers	16,305			214		163	
Early Retirement/HVAC	610	921	None	64	34	69	34
RCA Residential	1,703	2,349	None	50	20	38	20
Other than RCA or Early Retirement/HVAC	13,992		By Measure	100	NA	56	NA

[1] Targeted on-sites refers to our field sampling unit, which consists of one building where verification is performed and one unit is logged if necessary. As a result, entities that were very large sites were targeted for multiple "field on-sites," meaning that multiple buildings were logged at the largest installations. This is important for commercial RCA, where 3 building were logged at 1 location in stratum 1, and 2 buildings were logged at each of 2 locations in stratum 2.

The achieved *ex post* confidence and precision for each calculated NTG result are shown in Table 8-3.

Table 8-3. Palm Desert NTG *ex post* Summary

Level	Sector	Measure(s)	Sample Size	NTG	CV	Confidence Level	Precision
Measure	Residential	All Measures Excluding Early Retirement/HVAC and RCA	56	0.69	0.4	90%	13%
Measure	Residential	Early Retirement/HVAC	69	0.74	0.4	90%	11%
Measure	Residential	RCA	38	0.76	0.4	90%	14%
Measure	Commercial	All Measures Excluding RCA	74	0.85	0.3	90%	7%
Measure	Commercial	RCA	19	0.70	0.2	90%	11%

8.4 Validity and Reliability in Palm Desert

This section presents a summary of the major sources of uncertainty, efforts taken to mitigate the impact of these problems, and ideas for reducing uncertainty in future evaluations. In addition, the relative contribution to uncertainty was calculated using a Monte Carlo simulation in Crystal Ball. Additional detail can be found in Appendix C.

8.4.1 Sources of Uncertainty

Although some uncertainty exists for each input to the calculations described in the analysis methodology (See Appendix C), the Team focused on the uncertainties most likely to be highly influential to the end results of the analysis. Following is a list of the parameters for which uncertainty was analyzed:

1. *Sampling Uncertainty*

Uncertainty Item: There is always the possibility that the sample used does not accurately reflect the population of participants, as a result of non-response or skewing of the sample. In Palm Desert, a significant fraction of homes are unoccupied for large parts of the summer, a characteristic that is correlated with survey response.

Mitigation Strategy: Survey non-response was reduced using a variety of strategies, including calling people up to 15 times, varying the times at which people were contacted, and giving people a toll-free telephone number to call back in the event they were not reached directly. On-site non-response was mitigated by offering significant participant incentives, which increased for the most important sites, and calling back to schedule recruits within two business days. Extra effort was made to work around recruit's vacation schedules. Section d. of Appendix C explains the methods used by PA Consulting, who conducted the surveys, to minimize non-responses.

Future Mitigation: Potential non-response bias due to vacation impacts in Palm Desert could be mitigated by conducting surveys during the winter rather than summer months. This approach could improve the accuracy of the occupancy schedules of all participants. A billing analysis could be used to stratify participants by seasonal variability in consumption, to make sure an even mix of participants who live in Palm Desert seasonally vs. year-round.

2. *Spot Measurements*

Uncertainty Item: Spot measurements have uncertainty due to the quality of the measuring equipment and heterogeneity of the measured characteristic at the measurement point. The measurement of airflow was particularly difficult and has large uncertainty.

Mitigation Strategy: Spot measurements taken during the first site visits were analyzed to determine whether they were consistent with expectations. Measurements were retaken at the second visit, if necessary. Careful attention was paid to ensure that spot measurements of equipment performance characteristics were taken when the HVAC system had reached steady state operation in high stage. Multiple measurements of supply and return temperature and humidity were taken, with “typical” values estimated, to reduce the uncertainty associated with an individual measurement.

Future Mitigation: An additional spot measurement of supply temperature and humidity should be taken at a register. This measurement location will have well-mixed air and should be warmer than the temperature measured at the supply plenum. Airflow measurement could be improved by undertaking a research effort to determine the error inherent in the True-flow measuring device under different common installations. See Appendix C for more details on caveats associated with the True-flow device.

3. *Logged Sensor Data*

Uncertainty Item: Sensors have known error bands and can potentially be installed incorrectly, resulting in faulty or missing readings. Measurement of characteristics that are heterogeneous is difficult, as the placement of the sensor could impact the overall results.

Mitigation Strategy: Spot measurements were taken and compared to a set of logged data to ensure that the sensors and loggers were functioning correctly at launch. Efforts were made to use sensors with tight error bands.

Future Mitigation: The most notable issue encountered in the logger data was high supply temperatures associated with heterogeneous conditions in the supply plenum. One option for dealing with this would be to leave a HOBO temp/RH logger inside the register of a large supply duct as a backup and cross-check. :

4. *Pre-Installation Unit Characteristics*

Uncertainty Item: Characteristics of the pre-installation unit were collected by program administrators for a sample of installations but were not able to be verified during the evaluation, so there was uncertainty around the accuracy of data collected on the pre unit such as SEER, EER, and tons. The team therefore had to rely on the accuracy of data about the pre-installation condition collected by the implementation contractor.

Future Mitigation: Records of pre-installation unit size, efficiency, manufacturer and model number should be required to be kept by the implementation contractor. A telephone hotline could be used to permit verification of a sample of pre-installations.

5. *Remaining Useful Life*

Uncertainty Item: The estimation of RUL was based on an analysis of AC shipment data and home AC saturations from the last 35 years. There is uncertainty around both the results of this analysis and the extrapolation of this analysis to a climate with much higher runtime than the national average.

Future Mitigation: Sampling of non-participants in neighborhoods of a common vintage that had air conditioners installed at the same time could be used as a case study to validate the shape and mean of the lifetime curve.

6. *Extrapolation Process*

Uncertainty Item: Data were collected on site over a six-week period and were then used to calibrate an annual model. There are uncertainties associated with this extrapolation, as the usage in shoulder seasons was not measured. It is possible that occupancy and thermostat usage varied from what customers claimed when asked.

Future Mitigation: If possible, more of the cooling season could be monitored for at least a subsample of homes, i.e., April 1-November 1. Alternatively, additional end-use metering could be combined with a billing analysis to provide a better estimate of cooling energy consumption during shoulder seasons.

7. *Net to Gross*

Uncertainty Item and Mitigation Strategy: Construct validity for the Palm Desert Program survey has been greatly enhanced by the use of standard survey and analysis methods that have been pretested with multiple types of customers and have produced reasonable NTG estimates in the past. Internal validity could be affected by the decision to over sample the HVAC Early Retirement measure and RCA measure in the Residential Program and the RCA measure in the Commercial Program. This potential bias has been mitigated by weighting the measure data of the sample back to the population distribution before calculating Free Ridership for both the residential and commercial programs. There is no evidence to suggest that non response issues introduced any significant bias into the results. Response rates experienced by the survey team were in line with or slightly higher than other response rates experienced by the team in California (averaging about 40%). Reducing Uncertainty in Net-to-Gross Estimates from potential Social Desirability and Recall Biases is discussed in Section 6.4.1 Key Uncertainty Sources and Mitigation Methods.

8.5 Detailed Palm Desert Findings

8.5.1 Introduction

The detailed results of the measure research done in the evaluation of the Palm Desert Partnership program are presented in the following section. This section focuses on the updates to savings calculation parameters that were developed as part of the evaluation. Program measure-level energy and demand savings realization rates, where available, are found in Section 8.6.

8.5.2 Net to Gross Results

This section reveals the NTG results for the following measures for the Palm Desert Program (SCE 2566):

- the RCA (Refrigerant Charge and Airflow Adjustment) Measure; and
- the Early Retirement/HVAC Measure.

The RCA (Refrigerant Charge and Airflow Adjustment) measure was of special interest to the evaluation team and to CPUCs Energy Division due to its combination of uniqueness and fraction of program savings. To facilitate on-site recruitment, an oversample of RCA participants was planned as a subset of the population survey for both residential and commercial program participants. Completed NTG survey data was obtained from 38 residential customers and 19 commercial customers participating in the RCA sub-program. The savings-weighted NTGRs are 0.76 for Residential RCA, and 0.70 for Commercial (see Table 8-4). The savings-weighted NTGR for the group of the rest of the Commercial measures excluding RCA is a bit higher at 0.85, with a sample size of 75.

Also of special interest in the Palm Desert measure offerings was the HVAC Early Retirement measure. Residential HVAC Early Retirement participants were sampled separately to ensure a sufficient sample size for a separate NTGR analysis. There were 610 participating residential customers of the Central AC Early Retirement Program. 56 surveys were completed. All Early Retirement customers also had one of the following 3 HVAC measures installed:

- Central AC Tier 1
- Central AC Tier 2
- Central AC Super High Performance

Therefore, results for all of these measures were considered together to obtain a NTG result, since just one decision was made. Table 8-4 shows that the savings-weighted NTG ratios for Early Retirement/HVAC residential measures (0.74) were slightly higher than that for all Residential program measures excluding Early Retirement/HVAC and RCA (0.69).

In keeping with CPUC directives, participant spillover was measured and reported in this evaluation report (Appendix C), but not included in the program accomplishments credited to the IOUs toward goal attainment.

Table 8-4. Measure-Specific NTG Ratios for the Palm Desert Program

Measure	Residential	Commercial
RCA	0.76 (sample size 38)	0.70 (sample size 19)
Early Retirement /HVAC	0.74 (sample size 69)	NA
Total Sample Excluding Measures Evaluated (Early Retirement/HVAC and/or RCA[a])	0.69 (sample size 56)	0.85 (sample size 74)

a. Ratios were weighted to represent the population in addition to being weighted by measure savings.

8.5.3 Residential Early Retirement

Verification Rate

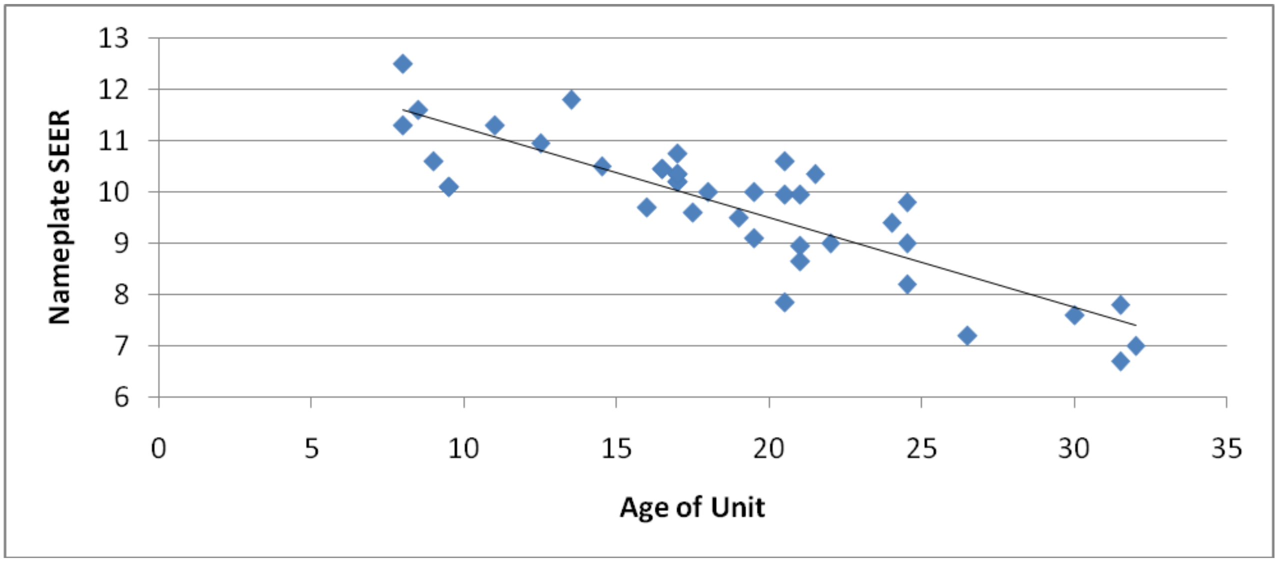
Thirty-four sites were visited for verification and post-only logging. All 34 sites had new equipment installed and each piece of new equipment indicated in the database was found on site, giving a verification rate of 100%. Verification of the early retirement pre-installation condition was not performed as part of this work. The tracking database units and unit energy savings did not add up. The units were supposed to be tons, but the quantity field showed a one or two for number of systems installed. Total savings appeared to be quantity times two times unit savings. As a result of this confusion in the database, a quantity/size verification rate would be difficult to calculate explicitly, so none is being reported.

Pre-Retirement Baseline Data

All available SCE site pre-installation inspection forms from Palm Desert were reviewed for manufacturer and model number. Forty of these forms had legible combinations of manufacturer and model number. These units were looked up in the Preston's Guide[57], and nameplate efficiency and years of manufacture were recorded. The average nameplate SEER rating observed in the SCE inspection was 9.74, and the average unit retired was 18.7 years old. A summary of the observed SEER and unit age in the sample is shown in Figure 8-1.

[57] Preston's Guide, http://www.hvacspecsonline.com, 2009.

Figure 8-1. Pre-Retirement Nameplate SEER and Age of Equipment



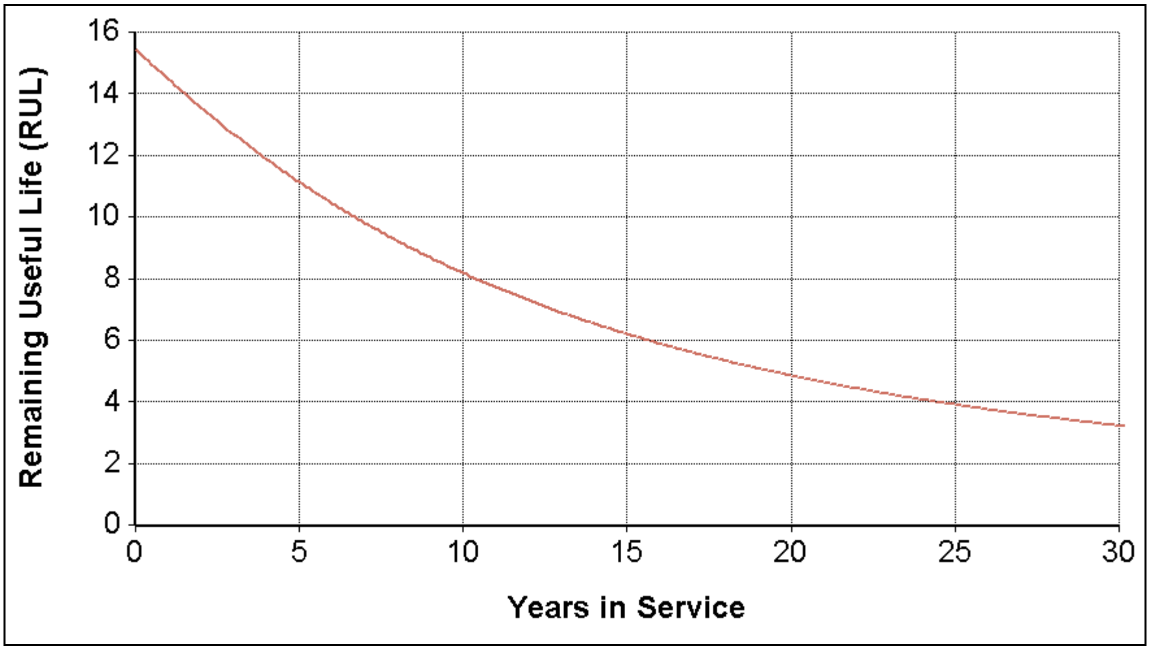
Remaining Useful Life

The Remaining Useful Life curve was estimated from appliance mortality curves fit by a Weibull distribution.[58] The shape factor for the Weibull distribution was chosen based on the tight range of shape factors for other types of appliances. The mean life (and scale factor) was estimated based on a system dynamic model that simulates the active stock of air conditioner units, unit shipments and unit retirements. The resulting Weibull parameters were consistent with parameters of other appliances.

The resulting RUL curve when applying a Weibull shape factor of 2.34 and a mean life of 15.5 years is shown in Figure 8-2. In the condition that an air conditioner unit has not been retired by its mean life (15.5 years), it should be expected to continue running for an additional 6 years.

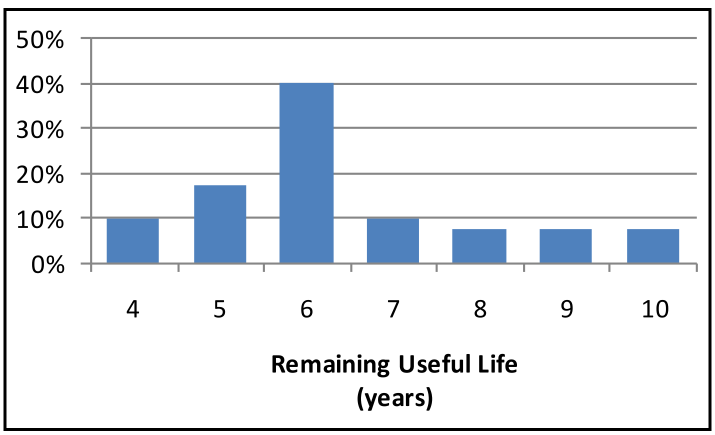
[58] See http://en.wikipedia.org/wiki/Weibull_distribution.

Figure 8-2. Remaining Useful Life of Air Conditioners



The estimated air conditioner RUL curve was applied to a sample of units that were retired early. The distribution of the remaining useful life of this sample is shown in Figure 8-3 below. The mean RUL of this sample is 5.9 years.

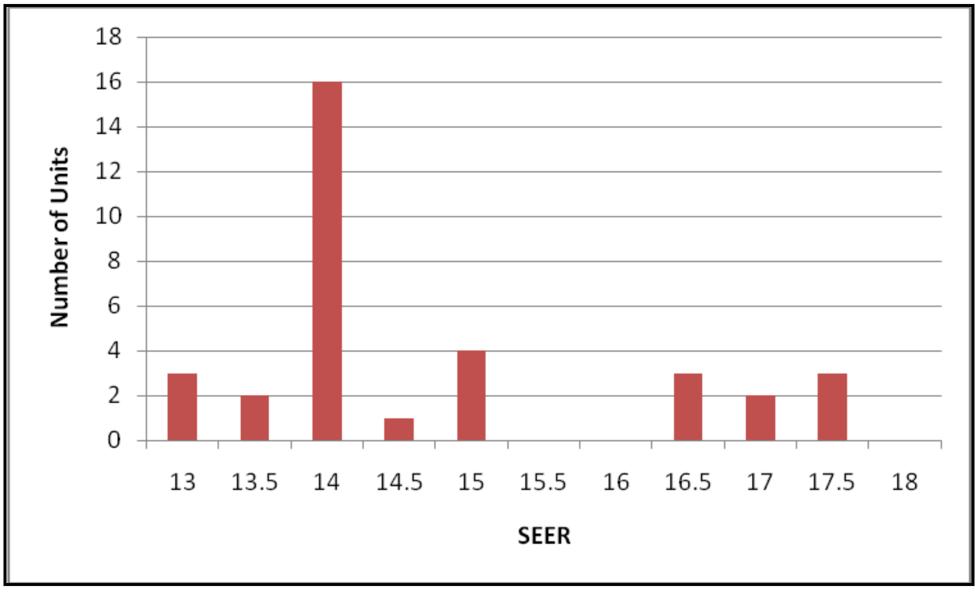
Figure 8-3. Distribution of RUL of Early-Retired AC Units from the Palm Desert Partnership Program



Updated DOE2 Equipment Performance Curves

A range of nameplate SEERs was observed in the field sample of early retirements, with an average SEER of 14.7, as shown in Figure 8-4.

Figure 8-4. Observed SEER Ratings

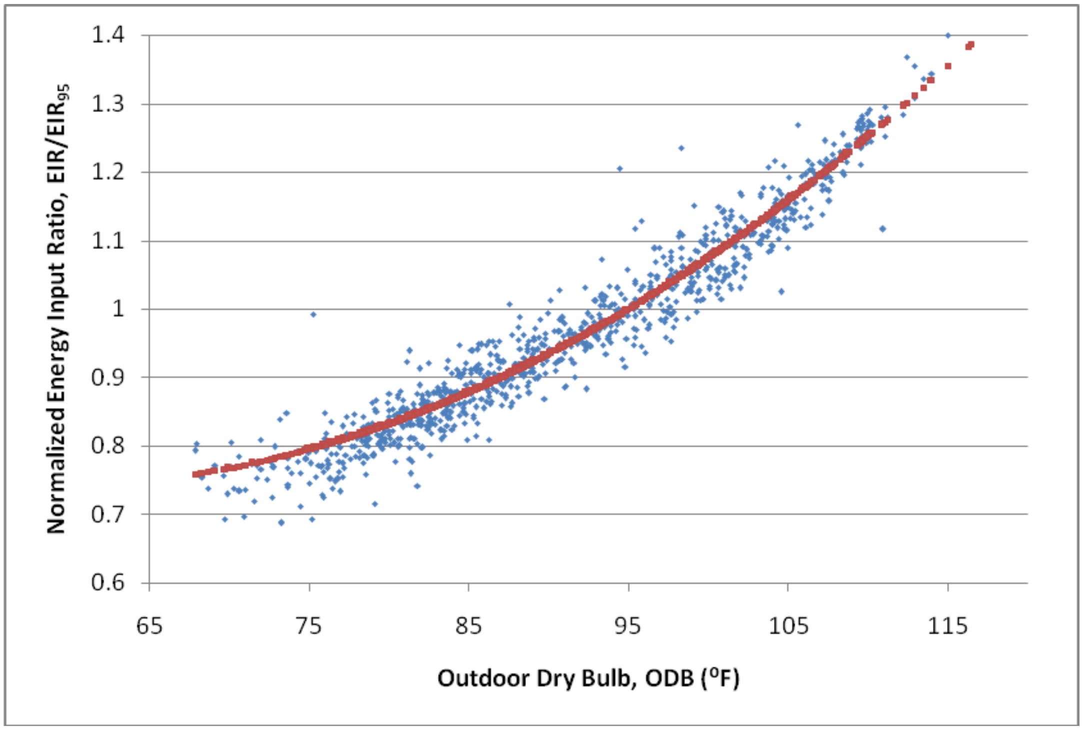


The results of the regression analysis showed that part load ratio and entering wet bulb did not show any significant correlation to Energy Input Ratio (EIR) for the compressor/condenser. As a result, a single efficiency curve was used to characterize the aggregate compressor/condenser unit performance of the monitored high efficiency equipment in Palm Desert. This equation had the form:

$$EIR = EIR_{base} * (A + B * ODB + C * ODB^2)$$

EIR_{base} is equal to the EIR at the reference ARI rating conditions. ODB is equal to the outdoor drybulb temperature. The following figure shows the shape of the curve, range of operation, and quality of fit.

Figure 8-5. Measured Aggregate EIR vs. ODB



It should be noted that this curve includes any part load or coil entering wet bulb impacts that were found in the underlying data. Because part load and entering wet bulb are correlated with outdoor dry bulb, it was difficult to separate out their impacts, given the limited range of observed operation and noise in the data.

Two baseline equipment efficiency curves were developed using data from other contract groups. For the pre-installation baseline, in-situ logged performance measurements from a sample of post-corrected RCA sites in the specialized commercial RCA HIM sample, all with nominal SEER 10, were used to derive an estimate of efficiency as a function of outdoor temperature. For the SEER 13 code-minimum baseline, in-situ logged performance measurements from SEER 13 units in the specialized commercial early retirement sample were used.

The resulting equation and coefficients are shown in Table 8-5.

Table 8-5. Coefficients for EIR = f(ODB)

Compressor/Condenser: $EIR = EIR_{base} * (A + B * ODB + C * ODB^2)$					Supply Fan
	EIR_{base}	A	B	C	W/cfm
High Efficiency measured	0.358	1.365	-0.0217	0.000188	0.586
SEER 10 measured baseline	0.552	1.004	-0.0128	0.000135	0.600
SEER 13 measured baseline	0.385	0.881	-0.0105	0.000123	0.586

Hourly Simulation Calibration Results

A calibrated DOE2.2 model was generated to extrapolate measured savings during summer of 2009 to a full 8,760 hour typical meteorological year savings estimate. Details of the model can be found in Appendix C. The model was calibrated to within 1% of measured peak demand and cooling energy consumption, as shown in Table 8-6.

Table 8-6. Model Calibration Results

	Energy (kWh/ton)	Peak Demand (kW/ton)
Measured	421.6	0.681
Modeled	422.5	0.687
Error	-0.2%	-1.0%

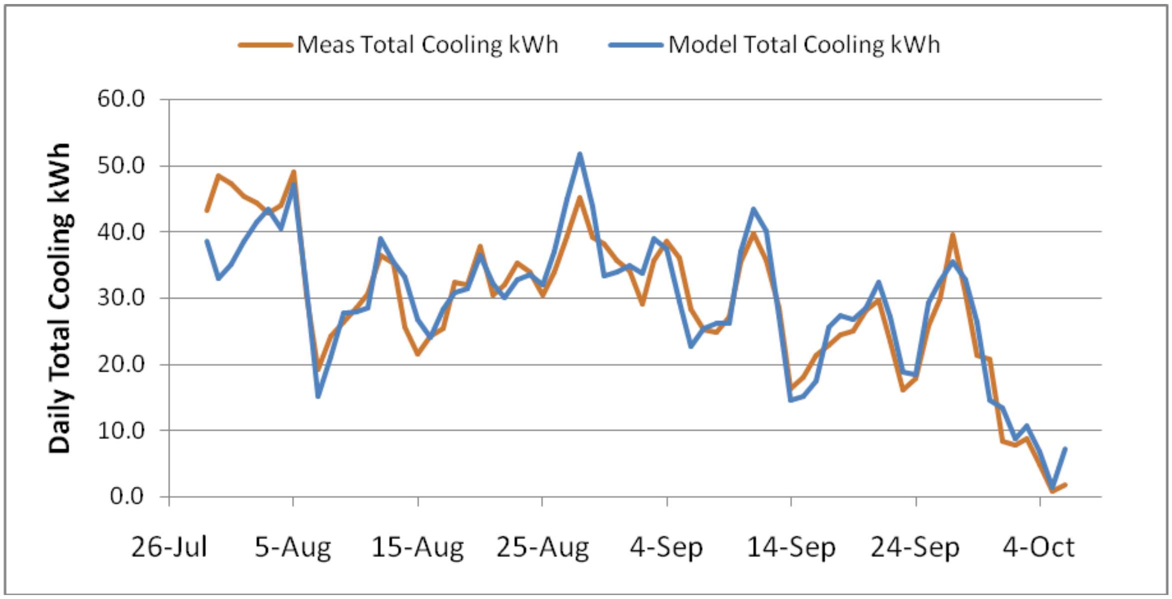
Table 8-7 shows the mean bias error and route mean squared error on a daily and hourly basis.

Table 8-7. Model Mean Bias Error and Root Mean Squared Error

	Mean Bias Error	Root Mean-Squared Error
Daily	-0.3%	14%
Hourly	-8%	33%

The model does a very good job of tracking day- to-day variation in cooling energy consumption, as shown in Figure 8-6.

Figure 8-6. Calibration Results: Daily Cooling Energy Consumption



Residential Early Retirement Unit Energy and Demand Savings and Realization Rates

The results of the modeling exercise showed the following verified gross unit savings for improvement from an early retirement of existing equipment and replacement with high efficiency equipment:

Table 8-8. *ex post* Unit Energy and Demand Savings and Tons/Unit[59]

Measure Category	Unit Energy Savings (kWh/ton)	Peak Demand Savings (kW/ton)	Quantity of Tons Installed per Claimed Units
Early Retirement (Existing up to Code)	326	0.21	3.73
High Efficiency Equipment(Code up to High Efficiency)[60]	68	0.03	3.73
Total	394	0.24	3.73

[59] The savings database for Palm Desert contains numerous apparent errors in association with these measures. The quantity field is supposed to be tons, but it actually indicates the number of units installed in conjunction with the measure. Multiplying the claimed units times the claimed unit savings does not give the claimed savings. It appears that different constant deemed savings values were used instead. For this reason, a comparison between *ex ante* and *ex post* unit savings would create significant confusion, so it is being left out of this report.

[60] The savings in this row should only be applied to high efficiency equipment installations that happened in conjunction with an early retirement. The field sample provides sufficient precision at the total level, but not when disaggregated into the high efficiency equipment portion.

The unit energy and demand savings include a billing normalization factor of 0.80, which was calculated by comparing seasonal consumption of sampled participants to non-sampled participants. See Appendix C for more information about the calculation of this factor. These gross energy and demand savings and verified tons were compared to the sample frame to derive realization rates:

Table 8-9. Derivation of Gross Savings Realization Rates[61]

	kWh	kW
ex ante Sample Gross Savings	34946	22
ex post Sample Gross Savings	60302	37
Gross Realization Rate[62]	173%	169%

The gross realization rates for energy and demand savings were found to be 173% and 169%, respectively. Measure-specific net-to-gross analysis was conducted in Palm Desert.

8.5.4 Refrigerant Charge and Airflow

This section presents the results and findings of the residential and commercial RCA measurement and verification (M &V) work. The installation rates (quantity-based) computed for residential and commercial RCA are 10 % and 4 %, respectively. In order to verify *ex ante* savings, the evaluation team conducted an analysis of the program documentation and field data that involved four major steps:

1. **Documentation review**. Analyze program installation forms to determine if a significant change in refrigerant charge occurred. This gives an installation rate.
2. **Field installation verification.** Verify on-site that the unit is still in use and did not receive significant repair including refrigerant charge after the initial installation.
3. **On-site RCA test.** Verify on-site that the unit has the correct refrigerant charge.
4. **Calculate the realization rate.** Calculate the overall verification rate as the fraction of claimed tons passing all three of the above criteria.

These criteria were applied to both the residential and commercial RCA samples.

Residential RCA Results

Based on the three screening tests described above, the evaluation team estimates that of the total tonnage of units in the verification sample (92.5 tons), only 10% (nine tons) passed all three tests and could be included in the calculation of *ex post* verified savings results. Table 8-10 summarizes the findings for the residential RCA verification analysis.

[61] The realization rate can be derived by multiplying the installation rate (Quantity of Tons Installed per Claimed Units) by the UES realization rate. Errors in the claimed number of units drive the high installation rate and high realization rate. The UES realization rates were actually lower (0.454 for kW and 0.462 for kWh).

[62] These gross realization rates are for illustrative purposes only. The verified tons per claimed unit and unit savings are used to calculate savings for this portion of the program.

Table 8-10. Residential RCA Verification Results

	Tons	Tested Units Passing[63]
Total sampled tons	92.5	100%
Field installation verified	71.5	77%
Pass documentation review test	28.5	30%
Pass onsite RCA test	23.5	32%
Pass all three tests	9	10%

This very low verification rate for residential refrigerant charge and airflow can be traced to problems in four different areas:

5. Refrigerant charging was not documented on the majority of units. An attempt was made to use a change in-refrigerant pressures on the installation forms as an indication that a charge was made.

6. Multiple units in the sample (3/22) had been replaced within a year of the program RCA visit.

7. Multiple units in the sample (2/22) had received significant repairs including a refrigerant charge adjustment within a year of the program RCA visit.

8. 75% of tons tested on site did not have proper charge, for a variety of reasons.

Table 8-11 summarizes the findings for the residential RCA verification analysis.

Table 8-11. Residential RCA Verification Rates

Sampled *ex ante* quantity (tons)	Sampled *ex post* quantity (tons)	Quantity-based Verification Rate
92.5	9	10%

Commercial RCA Results

The three screening tests described above were applied to sample of 138 tons of commercial RCA. Table 8-12 summarizes the findings for the commercial RCA verification analysis.

[63] In some cases, the results of a single test metric were inconclusive. However, in every case of this type, the unit failed a different test metric and failed overall. This explains why the total sampled tons times the percentage of tested units passing does not equal the number of tons passing.

Table 8-12. Commercial RCA Verification Results

	Tons	Tested Units Passing[64]
Total sampled tons	138	100%
Field installation verified	138	100%
Pass documentation review test	15	18%
Pass onsite RCA test	11	16%
Passes all three tests	6	4%

Based on the three screening tests described above, the evaluation team estimates that of the total tonnage of units in the verification sample (138 tons), only 4% (six tons) passed all three tests and could be included in the calculation of *ex post* verified savings results. This low verification rate is the result of insufficient documentation of refrigerant charging having occurred and a low percentage of units passing having the correct refrigerant charge when tested on site. Table 8-13 summarizes the findings for the commercial RCA verification analysis.

Table 8-13. Commercial RCA Verification Rates

Sampled *ex ante* quantity (tons)	Sampled *ex post* quantity (tons)	Quantity-based Verification Rate
138.4	6	4%

8.6 Palm Desert Program Findings

The Palm Desert evaluation focused on three particular measures in SCE 2566: residential AC early retirement, residential AC refrigerant charge and airflow, and commercial AC refrigerant charge and airflow. Net to Gross analysis of SCE 2566 was also conducted. SCG 3543 impacts were not evaluated because the claimed savings were very small (less than 1000 therms total).

8.6.1 Residential Early Retirement

The unit energy savings, installation rate, and net to gross can be applied to the savings claimed for early retirements and high efficiency equipment installed as part of an early retirement. These parameters are summarized in Table 8-14.

[64] In some cases, the results of a single test metric were inconclusive. However, in every case of this type, the unit failed a different test metric and failed overall. This explains why the total sampled tons times the percentage of tested units passing does not equal the number of tons passing.

Table 8-14. Summary of Early Retirement Savings Results[65,66]

	Energy Savings (kWh)	Peak Demand Savings (kW)
ex post Unit Savings	394	0.24
ex post Installation Rate	4.32	4.32
Gross Realization Rate	173%	169%
ex post Net to Gross	74%	74%

8.6.2 Refrigerant Charge and Airflow

Verification rates were derived as part of the Palm Desert evaluation. These verification rates were combined with the statewide RCA high impact measure study savings estimates for verified sites to develop realization rates in Palm Desert.

Residential RCA

Program results for Residential RCA are shown in Table 8-15. The gross unit savings are derived from the statewide RCA effort and provided for reference here. The Palm Desert residential RCA installation rate was then applied to get *ex post* gross savings and the Palm Desert net to gross value was applied to get *ex post* net savings.

Table 8-15. Summary of Residential RCA Savings Results

	Energy Savings (kWh)	Peak Demand Savings (kW)
ex post Unit Savings[67]	236	N/A
Palm Desert Installation Rate	10%	10%
Gross Realization Rate	5%	N/A
ex post Net to Gross	0.76	N/A

Commercial RCA

Program results for commercial RCA are shown in Table 8-166. The HIM-based gross savings are derived using the *ex ante* tons that the HIM % energy savings value from the statewide RCA effort and

[65] The early retirement savings shown in Table 1-15 include measures marked as early retirements and high efficiency air conditioners installed at the same site. The Palm Desert tracking data splits each early retirement into two line items.

[66] The realization rate can be derived by multiplying the installation rate (Quantity of Tons Installed per Claimed Units) by the UES realization rate. Errors in the claimed number of units drive the high installation rate and high realization rate. The UES realization rates were actually lower (0.454 for kW and 0.462 for kWh).

[67] To ensure there are no conflicts during the parameter update process, the unit savings value should be taken directly from the statewide RCA study, not from this report. The unit demand savings were unavailable at the time of this report.

the estimate of post-installation consumption from the Palm Desert field work. The Palm Desert commercial RCA verification rate was then applied to get *ex post* gross savings and the Palm Desert net to gross value was applied to get *ex post* net savings.

Table 8-16. Summary of Commercial RCA Savings Results

	Energy Savings (kWh)	Peak Demand Savings (kW)
ex post Gross Unit Savings[68]	110	N/A
Palm Desert Installation Rate	4%	4%
Gross Realization Rate	1%	N/A
ex post Net to Gross	0.70	N/A

8.6.3 Extrapolating High Impact Measure Results to Palm Desert

The Palm Desert Partnership Program is a multi-IOU program consisting of two partnership programs: SCE2566 and SCG3543. For the 2006-2008 program cycle, SCE2566 claimed total gross kWh and kW *ex ante* savings of 23,618,934 kWh and 6865 kW, respectively, while SCG3543 only claimed 768 net *ex ante* therms. Nearly all of the energy efficiency measures installed through SCE2566 were evaluated via HIM studies; consequently, the focus the focus of the program evaluation of the Palm Desert Partnership shifted towards leveraging HIM study results to derive gross program *ex post* savings. Ultimately, the gross impact evaluation of the Palm Desert Partnership involves the application of results of several HIM studies and, in some cases, applying DEER unit energy savings values and Energy Division (ED)-assigned realization rates, with the understanding that the ED-assigned realization rate could be 100%, or a pass-through of the *ex ante* savings estimates.

The field data collection and analysis effort by Summit Blue focused on three SCE2566 HIMs: residential HVAC early retirement (Res ER), residential refrigerant charge and airflow correction (Res RCA), and commercial refrigerant charge and airflow correction (Com RCA). The *ex post* results of these three studies will be applied to all measures in SCE2566 that were part of the sample frame of each respective study. The ED could also use the results of these three studies in the overarching Res RCA, Com RCA, and Res ER HIM studies. Since SCG3543 had very little program activity, the SCG portion of the Palm Desert Partnership did not receive any rigorous impact analysis.

The application of all HIM study results, as well as DEER UESs and ED-assigned realization rates will occur as part of the final Energy Division report. A final program-level Palm Desert Partnership *ex post* saving statement will be made after ED results are analyzed.

The proposed savings verification method is listed in Table 8-17 for each group of measures.

[68] During the parameter update, unit savings values should be taken directly from the statewide RCA HIM study. Unit demand savings were unavailable at the time of this report.

Table 8-17. Summary of SCE 2566 Savings

Res/ NonRes	DI/ NonDI	Measure	*ex ante* Gross kWh	*ex ante* Gross kW	Savings Method
NonRes	DI	CFL	5,244,179	798	HIM UES
		LFL	2,938,386	487	HIM UES
		RCA	2,141,566	533	Field Post-only runtime, Field Verification, HIM % Savings
		Strip Curtains	47,033	6	HIM
		Exit Sign	163,360	20	DEER update
		Occ Sensor	188,604	-	HIM
		Com Whole Bldg	110,542	34	RR from NCCS Eval
		Door Gaskets	38,469	2	HIM
		Other	2,779	2	CPUC Energy Division Realization Rate (ED RR)
NonRes	NonDI	CFL	5,587,310	439	HIM UES
		Ag Pumping	1,642,392	71	ED Realization Rate
		PC Operation	357,361	0	ED RR
		Door Gaskets	25,800	1	HIM
		Exit Sign	88,882	11	DEER Update
		Other	79,170	39	ED RR
		LFL	4,698	2	HIM
Res	DI	CFL	2,902,304	180	HIM UES
		Res Audits	1,418,844	305	ED RR
		RCA	4,000,439	2,731	CZ 15 HIM UES, Field Verification, Post-only unit logging for load profile
		Pool Pumps	342,102	78	ED RR

Res/ NonRes	DI/ NonDI	Measure	*ex ante* Gross kWh	*ex ante* Gross kW	Savings Method
		Night Light	95,289	-	DEER Update or ED RR
		Other	36,358	-	ED RR
Res	NonDI	HVAC ER	561,910	294	Post-only Field Runtime, Field Verification, SCE Inspections for base nameplate data, statewide RCA for in-situ performance de-rating
		Res Audits	306,705	66	ED RR
		Pool Pumps	350,612	80	ED RR
		HVAC Equip	111,420	139	HIM UES
		HVAC Maint	474,253	387	HIM UES or ED RR
		Duct Repair	151,281	163	HIM UES
		Other	104,872	1,710	ED RR
		Room AC	6,751	3	HIM UES

8.7 Discussion of Findings and Recommendations

The evaluation of the RCA program was performed on a program that was in the early phases of implementation. The evaluation was a challenge primarily as a result of insufficient data availability and documentation. While the evaluation team recognizes that programs in the startup phase are often in the process of developing or improving information systems, it nevertheless had to account for these data deficiencies in its estimate of the realization rate.

8.7.1 Conclusions

Refrigerant Charge and Airflow Adjustment:

RCA realization rates were found to be exceedingly low as a result of the following primary factors:

1. Claims of substantial savings were made where there was either no documentation or the documentation was insufficient to determine what actual field implementation of program measures occurred. For example, some installation forms had no indication that the coil had been cleaned, no indication of a change in refrigeration pressure, and no indication of a refrigerant charge treatment. The evaluation team recognizes that this could be a documentation issue, although anecdotal evidence also supported that in many cases there appeared not to have been

any refrigerant charge adjustment. As another example, some forms indicated in the notes that the coil had not been cleaned. The evaluation team did give savings credit to sites where there was an indication of a change in refrigerant pressure even though there was no documented refrigerant charge adjustment.

2. From the available documentation, there was little evidence that substantial improvements were made for most sites.
3. A significant fraction of the units in the sample had either been replaced or had had significant repairs made including refrigerant charge adjustments *after* participation in the program.
4. For sites where the documentation indicated some measure implementation, the evaluation field tests revealed that many of the units did not exhibit accurate refrigerant charge when checked on site.
5. Overall, the documentation of on-site actions and measure implementations did not provide sufficient information to provide for a robust technical analysis of savings.
6. The implementer did not appear to exercise adequate quality control over the installation contractors or oversee adequate documentation of actions taken and/or measures implemented on site.
7. In some cases, the evaluation field tests showed that the units were not properly charged. Such a finding indicates that the field testing by contractors, measure implementation activities, or subsequent events in the field outside of the control of the program did not result in units with properly adjusted refrigerant charge.

Early Retirement of Residential A/C Units:

1. The relatively low realization rates of the early retirement program were primarily a result of low net-to-gross ratios. Gross savings of the early retirement program were significantly higher than *ex ante* projections (173% energy and 169 % demand gross realization rates).The customer population in Palm Desert is comprised to a significant extent of people who are primarily winter residents (e.g., snow birds). Participation by winter residents has the effect of diminishing average peak demand savings and summer cooling energy savings.

NTG Conclusions:

Free-ridership in Palm Desert was found to be moderate with NTG ratios ranging from 0.69 for Residential HVAC/ER, to 0.85 for All Commercial Measures Excluding RCA. The following factors may help explain the high free-ridership:

1. The program had aggressive goals, high incentive levels, and significant marketing efforts, with high market penetration. See the Palm Desert process report for more details. High incentive levels and aggressive marketing of high incentive levels can lead to increased free-ridership.
2. The Commercial Program appears to have slightly less free-ridership than the Residential. This could be attributed to the fact that Commercial customers base decisions on financial results, and thus decisions are more likely to be directly attributable to incentives. In the Residential sector, customers' decisions can be less responsive to incentive amounts, and many customers may have decided to implement a measure regardless of incentives.

8.7.2 Recommendations

1. The program should improve documentation of RCA measures to ensure that ample evidence exists regarding the measures implemented at each site. Such documentation should include, at a minimum, the following information:
    - Amount of refrigerant added or removed
    - Type of refrigerant
    - Presence of TXV
    - Suction and discharge refrigerant pressure (pre and post charging)
    - Suction and liquid line temperatures (pre and post charging)
    - Ambient temperature (pre and post charging)
    - Entering wet bulb temperature (pre and post charging)
    - Target superheat and sub-cooling (depends on presence of TXV)
    - Actual superheat and sub-cooling (pre and post)
2. The program should provide a higher level of oversight and quality control of installation contractors, including reviewing claims of measure installations and documentation, particularly for new contractors who are just learning the goals and protocols of the program.
3. The program should consider implementing an electronic on-line program tracking database that includes requirements for key data elements and automatic checking of these data elements.
4. The program should improve the documentation requirements for identifying the pre-retirement manufacturer and model number. One possibility would be to require the submission of a photograph of the nameplate as part of the early retirement application.
5. The program should investigate mechanisms for minimizing the “snow bird” effect and should focus on permanent, year-round residents.