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IMPACT AND PROCESS EVALUATION FINAL REPORT

for

2004-2005 UC/CSU/IOU ENERGY EFFICIENCY PARTNERSHIP

Submitted to

CALIFORNIA PUBLIC UTILITIES COMMISSION, Sacramento, CA

Submitted by

SBW CONSULTING, INC., Bellevue, WA

in conjunction with

RESEARCH INTO ACTION, INC., Portland, OR

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1.1 Summary

This evaluation of the 2004-2005 UC/CSU/IOU Energy Efficiency Partnership Program estimated how much energy the program actually saved, as well as how effectively the program functioned. The evaluation allows policymakers to assess the program's cost-effectiveness and ways to improve similar programs in the future. The Partnership was a collaboration between the two university systems and the four largest investor-owned utilities in California. It aimed to obtain energy and demand savings, as well as establish a permanent framework for campus energy management, through energy efficiency retrofits, monitoring-based commissioning (MBCx), and training and education.

The Partnership program was generally considered by participants to be a success, a noteworthy accomplishment considering the program's complexity and tight schedule. It achieved its goals of implementing energy efficiency measures and establishing a working partnership framework, although progress in creating a comprehensive energy education program remains incomplete. The program is providing cost-effective savings of 18.7 million kWh/year and 872,000 therms/year and average peak demand reduction of 1.95 MW. The MBCx projects in aggregate performed better than the retrofit projects, although project development and accounting for both types should be improved for future programs. It is still uncertain at this point whether performance monitoring, implemented through the MBCx projects, will lead to more energy efficient building operation without additional support and follow-up.

1.2 Key Findings

We concluded the Partnership program achieved one its main goals, namely, to increase the rate of adoption for efficiency measures by the two university systems. The other main goal, of achieving more energy efficient building operation through increased performance monitoring, is still uncertain. The MBCx component consisted of three parts: (1) campuses implementing commissioning agent recommendations, yielding immediate savings, (2) campuses installing permanent metering, and (3) campus facility managers using this metering to optimize energy use in the future. To the program's credit, it provided the necessary resources and information to accomplish the first two parts. It is too early, however, to say if the last part can be achieved: that is, whether the new monitoring systems and campus resources for tapping these systems will be adequate to sustain the initial savings for many years.

Our quantitative analysis showed the Partnership program yielded cost-effective savings, although how and where this savings occurred was at times surprising.

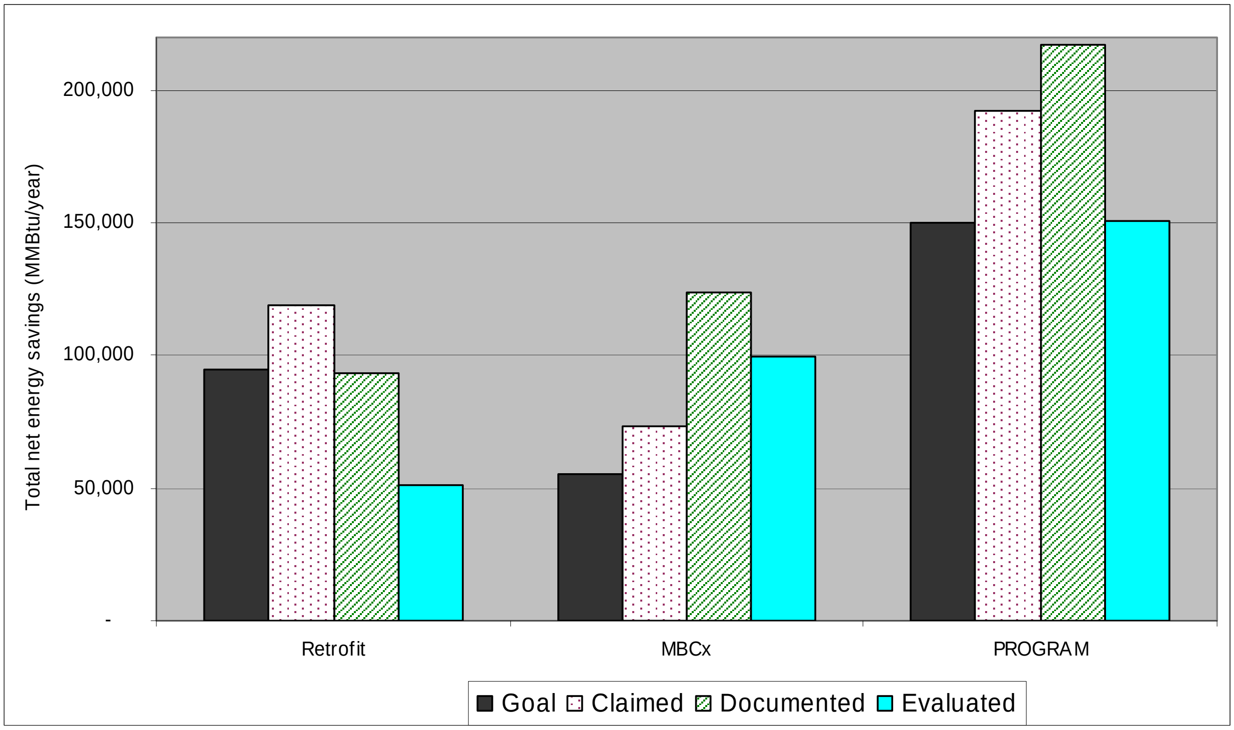
1. **<u>Program appears to be cost-effective</u>**. The Partnership program is saving 18.7 million kWh/year and 872,000 therms/year, or 100% and 101% of the program goals, respectively[1]. The average peak demand reduction of 1.95 MW represents 73% of the program goal. Over the expected 16-year lifetime of program measures, this translates to nearly 300 million kWh and 14 million therms of savings. The program's overall

[1] The relative precision of these net energy savings is ±20.9% at a 90% confidence level.

evaluated life cycle benefit-to-cost ratio (TRC Ratio) of 1.18 is very close to its original prediction of 1.20. The fact that this ratio exceeds one indicates the program is cost-effective.

Figure 1-1 shows the total net energy savings (combined kWh and therm savings) for the Retrofit and MBCx portions of the program. The former fell far short of targets, while the latter exceeded its targets. Results varied between utilities: the program was particularly cost-effective for PG&E and SoCalGas, but not so for SCE and SDG&E.

Figure 1-1: Evaluated Savings Results



2. **<u>Retrofit projects often did not yield expected savings.</u>** Many of the Retrofit projects suffered from inadequate scoping, inaccurate savings estimates, and poor execution. The poor performance of Retrofit projects was a particular surprise, since these types of projects are fairly standard.

3. **<u>MBCx projects, while often unpredictable, did produce projected savings overall.</u>** By their very nature, it is difficult to predict the savings an MBCx project will produce. So not surprisingly, we observed wide variations between projected savings and realized savings, just as we saw wide variations in the quality and style of the projects. We found the portfolio of completed MBCx projects yielded substantial savings that were close to the original program goals. In addition, some MBCx projects savings were not claimed by the program.

4. **<u>Spillover may be significant</u>.** We found evidence that additional savings may yet come from measures identified in this program round that will be completed in the future. In

many cases, campuses have already budgeted for this work. In addition, we uncovered situations where the initial MBCx investigation and implementation led to campuses finding other low-cost ways to reduce energy use. The overall impact of this so-called spillover is not known, but as one observed instance showed, it can be enormous.

The findings of this study point towards a number of ways that future programs of this type can be organized better, and can develop more successful projects.

Program Organization

5. **Fine-tune roles of partners** to alleviate problems associated with unequal fiscal and managerial authority. Program structure should emphasize (a) strong central leadership and facilitation, (b) continuity of staff participation for all partners, and (c) matching decision-making authority to the scope of responsibilities for each partnership committee.

6. **Streamline program procedures**: Continue to look for ways to obtain incremental improvements in program forms, project payment processes, and the program database and website.

7. **Prove the value of Training and Education**. Look for ways to measure the program's impact on energy savings, and give thought to alternative criteria for evaluating and validating T&E programs.

8. **Improve Training and Education, if it is desired**. Possible improvements might include increasing the number of in-house instructors, streamlining how these instructors are hired and paid, using more adult learning methods, targeting marketing efforts, better coordinating class locations and schedules, especially regarding the inclusion of community college staff, and removing attendance barriers.

9. **Provide more opportunities to exchange information and expand T&E participation.** It seems that little exchange of lessons learned from the projects among the campuses occurred. More venues need to be provided, with an effort made to increase participant, particularly among community college staff.

Project Development

10. **Improve accounting of project savings**. The lack of centralized, studiously maintained program database with well-documented projects made verifying claimed program savings extremely difficult. On a project level, savings documentation could benefit from more standardization and thoroughness.

11. **Provide participants with resources to facilitate estimating savings.** Future programs might establish simple guidelines so project applicants and implementation teams can assess the impact, if any, on project savings from campus cogeneration, heating/cooling interaction, and measure interaction. They might also provide clear guidelines and engineering resources so that participants can reliably "true up" their savings estimates after projects are complete.

12. **Ensure projects are sound**. Certain types of projects—for instance, fume hood occupancy sensors and variable speed drives—need more scrutiny to validate their effectiveness. Regular feedback on project successes and pitfalls would help campuses develop their projects more effectively. Additionally, more careful assessments of project sites during scoping might help avoid costly and time-consuming project delays. Proper selection and conceptualization is necessary for MBCx projects as well. Ideally, such projects should go beyond temporary or whole building monitoring so they can deliver on the MBCx premise of permanent, in-depth monitoring resulting in long-term savings.

13. **Use MBCx to generate future projects**. The MBCx projects can provide substantial information about the condition of building and central plant energy systems. Use MBCx as a gateway activity to define savings opportunities and future retrofit projects.

14. **Continue research on persistence of MBCx savings.** We feel, given what we know now, that 15-year effective useful life for MBCx projects is very optimistic. We recommend conducting a persistence study in 2008 or 2009 so that we can learn how the MBCx concept is playing out among projects sampled in this evaluation, and what programmatic changes could be made to improve savings persistence.

15. **Provide ongoing resources to help campuses use monitoring.** In some instances, campuses will need ongoing resources and support to realize the promise of the MBCx concept. They could benefit from expert guidance to augment their current capabilities, along with site-specific training on how to utilize the new monitoring resources. Additional permanent staff resources may be needed to fully meet the goal of ongoing analysis and corrective actions envisioned by this program's design. Future programs should consider integrating this sort of ongoing support in their delivery mechanisms.

1.3 Background

The 2004-2005 UC/CSU/IOU Energy Efficiency Partnership Program an innovative collaboration between the University of California and California State University systems, and the four largest investor-owned utilities in California—namely Pacific Gas and Electric, Southern California Edison, Southern California Gas, and San Diego Gas and Electric. The program aimed to obtain immediate and long-term energy and demand savings, as well as establish a permanent framework for a sustainable, long-term, comprehensive energy management program at the affected campuses. The three program elements were:

- **Energy Efficiency Retrofits**, such as lighting upgrades, improved control systems, pool covers, and variable frequency drives, provided immediate energy savings.
- **Monitoring-Based Commissioning**. At selected campus buildings, permanently installed monitoring capability allowed campus staff and commissioning agents to diagnose and fix energy use problems. After training, staff could then use the monitoring systems to operate the buildings efficiently for the long term.
- **Training and Education**. Energy education and information exchange for campus facility managers and utility staff, including case studies and training workshops, aimed to help sustain high levels of energy efficiency at the campuses.

1.4 Approach

To estimate the net energy savings the program produced, we first selected a representative sample of completed projects for more detailed analysis. This included eight of the 35 MBCx, and 17 of the 90 Retrofit projects. In total, the sampled projects accounted for 41% of the documented savings of this program, and the relative precision around the evaluated net savings was ±20.9% at 90% confidence, including the error associated with the gross savings calculation as well as the NTG ratio. For each sampled project, we visited the campuses, spoke to facilities staff, and took engineering measurements both before and after the projects were completed. This information supported rigorous analyses of the energy savings each project actually achieved. We also interviewed decision-makers for these projects to establish how likely it was the projects would have occurred in the absence of the program. We then extrapolated results for the sample to the population of projects in the program, yielding estimates of how much energy the overall program saved. Lastly, we examined available information to revise estimates of how long the program savings might last, and entered the savings amounts and expected durations into the CPUC-approved cost-effectiveness calculators.

The investigation of the program process was primarily qualitative, and drew from in-depth interviews with key program staff, project implementers, and training participants; and from our review of program materials.

2. Background

This report describes the results of an impact and process evaluation of the 2004-2005 UC/CSU/IOU Energy Efficiency Partnership Program. This evaluation was conducted by SBW Consulting, Inc. and Research Into Action, Inc., henceforth referred to collectively as the "evaluation team" or the "evaluators." This study was conducted at the request of the California Public Utilities Commission, and was managed by Southern California Edison. It was funded through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org.

2.1 About the Program

The 2004-2005 UC/CSU/IOU Energy Efficiency Partnership was an innovative collaboration between the University of California (UC) and California State University (CSU) systems, and the four largest investor-owned utilities (IOUs) in California. The latter consisted of Pacific Gas and Electric (PG&E), Southern California Edison (SCE), SoCalGas (SCG), and San Diego Gas and Electric (SDG&E). This statewide energy efficiency program aimed to obtain immediate and long-term energy and demand savings, as well as establish a permanent framework for a sustainable, long-term, comprehensive energy management program at the UC and CSU campuses served by the four IOUs. The partnership program consisted of the following three elements:

- **Energy Efficiency Retrofits.** The program provided up to 100 percent funding for campus energy efficiency Retrofit projects such as lighting upgrades, improved control systems, pool covers, and variable frequency drives. UC and CSU worked with the IOUs to identify and select appropriate Retrofit projects to be implemented as part of the program.

- **Monitoring-Based Commissioning**. The program provided up to 100 percent funding for monitoring-based commissioning (MBCx) activities. UC and CSU selected a group of buildings or a campus system to receive monitoring-based continuous commissioning. Monitoring capability was permanently installed to capture data on energy use and other measurements needed to diagnose energy use problems. Campus facility staff, working with commissioning agents, used these data to diagnose and correct problems. Campus staff was to receive training in how to use these monitoring systems to continuously commission these buildings, and subsequently apply this training and the monitoring system to maintain energy efficient operation of these buildings.

- **Training and Education**. The program also offered a program for energy education and information exchange among the campus facility managers and IOUs. This effort aimed to help sustain high levels of energy efficiency at the campuses. Key elements were a best practices case study compilation covering new construction, retrofits, retro-commissioning, and continuous commissioning, and a statewide series of training workshops. Community college energy staff was also to be invited to participate in the energy education program elements.

As outlined in the Program Implementation Plans (PIP) filed with the California Public Utilities Commission (CPUC), the objectives of the program are as follows:

1. Obtain statewide gross annual energy and demand savings of at least 21,174,194 kWh, 3,106 kW, and 952,423 therms by the end of December 2005.
2. Improve energy-efficient operations and maintenance practices by training campus energy managers and other staff on initial and continuous commissioning, and by providing tools to reduce energy consumption and peak demand through energy information at the building systems level.
3. Train campus energy managers and other staff in the use of a "best practices" methodology for identifying and implementing energy efficiency projects. This includes establishing a continuing UC/CSU comprehensive energy-efficiency program, which could be a model for other statewide partnership programs.

Table 2-1 shows energy savings goals for each utility. Overall, the program aimed to save about 18.4 million kWh and 875,000 therms annually, and reduce electric demand by 2.7 MW. Corresponding program costs, benefits, and cost-effectiveness forecasts are shown in Table 2-2.

Table 2-1: Energy Savings Targets by Utility

		Electric savings		Gas savings	Total energy savings	
Utility*	Savings type	kWh/year	Avg. peak kW	therms/year	MMBtu/year	% of total energy
Pacific Gas & Electric	Gross	8,619,555	1,224.8	319,491	61,368	37%
	Net	7,499,828	1,068.7	284,993	54,096	36%
Southern California Edison	Gross	7,835,864	1,183.8	-	26,744	16%
	Net	6,817,104	1,004.0	-	23,267	15%
Southern California Gas	Gross	-	-	451,209	45,121	27%
	Net	-	-	425,945	42,594	28%
San Diego Gas & Electric	Gross	4,718,775	668.4	183,922	34,497	21%
	Net	4,099,968	590.5	163,922	30,385	20%
PROGRAM TOTAL	**Gross**	**21,174,194**	**3,077.0**	**954,623**	**167,730**	**100%**
	Net	**18,416,901**	**2,663.1**	**874,859**	**150,343**	**100%**

* Program Goals obtained from Program implementation plan (PIP) workbooks posted on California Public Utilities Commission EEGA website as of July 2007.

Table 2-2: Projected Program Costs and Benefits

Utility	Total Resource Cost (TRC)*			
	Costs	Benefits	Net benefits	Ratio
Pacific Gas & Electric	$5,128,458	$6,397,946	$1,269,488	1.25
Southern California Edison	$4,083,442	$4,658,349	$574,907	1.14
SoCal Gas	$2,008,532	$2,209,268	$200,735	1.10
San Diego Gas & Electric	$2,820,131	$3,594,265	$774,134	1.27
PROGRAM TOTAL	**$14,040,564**	**$16,859,828**	**$2,819,265**	**1.20**

* TRC values obtained from revised Program implementation plan (PIP) workbooks filed with state on March 2, 2004.

There are two implicit program theories associated with the UC/CSU/IOU Partnership program:

- That the partnership will lead to a higher rate of adoption for efficiency projects by the two university systems,
- That greater availability of performance monitoring data will lead to more energy efficient operation of the monitored buildings.

2.2 Objectives of This Study

This evaluation, measurement, and verification (EM&V) study had two major components, an impact evaluation of the actual gross and net savings the program achieved, as well as a process evaluation of how the program functioned and participants' perceptions of it. Both components reinforced each other to meet study objectives, which are summarized below. These objectives are consistent with those described in the CPUC Energy Efficiency Policy Manual.[2]

1. **Measure achieved energy and peak demand savings:** The primary objective is to verify first-year electric and gas energy savings and electric peak demand reductions[3] from this program. We accomplished this by collecting data and modeling pre- and post-installation energy use for affected buildings, systems, and/or equipment for a stratified random sample of completed projects. We also conducted interviews with project decision makers to determine the level of free-ridership, i.e., the likelihood that these projects would have been implemented in the absence of the program. From these data,

[2] Version 2, prepared by the Energy Division, and released in August 2003.

[3] Defined as the average kW reduction during the period Monday-Friday 12 p.m. – 7 p.m., during the months of June through September, consistent with the *CPUC Energy Efficiency Policy Manual*.

we computed net-to-gross ratios and savings realization rates that were subsequently extrapolated to estimate program-level savings.

2. **Measure program cost-effectiveness:** We assessed program cost-effectiveness by entering our evaluated values for program savings, net-to-gross ratio, effective useful life, as well as the latest accounting of actual program costs, into the final PIP workbooks filed with the CPUC. This provided revised estimates of total resource cost (TRC) ratios.

3. **Provide feedback and guidance on program implementation:** We provided an interim EM&V report in March 2005 that provided suggestions for improving the program process to increase program cost-effectiveness and enhance participant satisfaction.

4. **Provide up-front market assessments and baseline analysis:** The program based their overall energy savings assumptions on the CPUC Energy Efficiency Policy Manual and the California Energy Commission Database for Energy Efficient Resources (DEER). The latter contains information on baselines, costs, market saturation, and energy savings for non-residential energy-efficiency technologies and measures. The program developed baseline analyses tailored to specific approved projects, and these were verified or refined through the EM&V effort.

5. **Measure indicators of program effectiveness, and test assumptions about program theory and approach:** The process portion of this evaluation reviewed program materials, interviewed project managers and facilities staff, and mapped actual program processes against proposed ones. From this, we identified effective aspects of the program, as well as those that could be improved. As much as the short timeframe of this study permitted, we also examined potential long-term impacts of MBCx projects, including the viability of the continuous monitoring concept.

6. **Assess overall levels of performance and success:** This evaluation of program savings and cost-effectiveness provides a good measure of actual program performance.

7. **Inform decisions about compensation and final payments:** The evaluated results and process and satisfaction findings should provide a solid basis for the CPUC to make these decisions.

8. **Assess continuing need for the program:** Given limited program funding and duration, only a small fraction of the total potential savings at the UC/CSU campuses were addressed under this program. As a result, a subsequent 2006-2008 phase of this program is currently underway. Results from this evaluation, in conjunction with information from the 2006-2008 program, can inform decisions about the need and cost-effectiveness of similar programs for the 2009-2011 program cycle.

2.3 How This Report Is Organized

The Executive Summary of this report, which precedes this section, briefly summarizes key aspects of this study in non-technical terms easily accessible to the general public. In addition to this Background section, which outlines the structure and goals of the program and this evaluation, the body of the report contains Methodology and Results sections. Each of these sections is divided into two subsections, one for the impact evaluation (evaluation of gross and net savings) and another for the process evaluation (program function and perceptions). From these results, we offer conclusions about how this program performed, and recommendations for improving future programs of a similar nature in the Conclusions and Recommendations section. Lastly, the Appendices provide supporting information for those interested in the details behind the analysis.

2.4 Contacts

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2.5 Acknowledgments

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3. Methodology

This section discusses how we estimated actual energy impacts, and how we investigated the program process.

3.1 Estimating Energy Impacts

3.1.1 Overview

The process of estimating the net energy impacts of the program involved several steps.

> **Sampling:** First, we selected a representative sample of both Retrofit and MBCx projects for more detailed analysis.
>
> **Project-Level Gross Savings:** Next, for each sampled projects, we obtained detailed project data to support engineering estimates of gross savings.
>
> **Project-Level Net Savings:** We also interviewed decision-makers for these projects to establish how likely it was that the project would have occurred in the absence of the program.
>
> **Program Savings:** We then extrapolated aggregate results from the sample (realization rates for gross savings and net-to-gross ratios for net savings) to the population of projects in the program, yielding estimates of how much energy the program saved (gross and net energy impacts).
>
> **Effective Useful Life:** Lastly, we examined available information to revise estimates of how long the program savings might last.

Each of these steps is described in more detail below.

3.1.2 Sampling Strategy

The objective of our sampling strategy was to select a sample of projects from the program database that allowed us to accurately represent the savings from the entire program. The primary question was how to allocate this sample among important domains of study and furthermore, to select projects within these domains in a manner that maximizes the statistical precision of the savings estimates.

We defined energy efficiency *projects* for this program as follows. For Retrofit activities, a *project* was defined as a particular kind of measure (e.g., VAV conversion, efficient fluorescent fixtures) corresponding to a particular end use (lighting, HVAC, or miscellaneous). The extent of the project can vary, though, from a single system to an entire campus. For MBCx activities, a project is defined as a single facility or system to which the monitoring-based, retrocommissioning is applied. The commissioning may uncover a variety of problems or issues that affect particular devices, systems, end uses, or perhaps the entire building, resulting in decreased energy efficiency, comfort, or operability.

Examples of projects, using the evaluation definition, include installing a pool cover at a certain pool, retrofitting efficient lighting and occupancy controls at a certain building, or retrocommissioning a central plant system or a library on campus. The program documentation sometimes applied a comparable definition to define projects; in other instances, though, the program grouped projects at a given campus, perhaps for administrative convenience. Examples might include groupings of all pool cover projects at a university; or a combination of lighting, VFD, and Vending Miser projects at a campus. In these cases, we disaggregated the groupings to create projects that conformed to our definition of a project.

Since the onset of the EM&V effort in July 2004, we regularly collected information from the program team on the status, nature, and estimated savings of projects. We categorized Retrofit projects as one of three end uses, for which typical projects are listed below in order of significance. Each of these end uses constituted a single domain in the sample frame:

HVAC: Variable-frequency drives on fans and pumps; laboratory fume hood occupancy sensors; conversions from constant-volume to VAV systems; other assorted measures.

Lighting: Efficient fluorescent fixtures; combinations of efficient fluorescent fixtures and lighting controls; lighting controls only; other efficient fixtures.

Miscellaneous: Pool covers; Vending Misers.

We categorized MBCx projects as one of three types, for which typical projects are listed below. While we differentiated between these types to ensure each type was represented in the sample, we treated results from all three types as part of a single domain (MBCx) in the sample frame:

Central plant: District steam systems, campus hot and/or chilled water loops.

Lab building: Dedicated laboratory buildings, as well as combination lab/classroom facilities.

Non-lab building: Offices, classroom buildings, libraries.

We performed two rounds of sampling—a first round in August 2004 when the early Retrofit projects (accounting for approximately half of the Retrofit savings goal) were known, and a second round in February 2005 after nearly all of the Retrofit and MBCx projects had been approved. For each round, we examined the distribution of savings among the projects in a given category. We then made certainty selections to include especially large savers and/or early implementers, and randomly selected other projects. As appropriate, we excluded particularly small savers. Sample counts were established by balancing the expected EM&V costs per project against the types of projects necessary to maximize precision.

3.1.3 Project-Level Gross Savings

Figure 3-1 illustrates the standard procedure for evaluating a sampled project, from the perspective of the campus, program staff, and the EM&V team. The level of complexity inherent in this procedure varied significantly, depending on the nature of the project. To estimate gross savings for each sampled project, we first reviewed project documentation, contacted the campus, and developed a preliminary evaluation plan. Next, we visited the site to interview staff, inspect equipment, and begin pre/post data collection. Based on the site visit, we enhanced the plan, and then completed data collection. Lastly, we analyzed data, estimated savings, and prepared brief reports of our methodology and findings. This process is described in more detail below.

3.1.3.1 Developing Project-Specific Evaluation Plans

After we sampled a project from the program database of approved projects, we notified program staff, so they could in turn tell campus staff that their project was going to be evaluated, and urge them to provide necessary support for evaluation activities. The program's utility representative for the campus provided us with necessary contact and background information, savings calculations, and supporting data.

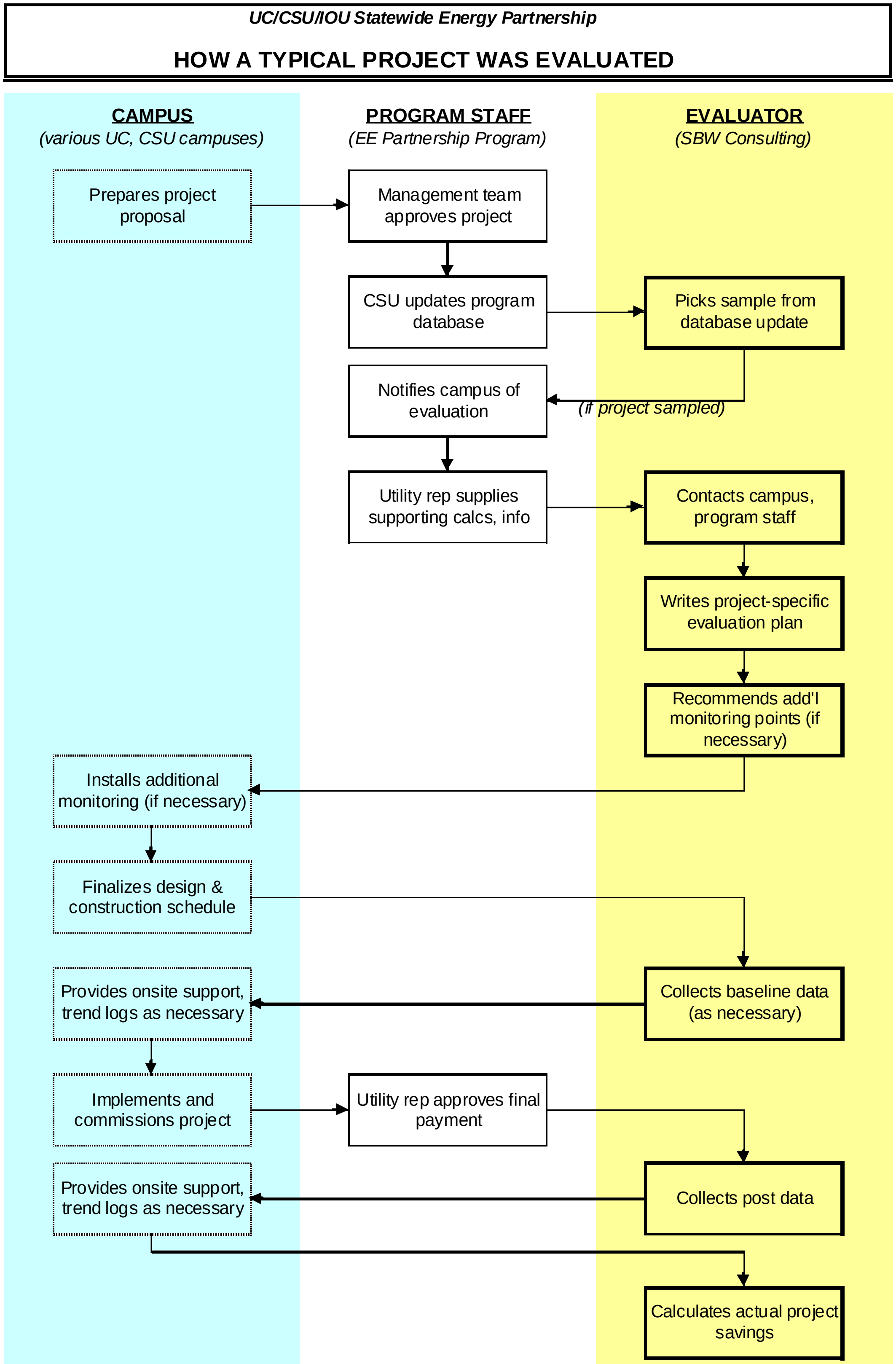
For each sampled Retrofit project, we reviewed the project application, supporting documentation, and when available, underlying reports or calculation spreadsheets. In addition, we contacted the project manager for the specific project at the campus, and got further information about project scope, schedule, baseline data, and evaluation measurement capabilities. Based on this information, we developed a project-specific M&V plan. These plans critiqued the program savings estimation methodology, and described the evaluation approach to collecting additional data and calculating verified savings. These calculations could either integrate additional data into the original analysis framework developed by the program implementer to estimate savings, or could substitute a more appropriate savings estimation method.

For each sampled MBCx project, we carefully reviewed project documentation to understand the scope of the commissioning effort, and the type of monitoring system installed to support the commissioning. Subsequently, we contacted the campus project manager to discuss the project in more detail. Important issues that generally were addressed included the expected timeline for MBCx activities, the availability of baseline and post-commissioning monitored data, current system monitoring and oversight practices for the affected building/system among operations staff, and the best avenues for us to collect ongoing information about the commissioning effort throughout its duration. From this information, we developed a specific M&V approach for the project, although we had to remain flexible to accommodate the wide range of possible actions and situations that resulted from the commissioning efforts.

3.1.3.2 Collecting Baseline and Post Data

The project-specific evaluation plans were drafted to be consistent with the requirements of the International Performance Measurement and Verification Protocol (IPMVP), Option B – Retrofit Isolation. As IVMVP requires, savings estimates were based on short-term performance measurements of the affected equipment, systems, or buildings, as appropriate, for a random sample of projects. These included instantaneous measurements (such as a true power measurement for a constant speed fan) as well as short-term monitoring (such as lighting "on" hours) sufficient for a credible extrapolation to a typical year of facility or system operation. Some performance parameters were stipulated, if the total impact of the stipulation error did not significantly affect savings (for example, watts per fixture for a common type of light fixture).

Figure 3-1: Typical Project Evaluation Procedure



EM&V team engineers visited each sampled project and collected data specified by the evaluation plan both before and after the implementation of energy efficiency improvements. The only exceptions were in instances when the baseline data supplied by program staff were adequate, and thus no pre-implementation visit was needed. The *source*, *duration*, and *level* of data to be collected were specified by the project-specific evaluation plan, adjusted if necessary for onsite conditions and limitations. In general, we made the best possible use of facility trend logging capabilities, supplemented when needed with our own temporary data loggers. In addition, onsite observations, measurements, and information from facilities staff provided critical data for developing robust savings estimates. Further details on the *source*, *duration*, and *level* of data collection are provided below.

Data Sources

- **Facility trend logs**: Trend log data from the building control system (BCS) and from additional monitoring equipment installed in MBCx projects, were obtained as needed to understand the operation and performance of systems affected by the project. Energy parameters, such as kWh, therms, and/or Btu for affected buildings, end use systems, or components were usually most helpful, but building control system often provides only temperatures, equipment run status, or percent of full load/speed. Many of the MBCx projects had additional monitoring installed, and we used these data as available and appropriate.

- **Temporary data loggers**: EM&V team data loggers supplemented available trend logs, providing additional short-term data needed specifically to calculate savings. The parameters and corresponding types of equipment used are as follows:

Measurement parameter	Equipment used
True RMS power	AEC four-channel MicroDataLoggers with Veris Hawkeye kW transducers
Electrical current (where amps, along with one-time kW, are an acceptable proxy for true power)	Pace Scientific Technologies four-channel Pocket Loggers
Motor run times Lighting times of use	DENT Instruments single-channel SmartLoggers
Temperatures	Onset HOBO single-channel loggers

- **Onsite measurements and observations**: In addition to installing data loggers and collecting trend logs, EM&V engineers collected other key information to supplement short-term metering and to inform the engineering model. This information included one-time measurements of temperature, motor speed, or true power (the latter using Fluke 39 hand-held, clamp-on power meters). It also included control settings, square footage of affected areas, nameplate efficiencies, and flow rates, either collected by direct observations or from reviewing drawings and other technical documentation.

- **Facility staff interviews**: Discussions in person or by phone/email with facility operations staff were critical for interpreting data and developing bases for adjusting data to represent typical conditions. Key information included such parameters as daily, weekly, and seasonal on/off schedules and temperature setpoints, controls strategy, lock-out temperatures, and anomalous conditions.

Duration of Data Collection

- **Full year**: An entire year of data is desirable; however, it was difficult in most instances to collect for the post-installation period, given the study timeline and budget limitations. Full-year data must sometimes be adjusted to account for anomalous factors so that the data represent a "typical" year.

- **Short-term**: Short-term data was collected for a few hours to many months, depending on the variability and/or seasonality of the parameter being measured. As with full year data, short-term data was sometimes adjusted (and extrapolated) to represent a typical year.

- **One-time**: We generally take single readings for relatively constant parameters (e.g., motor kW for constant speed motor, setback temperature for unoccupied spaces).

Level of Data Collection

- **Whole building**: Many MBCx projects had metered energy data for an entire building/facility (for example, daily electric kWh and heating Btu for the Physical Science Building). These data could be useful for projects expected to have large energy savings, and where metering could occur for extended periods of time. Interval demand metering for individual buildings could also be valuable in understanding building performance.

- **End use system**: Through metering installed by MBCx or the EM&V team, we could meter energy use for an entire end use system (for example, hourly average kW and Btu for the main HVAC system in the Physical Science Building). This level of measurement is very useful when modeling the combined effect of multiple small MBCx changes, which are mutually interactive and affect the energy use of a specific end use, such as HVAC.

- **Component**: Metering of individual components (for example, installing data loggers or utilizing monitoring installed under the MBCx program to record hourly kW for the supply and return fans for air handler unit AHU-1) was most appropriate for Retrofit projects, or MBCx measures suggested by a commissioning agent that only affect a discrete portion of an end use system.

As part of our overall data collection effort for each sampled project, we also noted measures that were identified by the MBCx process, but not implemented because of budget or schedule limitations. For each MBCx project, we also noted improvements and adjustments made by facility staff as a result of additional information from monitoring data. Sources of this sort of data included discussions with facility staff and information from the process portion of the evaluation. We also recorded anecdotal information that might shed light on the expected persistence of commissioning measures.

For Retrofit projects, we reviewed the baseline analysis developed by campus facility staff and approved by program staff. The data supporting these analyses varied, and could include metering data, trend logs, one-time measurements, or results from other relevant studies. As part of our development of project-specific EM&V plans, we determined whether additional baseline data was needed and if so, we worked with campus facility staff to obtain it. These data included visual inspection of affected systems, one-time measurements, short-term trend logging (EMCS trends or special metering), manufacturers' specifications, and self-reports from building operators and tenants.

Similarly, for MBCx projects, the relevant baseline information depended on which retro-commissioning measures are found to be applicable. For sampled projects, the EM&V team reviewed available baseline data the implementer obtained as part of the diagnostic process used to identify these measures and to estimate the costs and benefits associated with each measure. As necessary and feasible, we collected additional baseline data to support or strengthen our savings analysis.

3.1.3.3 Analyzing Project-Specific Gross Savings

Our general analysis approach was to collect data for building systems affected by a given project, and use engineering models to estimate corresponding savings. This involved developing an as-built model of the annual energy performance of the affected energy systems. The inputs to the model, as much as possible, accurately reflected the as-built and operated characteristics of the affected systems. The inputs also included weather data (as needed) for the corresponding post-installation period. In a few instances, we developed regression models to derive critical input parameters for engineering models (a regression model develops a statistical correlation between independent variables such as outside air temperature and dependent variables such as chiller kW, based on measured data).

We checked model outputs for reasonableness, and when possible, calibrated the model to measured performance. We created baseline models by changing the as-built model to reflect the characteristics of the affected system prior to implementation of the efficiency improvement. The difference between the baseline and as-built models, under typical weather conditions, was the evaluated gross annual energy savings for the measure.

Our analyses took into account a wide variety of primary and secondary factors affecting savings, with the intent that evaluation estimates of savings should be at least as accurate, and generally more so, than the original program estimates. These factors included:

- **<u>Cogeneration</u>**: Some of the university campuses have gas-fired cogeneration systems that supply some of their electric and thermal loads. Nearly all of the project applications stated savings from a building perspective--that is, as if the building(s) where the project occurs is served directly and solely by the utility electric grid or gas network. The latter savings can be dramatically different from the campus-level savings, and it is at the campus level that the utilities are supplying energy. For example, a nominal electrical savings project, such as a lighting retrofit, could conceivably result in gas savings if the lights are powered by dedicated gas-fired cogeneration units, where the reduced electrical load meant the cogenerators could run less. Whether or not this actually occurs will depend on many site-specific factors, such as the parts of the campus supplied by the cogeneration system, whether those parts are connected to the utility grid, whether the cogenerators follow the campus thermal or electrical loads, seasonal variation, and so forth.

  The program approach for accounting for cogeneration was consistent with utility policies, which allow electric incentives to be paid at campuses with cogeneration, provided that the electricity savings are less than the net electricity the campus purchases from the utility. Our general approach in this evaluation was to determine the actual effects, regardless of any policy assumptions, of the combination of the efficiency project and the campus cogeneration system on the utility billing meters serving the campus. As it turned out, cogeneration only materially affected two projects, each of which is described below. Also, because the realized savings at the two UCSD projects mentioned below were small, accounting for cogeneration as we did only had a small effect on the overall evaluation results.

  At UCLA (Project 58.01), the situation was clear, because our evaluation confirmed the program's assumption that electric savings at the building level translated directly into gas savings at the campus level.

  At UCSD (Projects 12.01 and 12.03), the energy effects were murkier and more complex. On this campus, 80% of all chilled water for cooling comes from steam-driven chillers, with 20% coming from electric chillers recharging TES at night (likely using cogenerated electricity). If cogeneration operation is driven by electrical production, then one could argue that the cooling is essentially "free" – that is, the waste heat from electrical production, rather than being exhausted, is being harnessed to generate chilled water. If the Retrofit project reduces the cooling load, then the load on the steam chiller decreases. The steam that would have run the chiller then just gets exhausted through a cooling tower instead. Whether or not the nominal electric savings are less than the campus purchase is immaterial here: the water is chilled indirectly by steam, which comes from burning gas, so utility-supplied electricity really does not enter into the picture for cooling. The same general argument can be made for the heating hot water supply.

  How to account for electric savings associated with HVAC fans is admittedly harder to discern at UCSD. Given that, the evaluation credited the program with the electric savings associated with the fans, but set the savings associated with chilled and hot water effects at this site to zero.

- **Thermal energy storage**: For projects we sampled at campuses with thermal energy storage, we ensured that evaluated electric impacts from chilled water systems took this into account. Such systems, by shifting chiller loads into off-peak times, would tend to reduce or eliminate peak demand reduction.

- **Heating and cooling interaction:** Project applications for efficient lighting retrofits generally did not account for decreases in space cooling requirements or increases in space heating requirements stemming from the reduced lighting loads. In cases where the lighting savings occur in unconditioned spaces, though, these interactions do not apply.

- **Project interaction:** Generally, the project applications did not account for interactions with other related projects. For example, separate efficient lighting fixture and lighting occupancy sensor projects did not account for the fact that the efficient lighting would reduce occupancy sensor savings, and vice versa.

- **Alternative energy sources**: Our analysis assessed the impact on sampled project savings from renewable energy systems employed at particular campus. Actual examples of these include solar photovoltaic arrays providing electricity, or landfill gas being fed to a cogeneration system. We also confirmed that program estimates correctly excluded savings that accrued to non-IOU energy suppliers, such as municipal utilities.

- **California energy efficiency standards**: Through conversations with campus project managers, we determined whether their projects were governed by the standards in 2001 Title 24, Part 6 (California's Energy Efficiency Standards for Residential and Nonresidential Buildings). Only projects involving substantial renovation to the building were likely to trigger this requirement. In such instances, the baseline condition for the analysis was the minimum system efficiency or configuration required by Title 24. This presumed that a given project would have had to comply with Title 24 regardless of whether it is considered an "early replacement" (equipment changed prior to end of useful life because of the program) or "normal replacement" (equipment changed because it is at the end of its useful life) project. We also took into account the impact of Title 20, which provides minimum appliance efficiency standards for motors, unitary heating and cooling, traffic signals, and lamps and ballasts. To the extent that projects involved replacement of equipment at the end of its useful life, Title 20 efficiency standards were used in setting an appropriate baseline for our energy efficiency savings calculations.

3.1.4 Project-Level Net Savings

A key question for impact estimation was to determine the net-to-gross ratio (NTGR) for each project. The NTGR reflects the percent of gross energy savings, that is, the net savings that can be attributed to the program. In order to estimate energy savings directly attributable to the Partnership program, campus project contacts were asked a series of questions designed to understand the decision making process for these projects, and to estimate whether and when their projects might have been installed without the program. Projects that might have been installed at the same time as the Partnership effort should have an NTGR of less than one. Net savings for each project equal the NTGR multiplied by the evaluated gross savings.

We conducted interviews for 16 of the 17 Retrofit projects (one Retrofit contact refused to be interviewed). We also interviewed contacts for all seven of the MBCx projects sampled for the impact evaluation, as well as an additional 17 MBCx projects completed by the program. The first step was to determine whether projects similar to their Partnership projects had occurred on their campuses during the preceding year, and whether their Partnership projects had been considered for inclusion with any capital or maintenance projects on their campuses during the preceding two years. We also asked for the criteria that each campus used to prioritize capital and maintenance projects. The final step was to ask contacts to report the probability, from 0% to 100%, that their projects would have been installed when they were installed if those projects had not been selected for the Partnership program. The responses to all these questions were considered in estimating the NTGR for each project.

3.1.5 Program Savings

3.1.5.1 Developing population database

The combination of the long duration of the Partnership program and the complex and evolving management structure made it difficult to establish a final database of savings claimed by the program for each project. Initially, the program maintained a web-based database, which listed each project, its status, and its estimated savings upon completion. This database ceased operation in late 2005 or early 2006. During this period until late 2007, however, the program enlisted the help of a consultant, Newcomb Anderson McCormick (NAM), to carefully track MBCx projects.

Ideally, the evaluation team would have received a final program tracking database that clearly listed each project, its disposition, and the final savings claim associated with it. These project claims, in turn, would have added up to the overall utility savings claims reflected in the final quarterly report posted on the EEGA website4. Unfortunately, we found no such tracking database, nor were we able to reconcile the detailed project documentation we requested from the utilities with their claims.

An additional complication sprang from the fact that our sampling protocol relied on projects being classified by end use (as they were early in the program), so that we could cleanly extrapolate our sample results to the population. Originally, we drew our impact sample from separate interim databases of Retrofit and MBCx projects that contained the most-up-to-date project listings as of March 2005. No such end use classification existed in the final program accounting, so we had to create it to complete our evaluation properly. From a statistical standpoint, it would have been impossible to extrapolate our sample results to the population using the program claimed savings.

We concluded, after consulting with the program evaluation team, that the best approach from an evaluation standpoint would be to recreate the database using source materials obtained directly

[4] California Public Utilities Commission Energy Efficiency GroupWare (EEGA) website. This site allows public access to Energy Efficiency program reports and the most recently approved Excel workbooks submitted by the program implementers containing program-level information on budgets, monthly expenditures, goals, and recorded EE activities.

from each participating utility. To that end, on June 13, 2007, the SCE Measurement and Evaluation Manager sent a formal request to each utility requesting the following information:

- What projects at each campus were part of the 2004-5 program;
- Which ones have been completed, approved and paid;
- What were the estimated kWh/therm savings for each paid project;
- Which projects have funding committed but not yet paid (and their estimated kWh and dollar commitment).

Each utility responded by sending spreadsheets that provided this information for each project grouping. While this was helpful, the evaluation required much more detailed information on claimed projects, as well as backup information documenting the basis for the savings claim. The evaluation team made a follow-up request to each utility at the end of June 2007, and the utilities provided detailed documentation in a variety of formats by mid-July. Examples of this documentation include project proposals, final MBCx reports, retrofit inspection information and savings verification, and invoices showing utility payments. The types of documentation provided varied widely among projects and between the utilities. We carefully reviewed this documentation, created the evaluated program database, and attempted to reconcile the information obtained from the original project lists, the detailed documentation, and other project data available. About half of the project information packages presented, to varying degrees, unclear or conflicting information. Typical discrepancies included (a) utility database summaries not matching completed project documentation, (b) final project incentive payment having been paid, but insufficient documentation of energy savings verification, (c) unclear disposition of projects that had not been fully paid out, (d) projects accepted by one utility for one fuel, but rejected by another utility for another fuel.

We made our best effort, given the evidence we were provided with, to consistently and accurately categorize the disposition and savings for all projects. When we found clear evidence that the program had developed a project that led to energy-saving actions, we included the project in our database. Conversely, projects where the paper trail suggested that no tangible energy impacts resulted (such as projects that were cancelled because the commissioning agent could not identify sufficient savings potential) were not included.

As necessary, we contacted each utility by phone and e-mail with clarifying questions. By mid-August, we felt confident that we had sufficient information at our disposal to be able to develop a final program database that contained what we judged to be the best available program estimates of savings, with each project assigned to its proper end use. We refer to this final database henceforth as containing *documented savings estimates*.

The fact that we could not fully reconcile the various program data sources was not surprising, given the decentralized nature of this program and the extended evaluation timeframe. Some managers with the program acknowledged that subsequent estimates may improve upon the formal claims, since the claims represent a snapshot of the best estimates at a single point in time.

Given the major flaws in the program savings data we received, we felt our approach of essentially creating the program tracking database for the program yielded the most precise estimate of evaluated program savings that could be hoped for under the circumstances.

Our formal data request also sought final program cost information. We ultimately decided that the most consistent source of this information was the final quarterly report workbooks filed with CPUC, and placed on the EEGA website.

3.1.5.2 Extrapolating

For each domain of study (MBCx, Lighting, HVAC and Miscellaneous) we developed an aggregate savings gross realization rate based on the sampled projects. This realization rate compared the documented savings estimate to our evaluated estimate of gross savings. For example, if we found that the realized savings matched the documented savings estimate for a particular project, then the realization rate would be 100%. Similarly, we developed aggregate net-to-gross ratios for each study domain.

We then applied the domain-level gross realization rates and net-to-gross ratios to the total documented savings estimate for each domain to calculate total evaluated net and gross savings for each domain. We also developed estimates of total savings by utility service area, applying the assumption that the domain-specific realization rates were constant across utilities.

3.1.6 Effective Useful Life

The program implementers chose not to include a study of measure effective useful life (EUL) in the scope of work for this evaluation. As independent evaluators, we believe this was fully justified for the Retrofit portion of the program. Substantial resources have been applied to persistence studies in California, and the validity of the *CPUC Energy Efficiency Policy Manual* measure lives for Retrofit projects has been confirmed. Consequently, our efforts in this area were limited to us applying appropriate EUL values from the Policy Manual table to each Retrofit project, and recalculating a program-wide average EUL. Relevant EUL values are shown in Table 3-1.

Our position on EULs for MBCx projects is similar. The program, in the PIP workbooks, stipulated a EUL of 15 years. This figure implicitly assumes that the universities will succeed in implementing a continuous long-term commissioning effort. This part of the program theory could not be tested in any meaningful way within the timeframe of this evaluation, so we had no basis for modifying the stipulated value.

3.2 Investigating Program Process

The investigation of the program process drew from the interviews with key program staff, Retrofit and MBCx project implementers, and from the simple frequencies and more complex analyses of the student sample data. This effort built upon the work completed for the interim report (issued in March 2005), and describes the status of the program through December 2006.

Table 3-1: Standard Values for Effective Useful Lives and Net-to-Gross Ratios

Measure type / end use load	Measure / activity	Effective useful life (years)	Net-to-gross ratio
HVAC - Air Conditioning Systems	Chiller replacement	20	0.80
HVAC - Controls	Programmable thermostat	11	0.96
HVAC - Controls	Time clocks	10	0.80
Lighting - Comprehensive Measures	Buildingwide lighting control units	16	0.80
Lighting - Comprehensive Measures	HID retrofits	16	0.80
Lighting - Comprehensive Measures	HID to T5 retrofits	16	0.80
Lighting - Comprehensive Measures	Incandescent to CFL	16	0.80
Lighting - Comprehensive Measures	LED exit sign retrofits	16	0.80
Lighting - Comprehensive Measures	T12 to T8 fluor. fixture/ballasts	16	0.80
Nonresidential - Comprehensive Measures	Motors/VFDs	15	0.80
Nonresidential - Comprehensive Measures	Retro-/continuous commissioning	15	1.00
Nonresidential - Custom End Use	Pipe insulation	20	0.96
Nonresidential - Custom End Use	Steam boilers	20	0.96
Water Heating - Systems	Hot water boiler	20	0.80
Water Heating - Systems	Instantaneous gas water heater	15	0.80
Water Heating - Controls	Boiler controller	15	0.80

The data used for the process evaluation were from a review of program materials and from analysis of interview data collected from in-depth interviews with program and campus staff. The process analysis was primarily qualitative. The following describes the approach taken in collecting and analyzing these data.

3.2.1 Reviewing Program Materials

Copies of program materials were obtained and reviewed to gain an understanding of the program flow and processes. Experience has demonstrated repeatedly that when programs are implemented in multiple locations with different implementation teams, the as-implemented programs can look quite different from the as-designed.

This review of program materials at the outset of the project, along with the information gained in the project initiation meeting, enabled us to develop a clear sense of the program as it was designed. We used this assessment to develop hypotheses that drove our questions for the interviews with program and campus staff.

As additional program materials became available, the team requested copies and reviewed these as well. The additional material was primarily workshop material.

3.2.2 Collecting and Analyzing Data

The data collection began with the development of protocols for in-person or telephone interviews with program and campus staff. The data collection protocols were designed to identify what type of experiences each contact had and to focus the questions asked on those experiences. Key issues covered in these interviews included:

- Knowledge of and understanding of the goals and objectives for the program.
- Administrative experience, including paperwork, project progress, communication, timing, scheduling, and payments.
- Assessment of communication, information flows, and ease or difficulties with project implementation.
- Previous plans and experience implementing similar projects.
- Assessment of the benefits of participation.

Data collection through this second round of interviews with members of the program management teams, campus project managers, and facility operations staff occurred predominantly in the first half of 2006. Delays in completing a few MBCx projects required follow-up interviews through December 2006 with the campus project managers for those projects.[5] The interview data provided substantial documentation of the comments and thoughts of the contacts. A matrix approach was used in which the responses of each contact to each question were compared and contrasted. The intention of the analysis was to ensure that no single voice dominated the findings and that no important comment or thought was ignored.

Throughout the analysis process, the goal was to present a comprehensive and unbiased assessment of the program experiences from multiple points of view, and to identify opportunities to improve program cost effectiveness and enhance program success. Key to understanding the process evaluation is to recognize these are perceptions of the process based on the experience each individual had. Wherever possible, we sought documentation of the factual details of the process, but in many cases, the primary information was simply the experiences of the individuals.

Key Contacts - We identified key contacts from each of the active teams involved in implementing the partnership program. These included, at the time of these interviews, members of the executive team, the management team, the MBCx team and the training and education (T&E) team (Table 3-2). Some of these key contacts served on more than one team. We identified 19 key contacts and were able to interview all of them. They included nine employees or consultants of the four investor owned utilities, six employees of the UC Office of the President and CSU Chancellor's Office, and four individuals from organizations subcontracted by, or working with a component of, the Partnership program (Table 3-3).

[5] Three MBCx projects had not been completed by the end of 2006. Unfinished work included meter installation, a program download and wet bulb installation, and a static pressure reset. Based upon the information provided by the campus managers for those projects, the evaluation team determined further interviews would provide no additional insight into program processes.

Table 3-2: Key Contacts' Teams

TEAM	POPULATION	SAMPLE
Executive Team	8	7
Management Team	9	9
MBCx Team	22	4
T&E Team	24	3
Total	62	23*

*Four individuals were on two different teams, so this represents 19 unique individuals.

Table 3-3: Key Contacts' Affiliations

AFFILIATION	POPULATION	SAMPLE
IOUs	9	9
UCOP	5	4
CSUCO	2	2
Other	4	4
Total	20	19

Retrofit Participants – Sixteen Retrofit projects at nine campuses were selected for inclusion in the gross savings analysis sample. The primary contacts for these projects also comprised the Retrofit participant interview sample for the process evaluation. Four of these contacts were with UC campuses and five were with CSU campuses.

MBCx Participants – Seven MBCx projects representing nine buildings or central plants on seven campuses were selected for inclusion in the gross savings analysis sample. Five of these campuses were in the UC system and two were in the CSU system. For the process evaluation, contacts from an additional 11 campuses with 15 additional projects comprising 24 additional buildings or central plants were interviewed. The total of 18 campuses from which contacts were interviewed comprised seven campuses from the UC system and 11 from the CSU system.

Training and Education – To assess the impact of the Partnership's T&E component on the university staff who attended the courses, an on-line, web-based survey was developed. The survey focused upon the five courses that had the most new content, that is, the five courses with the most content that had not been offered in California prior to this Partnership program. The data collection protocols were designed to identify the satisfaction of the respondents with those courses, and the utility of the courses relative to the respondents' jobs. Key issues covered in the survey included:

- Satisfaction with the courses.

- Practical on-the-job use of the knowledge gained from the courses.
- Assessment of the benefits of the training to the respondents' job performance.
- Previous training on the same topic.
- Additional training desired by the respondents.
- Suggested course improvements.

We identified 175 students who had taken one or more of the five selected courses. The web-based survey was sent to them on June 1, 2006. Of these 175 staff, 85 completed the survey.

The web survey data from the students were both qualitative, such as results from using a rating scale to assess one's experience, and quantitative. The first steps in data analysis were to clean the data and recode selected variables, such as creating categorical variables from open-ended responses, and creating "top-two boxes" responses from scale data.

The next step in data analysis was to calculate simple frequencies to understand the information in aggregate.

The last data analysis steps involved identifying and executing more complex analyses, such as comparisons of subgroups of non-participants and exploring the characteristics of the respondents who answered a question in a particular way. In these steps, we considered the implications of the program theory and its field implementation, as well as any concerns raised by interviewed staff. We then explored the data in light of these implications and concerns.

4. Results

The first part of this section (Energy Impacts) documents our findings of the program's gross and net savings. It covers all versions of these results: final program goals, program claimed, program documented (based on our review of project-specific documentation provided by each utility, and our evaluation estimates. We also document the cost-effectiveness of the program. The second part of this section discusses the findings from the process evaluation.

4.1 Energy Impacts

4.1.1 Program Savings Goals and Claims

Table 4-1 and Table 4-2 compare the original program savings goals with the final program claimed savings, as obtained from the final PIP workbooks, as well as the final documented savings we obtained by careful examination of program documents. It is important to note that the program claims in the PIP workbooks did not reconcile with the summaries the utilities provided at the end of the evaluation. Consequently, we needed to develop a database of documented results so that we could reliably extrapolate results from our evaluation sample to the program population.

These tables show that for every utility and nearly every end use/category, the claimed savings exceeded the original goal. The only exception is the HVAC end use, and in this case it is likely that some of the projects we classified as being in the Miscellaneous end use, the program might have considered to be HVAC, thus explaining the difference. The program claims easily exceeded each goal: overall, net electric energy saving (kWh/year) was 58% over the goal, average peak demand reduction (kW) and gas energy savings (therms/year) were 74% and 7% over, respectively. On a total energy basis (MMBtu/year), the program claim exceeded the goal by 28%.

Our documented savings differed significantly from the program claims in many cases. For example, documented energy savings for SCE were almost half of claimed savings, while conversely for SoCalGas, documented savings were nearly double the claim. We documented nearly twice as much savings from MBCx projects as the program claimed, perhaps because the claims did not include results from some of the MBCx projects that were completed late in 2006 and 2007. Overall, our documented savings were somewhat lower for electric savings, and higher for gas savings. Documented energy savings were 48% higher than the goal (compared to the program claim of 28% over the goal).

Table 4-1: Program Savings Goals and Claims, by Utility

Utility*	Net electric savings		Net gas savings	Total net energy savings
	kWh/year	Avg. peak kW	therms/year	MMBtu/year
Pacific Gas & Electric				
Program Goals	7,499,828	1,068.7	284,993	54,096
Claimed Results	11,717,105	2,002.3	318,970	71,887
Documented Results	13,452,562	1,932.6	342,265	80,140
Claimed % of goal	**156%**	**187%**	**112%**	**133%**
Documented % of goal	**179%**	**181%**	**120%**	**148%**
Southern California Edison				
Program Goals	6,817,104	1,004.0	-	23,267
Claimed Results	12,348,460	1,995.2	-	42,145
Documented Results**	6,666,602	1,263.2	-	22,753
Claimed % of goal	**181%**	**199%**	**N/A**	**181%**
Documented % of goal	**98%**	**126%**	**N/A**	**98%**
Southern California Gas				
Program Goals	-	-	425,945	42,594
Claimed Results	-	-	443,289	44,329
Documented Results**	-	-	786,107	78,611
Claimed % of goal	**N/A**	**N/A**	**104%**	**104%**
Documented % of goal	**N/A**	**N/A**	**185%**	**185%**
San Diego Gas & Electric				
Program Goals	4,099,968	590.5	163,922	30,385
Claimed Results	5,029,530	639.0	169,750	34,141
Documented Results	5,764,072	710.7	159,973	35,670
Claimed % of goal	**123%**	**108%**	**104%**	**112%**
Documented % of goal	**141%**	**120%**	**98%**	**117%**
PROGRAM TOTAL				
Program Goals	18,416,901	2,663.1	874,859	150,343
Program NTGR	87%	87%	92%	90%
Claimed Results	29,095,095	4,636.4	932,009	192,502
Documented Results	25,883,236	3,906.5	1,288,344	217,174
Claimed % of goal	**158%**	**174%**	**107%**	**128%**
Documented % of goal	**141%**	**147%**	**147%**	**144%**

* Both Program Goals and Claimed Results obtained from Program implementation plan (PIP) workbooks posted on California Public Utilities Commission EEGA website as of July 2007.

** Documented gas savings from SCE projects is credited to SoCal Gas, and documented electric savings from SoCal Gas projects is credited to SCE.

Table 4-2: Program Savings Goals and Claims, by End Use

Category / End Use*	Net electric savings kWh/year	Net electric savings Avg. peak kW	Net gas savings therms/year	Total net energy savings MMBtu/year
MONITORING-BASED COMMISSIONING (MBCx)				
Program Goals	7,387,726	1,007.8	302,560	55,470
Program NTGR	100%	100%	100%	100%
Claimed Results	10,307,865	1,181.0	381,226	73,303
Documented Results	10,555,203	1,115.4	879,015	123,926
Claimed % of goal	**140%**	**117%**	**126%**	**132%**
Documented % of goal	**143%**	**111%**	**291%**	**223%**
RETROFIT				
HVAC				
Program Goals	4,735,449	273.2	563,729	72,535
Claimed Results	8,223,294	809.2	272,659	55,332
Documented Results	4,307,781	536.2	289,374	43,640
Claimed % of goal	**174%**	**296%**	**48%**	**76%**
Documented % of goal	**91%**	**196%**	**51%**	**60%**
Lighting				
Program Goals	6,293,726	1,382.1	1,760	21,656
Claimed Results	10,563,936	2,646.2	4,154	36,470
Documented Results	10,608,477	2,247.8	-	36,207
Claimed % of goal	**168%**	**191%**	**236%**	**168%**
Documented % of goal	**169%**	**163%**	**0%**	**167%**
Miscellaneous**				
Program Goals	-	-	6,810	681
Claimed Results	-	-	273,970	27,397
Documented Results	411,775	7.1	119,955	13,401
Claimed % of goal	**N/A**	**N/A**	**4023%**	**4023%**
Documented % of goal	**N/A**	**N/A**	**1761%**	**1968%**
All Retrofit				
Program Goals	11,029,175	1,655.4	572,299	94,873
Program NTGR	80%	80%	88%	85%
Claimed Results	18,787,230	3,455.4	550,783	119,199
Documented Results	15,328,033	2,791.1	409,329	93,247
Claimed % of goal	**170%**	**209%**	**96%**	**126%**
Documented % of goal	**139%**	**169%**	**72%**	**98%**
PROGRAM TOTAL				
Program Goals	18,416,901	2,663.1	874,859	150,343
Program NTGR	87%	87%	92%	90%
Claimed Results	29,095,095	4,636.4	932,009	192,502
Documented Results	25,883,236	3,906.5	1,288,344	217,174
Claimed % of goal	**158%**	**174%**	**107%**	**128%**
Documented % of goal	**141%**	**147%**	**147%**	**144%**

* Both Program Goals and Claimed Results obtained from Program implementation plan (PIP) workbooks posted on California Public Utilities Commission EEGA website as of July 2007.

** End use definitions for Miscellaneous were not always clear in the PIP workbooks, so this is an approximation.

4.1.2 Sample Disposition

The final documented program database consisted of 35 MBCx projects and 90 Retrofit projects, for a total of 125 projects. We selected a sample of projects for the impact portion of the evaluation in February 2005, when a significant number of Retrofit and MBCx projects were already far along in the program planning process. Our sample included eight MBCx and 17 Retrofit projects for a total of 25 projects, or 20% of all projects. Table 4-3 describes the 25 projects in the final sample. Table 4-4 provides a cross tabulation of these sampled projects by utility and by end use/category.

We based our sampling strategy on best estimates at the time of the distribution of electric and natural gas savings between the Retrofit and MBCx portions of the program. We knew that savings estimates for a small number of projects might change as campuses adjusted the scope of projects, but felt confident that these revisions would only have minor effects on our sampling precision. Fortunately, throughout the evaluation, only one sampled project (in the HVAC end use) was dropped and thus needed to be replaced.

In this original sampling frame, Lighting and HVAC projects accounted for 49% and 41% of the project counts, respectively, but HVAC projects comprised 61% of the MMBtu savings. We sampled eight HVAC projects that accounted for 62% of the ex ante savings, acknowledging the HVAC end use is the largest, as well as one where a high degree of uncertainty often exists when estimating savings. These eight projects included the four HVAC projects with the largest savings. Similarly, for Lighting projects, we selected six projects that account for 40% of the lighting end use savings. These six included the three largest lighting projects. The Miscellaneous end use consisted predominantly of six pool cover projects, of which we selected three that accounted for 88% of the end use savings. Overall, the 17 sampled Retrofit projects made up 18% of the 92 Retrofit projects in the sample frame, but accounted for 60% of the MMBtu savings.

Only seven Central Plant projects exist (20% of the projects), but not surprisingly, they tend to be large savers, accounting for 41% of the MBCx MMBtu savings. Lab and Non-Lab projects account for 37% and 43% of the project counts, respectively, and 26% and 33% of the savings.

Of the 35 MBCx projects, we limited our sample frame to projects that accounted for at least 1% of the total MBCx MMBtu savings. This reduced the frame to 22 projects, although we did include one small Non-Lab project that appeared to be farthest along in the commissioning process. We felt it was important to include the first MBCx project to implement so that we could obtain early feedback about the process. We selected the largest Central Plant project with certainty, and randomly selected another project, so combined, the two projects accounted for 57% of the Central Plant MMBtu savings. We followed a similar approach for the Lab Building and Non-Lab Building categories, so that sample accounted for 45% and 36% of the MMBtu savings, respectively, for these two categories. Overall, the seven sampled projects accounted for nearly half (47%) of the MBCx MMBtu savings in the sample frame.

Overall, our sample covered about half of total documented MBCx energy savings and a third of documented Retrofit energy savings, for 41% of the overall ex ante net energy savings.

Table 4-3: Sampled Projects

End Use	N	Description of sampled project
MBCx - Central	**2**	Campus chilled/hot water system
		Campus thermal plant
MBCx - Lab	**2**	Lab/classroom building
		Lab/classroom building
MBCx - NonLab	**4**	Classrooms/offices
		Information Center
		Library
		Library
HVAC	**7**	Chilled water loop optimization controls
		Lab fume hood occupancy sensors
		Lab fume hood occupancy sensors
		Lab fume hood occupancy sensors
		VFD and rebalancing for lab building
		VFD and rebalancing for lab building
		VFDs for theater, gym
Lighting	**6**	Efficient fixtures, occupancy sensors in bathrooms
		Occupancy sensors in offices & bathrooms
		T8 conversion - classrooms & offices
		T8 conversion - classrooms & offices
		T8 conversion - library
		T8 conversion - parking lot
Miscellaneous	**4**	Swimming pool cover
		Swimming pool cover
		Swimming pool covers
		VFDs for gym, classrooms/offices

Table 4-4: Sampled Project Tabulation

	MBCx				**Retrofit**				
	Central plant	Labs	Non-labs	SUB-TOTAL	HVAC	Lighting	Miscel-laneous	SUB-TOTAL	**Total**
Program Project Counts									
Pacific Gas & Electric	2	4	10	16	9	23	3	35	**51**
Southern California Edison	1	4	3	8	5	27	1	33	**41**
SoCal Gas	1	3	2	6	7	-	5	12	**18**
San Diego Gas & Electric	2	2	1	5	7	3	-	10	**15**
SUBTOTAL	6	13	16	35	28	53	9	90	**125**
% of Total	**5%**	**10%**	**13%**	**28%**	**22%**	**42%**	**7%**	**72%**	**100%**
Sample Project Counts									
Pacific Gas & Electric	1	-	2	3	1	3	1	5	**8**
Southern California Edison	-	1	-	1	1	2	-	3	**4**
SoCal Gas	-	1	2	3	3	-	3	6	**9**
San Diego Gas & Electric	1	-	-	1	2	1	-	3	**4**
SUBTOTAL	2	2	4	8	7	6	4	17	**25**
% of Population Count	**33%**	**15%**	**25%**	**23%**	**25%**	**11%**	**44%**	**19%**	**20%**

For each sampled project, we calculated the corresponding case weight representing their probability of selection during the sampling (for example, projects selected with certainty had a case weight of one, while two project that was randomly chosen out of a group of five had a case weight of 5÷2=2.5). We used these case weights to develop weighted-average realization rates and net-to-gross ratios for the HVAC, Lighting, Miscellaneous, and MBCx end use/categories. Finally, these average realization rates and NTGRs were applied to all projects in the program population to estimate program-level impacts.

4.1.3 Evaluated Savings for Sampled Projects

4.1.3.1 Realization Rates

The sampled projects were enormously diverse in terms of end uses, technological approaches, analysis complexity, available data, and campus capabilities and cooperation. This, coupled with the long duration of these projects—spanning several years in some cases—made for a particularly challenging impact evaluation. Nonetheless, we were able to develop credible estimates of savings for all 25 projects. We calculated gross realization rates for each project, with the realization rate defined as the documented gross savings divided by the evaluated gross savings. Figure 4-1 illustrates the wide range of realization rates we uncovered among the sampled projects by annual kWh, average peak kW, and annual therm savings, and by end use. Figure 4-2 shows these same results, expressed in terms of total energy savings (MMBtu/year). Note that these figures only show meaningful realization rates, so, for instance, a project that claimed only therm savings would have a realization rate shown on the therm figure, but not the kWh or kW figures.

As is typical for such diverse projects, the realization rates vary tremendously, although certain trends are clear. For instance, realization rates for Retrofit HVAC projects were almost without exception poor (5% - 31% averages), while energy savings realization rates from MBCx projects were generally favorable (78% - 99% averages). The reasons for poor realizations varied from project to project, although common themes included lower-than-expected operating hours, minimal reduction in airflows, poorly established baseline conditions, calculation errors, and reductions in project scope. Further details for each sampled project can be found in Appendix 6.1.

During the evaluation, we also identified three factors that were not generally accounted for in the program savings estimates. We incorporated each of these factors in our analyses. While their overall impact on projects in our sample was relatively small, they remain important factors to consider for future programs and evaluations of this type.

1. **Cogeneration**: Some university campuses have gas-fired cogeneration systems that supply some of their electric and thermal loads. Nearly all of the project applications stated savings from a building perspective--that is, as if the building(s) where the project occurs was served directly and solely by the utility electric grid or gas network. The latter savings can be dramatically different from the campus-level savings, and it is at the campus level that the utilities are supplying energy. Specific implications of this approach on the evaluation were discussed previously in the Methodology Section (Section 3.1.3.3 Analyzing Project-Specific Gross Savings; Cogeneration)

2. **Heating and cooling interaction:** Lighting retrofits in certain applications should account for any decreases in space cooling requirements or increases in space heating requirements stemming from the reduced lighting loads.

3. **Project interaction:** Interactions between projects can diminish savings. An example would be separate efficient lighting fixture and lighting occupancy sensor projects that should account for the fact that efficient lighting will reduce occupancy sensor savings, and vice versa.

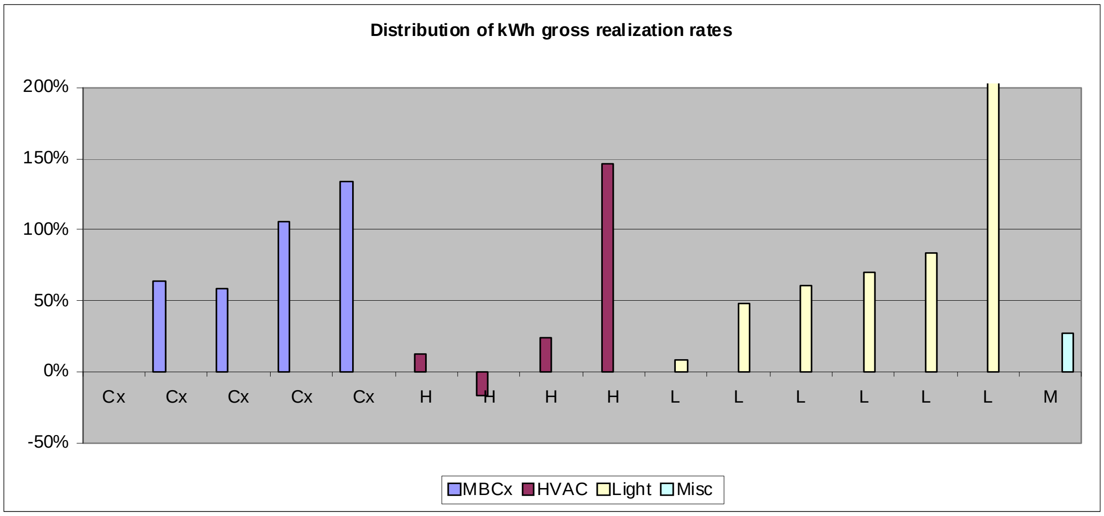
Figure 4-1 shows the final first-year gross realization rates, by end use and savings type, which take into account sample weighting. We applied these values to non-sampled projects to develop evaluation estimates of gross savings for all documented projects in the program.

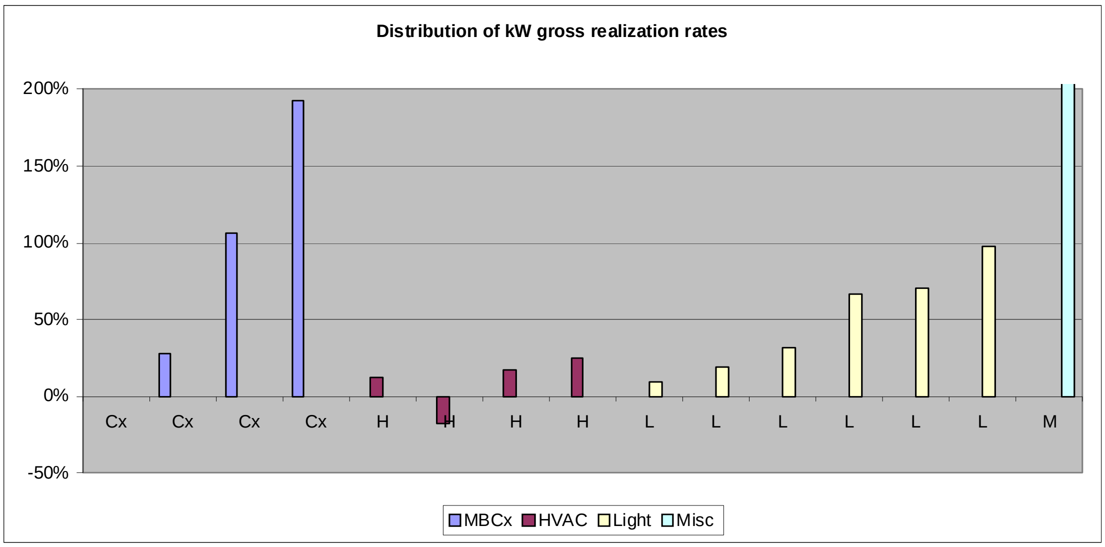
4.1.3.2 Net-to-Gross Ratios

From information obtained from interviews of campus contacts for 33 projects (16 Retrofit and 17 MBCx), we determined net-to-gross ratios (NTGR) for each project. The NTGR reflects the percent of gross energy savings (in other words, the net savings) that can be attributed to the program. Figure 4-3 shows the project-level NTGRs, by end use/category. It is clear from this figure that overall, freeridership was low—that is, the program generally played a primary role making the projects happen when they did. Retrofit Lighting projects are notable in that all that were sampled had NTGRs of 100%, which is significantly higher than the program assumption for most Retrofit projects of 80%. At the other extreme, the sampled Retrofit HVAC projects included several that were complete free-riders, so that the net electric savings for this end use are only slightly more than half of the gross savings.

Table 4-5 shows the final NTGRs, by end use and savings type, which take into account sample weighting. We applied these values to the evaluation estimates of gross savings for all projects to develop evaluation estimates of net savings for the projects. Refer to Appendix 6.1 for a detailed discussion of how we calculated project-level NTGRs.

Figure 4-1: Distribution of Project Gross Realization Rates (kWh, kW, therms)





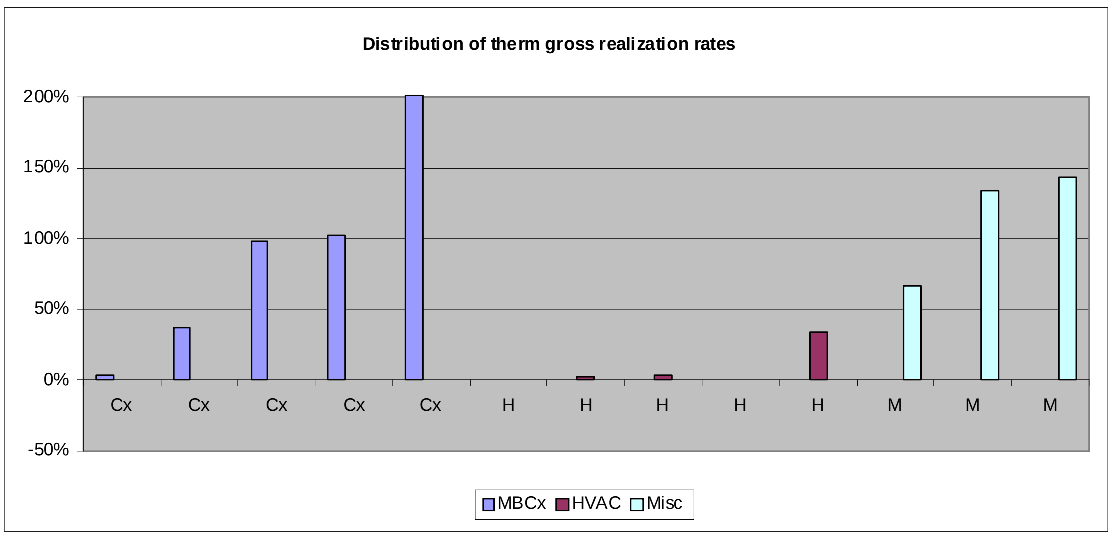


Figure 4-2: Distribution of Project Gross Realization Rates (total energy)

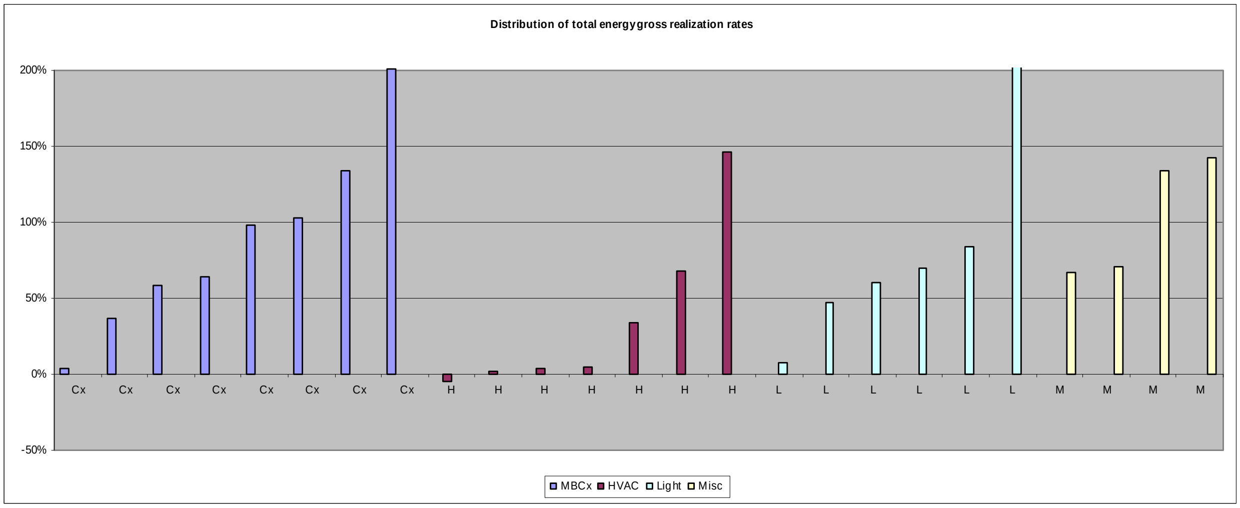


Figure 4-3: Distribution of Project Net-to-Gross Ratios

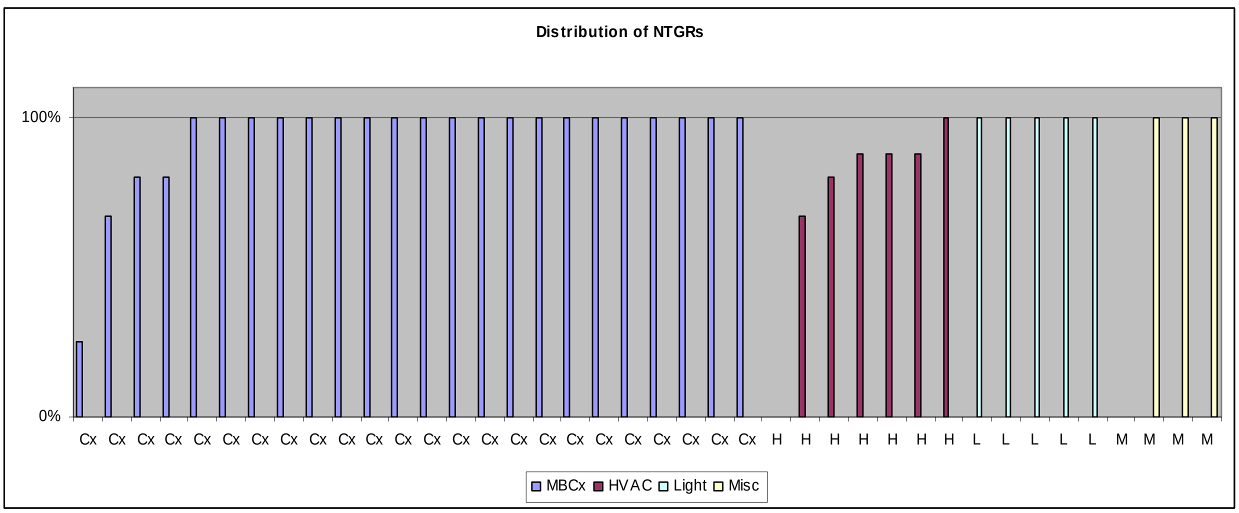


Table 4-5: Evaluated First-Year Gross Realization Rates and Net-To-Gross Ratios

	First-Year Gross Realization Rates			Net-to-Gross Ratios		
End Use / Category	kWh	Avg peak kW	therms	kWh	Avg peak kW	therms
MBCx	81%	36%	100%	96%	92%	81%
HVAC	31%	13%	7%	55%	53%	97%
Light	71%	54%	-	100%	100%	100%
Misc	27%	237%	91%	0%	0%	98%

4.1.4 Program-Level Gross and Net Savings

The final evaluated savings results are summarized, by utility and by end use/category, in Table 4-6 and Table 4-7, respectively. These tables provide key evaluation metrics, including gross and net realization rates, evaluated NTGRs, and net savings totals. Additionally, they compare the final net savings estimates with the original program goals, providing one quick assessment of program success. Figure 4-4 and Figure 4-5 compare, in graphical form, total net energy savings in a logical progression: (1) original program goals, (2) utility claims, (3) recently documented results, and (4) final evaluated results.

We highlight below some major observations from the results in these tables and figures:

1. The program yielded net savings for the participating utilities and universities in the state of California of 18,657,000 kWh/year and 872,000 therms/year, with average peak demand reduction of 1.95 MW. It is important to keep in mind, however, that because of evaluation sampling challenges, the relative error around these estimates is high. As a result, there is a fair amount of uncertainty as to the actual savings.
2. Overall, the program achieved its net savings goals, realizing 100% of its net electric savings goal and 101% of its net gas savings goal. With peak demand reduction, however, the program fell short, only obtaining 73% of its goal.
3. Overall, program claims and documented results far exceeded the goals, but the evaluated overall gross realization rate of 72% diminished these results, so in the end, the net savings were fairly close to the goals.
4. Program freeridership was near the levels expected, with an 88% evaluated NTGR, compared to the 90% that the program originally projected. Interestingly, the aggregate NTGR for MBCx is lower than the program projection (85% vs. 100%), while the aggregate Retrofit NTGR is higher (94% vs. 80%).
5. The PG&E and SoCalGas portfolios generally exceeded their goals, while the SCE and SDG&E portfolios fell significantly short of their goals.
6. The Retrofit projects generally underperformed, with low realization rates. The Program, by overshooting its goals, was able make up for these somewhat, but nonetheless, the Retrofit portfolio missed its electric goals slightly, and its gas goal significantly. HVAC projects as a group performed particularly poorly, achieving only about 8% of their energy goals.
7. The MBCx portion of the program had robust realization rates, so that it was able to exceed its goals significantly. A notable exception, however, was in peak demand reduction, where the MBCx portfolio only realized 37% of its claimed savings, thereby falling far short of the goal.

One particular measure that occurred at an MBCx project (Evaluation Project ID #63.01) deserves mention here, because it had potentially huge ramifications on the program results. This project involved retrocommissioning a central plant steam system. The commissioning agent recommended reducing the system steam pressure, which the campus did. Through the extended, trial-and-error process of doing so, however, the campus discovered that they could shut down their less-efficient steam-driven chillers and instead run their efficient electric chillers more. Doing so is providing the campus with huge natural gas savings, which are offset somewhat by increased electric usage and demand (though the gas savings dwarf the electric usage, so the cost savings to the university are still substantial). Program activity clearly motivated campus staff to make this improvement, although it was not explicitly recommended by the program-funded commissioning agent. According to current CPUC evaluation definitions, this action is considered spillover, so we did not include its effect in the final reckoning. Table 4-8, though, shows the dramatic program results had we included this measure: PG&E's and the program's evaluated gas savings would have increased by about fourfold, and the program would have exceeded its total energy savings goal by 130%, rather than just meeting it.

Table 4-6: Evaluated Savings Results, by Utility

Utility	Electric savings kWh/year	Electric savings Avg. peak kW	Gas savings therms/year	Total energy savings MMBtu/year
Pacific Gas & Electric				
Gross realization rate	69%	51%	94%	79%
Evaluated NTGR	95%	97%	81%	89%
Net realization rate	76%	59%	77%	77%
Evaluated net impacts	10,243,811	1,147.2	264,366	61,399
Evaluated % of goal	**137%**	**107%**	**93%**	**113%**
Southern California Edison*				
Gross realization rate	68%	40%	N/A	68%
Evaluated NTGR	95%	94%	N/A	95%
Net realization rate	74%	43%	N/A	74%
Evaluated net impacts	4,913,035	544.1	N/A	16,768
Evaluated % of goal	**72%**	**54%**	**N/A**	**72%**
Southern California Gas*				
Gross realization rate	N/A	N/A	74%	74%
Evaluated NTGR	N/A	N/A	85%	85%
Net realization rate	N/A	N/A	69%	69%
Evaluated net impacts	N/A	N/A	544,659	54,466
Evaluated % of goal	**N/A**	**N/A**	**128%**	**128%**
San Diego Gas & Electric				
Gross realization rate	61%	35%	42%	52%
Evaluated NTGR	89%	91%	83%	87%
Net realization rate	61%	36%	40%	51%
Evaluated net impacts	3,500,646	256.4	63,245	18,272
Evaluated % of goal	**85%**	**43%**	**39%**	**60%**
PROGRAM TOTAL				
Gross realization rate	67%	44%	75%	72%
Evaluated NTGR	94%	95%	84%	88%
Net realization rate	72%	50%	68%	69%
Evaluated net impacts	18,657,492	1,947.7	872,270	150,905
Evaluated % of goal	**101%**	**73%**	**100%**	**100%**

* Documented gas savings from SCE projects is credited to SoCal Gas, and documented electric savings from SoCal Gas projects is credited to SCE.

Table 4-7: Evaluated Savings Results, by End Use

Category / End Use*	Electric savings kWh/year	Electric savings Avg. peak kW	Gas savings therms/year	Total energy savings MMBtu/year
MONITORING-BASED COMMISSIONING (MBCx)				
Gross realization rate	81%	36%	100%	95%
Evaluated NTGR	96%	92%	81%	85%
Net realization rate	78%	33%	82%	81%
Evaluated net impacts	8,262,666	373.3	717,193	99,920
Evaluated % of goal	**112%**	**37%**	**237%**	**180%**
RETROFIT				
HVAC				
Gross realization rate	31%	13%	7%	15%
Evaluated NTGR	55%	53%	97%	67%
Net realization rate	21%	9%	8%	13%
Evaluated net impacts	921,007	48.1	24,457	5,589
Evaluated % of goal	**19%**	**18%**	**4%**	**8%**
Lighting				
Gross realization rate	71%	54%	N/A	71%
Evaluated NTGR	100%	100%	100%	100%
Net realization rate	89%	68%	N/A	89%
Evaluated net impacts	9,473,819	1,526.4	(2,635)	32,071
Evaluated % of goal	**151%**	**110%**	**-150%**	**148%**
Miscellaneous				
Gross realization rate	27%	237%	91%	84%
Evaluated NTGR	0%	0%	98%	94%
Net realization rate	0%	0%	111%	99%
Evaluated net impacts	-	-	133,255	13,325
Evaluated % of goal	**N/A**	**N/A**	**1957%**	**1957%**
All Retrofit				
Gross realization rate	59%	47%	31%	47%
Evaluated NTGR	92%	96%	98%	94%
Net realization rate	68%	56%	38%	55%
Evaluated net impacts	10,394,826	1,574.5	155,076	50,985
Evaluated % of goal	**94%**	**95%**	**27%**	**54%**
PROGRAM TOTAL				
Gross realization rate	67%	44%	75%	72%
Evaluated NTGR	94%	95%	84%	88%
Net realization rate	72%	50%	68%	69%
Evaluated net impacts	18,657,492	1,947.7	872,270	150,905
Evaluated % of goal	**101%**	**73%**	**100%**	**100%**

Figure 4-4: Evaluated Savings Results, by Utility

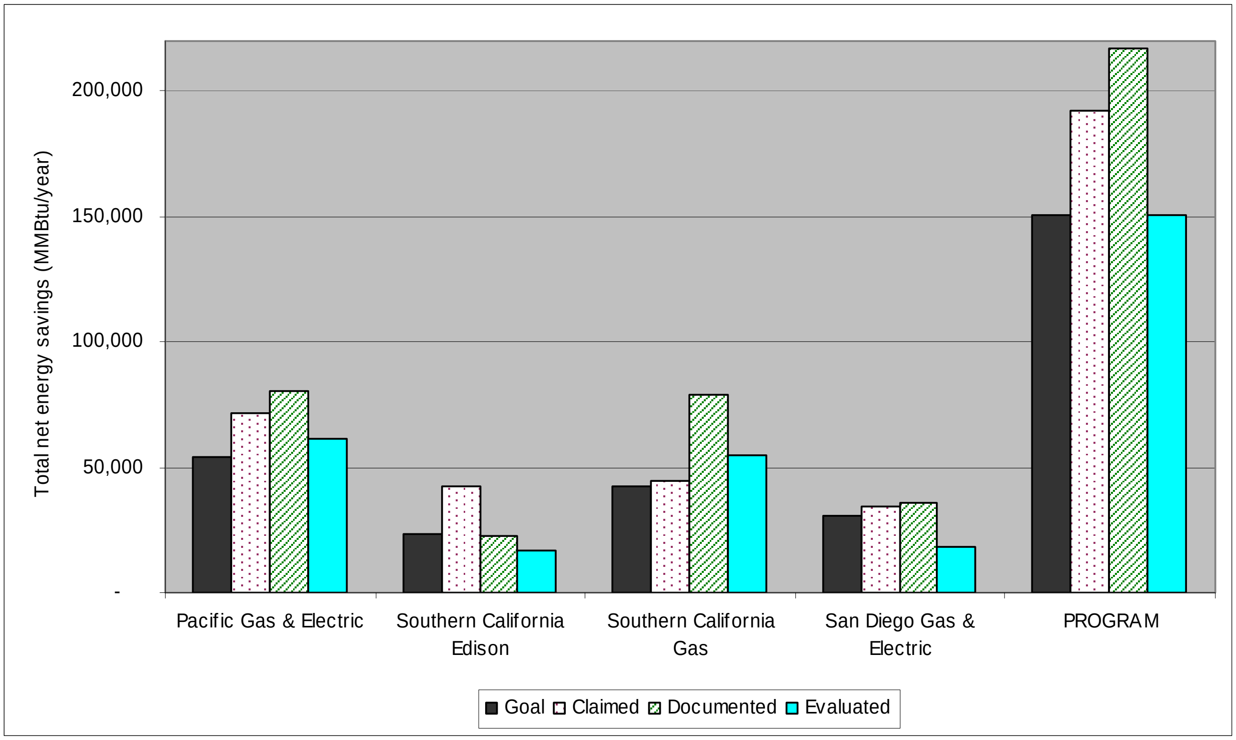


Figure 4-5: Evaluated Savings Results, by Category

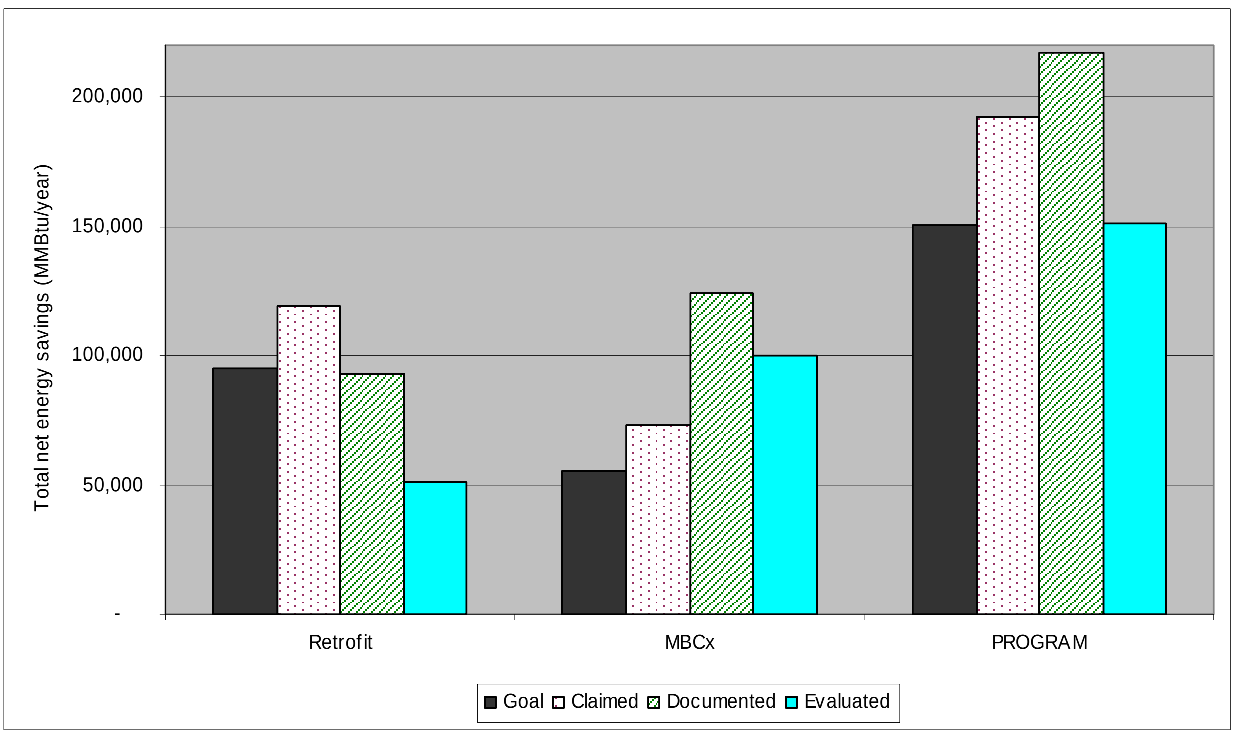


Table 4-8: Alternative Results, Including Effect of Large Spillover Case

Utility	Electric savings kWh/year	Electric savings Avg. peak kW	Gas savings therms/year	Total energy savings MMBtu/year
Pacific Gas & Electric (ALTERNATIVE)				
Gross realization rate	55%	38%	371%	179%
Evaluated net impacts	8,148,868	873.1	1,043,865	132,199
Evaluated % of goal	**109%**	**82%**	**366%**	**244%**
Pacific Gas & Electric (ORIGINAL)				
Gross realization rate	69%	51%	94%	79%
Evaluated net impacts	10,243,811	1,147.2	264,366	61,399
Evaluated % of goal	**137%**	**107%**	**93%**	**113%**

Category / End Use*	Electric savings kWh/year	Electric savings Avg. peak kW	Gas savings therms/year	Total energy savings MMBtu/year
MBCx (ALTERNATIVE)				
Gross realization rate	44%	-47%	397%	294%
Evaluated net impacts	4,447,860	(477.6)	2,831,083	298,289
Evaluated % of goal	**60%**	**-47%**	**936%**	**538%**
MBCx (ORIGINAL)				
Gross realization rate	81%	36%	100%	95%
Evaluated net impacts	8,262,666	373.3	717,193	99,920
Evaluated % of goal	**112%**	**37%**	**237%**	**180%**
PROGRAM TOTAL (ALTERNATIVE)				
Gross realization rate	52%	23%	260%	172%
Evaluated net impacts	14,293,148	1,032.3	2,964,800	345,263
Evaluated % of goal	**78%**	**39%**	**339%**	**230%**
PROGRAM TOTAL (ORIGINAL)				
Gross realization rate	67%	44%	75%	72%
Evaluated net impacts	18,657,492	1,947.7	872,270	150,905
Evaluated % of goal	**101%**	**73%**	**100%**	**100%**

4.1.5 Relative Error of Population Estimates

To estimate the relative precision of the evaluated ex post savings, we first examined the relative precision of the ratio estimates—that is, the ratio between the ex ante and ex post savings estimates. As prescribed in the *California Evaluation Framework*[6], the statistical precision of the ratio estimator b (the realization rate) can be estimated by calculating the standard error using the following equation:

[6] Found on page 331 of the June 2004 edition of the *California Evaluation Framework.*

$$se(b) = \frac{1}{\hat{X}} \sqrt{\sum_{i=1}^{n} w_i \left(w_i - 1\right) e_i^2}$$.

In this equation, *X* is the sum of the weighted ex ante impacts for the sampled sites (i.e., the ex ante estimate for each sample point multiplied by its case weight. For the MBCx cases, for example, this means that each of the 3 cases of the 30 in the sampled stratum was multiplied by 10.) The term *e* is the difference between the ex post impact estimate and the ex ante estimate multiplied by the realization rate, or y-bx. The resulting estimate of the standard error is then multiplied by 1.645 to determine the 90% error bound, and that error bound is divided by the realization rate to calculate the relative precision. Using this calculation, the relative precision, at 90% confidence, of the MBCx realization rate is ±15%, while the relative precision of the Retrofit realization rate is ±52%. These values are shown in Table 4-5.

In addition to the error associated with sampling for gross impacts, we also estimated the error associated with the estimated NTGR. We employed the same approach described above to calculate a standard error around the NTGR estimates that were used to derive net impacts from the evaluated gross impacts. Using this calculation, the relative precision around the aggregate NTGR for the MBCx sites is ±5%, while the relative precision of the Retrofit NTGR is ±11%.

To capture the propagation of error when the realization rate is multiplied by the NTGR, the two relative precision terms can be combined, as described on page 307 of the *Framework*, where it is noted that the relative precision of the net savings estimate RP(NS) is approximately equal to:

$$\sqrt{rp(GS)^2 + rp((NTGR))^2}$$

Combining the relative precision terms in this way yields an overall RP of ±15.8% for the MBCx net savings and ±53.6% for Retrofit net savings.

Using these relative precision estimates, we then developed a program level estimate of relative precision, shown in Table 4-9, using the approach described in the *Framework* on page 312, which shows the calculation of combined relative precision for different programs or program components. By first squaring the error bands for the MBCx and Retrofit program component and then taking the square root of the sum, we calculate a combined error band of 31,560 net MMBtu/year, representing relative precision of ±20.9% at the 90% confidence level for the total net savings estimate.

Table 4-9: Relative Precision of Population Estimates

	MBCx	Retrofit	Total
Sampling Precision			
Ex post total energy (net MMBtu/year)	99,920	50,985	**150,905**
Error band (ex post net MMBtu/year)	15,813	27,313	**31,560**
Relative precision at 90% confidence interval	15.8%	53.6%	**20.9%**

4.1.6 Effective Useful Life

For Retrofit projects, we applied the appropriate stipulated effective useful life (EUL) values to each documented project, so that the aggregate program EUL reflected the actual project mix (these values can be found in Table 3-1: Standard Values for Effective Useful Lives and Net-to-Gross Ratios in the Methodology section). As Table 4-10 shows, this analysis produced only a small change from the original program values, from 15.7 to 15.6 years.

For MBCx projects, some anecdotal evidence we found while visiting the sites and speaking with campus contacts suggests that the 15-year EUL assumption is optimistic and should be included in an EUL update study. This evidence includes the following:

- We encountered instances where meters had been improperly installed, or were of questionable quality, so campuses had to repair or replace them to maintain their ability to provide data. Even in the best of circumstances, the meters will require periodic upkeep and calibration to maintain their accuracy.
- Some campuses complained that they were awash in data, and lacked the time and the expertise to manage it effectively. It was clear in some cases too that campus facility staff was stretched very thin, and they would need additional resources to devote to monitoring and diagnosis.
- Several contacts expressed concern that staff turnover and institutional inertia might keep them from using the monitoring well into the future. Furthermore, a number of campuses we visited had plans to add cogeneration plants and solar arrays. This raises a question to us of whether program energy savings can continue to be claimed in years when that particular load is served by grid-connected self-generation projects.

Further study would be necessary to assess and substantiate the quantitative ramifications of these isolated observations.

Table 4-10: Program vs. Evaluated Effective Useful Lives

Category	Total energy savings - EUL (years)
MONITORING-BASED COMMISSIONING (MBCx)	
Program Stipulation	15.0
Evaluated Results	15.0
Evaluated % of program	**100%**
RETROFIT	
Program Stipulation	16.1
Evaluated Results	17.0
Evaluated % of program	**106%**
PROGRAM TOTAL	
Program Stipulation	15.7
Evaluated Results	15.6
Evaluated % of program	**99%**

4.1.7 Cost-Effectiveness

To assess the cost-effectiveness of the program, we updated the latest available PIP workbooks with evaluated net savings shown above for kWh, kW, and therms. We maintained the original EUL value of 16 years, since our analysis uncovered no basis for changing it. The evaluated first-year net savings, extrapolated over the expected 16-year lifetime of program measures, translates to nearly 300 million kWh and 14 million therms of savings. We also accepted as-is the total program costs stated in the PIP workbooks. The resulting TRC costs, benefits, net benefits and ratio are shown in Table 4-11.

Overall, the TRC costs for the program were nearly $1 million (or about 7%) more than those estimated in the original program documentation. The evaluated TRC benefits were only about $800,000 (or about 5%) more than the original program estimate, even though the values for the individual utilities varied significantly. The final evaluated TRC ratio of 1.18 is a mere 2% less than the original estimate of 1.20, and indicates that according to our evaluation, the Partnership program was cost-effective. Significant differences exist, however, between the four utilities. The program was particularly cost-effective for PG&E and SoCalGas, with TRC ratios of 1.44 and 1.48, respectively. It was not cost-effective, though, for SCE (0.85) and SDG&E (0.93).

Table 4-11: Evaluated Program Cost-effectiveness

Utility		Total Resource Cost (TRC) Costs	Benefits	Net benefits	Ratio
Pacific Gas & Electric	Projected	$5,128,458	$6,397,946	$1,269,488	1.25
	Evaluated	**$6,010,304**	**$8,637,601**	**$2,627,297**	**1.44**
Southern California Edison	Projected	$4,083,442	$4,658,349	$574,907	1.14
	Evaluated	**$4,121,565**	**$3,517,632**	**-$603,932**	**0.85**
Southern California Gas	Projected	$2,008,532	$2,209,268	$200,735	1.10
	Evaluated	**$1,811,440**	**$2,685,001**	**$873,560**	**1.48**
San Diego Gas & Electric	Projected	$2,820,131	$3,594,265	$774,134	1.27
	Evaluated	**$3,035,443**	**$2,818,169**	**-$217,274**	**0.93**
PROGRAM TOTAL	Projected*	$14,040,564	$16,859,828	$2,819,265	1.20
	Evaluated**	**$14,978,752**	**$17,658,402**	**$2,679,651**	**1.18**

* All projected TRC values obtained from revised Program implementation plan (PIP) workbooks filed with state on March 2, 2004.
* All evaluated TRC cost values obtained from PIP workbooks available from the CPUC EEGA website as of July 2007 (cumulative+committed costs). Corresponding benefit values obtained by entering evaluated net savings and EUL into those same workbooks.

4.2 Program Process

Below are summaries of process findings from interviews of major program groups, namely (1) key program staff, (2) campus staff involved with Retrofit projects, (3) campus staff involved with MBCx projects, and (4) individuals who attended T&E workshops. Subsequent sections describe findings in these four areas in more detail.

4.2.1 Summary

Key Staff

Key contacts unanimously termed the UC/CSU/IOU Partnership successful. Perhaps the most profound way in which they believed it was successful was in demonstrating a complex, statewide, multi-partner, energy-efficiency program is a viable and effective model. Things the key contacts valued most about the Partnership include higher campus-wide awareness of and attention to energy efficiency, a broader sharing of common problems with common solutions, and obtaining a commitment to energy efficiency from higher levels of management, both within the university systems and within the utilities. However, there remained some unresolved challenges for the program. Team-member turnover, especially on the management team, was problematic for most of 2004-05. This is an area where further monitoring is warranted. There was also an asymmetry of the partners in regard both to fiscal authority and assumed managerial authority. Addressing these imbalances explicitly will be key to overcoming the concerns they have generated.

Administratively, program communication was described by the key contacts as “active” and effective. Project forms had been standardized, and continued to be reviewed for possible improvements. Problems with project payments in 2004-05 were addressed through the intervention of executive team members. To avoid a recurrence of these payment problems in 2006-08, the program management consultant (NAM) developed contract forms for use directly between the utilities and each campus for each project, and standardized payment procedures. The program database was enhanced with the ability to track both proposed and measured savings, and the addition of the Microsoft Office Project’s tracking tool to increase its functionality.

Key contacts reported the Retrofit projects substantially exceeded their energy savings goals. Not all of the Retrofit projects were completed by the end of 2005, but they were completed by or close to the extended program deadline of June 30, 2006. Different circumstances delayed the projects, some of which were campus specific and unrelated to the program.

MBCx projects were also reported to have savings that “far exceeded expectations.” However, the MBCx projects were more problematic and experienced greater delays than the Retrofit projects. Many of the delaying factors were part of the “huge learning curve” inherent in this entirely new approach to energy efficiency programs.

T&E-instructor hiring and payments were problematic in 2004-05, resulting in part from a separation of the responsibilities for hiring instructors and for making program payments. This issue is being addressed in the subsequent 2006-08 phase of the program.

T&E's Sustainability Conferences have been effective crucibles for developing and showcasing best practices, and for contributing to the development of new courses.

There was an explicit ambivalence from the utilities toward the Partnership's T&E component. To overcome continuing reservations about T&E, it will be important to remain aware of this ambivalence, to look for ways to measure this component's impact on energy savings, and to "rethink what sort of activities generate savings that count."

It was suggested the courses would benefit from the use of more in-house instructors, and the use of adult-learning methods for course instruction. Additional changes that may increase attendance include a better understanding of the size of the population of prospective course participants, more targeted marketing, addressing the barrier to attendance posed by the difficulty staff have in taking one or more entire days off from their jobs to attend the courses, and better coordination of class locations and schedules between the two university systems.

Retrofit Project Staff

The Retrofit contacts described the Partnership as successful. Their projects were reported to have obtained the desired result of saving energy, and to have provided better lighting, reduced building noise, reduced water use, increased maintenance efficiencies, and increased awareness of energy use and conservation among building users. The Retrofit contacts had little to say about the program's administrative requirements, implying an absence of difficulties. They also reported little awareness of other campuses' Retrofit projects, a surprising circumstance given the many avenues available for intercampus communication. Those responses indicate the opportunity to share lessons learned from the projects had not been captured by the program.

MBCx Project Staff

Although nearly one third of the MBCx contacts reported it was too soon to be able to determine the results of their projects, overall, the contacts described the Partnership as successful. Their projects were reported to have obtained the desired result of saving energy, to have improved occupant comfort and safety, and to have increased maintenance awareness and efficiencies, among other benefits.

The program's administrative requirements were relatively trouble free for the MBCx contacts. The most significant administrative difficulties reported by them arose from individual internal campus processes. As did the Retrofit program contacts, the MBCx contacts reported little awareness of the details of other campuses' MBCx projects. Those responses again suggest the opportunity to share lessons learned from the projects was not captured by the program.

T&E Workshop Participants

The Partnership offered an energy efficiency T&E curriculum of 14 courses and events. Attendance at these courses and events exceeded 1,768 during 2004-05. That total attendance comprised 1,033 unique individuals, including staff from every UC and CSU campus. However, attendance was lower by CSU personnel than by UC personnel. Lower attendance from CSU campuses was attributed to a combination of smaller numbers of operations and maintenance staff at those campuses available to attend the courses, fewer CSU Partnership staff to administer the T&E component for that university system, and less experience in hosting such events by CSU staff. Additional staff to assist with the program has been hired both by CSU and NAM.

The T&E component needs to find ways to overcome the institutional barrier to course attendance posed by the difficulty university staff have in taking time away from their jobs, and the marketing challenge posed by incomplete information about the number of campus staff eligible for the training sessions.

The overall satisfaction of the 85 students who responded to a web-based survey of students who had taken at least one of five specific courses was high for all five of the surveyed courses. High numbers of these students also reported using the information from their respective classes in their jobs. Additionally, very high numbers (96% to 100%) of them reported the classes were worthy of being recommended to others with whom they work.

4.2.2 Key Staff Interviews

4.2.2.1 Introduction

To obtain a current understanding of the Partnership program's organizational structure, administrative requirements, and program processes, interviews with 19 key program contacts were conducted from April 11 through June 12, 2006. Those interviewed included nine employees or consultants of the four investor-owned utilities, six employees of the UC Office of the President or CSU Chancellor's Office, and four individuals from organizations subcontracted by, or working with a component of, the Partnership program. In this section, we present the results of those interviews.

More specifically, this section describes, as seen through the eyes of the key program contacts, the status of the program as it approached the end of the 2004-05 program period, including the key contacts' views of program administration, the Retrofit, MBCx, and training and education program elements, and their reflections upon the program's greatest successes and most needed changes.

Because at the time of the interviews, most contacts were directly involved in implementing the 2006-08 program, which was developed from lessons learned in the 2004-05 program, there were many times the two program periods merged in the minds of the contacts. Thus, throughout the interviews, it was important to emphasize to the contacts the focus of the interviews was the 2004-05 program period.

4.2.2.2 Program Overview

In the 2005 interim report, the key contacts' assessments of the Partnership were distilled into a single word: "challenging." Nonetheless, in spite of the program's challenges, we reported the Partnership had "sufficiently overcome [its] challenges to establish the foundation for a viable, replicable program that [was] moving toward its energy-savings and load-reduction targets."[7] If the current assessment of the program by its key contacts at the close of the 2004-05 period were similarly reduced to a single word, that word would be "successful." During the recent interviews, almost all of the contacts commented on their perception of the program's overall success at some point in their descriptions of the program.

A sampling of such comments includes remarks such as "[the Partnership] accomplished pretty much all of its goals even with its compressed time frame." Another contact reported university staff members "are looking forward to the next cycle." As evidence of the Partnership's success, a contact cited a substantial additional commitment of funding for lighting retrofit projects that was made to the program by Pacific Gas and Electric (PG&E) near the end of 2005.

One utility contact described himself as an early skeptic of the Partnership's ability to meet its goals, based upon his utility's lack of success in attempts to penetrate campuses with an earlier energy efficiency program. In spite of his early skepticism, he assessed the status of the Partnership as "amazingly successful." He commented further that energy savings were ahead of goal and the program was under budget. Other key contacts reported energy savings goals were exceeded by 20%, while one contact said the projects had "doubled" their energy savings goals.

Other achievements key contacts cited to show the program's success included its demonstration partnerships can work, the involvement of students in the Partnerships' activities, particularly through the training and education component's Sustainability Conferences, creation of a vehicle for campus energy efficiency projects that would otherwise not have been undertaken, and the program's educational component that would not otherwise exist.

While the key contacts unanimously termed the program successful, difficulties were nevertheless encountered. Some projects were scaled back or discontinued. Not all of the projects had been completed at the time of the initial interviews, requiring follow-up interviews through December 2006. Registrations and attendance for T&E classes was less than hoped for in some cases. Cultural differences between the partners continued to cause concern, as did turnover of team members, especially on the management team.

The foregoing successes and difficulties are addressed in greater detail in the remainder of this section and in subsequent sections, which include a discussion of program processes, a sampling of experiences with MBCx projects and with Retrofit projects, a description of the Partnership's T&E activities, and the results of a web-based survey of a sample of the T&E students.

4.2.2.3 Partner Asymmetry

There was an asymmetry of the partners that was of continuing concern for some of the key contacts. The asymmetry had two aspects. The first aspect was in regard to fiscal authority. The second aspect had to do with program management. Regarding the first aspect, one of the university contacts mentioned, "I don't think the partners are equal in that the utilities control the purse strings. If utilities want to go in a certain direction, the universities have to go along."

[7] SBW Consulting, Inc., *Evaluation, Measurement and Verification (EM&V) Interim Report for UC/CSU/IOU Energy Efficiency Partnership,* March 1, 2005

Regarding the second aspect, a utility contact reported, “The biggest challenge with partnerships in general is that the word is interpreted differently by different people. It doesn’t necessarily mean everyone is equal. There needs to be a managing partner.”

The Partnership Agreement did not define the term “partner,” nor did it set forth the specific responsibilities of the partners. However, the Program Implementation Plans (PIPs) do specify partner responsibilities. Under the heading “Utility Roles,” the PIPs say, “The utilities will have primary program administrative responsibility on behalf of the partners, including…making payments to UC/CSU and, as applicable, IOU subcontractors.” In this way, the PIPs addressed at least the first aspect of the partners’ asymmetry. Unavoidably, some party must have check writing authority for program funds. In the PIPs, that responsibility was allocated to the utilities.

Regarding the notion that one of the partners must function as a managing partner, neither the Partnership Agreement nor the PIPs offered clear direction. As just pointed out, the PIPs’ use the expression “primary program administrative responsibility” in regard to the role of the utilities. However, administrative responsibility is not necessarily the same as management responsibility. The Partnership Agreement singles out Southern California Edison to “…manage the evaluation, measurement and verification (‘EM&V’) of the Program in all Utility service territories….” However the document was silent as to any other partners’ management responsibilities. If one or more of the partners were to have management responsibility for the partnership, it would have been helpful to have this spelled out in the program’s defining documents.

4.2.2.4 Program Administration

In this section, we describe the Partnership’s structure, the management transition that occurred early in 2005, program communication, and program administration.

Program Management and Implementation Structure

The program design, as defined by the PIPs, included committees, or teams, to oversee and administer the program and its various elements. An executive team comprising the energy efficiency directors from each of the partner utilities, the UC and CSU energy managers from the Office of the President and Chancellor’s Office, respectively, and representatives of the program management contractor oversaw the entire program, ensuring budgets and savings goals were met. The executive team also coordinated CPUC activities, and resolved any critical disputes presented by the management team. Two program consultants were also members of the executive team.

Beneath the executive team was a management team comprised of the UC and CSU energy managers and at least one person from each of the four IOUs. Representatives of the program management contractor and other program consultants were also members of this team. The function of the management team was to establish the administrative structures needed to implement the program, oversee program administration (budgeting, timekeeping, invoicing, reporting, contract administration) in each of the program areas, ensure timely and accurate CPUC reports, approve the hiring of subcontractors, and resolve key issues presented by program teams.

Four program implementation teams were also part of the Partnership: (1) a Retrofit team, (2) a MBCx team, (3) a T&E team, and (4) an evaluation, measurement, and verification (EM&V) team. Each partner and each program consultant designated at least one person, including campus representatives, to be on each team. Each of these teams helped develop and oversee program implementation in their respective areas. Their assigned activities included conducting campus needs assessments, identifying and implementing key tasks consistent with budgets, identifying major risks and how those risks would be managed, conducting procurement processes, and recommending subcontractors and vendors to the management team. These teams reported to the management team on a regular basis.

The program plan also designated a legal team, composed of attorneys from all partner organizations, to draft the master agreement, to review all legal documents, and to assist the program as needed. Additionally, a media team and a workbook team were created. The workbook team developed the PIPs and the first workshop that was used to rollout the program to the campuses. The media team was expected to handle communications but had minimal activity.

By the end of 2005, the administrative structure was streamlined from these nine teams at the program's birth to five active teams: the executive, management, MBCx, T&E, and EM&V teams. Having served its purpose of "technical review on the front end," the Retrofit team became inactive, as the legal, media, and workbook teams previously had become, demonstrating the adaptability of the program to its existing and evolving needs. A map and narrative description of the program processes as they looked at the end of 2005 can be found in Appendix 6.4.

Contacts suggested the Retrofit team would be reactivated during the next program cycle, but also suggested it might be combined with the MBCx team. For example, one contact reported the absence of Retrofit team activity "simplified the program workings," and believed combining it with the MBCx team would be more efficient. More specifically, he reported that during the 2004-05 program cycle, the majority of the two teams' members were on both teams. The contact felt combining the two teams would allow the members to track both types of projects from inception to completion. He offered, "This will assist the management team with better updated project status and consistent technical assistance." Indeed, the MBCx team ended up carrying out one of the activities that would normally have been done by the Retrofit team. As mentioned earlier, at the end of 2005, PG&E made available an additional $2 million for lighting Retrofit projects. Because the Retrofit team had been disbanded, the MBCx team identified the projects to receive the additional funding.

Team Member Turnover

As was the case during the interviews for the interim evaluation report, team member turnover, especially among team members representing utilities, was again mentioned as a disruption to team communications. Such comments occasionally seemed to be implied criticism of the utilities' commitment to the Partnership. However, we believe to the extent such criticism was implied, it was mistaken. Based upon the comments of utility staff, it appears the turnover probably had more to do with California's history of uncertainty regarding the administration of energy efficiency programs, and with normal personnel adjustments, than it did with utility indifference to the Partnership.

On the contrary, far from being indifferent, during the final round of interviews we found utility staff to be uniformly impressed with, supportive of, and enthusiastic about the Partnership. One utility's support was evident in its creation in 2005 of a new staff position for the management of partnerships. It appears the combined effects of the continuity of energy-efficiency-program administration in California going into the 2006-08 cycle, and the apparent completion of a normal shakeout period of personnel changes will likely result in less turnover among utility staff participating on the program teams during the 2006-08 period.

Management Transition

To facilitate the program's startup, the PIPs specified Grueneich Resource Advocates (GRA) as the subcontractor to undertake program management activities. GRA provided staffing to every program team. In December 2004, the principal of GRA was appointed to the CPUC, which precluded continuation of the firm's role with the Partnership program. That was one of many challenging circumstances facing the program as described in the interim evaluation report.

In April 2005, the firm of Newcomb, Anderson, McCormick (NAM), was hired to take on the Partnership's management responsibilities, adding engineering expertise to program management. Key contacts specifically mentioned NAM's engineering expertise as being an asset to the program.

One of the challenges in making this management transition was arriving at a common, shared understanding of the new management firm's roles and responsibilities. An early misunderstanding in this regard occurred with respect to management of the program's database. One result of this misunderstanding was the unavailability of the database for several weeks. An executive team member reported that in order to resolve this difficulty, the team met to discuss and define roles and responsibilities. A contact who was quite critical of this misunderstanding, also reported it is "substantially resolved," and "the database is now on track to track the projects."

Thus, contacts who earlier had concerns arising from the management transition seemed to have overcome them, and contacts generally indicated the new management is working well. One key contact reported he appreciates NAM's "help in bringing program documentation together, in expediting project completion, and in setting up the project tracking database." He also observed, "One effect of [NAM] coming on board is that I am less aware of administrative requirements." Another contact who became a member of the management team roughly one month after NAM was hired, reported, "When I became involved, [NAM] seemed to have been doing it for a long time already." Finally a utility representative reported "The transition did not affect the process." Together, these comments suggest, with the exception of the "disruption" to the availability of the program's database, the transition of program managers was smooth and effective.

Communication

Program communication was described by the key contacts as “active.” The management team met every two weeks by means of a conference call, and met in person every two months. Meeting agendas, minutes of the previous meeting, and notice of any action items to be taken were prepared and delivered by NAM to the team members in advance of each meeting. However, one contact mentioned the amount of time between the delivery of these materials and the meeting time was too short to allow his organization to prepare adequately for the meeting. Apparently this was communicated to NAM, who was responsive to that concern. Management team meeting agendas and minutes were posted on the program’s website.

Between meetings, team members communicated with each other by email and telephone. Team members also “reported back,” or communicated meeting decisions and information to their colleagues and supervisors in their respective organizations. In this regard, one contact reported he tried to “over-communicate.” Communication between teams was also enhanced by the circumstance of many team members serving on multiple teams.

The executive team also received the minutes of management team meetings. The executive team met about four times a year. Its proposed meeting agendas were also prepared by NAM, and minutes of executive team meetings were distributed by NAM to the management team. Between meetings, executive team members were briefed by their management team counterparts, and consulted by them as needed.

Management team members representing the utilities tried to keep their campus account executives current with program information so they would be as informed about the program’s activities as were the campus staff with whom the account executives work. Additionally, utility staff, university systems’ staff, representatives from NAM, and members of the EM&V team communicated with campus staff as needed by email, telephone, and in-person.

In fact, there were so many people communicating so frequently with campus staff, the latter began to “push back.” That is, key contacts reported there were complaints from some campuses about being contacted too often by various program representatives. We encountered this ourselves when a campus-project contact declined to be interviewed on the grounds of being contacted too frequently by too many different people. One utility attempted to address this problem by channeling all of its communications or inquiries regarding the program through a single person.

4.2.2.5 Administrative Processes

During the first round of interviews in 2004-05, various contacts described difficulties with program forms and project payments, and described shortcomings of the program website and database. During the 2006 interviews, these issues were revisited to determine the extent to which those issues had been addressed. As reported more fully in the sections on the Retrofit contacts’ and MBCx contacts’ interviews, those contacts had little to say about the program’s administrative requirements. Their lack of comments suggests they encountered no significant obstacles or problems in the program's administrative requirements. The key contacts' observations regarding program administrative requirements follow.

Forms

A key contact reported the forms initially used in the program were based upon utility documents and were different from utility to utility. Throughout 2004-05, there was an ongoing evolution of the Partnership's various forms, payment procedures, and database. While key contacts mentioned no ongoing issues regarding program forms, it was reported the forms continued to be reviewed for possible improvements during the 2006-08 cycle. More specifically, NAM reported reviewing all of the program's forms, thinking through the information that was needed, and standardizing the forms, and was reportedly making them available on the program's website.

Project Payments

As reported in the interim report, 2004-05 project payments to the campuses were frequently not made in a timely manner. One cause of these delays occurred because the master agreement was between the IOUs on one hand and the UC Office of the President and CSU's Chancellor's Office on the other hand, rather than directly between the IOUs and the campuses. However, requests for project payments were generated by the individual campuses and sent directly to the IOUs. In the absence of contractual documents authorizing the specific projects, those responsible for issuing checks from the IOUs were reluctant to do so. A utility contact reported, "[The checks] take a while to process through [the] signature loops. It's difficult to know when a check is issued."

The payment problems were "escalated to the executive team," whose members' telephone calls to those within their respective organizations moved the payments forward. In order to make payments occur in a timelier manner during 2006-08, contracts were developed directly between the utilities and each campus for each project, and payment procedures were standardized.

Other difficulties regarding project payments seemed to arise internally at some campuses. For example, one campus contact reported, "Sometimes checks are received, and cashed, and the funds put into the wrong account. Even when the funds are in the right account, the project manager may not be notified the funds have been received."

The many checks and balances the various partners had in place to safeguard their funds and fund transfers might have resulted in occasional payment difficulties. Continued attention to the payment process by the program manager and at the executive team level, especially with emphasis upon streamlining check-signature authority, and active communication and discussion of such difficulties when they arise, may be the most effective approach to minimize such problems in the future.

In a final note regarding project payments, key contacts reported a problem arising from the 2004-05 schedule of payments. The interim report detailed three payment trigger points: 40% of the project amount upon project approval, 50% of the project amount upon campus receipt of the equipment for the project, and the final 10% of the project amount when the utility approved the project as complete. It was reported the final payment of 10% was inadequate to create the sense of urgency needed to complete some of the projects on time. To instill a greater sense of urgency within the 2006-08 Partnership, there will only be two payment trigger points: 60% upon project approval, and the remaining 40% after the project is completed.

Database and Website

The Partnership database as originally set up was a web-based program that collected proposal information to track committed Partnership funds and anticipated energy savings. The database was not designed to collect actual energy savings results as they were generated. Two of the key contacts began using a separate spreadsheet to track results of MBCx projects from information they collected from the campuses. The anticipated savings were included in the spreadsheet by downloading the data from the Partnership website. In this way, it was possible to compare actual savings to proposed savings for every MBCx project. This comparison spreadsheet was itself posted on the website.

In 2005, NAM added Microsoft Office Project tracking tool to the database to obtain greater functionality. In the 2006-08 program cycle, the website will track both proposed and measured savings. Key contacts suggested the website and database can benefit even further from continued incremental improvements in response to users' suggestions, with the Flex Your Power website mentioned as a model for the Partnership to emulate. More specifically, "the Flex Your Power type of marketing and communication" are desired for the Partnership.

4.2.2.6 Program Components

As mentioned earlier, the University Partnership program comprised three components: (1) building Retrofits, (2) monitoring-based commissioning, and (3) training and education. The following paragraphs present the key contacts' views of the performance and effectiveness of each of these three components.

Retrofit

According to one contact, "Retrofit is going to prove to be a real winner. In most cases it has proven to be exceptionally effective in delivering [energy] savings." Other contacts reported the savings from Retrofit projects have "exceeded goals by about 20%."

Although, not all of the Retrofit projects had been completed at the time of the interviews with key contacts, they expected almost all of the few remaining unfinished Retrofit projects to be completed by the program deadline of June 30, 2006.[8] The delayed projects were so for different reasons. One campus reportedly "had no energy manager to ramrod the project." Two projects were delayed by equipment procurement issues with vendors

[8] The last Retrofit projects were completed in the summer of 2006.

and contractors, which were not related to the program itself. However, most of the unfinished projects were delayed only because they had gotten a very late start.

The reasons for the late starts were twofold. A few of the original projects "fell out," and the funds allocated for them were reallocated to other projects "in November and December of 2005." Also in November 2005, PG&E allocated an additional $2 million for "large-scale, comprehensive, lighting Retrofits" in its service territory. In the absence of the disbanded Retrofit team, projects for the additional PG&E funding were identified by the MBCx team in December 2005, to be completed by June 2006.

More information about the Retrofit program component from the perspective of the campus staff who participated in it is presented in Section 4.2.3.

MBCx

MBCx was noted by the contacts as being a "tremendous success," with savings that "far exceeded expectations." Nonetheless, perhaps to no one's surprise, the MBCx projects were more problematic and experienced greater delays than the Retrofit projects, beginning with the initial delay, common to all program components, from the late signing of the master Partnership agreement. Additionally, as described in the interim report, there was initial uncertainty about the meaning of the term "monitoring-based commissioning," requiring time to reach a common understanding of its meaning.

Other factors reported to have slowed the MBCx projects included the time required to determine the eligibility of individual campus projects to participate in the program, and the inexperience of campus staffs with such projects. For example, the time required for, and the sequencing of, hiring commissioning agents, and ordering and receiving monitoring equipment were apparently unknown to most campus personnel. Other delaying factors included university bidding requirements, manpower limitations for meter installation, the lead time required to schedule building closures for meter installation, and the time required to learn to use new monitoring software.

The cumulative effect of the delays was summarized by one contact who said, "For new programs, you need to allow time both for development and implementation. We had 18 months of development and only six months for implementation." As a result of these delays, key contacts believed some of the MBCx projects were unlikely to be completed by the June 2006 deadline.[9]

Some of these delays can be minimized or avoided in the future by streamlining the process of identifying qualified projects. However, many of the delaying factors were part of the "huge learning curve" inherent in this entirely new approach to energy efficiency programs. Thus, it is encouraging that one utility contact reported, "Going

[9] Follow-up interviews through December 2006 revealed three MBCx projects had still not been completed. Unfinished work included meter installation, a program download and wet bulb installation, and a static pressure reset. Based upon the information provided by the campus managers for those projects, the evaluation team determined further interviews would provide no additional insight into program processes.

forward we should have many fewer problems. There was a lot learned, and we are ready." A university contact described the successful scaling of the MBCx learning curve by saying the program had "institutionalized a process the campuses hadn't thought of two years ago."

More information about the MBCx program component from the perspective of the campus staff who participated in it is presented in Section 4.2.4.

Training and Education

The Partnership's Training and Education (T&E) component was also described by the key contacts as "very successful". According to them, T&E exceeded its goals for numbers of classes and students. Nonetheless, both university and utility contacts reported attendance could have been higher. In fact, it was reported two classes were cancelled due to inadequate enrollment.

Attendance - Registration for the T&E courses was entirely on-line and paperless, and administered by a UC staff person through UC's Project Management Institute (PMI). Classes were held on various campuses of both systems and at utility energy resource centers. One contact reported it was learned "taking programs to campuses gets better results." However, according to another contact, attendance at campus locations was disappointing in that "staff from other campuses would not necessarily attend."

Attendance of CSU staff in particular was mentioned by contacts as being lower than attendance from UC staff at the courses.[10] However, both utility and university contacts explained this attendance difference as a function of lower staffing levels at CSU campuses than at UC campuses. These contacts were speaking of the numbers of operations, maintenance, and facilities staff available to take the courses, but CSU was also handicapped early on by a shortage of Partnership program staff. Furthermore, key staff observed CSU staff members were less experienced at hosting such events than their counterparts in the UC system. At the time of the interviews, CSU had responded to the staff shortage by hiring an additional staff person who is providing support in all of the program areas for 2006-08. In addition, NAM hired another staff person at the end of 2005 to provide support for the 2006-08 T&E component.

Additional staff support for the program will not by itself overcome an "institutional barrier" to attendance, however. That barrier is the limitation on staff time to attend the courses. To address that barrier, the T&E team looked at alternative offerings such as "shorter classes in really topical areas," and "training during campus staff meetings." Additional flexibility regarding attendance at the Building Operators Certification (BOC) courses presented through the Partnership was created by issuing coupons to campuses for tuition payments for individual courses in a series. With the coupons, a single campus staff person could attend an entire BOC Level I series, or different staff members could attend different courses in a series. The effectiveness of these approaches is a topic for future evaluations.

[10] For specific attendance figures, see the section entitled Course Attendance in Section 4.2.5.3 below.

Another suggestion to improve attendance was to enhance marketing of the courses on campuses both through the development of "campus champions," and recommendations from higher level staff on each campus to its lower level managerial staff, encouraging them to attend and have *their* staff attend as well. This approach will likely be explored in the 2006-08 program cycle.

Finally, one contact mentioned, "better north-south coordination" could improve attendance figures. The contact was referring to a tendency for courses in northern California, coordinated by the UC Office of the President, to be held on UC campuses, and for courses in southern California, coordinated by the CSU Chancellor's office, to be held on CSU campuses. As reported above, attendance at campus locations was disappointing in part because "staff from other campuses would not necessarily attend."

The program also faced a fundamental marketing problem. Information on the number of staff at the two university systems who were candidates for the Partnership's training courses was not readily available. So the extent to which T&E course attendance penetrated the market for the courses, and the size of the remaining pool of course candidates were unknown. Without specific knowledge of the number of prospective course participants, it will be difficult to fashion reliable expectations for course attendance.

Hiring and Paying Instructors - The allocation of T&E program responsibility was problematic for the T&E team throughout 2004-05, and may have continued to result in occasional difficulties. In attempting to distribute program responsibilities equitably among themselves, the IOUs allocated the responsibility for hiring teachers to PG&E, while allocating responsibility for payment of T&E invoices to SoCalGas.

Hiring the instructors reportedly occasioned delays in program delivery because "PG&E's contracting requirements are simply difficult." One consequence of these delays was a problem filling all of the courses in the fall of 2005.

Throughout 2004-05, the bifurcated responsibility also resulted in a "huge problem" in the payment of T&E invoices. It was reported the T&E team received no invoices for 2004-05 until 2006, making budget and expenditure tracking very difficult. To pay instructors, PG&E would issue checks, and be reimbursed by SoCalGas through an inter-utility transfer.

To address the payment problem in 2006-08, the T&E team has improved the process so that it is now working more effectively. However, the responsibilities for hiring instructors and for making program payments remained split, so the issues around hiring the instructors and the timeliness of program payments may need continued attention.

Sustainability Conferences - The annual Sustainability Conferences presented as part of the T&E activities were mentioned by the contacts as particularly successful in several ways. For example, the conferences provided a showcase for best practices at university campuses, with a competition and recognition of best practices. Attendance at the conferences was also mentioned positively, with more than 400 attendees each year. The high attendance figures provided an opportunity for broad dissemination of the best practices presented at the conferences, as well as an opportunity for networking with peers.

The Sustainability Conferences also contributed to the development of new courses for the program. For example, a course entitled "Selecting and Contracting the Right A&E Team" was offered by the Partnership in 2006 as an outgrowth of a conference presentation.

Further Potential - In addition to further program developments that may arise from the Sustainability Conferences, contacts mentioned the T&E component's potential as a conduit for more green building training. A contact also mentioned the T&E component as an important step toward meeting the universities' otherwise unfunded mandate to increase energy efficiency. However, in spite of the T&E component's recognized successes and potential, there remained some concerns about the program.

Ambivalence Toward T&E - Because the performance of the utility energy-efficiency-program portfolio is measured by energy savings, utilities were understandably less enthusiastic about programs for which such savings were difficult to measure. Interviews with key staff suggest this was true for the Partnership program as well. While key staff, and utility contacts in particular, were enthusiastic about all aspects of the program, there was an occasional hesitation or sense of tension in utility attitudes toward the MBCx and T&E components of the program. Preliminary results[11] and ongoing measurement of actual savings may overcome lingering reservations about the MBCx component.

With the T&E component in particular there was explicit ambivalence. For example, one utility contact underscored the importance of the T&E component to him by saying, "There needs to be a stronger tie between the training and the goals of the Partnership, training such as BOC and commissioning, for example. Campuses should not be able to apply for commissioning money unless their staff has attended commissioning training. The BOC should be a universal prerequisite for applying for all project funds."

However, other utility contacts seemed to want to like the program, but also seemed hesitant to embrace it fully. For example, one contact reported, "The benefits are fairly soft." And even though that contact said he had seen people take ideas from classes and work them into Retrofit or MBCx projects, he added, "There is the issue of what is the right mix."

Another utility contact spoke of the frustration of incurring a cost without an obvious benefit, necessitating picking up offsetting savings elsewhere. Nonetheless he added, "Still [T&E is] a pretty robust program."

To overcome reservations about the T&E component, it will be important to remain aware of this inherent bias, and to continue to look for ways to measure the program's

[11] Brown, et al, How Monitoring-Based Commissioning Contributes to Energy Efficiency for Commercial Buildings, 2006

impact on energy savings. Alternatively, as one utility contact suggested, "We need to rethink what sort of activities generate savings that count."

T&E Enhancements - A contact suggested the program could be improved by increasing the number of instructors from within the universities, and through the use of adult-learning methods rather than "conventional classroom lecture presentations." The contact continued, "The classes need interactive exercises and participant involvement to be effective."

Further information regarding the T&E program component from the perspective of the students can be found in Section 4.2.5.

4.2.2.7 Program Successes

Key contacts summarized the "best aspect" of the Partnership program in diverse ways. In addition to the obvious best aspect of energy savings, other "best aspects" mentioned included:

- Bringing the technical and administrative knowledge of the utilities and the universities together,
- The utilities getting to know their customers better,
- A higher awareness on campuses of energy inefficiencies,
- The development of a model of how to do a partnership,
- Obtaining a commitment to energy efficiency from higher levels of management at the utilities and the universities,
- The implementation of a more comprehensive approach to projects, allowing projects to be bundled to include some that might not have been done on their own,
- Cutting through the bureaucracies to accomplish something as new and complex as MBCx,
- Sharing of information about common problems with common solutions across campuses and across systems, and
- Providing targeted training for specific audiences.

Together these comments paint a positive picture of the T&E program, and suggest many of the ways in which the Partnership itself has been successful.

4.2.3 Retrofit Participant Project Staff Interviews

To obtain a more specific understanding of the performance of the Retrofit program, interviews with eight contacts for Retrofit projects from eight campuses were conducted. A contact at a ninth campus declined to be interviewed.[12] He reported he had been contacted too often about the program by too many different individuals, and the multitude of contacts was taking too much time from his job.

The eight interviewed project managers had engineering and/or energy manager titles. Their various Retrofit project roles included all aspects of project identification, application, and management. Four of the eight contacts had been interviewed about their Retrofit projects for the interim program report a year ago. The predecessors of two of the four remaining contacts had also been interviewed about their projects for that earlier report.

The eight campuses from which contacts were interviewed comprised four campuses from each of the university systems. Their Partnership Retrofit projects that were the subject of these interviews included installation of variable frequency drives (VFDs) for the fans in air handling systems, large-scale conversions of lighting fixtures to electronic ballasts and of lamps to T-8s, installation of lighting controls, installation of chiller optimization controllers, installation of swimming pool covers, and installation of laboratory-fume-hood occupancy sensors.

4.2.3.1 Overview

The eight contacts were unanimous in expressing the opinion the Partnership program was successful. When asked if the program provided any advantages over working directly with utilities to accomplish Retrofit projects, five of the eight contacts identified such advantages. Among these advantages were higher incentives (two mentions), funding at an amount that was certain rather than at a level “based on what the utility determined to be the energy savings,” and a longer time frame in which to complete projects. One contact also reported as an advantage the fact the Partnership “set up the application process for me.”

Three other intangible advantages mentioned by the contacts were the ability to bundle projects, allowing the inclusion of projects with a longer payback than could otherwise be done; peer pressure between campuses to participate and to do well; and a less combative or adversarial process than experienced with other utility programs. One contact reported the Partnership offered no advantages over working directly with the utilities.

Turning the preceding question on its head, Retrofit contacts were asked to identify disadvantages of the Partnership program relative to working directly with the utilities. Three contacts reported disadvantages. One reported disadvantage was the loss of direct communication with the utility resulting from the need to communicate through the management team. Because the team did not have representatives from every campus, this was a greater disadvantage for some campuses than for others. Two other reported disadvantages of the Partnership program were “more administrative delays,” and less clarity early on in regard to how much money was going to be available through the program.

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[12] This was a contact for a project at a CSU campus.

As was the case with the interviews for the interim evaluation, these contacts reported the best thing about the Partnership program was its funding. Specifically, the responses of six of the eight contacts expressed or implied funding was the best aspect of the program. For example, one of these contacts simply said "100% funding," while others offered comments which could be summarized as the opportunity provided by the funding to make improvements in campus energy efficiency, and the recognition for energy projects provided by the funding. A non-funding "best aspect" mentioned by one contact was the program-provided availability of the resources of the Chancellor's Office and the Partnership contractors.

Regarding program changes the contacts would like to see, one contact, in response to his experience with the program startup, suggested the program guidelines, processes, and procedures need to be clarified, documented, and shared with the campuses earlier. In keeping with the contacts' opinions that the best aspect of the program was its funding, two contacts suggested a change to the 2006-08 program cycle, saying the funding level should be the same per project as it was for the 2004-05 cycle.

4.2.3.2 Retrofit Project Changes

After formal project specification, changes were made to projects at three of the eight campuses from which contacts were interviewed. Of the three contacts who had project changes, the greatest changes occurred at a campus that had based its lighting controls project specifications upon a 1999 building survey that proved to be inaccurate in several respects. The survey included buildings that had been demolished, other buildings that were scheduled for demolition, and still other buildings in which lighting controls had already been installed. This resulted in the number of lighting sensors installed being diminished to roughly one third of the number in the original project description. Additionally, the sensors were installed only in portions of buildings rather than entire buildings, and only wall-mounted sensors were installed instead of some ceiling sensors as originally planned.

Even though the number of lighting controls was greatly reduced during project work, inaccuracies in the building survey regarding hazardous materials issues resulted in the proposed scope of work for the Retrofit projects on that campus being underestimated, and consequently, in underestimated project costs. To keep the project costs at the level proposed for the project, the scope of the project had to be reduced. This in turn, led to a significant reduction in the projects' energy savings estimates, which in turn, led to a reduction in the utility reimbursement for the projects. From this experience, that campus learned to "be much more cautious about developing the scope of work and cost estimates before submitting new projects."

The changes made to the other two projects were less drastic, but on one campus, still substantial. That campus eliminated occupancy sensor installation and delamping components from its project in order meet the program deadline. Those components accounted for roughly one half of the total project budget. That campus made a further change that had no impact on its project, substituting one building for another.

Changes to the Retrofit project on the third campus were relatively inconsequential, and included the use of a different brand of chiller equipment, the use of wall-mounted, lighting-control, occupancy sensors instead of ceiling sensors in some locations, the addition of "softer starts to lights with an electronic start ballast," and the expansion of the application of new chiller operation software to more units than originally proposed.

In sum, after initial specification, substantial changes were made to projects on two of the eight campuses from which staff were interviewed. Both of those situations suggest a need for better project scoping. The changes on one of these two campuses were program related, being made in order to complete the project by the program deadline. Other post-specification changes mentioned during these interviews were not program-related, or were relatively inconsequential.

4.2.3.3 Retrofit Project Installations

Project installation was straightforward at five of the eight campuses. That is, those installations encountered no unforeseen obstacles or unanticipated delays. Unexpected conditions were encountered during the installations of the projects at the three remaining campuses. For example, during a lighting Retrofit project, one campus encountered a building with lighting fixtures in a non-standard, six-foot length. According to the contact for that project, the ballasts had to be custom made to fit the fixtures. Furthermore, finding T-8 lamps in a six-foot length was reportedly difficult.

Another campus reported encountering deferred maintenance issues when preparing to install VFDs for air handling systems in older buildings. Specific problems included broken air dampers and simply "dirt." A delay resulted while additional funds were found and the deferred maintenance was done. In the future, that campus will approach such projects differently, delaying the purchase of the VFDs until any needed deferred maintenance nears completion.

The third campus was the one that had based its lighting-controls-project parameters upon the inaccurate building survey. As mentioned above, in addition to the other problems with that survey, during project installation, unforeseen hazardous materials issues also became apparent.

In addition to these installation difficulties, a minor installation glitch occurred on another campus. That was the placement of a few lighting occupancy sensors in locations where they could not "see" the rooms' occupants, necessitating the relocation of those sensors.

None of the difficulties encountered during the installation of these projects appears to have been program related. However, they do reinforce a need for careful assessment of project sites as part of project scoping.

4.2.3.4 Retrofit Project Results

All eight of the project managers reported they had originally hoped to obtain energy savings from participating in the Partnership Retrofit program. Other results they anticipated included saving money on the cost of equipment, energy, water, and swimming pool chemicals, and also included progress toward sustainability goals, reduced fan noise, increased efficiency of operations, and improved chiller efficiency.

For the most part, the actual results of these projects were reported to have met or exceeded their desired results. For example, one lighting project standardized fixtures, ballasts, and lamps throughout the campus. In addition to energy savings, this standardization reduced the kinds of replacement equipment that must be kept on hand, reducing purchasing costs and storage requirements, and simplifying lamp replacements. It was also reported that having only one type of light throughout a building improved the overall quality of the light in the building because "all of the lights are at the same temperature."

A reported additional benefit of one of the VFD installations was making a science building "less negative than it used to be." That is, before the project, the air handling system was set at such a high volume it caused outside doors to slam upon closing and created a noisy wind-tunnel effect in the building. This high setting was done to err on the side of caution in the evacuation of noxious and toxic fumes from the laboratories in the building. The new VFD and controls allow a more accurate adjustment of airflow, which has eliminated the door-slamming and wind-tunnel problems.

Another VFD project was reported to have had the unforeseen benefit of quieter start-ups in addition to energy savings and reduced airflow noise. According to the contact, the units' "soft starts" result in less belt slippage and consequent squealing noise. That contact believed the diminished belt slippage will also result in less wear, and therefore in less maintenance required for belt replacement.

Regarding another project, although it had not been possible to assess the energy-saving impact of the swimming pool covers by the time of the interview for that project (one of the boilers to heat the pools had been malfunctioning), it was believed the pool covers had already resulted in water savings through lowered evaporation, and in pool chemical savings from the diminished water use.

Three contacts reported there was a greater awareness of energy use and of conservation initiatives on their campuses as a result of the visibility of their projects (lighting occupancy sensors and swimming pool covers), and another contact reported his project provided an opportunity to work directly with the building occupants to raise their awareness of the energy-use implications of their behaviors.

Although one contact reported it was too early to be able to determine the results of his project (in addition to the contact who had not yet been able to determine energy savings resulting from the swimming pool covers), the remaining contacts' were very satisfied with their projects. The contact who seemed least satisfied with his project reported he would give it a "B" because it needs additional "tweaking" in order to perform optimally. Others made comments about the performance of their projects such as "better than imagined," "would do it again," and, "high satisfaction."

In summary, the Partnership Retrofit projects at campuses where staff were interviewed appear to have obtained the desired result of saving energy. In addition, the projects are reported to have provided better lighting, reduced building noise, reduced water use, increased maintenance efficiencies, and increased awareness of energy use and conservation among building users.

4.2.3.5 Program Administration

As occurred in the interviews for the interim program evaluation, the Retrofit project contacts again reported working with "varying numbers of people from campus to campus. [Typically] they worked with many other people, including their supervisors, people in other campus departments such as Purchasing, Environmental Health, or Design and Construction, the campus Energy Manager, campus electricians, representatives of the Chancellor's or President's offices, utility representatives, architects and engineers, and consultants."[13]

During these interviews, the contacts had little to say about the Retrofit program's administrative requirements. In part, this may have been because four of the eight contacts had assumed their roles with their projects after the projects had been approved, that is, after the project applications and initial payment requests had been submitted. Nonetheless, this absence of comments also suggests there were no significant obstacles or problems presented to these contacts by the program's administrative requirements.

The only negative comment made about the program's administration was in regard to a situation that occurred in the past, and that had already been improved according to that contact. The comment was in regard to the timing ("delayed") of the first project payments. That contact also mentioned subsequent payments had been "more or less on time." The minimal program difficulties reported by these contacts is also consistent with the responses of the Retrofit project contacts as discussed in the interim report, where it was stated "that at some point during the interviews with the campus representatives, those from four of the six campuses said they have had no difficulties with the program."

Utility involvement in the projects as described by the contacts included assistance with paperwork, project verification, and handling of payments. Some contacts reported utility involvement, particularly utility technical support, was not as evident through the Partnership program as it has been in other utility programs with which they were familiar.

4.2.3.6 Project Communication between Campuses

Campuses communicated with each other in several ways. UC held monthly energy manager's conference calls to discuss the projects that were being implemented through the Partnership, allowing campus energy managers to ask questions of one another and to discuss progress. CSU had quarterly meetings with the energy and utility managers' council. Feedback was provided on Partnership projects at these meetings. All but one of the eight campus contacts regularly participated in one or the other of those meetings, and the supervisor of the eighth contact also participated in the meetings.

There was also an annual joint energy manager's conference, where discussions and presentations on Partnership projects took place. That conference was held with all UC and CSU campuses. Additionally, there were "best practices" competitions for energy efficiency projects and programs. The winners of the competitions presented their projects at the annual Sustainability Conferences, and the presentations were posted on the Partnership website. The Green Building Research Center at UC Berkeley prepared case studies on the best practice winners.[14] Four of the eight contacts had attended Sustainability Conferences: three of them

[13] SBW Consulting, Inc., *Evaluation, Measurement and Verification (EM&V) Interim Report for UC/CSU/IOU Energy Efficiency Partnership,* March 1, 2005

[14] These best practices case studies may be found at http://greenbuildings.berkeley.edu/best_practices.htm.

attended the 2004 conference, and two attended the 2005 conference, including one respondent who attended both conferences.

In spite of these avenues for intercampus communication, the Retrofit project managers had little to say about projects on other campuses. The most elaborate response regarding what had been heard of other campuses' projects was, "Mostly good things. Everybody has difficulties getting projects going, purchasing difficulties, metering difficulties are common. The deadlines are extremely aggressive and difficult to meet."

The next most elaborate response to what had been heard about other projects was, "I haven't heard anything beyond what the projects were. Nothing about lessons learned, what worked or what didn't work." Surprisingly, given the communication opportunities detailed in the preceding paragraphs, the remaining contacts reported they had heard nothing about Partnership projects on other campuses.

The absence of intercampus project communication indicates a significant educational potential of the program remained unfulfilled. Specifically, other than the best practices showcased at the Sustainability Conferences, there seemed to be no exchange of lessons learned from the projects among the campuses. While best practices do offer valuable lessons, project difficulties, or even failures, can be equally instructive. The program would be enhanced in 2006-08 by the opening of effective intercampus communication channels for the exchange of lessons learned from the project experiences.

4.2.3.7 Contact Training and Education

Seven of the eight contacts reported they had taken training or education courses related to building operations during the previous year. Four of these seven contacts had taken courses through the Partnership's Training and Education component. Topics of non-Partnership training courses taken by these contacts included:

- Courses to become a certified energy manager (three mentions),
- The operation of central plants,
- Solar photovoltaic,
- Financing energy projects,
- The national electrical code,
- High and low voltage electrical safety, and
- LEED® for existing buildings through the U.S. Green Building Council.

Partnership courses taken by these contacts included:

- Monitoring Based Commissioning (two mentions),

- Commissioning Certification (two mentions),
- Exceeding 2005 Title 24 Energy Efficiency Standards,
- HVAC Design and Procurement Solutions for Energy Efficiency,
- Integrated Building Design, and
- LEED® for Project Managers.

All seven of the contacts who reported taking training during the previous year said the training was useful on the job. Of those contacts who reported taking multiple courses, the certified energy management training and the Partnership's Integrated Building Design courses were singled out as being the most useful. The former was mentioned because, "It's an integral part of my job." The latter was singled out because, "It provided practical information about insulation types and window films," rather than the "more ethereal" information presented in "some of the [other] courses" taken by that contact.

4.2.4 MBCx Participant Project Staff Interviews

Meeting the program deadline was more difficult for the Monitoring-Based Commissioning projects than it was for the Retrofit projects. The program schedule called for MBCx projects to begin in August 2004. However, due to a combination of factors, formal notification of project acceptance did not occur until January 2005.

Factors contributing to the delay in executing the MBCx projects included the Partnership program's complexity, which was previously described in this report. That complexity, along with the program's amorphous leadership structure and the unprecedented nature of the MBCx component of the program, made implementation of this program element much more difficult and time-consuming than was anticipated at the time the Partnership plan was developed.

An initial struggle with this program element was reaching agreement among the partners as to what "monitoring-based commissioning" meant. While the PIP refers to Texas A&M's Continuous Commissioning℠ program as a model for this program, different partners understood the application of the program in California in different ways. One understanding of continuous commissioning was periodic building commissioning using temporarily installed monitoring equipment. Another understanding of continuous commissioning required permanent installation of monitoring equipment to achieve continuous, real-time building tune-ups.

After a "couple of months," the latter view prevailed. Indeed, this was the approach the university systems, especially the UC system, had in mind when the PIP was written, leading to the adoption of the name "monitoring-based commissioning" for this program element. However, even late in the program implementation schedule, according to one respondent, "We don't have a shared understanding, but we do have a clearer understanding about what the money is being spent on." According to another respondent, the achievement of this limited understanding "was slowed by different attendees coming and going from meeting to meeting," a problem for early decision making in general, as discussed previously.

The greater complexity of commissioning projects themselves, compared to Retrofit projects, illuminates one of the difficulties of this ambitious collaboration. Although one key contact reported leadership was not an issue for the Retrofit program element, leadership does seem to have been an issue for MBCx. In this regard, a different key contact said, "[W]ho develops the projects? It has been, at times, the utilities need to help the campuses; at other times [the UC and CSU administrators] should do it; and at other times the campuses should do it. I don't think it was ever put in writing and it seems that everyone is helping, and that means no one is really in charge."

The time it took to address these unforeseen hurdles explains why the MBCx program ran behind schedule, and why not all of the MBCx projects were completed by the December 2005 deadline. Nonetheless, since the resolution of these differences and the adoption of co-chairs for the project implementation teams in summer 2004, key contacts believed great progress was made in the MBCx program, and that this program element moved forward at an appropriate pace.

To obtain a more specific understanding of the effects and effectiveness of the MBCx program, interviews with 20 contacts representing 24 MBCx projects comprising 33 buildings or central plants on 18 campuses were conducted. (For two of the campuses, the interviews were completed with two different contacts.) The interviewed project managers had engineering, construction manager, facilities manager, and/or energy manager titles. Their various MBCx project roles included all aspects of project identification, application, and management. The 18 campuses from which contacts were interviewed comprised seven campuses from the UC system and 11 from the CSU system. The MBCx projects that were the subject of these interviews included metering installation to provide continuous, real-time, building and system performance data, commissioning and retro-commissioning of both laboratory and non-laboratory buildings, and central plant installations and upgrades. Sixteen of the 18 campuses hired third-party commissioning agents to assist with their projects.

4.2.4.1 Overview

None of the 20 contacts had any reservations about the success of the Partnership program. When asked if the program provided advantages over working directly with utilities to accomplish their MBCx projects, the most commonly cited program advantage was assistance provided by, or resulting from, the Partnership itself (Table 4-12). Advantages mentioned included assistance in reviewing applications, in obtaining immediate "buy-in" from their own university administration, and in obtaining the attention of utilities. The next most commonly mentioned advantage was some aspect of the program funding, mentioned by seven contacts. Specific funding aspects mentioned included its larger amount than through utility programs, its availability for training, and its payment "up front" rather than after project completion. Other reported advantages over working directly with utilities were the training provided by the Partnership, greater cooperation with utilities than occurs when working directly through utility programs, the ability to combine campus projects in order to average project "paybacks" (an advantage also mentioned by Retrofit project contacts), the sharing of common experiences between university staff, and the program's focus upon the specific circumstances of universities.

Table 4-12: Partnership Advantages

ADVANTAGE*	UC	CSU	TOTAL
Partnership Entity	3	5	8
Funding	4	3	7
Training	4	--	4
Greater Utility Cooperation	3	--	3
Combining Projects	1	1	2
Sharing Common Experiences	2	--	2
University Specific Program	--	2	2

* Multiple responses allowed.

Responses regarding the "best aspect" of the Partnership echoed the descriptions of the Partnership's benefits. As was the case with Retrofit project contacts, MBCx contacts most often reported the best thing about the Partnership program was its funding (nine mentions). Five contacts reported the best aspects of the program were effects flowing from the creation of the Partnership, such as the collaboration of like-minded organizations and people, and the pressure to cooperate resulting from this collaboration. Other aspects of the Partnership mentioned once each as the best were the sharing of information, the ability to do multiple projects simultaneously, its training, and its focus on energy use.

Turning an earlier question on its head, the contacts were also asked to identify disadvantages of the Partnership program relative to working directly with utilities. Eight contacts reported there were no such disadvantages. However, disadvantages reported by other contacts included timeliness, fiscal-year-incompatibility, and bureaucracy issues. Addressing both program disadvantages and aspects of the Partnership in need of change, seven contacts mentioned issues of timeliness, including the need for faster project approvals, contracts, and payments. Another contact suggested it would have been helpful if the training had been held earlier in the process. Although it is not clear the fiscal cycles of utility energy efficiency programs correspond any more closely with those of California universities than does the Partnership's fiscal cycle, three contacts mentioned incompatibility with university fiscal years as a Partnership disadvantage or problem. Two contacts mentioned the Partnership has "more bureaucracy," than utility programs, with one of these two contacts specifying the Partnership's paperwork requirements as being more onerous than utility requirements.

4.2.4.2 MBCx Project Changes

Five contacts reported their MBCx projects changed from their original specifications. Of these five campuses, three reported substantial project changes. On two of these three campuses, the substantial changes were the elimination of a building from projects. One campus removed a building from a project because the building was found to have too many design flaws originating from its construction, and on the other campus a building was removed from a project simply for want of funds to do the MBCx work. The third campus with a substantial project change narrowed the scope of the work in a building from the entire building's 16 floors to the two floors served by the building's largest supply fans. The need to change that project was occasioned by a variety of problems: "20% to 30% leakage in 90% of the mixing boxes," inoperable dampers, and a shortage of campus staff, making it impossible to do the work in the entire building by the program deadline.

The contact for the fourth of these five campuses reported a change that might more properly be thought of as a *post hoc* adjustment. Specifically, the building's control parameters were changed from their as-designed settings in order to enhance the building's performance based upon its actual occupancy. The contact for the fifth campus reported some project changes, although he could not remember what the changes were, suggesting they were not of great significance.

As with the unanticipated situations encountered during the installation of Retrofit projects, none of the situations resulting in substantial changes to MBCx projects appears to have been program related. However, these situations again confirm a need for careful assessment of project sites and available resources as part of project scoping.

4.2.4.3 MBCx Project Expectations

Almost universally, the MBCx contacts expected their projects would result in energy savings, with a few of them also mentioning other expectations such as identification of building operation issues (two mentions), identification of maintenance issues, better use of limited staff to manage buildings, greater occupant comfort, staff training in building commissioning, and the development of a process to perform energy-saving work on other campus buildings.

4.2.4.4 MBCx Project Installations

Most, but not all, of the MBCx projects had been completed prior to the interviews. Incomplete projects included meters not yet installed on one campus, and on another campus, a small amount of work (less than $20,000) remaining to be done by an outside contractor. However, "complete" may be a relative term in this context. Seven contacts reported not all of the recommendations made by their commissioning agents had been implemented. All of these contacts comments were similar regarding the non-implemented measures, and were to the effect the "low hanging fruit" or "no- or low-cost" measures had been implemented, while more costly items such as damper or fan replacement, or other capital improvements, had been postponed indefinitely. However, to the extent the non-implemented recommendations can be characterized as Retrofit activities, it can be said the MBCx activities on those campuses were completed.

4.2.4.5 MBCx Project Results

Five of the contacts reported it was too soon for them to be able to say what the results of their MBCx projects were. The remaining contacts reported an array of positive results they had observed from their MBCx projects, with the most commonly reported benefit being improved occupant comfort. Nearly one half (eight) of the contacts mentioned this beneficial result, by which they meant improved safety and lower noise levels, as well as better temperature control (Table 4-13). Almost as many (seven) contacts reported observing energy or dollar savings resulting from their projects. Some specific comments describing these results included saving

"$135,000 to $140,000 per year on two buildings," cutting "25 percent off the building's kW consumption," and simply, "huge."

Table 4-13: MBCx Project Benefits

BENEFIT	COUNT	PERCENT (N=18)
Occupant Comfort	8	44%
Energy/Dollar Savings	7	39%
Improved Maintenance	6	33%
Too Early to Tell	5	28%
Diagnostic Improvements	3	17%
Other	6	33%

* Multiple responses allowed.

Maintenance improvements, meaning both reduced maintenance requirements (four mentions), and greater attention to maintenance (two additional mentions) were also reported as results of the MBCx projects. Three contacts reported improvements in diagnostic capabilities, ranging from a new ability to see and address problems earlier, to simply being more comfortable "reading computer data." Other reported beneficial results included learning more about campus building systems and equipment (two mentions), and mentioned once each:

- Requiring different campus staff to work together and to "think as a team,"
- Providing "a level platform for management and staff to talk with each other about building issues,"
- Providing "a solid basis for the next energy savings steps to be taken" on campus, and
- Reducing the "tyranny of the urgent."

4.2.4.6 Administrative and Internal Processes

Administrative difficulties encountered during the Partnership's start-up period were described in the interim evaluation report, and revisited earlier in this report. Given the complexities of the Partnership's new and unprecedented approach both to the delivery and to the substance of energy efficiency programs in California, the administrative processes for the MBCx program component were relatively trouble-free. The administrative aspects of the program were so unremarkable to eight of the 18 contacts that they had no comments about them. Of the comments that were made, most had already come up earlier such as payments were slow (four mentions), or the program had a late start resulting in a shortened time for project completion (three mentions), or there were other early application or paperwork difficulties (two mentions). The single new concern was the modest one that the required commissioning report was "lengthy."

Perhaps the most interesting insights offered by the MBCx contacts about administrative processes related to situations that arose internally at the contacts' own campuses. Five contacts reported internal administrative difficulties. For example, the purchasing department on one campus was reportedly confused about "how to accept the [Partnership] funds." On another campus, the contracting department reportedly had reservations about work being done on the project by an outside contractor who had not gone through the campus's competitive bid process. A contract dollar limit on a third campus required a new bid to be let in the middle of the work, disrupting the relationship with the contractor doing that work. A requirement on a fourth campus to take the low bid resulted in the purchase of meters from a vendor who lacked the knowledge to program them. The fifth contact who reported an internal problem was new to his job, and was unable to specify what that difficulty was.

Scheduling building closures was a problem on at least three campuses. The campus buildings involved with the MBCx projects were typically open and in use 24 hours per day, seven days per week. One contact who mentioned this scheduling difficulty added buildings on his campus are shut down (power, cooling and heating outages) for maintenance purposes twice per year, providing the opportunity to install meters. However, coordinating the project with this building schedule delayed the completion of the project.

4.2.4.7 Project Communication Between Campuses

As described in the Retrofit chapter above, communication between campuses occurred in several ways. UC held monthly energy managers' conference calls. CSU had quarterly meetings with the energy and utility managers' council. Feedback was provided on Partnership projects during these calls and meetings. There was also an annual joint energy manager's conference, with all UC and CSU campuses, where discussions and presentations on Partnership projects took place. Additionally, there were "best practices" competitions for energy efficiency projects and programs. The winners of the competitions presented their projects at annual Sustainability Conferences, and the presentations were posted on the Partnership website. Finally, those who attended training sessions had the opportunity to exchange project experiences with their peers at those sessions.

Comments by the contacts about intercampus communication, however, were limited, with the Sustainability Conferences most frequently mentioned. Ten of the 18 contacts had attended Sustainability Conferences: six of them attended the 2004 conference, and seven attended the 2005 conference, including three respondents who attended both conferences. Eight contacts mentioned participation in CSU's quarterly energy managers' conferences. Three contacts referred to UC's monthly conference calls, and one contact mentioned attending the annual joint conference. Two contacts mentioned training sessions as the source of their information about projects on other campuses.

However, MBCx contacts, similar to the Retrofit project managers, had little to say about projects on other campuses. One contact reported learning of two common campus problems which he described as simultaneous heating and cooling, and having multiple energy management systems and brands throughout a campus making monitoring difficult. However, beyond that response, comments suggest there was little exchange of substantive project information. Specific comments included, "Quarterly meetings are pep talks; there isn't much cross-pollination." Another contact reported there was no discussion of results, only of procedures, and in regard to their conversations with colleagues from other campuses, two other contacts reported there was "not really much detail" discussed, and the "information was cursory." The limited nature of intercampus communication about MBCx projects suggests an unfilled educational potential for the program.

4.2.4.8 Contact Training and Education

Two thirds (12 of 18 interviewed about training) of the MBCx contacts reported taking training during their projects that was useful in their project work. Of the 12 who took such training, 11 took a commissioning course through the Partnership's training and education component. Nine of the 11 contacts who took Partnership commissioning courses took the course entitled Monitoring-Based Commissioning and the other two took the week-long (five-day) commissioning course. The one contact who took project-related training, but did not take a Partnership commissioning course, reported taking a Johnson Controls class on computer use.

Of the six remaining contacts, most appear to have had sufficient commissioning training or experience prior to the Partnership's creation. In fact, one of these six contacts taught some of the Partnership's commissioning courses. Another reported being certified in commissioning as part of his engineering certification, and had served as the commissioning agent for the project on his campus. Among the remaining four contacts who took no training of any kind during that period, two were administrators who had taken over project management after their campuses' projects were underway, and both of whom sent a staff member to the Partnership's commissioning training. Another contact, with more than 25 years of experience in building operations, reported he had "ASHRAE down cold." The remaining contact, also with long experience in campus facilities management, had been on sick leave throughout most of the time his campus's project occurred. Consequently, he had taken no training during that time.

Thus, 12 contacts reported taking recent, project-related training, two others sent surrogates to such training, and three other contacts reported having sufficient experience not to need such training for their projects. Other recent training reported to have been useful by those who took training included "Labs 21," "Green Buildings for Project Managers," certified energy management training, commissioning training through the project commissioning agent, coursework in optimizing central plants, in HVAC systems, and in lighting, and "tidbits from energy managers' conferences."

4.2.5 T&E Participant Interviews

4.2.5.1 The T&E Team

To implement the third program element, a Partnership training and education (T&E) team was established to create and deliver it to campus facilities and construction staff. The Partnership T&E team included representatives from each of the four utilities, the two university systems, the managing consulting firm (GRA, followed by NAM), the California Institute for Energy and the Environment (CIEE), and the California Energy Commission's Public Interest Energy Research (PIER) program.

As discussed in the interim report, after some initial uncertainty about roles and responsibilities, common to and affecting all of the project teams, a system of co-chairs for each team was implemented. In December 2004, the Sustainability Specialist for the University of California, and the manager of PG&E's training center, the Pacific Energy Center (PEC) were appointed as co-chairs of the T&E team. Subcommittees of the T&E team were established to correspond to areas of curriculum interest, including a subcommittee to identify and publish a manual of best practices from the universities' Retrofit and MBCx projects. As mentioned previously, the Green Building Research Center at UC Berkeley prepared case studies on the best practice winners.

In order to maximize delivery of course curricula in the least amount of time, the T&E team drew upon existing programs and research in the development of its course offerings. For example, as reported in the New Buildings Institute's draft *Summary Report on UC/CSU/IOU Partnership Course Offerings Including PIER Materials Integration into Training and Education for Higher Education Campus Staff*, the New Buildings Institute (NBI), as the representative and manager of the PIER project, became a member of the T&E team, bringing PIER resources, training experience, team and instructor support, and additional funding for curriculum development to the group.

Other curriculum models, modified and adapted to meet the needs of the Partnership, came from the U.S. Department of Energy, the U.S. Green Building Council, and existing educational programs in California and Wisconsin.

The Partnership also co-sponsored two *Sustainability Conferences* at UC Santa Barbara in June 2004 and UC Santa Cruz in June 2005, and produced a preliminary *Kick-Off Workshop* with campuses to review in detail the program elements, campus roles, schedule, and deliverables. The events and courses were presented in various locations throughout the state. As described in greater detail below, total attendance for the partnership's T&E activities through 2005 was 1,768.

For two courses, Monitoring-Based Commissioning and Labs 21, the Partnership was able to supplement the instructors' classroom instruction with the participation of a university project manager who added first-hand, field experience. According to key staff, this proved an effective combination that increased course credibility and relevance for participants.

4.2.5.2 Course Descriptions

The Partnership offered an energy efficiency curriculum comprised of 14 courses and events. The first five of the following courses relied heavily upon PIER-developed content. These five courses were the subject of a web-based, evaluation survey described in a subsequent section of this report. More detailed course descriptions may be found in Appendix 6.5.

- *Exceeding 2005 Title 24 Energy Standards* was designed to assist campus project directors and project managers in implementing UC/CSU sustainability and energy efficiency goals in new construction projects.

- *Monitoring-Based Commissioning* was a two-day seminar presenting information on monitoring-based commissioning, the Partnership MBCx program guidelines and requirements.

- *A Project Manager's Guide to Energy Efficient Lighting* provided an overview of lighting design issues and various types of lighting equipment, and explored the trade-offs in long-term lighting system performance that may occur while balancing multiple goals of the lighting design.

- *A Project Manager's Guide to Building Controls and Energy Efficiency* was designed to present key issues for successful building control system procurement and commissioning.

- *HVAC Design and Procurement Solutions for Energy Efficiency* was designed to provide an overview of HVAC system types, commissioning, and controls procurement with a focus on key high level decisions that facilitate development of an energy efficient project.

The pre-existing statewide Building Operators Certification and Training program (BOC) was an energy efficiency program managed by the four California IOUs participating in the Partnership. The BOC curriculum was developed by the Northwest Energy Efficiency Council (NEEC), which has implemented the program for the four IOUs since the program's inception in California in 2002. For the Partnership, three of the BOC's Level I courses were adapted for university staff participants.

- *Energy Conservation Techniques (BOC 102)* helped operators gain a better understanding of how energy is used in commercial buildings and how to identify and prioritize conservation opportunities.

- *HVAC Systems and Controls (BOC103)* focused on the operation and maintenance of equipment and components typically found in commercial buildings, including central heating, cooling, air handling and ventilating systems in buildings.

- *Efficient Lighting Fundamentals (BOC 104)* covered types of lighting for economical and energy-efficient lighting systems.

The remaining courses and events included:

- *Commissioning for New Construction - Overview for Project Managers* was a one-day training for new construction project managers, focusing on the commissioning process for delivery of successful buildings and construction projects.

- *Commissioning Certification* was a five-day commissioning certification program.

- *Laboratories for the 21st Century: Managing High-Performance, Low-Energy Design (Labs 21)* introduced strategies for designing and constructing sustainable laboratories in both new and existing facilities.

- *Integrated Building Design* explored the concept of integrated building design as it relates to new construction projects.

- *LEED® for Project Managers* presented the process to successful implementation of green construction or LEED® certified buildings.

- *Sustainability Conferences*, held annually since 2002, were co-sponsored by the Partnership in 2004 and 2005. They explored ways to improve the design, operation, and maintenance of multiple building settings. The conferences highlighted best practices from UC, CSU and community college campuses in areas of greening campus operations.

4.2.5.3 Course Attendance

Total attendance at Partnership Training and Education courses and events exceeded 1,700 during the 2004-05 program cycle. Attendance of staff from the UC system was 779, and from the CSU system was 526 (Table 4-14). Other attendees included students and faculty members from both university systems, community college staff, utility staff, and staff from government agencies, and private business and industry.

The total attendance comprised 1,033 unique individuals. The largest group of attendees (407) consisted of staff from the UC system. Almost as many attendees (380) were university students, faculty or trustees, or were from other employers such as community colleges or other academic institutions, utilities, government agencies, or private business and industry. Ten percent (38) of the 380 "Other" attendees were utility staff or Partnership program consultants. Of the 81 university students, faculty, and trustees who attended partnership T&E events, all but three attended only the Sustainability Conferences.

Table 4-14: Course Attendance (2004-2005)

COURSE	UC	CSU	OTHER	TOTAL
Kick Off Workshop	33	36	21	90
Sustainability Conference I	73	28	123	224
Sustainability Conference II	154	55	186	395
Exceeding Title 24	67	16	25	108
Labs 21	104	31	18	153
Integrated Building Design	52	23	1	76
HVAC Design & Procurement	32	29	11	72
LEED® for Project Managers	73	12	16	101
Guide to Energy Efficient Lighting Design	28	8	5	41
BOC 102 (Energy Conservation Techniques)	18	82	9	109
BOC 103 (HVAC Systems and Controls)	22	89	10	121
BOC 104 (Efficient Lighting Fundamentals)	25	74	13	112
Commissioning for New Construction (1 Day)	14	8	0	22

COURSE	UC	CSU	OTHER	TOTAL
Commissioning Certification (5 Day)	26	13	0	39
Guide to Building Controls & Energy Efficiency	34	7	8	49
Monitoring-Based Commissioning	24	15	17	56
Total	779	526	463	1,768
Unique Individuals	407	246	380	1,033

Collectively, the 407 UC staff members who attended the courses were from all 10 campuses and the Office of the President (Table 4-15). These individuals attended 779 training courses and events. UC Davis provided the greatest number of staff: 81 people who attended 152 classes. The second greatest attendance from a single UC campus was from Berkeley, including Lawrence National Laboratory, with 58 individuals attending 103 classes. The Riverside campus sent the fewest staff to the courses, with nine staff attending 20 classes.

Table 4-15: UC Course Attendance (2004-2005)

UC CAMPUS (ALPHABETICALLY)	INDIVIDUALS	COURSES
Berkeley (Including LBNL)	58	103
Davis	81	152
Irvine	39	76
Los Angeles	41	72
Merced	11	19
Office of the President	32	94
Riverside	9	20
San Diego	33	54
San Francisco	22	44
Santa Barbara	40	69
Santa Cruz	41	76
Total	407	779

Similarly, attendance from the CSU system was also from every campus, and from the Chancellor's Office (Table 4-16). The greatest attendance from these campuses was from the Northridge campus. Fifty nine Northridge staff attended 146 classes. This was more than twice the number of staff and classes from the next well-represented CSU campus, San Luis Obispo, which sent 28 people to 57 classes. Bakersfield sent the fewest staff to the training (three individuals), while staff from the Channel Islands and Humboldt campuses took the fewest classes, a total of seven courses for the person from each campus, perhaps in part because of the relative difficulty their staff had reaching training locations.

Table 4-16: CSU Course Attendance (2004-2005)

CSU CAMPUS (ALPHABETICALLY)	INDIVIDUALS	COURSES
Bakersfield	3	9
Chancellor's Office	14	24
Channel Islands	6	7
Chico	6	8
Dominguez Hills	7	20
East Bay	7	14
Fresno	4	8
Fullerton	13	26
Humboldt	5	7
Long Beach	7	11
Los Angeles	7	12
Maritime Academy	5	13
Monterey Bay	9	21
Northridge	59	146
Pomona	8	10
Sacramento	8	20
San Bernardino	8	22
San Diego	5	8
San Francisco	6	15
San Jose	6	10
San Luis Obispo	28	57
San Marcos	10	26
Sonoma	9	23

CSU CAMPUS (ALPHABETICALLY)	INDIVIDUALS	COURSES
Stanislaus	6	9
Total	246	526

As a comparison of the two preceding tables shows, attendance from CSU campuses was generally lower than was attendance from UC campuses. Information as to the number of staff members at the two university systems who were candidates for these training courses was not readily available, so it was not possible to determine what portion of eligible staff from either system or from any particular campus attended the courses. However, as reported above in the section on the key staff interviews, the difference in overall attendance between the two systems was attributed to a combination of smaller numbers of operations and maintenance staff at CSU campuses available to attend the courses, fewer CSU Partnership staff to administer the T&E component for that university system, and less experience in hosting such events by CSU staff. Both CSU and NAM have hired additional staff to assist with the program.

4.2.5.4 Web-Based Training & Education Evaluation Survey

To assess the impact of the T&E component of the Partnership program on the university staff who attended the courses, we developed an on-line, web-based survey. The survey focused upon the five courses that had the most new content, that is, the five courses with the most content that had not been offered in California prior to this Partnership program. These five courses were:

- Exceeding 2005 Title 24 Energy Efficiency Standards
- Monitoring-Based Commissioning
- A Project Manager's Guide to Energy Efficient Lighting Design
- A Project Manager's Guide to Building Controls and Energy Efficiency
- HVAC Design and Procurement Solutions for Energy Efficiency.

Disposition and Respondent Characteristics

From the program administrator, we obtained a list of those who had attended any of the T&E offerings. The list contained the names of 1,033 unique individuals. We removed from this list the names of university administrators, faculty and students, attendees who were not employees of one of the two university systems, those who had not taken one of the five courses included in the web survey, and names with no recorded email address. This left a list of 175 attendees to whom the web survey was sent on June 1, 2006. Of these 175 staff, 85 completed the survey before the deadline of June 16 (Table 4-17). Of those who did not complete the survey, 20 responded they had no recollection of attending the classes, and 19 were staff for whom we had incorrect email addresses.

Table 4-17: Disposition of Evaluation Web-based Survey

DISPOSITION	COUNT	PERCENT
Completed	85	49%
Responded, Had Not Taken the Courses	20	11%
No Response	51	29%
Incorrect Email Addresses	19	11%
Total	175	100%

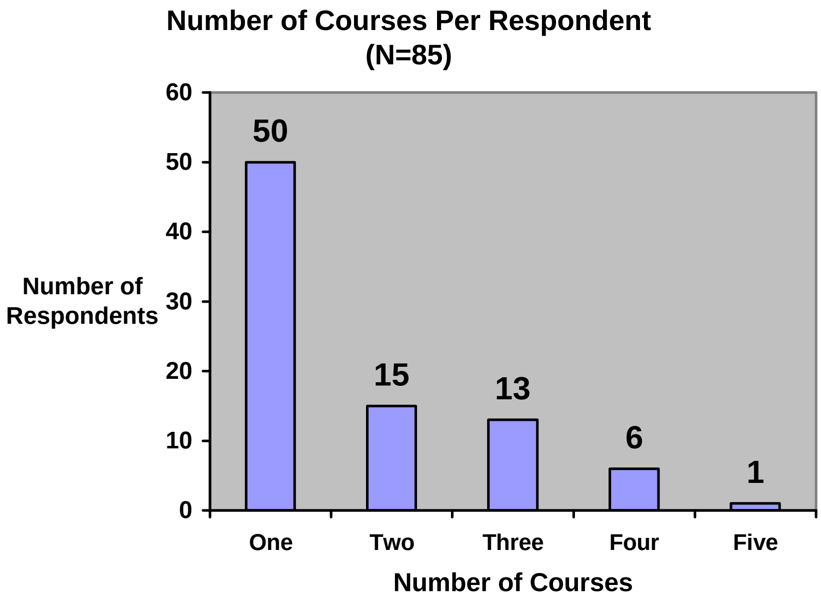
Collectively, the 85 respondents who had taken one or more of the five courses attended 147 classes. Because information about the number of individuals at the two university systems who were candidates for these training courses was not readily available, it was not possible to determine what portion of those who might benefit from the courses had taken them. The most well-attended course among these respondents was the Title 24 course, attended by roughly three fifths (59%) of the 85 respondents (Table 4-18). Attendance was smallest for the HVAC Design course, with 20% of the respondents indicating attendance.

Table 4-18: Course Attendance

CLASS	COUNT	PERCENT (N=85)
Title 24	50	59%
MBCx	31	36%
Lighting Design	28	33%
Building Controls	21	25%
HVAC Design	17	20%

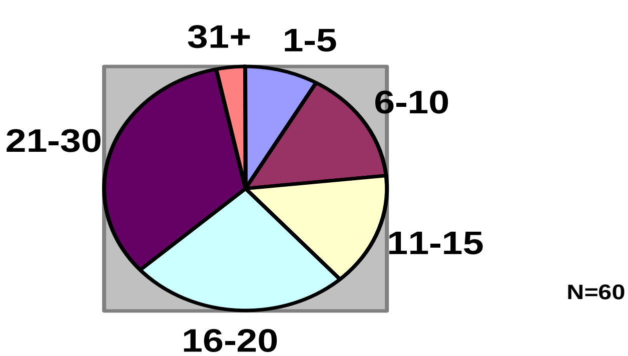
About three fifths (59%) of the respondents attended only one of the five surveyed courses (Figure 4-6). However, roughly one quarter (23%) of them attended three or more of the courses, with one respondent attending all five of them.

Figure 4-6: Number of Courses Attended per Respondent



The number of years the respondents had worked in building operations and maintenance ranged from none to 35 years. Roughly one tenth (11%) of the respondents had never worked in that field. Instead they were architects, designers, or project managers, or they were in planning or construction. An additional one fifth (19%) did not respond to this question. However, among the sixty remaining respondents, experience was generally high. Roughly one quarter (26%) of the respondents had worked in building operations and maintenance for more than 20 years (Figure 4-7). Less than one fifth (17%) had fewer than ten years of operations and maintenance experience. The average experience of these 60 respondents was more than 16 years, and the median was even higher at 18 years.

Figure 4-7: Years of O&M Experience per Respondent



The remainder of this chapter examines the students' responses to this survey.

Common Questions

Certain questions were common to the surveys for all five targeted courses. These questions were designed to determine the satisfaction of the attendees with the courses, and to gauge the appropriateness of the course content for the attendees. All of the surveyed attendees were also asked about additional training they would like to have.

Table 4-19 shows a comparison of the respondents' satisfaction with the five courses. The overall satisfaction of the respondents across all five of the surveyed courses was high. More than three quarters (76%) of them reported they were satisfied or very satisfied (a rating of "4" or "5" on a five-point scale) with the courses, with the highest percentages reporting satisfaction with the Building Controls and Lighting Design courses (81% and 89% respectively).

Four students (8%), reported dissatisfaction (a rating of "1" or "2") with Exceeding 2005 Title 24 Energy Efficiency Standards. However, their dissatisfaction was tempered by the fact that all three of the four dissatisfied respondents who answered a subsequent question regarding whether they would recommend the course to others with whom they worked, reported they would, in fact, recommend the course to their co-workers. One of them said, "It would be beneficial for our engineering group that monitors and communicates the campus HVAC system standards to the project consultants, to attend this course." No one reported dissatisfaction with any of the other four courses.

Table 4-19: Satisfaction with Courses

SATISFACTION	TITLE 24 (N=50)	MBCX (N=31)	LIGHTING DESIGN (N=28)	BUILDING CONTROLS (N=21)	HVAC (N=17)
Satisfied ("4" or "5")	76%	77%	89%	81%	76%
"3"	20%	23%	11%	19%	24%
Not Satisfied ("1" or "2")	8%	0%	0%	0%	0%

Regarding indicators of appropriateness of the course content for these attendees, Table 4-20 shows high numbers (82% to 90%) of respondents reported using the information from their respective classes in their jobs. Also, very high numbers (96% to 100%) of the respondents reported the classes were worthy of being recommended to others with whom they worked. Respondents who attended the Title 24 and Lighting courses most often reported they encountered difficulties putting the training into practice at their facilities. Roughly one third (36% and 30%, respectively) of the students from each course reported such difficulties.

Three of the 17 Title 24 respondents who encountered difficulty using their newly acquired knowledge elaborated on the reasons for their difficulty. One of them indicated he has to "battle value engineering." Another reported, "Our biggest roadblock is procurement. We tell them what we want, and they keep going to the same old contractors and suppliers." He suggested it would be helpful if their purchasing agents were required to attend the class. The third respondent explained most of the projects he works on "are laboratory renovations where Title 24 is difficult to apply," even though he "received very good information from the class."

Roughly one fifth (18%) of those who attended the HVAC course reported encountering difficulties putting the training into practice at their facilities. The one of these three respondents who explained his difficulties also reported difficulty in putting his Title 24 training into practice for the reason that his projects are mostly laboratory renovations. He said his “selection of new HVAC equipment is somewhat limited” by the nature of these projects.

One of the six MBCx respondents who reported encountering difficulties using the MBCx training at their facilities offered a possible explanation for his difficulty. His comments included, “It’s difficult to get backing from administrators. We’re out of money.” One of the four Building Controls respondents who reported difficulties putting their training into practice offered an explanation for his difficulty. He said, “… I don't have daily exposure to the campus building strategies. Also, campus politics…have been decidedly opposed to implementing LEED.” None of the Lighting Design respondents who encountering difficulties putting the training into practice offered a reason for this.

Table 4-20: Appropriateness of Course Content

INDICATOR	TITLE 24	MBCX	LIGHTING DESIGN	BUILDING CONTROLS	HVAC DESIGN
Used knowledge	85% (N=48)*	90% (N=31)*	89% (N=27)*	81% (N=21)*	82% (N=17)*
Would Recommend Course	96% (N=47)	97% (N=30)	100% (N=28)	100% (N=19)	100% (N=16)
Encountered Difficulties	36% (N=47)	19% (N=31)	30% (N=27)	19% (N=21)	18% (N=17)
Had Previous Training	32% (N=47)	30% (N=30)	46% (N=28)	50% (N=20)	63% (N=16)

*Some respondents did not complete the surveys.

The Title 24 attendee who reported he would not recommend the course to co-workers did not give a reason for this. The one MBCx respondent who reported he would not recommend the course to others with whom he works explained, “No one on campus does this but me.”

About one third (32%) of the Title 24 respondents had previously taken some other training on the topic. Of the 15 respondents who had previously taken such training, six reported the Partnership course offered new information, was more in-depth, or was simply “better.” Four others reported the Partnership training was similar to their earlier experience. The remaining Title 24 respondents were unresponsive.

Roughly one third (30%) of the MBCx students also reported having previously taken training in commissioning. Although one respondent commented the MBCx course was “very comprehensive,” and “more technical than some of the participants’ knowledge,” five of these nine respondents’ comments were to the effect the Partnership course was too rudimentary. Two respondents even suggested the course description should mention that it is for beginners. None of the other respondents who reported previous training in a topic made comparisons between their trainings.

Of the Lighting Design respondents who previously attended a course with the same subject matter, five commented the Partnership course was more current, more detailed, and/or more comprehensive than the previous trainings. Three respondents reported the Partnership course was similar in content to previous trainings, and one respondent reported the Partnership training was less comprehensive than his previous training.

As shown in Table 4-21, many of the respondents would like to have additional training related to energy efficiency in various areas. More specifically, roughly one half (ranging from 46% to 53%) of the respondents reported they would like additional training in LEED® requirements, HVAC systems, lighting, and/or controls. Besides naming two of the five surveyed courses (Title 24, and commissioning), other energy efficiency topics in which the respondents would like training included Labs 21, project management, equipment troubleshooting, building envelope modeling and performance, economic analysis of energy efficiency alternatives, green design and construction, daylighting, metering systems, and third-party power purchasing agreements.

Table 4-21: Desired Additional Training Topics

TRAINING	COUNT	PERCENT (N=85)
LEED® Requirements	45	53%
HVAC Systems	44	52%
Lighting	40	47%
Controls	39	46%
Building Operations	33	39%
Equipment Procurement	21	25%
Other	9	11%

The remaining survey questions were unique to particular courses, and designed to provide a deeper understanding of the effectiveness of those courses.

Exceeding 2005 Title 24 Energy Efficiency Standards

The survey included an additional question to measure the course's effectiveness in conveying a working understanding of Title 24. The question was framed in terms of the attendees' post-course confidence in their ability to implement the code's standards. According to the Title 24 respondents, the course provided the information most of them needed to give them confidence in their ability to exceed Title 24 standards in their next project. Roughly three fifths (58%) of the respondents indicated this (a rating of "4" or "5" on a five-point scale, Table 4-22). Less than one fifth (16%) indicated they still lack confidence in their ability to exceed Title 24 (a rating of

"1" or "2"). Two of these eight unsure respondents offered comments explaining their uncertainty. One felt a need for more practical suggestions for achieving energy savings, and the other works mostly on projects (laboratory renovations) where according to him, Title 24 is difficult to apply.

Table 4-22: Confidence in Ability to Exceed Title 24

CONFIDENCE	COUNT	PERCENT (N=50)
Confident ("4" or "5")	29	58%
"3"	13	26%
Not Confident ("1" or "2")	8	16%

The various respondents reported information they learned from the course made them feel more confident in their ability to exceed Title 24 requirements on their future projects. Most frequently mentioned was information that may be described simply as an awareness, or better awareness, of the code requirements. Roughly one quarter (28%) of the respondents responded in this way, including a subset of six respondents (12%) who mentioned more specifically, that information about changes to the code increased their confidence.

More specific, confidence-building information mentioned by the respondents included lighting requirements (two mentions), and mentioned once each, information about commissioning, insulation, controls systems, variable frequency drives (VFDs), chillers, carbon dioxide sensor placement, the importance of incorporating Title 24 requirements from the beginning of a project, and "new technologies."

Some Title 24 respondents offered suggestions for improving or augmenting the course. Suggestions included adding more practical examples or lessons learned (three mentions), adding unconventional or renewable energy information (two mentions), more electrical information, more LEED® information, including building Title 24 calculations, and adding a discussion of how Savings By Design criteria relate to Title 24 requirements. Four respondents mentioned it would be helpful to their efforts if others such as campus design engineers, campus procurement staff, and campus contractors attended this course.

Monitoring-Based Commissioning

More than four fifths (84%) of the MBCx course respondents reported they had a building or system that would soon be commissioned. Most of these buildings and systems to be commissioned were reported to have, or to be likely to have, thorough documentation, including a system diagram, a commissioning plan, and a systems manual. More specifically, one half (50%) of the pending commissioning projects already had a system diagram, and another one third (33%) of them were also expected to have a system diagram (Table 4-23). Roughly one quarter (23%) of the pending projects had a commissioning plan, and almost three fifths more (57%) were expected to have such a plan. Finally, about one third (30%) of the projects already had a systems manual, and an additional one half (53%) of these respondents reported they were also likely to develop a systems manual.

Table 4-23: Commissioning Document Availability (N=30)

DOCUMENT	HAVE	PERCENT	LIKELY TO HAVE	PERCENT	NOT LIKELY TO HAVE	PERCENT
System Diagram	15	50%	10	33%	0	0%
Commissioning Plan	7	23%	17	57%	1	3%
Systems Manual	9	30%	16	53%	0	0%

Since taking the MBCx course, roughly one half (47%) of the respondents had benchmarked their energy data. The most common benchmarking approach used by the respondents was averages, followed closely by the more reliable approach of normalized distributional ranking (Table 4-24).

Table 4-24: Benchmarking Approach

APPROACH	COUNT	PERCENT (N=14)
Averages	6	43%
Normalized Distributional Ranking	5	36%
Simple Distributional Ranking	1	7%
Medians	0	0%
Don't Know	2	14%

A Project Manager's Guide to Energy Efficient Lighting Design

Roughly one half (52%) of the Lighting Design course respondents reported they had purchased or installed premium T-8 lamps prior to the class (Table 4-25). Two fifths (four of ten) of the Lighting respondents who had purchased or installed T-8s since taking the course had not previously purchased or installed them. Roughly two thirds (64%) of the respondents reported they are likely to purchase or install T-8s in the future. The one respondent who said he is unlikely to purchase or install T-8s, commented his decisions are dictated by the design of the buildings in which he works.

About one third (32%) of the Lighting Design respondents reported purchasing or installing T-5 lamps prior to taking the class. Two thirds (six of nine) of the respondents who had purchased or installed T-5s since taking the class had not previously purchased or installed these items. Three fifths (60%) of the Lighting respondents reported they will purchase or install T-5s in the future. Only one of the three respondents who reported they are unlikely to purchase or install T-5s offered a reason, which was that the physical plant on his campus "does not stock or service these lamps."

Two fifths (40%) of the respondents had purchased or installed high-wattage compact fluorescent lights (CFLs) before taking the Lighting Design course. All of those who had purchased or installed such lamps since taking the course were among those who had previously purchased or installed the lamps. Roughly two thirds (64%) of the respondents reported they were likely to purchase or install high-wattage CFLs in the future. Of the four respondents who reported being unlikely to purchase or install such lamps, one was the respondent who was constrained by the design of his buildings. Another reported there were no applications for such lamps in his work. The third commented "there are better energy efficient choices." And the comment of the fourth respondent suggested he had not heard of high-wattage CFLs.

Table 4-25: Fluorescent Light Purchases and Installations

LAMP TYPE	BEFORE TRAINING	PERCENT	SINCE TRAINING	PERCENT	IN THE FUTURE	PERCENT	UNLIKELY	PERCENT
Premium T-8	13	52%	10	40%	16	64%	1	4%
T-5	8	32%	9	36%	15	60%	3	12%
High Watt CFL	10	40%	7	28%	16	64%	4	16%

*Multiple responses were allowed (N=25). Two respondents reported they had no involvement with lamp purchases or installations.

Four fifths (81%) of the Lighting Design course respondents had installed or purchased lighting occupancy sensors prior to taking the class (Table 4-26). Three of the 14 respondents who had purchased or installed occupancy sensors since the class had not previously purchased or installed such equipment. Roughly three fifths (58%) of the Lighting respondents expected to purchase or install occupancy sensors in the future. None of them reported they are unlikely to purchase or install such sensors.

About one half (54%) of the Lighting Design respondents had purchased or installed daylighting controls before taking the Lighting course. All of the four respondents who reported purchasing or installing such equipment since taking the course had also done so before taking the course. About two thirds (65%) of them said they expected to purchase or install daylighting controls in the future. One of the two respondents who reported he was unlikely to purchase or install daylighting controls was the design-constrained respondent mentioned previously. In fact, giving the same reason, that respondent reported being unlikely to purchase or install any lighting controls about which we asked, other than occupancy sensors. The other respondent who reported he was unlikely to purchase or install daylighting controls commented such controls were "unknown" to the staff at his campus.

About one third (35%) of the Lighting Design respondents reported the purchase or installation of networked lighting controls prior to taking the course. Two thirds (four of six) of those who had purchased or installed such equipment since taking the course, had no previous experience with networked controls. Roughly three quarters (73%) of the Lighting respondents indicated they were likely to purchase or install such controls in the future. The one respondent who said he was unlikely to install such controls was again the design-constrained individual.

Only about one tenth (12%) of the respondents in this group had purchased or installed a digital addressable lighting system prior to taking the Lighting course. The one respondent who had purchased or installed a digital system since the training had no previous experience with such systems. Roughly three fifths (62%) of the respondents reported they expected to purchase or install such a system in the future. Besides the design-constrained respondent, four others indicated they were unlikely to purchase or install a digital lighting system in the future. The three of those who offered explanatory comments mentioned a lack of knowledge about these systems, a lack of applications for such systems, and their cost.

Table 4-26: Lighting Control Purchases and Installations

CONTROL	BEFORE TRAINING	PERCENT	SINCE TRAINING	PERCENT	IN THE FUTURE	PERCENT	UNLIKELY	PERCENT
Occupancy Sensors	21	81%	14	54%	15	58%	0	0%
Daylighting Controls	14	54%	4	15%	17	65%	2	8%
Networked Controls	9	35%	6	23%	19	73%	1	4%
Digital System	3	12%	1	4%	16	62%	5	19%

Multiple responses were allowed (N=26). One respondent reported he had no involvement with lighting controls purchases or installations.

A Project Manager's Guide to Building Controls and Energy Efficiency

Two thirds (67%) of the Building Controls course respondents reported there were control system standards in place at their facilities (Table 4-27). Approximately one fifth (19%) more reported their facilities were likely to adopt such standards. Roughly one half (45%) of the respondents reported their facility had a master plan for building controls, with an additional one quarter of them reporting a master plan was likely to be adopted at their facility. All three of the respondents who reported their facility was not likely to adopt control system standards also reported it was unlikely a master plan for building controls would be adopted.

Table 4-27: Control Systems Policies

STATUS	SYSTEM STANDARDS	PERCENT (N=21)	MASTER PLAN	PERCENT (N=20)
Had in 2004	2	10%	2	10%
Have	12	57%	7	35%
Likely to Have	4	19%	5	25%
Not Likely to Have	3	14%	6	30%

Eleven Building Controls students (52%) reported they had purchased a direct-digital-controls (DDC) system in 2005 or 2006. Ten of these provided more detailed information about the systems they purchased. Of these ten, eight were proprietary systems, while the other two were more flexible, open-protocol systems (Table 4-28). The specifications for nine of these ten systems included an input/output (I/O) points list. The specifications for at least eight of the ten systems also included a detailed sequence of controls. The respondents with the two remaining systems reported they did not know whether this specification was included for their systems. Three of the ten respondents reported their DDC specifications included end-to-end time performance. Two others did not include such a specification, and the remaining five respondents did not know whether such a specification was included for their DDC systems.

Table 4-28: Direct Digital Control System Specifications

SPECIFICATION	COUNT	PERCENT (N=10)
I/O Points List	9	90%
Detailed Sequence of Controls	8	80%
End-to-End Time Performance	3	30%

Seven of the ten respondents who provided information about their new DDC systems reported the systems had been commissioned. For six of these seven commissioning projects, the control system designer took part in the commissioning, thus helping to assure the systems' control sequences were as designed.

HVAC Design and Procurement Solutions for Energy Efficiency

To further assess the effectiveness of this course, questions about life-cycle-cost analysis and types of controls were included. All but one respondent (94%) reported the course improved their ability to analyze the life-cycle cost of a new or replacement HVAC system (Table 4-29). This high percentage reporting improved analytic ability is particularly noteworthy in that more than three fifths (63%) of these respondents reported they had previously taken some HVAC training. Furthermore, the one respondent who reported the course did not improve his ability to analyze life-cycle costs, indicated in his response to a different question that he already possessed that ability before attending the class.

About four fifths (81%) of the respondents reported they were likely to specify digital controls when ordering a new HVAC control system.

Table 4-29: Value of HVAC Course Content

INDICATOR	COUNT	PERCENT (N=16)*
Improved Ability to Analyze Life-Cycle Cost	15	94%
Would Specify Digital Controls for HVAC	13	81%

*One respondent did not complete the HVAC survey.

In comparing the course to previous HVAC training they had taken, respondents reported the Partnership training was better in that it was more current, and that it included case studies (two mentions).

5. Conclusions and Recommendations

Our conclusions regarding program theories and cost-effectiveness are listed below. Also presented are recommendations that may be applicable to ongoing and future programs of this type.

5.1 Program Theory

We concluded that the Partnership program achieved one of its main goals, and had mixed results for the other.

1. **The Partnership program increased the rate of adoption for efficiency measures by the two university systems**. This theory seems to have been validated. Almost all of the Retrofit projects we examined occurred because the program provided higher levels of project funding than other utility programs. Similarly, nearly all of the MBCx projects were clearly a result of the program funding new types of O&M- oriented efficiency strategies, which at the time were not broadly supported by any other utility efficiency programs. Our freeridership analysis found that nearly 90% of the evaluated savings would not have occurred without the program. The Partnership also made the program visible to a higher level of management in the universities, resulting in a larger stream of campus projects. **Was goal achieved? YES**

2. **Greater availability of performance monitoring data leads to more energy efficient operation of the monitored buildings.** In general, MBCx project participants are looking forward to applying their ongoing monitoring capability in the future. It was not clear whether the program generated interest through MBCx workshops and other outreach, or it existed before. Clearly, the program provided resources to expand monitoring capabilities. A combination of enthusiastic users and these new resources may lead to this theory's validation. Nonetheless, we found some areas of concern. In some cases, the MBCx monitoring was only temporarily installed, precluding any long-term effort to monitor energy use. In other cases, the metering provided whole building data, which, while suitable for energy benchmarking, might not provide enough detail for in-depth diagnoses. We also felt substantial hurdles remain to this goal's long-term success, particularly with overstretched facility staff lacking the expertise or continuity to make good use of the data.

   Stated another way, the MBCx component consisted of three parts: (1) campuses implementing commissioning agent recommendations, yielding immediate savings, (2) campuses installing permanent metering, and (3) campus facility managers using this metering to optimize energy use in the future. To the program's credit, it provided the necessary resources and information to accomplish the first two parts. It is too early, however, to say if the last part can be achieved: that is, whether the new monitoring systems and campus resources for tapping these systems will be adequate to sustain the initial savings for many years.

   Was goal achieved? TOO SOON TO TELL

5.2 Program Cost-Effectiveness

Our quantitative analysis showed the Partnership program yielded cost-effective savings, although how and where this savings occurred was at times surprising. It is important to keep in mind, though, that because of evaluation sampling challenges, a fair amount of uncertainty exists around the evaluation estimates of program savings.

3. **Program appears to be cost-effective**. The program's overall evaluated TRC Ratio of 1.18 is very close to its original prediction of 1.20. The fact that the former value exceeds one indicates this analysis found the Partnership program to be cost-effective. Results varied between utilities, however. The program was particularly cost-effective for PG&E and SoCalGas, but not so for SCE and SDG&E.

4. **Retrofit projects often did not yield expected savings.** Many of the Retrofit projects suffered from inadequate scoping, inaccurate savings estimates, and poor execution. As a result, they yielded less than half of the energy savings they were expected to. In particular, HVAC controls projects underperformed, with variable speed drives and occupancy sensors not yielding the intended savings. Even relatively straightforward lighting projects were plagued by questionable assumptions about wattages and operating hours. The poor performance of Retrofit projects was a particular surprise, since these types of projects are fairly standard.

5. **MBCx projects, while often unpredictable, did produce projected savings overall.** By their very nature, it is difficult to predict the savings an MBCx project will produce. So not surprisingly, we observed wide variations between projected savings and realized savings, just as we saw wide variations in the quality and style of the projects. Because of the complexity of the changes that MBCx projects wrought, it was particularly challenging for us as evaluators to ascertain actual savings (this underscores the inherent difficulties commissioning agents face trying to document savings). We uncovered significant realized MBCx impacts that were not claimed by the program. In one example, the project suffered extreme delays and never produced necessary program documentation, but the project nonetheless produced verified energy savings. Despite it all, we found the portfolio of completed MBCx projects yielded substantial savings that were close to the original program goals.

6. **Spillover may be significant.** We found evidence that additional savings may yet come from measures identified in this program round that will be completed in the future. In many cases, campuses have already budgeted for this work. In addition, we uncovered situations where the initial MBCx investigation and implementation led to campuses finding other low-cost ways to reduce energy use. The overall impact of this so-called spillover is not known, but as one observed instance showed, it can be enormous.

5.3 Recommendations for Future Programs

Participants felt the Partnership was a successful new approach, which succeeded both in generating energy savings in the UC and CSU systems, and in modeling a complex, yet effective, statewide energy efficiency program with multiple partners. Further evidence of its success is the fact that the program was expanded and continued through the 2006-08 program cycle.

Nonetheless, the findings of this study point towards a number of ways that future programs of this type can be organized better, and develop more successful projects.

5.3.1 Program Organization

7. **Fine-tune roles of partners**: The partners were unequal in regard both to fiscal authority and assumed managerial authority (for example, the utilities controlled project funding). These imbalances should be addressed explicitly in the future to define them clearly for all partners, and to overcome concerns they have generated. Three design principles should be considered in formulating the structure of the program: (a) strong central leadership and facilitation, (b) continuity of staff participation for all partners, and (c) matching decision-making authority to the scope of responsibilities for each partnership committee.

8. **Streamline program procedures**: The program appeared to overcome early startup problems, including problems with timely payments to campuses, as well as a transition from the program's startup management consultant to a different management consultant. Nonetheless, program participants at all levels should continue to look for ways to obtain incremental improvements in program forms, project payment processes, and the program database and website.

9. **Prove the value of Training and Education**. Utilities are ambivalent about the program's T&E component. All partners should look for ways to measure the program's impact on energy savings, and give thought to alternative criteria for evaluating and validating T&E programs.

10. **Improve Training and Education, if it is desired**. Possible improvements might include increasing the number of in-house instructors, streamlining how these instructors are hired and paid, using more adult learning methods, targeting marketing efforts, better coordinating class locations and schedules, especially regarding the inclusion of community college staff, and removing attendance barriers (e.g., providing coupons to give staff flexibility in attendance).

11. **Provide more opportunities to exchange information and expand T&E participation**: In spite of the many avenues for intra-program communication, there seems to have been no exchange of lessons learned from the projects among the campuses. A venue or venues in addition to the Sustainability Conferences and existing communications, in which campus staff can exchange lessons learned, needs to be provided, and greater participation of community college staff needs to be sought.

5.3.2 Project Development

12. **Improve accounting of project savings**. The lack of centralized, studiously maintained program database with well-documented projects made verifying claimed program savings extremely difficult. Without proper accounting of project accomplishments,

estimates of the true impact of programs such as this one become highly uncertain. In general, we found campus staff and program administrators to be helpful and supportive of evaluation efforts. However, the long program duration, staff turnover, and lack of clear central authority proved problematic. With the start of the 2006-2008 Partnership program, attention seemed to be diverted, and the 2004-2005 program left to languish.

On a project level, savings documentation could benefit from more standardization and thoroughness. We frequently found poor savings documentation, especially for kW savings. We also had difficulty obtaining quality baseline data for MBCx projects, since pre-implementation metering was often substandard or missing. Even archived baseline data was often difficult to obtain in a timely manner.

13. **Provide participants with resources to facilitate estimating savings.** To follow on the previous recommendation, it would be beneficial to provide guidelines and resources to assist them. An example might be generic assumptions about operating hours for campus buildings, based on measured data that are specifically geared towards universities. Future programs might establish simple guidelines so project applicants and implementation teams can assess the impact, if any, on project savings from campus cogeneration, heating/cooling interaction, and measure interaction. They might also provide clear guidelines and engineering resources so participants can reliably "true up" their savings estimates after projects are complete.

14. **Ensure projects are sound**. Certain types of projects need more scrutiny as to how effective they are—for instance, Retrofit projects involving fume hood occupancy sensors. Also, variable speed drives, while a proven technology, must be applied judiciously to obtain cost-effective benefits (a conclusion also reached in other studies[15]). As noted in process findings, regular feedback on which projects were successful and which were not would help campuses develop their projects more effectively. Additionally, more careful assessments of project sites during scoping might help avoid costly and time-consuming project delays.

    Proper selection and conceptualization is necessary for MBCx projects as well. We heard cases of buildings being selected for monitoring, but then finding the building's systems were in such disrepair that commissioning was impossible until the major flaws were remedied. We also encountered projects where only temporary or whole building monitoring was installed. While this can be valuable, it falls short of the MBCx premise of permanent, in-depth monitoring resulting in long-term savings.

15. **Use MBCx to generate future projects**. The MBCx projects can provide substantial information about the condition of buildings and central plant energy systems. These can be an important source of future retrofit projects. Use MBCx as a gateway activity to define savings opportunities, in addition to a method for maintaining building/system performance over the long run. It is worth noting that often, the line between MBCx and

[15] Including the recently issued *Impact and Process Evaluation Final Report for QuEST's 2004-5 Building Tune-Up Program*

Retrofit projects is blurry. We observed MBCx projects that involved extensive capital improvements (converting a constant-volume system to VAV).

16. **Continue research on persistence of MBCx savings.** We feel, given what we know now, that 15-year effective useful life (EUL) for MBCx projects is very optimistic. We recommend conducting a persistence study in 2008 or 2009, which would examine the sampled projects, so we can learn how the MBCx concept is playing out, what the likely EUL value is, and what programmatic changes could be made to improve persistence.

17. **Provide ongoing resources to help campuses use monitoring.** We found the meters installed through the MBCx projects sometimes had little or no relation to the up-front commissioning recommendations. Nonetheless, campus staff members were enthusiastic about the new monitoring and looked forward to using it to diagnose problems. Yet it was apparent in some instances that the campuses would need ongoing resources and support to realize the promise of the MBCx concept. Facility operating personnel are often hamstrung by a lack of understanding of their systems, as well as burdened having to operate poorly-designed systems. They could benefit from expert guidance to augment their current capabilities, along with campus-, building- and system- specific training on how to utilize the new monitoring resources. It may be the case that additional permanent staff resources will be needed to fully meet the goal of ongoing analysis and corrective actions envisioned by this program's design. Future programs should consider integrating this sort of ongoing support in their design.

6. Appendices

6.1 Impact evaluation results for sampled projects

Table 6-1: Evaluated project-specific savings, realization rates, and NTGRs (unweighted)

				Documented gross savings			
End Use	Utility	ID	Description	kWh/year	Avg peak kW	therms/ year	MMBtu/ year
MBCx - Central	PG&E	63.01	UC Davis - Central Thermal Plant MBCx	3,010	-	56,541	5,664
MBCx - Central	SDG&E	30.01	CSU San Marcos - Chilled and Heating Hot watter	767,051	112.9	-	2,618
MBCx - Lab	SCG	58.01	UC Los Angeles - Factor Building MBCx	-	-	44,138	4,414
MBCx - Lab	SCE	32.02	UC Irvine - McGaugh Hall Labs/Classrooms	729,808	148.0	-	2,491
MBCx - NonLab	PG&E	37.01	UC Berkeley - Non-Laboratory Building, Soda Hall	1,125,657	69.0	95,365	13,378
MBCx - NonLab	SCG	31.01	UC Riverside - Riviera Library	-	-	64,410	6,441
MBCx - NonLab	SCG	31.03	UC Riverside - Science Library	-	-	42,326	4,233
MBCx - NonLab	PG&E	28.01	CSU Sonoma - #32 Schultz Info Center MBCx	454,586	39.0	-	1,552
HVAC	SCG	61.04	UC Riverside - Science Lab Fume Hood Occupancy Sensors	-	-	82,848	8,285
HVAC	SCG	61.02	UC Riverside - Boyce Hall Fume Hood Occupancy Sensors	-	-	59,475	5,948
HVAC	SDG&E	12.01	UC San Diego - Install VFD on supply and exhaust fans, rebalance zones	1,040,688	118.0	57,890	9,341
HVAC	SDG&E	12.03	UC San Diego - Install VFD on supply and exhaust fan, rebalance zones	699,048	80.0	56,230	8,009
HVAC	SCG	61.01	UC Riverside - Entomology Bld Fume Hood Ocupancy Sensors	-	-	23,003	2,300
HVAC	PG&E	15.01	CSU East Bay - Install VFDs on two main supply fans for main theatre (TH), Install VFDs on 6 fans systems serving gym.	187,920	52.2	-	641
HVAC	SCE	10.03	UC Santa Barbara - Install Trane chiller/tower optimization controller	481,092	207.0	-	1,642
Light	PG&E	23.03	CSU San Francisco - T12 to T8 conversion - HSS	203,442	58.0	-	694
Light	SDG&E	12.05	UC San Diego - Lighting retrofit - T-12 mag ballast to T-8	237,652	27.0	-	811
Light	PG&E	16.01	CSU San Luis Obispo - Lighting Retrofit	707,773	65.0	-	2,416
Light	SCE	10.01	UC Santa Barbara - Install occupancy sensors, ballasts, lamps in 450 toilet rooms	822,613	130.7	-	2,808
Light	PG&E	23.02	CSU San Francisco - T12 to T8 conversion - BUS	75,605	20.0	-	258
Light	SCE	18.11	CSU Long Beach - T12-T1/T5 Conversion with Occ Sensors (Bldg-84 NCL)	55,714	28.0	-	190
Misc	SCG	11.01	UC Los Angeles - Pool covers - 3 pools (19,320 sqft)	-	-	90,070	9,007
Misc	SCG	11.02	UC Los Angeles - Pool cover - 1 pool (6000 sqft)	-	-	23,470	2,347
Misc	SCG	11.03	UC Los Angeles - Pool cover - 1 pool (3,750 sqft)	-	-	17,910	1,791
Misc	PG&E	17.02	CSU Fresno - VFDs	162,279	8.9	-	554

	Evaluated gross savings				Realization rates				
ID	kWh/year	Avg peak kW	therms/ year	MMBtu/ year	kWh/year	Avg peak kW	therms/ year	MMBtu/ year	**Evaluated net-to-gross ratios***
63.01	-	-	20,745	2,075	0%	-	37%	37%	25%
30.01	488,787	-	-	1,668	64%	0%	-	64%	100%
58.01	-	-	43,217	4,322	-	-	98%	98%	0%
32.02	429,406	41.0	-	1,466	59%	28%	-	59%	67%
37.01	1,185,681	73.0	97,163	13,763	105%	106%	102%	103%	100%
31.01	-	-	129,232	12,923	-	-	201%	201%	80%
31.03	-	-	1,468	147	-	-	3%	3%	80%
28.01	609,177	75.0	-	2,079	134%	192%	-	134%	100%
61.04	-	-	3,040	304	-	-	4%	4%	88%
61.02	-	-	1,216	122	-	-	2%	2%	88%
12.01	127,545	14.6	-	435	12%	12%	0%	5%	0%
12.03	(121,671)	(13.9)	-	(415)	-17%	-17%	0%	-5%	80%
61.01	-	-	7,870	787	-	-	34%	34%	88%
15.01	45,462	9.3	2,783	433	24%	18%	-	68%	100%
10.03	704,431	51.7	-	2,404	146%	25%	-	146%	67%
23.03	96,899	11.2	(41)	327	48%	19%	-	47%	100%
12.05	165,965	18.9	-	566	70%	70%	-	70%	100%
16.01	54,039	6.3	(7)	184	8%	10%	-	8%	100%
10.01	500,016	87.5	(150)	1,692	61%	67%	-	60%	100%
23.02	230,374	19.6	(98)	776	305%	98%	-	301%	100%
18.11	46,825	8.9	(1)	160	84%	32%	-	84%	0%
11.01	-	-	60,041	6,004	-	-	67%	67%	100%
11.02	-	-	31,520	3,152	-	-	134%	134%	100%
11.03	-	-	25,576	2,558	-	-	143%	143%	100%
17.02	44,554	21.1	2,418	394	27%	237%	-	71%	0%

* The evaluation also included additional assessments of NTGRs for 17 MBCx projects (of all three end uses) beyond the nine listed here. The evaluated NTGRs for the 17 were uniformly 100%.

6.2 Net-to-gross analysis details for sampled projects

6.2.1 RETROFIT NTGR RESULTS

Four of the Retrofit projects were reported to be similar to projects done within the previous year on their respective campuses (Table 6-2). Two of the projects included the installation of VFDs, and a third reported a lighting project. The lighting project and one of the VFD installations were funded in part through utility rebate programs. The balance of the funding for those projects came from campus deferred-maintenance or operations-and-maintenance budgets. A piecemeal approach to upgrading lighting had occurred on a fifth campus (project #15). Other capital and maintenance projects that occurred on these campuses during the preceding two years included an array of new building construction projects, building remodels, deferred maintenance, seismic upgrades, and equipment upgrades. However, the contacts reported none of their Partnership projects were considered for inclusion with any of their campuses' capital or maintenance projects that occurred within the preceding two years.

Five contacts with eight projects reported "need" was the criterion for prioritizing capital and maintenance projects on their campuses. Typically, the underlying issues driving projects on those campuses were health and safety issues, or impairments to the function of the university (*e.g.,* road repairs). However, "need" also included accommodating an expanding student body. Two contacts representing five projects reported "energy savings and project payback" were the criteria for projects on their campuses. Based upon their stated criteria and their other responses, both of these contacts had projects deemed to have reduced net savings (projects #6 and #11, Table 6-4, below).

For twelve of the projects, the probability of occurring when they did without the program was given as zero. However, probability estimates for three of these projects at one campus were qualified by the contact who reported a probability of 50% that the project would be installed within four years based upon rising energy prices. For four other projects, respondents gauged the probability of their occurrence without the Partnership at between 25% and 100%.

Table 6-2: Probability of Retrofit Projects Occurring When They Did Without Program

ID NUMBER	DESCRIPTION	SIMILAR PROJECT IN PAST YEAR	CAMPUS CRITERIA	PROBABILITY
10.01	Occupancy sensors, ballasts, T8 lamps	Yes (Ballast and lamp retrofit in two buildings)	Energy savings/pay-back	25%
10.03	Install chiller optimization controller	No	Energy savings/pay-back	50%
11.01	Swimming pool cover	No	Need	0%
11.02	Swimming pool cover	No	Need	0%
11.03	Swimming pool cover	No	Need	0%
12.01	VFD on supply and exhaust fan, rebalance zones	Yes (HVAC deferred maintenance & VFD installation)	Energy savings/pay-back	100%
12.03	VFD on supply and exhaust fan, rebalance zones	Yes (HVAC deferred maintenance & VFD installation)	Energy savings/pay-back	0%
12.05	T12 magnetic ballasts to T8	Partial (Small piecemeal lighting projects)	Energy savings/pay-back	0%
15.01	VFDs on supply fans for main theatre & gym	No	Need	0%
16.01	Lighting controls	No	Need	0%
17.02	VFDs & HVAC fans	Yes (VFD upgrades)	Need	40%
18.11	T12 to T1/T5 conversions with occupancy sensors	Refused to be interviewed	NA	NA
23.02	T8 conversions	No	Need	0%
23.03	T8 conversions	No	Need	0%
61.01	Fume hood proximity sensors	No (Sensors installed as part of new construction	NA	0% (50% within four years)
61.02	Fume hood proximity sensors	No (Sensors installed as part of new construction)	NA	0% (50% within four years)
61.04	Fume hood proximity sensors	No (Sensors installed as part of new construction)	NA	0% (50% within four years)

To gain further insight into the probability estimates, contacts who responded with a percentage greater than zero were asked when they believed their projects would have occurred if they had not been done through the Partnership program. To this question, we received refined estimates ranging from “within the next year” to “over the next ten years,” (Table 6-3).

Table 6-3: Installation Timeline of Retrofit Projects Without Program

ID NUMBER	DESCRIPTION	TIMELINE
10.01	Occupancy sensors, ballasts, T8 lamps	During routine maintenance over 10 years
10.03	Install chiller optimization controller	Within three years
12.01	VFD on supply and exhaust fan, rebalance zones	This (program) year
12.03	VFD on supply and exhaust fan, rebalance zones	Within five years
17.02	VFDs & HVAC fans	Within the next year
61.01	Fume hood proximity sensors	50% within four years
61.02	Fume hood proximity sensors	50% within four years
61.04	Fume hood proximity sensors	50% within four years

Based on the responses to this set of questions, we calculated that 100% of the energy savings from projects reported to have a zero probability of occurring when they did without the Partnership could be attributed to the program (NTG=1, Table 6-4). This approach was also used for any project which was reported to be likely to occur within a time horizon of five years or more without the Partnership, including a lighting project on a campus where a similar project had occurred within the previous year (project #4). Using this logic, the two projects (#11 and #55) reported to be likely to have occurred independently within 12 months of their installation through the Partnership program, had none of their energy savings attributed to the program (NTG=0).

For the project which was reported to be likely to have occurred within three years without the Partnership, two thirds of the savings were attributed to the program. And for the projects that were reported to have a 50% probability of occurring within four years, seven eighths of their energy savings were attributed to the program.

Table 6-4: Percentage of Retrofit Project Savings Attributed to Program

ID NUMBER	DESCRIPTION	PARTNERSHIP ENERGY SAVINGS	NTG
10.01	Occupancy sensors, ballasts, T8 lamps	100%	1
10.03	Install chiller optimization controller	67%	.67
11.01	Swimming pool cover	100%	1
11.02	Swimming pool cover	100%	1
11.03	Swimming pool cover	100%	1
12.01	VFD on supply and exhaust fan, rebalance zones	0%	0
12.03	VFD on supply and exhaust fan, rebalance zones	80%	.80
12.05	T12 magnetic ballasts to T8	100%	1
15.01	VFDs on supply fans for main theatre & gym	100%	1
16.01	Lighting controls	100%	1
17.02	VFDs & HVAC fans	0%	0
23.02	T8 conversions	100%	1
23.03	T8 conversions	100%	1
61.01	Fume hood proximity sensors	88%	.88
61.02	Fume hood proximity sensors	88%	.88
61.04	Fume hood proximity sensors	88%	.88

6.2.2 MBCX RESULTS

The work involved in three MBCx projects comprising five buildings on three campuses was reported to be similar to work done for other projects on those campuses within the previous year (Table 6-5). However, the other reported activities that were similar to the Partnership activities on four of these five buildings were reported to have been “simpler” or “smaller in scope” than the Partnership MBCx activities.

Funding for the similar work at one of these campuses occurred as part of a new building’s construction. The Partnership activities were not considered for inclusion with that construction work. On another campus, operating funds paid for the similar project. The MBCx work done through the Partnership on one of the two buildings that were part of that campus’s project was considered for inclusion with that similar project. However, at the time the similar project was done, the Partnership MBCx work was not a high enough priority relative to “other fires to put out.” It is notable that the criteria given for prioritizing that campus’s capital and maintenance projects was “least cost.” On the third campus, the “similar work” was a Partnership MBCx project on a non-lab building.

Other capital and maintenance projects that occurred on these campuses during the previous two years included an array of new building construction projects, “major” building retrofits, a chiller replacement, infrastructure installations for future buildings, and lighting upgrades. However, the contacts reported none of their Partnership projects were considered for inclusion with any of their campuses’ capital or maintenance projects that occurred within the preceding two years.

Eleven contacts, representing eleven projects, reported “need” as the principal criterion for prioritizing capital and maintenance projects on their campuses, with need sometimes described as “life and safety issues,” “squeaky wheel,” “cold and broken,” and campus or student population growth. One contact representing two projects reported energy consumption as the driving criterion for capital projects on his campus, and another contact representing two projects reported “payback.” One contact reported least cost as the principal criterion. Four contacts representing six projects were unable to articulate the criteria used by their campuses to prioritize building and maintenance projects.

Table 6-5: Probability of Identical MBCx Project Timeline without Program

ID NUMBER	DESCRIPTION	SIMILAR PROJECT IN PAST YEAR	CAMPUS CRITERIA	PROBABILITY
28.01	Non-laboratory	Yes	"Squeaky wheel"	0%
30.01	Central plant	No	Broken; payback; politics	10%
31.01	Non-laboratory (two buildings)	Yes, but simpler	Student population growth	5%
32.02	Dense laboratory & non-laboratory	No	Campus growth; failures; age; energy efficiency	40%
33.02	Light laboratory & dense laboratory	Yes but smaller scope	Least cost	0%
36.01	Dense laboratory	No	Life/safety & maintenance needs	0%
37.01	Non-laboratory & dense laboratory	No	Life/safety & short payback	0%
38.01	Non-laboratory & dense laboratory	No	Energy consumption; maintenance needs	0%
40.01	Dense laboratory & central plant	No	DK	0%
65.01	Non-laboratory	No	Payback	0%
56.01	Central plant	No	Need & funding availability	4%
57.02	Dense laboratory	Yes (Non-lab building through Partnership)	Need & funding availability	0%
58.01	Dense laboratory	DK	DK	DK
60.01	Non-laboratory	No	DK	0%
60.02	Non-laboratory	No	DK	0%
63.01	Central plant	No	Energy consumption; maintenance needs	75%
64.01	Light laboratory	No	Payback	0%
52.01	Non-laboratory (three+ buildings)	No	"Cold or broken"	0%
44.01	Non-laboratory	No	Life/safety; energy efficiency; comfort	0%
51.01	Central plant	No	DK	0%

ID NUMBER	DESCRIPTION	SIMILAR PROJECT IN PAST YEAR	CAMPUS CRITERIA	PROBABILITY
50.01	Non-laboratory	No	DK	0%

For 16 of the 22 projects, the probability of occurring when they did without the program was given as zero. Three other projects were given low probabilities of four percent, five percent, and ten percent, and two others were given probabilities of 40 percent and 75 percent. For the remaining project, the contact was unable to estimate the probability of its occurrence without the Partnership program. To gain further insight into the probability estimates, contacts who responded with a percentage greater than zero were asked when they believed their projects would have occurred if they had not been done through the Partnership program. To this question, we received refined estimates ranging from “within two to three years” to “in 15 years,” (Table 6-6).

Table 6-6: Installation Timeline of MBCx Projects Without Program

ID NUMBER	DESCRIPTION	TIMELINE
30.01	Central plant	Ten years
31.01	Non-laboratory (two buildings)	Three to five years
32.02	Dense laboratory & non-laboratory	Three to four years
56.01	Central plant	15 years
63.01	Central plant	Two to three years

Based on the responses to this set of questions, we calculated that 100% of the energy savings from projects reported to have a zero probability of occurring when they did without the Partnership could be attributed to the program (NTG=1, Table 6-7). This approach was also used for any project which was reported to be likely to occur within a time horizon of five years or more without the Partnership. Using this logic, for the project that was reported to be likely to have occurred within two to three years without the Partnership (#320), one quarter of the savings were attributed to the program. For the project reported to have a probability of occurring within three to four years, two thirds of its energy savings were attributed to the program. And for the project reported to have a probability of occurring within three to five years, four fifths of its energy savings were attributed to the program.

Table 6-7: Percentage of MBCx Project Savings Attributed to Program

ID NUMBER	DESCRIPTION	PARTNERSHIP ENERGY SAVINGS	NTG
28.01	Non-laboratory	100%	1
30.01	Central plant	100%	1
31.01	Non-laboratory (two buildings)	80%	.80
32.02	Dense laboratory & non-laboratory	67%	.67
33.02	Light laboratory & dense laboratory	100%	1
36.01	Dense laboratory	100%	1
37.01	Non-laboratory & dense laboratory	100%	1
38.01	Non-laboratory & dense laboratory	100%	1
40.01	Dense laboratory & central plant	100%	1
65.01	Non-laboratory	100%	1
56.01	Central plant	100%	1
57.02	Dense laboratory	100%	1
58.01	Dense laboratory	--	NA
60.01	Non-laboratory	100%	1
60.02	Non-laboratory	100%	1
63.01	Central plant	25%	.25
64.01	Light laboratory	100%	1
52.01	Non-laboratory (three+ buildings)	100%	1
44.01	Non-laboratory	100%	1
51.01	Central plant	100%	1
50.01	Non-laboratory	100%	1

6.3 Energy Impact Reporting Tables for CPUC

Table 6-8: PG&E Program Energy Impact Reporting for 2004-2005 Programs

PG&E Program Energy Impact Reporting for 2004-2005 Programs

Program ID*: 1461-04
Program Name: IOU/UC/CSU Partnership for Energy Efficiency

Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	13,781	-	2.376	-	351,371	-
2	2005	13,781	10,244	2.376	1.147	351,371	264,366
3	2006	13,781	10,244	2.376	1.147	351,371	264,366
4	2007	13,781	10,244	2.376	1.147	351,371	264,366
5	2008	13,781	10,244	2.376	1.147	351,371	264,366
6	2009	13,781	10,244	2.376	1.147	351,371	264,366
7	2010	13,781	10,244	2.376	1.147	351,371	264,366
8	2011	13,781	10,244	2.376	1.147	351,371	264,366
9	2012	13,781	10,244	2.376	1.147	351,371	264,366
10	2013	13,781	10,244	2.376	1.147	351,371	264,366
11	2014	13,781	10,244	2.376	1.147	351,371	264,366
12	2015	13,781	10,244	2.376	1.147	351,371	264,366
13	2016	13,781	10,244	2.376	1.147	351,371	264,366
14	2017	13,781	10,244	2.376	1.147	351,371	264,366
15	2018	13,781	10,244	2.376	1.147	351,371	264,366
16	2019	13,781	10,244	2.376	1.147	351,371	264,366
17	2020	-	10,244	-	1.147	-	264,366
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	2004-2023	220,501	163,901			5,621,936	4,229,853

*Form completed for the PG&E program ID included in the evaluation.
**Definition of Peak MW as used in this evaluation: Average kW reduction during the period Monday-Friday 12 p.m. - 7 p.m., during the months of June through September (consistent with the CPUC Energy Efficiency Policy Manual, Version 2).
1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Table 6-9: SCE Program Energy Impact Reporting for 2004-2005 Programs

SCE Program Energy Impact Reporting for 2004-2005 Programs

Program ID*: 1324-04
Program Name: IOU/UC/CSU Partnership for Energy Efficiency

Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	14,182	-	2.364	-	-	-
2	2005	14,182	4,913	2.364	0.544	-	-
3	2006	14,182	4,913	2.364	0.544	-	-
4	2007	14,182	4,913	2.364	0.544	-	-
5	2008	14,182	4,913	2.364	0.544	-	-
6	2009	14,182	4,913	2.364	0.544	-	-
7	2010	14,182	4,913	2.364	0.544	-	-
8	2011	14,182	4,913	2.364	0.544	-	-
9	2012	14,182	4,913	2.364	0.544	-	-
10	2013	14,182	4,913	2.364	0.544	-	-
11	2014	14,182	4,913	2.364	0.544	-	-
12	2015	14,182	4,913	2.364	0.544	-	-
13	2016	14,182	4,913	2.364	0.544	-	-
14	2017	14,182	4,913	2.364	0.544	-	-
15	2018	14,182	4,913	2.364	0.544	-	-
16	2019	14,182	4,913	2.364	0.544	-	-
17	2020	-	4,913	-	0.544	-	-
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	**2004-2023**	226,907	78,609			-	-

* Form completed for the SCE program ID included in the evaluation.
**Definition of Peak MW as used in this evaluation: Average kW reduction during the period Monday-Friday 12 p.m. - 7 p.m., during the months of June through September (consistent with the CPUC Energy Efficiency Policy Manual, Version 2).
1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Table 6-10: SCG Program Energy Impact Reporting for 2004-2005 Programs

SCG Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	1475-04								
Program Name:	IOU/UC/CSU Partnership for Energy Efficiency								
	Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Peak MW Savings**	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
	1	2004	-	-	-	-	560,932	-
	2	2005	-	-	-	-	560,932	544,659
	3	2006	-	-	-	-	560,932	544,659
	4	2007	-	-	-	-	560,932	544,659
	5	2008	-	-	-	-	560,932	544,659
	6	2009	-	-	-	-	560,932	544,659
	7	2010	-	-	-	-	560,932	544,659
	8	2011	-	-	-	-	560,932	544,659
	9	2012	-	-	-	-	560,932	544,659
	10	2013	-	-	-	-	560,932	544,659
	11	2014	-	-	-	-	560,932	544,659
	12	2015	-	-	-	-	560,932	544,659
	13	2016	-	-	-	-	560,932	544,659
	14	2017	-	-	-	-	560,932	544,659
	15	2018	-	-	-	-	560,932	544,659
	16	2019	-	-	-	-	560,932	544,659
	17	2020	-	-	-	-	-	544,659
	18	2021	-	-	-	-	-	-
	19	2022	-	-	-	-	-	-
	20	2023	-	-	-	-	-	-
	TOTAL	2004-2023	-	-			8,974,912	8,714,542

*Form completed for the SCG program ID included in the evaluation.
**Definition of Peak MW as used in this evaluation: Average kW reduction during the period Monday-Friday 12 p.m. - 7 p.m., during the months of June through September (consistent with the CPUC Energy Efficiency Policy Manual, Version 2).
1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Table 6-11: SDG&E Program Energy Impact Reporting for 2004-2005 Programs

SDG&E Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	**1489-04**							
Program Name:	**IOU/UC/CSU Partnership for Energy Efficiency**							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings****	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004	5,772	-	0.751	-	193,310	-
	2	2005	5,772	3,501	0.751	0.256	193,310	63,245
	3	2006	5,772	3,501	0.751	0.256	193,310	63,245
	4	2007	5,772	3,501	0.751	0.256	193,310	63,245
	5	2008	5,772	3,501	0.751	0.256	193,310	63,245
	6	2009	5,772	3,501	0.751	0.256	193,310	63,245
	7	2010	5,772	3,501	0.751	0.256	193,310	63,245
	8	2011	5,772	3,501	0.751	0.256	193,310	63,245
	9	2012	5,772	3,501	0.751	0.256	193,310	63,245
	10	2013	5,772	3,501	0.751	0.256	193,310	63,245
	11	2014	5,772	3,501	0.751	0.256	193,310	63,245
	12	2015	5,772	3,501	0.751	0.256	193,310	63,245
	13	2016	5,772	3,501	0.751	0.256	193,310	63,245
	14	2017	5,772	3,501	0.751	0.256	193,310	63,245
	15	2018	5,772	3,501	0.751	0.256	193,310	63,245
	16	2019	5,772	3,501	0.751	0.256	193,310	63,245
	17	2020	-	3,501	-	0.256	-	63,245
	18	2021	-	-	-	-	-	-
	19	2022	-	-	-	-	-	-
	20	2023	-	-	-	-	-	-
	TOTAL	**2004-2023**	92,350	56,010			3,092,960	1,011,918

*Form completed for the SDG&E program ID included in the evaluation.
**Definition of Peak MW as used in this evaluation: Average kW reduction during the period Monday-Friday 12 p.m. - 7 p.m., during the months of June through September (consistent with the CPUC Energy Efficiency Policy Manual, Version 2).
1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

Table 6-12: Total Program Energy Impact Reporting for 2004-2005 Programs

Sum Of Energy Impacts for This 2004-2005 Program

Program IDs*: 1324-04; 1461-04; 1475-04; 1489-04
Program Name: IOU/UC/CSU Partnership for Energy Efficiency

Year	Calendar Year	Gross Program-Projected MWh Savings	Net Evaluation Confirmed Program MWh Savings	Gross Program-Projected Peak MW Savings	Evaluation Projected Peak MW Savings**	Gross Program-Projected Therm Savings	Net Evaluation Confirmed Program Therm Savings
1	2004	33,735	-	5.490	-	1,105,613	-
2	2005	33,735	18,657	5.490	1.948	1,105,613	872,270
3	2006	33,735	18,657	5.490	1.948	1,105,613	872,270
4	2007	33,735	18,657	5.490	1.948	1,105,613	872,270
5	2008	33,735	18,657	5.490	1.948	1,105,613	872,270
6	2009	33,735	18,657	5.490	1.948	1,105,613	872,270
7	2010	33,735	18,657	5.490	1.948	1,105,613	872,270
8	2011	33,735	18,657	5.490	1.948	1,105,613	872,270
9	2012	33,735	18,657	5.490	1.948	1,105,613	872,270
10	2013	33,735	18,657	5.490	1.948	1,105,613	872,270
11	2014	33,735	18,657	5.490	1.948	1,105,613	872,270
12	2015	33,735	18,657	5.490	1.948	1,105,613	872,270
13	2016	33,735	18,657	5.490	1.948	1,105,613	872,270
14	2017	33,735	18,657	5.490	1.948	1,105,613	872,270
15	2018	33,735	18,657	5.490	1.948	1,105,613	872,270
16	2019	33,735	18,657	5.490	1.948	1,105,613	872,270
17	2020	-	18,657	-	1.948	-	872,270
18	2021	-	-	-	-	-	-
19	2022	-	-	-	-	-	-
20	2023	-	-	-	-	-	-
TOTAL	2004-2023	539,757	298,520			17,689,808	13,956,313

*Form completed for the SCE, PG&E, SCG, and SDG&E program IDs included in the evaluation.
**Definition of Peak MW as used in this evaluation: Average kW reduction during the period Monday-Friday 12 p.m. - 7 p.m., during the months of June through September (consistent with the CPUC Energy Efficiency Policy Manual, Version 2).
1. Gross Program-Projected savings are those savings projected by the program before NTG adjustments.
2. Net Evaluation Confirmed savings are those documented via the evaluation and include the evaluation contractor's NTG adjustments.

6.4 Partnership Program Process Map

2004-05 UC/CSU/IOU Partnership Program Process Map Narrative

The following provides a narrative description of the UC/CSU/IOU Partnership program process map, reading from left to right.

The program was created through an RFP under the auspices of the California Public Utility Commission (CPUC). Program participants under the RFP were the four largest investor owned utilities (IOUs), the University of California (UC) and California State University (CSU) systems, and a program management contractor. Program management and delivery occurs through “teams.”

An executive team, comprising the energy efficiency directors from each of the partner utilities, the energy managers from the UC Office of the President and the CSU Chancellor’s Office, and staff from the program management contractor, oversees the entire program, ensuring budgets and savings goals are met. The executive team made the original funding allocation decision, and approved the campus allocations. The executive team also coordinates CPUC activities, and resolves issues presented by the management team to which program administration is delegated.

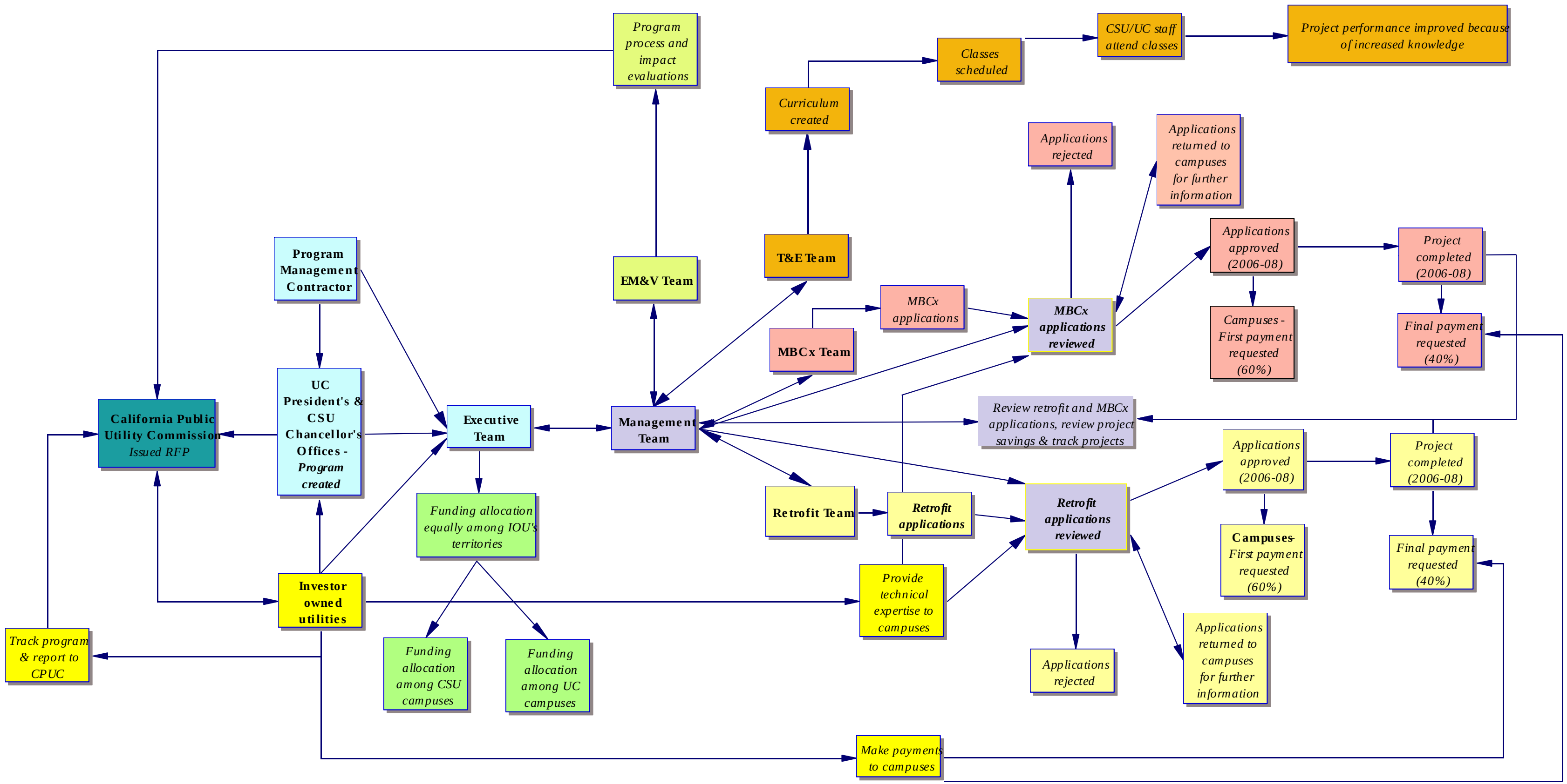
The function of the management team has been to establish the administrative structures needed to implement the program, oversee program administration (budgeting, timekeeping, invoicing, contract administration, reviewing and tracking project savings) in the three program areas, ensure timely and accurate CPUC reports, approve the hiring of subcontractors, and resolve issues presented by the program implementation teams. The management team also provides the final review of Retrofit and MBCx applications.

Four program implementation teams, a Retrofit team, a MBCx team, and a T&E team, representing the three program areas, and an evaluation, measuring, and verification (EM&V) team, identify and implement key tasks consistent with budgets, identify major risks and how those risks will be managed, conduct procurement processes, and recommend subcontractors and vendors to the management team. Team specific tasks include, for the MBCx and Retrofit teams, conducting campus needs assessments and providing the first review of program applications, for the T&E team, developing the training and education curricula and class schedule for delivery to the campuses, and for the EM&V team, conducting program process and impact evaluations to be filed with the CPUC.

The IOUs, through their team members, provide technical expertise to the campuses, particularly during the project application review process.

Upon approval of a project application, campuses were eligible to receive 60 percent of their project funding from their utility, with the balance being payable upon project completion.

Figure 6-1: Partnership Process Map



6.5 Partnership T&E Course Descriptions

Exceeding 2005 Title 24 Energy Standards was designed to assist campus project directors and project managers in implementing UC/CSU sustainability and energy efficiency goals in new construction projects. The course looked at California's Title 24 energy efficiency standards and identifies energy efficiency strategies to exceed the standards. The course also examined how Title 24 relates to the statewide new construction incentive program (Savings by Design), and the US Green Building Council's LEED® rating system. Code compliance issues, including the mandatory measures that all buildings must adhere to, were presented as they relate to lighting, mechanical and envelope systems.

HVAC Design and Procurement Solutions for Energy Efficiency was designed for project managers who work on medium to large capital projects. The course provided an overview of HVAC system types, commissioning, and controls procurement with a focus on key high level decisions that facilitate development of an energy efficient project. The program included case studies from UC and other school campuses.

Monitoring-Based Commissioning was designed for campus energy managers, facility managers, plant managers, campus engineers, campus construction inspectors, and others who implement monitoring-based commissioning projects. This two-day seminar presented information on monitoring-based commissioning including basic concepts, case study information, and UC/CSU/IOU Partnership Monitoring-Based Commissioning program guidelines and requirements.

A Project Manager's Guide to Building Controls and Energy Efficiency was designed for UC and CSU capital-programs project managers to present key issues for successful building control system procurement and commissioning. The course provided an overview of direct digital control systems with an emphasis on how to achieve a successful project. Through the use of case studies, the course presented a cost-effective process to procure controls from design through commissioning.

A Project Manager's Guide to Energy Efficient Lighting explored the trade-offs in long-term lighting system performance that may occur while balancing multiple goals of the lighting design, including providing a high level of efficiency, addressing the visual needs of occupants, creating an aesthetically pleasing environment, and meeting budget requirements. The course provided an overview of lighting design issues and various types of lighting equipment, and presented specific solutions for several space types, with a focus on how to steer the project toward effective and energy-efficient lighting.

Building Operators Certification - The pre-existing statewide Building Operators Certification and Training program (BOC) is an energy efficiency program managed by the four California IOUs participating in the Partnership. The BOC curriculum was developed by the Northwest Energy Efficiency Council (NEEC), which has implemented the program for the four IOUs since the program's inception in California in 2002. For the Partnership, three of the BOC's Level I courses were adapted for university staff participants.

BOC 102 – Energy Conservation Techniques helped operators gain a better understanding of how energy is used in commercial buildings and how to identify and prioritize conservation opportunities. The course included basic principles of energy accounting, evaluation of fuel options, operation and maintenance strategies to improve efficiency, and energy management planning techniques.

BOC 103 - HVAC Systems and Controls (2-Day) focused on the operation and maintenance of equipment and components typically found in commercial buildings, including central heating, cooling, air handling and ventilating systems in buildings. The course provided an introduction to automatic control systems and equipment, particularly for central air systems. Emphasis was placed on group problem solving and exercises with respect to preventive maintenance.

BOC 104 – Efficient Lighting Fundamentals covered types of lighting for economical and energy-efficient lighting systems. Participants learned principles of efficient lighting including evaluation of lighting levels, lighting quality, and maintenance. Other topics included lighting fixture and control technologies, common upgrades, Retrofit and redesign options, and management strategies as they apply to space use and function.

Commissioning for New Construction - Overview for Project Managers - This one-day training was targeted at new construction project managers and focused on the commissioning process for delivery of successful buildings and construction projects. This training covered commissioning activities throughout the commissioning process, emphasizing best practices and available guidelines. Information on commissioning costs and benefits was presented, along with the distinction between the commissioning process for new and for existing buildings. Interactive class activities included developing project intent, reviewing commissioning plan, and participating in a design review. This one-day training session was the first day of a five-day commissioning certification program developed by the University of Wisconsin - Madison.

Commissioning Certification was a five-day commissioning certification program originally developed by the University of Wisconsin - Madison. It was created for building owners, facility managers, commissioning authorities, and all members of the design and construction team. This course presented hands-on opportunities to learn the fundamentals of this effective method for whole building design, green buildings, and rehab or additions. It offered tools and techniques to incorporate full-quality project management from pre-design through the life of the facility. The course covered commissioning activities throughout the commissioning process, emphasizing best practices and available guidelines, and guides the students through the commissioning requirements of the LEED® Green Building Rating System. Interactive class activities were included throughout the five-day training. The course culminated with an examination to become an accredited commissioning process provider.

Laboratories for the 21st Century: Managing High-Performance, Low-Energy Design was based upon a program created and sponsored by the US Department of Energy (DOE) and Environmental Protection Agency (EPA). The Partnership offering of the program introduced strategies for designing and constructing sustainable laboratories in both new and existing facilities. While designed as an introductory course, students familiar with sustainable laboratory design were also invited to attend and contribute to the discussion. Seasoned laboratory designers, energy managers, and facilities professionals taught this full-day course.

Integrated Building Design - This course was also based upon a program of the DOE. The course as presented for university project managers, explored the concept of integrated building design as it relates to new construction projects. Participants were shown how building-envelope, design decisions regarding insulation, roofing, glazing, and shading could be integrated into a project to create comfortable and energy-efficient indoor environments that reduce electrical lighting and HVAC loads.

LEED® for Project Managers was based upon an interactive seminar developed by the US Green Building Council. It presented the process to successful implementation of green construction or LEED® certified buildings. A procurement checklist was provided to help track the consideration and inclusion of sustainable principles on a case project. Topics included: commitment, budgeting, programming, consultant selection, design, construction and operations. For each topic, additional information was provided on an annotated checklist.

Sustainability Conferences - Held annually since 2002, these two-day conferences were co-sponsored by the Partnership in 2004 and 2005. They explored ways to improve the design, operation, and maintenance of multiple building settings. Conference workshops examined best-practice examples of how to design buildings to minimize energy use in the provision of comfortable indoor environments, to provide high-quality low-energy lighting, and to provide other energy services efficiently. They provided an overview of California campuses as integrated systems and promoted opportunities to monitor and optimize these systems, saving not only the up-front cost of equipment, but the ongoing expenditure of energy over the lifetime of new buildings. The conferences highlighted best practices from UC, CSU and community college campuses in many areas of greening campus operations.

6.6 Implementer Comments on Draft Report with Evaluator Responses

2004-05 UC/CSU/IOU EE Partnership Draft Final EM&V Report
Partnership Comments – 12/10/07

A great deal of thought and analysis clearly went into the draft 2004-05 UC/CSU/IOU Energy Efficiency Partnership Impact and Process Evaluation Final Report. The comments contained herein, contributed by the Partnership team, highlight general areas of concern as well as provide representative, detailed project-level comments for some projects. By their nature, these comments focus on Partnership exceptions to the reported results and suggest areas where further analysis, refined assumptions or alternative approaches may be warranted. General comments are presented first, followed by Retrofit specific comments and then MBCx specific comments.

Evaluator Response (dated 12/20/07): *We appreciate the effort the Partnership team made to provide us with meaningful comments, particularly in light of the limited time they had to review a large body of material. The evaluation team carefully reviewed and discussed each comment. When necessary, we referred back to original source materials to understand the issue fully, and to assess whether changes or adjustments to the evaluation analyses and/or report were necessary.*

Generally, we found that the reviewers offered up thoughtful perspectives and observations, and we found several instances where we felt it appropriate to make changes or corrections to the analysis based on their points. In a few other cases, we revised the report write-up to better explain our points. The table below summarizes the disposition of each comment. In total, the changes we propose to make are expected to have fairly small effects on the evaluation results.

COMMENT	DISPOSITION*
General comments	
1	No inconsistency found, but we enhanced write-up of findings to be clearer.
2	No problems found, but we enhanced write-up of findings to be clearer.
3	**<u>Restored fan electric savings for projects</u>**. Added further discussion of cogen issue.
4	**<u>Provided final calculation and enhanced relative error write-up</u>.**
5	No change necessary.
6	Made minor changes to text.
Retrofit project-specific comments	
1 a, b, c	**<u>Adjusted savings to correct minor discrepancies.</u>**
2 a, b	**<u>Adjusted savings to correct minor discrepancies.</u>**
3 a, b	**<u>Adjusted savings for specific project to account for cogen</u>**. No other changes necessary.
4 a, b, c	No changes necessary.
5 a, b	**<u>Adjusted savings to correct minor discrepancies.</u>**
6 a	Made minor changes to project-specific report.
MBCx project-specific comments	
1	No change necessary.
2	No changes appear necessary, but we will review calculations again to confirm that the proper approach for calculating kW reduction was applied.
3	No change necessary.
4	Made minor changes to project-specific report.
5	Made minor changes to project-specific report.
6	**<u>Adjusted kW savings for Tan Hall</u>**. No other changes necessary.
7	No change necessary.

* Changes that materially affected the quantified evaluation results are highlighted in **<u>bold underline</u>**.

GENERAL COMMENTS:

1. Energy Efficient Building Operations. One of the stated key findings that, "The other main goal, of achieving more energy efficient building operation through increased performance monitoring, is still uncertain" (p. 2) seems inconsistent with the evaluator's own conclusions about the success of the MBCx program component and the qualitative observations of program participants and stakeholders.

Evaluator Response: *We do not feel that the key finding mentioned above is inconsistent with the generally positive feelings about MBCx or the fact that the MBCx component exceeded its savings goals. The MBCx component consisted, in essence, of three parts: (1) campuses implementing commissioning agent recommendations, yielding immediate savings, (2a) campuses installing permanent metering, and (2b) campus facility managers using this metering to optimize energy use in the future. Parts (1) and (2a) were accomplished successfully, and for that, the program deserves kudos. It is too early, however, to say with certainty whether campuses will be able to use the metering (Part 2b) effectively so that the savings from (2a) are sustained for many years.*

2. Documented Savings Database and Realization Rates. For the overall program, the evaluators created their own database for "documented" savings, which consisted of the "best available" numbers for any given project (and in some cases was different from the Partnership, and/or IOU's claimed savings). The realization rates (evaluated savings divided by documented savings) were then determined against this evaluator created number for the sample project set and applied to the evaluator documented savings number for the entire population. This approach creates an inherent inconsistency relative to what the Utilities reported to the CPUC and the very thing that realization is intended to measure. Realization rates should have been determined against the program's "claimed" savings. Among other problems created by the approach, the program's "claimed" savings already omitted savings for projects known to have unrealized savings. To the degree that these projects are in the sample set, it results in an underestimate of the true realization rate. This problem materially affects the MBCx program component realization rate. Please see additional detailed comments and examples under MBCx project specific comments below.

Evaluator Response: *Ideally, we would have received a final program tracking database that clearly listed each project, its disposition, and the final savings claim associated with it. These project claims, in turn, would have added up to the overall utility savings claims reflected in the final quarterly report posted on the EEGA website. Unfortunately, we found no such tracking database, nor were we able to reconcile the detailed project documentation we requested from the utilities with their claims. An additional complication sprang from the fact that our sampling protocol relied on projects being classified by end use (as they were early in the program), so that we could cleanly extrapolate our sample results to the population. No such end use classification existed in the final program accounting, so we had to create it to complete our evaluation properly. From a statistical standpoint, it would have been impossible to extrapolate our sample results to the population using the program claimed savings.*

We thus made our best effort, given the evidence we were provided with, to consistently and accurately categorize the disposition and savings for all projects. When we found clear evidence that the program had developed a project that led to energy-saving actions (such as MBCx Projects 31.01 and 31.03, which are alluded to in the comment), we included the project in our database. Conversely, projects where the paper trail suggested that no tangible energy impacts resulted (such as projects that were cancelled because the Cx agent could not identify sufficient savings potential) were not included.

Given the major flaws in the program savings data we received, we felt our approach of essentially creating the program tracking database for the program yielded the most precise estimate of evaluated program savings that could be hoped for under the circumstances. We are keenly aware, though, that the confusion around what the program should be claiming introduced uncertainty into our evaluation *results. That is why a key recommendation of this study is to improve accounting of project savings centrally.*

3. Cogeneration. The approach taken regarding campuses with cogeneration is unclear (p.19). This paragraph states the challenge, but stops short of describing the methodology applied when determining evaluated savings. The site specific EM&V reports appear to convert electric savings at campuses with significant cogeneration into equivalent natural gas savings. The Partnership Program tracked these as electricity savings at all campuses except UCLA, where there was no IOU electric utility. The Partnership approach was consistent with the utility policy which allows electric incentives to be paid at campuses with cogeneration, provided that the electricity savings are less than the net electricity the campus purchases from the utility. In all of the campuses with cogeneration the campuses purchase significant amounts of electricity, so the savings are accounted for by the utilities as electricity. The EM&V approach does not align with this policy.

***Evaluator Response**: We will elaborate more on our approach in the report, so that it is clearer. Our general approach was to determine the actual effects, regardless of any policy assumptions, of the combination of the efficiency project and the campus cogeneration system on the utility billing meters serving the campus. As it turned out, cogen only materially affected two projects, each of which is described below. Also, because the realized savings at UCSD were small, accounting for cogen as we did only had a small effect on the overall evaluation results.*

At UCLA (Project 58.01), the situation was clear, because our evaluation confirmed the program's assumption that electric savings at the building level translated directly into gas savings at the campus level.

At UCSD (Projects 12.01 and 12.03), the energy effects are murkier and more complex. On this campus, 80% of all chilled water for cooling comes from steam-driven chillers, with 20% coming from electric chillers recharging TES at night (likely using cogenerated electricity). If cogen operation is driven by electrical production, then one could argue that the cooling is essentially "free" – that is, the waste heat from electrical production, rather than being exhausted, is being harnessed to generate chilled water. If the Retrofit project reduces the cooling load, then the load on the steam chiller decreases. The steam that would have run the chiller then just gets exhausted through a cooling tower instead. Whether or not the nominal electric savings are less than the campus purchase is immaterial here: the water is chilled indirectly by steam, which comes from burning gas, so utility-supplied electricity really does not enter into the picture for cooling. The same general argument can be made for the heating hot water supply.

How to account for electric savings associated with HVAC fans is admittedly harder to discern at UCSD. Given that, we feel comfortable restoring the electric savings associated with the fans, but believe that the savings associated with chilled and hot water impacts at this site should remain zero.

4. Relative Error. Pages 30-31 state: "Overall, our sample covered about half of total documented MBCx energy savings and over two-thirds of documented Retrofit energy savings, for 58% of the overall energy savings. Their respective relative error levels at the 90% confidence interval were ±64% and ±32%, respectively." The paragraph goes on to state that: "…latecomer projects increased the relative error of our estimates of total program savings." These seem like large uncertainties at a 90% confidence level, particularly if they are lower than what is believed to be the actual ranges given additional projects. A footnote states that these were preliminary numbers – were final numbers calculated? With this level of uncertainty it is difficult to truly asses the program's impact and perhaps the discussion of such uncertainty should be included in the key findings.

Evaluator Response: *We did complete final calculations of relative error around the evaluation savings.* ~~*The relative error levels at the 90% confidence interval were ±135% for the MBCx sample and ±67% for the Retrofit sample, so that the overall relative error was 114%. We revised the report to discuss the reasons for this high relative error. Essentially, the first reason boils down to the large amount of variance among the savings results, within a small sample. The second reason is that using a certainty stratum to reduce the variation for the sample did not work here. This occurred because the certainty selections based on early ex ante savings estimates ended up accounting for a much smaller fraction of the savings than we had hoped, partly because project scopes changed and other projects were added later. The necessity to pick projects early to permit pre-post data collection worked against our being able to oversample large savers. We agree that the large relative error creates significant uncertainties around the actual savings, and that one should view the study findings with this in mind. We have added language to the key findings to highlight this point.*~~ ***[Final note: Since this response was drafted in December 2007, the evaluation team performed subsequent in-depth statistical analysis of the relative error. This analysis found that applying a ratio-estimator-based approach to estimating error around both gross savings and NTGRs was most appropriate for this situation, and yielded a dramatically lower total estimate of relative error (±20.9%). The latter is documented in Section 4.1.5 of the report.]***

5. MMBTU Conversion Factor. When the total program results are presented, the savings value and percentage of goal are based on MMBTU converted at 3,413 BTU/kWh rather than the source BTU rate 10,239 BTU/kWh. To accurately report the true energy savings accrued to the state, as well as its economic value, the higher source conversion rate should used.

Evaluator Response*: The MMBtu savings stated in the evaluation report are provided as a simple way to group electric (kWh) and gas (therm) savings, so that combined energy savings can be discussed and compared. These savings are stated from the perspective of customers' utility meters. The CPUC-provided TRC calculators and reporting tables are consistent with that perspective, and to our knowledge, so are all evaluations for the 2004-5 program cycle. The CPUC has confirmed that there is no need to apply source conversion rates.*

6. T&E Invoices. Page 57 states "To address the payment problem in 2006-08, NAM is to receive invoices each month from SoCalGas, and that utility will participate in T&E team meetings." This may have been one or more party's suggestion to improve the process, but it was not implemented exactly as stated for 2006-08. That said, the T&E team has changed the process in a way that is now working more effectively.

Evaluator Response: *We revised this passage to more accurately reflect what has occurred.*

RETROFIT PROJECT SPECIFIC COMMENTS:

1) Project 16.01 - CSU SLO – Lighting Retrofit

a) Issue: The reported realization rate in Appendix 6 (8%) does not match the realization rate in the site specific report (43%) and requires clarification.

b) Issue: Incorrect wattages appear to be documented in the revised savings estimates.

Details: In the calculation, the wattages for the fixtures in the sample appear to reference incorrect lines in the lighting reference table. At a minimum, the fixtures in Building 10, Rooms 130-147 all indicate by the color coding that the ENRON audit information was verified. These fixtures are listed in the ENRON audit as 4 lamp fixtures, but indicated in the evaluation as 2 lamp fixtures, significantly impacting the kW/sensor average. If this apparent error is consistent throughout, correcting it for all fixtures in the sample, the result is approximately 62% realization rate (up from 43%) (file CSU_SLO_SavingsAnalysis2.xls, Sheet InstallationSummary)

c) Issue: The installation dates do not appear to correlate with the logger data, and the logger data patterns indicate potential problems.

Details: Six office spaces were logged, of which only 3 had OS reportedly installed during the logged period. For the three that had no occupancy sensors installed, the fixture on time recorded were 12.7%, 16.7%, and 13%, which is consistent with the expected schedule and further validated by the one-time checks indicating 61% of office lights were on in Building 10 (61% x 8-5 M-F Schedule is approximately 16% overall on time). However, where sensors were installed, logged data indicates 2.3%, 4.9% and 0.3% fixture on times in the pre case, which are suspiciously low, and use increases after the reported installation date. It is possible this data represents all post installation, in which case the average is 4.5% on time (including all data for these three). If this were true and the average on time might be 14% reduced to 4.5%, which would yield: 841 hours reduced/yr x 0.134 average kW/sensor (not adjusted for comment above) = 112 kWh/sensor, which is a 120% realization rate.

d) Conclusion: Given the apparent errors and potential data inconsistencies, further analysis is appropriate.

Evaluator Response:
<u>Issue (a)</u>: The gross program savings in the site specific report were based on initial program estimates. We have corrected the site-specific report after adjusting for the changes discussed below.

<u>Issue (b)</u>: We rechecked fixture types and quantities for all the rooms that were verified. We found that the correct fixture types have been used, although the color coding was incorrect. We did, however, notice that the fixture quantity for some of the rooms mentioned above (130-136, 147-8) were incorrect and have adjusted the calculations accordingly. We were conservative in our calculations and only adjusted fixture type and quantity for those rooms that were verified. As such this does not impact all the fixtures in the sample. There is small increase in savings with a negligible change in the realization rate.

<u>Issue (c)</u>: Occupancy sensor installation dates for each building were obtained from the facility manager as of Dec 21st for Bldg 10 (first office space logger) and Dec 27th for Bldg 34 (other two office space loggers). It took a maximum of one week to complete installation in each building. We did not use data for the five days before these dates for pre or post fixture on-time calculations.

- Pre on-time was correctly calculated using data from May 11th (logger installation date) to Dec 14th – for Bldg 10 and Dec 20th –for Bldg 34.

- Post on-time was correctly used from Dec 20th – for Bldg 10.

- Post on-time was incorrectly used from Dec 20th – for Bldg 34. We have recalculated to use data starting Dec 27th. This increased the post on-time from 6.5% to 6.7%.

2) Projects 23.xx - SFSU Lighting Projects

a) Issue: Apparent non-functional lighting logger results are included in analysis.

Details: Lighting loggers LL39 in Humanities 279 recorded no on-time during the logging period, likely indicative of a failed logger. Additionally, LL81 in Humanities recorded nearly zero, which is suspicious of a malfunctioning logger.

b) Issue: Summer hours of operation are assumed reduced without reasonable substantiation.

Details: The hours of operation for the summer period are reduced to correlate with site personnel's estimates of 25% of normal use during the period. It is not clear that less utilization of the building will reduce the lighting hours, and even so it is based on hearsay, not hard data (if the site personnel's accounts were used as the basis for savings, the 3,500 or 4,000 hrs/yr would stand). Additionally, the logger data indicates 100% use for some fixtures (bathrooms, hallways), but the hours are reduced from 8760.

***Evaluator Response**:*
Issue (a): LL81 was not used to compute % on time. The formula reference in cell Z6 in worksheet 'SBWSavingsCalc', uses 100% on-time (as recorded for the Humanities bldg bathroom – LL71) and not 0% (as recorded for the Science bldg bathroom – LL81).

LL39 was installed in a classroom. Data from LL39 was originally retained because it recorded operations of bi-level controls and it is possible that one set of lights were not used at all. However, a check against other classrooms with bi-level controls showed consumption for both levels of controls. LL39 was installed at another campus soon after being removed from this campus, and it recorded properly. It is likely that the sensitivity for LL39 was improperly set, so we have removed it from the calculations.

Issue (b): The summer semester is from June to August. We did not obtain logger data for these months. Building use in the summer does decrease, because fewer students and faculty remain on campus, so some adjustment to operating hours is justified. However, we agree with the assertion that the exact reduction factor is not known. As with Project 10.01, we have applied a much more conservative estimate of the reduction (reduced to 80% of normal use instead of 25%).

3) Projects 12.01 & .03 – UCSD VFDs in Stein & Pacific

a) Issue: Realization rates in Appendix 6 do not match project specific EM&V Report.

Details: The realization rates listed in the appendix appear to portray an adjusted rate for the impacts considering cogeneration. This raises a larger issue of whether the impacts of self generation should be evaluated at project levels, or whether it is in the right spirit to incent on savings at a building level (consideration of generation source doesn't normally occur except as applicable to payment of PPP charges for eligibility).

***Evaluator Response**: Refer to the discussion under General Comments #3.*

b) Issue: Project savings are penalized by inclusion of increased air flows required to meet peak airflow requirements.

Details: As a result of TAB, some fans were resheaved to achieve adequate peak airflow. While this has an absolute impact on energy savings, it is conceivable that this would have happened in absence of the program, and therefore the increased airflow (at constant volume) should be the baseline.

> ***Evaluator Response**: While it is conceivable, it is a stretch to say that the resheaving would have happened in the absence of the program. Resheaving occurred at Project 12.03, where the NTGR analysis revealed that there was only a 20% chance of the project occurring without Partnership assistance. Additionally, proper resheaving could only happen after the TAB agent had systematically measured and adjusted airflows in the building. The TAB effort was a key part of the Partnership project.*

4) Projects 61.xx – UC Riverside Fume Hood Sensors

a) Issue: Measured data has large degree of uncertainty.

Details: The measured data does not measure airflow directly, which would be the preferable method, but instead uses a combination of amperage and kW readings as a proxy. Some of the data, by the evaluation team's indication, is invalid such as negative kW being registered. Although the evaluation attempted to choose the "best" data hour by hour, this introduced yet another degree of uncertainty. Additionally, within the small range of apparent savings, the fan power can be affected relatively significantly by static pressure, which was not considered. It is conceivable that the airflow reduced significantly more than determined by the evaluation, if the static pressure changed even slightly.

> ***Evaluator Response**: Measuring airflow directly, while it could improve the accuracy of the flowrates used in the analysis, can be costly, intrusive, and unless done fastidiously, can introduce significant measurement error of its own. Given the challenges of working with this campus, coupled with the budgetary constraints of this evaluation, direct airflow measurement was not practical. Using time-series power data as a proxy for flowrate is a commonly-used technique for this type of energy analysis, and done carefully, can provide reliable results.*
>
> *The point about static pressure does not jibe with our understanding of fan affinity laws. Theoretically, all other things being equal, reducing fan speed will reduce fan power to the third power and fan pressure to the 1.5th power. Speed, power, and pressure are interrelated by the laws, so by accounting for speed and power, we are implicitly accounting for pressure. Practically speaking, though, the fan systems in these buildings are controlled based on static pressure, so the fan speed varies to maintain a constant static pressure. In such a dynamic environment where the system curves are constantly changing, airflows can indeed diminish while static pressure remains the same.*
>
> *Ultimately, the effect we documented was enormous. We estimated that realized savings across the three projects here were an order of magnitude smaller than the program estimated. Even accounting for some measurement uncertainty, we can say with great confidence that the savings for these projects were not realized.*

b) Issue: Airflow measurements and fan power coefficients used add to the uncertainty of the results.

Details: The airflow measurements for some fans come from EMS readings, which may or not be calibrated or accurate. Further the fan power coefficients in the evaluation appear to be simple exponents correlated to a single point on these potentially erroneous measurements (a potentially oversimplified attempt to adjust fan affinity laws for real system effects), instead of using more accurate methods such as fan curves or CEC/DOE fan curves.

***Evaluator Response**: Much of the response under Issue (a) also applies to this comment. We attempted to obtain fan curves for the measured units, but they were not available.*

c) Issue: Heating plant efficiency may not be representative.

Details: The heating plant efficiency used in the evaluation is stated to be a tested number by site personnel, rather than findings of the evaluation team. Any measured number by the site most likely does not include distribution losses, and in absence of an evaluation of the program estimated efficiency should remain unchanged.

***Evaluator Response:** The program analysis assumed an efficiency of 70%, which, as far as we could tell, was a generic assumption. We determined from an interview with the campus engineer that their tests showed their boiler was 80% efficient, but that they would be replacing the unit with a 90% efficient one this year. Even though the 80% value does not include distribution losses, it is site-specific, and if the boiler has already been replaced, then it is a generous evaluation assumption. We see no reason to revert back to the ex ante value.*

Practically speaking, determining overall central heating system efficiency is very difficult to do, especially if one wanted to establish an average value over the wide range of heating system operating conditions generally seen in a typical year. Because of the nature of distribution systems, the losses are not necessarily proportional to usage. So, just because heating hot water use decreases by 10%, it does not follow that the distribution losses would decrease by 10%. Fortunately, heating system efficiency, in the context of an airflow measure such as this one, is a second-order effect, and thus generally does not warrant extensive evaluation. Ideally, we could apply a set of deemed efficiencies based on rigorous, measurement-based analyses of a wide variety of heating/boiler systems. To my knowledge, no such database of deemed efficiencies exists.

5) Project 10.01 – UCSB Lighting

a) Issue: The reported realization rates in Appendix 6 (59% for kWh, 64% for kW) does not match the realization rate in the site specific report (91.7% and 92.4% respectively) and requires clarification.

b) Issue: Summer hours of operation are assumed reduced without reasonable substantiation.

Details: The hours of operation for the summer period are reduced to an estimated 25% of normal use during the period. It is not clear that less utilization of the building will reduce the lighting hours, and even so it is not even based on information specific to this campus or project (the evaluation makes an assumption that this is the same as at SFSU).

Evaluator Response:

Issue (a): The gross program savings in the site specific report were based on initial program estimates. We have corrected the site specific report after adjusting for the changes discussed below.

Issue (b): Building use in the summer does decrease, because fewer students and faculty remain on campus, so some adjustment to operating hours is justified. However, we agree with the assertion that the exact reduction factor is not known. As with Projects 23.02 and 23.03, we have applied a much more conservative estimate of the reduction (reduced to 80% of normal use instead of 25%).

6) Project 11.01 – UCLA Pool Covers – 3 pools

a) Issue: The reported realization rates in Appendix 6 (63%) do not match the realization rate in the site specific report (67%) and requires clarification.

Evaluator Response: *We have corrected the site specific report. It now matches Appendix 6.*

MBCx SPECIFIC COMMENTS

1) Documented Gross Savings of Sampled Projects

The MBCx "Documented Gross Savings" values of sample projects in table 6-1 do not always match the Partnership's "MBCx Project Data Proposed and Implemented" comprehensive MBCx documentation for the sampled projects. It appears that the evaluator in some instances took Cx Agent reports as a more authoritative source than the campus reported summary results. The Partnership chose just the opposite approach. We placed much greater credence in the metered savings of implemented measures reported by the campus than the calculated savings of proposed measures typically reported in Cx Agent documentation. As a result, the evaluators over-estimated the "Documented Gross Savings" for the MBCx sample. The total effect on the domain of the MBCx sample was then to under-estimate the sample realization rate by comparing the evaluated savings to the larger evaluator "documented" number. When extrapolated to the program, this results in a material underestimate of the savings provided by MBCx. The UCR MBCx projects 31.01 and 31.03 have the largest effect in this regard – please see UCR MBCx project specific comment below for additional detail.

Evaluator Response: *The assertion that we gave commissioning agent reports greater credence than metered savings is inaccurate. We also used measured savings estimates whenever available, and did not favor any one particular type of document. Unfortunately, we may not have had all of the information that likely was available to the Partnership team to make the determination. Nonetheless, we did our best to establish whether Partnership-induced savings truly occurred for a project or not—if they did, we included it; if not, we did not. In many instances, such as with Project 56.01, this was extremely challenging (see MBCx comment #7 below).*

The particular instance mentioned here (Projects 31.01 and 31.03) was a case where program actions did indeed result in implemented measures. The campus was delinquent in providing documentation, but because that site was sampled, we knew for a fact that savings were realized prior to the program deadline. So our task was to evaluate how much savings were realized, and to compare that with the best ex ante estimate of savings. In this case, the Cx agent had prepared an estimate. The program did not claim savings for administrative reasons, but still, the best ex ante estimate is the Cx agent number, not the zero that was imposed for non-technical reasons. If we were to use the utility claim criterion, then if the utility did not claim the project, then we should not credit the program (especially since spillover is not to be quantified for 2004-5 programs). Alternatively, if we apply the evaluation criterion (essentially, if there is evidence the project yielded savings then it should be included), then we should compare the original estimate of realized savings with our evaluation findings. The latter is what we did, both for these projects and the other six sampled ones. <u>We recommend leaving the Documented Gross Savings as is</u>.

2) Peak Demand Savings

The approach taken to evaluate Peak savings, which appears to be spot measurements, is inconsistent with the average demand definition cited in the footnote on pg 9 of the report, which was the definition applied by the program (attributed to the CPUC Energy Efficiency Policy Manual). Therefore, evaluated peak savings do not accurately reflect the policies in place at the time projects were implemented and reported.

> ***Evaluator Response**: We are unsure what the basis for this comment is. We conducted our project-specific analyses with clear instructions to analysts to calculate demand reduction as stated in the Policy Manual. A spot check of the evaluation calculations did not reveal any instances where spot measurements were the sole basis for estimating average peak demand reduction. We will review all project calculations to confirm that the proper approach is being applied.*

3) Projects 31.01 and 31.03 – UCR Riviera Library and Science Library MBCx

The Partnership database and SCG booked zero savings for these projects since they were not completed by the December 2006 cut-off, yet the evaluators attributed approximately 107,000 gross therms to the projects as "documented savings." The evaluators then assign approximately 131,000 therms to the projects as evaluated gross savings. However, because the program actually booked no savings for these projects, it more than accounted for other unrealized savings in this and other projects, provided the evaluated savings numbers were actually realized as the evaluators have determined. Clearly, a realization rate at the project level does not make sense in this case (divide by zero), so this effect must be accounted by determining the realization rate at the MBCx sample domain level, with these UCR MBCx projects contributing nothing to the total "documented" sample savings, but their evaluated savings contributing to the total evaluated number. This correction would move the MBCx realization rate for therms from 101% to approximately 150%.

> ***Evaluator Response**: Refer to the discussion under MBCx Comments #1.*

4) Project 30.01 - CSU San Marcos Central Plant MBCx

The MBCx report identifies savings through operational changes to the central chillers and chilled water loop. The EM&V Report indicates the chiller savings were calculated incorrectly. It indicates the base case chiller load includes the entire chiller plant, while the proposed case represents just the chillers (and not the pumps and cooling towers). However, the MBCx report describes in Figure 8 a chiller plant efficiency improvement from 0.652 to 0.414 kW/ton (or 0.238 kW/ton) for the chiller, including the CW pumps and CT fans. This plant improvement calculation appears to correctly account for the CW pump load and fan load in both the pre and post case.

> ***Evaluator Response:** The project's documented savings estimates were calculated based on the entire chiller plant consumption, which included chiller, cooling towers, and chilled water and condenser pumps. The report has been modified to reflect this. Baseline and efficient system efficiencies were calculated to be 0.93 and 0.69 kW/ton, respectively. This resulted in an efficiency improvement of 0.24 kW/ton, similar to the value stated above. Changes to the calculations are not necessary.*

In addition, the MBCx report indicates that there were On-Peak savings. The EM&V Report indicates that the chillers are off during the day because of the TES so the peak savings should be zero. The MBCx Report states that bypasses were closed in the chilled water three way valves in the buildings served by the chiller plant (page 19, last bullet). This would result in reduced chilled water distribution system pumping, which would account for the On-Peak demand savings. The EM&V Report did not address this deficiency resolution so these savings were not counted in the evaluated results.

> ***Evaluator Response:** The program's documented kW savings estimates were based entirely on chiller and condenser water pump reductions in kW and did not account for any kWh or kW savings estimates for the reduction in distribution system pumping. In fact, kW for the distribution pumping was shown to increase very slightly (less than 0.5%). Since the EM&V analysis did include total chiller plant consumption, any kWh savings would be reflected in the evaluation estimate. Changes to the calculations are not necessary.*

Further, the TES is not a full capacity system, but rather a partial TES system. As a result, the chillers do operate during on peak hours and it is proper to identify project savings from the chillers that contribute to peak demand reduction.

Evaluator Response: *Based on detailed run time data of the chillers during the post period, the chillers only ran about 3.7% of the on-peak period. Therefore, average peak demand reduction would be very small. Since no baseline on-peak demand data was available, it is impossible to reasonably estimate average on-peak savings, and in any case, it would be very small because of the negligible on-peak run time. Changes to the calculations are not necessary.*

5) Project 32.02 - UC Irvine McGaugh Hall MBCx

The MBCx report identifies a project to fix leaking preheat valves on two air handlers which are causing unnecessary heating and subsequent recooling of the whole air stream. The EM&V Report indicates that since this was deemed to require capital expenditures it was deferred to a later time. The campus is, in fact, replacing the valves in December 2007 as a part of a system upgrade. However, as a temporary measure, isolation valves were manually closed during the summer months as a result of the MBCx report so this heating and cooling savings actually was achieved. Therefore, this heating and cooling savings should have been included in the evaluated results.

Evaluator Response*: The evaluation site visit occurred during the winter, and at that time, we got no indication that the isolation valves would be manually closed during the summer. We thus had no basis for including savings from this temporary measure, since our evaluation is based on information available at the time of the original evaluation work.*

In any case, were we to have included this measure, two factors would have resulted in a much lower realization rate for the project. The database estimate of savings would have to be increased to reflect that the measure was completed. The estimate provided in the commissioning report assumed that the leaking valves provided unneeded heat all hours of the year and would require mechanical cooling to offset the waste. This is a serious error in the savings estimate, since it should only have included hours where the outside air temperature plus heat leakage temperature rise exceeds the supply air temperature. Closing the valves for only the summer months would result in significantly lower savings than the program's estimate. Also, based on observations made during the site visit and from data provided in the commissioning report, the increased air temperature due to the leaking valves appears to be about half that assumed in the commissioning report savings estimate, which also significantly overstated estimated savings.

Changes to the calculations are not necessary.

6) Project 37.01 - UC Berkeley Soda Hall and Tan Hall MBCx

For Soda Hall, the evaluation seems to have compared the savings from the investigation report (or pre-report), not the verified savings report. The verified savings report documented demand savings (about 50 kW), whereas the investigation report did not. The verified savings report also showed much less steam savings, but basically confirmed the kWh savings. So there is over counting on the steam side and undercounting on the demand side.

For Tan Hall, the kW reduction was based on the measured kW for shutting off the lag pumps for both chilled and condenser water systems, as these pumps were operating in parallel with balancing valves closed down in the base case. There was also a leaky steam pre-heat coil that was repaired. This was not accounted for in the evaluation. This pre-heat coil introduced unnecessary load on the chiller. Reducing it also reduces load on the chiller, and should provide some kW savings. The kW savings are documented in the verified savings report in the "average peak demand reduction" calculation with the whole-building kW data.

***Evaluator Response**: We are not sure what verified savings report is being referred to here, but the estimates we used appear sound. Our documented savings came from the Cx provider's (QuEST's) final report, dated March 2006. That report documents combined savings of 1,125,657 kWh, 69 kW, and 95,365 therms. These values are very close to those reported by NAM in their October 15, 2007 final database (1,125,656 kWh, 52 kW, and 94,136 therms). The kWh savings are essentially identical, therm savings differ by about 1%, and kW savings by about a third. Both sets of numbers far exceed both (a) the original proposed savings for these projects of 400,576 kWh, 52 kW, and 7,160 therms, and (b) a rather mysterious, unsubstantiated payment basis of 0 kWh/kW savings and 23,010 therms. At this point, we are not clear why the final NAM numbers differ from our documented savings, but given that the difference is so small, we feel comfortable retaining our original numbers.*

Regarding the second point for Tan Hall, we agree with the implementer suggestion that the program should be credited with additional kW savings associated with the evaluated kWh savings. We increased the evaluated kW demand reduction by 31.8 kW, so the total reduction is 71.5 kW.

7) Project 56.01- CSU Dominguez Hills Central Plant MBCx

The Evaluator's Documented Savings database shows only gas savings, no electric savings. The program documentation, however, shows significant electric savings but no gas savings.

***Evaluator Response**: This is an example of an instance where conflicts between program-supplied data sources, coupled with insufficient information to resolve the conflicts, left us in a quandary trying to ascertain what really happened. Documentation supplied by Sempra Energy for this project ("MBCx Due Diligence Review") shows pre and post MBCx project natural gas metering data and the calculation methodology to support a claim of 55,755 annual therm savings. Electrical savings of 1,124,009 kWh/year were noted in the "MBCx Project Reporting Summary for Program Database" form, matching the kWh savings estimates in the commissioning report submitted by Fundament & Associates, Inc. The MBCx report submitted to us did not address natural gas savings although SDG&E's Due Diligence report cited the Cx agent's work with the natural gas absorption chillers resulting in the natural gas savings.*

SCG claimed the natural gas savings in their project summary spreadsheet. The electrical savings for the Central Plant MBCx, however, were not claimed by SCE, the electrical utility serving the campus. The utility documentation does not explain the reason they were not claimed.

Another CSU Dominguez Hills campus building, the Social and Behavioral Sciences Building (Project 48.01) also participated in the MBCx program with the same commissioning firm. The MBCx final report estimated savings of 649,872 kWh/year. After review, SCE only claimed 155,969 kWh/year. In the documentation available to us for both projects, accounting of savings was minimal and we surmised that SCE had chosen not to claim any of the electrical savings associated with the Central Plant project. Whether or not that was the actual case, SCE did not claim the savings, and we decided to take the conservative approach for this project, follow the utility lead, and not include the kWh savings in the evaluation.

Changes to the calculations are not necessary.

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From: Richard.Pulliam@sce.com
Sent: Monday, December 10, 2007 4:18 PM
To: Bing Tso
Cc: Michael Baker; Marian.Brown@sce.com; Richard.Pulliam@sce.com
Subject: Comments on SBW's Draft EM&V Evaluation - UC/ CSU EE Partnership

Bing:
Thank you for your excellent work on this UC/ CSU EE Partnership evaluation. Please see the comments on the CSU/ UC Evaluation from Marian Brown below:

Rich,

As I mentioned to you, SBW's comments on EULs on pp. 42-43 provide good information that indicates EULs for retrocommissioning activities may need to be subjected to more study.

However, the wording includes two statements that are out of sync with accepted California approaches for developing EUL estimates. These are:

> "For MBCx projects, we did not change the 15-year EUL assumption, since we did not have a firm basis for doing so" (p. 42) and

> "Furthermore, a number of campuses we visited had plans to add cogeneration plants and solar arrays. Such changes in the energy resource mix could affect EULs for program projects." (p. 43)

Generally, we make changes to EULs based on actual historical experience, not people's projections of what may happen in the future. Further, the second statement assumes that energy savings won't count if they are served by self-generation. I don't believe that policy decision has been made for
2004-5 or later.

Statements more in tune with current policy and approaches would be along the following lines:

> "For MBCx projects, some anecdotal evidence we found while visiting the sites and speaking with campus contacts suggests that the 15-year EUL assumption is optimistic and should be included in an EUL update study."

> "Furthermore, a number of campuses we visited had plans to add cogeneration plants and solar arrays. This raises a question to us of whether program energy savings can continue to be claimed in years when that particular load is served by grid-connected self-generation projects."

These sentences (pre-revision) are currently combined with a statement about future inability to use data from monitoring equipment. They would better be broken out and reworded as a separate bullet, because they raise a separate, unresolved, policy issue:

Marian

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Evaluator Response: We incorporated the suggested text edits into the report.