



ENERGY · WATER · EFFICIENCY

2006-08 California RCx Portfolio: CPUC Evaluation Results

June 10, 2010

California Commissioning Collaborative Meeting
Monrovia, CA

Presented by: Bing Tso, P.E. LEED AP

Overview of Presentation

- What the evaluation team did and found:
 - Gross savings
 - Net savings
 - Effective useful life (EUL)
- For each part:
 - Objectives
 - Methodology
 - Results
 - Recommendations

Summary of Evaluation Activities

What happened?

Gross Savings

Project realization rates = achieved/claimed savings

What would have happened without program?

Net Savings

Project net-to-gross ratios = savings from program effect/gross savings

What else happened?

Spillover

Additional savings from program influence

How long will savings last?

Effective Useful Life

How many years savings last, on average

Programs that Implemented RCx Projects

Programs Included in this evaluation*		#/% of RCx Projects**	
PGE2036, SCE2530, SCG3520, SDG&E3029	UC-CSU-IOU Partnership (state universities and investor-owned utilities, retrofit and monitoring-based Cx projects and education)	54	21%
SCE2528, SCG 3527	County of Los Angeles Partnership	53	20%
PGE2007	Office Buildings (Large Commercial)	28	11%
SCE2508	Retro-Commissioning (general)	22	8%
PGE2094	Macy's Comprehensive Energy Management	18	7%
PGE2091	Retrocommissioning Services and Incentives	15	6%
PGE2015	Partnership - Association of Bay Area Governments	10	4%
PGE2002	Schools and Colleges	10	4%
PGE2052	Lodging Savers	9	3%
PGE2072	Hospitals Pilot	7	3%
PGE2070	Data Centers	5	2%
PGE2032	Partnership - Sonoma County	4	2%
PGE2005	Hi-Tech Facilities	4	2%
PGE2088	State Leased Facilities	3	1%
PGE2071	Hospitality Energy Efficiency Program	3	1%
PGE2056	Monitoring-Based Persistence Commissioning	3	1%
PGE2035	Partnership - Silicon Valley Leadership Group Energy Watch	3	1%
SCE2526, SCG 3518	California Community Colleges Partnership	2	1%
PGE2025	Partnership - Marin County	2	1%
PGE2006	Medical Facilities	2	1%
SDGE3010	Energy Savings Bids	1	0.4%
PGE2090	Airflow and Fume Hood Control Systems Re-Commissioning	1	0.4%
PGE2001	Ag & Food Processing	1	0.4%
Total		260	100%

Gross Savings Evaluation Objectives

- Estimates of electric, peak kW, natural gas savings for each utility's 2006-08 RCx portfolio
- Information about savings by measure group, affected building system

Gross Sample Design and Selection

- 90/10 precision based on program tracking estimates
- Four stratified random samples
 - PG&E: 24 out of 135 projects
 - SCE: 13 out of 58 projects
 - SoCalGas: 10 out of 28 projects
 - SDG&E: 3 out of 4 projects
 - Overall: 50 out of 252 projects
- Excluded very small, retrofit-only projects
- Minimal non-response: only 1 out of 51 could not participate

Gross Savings Methodology

- Customized baseline for each project
- Custom savings algorithm(s) for each project
 - 1-19 measures/project
 - Used program's methods if appropriate and practical
 - Engineering calculations, regression, building simulations, whole building data, or combination
 - Trend logs, one-time measurements, short-term metering, observations, interviews, manufacturer's data, customer data, project documents, etc.
 - Applied highest level of analysis rigor as defined by CPUC.

Example 1: Large Office/Laboratory Campus

- Project involved 330,000 ft² out of 750,000 ft² campus
- 19 measures / 4 general types:
 - Schedule modifications
 - Repair/replace equipment (mostly controls)
 - Modify control operating sequence
 - VFD installations
- 6 measures sampled for detailed analysis
 - 3 measures representing 70% of program savings
 - 3 of 12 measures representing the next 29% of program savings selected randomly, then extrapolated to other measures not investigated

Example 1: Large Office/Laboratory Campus

- Third-party RCx provider has good relationship with facility personnel, provides ongoing RCx services
- EM&V team collected electrical and temperature data and had access to a large body of EMS data for use in highly detailed bin analysis
- Mixed outcome for measure results:
 - Some measures achieved significantly more than program estimates, others much less
 - Realization rates: kWh – 81%, kW - 232%, Therms – 12%
 - Overall MMBtu realization rate for project was 46%

Example 2: Government Multi-Use Building

- 112,000 ft² facility - variety of uses and schedules (offices, library, police station, etc.)
- Natural gas measures only
 - HVAC units scheduling
 - Boiler
 - HVAC supply air temperature reset
 - Economizer controls
- Program used eQuest modeling to estimate measure savings
- EM&V approach
 - Reviewed implementer's eQuest models, made corrections as necessary for baseline
 - Gathered extensive data from field loggers, meters and EMS data for post-installation version of eQuest model

Example 2: Government Multi-Use Building

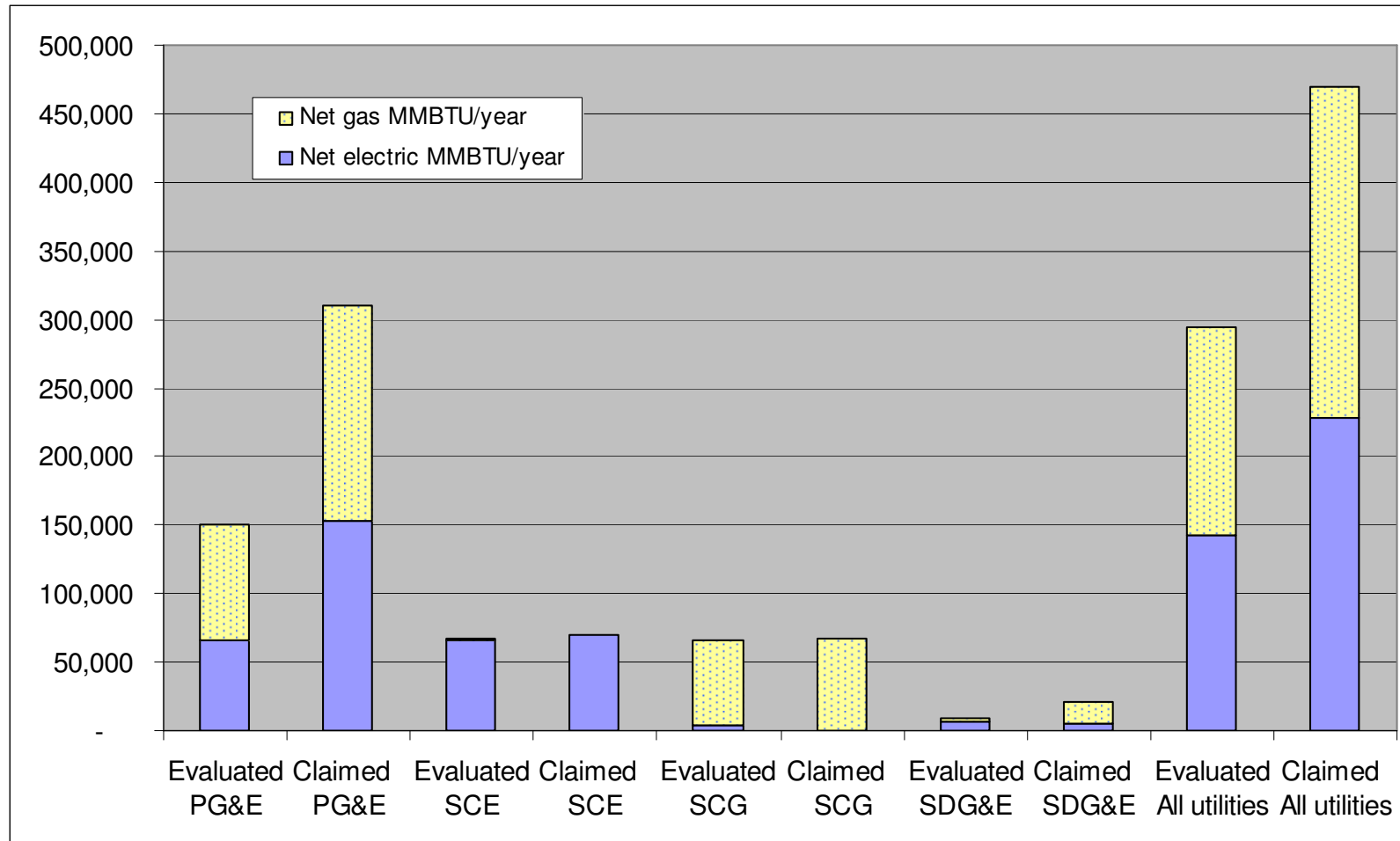
■ EM&V Results

- AHU scheduling was overridden and no savings were realized
- The economizer-related control modifications functioned well and exceeded program estimates
- HVAC supply air temperature resets were working properly and exceeded program estimates
- Heating hot water circulation pump was locked out at a higher outside air temperature than specified – no savings
- Gas realization rate = 93%

Gross Analysis Approaches

Evaluation Gross Analysis Approach	# of projects
Detailed monitoring / custom analysis	28
Building simulation - updated program model	13
Building simulation - created new model	1
Whole building/system analysis	5
Verification	2
None needed	1
Total	50

Evaluated Gross Savings by Utility



Detailed Gross Savings Findings

Utility (a)	Number of projects			Gross savings realization rate (b)				Evaluated gross savings per project (c)			
	Popu- lation	Net sample	Gross sample	Peak kW	kWh /year	Therms/ year	MMBTU/ year	Peak kW	kWh /year	Therms/ year	MMBTU/ year
PG&E	135	73	24	0.31	0.45	0.53	0.49	13	178,355	7,334	1,342
SCE	58	29	13	2.07	0.94	N/A	0.97	30	383,712	462	1,356
SCG	28	15	10	N/A	N/A	0.93	0.97	6	28,781	23,735	2,472
SDG&E	4	3	3	2.60	1.23	0.21	0.45	129	606,849	11,454	3,217
All (d)	225	120	50	0.62	0.63	0.62	0.62	23	227,543	9,075	1,684

Evaluated Savings by Building System, Measure

Table 3. : Percent of Evaluated Savings, by Building System Class

Type of System	% of			
	Measures	kW	kWh	Therms
Central plant	19	22	20	19
HVAC (general)	29	18	12	41
HVAC (air distribution system)	36	18	37	34
Other/unclassified	17	41	32	6

Table 4. : Percent of Evaluated Savings, by Measure Class

Type of Measure	% of			
	Measures	kW	kWh	Therms
Improve control strategies	36	38	29	48
Improve outside air use	13	9	14	4
Improve scheduling*	18	-3	11	28
Other/unclassified	17	40	29	12
Install/replace variable speed drive	16	15	16	7

*The negative demand savings are driven mostly by a single measure at a single site, where revised chiller schedules led to higher demand over the 3-day peak period.

Program-Related Recommendations

- Provide program participants with adequate follow-up RCx services
- Reduce RCx service providers' burden for quantifying energy savings
- Give program staff primary responsibility for collecting baseline data

Evaluation-Related Recommendations

- Improve baseline data collection
- Specify post-only sample designs
- Balance the need for accurate first-year savings against the need to track savings over time
- Maximize time allotted for onsite data collection
- Minimize the use of whole-building analysis

Future Research–Related Recommendations

- Continue refining the measure classification scheme (compare w/PECI-LBNL study from Dec 2009)
- Study the relative effectiveness of different programmatic approaches
- Compare retro- and monitoring-based commissioning

Net Savings Evaluation Objectives

- Determine how much of gross savings should be attributed to the intervention of the RCx programs.
- Estimate project-specific net to gross ratios (NTGRs).

Net Sample Design and Selection

- Built on the gross sample stratification
- 50% of projects per stratum
- Total of 120 projects in net sample (out of 225)
 - 50 net and gross
 - 70 net only

Net Savings Methodology

- Self-report method, using common framework developed for all CPUC evaluations
- Questions were tailored to retro-commissioning
 - Influence of both study incentive and implementation incentive
 - Measure-specific score if measures were already under consideration
 - Take into account the amount that would have been spent on RCx if done in the absence of the program

Net Data Collection – Illustrative Examples

- High NTGR – 1.0
 - University Building
 - Scores of 10 for Timing and Selection, Relative Program Influence and No-Program components
 - “Our maintenance budget has been cut from \$10 million in 1999 to zero.... There just would not have been money to do this without the program.”

Net Data Collection – Illustrative Examples (cont.)

■ Low NTGR – 0.18

- Municipality doing retro-commissioning, installation of VFDs on swimming pool pumps prompted by “green” policy more than the program.
- Some program influence, but “the goal of doing the green policy came first, doing it most cost-effectively through the program came second, so I think we would have done it anyway.”

Detailed Net Savings Findings

- Overall, NTGR scores are relatively high across fuel types and utilities, reflecting the continued influence of a variety of programs on the motivation and ability of organizations to pursue RCx projects.

Utility (a)	Evaluated net to gross ratios			Net savings realization rate (b)				Evaluated net savings per project (c)			
	kW	kWh	Therms	Peak kW	kWh /year	Therms/ year	MMBTU/ year	Peak kW	kWh /year	Therms/ year	MMBTU/ year
PG&E	0.76	0.80	0.86	0.28	0.43	0.54	0.49	10	142,684	6,307	1,118
SCE	0.78	0.86	0.91	1.86	0.93	N/A	0.96	23	329,992	420	1,168
SCG (e)	N/A	N/A	0.92	N/A	N/A	0.91	0.94	5	23,121	21,836	2,263
SDG&E	0.75	0.75	0.68	2.64	1.25	0.19	0.44	97	455,137	7,789	2,332
All (d)	0.80	0.84	0.88	0.59	0.62	0.63	0.62	15	180,816	6,862	1,303

Detailed Net Savings Findings (cont.)

- Hypothesized reasons for the NTGR scores include:
 - Programs that cover all or part of the cost of the RCx study reduce the risk associated with a RCx project significantly and lead many organizations to proceed with the project.
 - RCx programs help offset funding cutbacks, staffing shortages, and reductions in maintenance budgets in public institutions and in hard-hit private sectors such as office buildings and the hospitality industry.
 - The most significant non-program influences in the decision to pursue RCx projects appear to be government or corporate “green” policies that require or encourage implementation of RCx or other energy efficiency measures.

Net Savings Recommendations

- Incentives to cover the cost of the RCx study should remain a key attribute of RCx programs.
- Requiring implementation of measures that meet specific payback criteria with no added incentive helps ensure that cost-effective recommended measures are actually implemented.
- Partnership programs promote RCx projects that otherwise would not happen.
- Projects should be screened before the RCx study is initiated to ensure that a similar project is not already planned.
- “Green” policies encourage participation in RCx programs, but may also cause “free riders”. Their effect on the RCx market should be monitored; e.g., if they cause organizations to pursue RCx outside of utility programs elsewhere in the country.

Effective Useful Life Evaluation Objectives

- Estimate EUL (average number of years RCx measures yielded savings)
 - *Not* a formal, protocol-based EUL study
- Rely on observations of projects from past RCx programs
- Develop recommendations for future studies

Sample Design and Selection

- 32 projects, 101 measures previously evaluated
 - Oakland Energy Partnership BTU (2002-03)
 - Statewide Building Tune-Up (2004-05)
 - UC-CSU-IOU Partnership Monitoring-Based Cx (2004-05)

Methodology

- For each site
 - Review project files
 - Original program
 - Follow-on evaluation
 - Recruitment
 - Site visit
 - Inspections
 - Interviews
 - Observations
 - Documentation
 - QC
- Aggregate results for all measures and sites

Example: Large Hotel

■ 5 measures installed in 2006

- Economizer repair
- Cooling tower sequencing
- Fan VFD operation
- Guest corridors supply air setback
- Conference room lighting control scheduling

■ Investigation results

- Hotel engineers helpful but had difficulty recalling original RCx project due to frequent participation in utility programs.
- Through interviews, EMS review and equipment inspection, EUL investigator concluded the economizers, cooling towers and VFDs were all operating well and achieving savings.
- Guest room corridor supply air temperature setback was disabled.
- Shortly after implementation, the conference room lighting controls shut lights off while occupied – end of story!

Detailed Findings

- Access, staff turnover, lack of knowledge were challenging
- 77% (74 of 96) measures still functioning
- ~8 year EUL
- Utility claims varied significantly:
 - 3-20 year range for items
 - 7-14 year range between utility portfolios
 - Different claims between utilities for same program (e.g. 10, 15 years depending on utility)
- Additional study needed to confirm EUL:
 - This group
 - 2006-08 group

Reasons for failures

- 22 failures observed among 101 measures

Control sequence changed due to perception that the RCx measure compromised occupant comfort	35%
Control sequence changed - reason unknown	22%
Lack of maintenance compromised the measure	22%
Facility operating hours extended	9%
Miscellaneous	12%

Summary of Evaluation Results

What happened?

Gross Savings

Achieved 62% of claimed savings.
Average annual savings per project:

- 228,000 kWh/year
- 9,100 therms/year

What would have happened without program?

Net Savings

Project net-to-gross ratios > 75% means programs strongly influenced participants.

What else happened?

Spillover

Negligible additional savings from program influence.

How long will savings last?

Effective Useful Life

Rough estimate of 8 years for past portfolio.

Wrap-up

- Questions
- For full report, download from :
 - CALifornia Measurement Advisory Council (CALMAC) website
www.calmac.org (search for retro-commissioning)
- Next evaluation cycles: 2010-12, 2013-15