Evaluation, Measurement, and Verification Report for the Small Nonresidential Energy Fitness Program #1409-04

Study ID: RHA0002.01

FINAL REPORT

Prepared for
California Public Utilities Commission
San Francisco, California
RHA, Inc.
Chico, California

Prepared by
Principal Investigators: Robert Mowris, Ean Jones, Anne Jones
Robert Mowris & Associates
Olympic Valley, California

Draft January 8, 2007
Final April 20, 2007

Funded with Public Goods Charge Funds

TABLE OF CONTENTS

1. Executive Summary

This report provides the Evaluation, Measurement, and Verification (EM&V) findings for the Richard Heath and Associates (RHA) Energy Fitness Program (EFP) #1409-04. This study was conducted by Robert Mowris & Associates (RMA) with public goods charge (PGC) funds under the auspices of the California Public Utilities Commission and is available for download at www.calmac.org. The program implementation plan (PIP) ex ante goals were to reach 1,399 hard-to-reach nonresidential business customers in the Pacific Gas and Electric (PG&E) service area, perform an audit of energy-using equipment, directly install 39,627 energy efficiency measures, and conduct follow-up activities to achieve energy savings of 7,381,944 first-year kWh, 1,592 kW, and 66,264,696 lifecycle kWh. The program exceeded all of its goals except the first-year savings goals which fell short by 9.1% not including spillover (as shown in **Table 1.1**). The program installed 44,877 energy efficiency measures at 1,539 hard-to-reach businesses. Ex post accomplishments were verified by checking the tracking database, randomly inspecting 2,842 measures at 73 sites, installing light loggers on 1,842 fixtures at 68 sites, evaluating billing data for 59 sites, and conducting surveys of participants, non-participants, and non-contacts. The EM&V study net ex post savings are based on pre and post-retrofit utility billing data, light logger data, previous evaluation studies, and building energy simulations calibrated to normalized billing data.

Table 1.1 Ex Ante Goals and Ex Post Accomplishments for the Energy Fitness Program

Description	Program Implementation Plan Ex Ante Goal	Ex Post Accomplishment
Total Direct Install Measures	39,627	44,877
Compact Fluorescent Lamps (CFL)	14,165	22,271
Delamp Fluorescent Fixtures	14,270	6,240
T8 Fluorescent Lamps and Ballasts	10,634	15,596
LED Exit Signs	91	488
Programmable Thermostats	175	151
Vender Misers	17	28
HVAC Tune-up	100	103
Nonresidential Hard-to-Reach Energy Fitness Audits	1,399	1,539
Net Annual Electricity Savings (kWh/yr)	7,381,944	6,712,686
Net Demand Savings (kW)	1,592	2,385
Net Annual Therm Savings (therms/yr)	0	0
Net Lifecycle Electricity Savings (kWh)	66,264,696	66,827,070
Net Lifecycle Gas Savings (therms)	0	0
Total Resource Cost (TRC) Test	1.8	1.2
TRC Test Costs	$1,874,339	$2,136,608
TRC Test Benefits	$3,406,078	$2,513,382
TRC Test Net Benefits	$1,531,739	$376,773
Participant Test	10.3	5.9
Participant Test Costs	$1,214,347	$1,335,975
Participant Test Benefits	$12,515,915	$7,815,193
Participant Test Net Benefits	$11,301,568	$6,479,218

The ex ante first-year savings are summarized in **Table 1.2**, and the ex post first-year savings are summarized in **Table 1.3**. The net-to-gross ratio (NTGR) is 0.96 based on the Express Efficiency

Program and reflects what customers would have done in the absence of the program (i.e., 4 percent free riders).[1] The ex ante savings goals are 7,381,944 first-year kWh, 1,592 kW, and 66,264,696 lifecycle kWh.[2] The EM&V study found first-year net ex post program savings of 6,712,686 ± 402,325 kWh per year and 2,385 ± 309 kW per year at the 90 percent confidence level. The net realization rate for kWh savings is 0.91 ± 0.05 and the net realization rate for kW savings is 1.50 ± 0.19.

Table 1.2 Ex Ante First-year Electricity Savings for the Energy Fitness Program

Installed Measure	Units	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Net-to-Gross Ratio	Net Ex Ante Program Savings (kWh/y)	Net Ex Ante Program Savings (kW)
HVAC Tune-up Pilot Program	100	360	0.320	0.80	28,800	25.6
Energy Conservation Package	1,399	6570	1.400	0.80	7,353,144	1,566.9
Total	1,499				7,381,944	1,592

Table 1.3 Ex Post First-year Savings for the Energy Fitness Program

Measure	Units	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Net-to-Gross Ratio	Net Ex-Post Program Savings (kWh/y)	Net Ex-Post Program Savings (kW)	Net Realization Rate kWh	Net Realization Rate kW
CFL	22,271	156.6	0.056	0.96	3,348,133	1197.3	0.68	0.98
Delamp Fluor. Fixtures	6240	264.8	0.092	0.96	1,586,258	551.1	0.84	0.94
T8 Fluor. Fixtures	15596	93.5	0.032	0.96	1,399,897	479.1	0.64	0.70
LED Exit Signs	488	315.4	0.036	0.96	147,759	16.9	1.07	0.64
Programmable Tstats	151	802	0.55	0.96	116,258	79.7	0.84	n/a
Vender Misers	28	1590	0	0.96	42,739	0.0	1.20	n/a
HVAC Tune-up	103	709	0.61	0.96	70,106	60.3	2.36	n/a
Audit Measures	2	800	0.485	0.96	1,536	0.9	undefined	undefined
Total	44,879				6,712,686	2,385	0.72	0.95

The EM&V study lifecycle kWh savings are summarized in **Table 1.4**. The required energy impact reporting for 2004-05 programs is provided in **Table 1.5**. The net ex-ante lifecycle savings are 66,264,696 lifecycle kWh. The EM&V study net ex-post lifecycle savings are 66,827,070 ± 4,222,343 kWh. The lifecycle ex-post net lifecycle kWh realization rate is 1.01 ± 0.06 and the net lifecycle therm realization rate is undefined.

[1] *Energy Efficiency Policy Manual*, Chapter 4, Table 4.2, page 23, prepared by the California Public Utilities Commission, 2001.

[2] The reported net ex ante program savings in the final report are 9,328,191 kWh per year and 2,521 kW. See *Small Nonresidential Energy Fitness Program Final Report*, Table 12, page 17 of 33, submitted to Pacific Gas & Electric Company, Lisa Cosby, Third Party Contracts Group, 245 Market Street, Room 756D, Mail Code N7K, San Francisco, CA 94105, submitted by Richard Heath and Associates, Inc. (RHA), Teresa Enos, Senior Manager, 1026 Mangrove Avenue, Suite 20, Chico, California 95926, May 1, 2006.

Table 1.4 Lifecycle Electricity Savings for the Energy Fitness Program

Measure	Net Ex-Ante Program Savings (kWh)	Ex Ante Effective Useful Life (EUL)	Net Ex-Ante Lifecycle Program Savings (kWh)	Net Ex-Post Program Savings (kWh)	Ex Post Effective Useful Life (EUL)	Net Ex-Post Lifecycle Program Savings (kWh)	Net Lifecycle Realization Rate
CFL	3,893,207	9.0	35,038,864	3,348,133	3.6	12,053,279	0.34
Delamp Fluor. Fixtures	1,486,268	9.0	13,376,408	1,586,258	17.0	26,966,385	2.02
T8 Fluorescent Fixtures	1,726,616	9.0	15,539,542	1,399,897	17.0	23,798,248	1.53
LED Exit Signs	109,597	9.0	986,369	147,759	16.0	2,364,137	2.40
Programmable Tstats	109,292	9.0	983,631	116,258	11.0	1,278,837	1.30
Vender Misers	28,165	9.0	253,482	42,739	3.0	128,218	0.51
HVAC Tune-up	28,800	3.0	86,400	70,106	3.0	210,318	2.43
Audit Measures	0	18.0	0	1,536	18.0	27,648	undefined
Total	7,381,944		66,264,696	6,712,686		66,827,070	1.01

Table 1.5 Required Energy Impact Reporting for 2004-2005 Programs

	Program ID:	1409-04					
	Program Name:	Energy Fitness Program (EFP)					
Year	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	7,382	6,713	1.592	2.385		
2	2005	7,382	6,713	1.592	2.385		
3	2006	7,382	6,713	1.592	2.385		
4	2007	7,353	5,261	1.567	1.846		
5	2008	7,353	3,252	1.567	1.128		
6	2009	7,353	3,252	1.567	1.128		
7	2010	7,353	3,252	1.567	1.128		
8	2011	7,353	3,252	1.567	1.128		
9	2012	7,353	3,252	1.567	1.128		
10	2013	0	3,252	0	1.128		
11	2014	0	3,252	0	1.128		
12	2015	0	3,135	0	1.048		
13	2016	0	3,135	0	1.048		
14	2017	0	3,135	0	1.048		
15	2018	0	3,135	0	1.048		
16	2019	0	3,135	0	1.048		
17	2020	0	2,988	0	1.031		
18	2021	0	2	0	0.001		
19	2022	0	0	0	0.000		
20	2023	0	0	0	0.000		
TOTAL		66,265	66,827				

** Peak MW savings are defined in this evaluation as the weekday peak period Monday through Friday from 2PM to 6PM during the months of May through September.

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.

Differences between the ex ante estimates and ex post accomplishments are due to the 9-year EUL assumed for all direct-install measures and greater hours of operation assumed for all lighting measures. The weighted average ex post EUL for CFL measures is 3.6 years based on annual hours of operation from logger data and 10,000 hour lifetime from manufacturer data. If the 9-year EUL for CFL measures is used, then the ex post TRC would be closer to the PIP/ex ante value. The ex ante lighting measure savings assumed 4,000 annual hours of operation. The average ex post operating hours are 2,822 ± 292 hours/yr based on light logger data for 1,842 fixtures at 68 sites. This is 30% less than the 4,000 hours/yr assumed in the PIP goals and ex ante estimates. If the higher hours of operation and longer EUL values are used, then the ex post kWh savings, realization rates and TRC would be closer to the ex ante values. The net ex post first-year savings are 6,712,686 kWh/yr and this is 9.1% less than the PIP goal.[3] The difference is largely due to lower operating hours for lighting measures.

Participant and non-participant process surveys were used to obtain general feedback and suggestions. Survey results indicate 90 percent of participants were satisfied with the program based on survey responses to 852 questions from 68 randomly selected participants. Most participants expressed appreciation for measures installed by courteous RHA technicians. Process survey responses indicated significant demand for the program with an overall satisfaction rating of 9.0 ± 0.1 out of 10 points. Participants indicated that they would like to see the program continue to serve businesses in the Chico, Orland, and Yuba City area and expand to other communities in California. Non-participant survey results within the program area (i.e., Chico, Orland, and Yuba City) and non-participant survey results outside the program area (i.e., Colusa, Grass Valley, Nevada City, Red Bluff, Willows, and Cottonwood) indicate 39 percent would have participated if they had known about the program or the program was available in their area. Most indicated better advertising would have helped. Process survey results, on-site verification inspections, and field measurements were used to guide the overall process evaluation in terms of investigating operational characteristics of the program and developing specific recommendations to help make the program more cost effective, efficient, and operationally effective. The most important process recommendations are as follows.

- Compare pre- and post-retrofit billing data to verify customers are saving energy. Sites with billing data indicating low or negative savings should be checked for proper installation and operation of measures (i.e., programmable thermostats).
- Use light loggers and average light logger data for hours of operation for lighting fixtures.
- Make sure technicians take time to properly explain programmable thermostats to participants and provide user-friendly instructions in various languages.
- Install night-time security lighting measures for customers to reduce the tendency to have all lights on at the businesses during unoccupied night-time hours.
- Provide HVAC diagnostic tune-up measures including checking and correcting refrigerant charge and airflow to increase savings, cost effectiveness, and reduce lost opportunities.
- Based on findings from this and other studies, hard-to-reach small commercial tenants are not generally motivated to invest in improving rental space. Due to this problem, program efforts spent on the *Energy Fitness* report might not yield significant savings creditable to the program. Therefore, RHA should install as many cost effective measures as possible, provide generic recommendations, and reduce efforts spent on providing custom audit measure recommendations in the *Energy Fitness* report.

A discussion of actionable recommendations for program changes that can be expected to improve the cost effectiveness of the program, improve overall or specific operations, or improve satisfaction or, of course, all three are provided in the process evaluation section (see section **3.2.3 Process Evaluation Recommendations**).

Section 2 describes how the EM&V study addresses the required CPUC Energy Efficiency Policy Manual objectives, including baseline information, energy efficiency measure

[3] The ex ante savings assume actual unit accomplishments, ex ante savings, and ex ante EUL values. The PIP savings assume ex ante unit goals, ex ante savings, and ex ante EUL values.

information, measurement and verification approach, and the evaluation approach. **Section 2** also includes equations used to develop energy and peak demand savings, sample design, methods used to verify proper installation of measures, and methods used to perform field measurements.

Section 3 provides EM&V study findings including load impact results and process evaluation results regarding what works, what doesn't work, and recommendations to improve the program's services and procedures. **Section 3** also includes measure recommendations to increase savings, achieve greater persistence, and improve customer satisfaction.

Appendix A provides the participant and non-participant survey instruments. **Appendix B** provides the audit data collection form.

2. Required CPUC Objectives and Components

This section discusses how the EM&V study meets the required CPUC objectives and components including baseline information, energy efficiency measure information, measurement and verification approach, and the evaluation approach.

2.1 Baseline Information

Existing studies were used to evaluate baseline and measure-specific energy savings data. Existing baseline data was obtained from prior EM&V studies, the CALIFORNIA MEASUREMENT ADVISORY COMMITTEE (CALMAC, www.calmac.org), and the California Energy Commission (CEC, www.energy.ca.gov). Existing baseline studies for small commercial customers are provided in **Table 2.1**.

Table 2.1 Existing Baseline Studies for Small Commercial Customers

1	*Filing of Pacific Gas and Electric Company Requesting Approval of Proposed Energy Efficiency Programs and Budgets as Part of the 2004-05 Energy Efficiency Program Selection Process Required by Rulemaking 01-08-028,* December 2003.
2	*2004-05 Energy Efficiency Program Selection R.01-08-028, Energy Efficiency Proposal, Statewide Nonresidential Retrofit Express Efficiency*, Appendix C, References/Workpapers/Data Assumptions, prepared by PG&E, December 2003.
3	*California Energy Demand: 1995-2015,* P300-95-008, California Energy Commission, 1516 Ninth Street, Sacramento, CA 95814, 1995
4	*Southern California Edison Energy Efficiency Potential Study,* prepared for Southern California Edison Company, prepared by XENERGY, 1992.
5	*2004-2005 Database for Energy Efficiency Resources (DEER) Update Study,* page 7-40, prepared for Southern California Edison, prepared by Itron, Inc., Vancouver, Washington 2005.
6	*California Commercial End-Use Survey,* prepared for: California Energy Commission, prepared by: Itron, Inc., CALMAC Study ID: CEC0023.02. 2006.

Ex ante baseline cooling and heating Energy Use Intensity (EUI) data for small commercial customers are provided in **Table 2.2**. These values are from the studies listed in **Table 2.1**.

Table 2.2 Existing Baseline Cooling EUI Data for Small Commercial Customers

Building	CEC Climate Zone	CEUS Study 6 Cooling EUI (kWh/ft2)†	SCE Study 4 Cooling EUI (kWh/ft2)	CEUS Study 6 Heating EUI (kBtu/ft2)
Retail	All	3.03	5.65	3.02
Small Office	All	2.90	3.95	8.62
Restaurant	All	8.22	6.92	7.70
Average		4.71	5.51	6.45

The baseline EUI values for the study are shown in **Table 2.3**. These values are based on participant utility billing data for 59 sites, eQuest (i.e., DOE-2.2) simulations, detailed site audits, and pre-retrofit thermostat schedules.

Table 2.3 Existing Baseline EUI Data for Small Commercial Customers

End Use	EUI W/ft^2	EUI kWh/yr-ft^2	EUI therm/yr-ft^2	Source
Cooling	3.9	3.23		EM&V Study (2.05 PG&E Study 2, Table 2.1)
Space Heating			0.526	PG&E Study 2, Table 2.1
Lighting	2.1	8.1		PG&E Study 2, Table 2.1

2.2 Energy Efficiency Measure Information

This section provides energy efficiency measure information including assumptions about important variables and unknowns, especially those affecting energy savings. Ex ante deemed energy savings for installed measures are provided in **Table 2.4** and are based on RHA estimates and the Statewide Nonresidential Express Efficiency Program (see PG&E Studies 1 and2 **Table 2.1**). Ex ante deemed savings for audit recommended measures are provided in **Table 2.5** and are based on the Statewide Nonresidential Express Efficiency Program. Savings and effective useful lifetime (EUL) for these measures are from RHA or other sources.[4]

Table 2.4 Ex Ante Savings for Installed Measures

#	Direct Install Measures	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTGR	Qty.
1	Screw-in CFL (27-watt)	Unit	0.046	n/a	246	n/a	8	0.80	12,000
2	T8 Fluorescent w/ Elec. Ballasts	Unit	0.043	n/a	121	n/a	16	0.80	10,000
3	Delamp Fixtures (3 to 2 lamp)	Unit	0.094	n/a	256	n/a	16	0.80	2,000
4	LED Exit Signs	Unit	0.038	n/a	352	n/a	16	0.80	2,000
5	Programmable Thermostats	Unit	0.563	n/a	819	n/a	11	0.80	n/a
6	Vendor Miser	Unit	0	n/a	1,590	n/a	3	0.80	n/a

[4] The Energy Fitness Report is based on the facility energy analysis that provides no-cost energy savings modifications, installs cost-effective energy savings measures, and provides on-site energy education including recommendations of audit measures.

Table 2.5 Ex Ante Savings for Recommended Audit Measures

#	Audit Measures	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTGR	Qty.
1	Seasonal HVAC Maintenance	Site	0.45	n/a	487	26	1	0.80	n/a
2	HVAC Tune-up	Site	0.19	n/a	340	18	10	0.80	n/a
3	Duct Test & Seal and Insulation	Site	0.07	n/a	1,126	65	15	0.80	n/a
4	Programmable Thermostat	Site		n/a	819	55	11	0.80	n/a
5	Efficient HVAC Equipment	Unit	0.20	n/a	921	76	15	0.80	n/a
6	Reflective Window Film	Site	0.634	n/a	555	n/a	15	0.80	n/a
7	Advanced Evaporative cooler	Site	0.54	n/a	502	n/a	15	0.80	n/a
8	Ceiling Fan	Site	0.023	n/a	238	11	15	0.80	n/a
9	Delamp (3 to 2 lamp T12ES/Mag)	Unit	0.043	n/a	201	n/a	16	0.80	n/a
10	Delamp Other	Unit	0.038	n/a	179	n/a	16	0.80	n/a
11	Occupancy Sensors	Site	0.089	n/a	417	n/a	15	0.80	n/a
12	Lower Water Heater Temp.	Unit		n/a	475	11	3	0.80	n/a
13	Time Clock for Elec. Water Heater	Unit		n/a	273	n/a	3	0.80	n/a
14	Insulate Tank & Pipes	Unit		n/a	371	31	11	0.80	n/a
15	Infiltration Reduction	Site		n/a	467	22	20	0.80	n/a
16	R-30 Ceiling Insulation	Site		n/a	1022	102	25	0.80	n/a
17	R-11 to R-19 Wall Insulation	Site		n/a	671	60	25	0.80	n/a
18	High Performance Windows	Site		n/a	820	66	25	0.80	n/a
19	Auto-Closers on Exit Doors	Unit		n/a	85	n/a	8	0.80	n/a
20	Insulated Ice Machine Dispenser	Unit		n/a	2,190	n/a	8	0.80	n/a
21	Auto-Closers for Cooler Boxes	Unit		n/a	929	n/a	8	0.80	n/a
22	Strip Curtain for Walk-in Boxes	sf		n/a	85	n/a	4	0.80	n/a
23	Vending Miser	Unit		n/a	1,590	n/a	3	0.80	n/a
24	Glass Cooler Door Gaskets	lf		n/a	10	n/a	4	0.80	n/a
25	Energy Star Computers, Copiers	Site		n/a	294	n/a	4	0.80	n/a

2.2.1 Measure Assumptions and Intended Results

Measure assumptions were provided by RHA in their PIP as shown in **Table 2.6**. Unless otherwise noted, assumptions for “Energy Fitness Audit Measures” were taken from the Statewide Nonresidential Express Efficiency Program. The EM&V study evaluated the ex ante assumptions.

Table 2.6 Baseline and Energy Efficiency Measure Assumptions

#	Direct Install Measures	Baseline Assumption	Measure Assumption	Annual Hours of Operation	Minimum Savings Target
1	Screw-in CFL (27-watt)	100W	27W	5,703	73% savings
2	T8 Fluorescent Fixtures with Electronic Ballasts	143W	90W	3,267	37% savings
3	Delamp 3-lamp to 2-lamp fixture	143W	96W	3,279	33% savings
4	LED Exit Signs	40W	1W	8,760	97% savings
5	Programmable Thermostat	None	Setup cooling, setback heating	n/a	10% cooling and heating savings
6	Vendor Miser	No control	Control	n/a	49% savings
7	HVAC Tune-up	Dirty Condenser Coil and Air Filter	Clean Condenser Coil and Air Filter	n/a	12.4% savings
	Energy Fitness Audit Measures				
1	Seasonal Maintenance	Dirty Filters/Coil	Clean Filters/Coils		7%
2	HVAC Tune-up	Incorrect RCA	Correct RCA		13%
3	Duct Test and Seal and Insulation	Leaks No Insul.	Seal/Insul. Ducts		Seal 14%/Insul. 3%
4	Programmable Thermostat	None	Setback/setup		20%
5	Energy Efficient HVAC Equipment	7.4 SEER/7.7 EER	11 SEER/10.3 EER		25-33%
6	Reflective Window Film	Clear: 0.83 SHGC	Film: 0.47 SHGC		14%
7	Advanced Evaporative cooler	DX Air Cond.	Evap. Cooler		49%
8	Ceiling Fan	None	Ceiling Fan		10%
9	Delamp. (3 to 2 lamp T12ES/Mag)	143W	90W		37%
10	Delamp Other				33%
11	Occupancy Sensors	3,200 hours	1,500 hours		53%
12	Lower Water Heater Temperature	130F	120F		8%
13	Time Clock for Elec. Water Heater	8,760 hrs/y	4,380 hrs/y		4%
14	Insulate Tank & Pipes	No Insulation	R8 Tank, R4 Pipe		10%
15	Infiltration Reduction	0.5 ACH	0.4 ACH		2%
16	R-30 Ceiling Insulation	None	R-30		10-20%
17	R-11 to R-19 Wall Insulation	R-11	R-19		-
18	High Performance Windows	Single Pane	Low-E		30%
19	Auto-Closers on Exit Doors	None	Auto Closer		1%
20	Insulated Ice Machine Dispenser	Uninsulated Box	Insulated Box		20%
21	Auto-Closers for Cooler Boxes	None	Auto Closer		2%
22	Strip Curtain for Walk-in Boxes	None	Strip Curtain		3%
23	Vending Miser	No Control	Vending Miser		30-55%
24	Glass Cooler Door Gaskets	Leaky Gasket	Tight Gasket		2%
25	Energy Star Computers & Copiers	None	Power Manage		10%

The program ex ante and ex post energy and demand savings are shown in **Table 2.7**. The lifecycle ex-post net lifecycle kWh realization rate is 0.80 ± 0.05. The program implementation plan (PIP) cost effectiveness is 1.8 for the TRC test and 10.3 for the participant test. The ex ante TRC is 2.2 and the participant test is 11.7. The EM&V ex-post TRC is 1.2 and the participant test is 5.9. Ex post cost effectiveness is less than PIP/ex ante due to assuming greater hours of operation for lighting measures and greater effective useful lifetimes. The PIP/ex ante net savings were reduced by using lower net to gross ratios (i.e., ex ante used a net to gross ratio of 0.80 instead of 0.96 for Express Efficiency type measures).

Table 2.7 Ex Ante and Ex Post Load Impacts

Program	Utility	Net kWh/yr	Net kW	Net therm/yr	Net Lifecycle kWh	Net Lifecycle therm
RHA #1409-04 PIP goal	PG&E	7,381,944	1,592		66,264,696	
RHA #1409-04 ex ante	PG&E	9,328,191	2,521		83,775,737	
RHA #1409-04 ex post	PG&E	6,712,686	2,385		66,827,070	

2.2.2 Description of Installed Energy Efficiency Measures

This section provides a full description of each energy efficiency measure including assumptions about important variables and unknowns, especially those affecting energy savings. The study evaluated the ex ante measure savings and assumptions and developed ex post savings values for each measure.

1. Screw-in Compact Fluorescent Lamps (CFLs) – Direct Install Measure

Compact fluorescent lamps are designed to replace standard incandescent lamps. They are approximately four times more efficacious than incandescent light sources. Screw-in modular lamps have reusable ballasts that typically last four lamp lives. Commercial applications for compact fluorescent lamps include general lighting, accent and specialty lighting, decorative and portable lighting, utility lighting, and exterior illumination. As with all fluorescent lamps, CFLs emit light when low-pressure mercury vapor is energized inside the lamp, which produces ultraviolet (UV) radiation. The UV radiation is absorbed by a phosphor coating on the inner surface of the lamp, which converts the radiation into light. Ballasts provide initial voltage for starting lamps and regulate lamp current during operation. CFL ballasts are electronic. Incandescent lamps typically use 15 to 100W and can be replaced with CFLs using 4 to 27W. The ex ante savings for CFLs were 0.046 kW and 246 kWh/yr (based on replacing 100W incandescent lamps with 27W CFLs). Energy Fitness ex ante deemed savings for other CFL measures are shown in **Table 2.8**.

Table 2.8 Ex Ante Savings for CFLs

#	Description	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTGR	Qty.
1a	150W Incandescent to 42W CFL	Unit	0.108	4,000	432	n/a	2.5	0.80	
1b	100W Incand. to 29W CFL	Unit	0.071	4,000	284	n/a	2.5	0.80	
1c	100W Incand. to 26W CFL	Unit	0.074	4,000	296	n/a	2.5	0.80	
1d	75W Incand. to 22W CFL	Unit	0.053	4,000	212	n/a	2.5	0.80	
1e	60W Incand. to 16W CFL	Unit	0.044	4,000	176	n/a	2.5	0.80	
1f	60W Incand. to 13W CFL	Unit	0.047	4,000	188	n/a	2.5	0.80	
1g	40W Incand. to 9W CFL	Unit	0.031	4,000	124	n/a	2.5	0.80	
1h	R-30 65W Incand. to 16W CFL	Unit	0.049	4,000	196	n/a	2.5	0.80	
1i	R-30 65W Incand. to 14W CFL	Unit	0.051	4,000	204	n/a	2.5	0.80	
1j	R-40 75W Incand. to 19W CFL	Unit	0.056	4,000	224	n/a	2.5	0.80	
1k	PAR-38 69W Incan. to 19W CFL	Unit	0.050	4,000	200	n/a	2.5	0.80	
1l	R-20 50W Incand. to 9W CFL	Unit	0.041	4,000	164	n/a	2.5	0.80	
1m	R-20 30W Incand. to 5W CFL	Unit	0.025	4,000	100	n/a	2.5	0.80	
1n	60W Candella to 14W CFL	Unit	0.046	4,000	184	n/a	2.5	0.80	
1o	15W Candella to 4W CFL	Unit	0.011	4,000	44	n/a	2.5	0.80	
1p	60W Globe G-25 to 16W CFL	Unit	0.044	4,000	176	n/a	2.5	0.80	

2. LED Exit Signs from Incandescent – Direct Install Measure

LED exit signs are used to replace incandescent or fluorescent exit signs. LED exit signs last up to 16 years, making the technology suitable to all situations, particularly where maintenance is a concern or where relamping is performed. LED exit signs require no maintenance. They are used until they burn out and then the exit sign is replaced. LED exit signs contain light emitting diodes (LED). The LED produces light when low-voltage direct current crosses a suitable semiconductor junction. The color of the light that is produced is determined by the composition of the semiconductor junction. Exit signs typically contain red or green LED lamps. Some exit signs use a diffuser to spread the light emitted by the LED. Typically, LED exit signs consume one to four Watts compared to incandescent exit signs which typically consume 40 Watts. The Energy Fitness direct-install measure LED exit sign involves replacing 40W incandescent or 14W fluorescent exit signs with 1W LED (or 2W) exit signs. The program implementation plan savings for LED exit signs are 0.039 kW and 355 kWh/yr. The Energy Fitness ex ante deemed savings for LED exit signs are shown in **Table 2.9**.

Table 2.9 Ex Ante Savings for LED Exit Signs

#	Description	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTGR	Qty.
2a	Incand. to LED Exit – 1 socket	Unit	0.039	8,760	342	n/a	16	0.80	
2b	Incand. to LED Exit – 2 socket	Unit	0.038	8,760	333	n/a	16	0.80	
2c	Fluorescent to LED Exit	Unit	0.013	8,760	114	n/a	16	0.80	

3. Replace 100W Incandescent with Fluorescent – Direct Install Measure

High efficiency fluorescent fixtures are four times more efficient than conventional incandescent fixtures. The Energy Fitness direct-install measure fluorescent measure involves replacing incandescent fixtures with fluorescent fixtures. The program implementation plan savings for replacing 100W incandescent with fluorescent fixtures are 0.074 kW and 346 kWh/yr.

4. Delamp Three-Lamp Fixtures to Two-Lamp Fixtures – Direct Install Measure

Delamping three-lamp to two-lamp fixtures saves 37 percent on lighting and often provides adequate illumination. The program implementation plan savings for delamping are 0.043 kW and 201 kWh/yr. The Energy Fitness deemed savings for delamping are shown in **Table 2.10**.

Table 2.10. Ex Ante Savings for Delamping

#	Description	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTGR	Qty.
4a	Delamp 150W Incandescent	Unit	0.150	4,000	600	n/a	16	0.80	
4b	Delamp 100W Incandescent	Unit	0.100	4,000	400	n/a	16	0.80	
4c	Delamp 75W Incandescent	Unit	0.075	4,000	300	n/a	16	0.80	
4d	Delamp 60W Incandescent	Unit	0.060	4,000	240	n/a	16	0.80	
4e	Delamp 40W Incandescent	Unit	0.040	4,000	160	n/a	16	0.80	
4f	Delamp 25W Incandescent	Unit	0.025	4,000	100	n/a	16	0.80	
4g	Delamp T12 F40/Mag Ballast – 1 Lamp Fixture	Unit	0.044	4,000	176	n/a	16	0.80	
4h	Delamp T12 F40/Mag Ballast – 2 Lamp Fixture	Unit	0.082	4,000	328	n/a	16	0.80	
4i	Delamp T12 F96/Mag Ballast – 1 Lamp Fixture	Unit	0.064	4,000	256	n/a	16	0.80	
4j	Delamp T12 F96/Mag Ballast – 2 Lamp Fixture	Unit	0.128	4,000	512	n/a	16	0.80	

5. Change T-12 Fluorescent to T-8 with Electronic Ballasts – Direct Install Measure

Change T-12 fluorescent to T-8 with electronic ballasts involves replacing 1½-inch diameter T-12 fluorescent lamps and standard magnetic ballasts. High efficiency components use tri-phosphor 1-inch diameter T-8 lamps (32 W), and electronic ballasts. The Energy Fitness deemed savings for changing T-12 magnetic to T-8 electronic ballasts are shown in **Table 2.11**.

Table 2.11 Ex Ante Savings for Changing T-12 Magnetic to T-8 Electronic Ballasts

#	Description	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Ante NTGR	Qty.
5a	Change T12 F40/Mag to T-8 Elec. Ballast – 1 Lamp Fixture	Unit	0.020	4,000	80	n/a	16	0.80	
5b	Change T12 F40/Mag to T-8/Elec. Ballast – 2 Lamp Fixture	Unit	0.024	4,000	96	n/a	16	0.80	
5c	Change T12 F40/Mag to T-8/Elec. Ballast – 3 Lamp Fixture	Unit	0.044	4,000	176	n/a	16	0.80	
5d	Change T12 F40/Mag to T-8/Elec. Ballast – 4 Lamp Fixture	Unit	0.052	4,000	208	n/a	16	0.80	
5e	Change T12 F96/Mag F96 to T-8/Elec. Ballast – 1 Lamp Fixture	Unit	0.017	4,000	68	n/a	16	0.80	
5f	Change T12 F96/Mag to T-8/Elec. Ballast – 1 Lamp Fixture	Unit	0.019	4,000	76	n/a	16	0.80	

6. Programmable Thermostat –Direct Install/Audit Measure

Programmable thermostats are used to turn-off or setup HVAC equipment during periods when the building is unoccupied. Setup thermostats are typically used for areas where it is undesirable to shut off equipment due to such concerns as freeze protection or the need to provide some conditioning for equipment. The Statewide Express Efficiency deemed savings for programmable thermostats are 4,093 kWh/yr and 1,095 therm/yr based on PG&E calculations for a programmable thermostat on a small package AC system serving 5,000 ft^2 of an office facility with estimated energy savings of 40 percent for cooling and heating (and zero kW savings).[5] The Energy Fitness savings for programmable thermostats are 819 kWh/yr and no kW or therm savings are indicated.

7. Vending Miser – Direct Install/Audit Measure

Vending Misers reduce energy use in vending machines by using a passive infrared sensor to power down a vending machine when the area surrounding it is unoccupied and automatically repowers the vending machine when the area is reoccupied. The Vending Miser controller uses fuzzy logic to learn from the habits of the building occupants, and modifies the time-out period accordingly. An optional Sensor Repeater allows the control of a bank of vending machines with a single sensor, minimizing installation time and visual impact. Additionally, Vending Misers monitor the ambient temperature while the vending machine is powered down. Using this information, Vending Misers automatically power up the vending machine at appropriate intervals, independent of occupancy, to ensure that the vended product stays cold. Vending Misers also monitor electrical current used by the vending machine. This ensures that Vending Miser will never power down a vending machine while the compressor is running, so a high head pressure start never occurs. In addition, the current sensor also ensures that every time the vending machine is powered up, the cooling cycle is run to completion before again powering down the vending machine. The effective useful lifetime is 3 years.

8. HVAC Tune-up

The HVAC tune-up measure included installation of clean air filters and chemical condenser coil cleaning. According to the 2004-05 DEER Update Study, cleaning condenser coils saves 12.4%.[6] Chemical cleaning of condenser coils with an alkaline cleaner emulsifies baked-on dirt and grime so it can be rinsed away with water to restore the design heat transfer. Condensing coils are similar to a vacuum cleaner sucking in greasy dirt and dust that collects on the coils that gets baked on over time. When finned coils get dirty, heat transfer is reduced. In turn, compressors have to work much harder, operating costs go up, and valuable equipment can break down when it is needed most. For every 2°F rise in condensing temperature caused by dirty coils, efficiency is reduced by 1% and power consumption is increased by 1%. Cleaning coils protects equipment and helps maintain peak operating efficiency.

2.2.3 Description of Energy Fitness Audit Measures

This section provides a full description of the Energy Fitness audit measures including assumptions about important variables and unknowns, especially those affecting energy savings.

1. Seasonal Maintenance (i.e., Clean Air Filters)

Seasonal maintenance involves cleaning air filters to save cooling and heating energy by improving airflow across the evaporator heat transfer and this increases cooling capacity.

[5] The PG&E baseline cooling for a 5,000 ft^2 office building is 10,353 kWh/yr (EUI is 2.05 kWh/yr-ft^2) and baseline heating is 2,631 therm/yr (EUI is 0.5262 therm/yr-ft^2). See PG&E Study 2, Appendix C.
[6] Itron, Inc. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report*. 2005. page 7-40, Prepared for Southern California Edison Company. Prepared by Itron, Inc., Vancouver, WA. Available online: http://eega.cpuc.ca.gov/deer/.

2. HVAC Tune-up

HVAC tune-ups involve installation of clean air filters, chemical condenser coil cleaning, and refrigerant charge and airflow diagnostics.

3. Duct Test and Seal and Insulation

Duct leakage in forced-air distribution systems represents a large efficiency loss in small commercial buildings adding 20-30 percent to heating and cooling energy use. California field studies have shown that duct leakage in small commercial buildings is 35 percent of fan flow, with a larger fraction on the supply side. These studies have also shown duct leaks in small commercial buildings are outside conditioned space more than 50 percent of the time, and that contractors have no difficulty finding duct leaks in systems located outside the building insulation. The impacts of duct leakage increase rapidly at high outdoor temperatures (peak demand periods), which means fixing leaks has a greater impact on energy use during peak periods as compared to milder weather conditions. The full peak electricity demand reduction associated with duct sealing can be realized in small commercial buildings since these buildings are cooled throughout the day. Duct sealing requires use of duct pressurization equipment to detect the leaks. Leaks are sealed using hand or Aeroseal applied mastic, or UL-rated metal or butyl tape. Savings are based on measured data. Duct testing and sealing savings are based on sealing both supply and return ducts to a maximum leakage of 15 percent of measured system flow at 25 Pascal pressure (supply and return).

4. Programmable Thermostat

Programmable thermostats are discussed above.

5. Efficient HVAC Equipment

The 1990 national appliance efficiency standards for packaged and split-system central air conditioners with cooling capacities less than 65,000 Btu/hr (i.e., < 5.4 tons) require a minimum Seasonal Energy Efficiency Rating of 10. Approximately 50 percent of small commercial air conditioners are packaged units with air handler, evaporator, compressor, and condenser mounted in a metal box and typically roof-mounted to save interior space. The rest are split systems with an outdoor section housing the compressor and condenser and an indoor section housing the evaporator.

6. Reflective Window Film

Reflective window film reduces solar energy gains, thus reducing mechanical cooling energy consumption. Addition of film is often cost effective on all clear glass except north-facing exposures. Typical film thickness is 0.001 to 0.004 inches. Films are made with a variety of adhesives and are applied on-site to the interior surface (i.e., facing the room) of single- or double-pane windows. Historical problems of fading, installation difficulties, and poor adhesive performance have been solved through advancements in film and adhesive technologies and better application processes. “Second generation” window films often have low-emissivity coatings that provide good visible transmittance (VT), solar heat gain coefficients (SHGC), and shading coefficients (SC). Besides reducing cooling loads, adding reflective films improves shatter resistance and blocks up to 99 percent of ultraviolet radiation. Summer comfort near windows is improved as well. However, winter space heating energy use will typically increase from 10 to 25 percent due to the loss of winter-time solar gains. **Shading Coefficient** (SC) is the historical performance metric for rating solar gain. SC is the ratio of total solar transmission to the transmission through 1/8-inch clear glass. **Solar Heat Gain Coefficient** (SHGC) is similar to shading coefficient and is becoming the standard for window solar performance. SHGC is the fraction of incident solar energy transmitted through the window. SHGC is expressed as a number between 0 and 1, and a lower SHGC means less heat gain. SHGC is particularly important in southern climates. Shading coefficient times 0.87 equals SHGC. **Visible Transmittance** (VT) is the percentage of visible light that makes it through a window. VT is expressed as a number between 0 and 1. Heavily tinted products with low shading coefficients typically have low VT. **Luminous Efficacy (Ke)** is the ratio of daylight transmittance to shading coefficient (VT/SC). This dimensionless ratio is also called the lighting-and-cooling selectivity index (LCS). Film must have a minimum five-year manufacturer's warranty. Statewide rebates are not available for windows with northern exposure. Additionally, film must have either a solar heat gain coefficient (SHGC) ≤ 0.39 and be applied to single-pane glass, or film can have an SHGC ≤ 0.47 and Luminous Efficacy, i.e., visible transmittance to shading coefficient ratio (VT/SHGC) ratio > 1.3. The Statewide Express Energy program savings for reflective window film are as follows: 13 kWh/yr-ft^2 for coastal areas; 16 kWh/yr-ft^2 for inland areas; and 24 kWh/yr-ft^2 for desert areas. No kW savings are given. Statewide savings appear to be unrealistic.

Average commercial building loads for a typical office building are shown on **Figure 2.1**. Solar heat gains represent the largest building load at 27 percent.

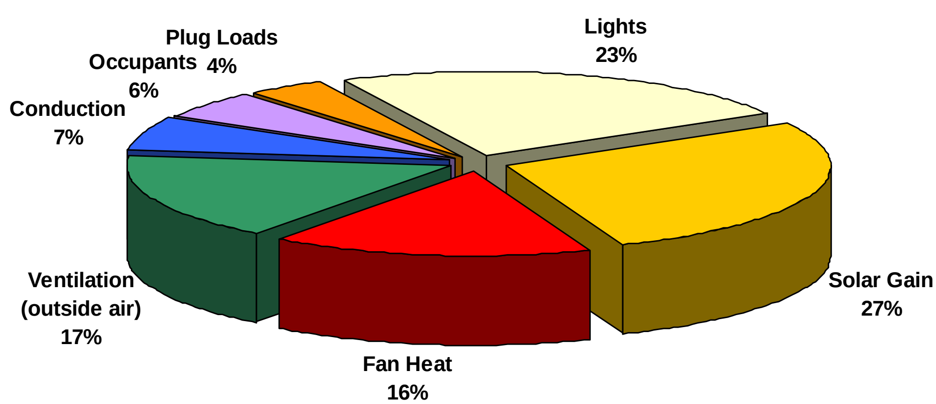

Figure 2.1. Air Conditioning Loads in Commercial Buildings

7. Advanced Evaporative Cooler

Advanced direct evaporative coolers contain evaporative pads (usually of aspen wood fibers), a pump, sump, and fan. A pump lifts sump water to the distributing system and it flows down through the pads back to the sump. A fan within the cooler pulls the hot, dry outdoor air through the evaporative pad. As the air passes through the wetted pad, water evaporates, and the air becomes both cooler and more humid. Cooler and more humid air is then delivered to the conditioned space. As air passes through a direct evaporative cooler, its dry-bulb temperature approaches the wet-bulb temperature. Energy is neither gained nor lost from the air, but is exchanged within the air such that the air becomes both cooler and more humid. Sensible heat in the air is converted to latent heat through evaporation, creating an energy-equivalent rise in the air's humidity as the dry-bulb temperature is lowered. This is an "adiabatic" process. The effectiveness of the evaporative cooler is defined as the dry-bulb temperature drop of the air divided by the maximum potential temperature drop. This is also known as the wet-bulb depression, which is the incoming dry-bulb temperature minus the incoming outdoor wet-bulb temperature. Direct evaporative cooling effectiveness depends upon the outdoor wet bulb temperatures and humidity levels. Most commercial evaporative coolers have an effectiveness of 85 percent, which means that the dry-bulb temperature of the incoming air is reduced by 85 percent of the difference between the dry-bulb and the wet-bulb temperature of the air.

Direct evaporative coolers are manufactured in sizes ranging from 2,000 to 20,000 cfm using current technology and available equipment. Evaporative coolers are not applicable to sites where high indoor humidity is a concern. If an evaporative cooler is used in an inappropriate climate, it may not have the ability to cool but instead raise the humidity level in the room. Evaporative coolers must replace an existing, vapor-compression air conditioning system, or the existing system must be made inoperable. Energy and demand savings assume vapor-compression air conditioners (typically package units) are replaced with direct evaporative cooling. Peak demand savings (kW) and annual energy savings (kWh/yr) are the difference in use between operating an air conditioning unit and a direct evaporative cooler. This is applicable to small commercial and industrial customers with a moderate to low concern about humidity.

8. Ceiling Fan

Ceiling fans save energy by reducing the mean average temperature experienced by occupants in the space by circulating cooling or heating air more effectively.

9. Delamping Three-Lamp Fixtures to Two-Lamp Fixtures

Delamping three-lamp to two-lamp fixtures saves 37 percent on lighting and often provides adequate illumination (see direct install measure 4, above).

10. Delamping Other

Delamping other assumes other combinations of lamps, i.e., 4 to 3 lamps or 2 to 1 lamp, saving 33 percent on average.

11. Occupancy Sensors in Areas with Intermittent Occupancy

Occupancy sensors are used to automatically turn on and off lights when people enter or leave rooms. They can be wall or ceiling mounted, passive infrared (PIR) or ultrasonic. Occupancy sensors are reliable, market tested products, but require proper installation and calibration. Understanding the difference in operation between PIR and ultrasonic products is the key to proper installation. Occupancy sensors are applicable in most market sectors except retail and should only be connected to lighting loads that have instant start characteristics (incandescent or fluorescent).

12. Lower Hot Water Set Point Temperature

Lowering hot water set point temperature saves gas energy by reducing the hot temperature difference from inlet to tank and standby losses.

13. Time Clock for Electric Water Heater

The time clock for electric water heaters saves energy by setting back or turning off the tank when not in use.

14. Insulate Tank and Hot Water Pipes

Hot water tank and pipe insulation saves energy by reducing standby and distribution pipe losses.

15. Infiltration Reduction

Infiltration reduction saves cooling and heating energy by reducing building envelope leakage.

16. R-30 Ceiling Insulation

R-30 ceiling insulation saves 10 to 20 percent on cooling and heating from reduced heat gain or loss through the ceiling.

17. R-11 to R-19 Wall Insulation

Wall insulation saves cooling and heating energy from reduced heat gain or loss through the walls.

18. High Performance Windows

High performance windows save cooling and heating energy by reducing heat gain or heat loss through windows. Standard windows are single pane. High performance windows are low-e with a solar heat gain coefficient of 0.4 or less and u-value of 0.23 Btu/ft^2-hr-°F.

19. Auto-Closers on Exit Doors.

Automatic, hydraulic-type door closers on exit doors will reduce air infiltration and save energy.

20. Insulated Ice Machine Dispenser Box

The insulated dispenser box maintains ice longer and reduces heat gain to the ice maker. When RHA performs an energy audit, they determine the connected load (kW) for the ice dispenser box from the name plate information. Ice boxes are typically on all the time. RHA assumes 4,380 hours of operation per year (8,760 hrs/yr with 50 percent cycling) to estimate the total annual usage in kWh. A savings of 20 percent is assumed for the insulated boxes. For example, if the total connected load is 2.5 kW, then annual usage is assumed to be 10,950 kWh/yr (i.e., 2.5 kW x 4380 hrs/yr. = 10,950 kWh). Annual savings are assumed to be 20 percent or 2,190 kWh/yr.

21. Auto-Closers for Cooler Boxes

Automatic, hydraulic-type door closers on cooler box doors to walk-in coolers or freezers will reduce air infiltration and save energy. The door size on a walk-in cooler or freezer must have a minimum perimeter of 16 ft. The auto-closer must use hydraulic action to firmly close a door which is within 1" of full closure.

22. Strip Curtain for Walk-in Boxes

Strip curtains installed on doorways to walk-in boxes and refrigerated warehouses save energy by decreasing infiltration of outside air into the refrigerated space. Although refrigerated spaces have doors, which if kept closed would make strip curtains obsolete, they are often left open. Strip curtains are a simple application and have been supported in the technical field for years. Though the consumer market has been receptive to their use, there is still potential for additional market penetration.

23. Vending Miser

Vending Misers reduce energy use in vending machines by using a passive infrared sensor to power down a vending machine when the area surrounding it is unoccupied and automatically repowers the vending machine when the area is reoccupied (see direct install measure 7, above).

24. Glass Cooler Door Gaskets (Reach-in or Walk-in)

Glass cooler door gaskets replace weak and worn-out glass-door gaskets. New better-fitting gaskets reduce air infiltration into the refrigerated display case and save energy. Statewide rebates require minimum perimeter of 16 feet. Replacement gaskets must be framed to meet the manufacturer’s specifications, specifically regarding dimensions, materials, attachment method, style, compression, and magnetism.

25. Energy Star Computers and Copiers

Energy Star computers and copiers include power management software to turn off the products when not in use. Savings are 10 percent.

2.3 Measurement and Verification Approach

The measurement and verification approach for the study is based on the *International Performance Measurement & Verification Protocols* (IPMVP) defined **Table 2.12**.[7]

Table 2.12 IPMVP M&V Options

M&V Option	How Savings Are Calculated	Typical Applications
Option A. Partially Measured Retrofit Isolation Savings are determined by partial field measurement of energy use of system(s) to which a measure was applied, separate from facility energy use. Measurements may be either short-term or continuous. Partial measurement means that some but not all parameters may be stipulated, if total impact of possible stipulation errors is not significant to resultant savings. Careful review of measure design and installation will ensure that stipulated values fairly represent the probable actual value.	Engineering calculations using short term or continuous post-retrofit measurements or stipulations.	Showerhead/aerator pre- and post-retrofit flow rates are measured and operating hours are based on interviews with occupants or stipulated values.
Option B. Retrofit Isolation Savings are determined by field measurement of the energy use of the systems to which the measure was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements	Variable speed controls used on a constant speed pump. . Electricity use is measured with a kWh meter on pump motor. Metering is performed to verify pre-retrofit constant speed operation and post-retrofit variable speed operation.
Option C. Whole Facility Savings are determined by measuring energy use (and production) at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period. Continuous measurements are based on whole-facility billing data.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis or conditional demand analysis.	Energy management program affecting many systems in a building. Utility meters measure energy use for 12-month base year and throughout post-retrofit period.
Option D. Calibrated Simulation Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.	Project affecting many systems in a building but where base year data are unavailable. Utility meters measure post-retrofit energy use. Base year energy use is determined by simulation using a model calibrated with post-retrofit utility data.

2.3.1 M&V Approach for Load Impact Evaluation

The M&V approach for the load impact evaluation involved performing on-site measurement and verification activities for a statistically significant random sample of participating customers. Ex post energy savings for each measure were determined using the following IPMVP Options.

- The Energy Fitness lighting measures were evaluated using IPMVP Option B (i.e., retrofit isolation), and programmable thermostats and vendor misers were evaluated using Option A (i.e., stipulated or deemed values). Field measurements of lighting fixture power usage and hours of operation were evaluated using lighting loggers or participant reported hours of operation.

- Energy Fitness audit measures were evaluated using IPMVP Option A (i.e., stipulated values or deemed savings). RHA provided the number of audit checklist measures installed and telephone survey results from participating customers were used to develop

[7] See *International Performance Measurement & Verification Protocols*, DOE/GO-102000-1132, October 2000.

an estimate of the adoption of audit measures.[8] The study verified whether customers participated in both the RHA Program and one or more other CPUC-funded programs (e.g., Express Efficiency Rebates, etc.) to ensure that no "double dipping" occurred for the same measures. Data collected from the Energy Fitness database and telephone surveys were analyzed to measure the energy and peak demand savings achieved by the program.

Gross ex post savings for each measure was calculated based on information or measurements collected in the statistical random sample of on-site inspections, telephone surveys, engineering analyses, and simulations or stipulated values. **Sample mean savings estimates** were calculated using **Equation 1**.

Eq. 1 $\bar{y}_i = \text{Mean Savings} = \frac{1}{n_i}\sum_{j=1}^{n_i} y_j$

Where,

$\bar{y}_i =$ Mean savings for measure "i" in the sample (i.e., therm/yr).

$n_i =$ Number of measures "i" in the sample.

Savings were adjusted based on the proportion of measures, $\hat{p}_i$ **,** found properly installed during verification inspections.

Eq. 2 Adjusted savings = $\hat{p}_i \bar{y}_i$

Where,

$\hat{p}_i =$ Proportion $= \frac{n_{verified}}{n_i}$

$n_{verified} =$ Number of verified measures in the sample.

The standard error, se$_i$**, of the measure sample mean** was calculated using **Equation 3, Equation 4** or both depending on the measure.[9]

Eq. 3 se_{i_p} = Standard Error of the Proportion $= \sqrt{\frac{\hat{p}_i(1-\hat{p}_i)}{n_i}}$

The standard error of mean savings was calculated using **Equation 4**.

[8] The RHA tracking database contained customer name, address, telephone, contact, square feet, direct install measures, recommended measures, and estimated savings for measures.

[9] The standard error for all measures was calculated based on the proportion of measures found properly installed from the on-site surveys. In addition, for measures where weighted average savings were for each climate zone were available, the standard error of the mean savings was also calculated. These two standard errors were then combined to characterize the statistical precision of the sample mean as an estimator of the population mean. The population total was estimated by multiplying both the sample mean and the corresponding combined error bound by the number of units in the population as per sampling procedures from *The California Evaluation Framework*, prepared for the CPUC and Project Advisory Committee, prepared by TecMarktWorks Framework Team, Chapter 13: Sampling, February 2004.

Eq. 4 se_{i_s} = Standard Error of Mean Savings $= \sqrt{\dfrac{\sum_{j=1}^{n}\left(y_j - \bar{y}\right)^2}{n(n-1)}}$

The measure error bound at the 90 percent confidence level was calculated using **Equation 5** combining the applicable standard errors from **Equations 3** and **4**.

Eq. 5 Measure Error Bound $= \hat{p}_i \bar{y}_i (1 \pm (t)\sqrt{se_{i_p}^2 + se_{i_s}^2})$

Where,

t = The value of the normal deviate corresponding to the desired confidence probability of 1.645 at the 90 percent confidence level per CADMAC Protocols.

Savings for all measures "m" in the program was calculated using **Equation 6**.

Eq. 6 $\hat{Y} =$ Program Savings $= \sum_{i=1}^{m}\left(N_{p_i} \times \hat{p}_i \bar{y}_i\right)$

Where,

N_{p_i} = Number of "i" measures in the entire program population.

The program error bound for all measures was calculated using **Equation 7**.

Eq. 7 Program Error Bound $= \sum_{i=1}^{m} N_{p_i}\left\{\hat{p}_i \bar{y}_i \left(1 \pm (t)\sqrt{se_{i_p}^2 + se_{i_s}^2}\right)\right\}$

Net savings were calculated as gross savings times the CPUC-accepted 0.96 net-to-gross ratio.

2.3.2 Sampling Plan

The sampling plan was used to verify measure installation as well as for estimate ex post energy savings. The statistical sample design involved selecting a random sample of customers from the program participant population. Samples were selected to obtain a reasonable level of precision and accuracy at the 90 percent confidence level per CPUC Energy Efficiency Policy Manual (EEPM). The sample design was based on statistical survey sampling methods to select a sample of participants to meet the CADMAC Protocols.[10] Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results.[11]

---

[10] See Table 5c, Protocols for the General Approach to Load Impact Measurement, page 14, Evaluation design decisions related to sample design will be determined by the following protocols: if the number of program participants is greater than 200 for residential programs, a sample must be randomly drawn and be sufficiently large to achieve a minimum precision of plus/minus 10 percent at the 90 percent confidence level, based on total annual energy use. A minimum of 200 for residential programs must be included in the analysis dataset for each applicable end-use. *Protocols and Procedures for Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs*, as adopted by the California Public Utilities Commission Decision 93-05-063, Revised March 1998.

[11] Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

The sample size necessary to obtain the desired 10 percent relative precision for program mean savings estimates was calculated using **Equation 8**.

Eq. 8 $$\text{Sample Size} = n_i = \frac{t^2 C_{vi}^{\ 2}}{r^2}$$

Where,

n_i = Required sample size for measure "i",

t = The value of the normal deviate corresponding to the desired confidence probability of 1.645 at the 90 percent confidence level per CADMAC Protocols,

r = Desired relative precision, 10 percent per CADMAC Protocols,

C_{vi} = Coefficient of variation, $\frac{s_i}{\bar{y}_i}$, for measure "i."

For small populations, the sample size was corrected using the finite population correction (FPC) equation as follows.[12]

Eq. 9 $$\text{FPC Sample Size} = n_{FPCi} = \frac{n_i}{1+(n_i - 1)/N}$$

Where,

n_{FPCi} = Sample size for measure "i" with finite population correction.

The preliminary and actual statistical sample sizes for the EM&V study are shown in **Table 2.13**.

Table 2.13 Statistical Sample Size for the EM&V Study

Measure Description	Ex Ante Units	Proposed Sample	Preliminary Cv	Ex Post Units	Actual Sample	Actual Cv	Relative Precision
Screw-in CFL (4-65-watt)	14,165	68	0.5	22,271	705	0.68	0.042
T8 Fluorescent Fixtures with Electronic Ballasts	14,270	68	0.5	6,240	668	0.40	0.026
Delamp Fluorescent or Incandescent Fixtures	10,634	68	0.5	15,596	1446	0.53	0.023
LED Exit Signs	91	68	0.5	488	17	0.00	0.000
Programmable Thermostats	175	10	0.5	151	4	0.12	0.100
Vendor Misers	17	2	0.5	28	0	n/a	n/a
HVAC Tune-up	100	10	0.5	103	2	0.09	0.100

2.3.2 M&V Approach for Process Evaluation

The M&V approach for the process evaluation involved designing and implementing pre-process participant and non-participant surveys to evaluate participant satisfaction, and to obtain suggestions to improve the program's services and procedures. Interview questions assessed how the program influenced awareness of linkages between efficiency improvements, bill savings, and increased comfort for customers. A sample of 68 small commercial participants, 68 non-participants, and 20 non-contacted businesses were asked process questions. The 68 participants were asked questions to evaluate the adoption rate of audit measures. The participant, non-participant, and non-contacted surveys are provided in the **Appendices**. Participants were asked

[12] Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

why and how they decided to participate in the program. Non-participants were asked why they chose not to participate in order to identify reasons why program marketing efforts were not successful with some customers as well as to identify additional hard-to-reach market barriers. Non-contacted businesses were asked if they would have participated in the program if they had been made aware of the program to identify reasons why program marketing efforts were not successful reaching some customers as well as to identify additional hard-to-reach market barriers. Analysis of process evaluation survey data includes a summary of what works, what doesn't work, and the level of need for the program.

2.4 Evaluation Approach

The evaluation approach included:

- A list of questions to be answered by the study;
- A list of evaluation tasks to be undertaken by the study; and
- A description of how the study will be used to meet all of the Commission objectives described in the CPUC EEPM (page 31).

2.4.1 List of Questions Answered by the Study

The study answered the following list of questions.

1. **Are the ex ante measure assumptions appropriate and relevant with respect to actual measures being installed in the program?**
   The study answered this question by evaluating the baseline UEC values and ex ante energy savings estimates using on-site measurements and inspections, engineering analysis, building energy simulations, and billing data (i.e., IPMVP Options A, C, and D). Existing baseline UEC values were evaluated and refined, and ex post savings estimates are provided for each measure based on research performed for this study. The study performed an analysis of the quantity and type of measures that were installed or adopted by program participants by conducting on-site inspections and audits at 68 participant sites to determine if the ex ante measure assumptions are appropriate and relevant.

2. **Is the ex ante net-to-gross ratio of 0.80 appropriate and relevant to this program?**
   The ex ante 0.80 net-to-gross ratio (NTGR) is not correct. Instead the study uses a 0.96 NTGR since the RHA Energy Fitness Program is similar to the Statewide Express Efficiency Program (for small and medium commercial customers). This is based on Table 4.2 Net-to-Gross Ratios, page 23, CPUC *Energy Efficiency Policy Manual*, November 29, 2001.

3. **Are the total program savings estimates accurate?**
   The study answered this question by developing ex post energy savings for the program at the 90 percent confidence level as per CADMAC Protocols.

4. **Are customers satisfied with the program implementation and are customers satisfied with the measures that were offered and installed in the program?**
   The study answered this question by summarizing customer satisfaction responses to process survey questions. Participant satisfaction was found to be generally very high (see **Section 3.2** for more information).

5. **Have some small commercial customers decided not to participate in the program?**

The study answered this question by conducting in-person and telephone interviews with 20 non-participants. The following questions were included:

1. What reasons are there for not participating and how might conditions be revised to motivate participation?
2. Why have non-participants decided not to install similar measures (i.e., compact fluorescent lamps, T8 fluorescent fixtures with electronic ballasts, delamping, LED exit signs, programmable thermostats, and vendor misers)?
3. What barriers tend to reduce or restrict participation?
4. What percent of the small commercial market are affected by each of these barriers?
5. How can marketing, design, implementation, delivery, and follow-up efforts be changed to address these barriers?

6. Is there a continuing need for the program?

The study answered this question by evaluating ex post savings and responses from the in-person and telephone process surveys of participants and non-participants. The RHA Energy Fitness Program provided energy efficiency services to 1,539 small commercial businesses and overall participant satisfaction with the program was 90 percent. Ex post measure savings and implementation costs were used to develop ex post Total Resource Cost (TRC) test values for the program using the CPUC cost effectiveness worksheets. Approximately 38 percent of non-participants would have participated if they knew the program installed no-cost/low-cost energy efficiency improvements in businesses like theirs, indicating a continuing need for the program.

7. Are there measurable program multiplier effects?

Program multiplier effects questions are used to measure program participants sharing information learned from the program with non-participants, and if sharing of information is acted upon in a way that results in the installation of similar measures within a non-participant population. For example, the program installs efficient lighting, programmable thermostats and vendor misers and performs audits to educate small commercial customers on the value of these and other measures. Based on process survey responses, 100 percent of interviewed customers shared program information with 10.3 times as many peers (68 participants shared information with 698 businesses). Approximately 51 percent of these businesses (i.e., 358) decided to install similar measures or participate in the Energy Fitness program. The program helped expand impacts beyond the participant group to a larger group through direct installation of measures and the *Energy Fitness* audit measure recommendations. The multiplier effect for the program is estimated at 88 percent.[13] Programs that link technologies with educational measures can have multiplier effects as high as 25-30 percent including the sharing of program information to a population that is several times larger than the participant population. The following questions were included in the participant process surveys.

1. Have you shared program information with any of your business associates about the benefits of screw-in CFLs, LED exit signs, hardwired T8 fixtures with electronic ballasts, or other measures offered in the program or from the Energy Fitness Report?
2. With how many other businesses have you shared this information in the last 12 months?

[13] Spillover of 88 percent is calculated based on 358 businesses adopting at least one spillover measure based on information shared by a group of 68 participants who adopted six measures (i.e., 358 × (1÷ 6) ÷ 68 = 0.88).

3. About how many people have installed any of these measures?

8. Are measures being installed properly?
The study answered this question by performing 2,842 inspections at a random sample of 68 participant sites. Light loggers were installed at 73 sites to measure hours of operation. These were left at the sites for a period of up to four weeks and then rotated to other sites. Sixty-eight (68) were successfully downloaded to monitor hours of operation on 1,842 fixtures. Two (2) were lost at customer sites and three (3) did not collect data due to customer interference. In addition, billing analysis for 68 sites provided additional verification that measures were installed properly. These efforts provided useful information in developing best practices recommendations to ensure measures are installed properly (see **Section 3.2.3**).

2.4.2 List of Tasks Undertaken by the Study

Four tasks were undertaken by the study. These tasks are briefly summarized as follows.

Task 1. Project Initiation Meeting
The project initiation meeting refined the research objectives and methods, clarified pertinent issues, data requirements, and the detailed work plan and schedule for the project.

Task 2. Prepare EM&V Plan
The EM&V Plan contained a detailed description of all activities required to complete the study.

Task 3. Perform EM&V Work
EM&V work for the Energy Fitness Program assessed baseline UEC values and ex ante energy savings estimates using on-site measurements and inspections, engineering analysis, building energy simulations, and billing data (i.e., IPMVP Options A, C, and D). Existing baseline UEC values for space cooling and heating and programmable thermostats were evaluated and refined. Ex post savings estimates are provided for each measure based on research performed for this study. The study performed an analysis of the quantity and type of measures that were installed or adopted by program participants by conducting on-site inspections and audits at 68 participant sites (while doing 68 participant surveys, 68 non-participant refuser surveys, and 20 non-contact surveys) to determine if the ex ante measure assumptions are appropriate and relevant. RHA provided the number of direct install measures installed and survey results from participating customers were used to develop an estimate of the adoption of audit measures. Data collected from the RHA database and telephone surveys were analyzed to measure the energy and peak demand savings achieved by the program. Installation quality and measure retention were verified by performing 68 on-site inspections. The process evaluation identified what works, what doesn't work, the level of need for the program, and recommendations to improve the program. The process evaluation included in-person surveys of 68 participants, 68 non-participants, and 20 non-contacts to evaluate the adoption rate of audit measures.

Task 4. Progress, Draft, and Final EM&V Reports
Progress, draft, and final EM&V reports included a description of the study methodology and all deliverables as per the CPUC EEPM. The reports provided results

of the impact evaluation including gross and net energy savings for each measure and the program as well as results.

2.4.3 How Study met CPUC EEPM Objectives

The study met the following Commission objectives described in the CPUC EEPM (pg. 31).

- **Measure the level of energy savings achieved.**
  The study met this objective by performing detailed on-site visits for a statistically significant sample of 68 participants to gather pre- and post-installation measurements for energy efficiency measures installed under the program. Sites in the statistical sample included verification of proper installation of program measures and operation of equipment the measures were installed on (i.e., HVAC equipment). EM&V efforts included gathering enough information and measurements to develop savings estimates for each measure and number of small commercial businesses served by the program. Statistical analyses were used to extrapolate energy savings at the sample level to the program level. This step included an assessment of the relative precision of program-level savings, mean savings estimates, standard deviations, and confidence intervals. This analysis included an assessment of all major assumptions used to calculate program ex ante savings.

- **Measure the cost-effectiveness.**
  The study met this objective by developing ex post average energy savings for all measures. Ex post measure savings and implementation costs were used to develop ex post Total Resource Cost (TRC) test values for the program using the CPUC cost effectiveness worksheets. The ex post TRC is 1.2 and the ex post participant test is 5.9.

- **Provide up-front market assessments and baseline analysis.**
  The study met this objective by performing a simple market assessment and baseline analyses including an evaluation of the baseline unit energy consumption values for space cooling, space heating, water heating, lighting, and refrigeration. Process survey interviews included questions about market barriers to energy efficiency and the success of the program in meeting the needs of hard-to-reach customers.[14]

- **Provide ongoing feedback and corrective or constructive guidance regarding the implementation of programs.**
  The study met this objective by performing on-site inspections to verify that measures were installed properly. Results of on-site inspections were used to provide ongoing feedback and corrective or constructive guidance regarding installation best practices and implementation of the program. This included recommended improvements to the installation efforts and procedures. Inspections also documented that all activities were completed as per the contract requirements.

[14] The CPUC definition of small commercial hard-to-reach customers are those who do not have easy access to program information or generally do not participate in energy efficiency programs due to language (i.e., primary language non-English), business size (less than ten employees); geographic (i.e., outside San Francisco Bay Area, Sacramento), or lease (i.e., split incentives barrier).

- **Measure indicators of the effectiveness of the programs, including testing of the assumptions that underlie the program theory and approach.**
  The study met this objective by performing a process evaluation of the program including surveys of participants and non-participants.

- **Assess the overall levels of performance and success of the program.**
  The study provided ex post energy savings at the 90 percent confidence level as per the CADMAC Protocols. The study determined participant satisfaction and ways to improve the program. Non-participating customers were interviewed to evaluate why they chose not to participate.

- **Help to assess whether there is a continuing need for the program.**
  The study met this objective by assessing overall cost effectiveness, the number of small commercial businesses treated by the program, and survey responses from participants and non-participants. Ex post measure savings and implementation costs were used to develop ex post Total Resource Cost (TRC) test values for the program using the CPUC cost effectiveness worksheets. The overall ex post TRC is 1.2 and this was 33 percent lower than the PIP TRC of 1.8. The program treated 1,539 small commercial customers with 22,271 compact fluorescent lamps, 488 LED exit signs, 151 set-back thermostats, 28 vending misers, 31,430 T8 fluorescent lamps, 15,331 ballasts, delamped 6,240 incandescent and fluorescent lamps (and ballasts), and 103 HVAC tune-ups. In-person interviews were conducted with 68 participants. Telephone surveys were conducted with 68 non-participants and 20 non-contacts to evaluate audit measure adoption rates. Interviews assessed how the program influenced awareness of linkages between efficiency improvements, bill savings, and increased comfort for customers. The study also identified what works, what doesn't work, and the level of need for the program. Approximately 39 percent of non-participants who were interviewed said they would have participated if they knew the program installed no-cost energy efficiency improvements.

3. EM&V Findings

This section provides load impact results for the program and for each measure. This section also provides the process evaluation results based on participant and non-participant surveys and recommendations regarding what works, what doesn't work, and the continuing need of the program. Also provided are recommendations for each measure to increase savings, achieve greater persistence of savings, and improve customer satisfaction.

3.1 Load Impact Results

The program implementation plan ex ante goals were to directly install 39,627 energy efficiency measures at 1,399 hard-to-reach small business customer sites in the PG&E service area (as shown in **Table 3.1**). The program exceeded these goals and installed 44,877 energy efficiency measures at 1,539 sites. Ex post accomplishments were verified by reviewing the tracking database, randomly inspecting 2,842 measures at 73 sites, installing light loggers on 1,842 fixtures at 68 sites, evaluating billing data for 59 sites, and conducting surveys of participants, non-participants, and non-contacts. The EM&V study net ex post savings are based on pre and post-retrofit utility billing data, light logger data, previous evaluation studies, and building energy simulations calibrated to normalized billing data.

Table 3.1 Ex Ante Goals and Ex Post Accomplishments for the Energy Fitness Program

Description	Program Implementation Plan Ex Ante Goal	Ex Post Accomplishment
Total Direct Install Measures	39,627	44,877
Compact Fluorescent Lamps (CFL)	14,165	22,271
Delamp Fluorescent Fixtures	14,270	6,240
T8 Fluorescent Lamps and Ballasts	10,634	15,596
LED Exit Signs	91	488
Programmable Thermostats	175	151
Vender Misers	17	28
HVAC Tune-up	100	103
Nonresidential Hard-to-Reach Energy Fitness Audits	1,399	1,539
Net Annual Electricity Savings (kWh/yr)	7,381,944	6,712,686
Net Demand Savings (kW)	1,592	2,385
Net Annual Therm Savings (therms/yr)	0	0
Net Lifecycle Electricity Savings (kWh)	66,264,696	66,827,070
Net Lifecycle Gas Savings (therms)	0	0
Total Resource Cost (TRC) Test	1.8	1.2
TRC Test Costs	$1,874,339	$2,136,608
TRC Test Benefits	$3,406,078	$2,513,382
TRC Test Net Benefits	$1,531,739	$376,773
Participant Test	10.3	5.9
Participant Test Costs	$1,214,347	$1,335,975
Participant Test Benefits	$12,515,915	$7,815,193
Participant Test Net Benefits	$11,301,568	$6,479,218

The program succeeded in providing energy efficiency incentives at 1,539 hard-to-reach businesses and directly installed 22,271 compact fluorescent lamps, 488 LED exit signs, 151 set-back thermostats, 28 vending misers, 31,430 T8 fluorescent lamps, 15,331 ballasts, delamped 6,240 incandescent and fluorescent lamps (and ballasts), and 103 HVAC tune-ups. Ex post accomplishments were verified by randomly inspecting 2,842 measures at 73 sites. Light loggers were installed at 73 sites to measure operating hours on 1,842 lighting fixtures, AC tune-ups inspections were conducted for 1 unit, three-years of pre-post billing data were analyzed for 59 sites, and in-person and telephone follow-up surveys were conducted for 68 customers.

Non-normalized pre- and post-retrofit utility bill data and savings are provided in **Table 3.2**. The average non-normalized gross ex post bill savings are 2,003 kWh/yr-site. The average gross ex ante savings are 6,709 kWh/yr-site, and the average gross ex post EM&V savings are 3,899 kWh/yr-site. The gross ex post realization rate based on non-normalized billing savings is 0.30 ± 0.14. The ex post bill savings realization rate is low due to not normalizing the billing data, and many sites having relatively low pre-post utility bill savings, and 13 percent of sites having negative pre-post bill savings (i.e., 9 out of 68 with pre/post data). The non-normalized EM&V realization rate is 0.58 ± 0.11. The non-normalized EM&V realization rate is low due to lower hours of operation found in the light logger data. Customers with negative savings indicated that post-retrofit hours of operation increased due to new equipment or expanded business schedules.

Further analysis was performed to evaluate the normalized ex post savings using pre/post fixture wattage measurements, light logger data, and calibrated building energy simulations (see **Sections 3.1.2** through **3.1.22**).

Table 3.2 Pre/Post Utility Bill Data and Savings versus Ex Ante Savings

#	Pre-Retrofit Bill kWh	Post-Retrofit Bill kWh	Pre-Post Bill Savings kWh	Ex Ante Savings kWh	Ex Post EM&V Savings kWh	Notes
1	57,200	55,040	2,160	17,336	11,252	
2	4,110	3,875	235	4,000	1,189	Longer hours of operation
3	30,852	22,302	8,550	21,640	15,469	
4	9,420	8,232	1,188	1,560	1,043	
5	n/a	n/a	n/a	2,852	715	
6	18,711	15,452	3,259	6,916	7,399	
7	35,714	34,140	1,574	13,480	7,417	
8	137,440	141,240	-3,800	7,239	2,852	Installed new equipment with longer hours of operation
9	59,760	74,280	-14,520	3,405	1,971	Installed new equipment with longer hours of operation
10	7,305	6,851	454	4,260	3,621	
11	43,620	37,642	5,978	4,780	8,652	
12	21,209	18,960	2,249	2,208	1,673	
13	9,932	9,967	-35	2,928	643	
14	155,249	140,180	15,069	22,803	17,407	
15	197,160	183,480	13,680	31,131	2,259	
16	142,796	143,057	-262	10,288	5,782	Installed new equipment with longer hours of operation
17	95,197	95,372	-175	8,512	4,554	
18	21,531	14,799	6,732	5,256	1,965	
19	9,600	11,680	-2,080	8,536	1,619	Installed new equipment with longer hours of operation
20	89,247	89,411	-164	7,460	5,352	AC runs more now
21	36,896	29,451	7,445	5,183	938	
22	19,172	15,618	3,554	3,443	1,152	
23	19,190	18,875	315	7,239	1,865	
24	n/a	n/a	n/a	740	529	
25	n/a	n/a	n/a	2,220	2,382	
26	232,834	231,760	1,074	4,020	9,102	
27	n/a	n/a	n/a	2,220	1,642	
28	5,346	5,124	222	3,008	637	
29	11,255	10,362	893	576	633	
30	29,479	29,032	446	6,676	5,165	
31	62,326	60,809	1,517	4,597	3,900	
32	65,336	53,471	11,865	2,928	1,933	
33	9,036	7,399	1,637	5,183	2,494	
34	11,110	10,226	884	9,896	7,790	
35	13,102	9,337	3,765	3,746	2,347	
36	n/a	n/a	n/a	4,226	2,274	
37	7,454	4,794	2,660	6,280	1,570	
38	n/a	n/a	n/a	6,510	2,999	
39	n/a	n/a	n/a	9,181	4,348	
40	n/a	n/a	n/a	5,516	3,612	
41	15,578	11,151	4,427	10,039	5,187	AC runs more now
42	16618	15256	1,362	6,384	3,374	
43	12,869	12,654	215	1,764	860	
44	12,629	10,880	1,749	13,807	6,405	
45	3,936	3,287	649	2,960	803	
46	2,736	2,134	602	3,963	1,340	
47	22,957	21,283	1,674	6,000	2,784	
48	15,277	14,895	382	1,960	1,019	
49	55,573	54,911	662	12,736	14,320	
50	14,907	14,729	178	1,828	63	
51	84,232	81,502	2,730	2,911	1,421	
52	27,488	22,217	5,271	14,012	12,218	
53	3,405	3,223	182	3,760	2,291	Installed new equipment with longer hours of operation
54	14,781	12,859	1,922	6,844	2,303	
55	8,218	7,298	920	3,288	1,357	)
56	8,040	5,564	2,476	11,912	3,837	

Table 3.2 Pre/Post Utility Bill Data and Savings versus Ex Ante Savings

#	Pre-Retrofit Bill kWh	Post-Retrofit Bill kWh	Pre-Post Bill Savings kWh	Ex Ante Savings kWh	Ex Post EM&V Savings kWh	Notes
57	21,471	11,431	10,040	8,344	2,083	
58	42,770	47,345	-4,575	7,596	5,812	Installed new equipment or longer hours of operation
59	n/a	n/a	n/a	7,484	8,004	
60	11,030	9,618	1,412	4,092	2,518	
61	21,384	20,522	862	1,544	1,186	Schedule change open more hours
62	80,242	77,833	2,409	6,972	5,092	
63	5,633	4,874	759	5,024	2,000	
64	15,530	17,232	-1,703	6,108	3,755	Installed new equipment with longer hours of operation
65	2,307	2,171	137	3,680	1,283	
66	18,435	12,366	6,069	8,868	6,658	
67	11,758	10,768	990	3,976	1,544	
68	4,985	4,963	22	8,403	5,460	Schedule change open more hours
Ave.	37,684	35,681	2,003	6,709	3,899	

The ex ante first-year savings are summarized in **Table 3.3**, and the ex post first-year savings are summarized in **Table 3.4**. The net-to-gross ratio (NTGR) is 0.96 based on the Express Efficiency Program and reflects what customers would have done in the absence of the program (i.e., 4 percent free riders).[15] The ex ante savings goals are 7,381,944 first-year kWh, 1,592 kW, and 66,264,696 lifecycle kWh.[16] The EM&V study found first-year net ex post program savings of 6,712,686 ± 402,325 kWh per year and 2,385 ± 309 kW per year at the 90 percent confidence level. The net realization rate for kWh savings is 0.91 ± 0.05 and the net realization rate for kW savings is 1.50 ± 0.19.

Table 3.3 Ex Ante First-year Electricity Savings for the Energy Fitness Program

Installed Measure	Units	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Net-to-Gross Ratio	Net Ex Ante Program Savings (kWh/y)	Net Ex Ante Program Savings (kW)
HVAC Tune-up Pilot Program	100	360	0.320	0.80	28,800	25.6
Energy Conservation Package	1,399	6570	1.400	0.80	7,353,144	1,566.9
Total	1,499				7,381,944	1,592

Table 3.4 Ex Post First-year Savings for the Energy Fitness Program

Measure	Units	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Net-to-Gross Ratio	Net Ex-Post Program Savings (kWh/y)	Net Ex-Post Program Savings (kW)
CFL	22,271	156.6	0.056	0.96	3,348,133	1197.3
Delamp Fluor. Fixtures	6240	264.8	0.092	0.96	1,586,258	551.1
T8 Fluor. Fixtures	15596	93.5	0.032	0.96	1,399,897	479.1
LED Exit Signs	488	315.4	0.036	0.96	147,759	16.9
Programmable Tstats	151	802	0.55	0.96	116,258	79.7
Vender Misers	28	1590	0	0.96	42,739	0.0
HVAC Tune-up	103	709	0.61	0.96	70,106	60.3
Audit Measures	2	800	0.485	0.96	1,536	0.9
Total	44,879				6,712,686	2,385

[15] *Energy Efficiency Policy Manual*, Chapter 4, Table 4.2, page 23, prepared by the California Public Utilities Commission, 2001.
[16] The reported net program savings in the final report are 9,328,191 kWh per year and 2,521 kW. See *Small Nonresidential Energy Fitness Program Final Report*, Table 12, page 17 of 33, submitted to Pacific Gas & Electric Company, Lisa Cosby, Third Party Contracts Group, 245 Market Street, Room 756D, Mail Code N7K, San Francisco, CA 94105, submitted by Richard Heath and Associates, Inc. (RHA), Teresa Enos, Senior Manager, 1026 Mangrove Avenue, Suite 20, Chico, California 95926, May 1, 2006.

Lifecycle kWh savings are summarized in **Table 3.5**. The required energy impact reporting for 2004-05 programs is provided in **Table 3.6**. The net ex-ante lifecycle savings are 66,264,696 lifecycle kWh. The EM&V study net ex-post lifecycle savings are 66,827,070 ± 4,222,343 kWh. The lifecycle ex-post net lifecycle kWh realization rate is 1.01 ± 0.06 and the net lifecycle therm realization rate is undefined.

Table 3.5 Lifecycle Electricity Savings for the Energy Fitness Program

Measure	Net Ex-Ante Program Savings (kWh)	Ex Ante Effective Useful Life (EUL)	Net Ex-Ante Lifecycle Program Savings (kWh)	Net Ex-Post Program Savings (kWh)	Ex Post Effective Useful Life (EUL)	Net Ex-Post Lifecycle Program Savings (kWh)	Net Lifecycle Realization Rate
CFL	3,893,207	9.0	35,038,864	3,348,133	3.6	12,053,279	0.34
Delamp Fluor. Fixtures	1,486,268	9.0	13,376,408	1,586,258	17.0	26,966,385	2.02
T8 Fluorescent Fixtures	1,726,616	9.0	15,539,542	1,399,897	17.0	23,798,248	1.53
LED Exit Signs	109,597	9.0	986,369	147,759	16.0	2,364,137	2.40
Programmable Tstats	109,292	9.0	983,631	116,258	11.0	1,278,837	1.30
Vender Misers	28,165	9.0	253,482	42,739	3.0	128,218	0.51
HVAC Tune-up	28,800	3.0	86,400	70,106	3.0	210,318	2.43
Audit Measures	0	18.0	0	1,536	18.0	27,648	undefined
Total	7,381,944		66,264,696	6,712,686		66,827,070	1.01

Table 3.6 Required Energy Impact Reporting for 2004-2005 Programs

Program ID:		1409-04					
Program Name:		Energy Fitness Program (EFP)					
Year	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	7,382	6,713	1.592	2.385		
2	2005	7,382	6,713	1.592	2.385		
3	2006	7,382	6,713	1.592	2.385		
4	2007	7,353	5,261	1.567	1.846		
5	2008	7,353	3,252	1.567	1.128		
6	2009	7,353	3,252	1.567	1.128		
7	2010	7,353	3,252	1.567	1.128		
8	2011	7,353	3,252	1.567	1.128		
9	2012	7,353	3,252	1.567	1.128		
10	2013	0	3,252	0	1.128		
11	2014	0	3,252	0	1.128		
12	2015	0	3,135	0	1.048		
13	2016	0	3,135	0	1.048		
14	2017	0	3,135	0	1.048		
15	2018	0	3,135	0	1.048		
16	2019	0	3,135	0	1.048		
17	2020	0	2,988	0	1.031		
18	2021	0	2	0	0.001		
19	2022	0	0	0	0.000		
20	2023	0	0	0	0.000		
TOTAL		66,265	66,827				

** Peak MW savings are defined in this evaluation as the weekday peak period Monday through Friday from 2PM to 6PM during the months of May through September.
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.

The EM&V ex-post cost effectiveness is 1.2 for the total resource cost (TRC) test and 5.8 for the participant test. The program implementation plan TRC is 1.8 and the participant test is 10.3. Differences between the PIP ex ante estimates and ex post accomplishments are due to the 9-year

EUL assumed for all direct-install measures and greater hours of operation assumed for all lighting measures. The weighted average ex post EUL for CFL measures is 3.6 years based on annual hours of operation from logger data and 10,000 hour lifetime from manufacturer data. If the 9-year EUL for CFL measures is used instead, then the ex post TRC would be closer to the PIP/ex ante value. The ex ante lighting measure savings assumed 4,000 hours of operation. The weighted average ex post operating hours are 2,822 ± 292 hours/yr based on light logger data. This is 30% less than the 4,000 hours/yr assumed in the PIP ex ante estimates. If the higher hours of operation and longer EUL values are used, then the ex post kWh savings, realization rates, and TRC would be closer to the ex ante values. The verification inspection findings and detailed load impact results are provided in the following sections.

3.1.1 Verification Inspection Findings

Verification inspections were conducted for the study from December 2004 through August 2005. All measures were verified as properly installed consistent with the RHA database. Results of the on-site verification inspections were used in the impact evaluation to estimate the overall energy savings. Electric power measurements were made on a number of fixtures at different sites as shown in **Table 3.7**. On-site inspections and survey responses were used to evaluate pre- and post-retrofit lighting fixture wattages. A total of 2,842 measures were inspected. Light loggers were installed at 73 sites to measure hours of operation. These were left at the sites for a period of up to four weeks and then rotated to other sites. Sixty-eight (68) were successfully downloaded to monitor hours of operation on 1,842 fixtures. Two (2) were lost at customer sites and three (3) did not collect data due to customer interference. Survey responses were used to evaluate thermostat settings before and after RHA installed programmable thermostats. Responses were used to evaluate ex ante assumptions and determine an appropriate ex post savings estimate for programmable thermostats. On-site verification of the remaining measures along with engineering analysis and existing studies were used to determine appropriate ex post savings estimates for the other measures.

Table 3.7 Field Measurements of Lighting Fixture Average Power

Description	1 lamp W	2 lamp W	3 lamp W	4 lamp W
T12 F40 (4 ft) with magnetic ballast	57	96	143	189
T8 F32 (4 ft) with 4 lamp electronic ballast	41	64	90	108
T8 F32 (4 ft) with 2 lamp electronic ballast	39	61		
T12 F34 (4 ft) with magnetic ballast	43	78	116	154
T8 F32 (4 ft) with 4 lamp electronic ballast	41	64	90	108
T8 F32 (4 ft) with 2 lamp electronic ballast	39	61		
T12 F96 (8 ft) with magnetic ballast	75	128		
T8 F96 (8 ft) with electronic ballast	61	111		
LED Exit Sign	1.5			
LED Exit Sign	0.8			
Incandescent Exit Sign	40			

3.1.2 Load Impacts for CFLs

Load impacts for CFLs are based on field inspections of 705 fixtures at 68 participant sites, and lighting logger measurements of 701 fixtures consistent with IPMVP Option B. Pre- and post-retrofit fixture quantities, hours of operation and savings are shown in **Table 3.8**. RHA assumed ex ante savings are 246 kWh/yr and 0.05 kW. The gross ex post savings per measure are 156.6 ± 15.1 kWh/yr and 0.056 ± 0.003 kW at the 90 percent confidence level. The difference between ex ante and ex post savings for CFLs is primarily due to EM&V findings of lower ex post annual hours of operation. The RHA database reported installing 22,271 CFLs, and the total gross ex post savings are 3,487,639 ± 335,645 kWh/year and 1,252.5 ± 56.72 kW at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The CFL effective useful lifetime (EUL) for this study is assumed to be 3.6 years. The 3.6 year EUL is based on average annual hours of operation of 2,744 ± 195 hours per year assuming 10,000 lifecycle operational hours.

Table 3.8 Load Impacts for CFLs

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
60	40W Incand.	1	2,829	40	0.04	113	9W A-Lamp	1	2,829	9	0.009	25	0.031	87.7
60	65W Incand.	6	2,829	65	0.39	1103	16W R30	6	2,829	16	0.096	272	0.294	831.9
60	100W Incan.	2	2,829	100	0.2	566	14W Spiral	2	2,829	14	0.028	79	0.172	486.7
34	60W Incand.	3	3,294	60	0.18	593	14W A-Lamp	3	3,294	14	0.042	138	0.138	454.5
62	60W Incand.	1	3,679	60	0.06	221	14W A-Lamp	1	3,679	14	0.014	52	0.046	169.2
62	65W Incand.	11	3,679	65	0.715	2631	14W R30	11	3,679	14	0.154	567	0.561	2,064.0
61	60W Incand.	1	3,224	60	0.06	193	14W A-Lamp	1	3,224	14	0.014	45	0.046	148.3
61	100W Incan.	1	3,224	100	0.1	322	14W Spiral	1	3,224	14	0.014	45	0.086	277.2
2	PAR38 69W	5	1,410	69	0.345	487	19W PAR38	5	1,410	19	0.095	134	0.25	352.6
2	PAR40 75W	2	1,410	75	0.15	212	19W R40	2	1,410	19	0.038	54	0.112	158.0
59	60W Incand.	2	4,459	60	0.12	535	14W A-Lamp	2	4,459	14	0.028	125	0.092	410.2
68	60W Incand.	1	3,048	60	0.06	183	19W A-Lamp	1	3,048	19	0.019	58	0.041	125.0
68	40W Incand.	2	3,048	40	0.08	244	14W A-Lamp	2	3,048	14	0.028	85	0.052	158.5
68	PAR38 69W	1	3,048	69	0.069	210	19W PAR38	1	3,048	19	0.019	58	0.05	152.4
68	100W Incan.	2	3,048	100	0.2	610	14W Spiral	2	3,048	14	0.028	85	0.172	524.3
1	65W Incand.	6	3,688	65	0.39	1438	16W PAR30	6	3,688	16	0.096	354	0.294	1,084.3
1	69W Incand.	5	3,688	69	0.345	1272	19W PAR38	5	3,688	19	0.095	350	0.25	922.0
1	65W Incand.	30	3,688	65	1.95	7192	14W R30	30	3,688	14	0.42	1549	1.53	5,642.6
1	100W Incan.	3	3,688	100	0.3	1106	26W Spiral	3	3,688	26	0.078	288	0.222	818.7
1	100W Incan.	4	3,688	100	0.4	1475	14W Spiral	4	3,688	14	0.056	207	0.344	1,268.7
66	60W Incand.	2	3,048	60	0.12	366	14W A-Lamp	2	3,048	14	0.028	85	0.092	280.5
66	100W Incan.	3	3,048	100	0.3	915	14W Spiral	3	3,048	14	0.042	128	0.258	786.5
64	69W Incand.	2	2,435	69	0.138	336	19W PAR38	2	2,435	19	0.038	93	0.1	243.5
64	100W Incan.	7	2,435	100	0.7	1705	14W Spiral	7	2,435	14	0.098	239	0.602	1,466.0
63	69W Incand.	2	1,691	69	0.138	233	19W PAR38	2	1,691	19	0.038	64	0.1	169.1
63	100W Incan.	1	1,691	100	0.1	169	14W Spiral	1	1,691	14	0.014	24	0.086	145.4
65	60W Incand.	4	1,673	60	0.24	402	14W A-Lamp	4	1,673	14	0.056	94	0.184	307.9
65	40W Incand.	1	1,673	40	0.04	67	CFL 9W	1	1,673	9	0.009	15	0.031	51.9
65	PAR38 69W	2	1,673	69	0.138	231	PAR38 19W	2	1,673	19	0.038	64	0.1	167.3
65	100W Incan.	2	1,673	100	0.2	335	14W Spiral	2	1,673	14	0.028	47	0.172	287.8
44	65W Incand.	12	2,111	65	0.78	1647	14W R30	12	2,111	14	0.168	355	0.612	1,292.0
44	100W Incan.	5	2,111	100	0.5	1056	14W Spiral	5	2,111	14	0.07	148	0.43	907.8
14	60W Incand.	2	4,459	60	0.12	535	14W A-Lamp	2	4,459	14	0.028	125	0.092	410.2
14	40W Incand.	14	4,459	40	0.56	2497	4W Candella	14	4,459	4	0.056	250	0.504	2,247.3
14	60W Incand.	7	4,459	60	0.42	1873	14W G30	7	4,459	14	0.098	437	0.322	1,435.7
14	65W Incand.	25	4,459	65	1.625	7246	16W PAR30	25	4,459	16	0.4	1784	1.225	5,462.1
14	65W Incand.	25	4,459	65	1.625	7246	14W R30	25	4,459	14	0.35	1561	1.275	5,685.0
14	100W Incan.	4	4,459	100	0.4	1784	26W Spiral	4	4,459	26	0.104	464	0.296	1,319.8
12	100W Incan.	1	3,092	100	0.1	309	14W Spiral	1	3,092	14	0.014	43	0.086	265.9
7	40W Incand.	1	2,365	40	0.04	95	4W LED	1	2,365	4	0.004	9	0.036	85.1
7	50W Incand.	15	2,365	50	0.75	1774	9W R20	15	2,365	9	0.135	319	0.615	1,454.6
7	100W Incan.	3	2,365	100	0.3	710	14W Spiral	3	2,365	14	0.042	99	0.258	610.2
18	60W Incand.	6	1,761	60	0.36	634	14W A-Lamp	6	1,761	14	0.084	148	0.276	486.0
16	60W Incand.	4	2,497	60	0.24	599	19W A-Lamp	4	2,497	19	0.076	190	0.164	409.4
16	60W Incand.	24	2,497	60	1.44	3595	14W G30	24	2,497	14	0.336	839	1.104	2,756.2
20	60W Incand.	2	3,022	60	0.12	363	19W A-Lamp	2	3,022	19	0.038	115	0.082	247.8
20	40W Incand.	1	3,022	40	0.04	121	9W A-Lamp	1	3,022	9	0.009	27	0.031	93.7

Table 3.8 Load Impacts for CFLs

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
20	100W Incan.	1	3,022	100	0.1	302	14W Spiral	1	3,022	14	0.014	42	0.086	259.9
15	60W Incand.	6	377	60	0.36	136	14W A-Lamp	6	377	14	0.084	32	0.276	104.0
15	100W Incan.	34	377	100	3.4	1281	29W Dimm	34	377	29	0.986	371	2.414	909.3
15	60W Incand.	44	377	60	2.64	994	14W G30	44	377	14	0.616	232	2.024	762.4
15	50W Incand.	3	377	50	0.15	57	9W R20	3	377	9	0.027	10	0.123	46.3
15	65W Incand.	22	377	65	1.43	539	14W R30	22	377	14	0.308	116	1.122	422.6
19	100W Incan.	5	788	100	0.5	394	14W Spiral	5	788	14	0.07	55	0.43	339.0
32	40W Incand.	8	3,776	40	0.32	1208	4W Candella	8	3,776	4	0.032	121	0.288	1,087.4
32	60W Incand.	3	3,776	60	0.18	680	14W G25	3	3,776	14	0.042	159	0.138	521.0
32	100W Incan.	1	3,776	100	0.1	378	14W Spiral	1	3,776	14	0.014	53	0.086	324.7
11	60W Incand.	13	8,383	60	0.78	6539	14W A-Lamp	13	8,383	14	0.182	1526	0.598	5,013.2
11	100W Incan.	2	8,383	100	0.2	1677	14W Spiral	2	8,383	14	0.028	235	0.172	1,441.9
33	60W Incand.	5	2,637	60	0.3	791	19W A-Lamp	5	2,637	19	0.095	250	0.205	540.5
33	100W Incan.	1	2,637	100	0.1	264	14W Spiral	1	2,637	14	0.014	37	0.086	226.8
23	100W Incan.	2	1,156	100	0.2	231	14W Spiral	2	1,156	14	0.028	32	0.172	198.9
39	60W Incand.	6	2,321	60	0.36	836	14W A-Lamp	6	2,321	14	0.084	195	0.276	640.7
39	40W Incand.	1	2,321	40	0.04	93	9W A-Lamp	1	2,321	9	0.009	21	0.031	72.0
39	65W Incand.	4	2,321	65	0.26	604	16W PAR30	4	2,321	16	0.064	149	0.196	455.0
39	65W Incand.	3	2,321	65	0.195	453	14W R30	3	2,321	14	0.042	97	0.153	355.2
39	100W Incan.	5	2,321	100	0.5	1161	14W Spiral	5	2,321	14	0.07	162	0.43	998.2
37	60W Incand.	6	1,612	60	0.36	580	14W G25	6	1,612	14	0.084	135	0.276	444.9
37	65W Incand.	2	1,612	65	0.13	210	16W PAR30	2	1,612	16	0.032	52	0.098	158.0
37	65W Incand.	1	1,612	65	0.065	105	14W R30	1	1,612	14	0.014	23	0.051	82.2
37	100W Incan.	4	1,612	100	0.4	645	14W Spiral	4	1,612	14	0.056	90	0.344	554.5
35	40W Incand.	1	3,040	40	0.04	122	9W A-Lamp	1	3,040	9	0.009	27	0.031	94.2
36	60W Incand.	1	2,462	60	0.06	148	14W A-Lamp	1	2,462	14	0.014	34	0.046	113.2
36	100W Incan.	2	2,462	100	0.2	492	14W Spiral	2	2,462	14	0.028	69	0.172	423.4
40	100W Incan.	1	2,637	100	0.1	264	14W Spiral	1	2,637	14	0.014	37	0.086	226.8
26	100W Incan.	4	8,760	100	0.4	3504	14W Spiral	4	8,760	14	0.056	491	0.344	3,013.4
43	60W Incand.	1	2,199	60	0.06	132	19W A-Lamp	1	2,199	19	0.019	42	0.041	90.1
45	100W Incan.	1	1,542	100	0.1	154	14W Spiral	1	1,542	14	0.014	22	0.086	132.6
41	120W Flood	1	2,558	120	0.12	307	65W PAR30	1	2,558	65	0.065	166	0.055	140.7
41	60W Incand.	3	2,558	60	0.18	460	14W A-Lamp	3	2,558	14	0.042	107	0.138	353.0
41	40W Incand.	2	2,558	40	0.08	205	9W A-Lamp	2	2,558	9	0.018	46	0.062	158.6
46	60W Incand.	2	1,892	60	0.12	227	14W A-Lamp	2	1,892	14	0.028	53	0.092	174.1
46	60W Incand.	2	1,892	60	0.12	227	14W Spiral	2	1,892	14	0.028	53	0.092	174.1
57	60W Incand.	5	1,577	60	0.3	473	19W A-Lamp	5	1,577	19	0.095	150	0.205	323.2
57	50W Incand.	1	1,577	50	0.05	79	9W R20	1	1,577	9	0.009	14	0.041	64.6
57	65W Incand.	11	1,577	65	0.715	1127	14W R30	11	1,577	14	0.154	243	0.561	884.6
57	100W Incan.	4	1,577	100	0.4	631	14W Spiral	4	1,577	14	0.056	88	0.344	542.4
22	60W Incand.	1	2,076	60	0.06	125	14W A-Lamp	1	2,076	14	0.014	29	0.046	95.5
22	40W Incand.	3	2,076	40	0.12	249	4W LED	3	2,076	4	0.012	25	0.108	224.2
22	65W Incand.	2	2,076	65	0.13	270	16W R30	2	2,076	16	0.032	66	0.098	203.5
22	100W Incan.	2	2,076	100	0.2	415	14W Spiral	2	2,076	14	0.028	58	0.172	357.1
48	60W Incand.	5	3,215	60	0.3	964	14W A-Lamp	5	3,215	14	0.07	225	0.23	739.4
54	60W Incand.	1	1,910	60	0.06	115	19W A-Lamp	1	1,910	19	0.019	36	0.041	78.3
54	40W Incand.	9	1,910	40	0.36	687	9W A-Lamp	9	1,910	9	0.081	155	0.279	532.8
54	65W Incand.	14	1,910	65	0.91	1738	14W R30	14	1,910	14	0.196	374	0.714	1,363.5
54	100W Incan.	2	1,910	100	0.2	382	14W Spiral	2	1,910	14	0.028	53	0.172	328.5
55	100W Incan.	4	2,610	100	0.4	1044	26W Spiral	4	2,610	26	0.104	271	0.296	772.7
49	69W Incand.	6	4,748	69	0.414	1966	19W PAR38	6	4,748	19	0.114	541	0.3	1,424.4
49	100W Incan.	2	4,748	100	0.2	950	26W Spiral	2	4,748	26	0.052	247	0.148	702.7
51	60W Incand.	1	2,917	60	0.06	175	19W A-Lamp	1	2,917	19	0.019	55	0.041	119.6
51	60W Incand.	4	2,917	60	0.24	700	14W G30	4	2,917	14	0.056	163	0.184	536.7
51	75W Incand.	4	2,917	75	0.3	875	19W R40	4	2,917	19	0.076	222	0.224	653.4
28	60W Incand.	1	2,146	60	0.06	129	14W A-Lamp	1	2,146	14	0.014	30	0.046	98.7
28	100W Incan.	1	2,146	100	0.1	215	19W Spiral	1	2,146	19	0.019	41	0.081	173.8
9	69W Incand.	3	5,133	69	0.207	1063	19W PAR38	3	5,133	19	0.057	293	0.15	770.0
9	75W Incand.	2	5,133	75	0.15	770	19W R40	2	5,133	19	0.038	195	0.112	574.9
9	100W Incan.	1	5,133	100	0.1	513	14W Spiral	1	5,133	14	0.014	72	0.086	441.5
52	60W Incand.	4	3,618	60	0.24	868	14W A-lamp	4	3,618	14	0.056	203	0.184	665.7

Table 3.8 Load Impacts for CFLs

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
52	65W Incand.	2	3,618	65	0.13	470	16W PAR30	2	3,618	16	0.032	116	0.098	354.6
52	100W Incan.	4	3,618	100	0.4	1447	14W Spiral	4	3,618	14	0.056	203	0.344	1,244.6
53	100W Incan.	2	2,391	100	0.2	478	14W Spiral	2	2,391	14	0.028	67	0.172	411.3
30	60W Incand.	8	3,136	60	0.48	1505	14W G30	8	3,136	14	0.112	351	0.368	1,154.1
30	69W Incand.	2	3,136	69	0.138	433	19W PAR38	2	3,136	19	0.038	119	0.1	313.6
30	65W Incand.	9	3,136	65	0.585	1835	14W PAR30	9	3,136	14	0.126	395	0.459	1,439.5
5	60W Incand.	2	2,032	60	0.12	244	14W A-lamp	2	2,032	14	0.028	57	0.092	187.0
5	50W Incand.	3	2,032	50	0.15	305	9W R30	3	2,032	9	0.027	55	0.123	250.0
10	60W Incand.	3	4,389	60	0.18	790	14W A-lamp	3	4,389	14	0.042	184	0.138	605.6
10	65W Incand.	2	4,389	65	0.13	571	16W PAR30	2	4,389	16	0.032	140	0.098	430.1
10	65W Incand.	5	4,389	65	0.325	1426	14W PAR30	5	4,389	14	0.07	307	0.255	1,119.1
10	75W Incand.	2	4,389	75	0.15	658	19W R40	2	4,389	19	0.038	167	0.112	491.5
10	100W Incan.	3	4,389	100	0.3	1317	26W Spiral	3	4,389	26	0.078	342	0.222	974.3
8	60W Incand.	8	2,348	60	0.48	1127	14W A-lamp	8	2,348	14	0.112	263	0.368	863.9
8	69W Incand.	5	2,348	69	0.345	810	19W PAR38	5	2,348	19	0.095	223	0.25	586.9
8	100W Incan.	1	2,348	100	0.1	235	19W Spiral	1	2,348	19	0.019	45	0.081	190.2
21	60W Incand.	7	1,051	60	0.42	442	14W G30	7	1,051	14	0.098	103	0.322	338.5
21	65W Incand.	4	1,051	65	0.26	273	16W PAR30	4	1,051	16	0.064	67	0.196	206.0
21	75W Incand.	6	1,051	75	0.45	473	19W R40	6	1,051	19	0.114	120	0.336	353.2
3	60W Incand.	6	2,970	60	0.36	1069	14W G30	6	2,970	14	0.084	249	0.276	819.6
47	60W Incand.	8	2,085	60	0.48	1001	14W A-lamp	8	2,085	14	0.112	234	0.368	767.2
47	69W Incand.	3	2,085	69	0.207	432	19W PAR38	3	2,085	19	0.057	119	0.15	312.7
47	100W Incan.	7	2,085	100	0.7	1459	26W Spiral	7	2,085	26	0.182	379	0.518	1,080.0
50	69W Incand.	3	289	69	0.207	60	19W PAR38	3	289	19	0.057	16	0.15	43.4
56	60W Incand.	1	1,936	60	0.06	116	16W A-lamp	1	1,936	16	0.016	31	0.044	85.2
56	40W Incand.	18	1,936	40	0.72	1394	9W A-Lamp	18	1,936	9	0.162	314	0.558	1,080.3
56	100W Incan.	1	1,936	100	0.1	194	26W Spiral	1	1,936	26	0.026	50	0.074	143.3
67	60W Incand.	4	2,225	60	0.24	534	14W A-Lamp	4	2,225	14	0.056	125	0.184	409.4
Total		701						701					37.1	96,326
Ave													0.056	156.6

3.1.3 Load Impacts for Delamping Fluorescent Fixtures

Load impacts for delamping fluorescent fixtures are based on field inspections of 668 fixtures at 37 participant sites, electric power measurements, and lighting logger measurements of 352 fixtures consistent with IPMVP Option B. Pre- and post-retrofit fixture quantities, hours of operation and savings are shown in **Table 3.9**. RHA assumed ex ante savings are 256 kWh/yr and 0.09 kW. The gross ex post savings per measure are 264.8 ± 28.9 kWh/yr and 0.092 ± 0.005 kW at the 90 percent confidence level. The difference between ex ante and ex post savings is primarily due to EM&V findings of lower ex post annual hours of operation. The RHA database reported delamping 6,240 fixtures, and the total gross ex post savings are 1,652,607 ± 180,174 kWh/year and 577 ± 30.3 kW at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The ex ante effective useful lifetime (EUL) was assumed to be 18 years. The ex post EUL is 17 years based on average annual hours of operation of 2,995 ± 221 hours per year and 50,000 lifecycle operational hours before failure.

Table 3.9 Load Impacts for Delamping Fixtures with Electronic Ballasts

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
60	2-F40T12 Mag.	3	2,829	96	0.288	815	Delamp	3	2,829	0	0	0	0.288	814.9
34	2-F40T12 Mag.	17	3,294	96	1.632	5375	Delamp	17	3,294	0	0	0	1.632	5,375.4
62	2-F40T12 Mag.	3	3,679	96	0.288	1060	Delamp	3	3,679	0	0	0	0.288	1,059.6
61	2-F40T12 Mag.	1	3,224	96	0.096	309	Delamp	1	3,224	0	0	0	0.096	309.5
2	2-F40T12 Mag.	1	1,410	96	0.096	135	Delamp	1	1,410	0	0	0	0.096	135.4

Table 3.9 Load Impacts for Delamping Fixtures with Electronic Ballasts

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
59	2-F40T12 Mag.	13	4,459	96	1.248	5565	Delamp	13	4,459	0	0	0	1.248	5,564.6
68	2-F40T12 Mag.	11	3,048	96	1.056	3219	Delamp	11	3,048	0	0	0	1.056	3,219.2
1	2-F40T12 Mag.	1	3,688	96	0.096	354	Delamp	1	3,688	0	0	0	0.096	354.0
66	2-F40T12 Mag.	14	3,048	96	1.344	4097	Delamp	14	3,048	0	0	0	1.344	4,097.2
63	2-F40T12 Mag.	2	1,691	96	0.192	325	Delamp	2	1,691	0	0	0	0.192	324.6
44	2-F40T12 Mag.	12	2,111	96	1.152	2432	Delamp	12	2,111	0	0	0	1.152	2,432.1
58	2-F40T12 Mag.	14	3,110	96	1.344	4180	Delamp	14	3,110	0	0	0	1.344	4,179.6
7	2-F40T12 Mag.	17	2,365	96	1.632	3860	Delamp	17	2,365	0	0	0	1.632	3,860.0
16	2-F40T12 Mag.	8	2,497	96	0.768	1917	Delamp	8	2,497	0	0	0	0.768	1,917.4
17	2-F40T12 Mag.	16	2,172	96	1.536	3337	Delamp	16	2,172	0	0	0	1.536	3,336.9
20	2-F40T12 Mag.	12	3,022	96	1.152	3482	Delamp	12	3,022	0	0	0	1.152	3,481.6
19	2-F40T12 Mag.	12	788	96	1.152	908	Delamp	12	788	0	0	0	1.152	908.2
11	2-F40T12 Mag.	2	8,383	56	0.112	939	Delamp	2	8,383	0	0	0	0.112	938.9
6	2-F40T12 Mag.	13	4,345	96	1.248	5423	Delamp	13	4,345	0	0	0	1.248	5,422.5
33	2-F40T12 Mag.	5	2,637	96	0.48	1266	Delamp	5	2,637	0	0	0	0.48	1,265.6
23	2-F40T12 Mag.	11	1,156	96	1.056	1221	Delamp	11	1,156	0	0	0	1.056	1,221.1
39	2-F40T12 Mag.	3	2,321	96	0.288	669	Delamp	3	2,321	0	0	0	0.288	668.6
38	2-F40T12 Mag.	14	1,463	56	0.784	1147	Delamp	14	1,463	0	0	0	0.784	1,146.9
40	2-F40T12 Mag.	9	2,637	96	0.864	2278	Delamp	9	2,637	0	0	0	0.864	2,278.2
26	60W Incand.	4	8,760	60	0.24	2102	Delamp	4	8,760	0	0	0	0.24	2,102.4
45	2-F96T12 Mag.	3	1,542	162	0.486	749	Delamp	3	1,542	0	0	0	0.486	749.3
41	2-F40T12 Mag.	13	2,558	96	1.248	3192	Delamp	13	2,558	0	0	0	1.248	3,192.3
46	2-F40T12 Mag.	4	1,892	96	0.384	727	Delamp	4	1,892	0	0	0	0.384	726.6
22	2-F40T12 Mag.	1	2,076	96	0.096	199	Delamp	1	2,076	0	0	0	0.096	199.3
42	2-F40T12 Mag.	12	2,146	96	1.152	2472	Delamp	12	2,146	0	0	0	1.152	2,472.4
49	2-F40T12 Mag.	18	4,748	96	1.728	8204	Delamp	18	4,748	0	0	0	1.728	8,204.4
52	2-F40T12 Mag.	21	3,618	96	2.016	7294	Delamp	21	3,618	0	0	0	2.016	7,293.6
53	2-F40T12 Mag.	6	2,391	96	0.576	1377	Delamp	6	2,391	0	0	0	0.576	1,377.5
8	2-F40T12 Mag	1	2,348	96	0.096	225	Delamp	1	2,348	0	0	0	0.096	225.4
3	1-F40T12 Mag.	13	2,970	56	0.728	2162	Delamp	13	2,970	0	0	0	0.728	2,161.9
3	2-F40T12 Mag.	32	2,970	96	3.072	9123	Delamp	32	2,970	0	0	0	3.072	9,122.7
56	1-F40T12 Mag.	10	1,936	56	0.56	1084	Delamp	10	1,936	0	0	0	0.56	1,084.1
Total		352						352					32.3	93,224.0
Ave													0.092	264.8

3.1.4 Load Impacts for T8 Fluorescent Fixtures

Load impacts for T8 fluorescent fixtures with electronic ballasts are based on field inspections of 1,446 fixtures at 67 participant sites, electric power measurements, and lighting logger measurements of 772 fixtures consistent with IPMVP Option B. Pre- and post-retrofit fixture quantities, hours of operation and savings are shown in **Table 3.10**. RHA assumed ex ante savings are 121 kWh/yr and 0.04 kW. The gross ex post savings per measure are 93.5 ± 10.9 kWh/yr and 0.032 ± 0.02 kW at the 90 percent confidence level. The difference between ex ante and ex post savings is primarily due to EM&V findings of lower ex post annual hours of operation. The RHA database reported installing 15,331 T8 fixtures with ballasts, and the total gross ex post savings are 1,433,651 ± 167,656 kWh/year and 490.8 ± 30.3 kW at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The ex ante effective useful lifetime (EUL) was assumed to be 18 years. The ex post EUL is 17 years based on average annual hours of operation of 2,774 ± 284 hours per year and 50,000 lifecycle operational hours before failure.

Table 3.10 Load Impacts for T8 Fluorescent Fixtures with Electronic Ballasts

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
60	2-F40T12 Mag	3	2,829	96	0.288	815	2-F32T8 Elec	3	2,829	61	0.183	518	0.105	297.1
34	2-F40T12 Mag	17	3,294	96	1.632	5375	2-F32T8 Elec	17	3,294	61	1.037	3416	0.595	1,959.8
62	2-F40T12 Mag	13	3,679	96	1.248	4592	2-F32T8 Elec	13	3,679	61	0.793	2918	0.455	1,674.0
62	2-F96T12 Mag	2	3,679	128	0.256	942	2-F96T8 Elec	2	3,679	111	0.222	817	0.034	125.1
61	2-F40T12 Mag	4	3,224	96	0.384	1238	2-F32T8 Elec	4	3,224	61	0.244	787	0.14	451.3
2	2-F40T12 Mag	11	1,410	96	1.056	1489	2-F32T8 Elec	11	1,410	61	0.671	946	0.385	543.0
59	2-F40T12 Mag	13	4,459	96	1.248	5565	2-F32T8 Elec	13	4,459	61	0.793	3536	0.455	2,028.8
68	2-F40T12 Mag	12	3,048	96	1.152	3512	2-F32T8 Elec	12	3,048	61	0.732	2231	0.42	1,280.4
1	2-F40T12 Mag	9	3,688	96	0.864	3186	2-F32T8 Elec	9	3,688	61	0.549	2025	0.315	1,161.7
66	2-F40T12 Mag	14	3,048	96	1.344	4097	2-F32T8 Elec	14	3,048	61	0.854	2603	0.49	1,493.8
64	2-F40T12 Mag	24	2,435	96	2.304	5611	2-F32T8 Elec	24	2,435	61	1.464	3565	0.84	2,045.6
63	2-F40T12 Mag	23	1,691	96	2.208	3733	2-F32T8 Elec	23	1,691	61	1.403	2372	0.805	1,361.0
65	2-F96T12 Mag	8	1,673	96	0.768	1285	2-F32T8 Elec	8	1,673	61	0.488	817	0.28	468.5
44	2-F40T12 Mag	24	2,111	96	2.304	4864	2-F32T8 Elec	24	2,111	61	1.464	3091	0.84	1,773.4
4	4-F40T12 Mag	5	2,575	189	0.945	2434	4-F32T8 Elec	5	2,575	108	0.54	1391	0.405	1,043.1
58	2-F40T12 Mag	15	3,110	96	1.44	4478	2-F32T8 Elec	15	3,110	61	0.915	2845	0.525	1,632.6
12	2-F40T12 Mag	13	3,092	96	1.248	3859	2-F32T8 Elec	13	3,092	61	0.793	2452	0.455	1,407.0
13	2-F96T12 Mag	12	3,154	128	1.536	4844	2-F32T8 Elec	12	3,154	111	1.332	4201	0.204	643.3
7	2-F40T12 Mag	17	2,365	96	1.632	3860	2-F32T8 Elec	17	2,365	61	1.037	2453	0.595	1,407.3
18	2-F40T12 Mag	24	1,761	96	2.304	4057	2-F32T8 Elec	24	1,761	61	1.464	2578	0.84	1,479.0
16	2-F40T12 Mag	8	2,497	96	0.768	1917	2-F32T8 Elec	8	2,497	61	0.488	1218	0.28	699.0
17	2-F40T12 Mag	16	2,172	96	1.536	3337	2-F32T8 Elec	16	2,172	61	0.976	2120	0.56	1,216.6
20	2-F40T12 Mag	12	3,022	96	1.152	3482	2-F32T8 Elec	12	3,022	61	0.732	2212	0.42	1,269.3
19	2-F40T12 Mag	12	788	96	1.152	908	2-F32T8 Elec	12	788	61	0.732	577	0.42	331.1
19	2-F96T12 Mag	3	788	128	0.384	303	2-F96T8 Elec	3	788	111	0.333	263	0.051	40.2
11	2-F40T12 Mag	2	8,383	96	0.192	1610	2-F32T8 Elec	2	8,383	61	0.122	1023	0.07	586.8
6	2-F40T12 Mag	13	4,345	96	1.248	5423	2-F32T8 Elec	13	4,345	61	0.793	3446	0.455	1,977.0
33	2-F40T12 Mag	5	2,637	96	0.48	1266	2-F32T8 Elec	5	2,637	61	0.305	804	0.175	461.4
23	2-F40T12 Mag	11	1,156	96	1.056	1221	2-F32T8 Elec	11	1,156	61	0.671	776	0.385	445.2
39	2-F40T12 Mag	11	2,321	96	1.056	2451	2-F32T8 Elec	11	2,321	61	0.671	1558	0.385	893.7
37	2-F40T12 Mag	1	1,612	96	0.096	155	2-F32T8 Elec	1	1,612	61	0.061	98	0.035	56.4
37	2-F96T12 Mag	10	1,612	128	1.28	2063	2-F96T8 Elec	10	1,612	111	1.11	1789	0.17	274.0
35	2-F40T12 Mag	19	3,040	96	1.824	5544	2-F32T8 Elec	19	3,040	61	1.159	3523	0.665	2,021.4
36	2-F40T12 Mag	18	2,462	96	1.728	4254	2-F32T8 Elec	18	2,462	61	1.098	2703	0.63	1,550.8
38	2-F40T12 Mag	18	1,463	96	1.728	2528	2-F32T8 Elec	18	1,463	61	1.098	1606	0.63	921.6
40	2-F40T12 Mag	12	2,637	96	1.152	3038	2-F32T8 Elec	12	2,637	61	0.732	1930	0.42	1,107.4
26	2-F40T12 Mag	13	8,760	96	1.248	10932	2-F32T8 Elec	13	8,760	61	0.793	6947	0.455	3,985.8
24	2-F40T12 Mag	5	3,022	96	0.48	1451	2-F32T8 Elec	5	3,022	61	0.305	922	0.175	528.9
27	2-F40T12 Mag	15	3,127	96	1.44	4503	2-F32T8 Elec	15	3,127	61	0.915	2861	0.525	1,641.8
25	2-F40T12 Mag	15	4,538	96	1.44	6534	2-F32T8 Elec	15	4,538	61	0.915	4152	0.525	2,382.3
43	2-F40T12 Mag	10	2,199	96	0.96	2111	2-F32T8 Elec	10	2,199	61	0.61	1341	0.35	769.6
45	2-F96T12 Mag	3	1,542	128	0.384	592	2-F96T8 Elec	3	1,542	111	0.333	513	0.051	78.6
41	2-F40T12 Mag	15	2,558	96	1.44	3683	2-F32T8 Elec	15	2,558	61	0.915	2340	0.525	1,342.9
46	2-F40T12 Mag	4	1,892	96	0.384	727	2-F32T8 Elec	4	1,892	61	0.244	462	0.14	264.9
57	2-F96T12 Mag	10	1,577	128	1.28	2018	2-F96T8 Elec	10	1,577	111	1.11	1750	0.17	268.1
22	2-F40T12 Mag	1	2,076	96	0.096	199	2-F32T8 Elec	1	2,076	61	0.061	127	0.035	72.7
48	2-F40T12 Mag	2	3,215	96	0.192	617	2-F32T8 Elec	2	3,215	61	0.122	392	0.07	225.0
48	2-F96T12 Mag	1	3,215	128	0.128	412	2-F96T8 Elec	1	3,215	111	0.111	357	0.017	54.7
55	2-F40T12 Mag	3	2,610	96	0.288	752	2-F32T8 Elec	3	2,610	61	0.183	478	0.105	274.1
55	2-F96T12 Mag	7	2,610	128	0.896	2339	2-F32T8 Elec	7	2,610	111	0.777	2028	0.119	310.6
42	2-F40T12 Mag	12	2,146	96	1.152	2472	2-F32T8 Elec	12	2,146	61	0.732	1571	0.42	901.4
49	2-F40T12 Mag	24	4,748	96	2.304	10939	2-F32T8 Elec	24	4,748	61	1.464	6951	0.84	3,988.3
28	2-F96T12 Mag	10	2,146	128	1.28	2747	2-F96T8 Elec	10	2,146	111	1.11	2382	0.17	364.9
9	1-F40T12 Mag	2	5,133	57	0.114	585	1-F32T8 Elec	2	5,133	39	0.078	400	0.036	184.8
52	2-F40T12 Mag	21	3,618	96	2.016	7294	2-F32T8 Elec	21	3,618	61	1.281	4635	0.735	2,659.1
53	2-F40T12 Mag	6	2,391	96	0.576	1377	2-F32T8 Elec	6	2,391	61	0.366	875	0.21	502.2
29	1-F40T12 Mag	18	1,953	57	1.026	2004	1-F32T8 Elec	18	1,953	39	0.702	1371	0.324	632.9
30	1-F40T12 Mag	40	3,136	57	2.28	7150	1-F32T8 Elec	40	3,136	39	1.56	4892	0.72	2,258.0
5	2-F40T12 Mag	1	2,032	96	0.096	195	2-F32T8 Elec	1	2,032	61	0.061	124	0.035	71.1
5	2-F96T12 Mag	6	2,032	128	0.768	1561	2-F96T8 Elec	6	2,032	111	0.666	1354	0.102	207.3
8	2-F40T12 Mag	12	2,348	96	1.152	2705	2-F32T8 Elec	12	2,348	61	0.732	1719	0.42	986.0

Table 3.10 Load Impacts for T8 Fluorescent Fixtures with Electronic Ballasts

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
31	2-F40T12 Mag	20	5,571	96	1.92	10697	2-F32T8 Elec	20	5,571	61	1.22	6797	0.7	3,900.0
3	2-F40T12 Mag	32	2,970	96	3.072	9123	2-F32T8 Elec	32	2,970	61	1.952	5797	1.12	3,326.0
47	2-F40T12 Mag	6	2,085	96	0.576	1201	2-F32T8 Elec	6	2,085	61	0.366	763	0.21	437.8
50	2-F96T12 Mag	4	289	128	0.512	148	2-F96T8 Elec	4	289	111	0.444	128	0.068	19.7
56	2-F40T12 Mag	2	1,936	96	0.192	372	2-F32T8 Elec	2	1,936	61	0.122	236	0.07	135.5
56	2-F96T12 Mag	8	1,936	128	1.024	1982	2-F96T8 Elec	8	1,936	111	0.888	1719	0.136	263.3
56	3-F40T12 Mag	10	1,936	143	1.43	2768	3-F32T8 Elec	10	1,936	90	0.9	1742	0.53	1,026.1
Total		772											25.0	72,192
Ave													0.032	93.5

3.1.5 Load Impacts for LED Exit Signs

Load impacts for LED exit signs are based on field inspections of 17 fixtures at 8 participant sites, electric power measurements, and lighting logger measurements of 17 fixtures consistent with IPMVP Option B. Pre- and post-retrofit fixture quantities, hours of operation and savings are shown in **Table 3.11**. RHA assumed ex ante savings are 352 kWh/yr and 0.04 kW. The gross ex post savings per measure are 315.4 ± 32 kWh/yr and 0.036 ± 0.004 kW at the 90 percent confidence level. The difference between ex ante and ex post savings is primarily due to EM&V findings of lower ex post annual hours of operation. The RHA database reported 488 LED exit signs, and the total gross ex post savings are 153,896 ± 15,390 kWh/year and 17.6 ± 1.8 kW at the 90 percent confidence level. The inspections verified proper installation at 100 percent of sites. The effective useful lifetime (EUL) is assumed to be 16 years. The 16 year EUL is based on average annual hours of operation of 8,760 hours per year assuming 140,000 lifecycle operational hours.

Table 3.11 Load Impacts for LED Exit Signs

Site	Pre-retrofit	Pre-Qty	Pre-Hours	Pre W/Fix.	Pre kW	Pre kWh/y	Post-Retrofit	Post-Qty	Post-Hours	Post W/Fix.	Post kW	Post kWh/y	KW Savings	kWh Savings
14	40W Incand.	5	8,760	38	0.19	1664	2W LED	5	8,760	2	0.01	88	0.18	1,576.8
15	40W Incand.	1	8,760	38	0.038	333	2W LED	1	8,760	2	0.002	18	0.036	315.4
39	40W Incand.	3	8,760	38	0.114	999	2W LED	3	8,760	2	0.006	53	0.108	946.1
35	40W Incand.	2	8,760	38	0.076	666	2W LED	2	8,760	2	0.004	35	0.072	630.7
36	40W Incand.	2	8,760	38	0.076	666	2W LED	2	8,760	2	0.004	35	0.072	630.7
38	40W Incand.	2	8,760	38	0.076	666	2W LED	2	8,760	2	0.004	35	0.072	630.7
51	40W Incand.	1	8,760	38	0.038	333	2W LED	1	8,760	2	0.002	18	0.036	315.4
21	40W Incand.	1	8,760	38	0.038	333	2W LED	1	8,760	2	0.002	18	0.036	315.4
Total		17				333		17	8,760		0.646		0.6	5,361.1
Ave									0				0.036	315.4

3.1.6 Load Impacts for Programmable Thermostats

Load impacts for programmable thermostats were evaluated using historical billing data, the PRInceton Scorekeeping Method (PRISM), on-site audits, and calibrated eQuest building energy simulations consistent with IPMVP Options C and D. Two or three years of historical electric billing data were obtained for a sample of 59 participant sites located in Chico, Corning, Orland, and Yuba City, California. This data was then analyzed using the PRISM statistical regression model to develop normalized annual consumption (NAC) and cooling unit energy consumption (UEC) values. The average pre-NAC from PRISM is 30,779 ± 7,897 kWh per year and the average cooling UEC from PRISM is 8,347 ± 2,681 kWh per year. The average floor area is

2,586 ± 926 ft^2 at the 90 percent confidence level and the average EUI is 3.23 ± 1.04 kWh/yr-ft^2. This EUI compares reasonably well with the average cooling EUI of 3.95 kWh/yr-ft^2 from SCE Study 4 in **Table 2.1**. For comparison, the 2005 DEER Update Study provides an average EUI of 7.04 kWh/yr-ft^2 and programmable thermostat savings of 1.31 kWh/yr-ft^2.

Only four of the EM&V sites had a programmable thermostat installed, and one site (a brewery) had one thermostat serving 10 percent of the conditioned space with significant equipment loads in the remaining space. Therefore, this site was removed from the PRISM sample. The PRISM results for three sites show savings of 1,391 ± 1,847 kWh/year. The small sample size and large confidence interval makes these results unreliable. Therefore, eQuest and DOE-2.2 simulation models were used to develop energy savings for programmable thermostats based on calibration to average EUI values from billing data for the audit sample sites located in Climate Zone 11.

The eQuest model for the prototypical small commercial building is shown in **Figure 3.1**. The model was calibrated using average baseline space cooling values from PRISM and Typical Meteorological Year (TMY) weather data for CEC climate zone 11.[17] The pre- and post-retrofit thermostat schedules are shown in **Table 3.12**. The eQuest building characteristics are provided in **Table 3.13**.

RHA assumed gross cooling savings per programmable thermostat of 819 kWh/yr per thousand square feet (ft^2) of conditioned floor area. Zero savings are assumed for kW and therms. The ex ante savings are 1,638 kWh/yr per 2,000 ft^2 and 2,457 kWh/yr per 3,000 ft^2. The total gross ex ante savings for programmable thermostats are 172,759 kWh/yr.

Ex post gross savings per thermostat are 802 ± 218 kWh/yr and 0.55 ± 0.15 kW at the 90 percent confidence level with zero savings for therms. The RHA database reported 151 programmable thermostats. Therefore, the total gross ex post savings are 121,102 ± 32,918 kWh/year and 83.1 ± 22.7 kW at the 90 percent confidence level. The effective useful lifetime (EUL) is assumed to be 11 years per the 2005 DEER Update Study.[18]

[17] *California Thermal Climate Zones*, California Energy Commission, 1516 9th St., Sacramento, CA 95814, 1992.
[18] See the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study*, prepared for Southern California Edison, prepared by Itron, Inc., Vancouver, Washington 2005, http://eega.cpuc.ca.gov/deer/

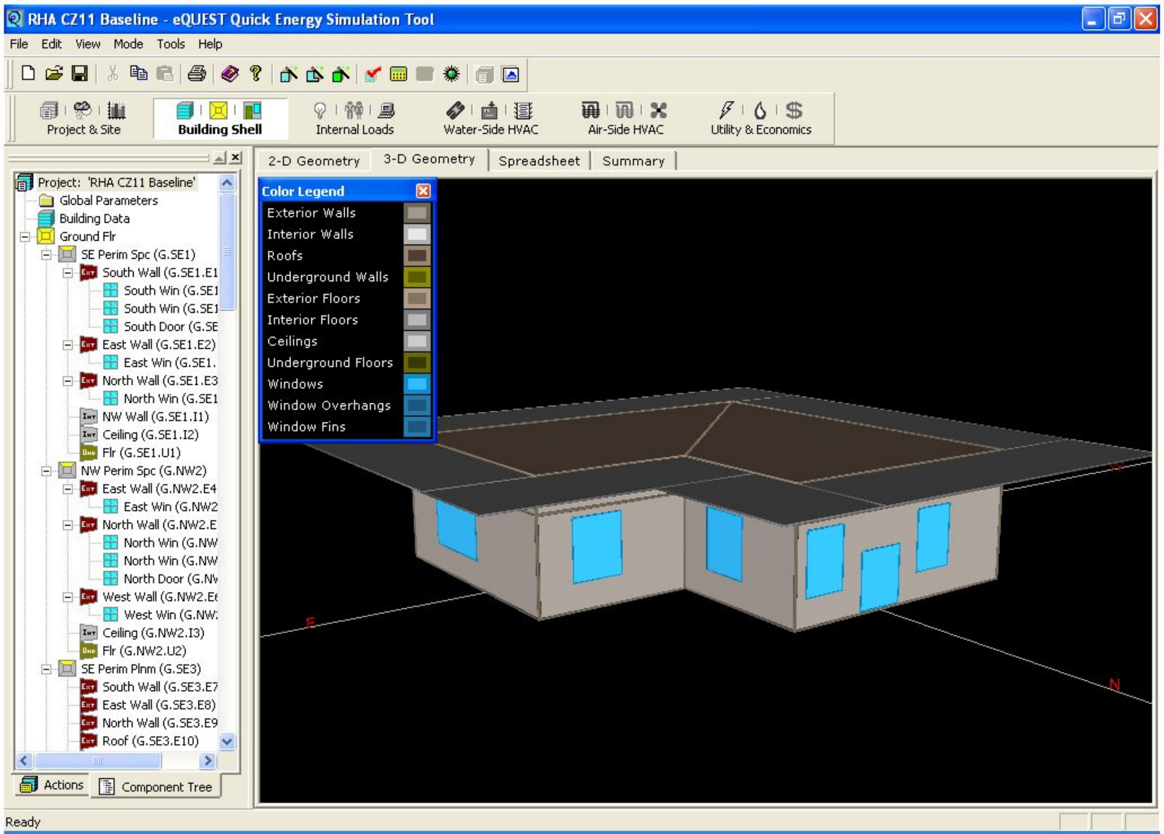

Figure 3.1 eQuest Small Commercial Building Model

Table 3.12 Average Pre- and Post-Retrofit Thermostat Schedules from On-Site Audits

Weekday Schedule	Midnight to 9 AM	9AM to 9PM	9PM to Midnight
Pre-Retrofit Cooling Schedule °F	off	76	Off
Post-Retrofit Cooling Schedule °F	off	79	Off
Pre-Retrofit Heating Schedule °F	off	66	Off
Post-Retrofit Heating Schedule °F	off	Same	Off
Weekend and Holiday Schedule	Midnight to 10 AM	10AM to 4PM	4PM to Midnight
Pre-Retrofit Cooling Schedule °F	off	79	Off
Post-Retrofit Cooling Schedule °F	off	Same	Off
Pre-Retrofit Heating Schedule °F	off	65	Off
Post-Retrofit Heating Schedule °F	off	Same	Off

Table 3.13 Small Commercial Building Characteristics

Characteristic	Existing Vintage
Total Floor Area (sf)	2,598
Average Floor Height	10
Wall R-value [cavity only]	2.6 [1]
Wall Type	Concrete Block
Ceiling R-value [cavity]	17.2 [11]
Ceiling Area, total exterior (sf)	2,077
Floor R-value [cavity]	Concrete
Window-to-Floor Area Ratio	0.25
Window u-value	1.0
Number of Panes	1
Occupancy (people)	6
Lighting Intensity (W/sqft)	1.89
Electric Internal Loads (kW/sqft)	1.6
HVAC Zoning	Single zone
Heating System Type	Gas furnace
Heating Capacity (kBtu/hr-unit)	120
Heating System Efficiency	0.77
Cooling System Type	Split/Packaged
Cooling Capacity (kBtu/hr-unit)	60
Cooling System EER	7.4
Design Air (cfm/sqft)	0.9

3.1.7 Load Impacts for Vending Misers

Load impacts for vending misers are based on the PG&E Statewide Express Efficiency Program showing average savings of 1,590 ± 159 kWh/year , and a study from the University of Illinois at Urbana-Champaign showing average savings of 1,554 kWh/year for Vending Misers.[19] RHA assumed ex ante savings of 1,590 kWh/year and 0 kW. The gross ex post savings per measure are assumed to be 1,590 ± 159 kWh/yr and 0 kW. The RHA Energy Fitness database reported installing Vending Misers at 28 sites. The total gross ex post savings are 44,520 ± 4,450kWh/year. The ex ante effective useful lifetime (EUL) was assumed to be 3 years consistent with the PG&E Express Efficiency EUL. An evaluation study by Foster-Miller, Inc., found an effective useful lifetime for the vending miser of 13 years or more.[20] Based on findings from Foster-Miller a 13 year EUL is used for this study.

3.1.8 Load Impacts for HVAC Tune-ups

Load impacts for HVAC tune-ups were evaluated using stipulated savings per IPMVP Option A. An effort was made to evaluate HVAC tune-up savings using historical billing data and the PRInceton Scorekeeping Method (PRISM) consistent with IPMVP Option C. Only one EM&V site had an HVAC tune-up installed, and the PRISM results for this site show savings of -1,149 kWh/yr. The small sample size and large confidence interval makes these results unreliable.

[19] Luo, J. 2003. Express Efficiency 2004-05 Workbook. 2-MeasureableEEActivities, Vending Machine Controller, San Francisco, Calif: Pacific Gas and Electric Company (PG&E). Taguchi, H., Jeong Lee, H., Pansare, P., Gentry, T. 2002. *The Vending Miser: A Pilot Study of Its Use at the University of Illinois at Urbana-Champaign.* Urbana-Champaign, Ill.: University of Illinois.

[20] Foster-Miller, Inc. 2000. *Vending Machine Engineering Evaluation and Test Report*. Waltham, MA.: Foster-Miller, Inc.

The HVAC tune-up measure involved filter replacement, chemical coil cleaning, check of refrigerant charge via temperature split, and replacement of Schrader caps where applicable. The measure is similar to DEER measure 061: clean condenser coils. The 2005 DEER Update Study provides savings for clean condenser coils of 142 ± 8 kWh/yr-ton and 0.123 ± 0.005 kW/ton or 709 ± 42 kWh/yr and 0.61 ± 0.25 kW per unit (assuming a 5-ton unit) and these savings are used for gross ex post savings. RHA assumed gross cooling savings per HVAC tune-up of 360 kWh/yr per unit.

The RHA database reported 103 HVAC tune-ups. Therefore, the total gross ex post savings are 73,027 ± 4,326 kWh/year at the 90 percent confidence level. The effective useful lifetime (EUL) is assumed to be 3 years per the 2005 DEER Update Study.[21]

3.1.9 Load Impacts for Energy Fitness Audit Measures

Load impacts for Energy Fitness audit measures are based on verification of customer adoption rates that were reported in the RHA tracking database and stipulated savings estimates according to IPMVP Option A. Participant surveys were completed from December 2004 through August 2005 to verify adoption of audit measures. These surveys were completed in-person with 68 participants.

The *Energy Fitness* audit included 25 energy efficiency measures. Gross ex post savings for each recommended audit measure are provided in **Table 3.14**. Ex post savings shown in **Table 3.14** are calculated using baseline EUI values from **Table 2.3** and average percentage savings from **Table 2.4**. For some measures, the savings are different than the ex ante savings in **Table 2.4**.

[21] See the *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study*, prepared for Southern California Edison, prepared by Itron, Inc., Vancouver, Washington 2005, http://eega.cpuc.ca.gov/deer/

Table 3.14 Ex Post Savings for Recommended Audit Measures

#	Audit Measures	Units	Demand Savings per unit kW	Annual Hours of Operation per unit	Savings per unit kWh	Savings per unit therm	EUL	Ex Post NTGR	Qty.
1	Seasonal HVAC Maintenance	Site	0.45	n/a	487	26	1	0.96	n/a
2	HVAC Tune-up	Site	0.51	n/a	793		10	0.96	n/a
3	Duct Test & Seal and Insulation	Site	0.07	n/a	1,126	65	15	0.96	n/a
4	Programmable Thermostat	Site		n/a	802	55	11	0.96	n/a
5	Efficient HVAC Equipment	Unit	0.63	n/a	921	76	15	0.96	n/a
6	Reflective Window Film	sf	0.0016	n/a	1.4	n/a	15	0.96	n/a
7	Advanced Evaporative cooler	Site	2.69	n/a	3,920	n/a	15	0.96	n/a
8	Ceiling Fan	Site	0.16	n/a	238	11	15	0.96	n/a
9	Delamp (3 to 2 lamp T12ES/Mag)	Unit	0.086	n/a	235	n/a	16	0.96	n/a
10	Delamp Other	Unit	0.038	n/a	179	n/a	16	0.96	n/a
11	Occupancy Sensors	Site	0.09	n/a	417	n/a	15	0.96	n/a
12	Lower Water Heater Temp.	Unit		n/a	71	11	3	0.96	n/a
13	Time Clock for Elec. Wtr Heater	Unit		n/a	36	n/a	3	0.96	n/a
14	Insulate Tank & Pipes	Unit		n/a	230	31	11	0.96	n/a
15	Infiltration Reduction	Site	0.11	n/a	160	22	20	0.96	n/a
16	R-30 Ceiling Insulation	sf	0.0002	n/a	0.38	102	25	0.96	n/a
17	R-11 to R-19 Wall Insulation	sf		n/a		60	25	0.96	n/a
18	High Performance Windows	sf	0.004	n/a	0.615	66	25	0.96	n/a
19	Auto-Closers on Exit Doors	Unit		n/a	85	n/a	8	0.96	n/a
20	Insulated Ice Machine Dispenser	Unit		n/a	600	n/a	8	0.96	n/a
21	Auto-Closers for Cooler Boxes	Unit		n/a	929	n/a	8	0.96	n/a
22	Strip Curtain for Walk-in Boxes	sf		n/a	85	n/a	4	0.96	n/a
23	Vending Miser	Unit		n/a	1,590	n/a	3	0.96	n/a
24	Glass Cooler Door Gaskets	lf		n/a	10	n/a	4	0.96	n/a
25	Energy Star Computers, Copiers	Unit		n/a	294	n/a	4	0.96	n/a

RHA technicians provided relevant recommendations to each participant in *Energy Fitness* report as part of the energy audit included during installation of no-cost measures. The in-person and telephone surveys asked the following questions to determine three findings.

1. Adoption rate. Did the participant adopt or install any of the energy efficiency improvements recommended by RHA in their *Energy Fitness* report?
2. Double-dipping. Did the participant receive a rebate (from a utility or other entity) for any of the adopted measures?
3. Influence of RHA. How influential were the *Energy Fitness* recommendations in terms of motivating the participant to implement the improvement on a scale of 1 to 10 (where 1 represented zero influence and 10 represented significant influence)?

Survey responses to these questions were filled into the survey questionnaire form. The 68 participant surveys found two measures adopted, no double-dipping, and the influence of RHA being 100 percent as shown in **Table 3.15**. The total gross ex post savings for audit measures are 1,600 kWh/year and 0.97 kW and lifecycle savings are 28,772 kWh. The average EUL for the audit measures is 18 years.

Table 3.15 Gross Ex Post Savings for Adopted Audit Measures

Site	Audit Measures	Adopted Measure	Rebate (0 or 1)	Influence (0 to 10)	Gross Ex Ante Savings kWh	Gross Ex Ante Savings kW	Gross Ex Post Savings kWh/yr	Gross Ex Post Savings kW	EUL	Lifecycle Ex Post Savings kWh/yr
16	R-30 Ceiling Insulation	1	0	10	798	0.42	798	0.42	25	19,950
25	Prog. Thermostat	1	0	10	819	0	802	0.55	11	8,822
Total		2		10	1,617	0.42	1,600	0.97	18	28,772

3.2 Process Evaluation Results

Process evaluation recommendations are based on process surveys conducted in-person with 68 participants, 68 non-participants (i.e., refusers), and 20 non-contacted businesses. The process surveys were used to evaluate participant satisfaction and obtain suggestions to improve the program's services and procedures. Interview questions assessed how the program influenced awareness of linkages between efficiency improvements, bill savings, and increased comfort for customers. Participants were asked why and how they decided to participate in the program. Non-participants were asked why they chose not to participate. Non-contacted businesses were asked if they would have participated had they been made aware of the program. The surveys identified reasons why program marketing efforts were not successful with non-participants as well as to identify additional hard-to-reach market barriers. The process survey instruments are provided in Appendix A.

3.2.1 Participant Survey Results

Participant process survey results are summarized to answer the following questions from the CPUC-approved EM&V plan.

1. **Are participants satisfied with services or information provided by the program?**
   Participant satisfaction is very high as indicated by the following survey responses.
   - Overall Satisfaction with Program – 90 percent satisfaction rating (i.e., average score of 9.0 ± 0.1 out of 10 points).
   - Courteous and Professional Crew – 93 percent satisfaction rating (i.e., 9.3 ± 0.2 out of 10 points).
   - Timeliness (i.e., work scheduled and completed on time) – 100 percent satisfaction rating (average reported time per installation 108 ± 9 minutes).
   - Increased Understanding of Link between Energy Efficiency, Savings, and Comfort – 79 ± 4 percent indicating *Energy Fitness* energy education efforts could be improved.

2. **Are customers satisfied with measures offered or installed by the program?**
   Customers were satisfied with measures as indicated by the following ratings.
   - 97 percent of customers are still using the measures installed by the program (i.e., 66 out of 68 surveyed customers were still using all installed measures).
   - 92 percent of customers were satisfied with measures offered or installed by the program.

3. **Are customers satisfied with services or information provided by the program?**
   Customer satisfaction with the services or information provided by the program is indicated by the following customer ratings.
   - 84 ± 3 percent usefulness rating for *Energy Fitness* report.

- 87 ± 3 percent presentation rating for *Energy Fitness* report.
- 88 ± 3 percent accuracy rating for *Energy Fitness* report.
- 79 ± 4 percent rating of program increasing understanding of the linkage between energy efficiency, bill savings, and comfort.
- 100 percent of participants indicated that neighboring businesses would benefit from the program.

One participant didn't receive the *Energy Fitness* report and was unable to answer questions about this aspect of the program.

4. What are the participant hard-to-reach demographics?

Participant demographics have been verified as "hard-to-reach" as indicated by the following results.[22]

- 100 percent of participants were outside major metropolitan areas (i.e., San Francisco, Sacramento).
- Average conditioned floor area is 2,586 ft^2 ± 926 ft^2.
- Average number of employees is 4.6 ± 0.6.
- 100 percent spoke English well enough to understand and answer the questions.
- 16 percent spoke Spanish, 4 percent spoke Chinese, and 2 percent spoke Vietnamese as their primary language.

5. Do participants have any suggestions to improve the program?

84 percent of participants provided comments or suggestions to improve the program.

- 67 percent said "great program, great job, nice employees" and would like to see it continue to serve small businesses in the area or expand to other communities in California.
- 31 percent said they "really liked the brightness of the new T-8 fixtures and the CFLs" compared to their old lights.
- 16 percent said that their electric utility bill had gone down since RHA has performed their work. One customer reported that their bill had increased.
- 7 percent said the program would benefit from better advertising. Five customers found out about the program by word of mouth. Three customers suggested official handouts that told the customer about the purpose of the program, funded source, and that services would be free of charge.
- 4 percent said they would like to see additional measures installed at their businesses such as more lights or a programmable thermostat.
- 1 customer didn't like the lower wattage CFLs since they didn't put out enough light.
- 1 customer removed their programmable thermostat because it was too hard for them to use.

[22] The CPUC definition of small commercial hard-to-reach customers are those who do not have easy access to program information or generally do not participate in energy efficiency programs due to language (i.e., primary language non-English), business size (less than ten employees); geographic (i.e., outside San Francisco Bay Area, Sacramento, Los Angeles Basin or San Diego), or lease (i.e., split incentives barrier). ADM further defines hard-to-reach as less than 50kW and 5,000 ft^2.

6. **Did participants share information with business associates about the benefits of measures offered by the program (i.e., multiplier effects)?**
   Based on process survey responses, 100 percent of interviewed customers shared program information with 10.3 times as many peers (68 participants shared information with 698 businesses). Approximately 51 percent of these businesses (i.e., 358) decided to install similar measures or participate in the Energy Fitness program. The program helped expand impacts beyond the participant group to a larger group through direct installation of measures and the *Energy Fitness* audit measure recommendations. The multiplier effect for the program is estimated at 88 percent.[23] Programs that link technologies with educational measures can have multiplier effects as high as 25-30 percent including the sharing of program information to a population that is several times larger than the participant population.

3.2.2 Non-Participant Survey Results

Non-participant process survey results are summarized to in order to answer the following questions from the CPUC-approved EM&V plan.

1. **Is there a continuing need for the program?**
   The following responses indicate a continuing need for the program.
   - 71 percent of participants said they and would like to see the program continue to serve small businesses in the Chico, Orland, and Yuba City area or expand to other communities in California.
   - 39 percent of non-participants would have participated if they knew the program installed no-cost energy efficiency improvements at small commercial businesses like theirs.
   - 61 percent of non-participants would not have participated in the program.

2. **Why have customers chosen not to participate (i.e., market barriers)?**
   - 79 percent indicated lack of interest in participating due to already having “efficient lighting,” but didn’t explain whether they knew what “efficient lighting” meant (i.e., information barrier).
   - 64 percent were tenants and did not own the building (i.e., misplaced or split incentive).
   - 15 percent didn’t participate due to not understanding the benefits (i.e., performance uncertainty).
   - 6 percent didn’t participate due to lack of time or scheduling problems (i.e., hassle cost).
   - 12 percent gave other reasons for not participating.

   Most non-participants didn’t participate due to not knowing about the program. Thirty-nine percent said they would have participated if they knew the program installed no-cost energy efficiency improvements. While better advertising would have helped, the RHA Energy Fitness Program was oversubscribed in 2004-05. The most often cited barriers to participation include information costs (79%), misplaced or split incentives (64%), performance uncertainty (15%), and hassle costs (6%). Although difficult to quantify, it appears that a large segment of the market is affected by each of these barriers. Most customers indicated that better marketing, delivery, or follow-up efforts would overcome

[23] Spillover of 88 percent is calculated based on 358 businesses adopting at least one spillover measure based on information shared by a group of 68 participants who adopted six measures (i.e., 358 × (1÷ 6) ÷ 68 = 0.88).

barriers to participation. A discussion of actionable recommendations for program changes that can be expected to improve the cost effectiveness of the program, improve overall or specific operations, or improve satisfaction or, of course, all three are provided in the executive summary and in the process evaluation section (see section 3.2.3 Process Evaluation Recommendations). Better marketing, delivery, or follow-up efforts will help overcome barriers to participation. Marketing materials should include an explanation of what "efficient lighting" means and how and why "better lighting" or other "measures" are of interest to small business owners. Marketing information should include an explanation of the "measures" (e.g., efficient lighting, HVAC tune-ups, programmable thermostats, etc.) with user-friendly instructions in various languages. The follow-up customer report should compare pre- and post-retrofit billing data to verify energy savings. Installing light loggers at each site and then showing the measured savings from lighting measures would be very helpful. Sites with billing data indicating low or negative savings should be checked for proper installation and operation of measures (i.e., programmable thermostats). This will also facilitate better EM&V analyses of program savings.

3. **Do non-participants have any suggestions to improve participation?**
   - 22 percent of non-participants suggested offering discounts on the energy bill for already installing energy efficiency measures, or to offer on-bill financing to pay for measures not offered by the program. These suggestions make sense and could easily be adopted by the Energy Fitness program if the program is continued and coordinated with PG&E.

4. **What are the non-participant hard-to-reach demographics?**
   Non-participants had the following hard-to-reach demographics.
   - 56 percent of non-participants were tenants.
   - 100 percent spoke English well enough to understand and answer the questions.
   - 100 percent of non-participant businesses were outside major metropolitan areas such as San Francisco or Sacramento.
   - Non-participants had an average of 5.4 ± 0.7 employees.

The following section provides process evaluation recommendations to improve the program.

3.2.3 Process Evaluation Recommendations

The following process evaluation recommendations are provided as per the CPUC-approved EM&V plan regarding what works, what doesn't work, and suggestions to improve the program's services and procedures.

3.2.3.1 General Program Recommendations

This program was exceptionally well managed and implemented. The following general program recommendations are provided to improve the program's services, procedures, and cost effectiveness.

1. Compare pre- and post-retrofit billing data to verify customers are saving energy.
2. Use light loggers and average light logger data for hours of operation for lighting fixtures.
3. Make sure technicians take time to properly explain programmable thermostats to participants and provide user-friendly instructions in various languages. Include a toll-free

number on thermostats for participants to call if they have questions. Programmable thermostats should include instructions for the technicians to follow when reprogramming the thermostat for both cooling and heating and all old and new settings should be documented in the tracking database.

4. Install night-time security lighting measures for customers to reduce the tendency to have all lights on at the businesses during unoccupied night-time hours.
5. Offer more comprehensive air conditioner tune-ups to save energy or a smaller efficient air conditioner to replace their big and old inefficient units. Provide comprehensive HVAC diagnostic tune-ups since most customers are tenants and air conditioner maintenance is the responsibility of the landlord who doesn't have a financial interest in maintenance (i.e., split incentive). Provide customers with extra air filters to increase HVAC diagnostic tune-up measure EUL.
6. Label all installed measures with a permanent sticker or mark to ensure measures can be properly verified by EM&V inspectors as having been installed.
7. Make sure all participants receive a generic *Energy Fitness* report.
8. Participants provided the following suggestions to improve the program.
   - Better advertising through landlord, telephone, email, mail, newspapers, or television will increase participation. Advertising should explain how small commercial businesses can take advantage of no-cost energy efficiency improvements offered by the program.
   - Offer services in the evening after business hours.
   - Marketing to corporate offices or landlord to gain approval for work.
9. Compare pre- and post-retrofit billing data to verify customers are saving energy. Sites with billing data indicating low or negative savings should be checked for proper installation and operation of measures (i.e., programmable thermostats). This will also facilitate better EM&V analyses of program savings.
10. Conduct follow-up calls and site-visits to verify proper installation and operation of measures (i.e., programmable thermostats). Review customer billing data to ensure the program is delivering measurable savings. Sites with billing data indicating low or negative savings can be checked for proper installation of measures. This will also facilitate better EM&V analysis of program savings.

3.2.3.2 Recommendations for Training

All technicians were courteous, well trained, and equipped to implement the program. Several RHA technicians indicated they were EPA certified and familiar with performing AC tune-ups. The following list of equipment is provided if adding refrigerant charge and airflow diagnostic tune-ups to the program.

- Bacharach sling psychrometer for calibrating digital temperature measurements.
- Fluke Model 52 II two-temperature probe digital thermometer (or equivalent).
- Fluke Model 80PK-8 Clamp-on Type K digital thermometer (or equivalent).
- Carrier Model 020-434 Superheat Calculator or Verified, Inc. PDA (www.verify-rca.com) to check proper refrigerant charge and airflow (RCA).
- Compound refrigerant pressure gauge.
- Digital scale for weighing refrigerant.
- Refrigerant leak detection equipment.
- Schrader core removal tool and core valves with locking Schrader caps.

Train technicians on proper installation procedures and materials for all measures. Provide each technician with installation specifications and quality control guidelines to ensure proper installation of all measures. Make sure technicians take time to properly explain programmable thermostats to participants and consider providing simple instructions in various languages and placing a toll-free number on the thermostats for participants to call if they have any questions. When the lighting retrofits are completed the buildings will have less air conditioning loads. Consider training auditors and HVAC technicians to perform air conditioning load calculations on the building so if the air conditioner fails, a smaller, properly sized unit can be installed to reduce peak air conditioning connected electric loads and demand.

3.2.3.3 Recommendations for Database

RHA has an excellent program tracking database. The EM&V study evaluated the database and found areas where it might be improved. Most important is capturing operational hours for lighting fixtures based on customer interviews (i.e., number of hours fixtures are on rather than hours business is open). Operational hours based on interviews with participants were compared to lighting logger data and findings indicated most customers had an accurate understanding of their operational hours. Capturing this information in the RHA program tracking database will help make measure savings more accurate. Also consider capturing the old and new thermostat schedules for programmable thermostats to document savings. It might be easier to manage and view data in Microsoft Access with functions to export data formatted in Microsoft Excel. This would allow for easier analysis and reporting for EM&V purposes.

3.2.3.4 Compact Fluorescent Lamps (CFLs)

Some customers complained that the installed CFLs were not bright enough. Check to make sure CFLs provide enough light for customers. If not, install higher Wattage CFLs.

3.2.3.5 T8 Fluorescent Lamps with Electronic Ballasts

No problems were found with T8 fluorescent lamps with electronic ballasts and no recommendations are provided.

3.2.3.6 LED Exit Signs

The inspection verification rate for LED exit signs was 100%. No recommendations are provided for LED exit signs.

3.2.3.7 Programmable Thermostats

Some participants removed the programmable thermostats due to not understanding how to operate them properly. Technicians should properly explain programmable thermostats to participants and provide user-friendly instructions in various languages. Include a toll-free number on thermostats for participants to call if they have questions. Programmable thermostats should include instructions for the technicians to follow when reprogramming the thermostat for both cooling and heating and all old and new settings should be documented in the tracking database. To improve persistence post thermostat schedules should be stored in ROM or backed up with an 11-year "leak-charge" NiCad battery.

3.2.3.8 Recommendations for HVAC Tune-ups

Participants suggested offering more comprehensive air conditioner tune-ups to save energy. Most customers are tenants and air conditioner maintenance is the responsibility of the landlord who doesn’t have a financial interest in maintenance (i.e., split incentive). The RHA program included chemical condenser coil cleaning, but did not include refrigerant charge and airflow (RCA) diagnostic tune-ups.

3.2.3.9 Other Cost Effective Measures to Consider

RHA might consider other cost effective measures for the future as follows.

1. Correcting refrigerant charge and airflow in the HVAC tune-up measure will increase savings. Many customer sites do not receive regular AC maintenance and don’t know that their AC units aren’t working properly. Studies show roughly 50 to 60 percent of small commercial air conditioners have improper refrigerant charge and airflow. This is a relatively low cost measure to implement and should yield cost effective savings (see the DEER Database for more information). The time required to perform this measure is typically 30-45 minutes including 15 minutes of time to ensure steady state conditions to make final measurements. The equipment and training for this measure is discussed above.
2. Combing condenser coil fins will improve airflow across the condenser.
3. Installing washable plastic mesh air filters or giving customers twelve free air filters at time of installation to allow annual replacement and persistence of the HVAC tune-up measure for eight years. Every dollar spent on free air filters will increase net benefits by roughly $5 and provide a 5 percent improvement in the total resource cost effectiveness for air filter replacement measures.
4. Installing suction line insulation on bare refrigeration suction lines will save 1-2%. Insulating the suction line maintains lower suction temperatures and pressures and saves energy. Heat gain to un-insulated suction lines add cooling loads and cause the compressor to run hotter and less efficiently. The liquid line should only be insulated if it runs through a freezer or refrigerated space. Otherwise, it should be left un-insulated. Follow the California Energy Commission (CEC) requirements regarding installation of refrigerant line insulation and install minimum ¾” thick insulation according to manufacturers’ installation instructions regarding seam and butt sealing joints as well as proper inside diameter of the insulation to match the outside diameter of the pipe (i.e., eliminate plastic ties). Consider using insulation with better UV protection and a guaranteed 10-year life for exterior applications or factory- or field-installed white UV coatings to protect insulation from solar radiation, reduce heat gain, and improve persistence and savings.
5. Lowering hot water temperatures is a low-cost measure with significant savings opportunities. If implemented make sure to capture pre/post hot water temperature readings in the RHA database for verification.
6. Insulating hot water supply and cold water return on water heaters is a low-cost measure with significant savings opportunities. If implemented this measure should include installation of 1” thick insulation (minimum) on the first 5 feet of the hot pipe coming out of the storage tank and the first 5 feet going into the storage tank or the first major bend as per CEC standards.

3.2.3.10 Audit Measures

Based on findings from this and other studies, hard-to-reach small commercial tenants are not motivated to invest in improving rental space. Due to this problem, program efforts spent on the *Energy Fitness* report might not yield significant savings creditable to the program. Therefore, it might be better for RHA to install as many cost effective measures as possible, provide generic recommendations, and reduce efforts spent on providing custom audit measure recommendations in the *Energy Fitness* report.

Appendix A: Process Survey Instrument
RHA #1409-04 Energy Fitness Program

Interview Instructions for Process Survey

1. Purpose

The purpose of the Process Survey is to evaluate what works, what doesn't work, customer satisfaction, and suggestions for improvement in the program's services and procedures.

2. Selection of Respondent

1. **Participants** must be the person responsible for allowing program measures to be installed at the site. If this person is unavailable locate someone who is at least familiar with how that decision was made. Participant question #20 is used to verify that participant is a small-business with one or more of the following attributes: 1) Primary language non-English; 2) <10 employees; 3) Lease; 4) Use <100 kW or <10,000 therm/yr; or 5) Located outside Sacramento/San Francisco Bay Area.
2. **Non-participants** must be a small-business in the local utility service area who was unaware of the program or decided not to allow program measures to be installed at their facility (see non-participant survey at end). Non--participant question 3 is used to verify one or more of the following attributes: 1) Primary language non-English; 2) <10 employees; 3) Lease; 4) Use <100 kW or <10,000 therms/yr; or 5) Located outside Sacramento/San Francisco Bay Area.

3. Two Types of Sites

This survey will be used for two types of sites:

1. **On-Site EM&V Only**. Sites that receive an EM&V on-site inspection or process survey.
2. **Telephone Only**. Sites that only receive a telephone survey (participants or non-participants).

4. How to Start a Survey

Complete the following steps to start one of these surveys:

1. Review RHA customer file information (for participants).
2. Make sure you understand what RHA installed prior to initiating the visit or call.
3. Participant Survey Introduction.
   Say: "Hello! My name is [________], and I am conducting a survey regarding the RHA, Inc. Small Nonresidential Energy Fitness Program. The program installed no-cost/low-cost energy efficiency improvements for your business. Funding for the program came from the California Public Utilities Commission. Would you mind spending 10 minutes to answer a few questions to help us evaluate and improve the program?
4. Non-participant Survey Introduction.
   Say: "Hello! My name is [________], and I am conducting a survey regarding the RHA, Inc. Small Nonresidential Energy Fitness Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program installed a package of energy conservation measures including: 1) Ten to twelve screw-in, 27-watt CFLs; 2) Two LED Exit Signs; 3) One hardwired T-8/electronic ballasted fluorescent fixture replacement of incandescent fixtures; and 4) Removed or delamped unnecessary incandescent or fluorescent lamps. Would you mind spending 10 minutes to answer a few questions?

RHA ENERGY FITNESS PARTICIPANT SURVEY #______

Business___________________________________ Name ______________________________ Title __________

Address ___________________________________ City ___________________________________ ZIP ________

Phone Number_______________________ Survey Date ___________________________Surveyor Initials ________

Participant Survey

1. Do you remember an RHA crew installing no-cost energy efficiency improvements at your facility?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

2. How would you rate the crew in terms of being courteous and professional on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer

3. Was the work scheduled and completed within a reasonable timeframe?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

4. How long was the technician at your facility?
   ___ 1 hr ___2 hrs ___3 hrs ___4 hrs ___>4 hrs **98** Don't Know **99** Refused to Answer

5. Did you receive *Energy Fitness Reports* from RHA? ___ **1** (Yes) ___ **2** (No, ***Skip to Q8***) **98** DK **99** Refused
   If yes, how would you rate the *Energy Fitness Reports* in terms of usefulness on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer

6. How would you rate the *Energy Fitness Reports* in terms of presentation on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer

7. How would you rate the *Energy Fitness Reports* in terms of accuracy on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer

8. Did you receive *Energy Fitness* advice to obtain financing or rebates? ___ **1** (Yes) ___ **2** (No) **98** DK **99** Refused
   If yes, how satisfied were you with the *Energy Fitness* advice on a scale from 1 to 10?
   ___ Financing Advice (**1=low, 10=high**) ___ Rebate Advice (**1=low, 10=high**) **98** DK **99** Refused

9. How would you rate the overall service you received on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer

10. How would you rate the program in terms of increasing your understanding of the linkage between energy efficiency, bill savings, and comfort?
    ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer

11. To the best of your knowledge was everything installed correctly?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

12. Are you still using all the measures that were installed?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

    Please list measures not used? ____

13. Were there any measures that were not installed (i.e., check RHA database to verify measures were installed such as screw-in CFLs, LED Exit Signs, hardwired T-8/electronic ballasted fluorescent fixtures, etc.)?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

    Please list measures not installed? ____

14. Have you shared information with any of your business associates about the benefits of screw-in CFLs, LED Exit Signs, hardwired T-8/electronic ballasted fluorescent fixtures, or other measures from the *Fitness Report*?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

    With how many other businesses have you shared this information in the last 12 months? _______________

    About how many of these people have installed any of these measures? ____________________________

15. Do you know any other businesses that would benefit from this program (name/address)? _______________

    ____

RHA ENERGY FITNESS PARTICIPANT SURVEY (cont'd) #______

16. What make and model or size (i.e., ton) air conditioner do you have? (Deduce tons from model number.)
______________ Make ___________________ Model ____tons **98** Don't Know **99** Refused to Answer

17. How many hours per day do you use the CFLs or Lighting Fixtures that RHA installed? **98** (DK) **99** (Refused)

Location	Old Type	Old Qty.	Old Hrs	Old W/Fix	New Type	New Qty.	Old Hrs	New W/Fix
1.			hrs	W			hrs	W
2.			hrs	W			hrs	W
3.			hrs	W			hrs	W
4.			hrs	W			hrs	W
5.			hrs	W			hrs	W
6.			hrs	W			hrs	W
7.			hrs	W			hrs	W
8.			hrs	W			hrs	W
9.			hrs	W			hrs	W
10.			hrs	W			hrs	W

Type: 1 = CFL; 2 = LED Exit; 3 = Replace Incandescent with Fluorescent; 4 = Delamp T12-Mag with T8-EB; 5 = Replace T12-Mag with T-8-EB

18. Did you receive an Energy Fitness audit checklist of opportunities for saving energy at your facility?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

Have you adopted any measures since the RHA *Energy Fitness* audit was performed? (Ask six months after audit.)

#	Energy Fitness Audit Measures	Baseline	Measure	Hrs/yr	Savings	Adopted	Cust.
1	Seasonal Maintenance (Clean Air Filters)	Dirty Filters/Coil	Clean Filters/Coils		7%		
2	HVAC Tune-up	Incorrect Ref. Charge	Correct Ref. Charge		13%		
3	Duct Testing and Sealing and Insulation	Leaky No Insulation	Seal/Insul. Ducts		Seal 14%/ 3%		
4	Programmable Thermostat	None	Setback/setup		20%		
5	Energy Efficient HVAC Equipment	7.4 SEER/7.7 EER	11 SEER/10.3 EER		25-33%		
6	Reflective Window Film	Clear: 0.83 SHGC	Film: 0.47 SHGC		14%		
7	Advanced Evaporative cooler	DX Air Cond.	Evap. Cooler		49%		
8	Ceiling Fan	None	Ceiling Fan		10%		
9	Delamp. (3-T12ES/Mag to 2-T12ES/Mag)	133W	82W		39%		
10	Delamp Other						
11	Occ. Sensors in Areas with Intermittent Use	3,200 hours	1,500 hours		53%		
12	Lower Water Heater Temperature	130F	120F		8%		
13	Time Clock for Electric Water Heater	8,760 hrs/y	4,380 hrs/y		4%		
14	Insulate Tank & Pipes	No Insulation	R8 Tank and R4 Pipe		10%		
15	Infiltration Reduction (leaks, weatherstripping)	0.5 ACH	0.4 ACH		2%		
16	R-30 Ceiling Insulation	None	R-30		10-20%		
17	R-11 to R-19 Wall Insulation	R-11	R-19		-		
18	High Performance Windows	Single Pane	Low-E		30%		
19	Auto-Closers on Exit Doors	None	Auto Closer		1%		
20	Insulated Ice Machine Dispenser Box	Uninsulated Box	Insulated Box		20%		
21	Auto-Closers for Cooler Boxes	None	Auto Closer		2%		
22	Strip Curtain for Walk-in Boxes	None	Strip Curtain		3%		
23	Vending Miser	No Control	Vending Miser Control		30-55%		
24	Glass Cooler Door Gaskets	Leaky Gasket	Tight Gasket		2%		
25	Energy Star Computers & Copiers (or controls)	None	Power Management		10%		

19. Please provide your thermostat settings before and after RHA performed their audit?

Weekday Cooling Schedule				Weekend Cooling Schedule				Weekday Heating Schedule				Weekend Heating Schedule			
OLD Time	OLD Temp	NEW Time	NEW Temp	OLD Time	OLD Temp	NEW Time	NEW Temp	OLD Time	OLD Temp	NEW Time	NEW Temp	OLD Time	OLD Temp	NEW Time	NEW Temp
	°F		°F		°F		°F		°F		°F		°F		°F
	°F		°F		°F		°F		°F		°F		°F		°F
	°F		°F		°F		°F		°F		°F		°F		°F
	°F		°F		°F		°F		°F		°F		°F		°F

20. Please provide the following demographic information (*obtain utility bill data from RHA*)?
________Language ____# Employees Own Lease _______ Floor Area ____kW _________kWh/yr _________therm/yr **99** Refused

21. Do you have any suggestions to improve the program?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

If so, please provide the suggestion(s). ____

RHA ENERGY FITNESS NON-PARTICIPANT SURVEY #______

Business ________________________________ Name _____________________________ Title __________

Address _________________________________ City _________________________________ ZIP _______

Phone Number ______________________ Survey Date __________________________ Surveyor Initials _______

Non-Participant Survey

I am conducting a survey regarding a RHA, Inc. *Energy Fitness* Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program installed a package of energy conservation measures including: 1) Ten to twelve screw-in, 27-watt CFLs; 2) Two LED Exit Signs; 3) One hardwired T-8/electronic ballasted fluorescent fixture replacement of incandescent fixtures; and 4) Removed or delamped unnecessary incandescent or fluorescent lamps. Would you mind spending 5 minutes to answer a few questions?

1. Would you have participated if you knew the program installed no-cost/low-cost energy efficiency improvements measures in businesses like yours?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

2. Please tell me why you choose not to participant in the program?
   (Read list – Multiple answers are okay.)

   1 Didn't know about the program (i.e., information cost).

   2 Didn't understand energy savings benefits of the program (i.e., performance uncertainty).

   3 Don't own the building (i.e., renter–misplaced or split incentive).

   4 Unable to be available for crew to perform work (i.e., hassle cost).

   Would you have participated if someone else you know (i.e., an employee) could have been present at your business while the RHA crew did their work?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   5 Would you have participated if the program provided services at other times?

   ___ Evenings ___ Saturdays ___Sundays **98** Don't Know **99** Refused to Answer

   6 Other ____

   98 Don't Know **99** Refused to Answer

3. Please provide the following demographic information?

   ________Language ____# Employees Own Lease ______ Floor Area ____kW _________kWh/yr _______therm/yr **99** Refused

4. Do you have any suggestions that might have helped you participate in the program?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

If so, please provide the suggestion(s).____