Evaluation, Measurement, and Verification Report for the Moderate Income Comprehensive Attic Insulation Program #1082-04

Study ID: BOE0001.01

FINAL REPORT

Prepared for
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BO Enterprises, Inc.
Los Gatos, California

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1. Executive Summary

This report provides the Evaluation, Measurement, and Verification (EM&V) findings for the BO Enterprises (BO) Moderate Income Comprehensive Attic Insulation Program (MICAP) #1082-04. 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 6,000 residential customers in the Pacific Gas and Electric (PG&E) service area, perform an energy audit, directly install 3,518,402 square feet of attic insulation and 51,630 energy efficiency measures, and conduct follow-up activities to achieve net energy savings of 5,224,911 first-year kWh, 2,746 kW, 622,607 first-year therms, 65,861,867 lifecycle kWh and 10,825,954 lifecycle therms.

The program exceeded its measure installation goals by 50% and electricity savings goals by 28%, but fell short by 8% on first-year and 16% on lifecycle gas savings goals (as shown in **Table 1.1**). The program installed 3,561,844 square feet of attic insulation and 77,738 energy efficiency measures at 6,570 moderate income residential customers. Ex post accomplishments were verified by checking the tracking database, randomly inspecting 91,364 square feet of attic insulation and 1,763 energy efficiency measures at 158 customer sites (90 more than anticipated and budgeted), installing light loggers on 1,244 fixtures at 69 sites, evaluating billing data for 58 sites, and conducting surveys of participants, non-participants, and non-contacts.

Table 1.1 Ex Ante Goals and Ex Post Accomplishments

Description	Program Implementation Plan Ex Ante Goal	Ex Post Accomplishment
Total Direct Install Measures		
Attic Insulation	3,518,402	3,561,844
AC Diagnostic	1,400	1,651
Duct Seal	900	1,060
Aerators	10,800	13,978
Showerhead	5,760	7,848
Energy Star® CFL Torchiere	1,150	1,606
Water Heater Blanket	720	979
Pipe Insulation	360	10
Energy Star® CFL (15, 20, 24W)	30,000	49,462
Energy Star® Thermostat	900	1,146
Moderate Income Energy Education and Direct Installations	6,000	6,570
Net Annual Electricity Savings (kWh/yr)	5,224,911	6,682,098
Net Demand Savings (kW)	2,746	2,934
Net Annual Therm Savings (therm/yr)	622,607	572,704
Net Lifecycle Electricity Savings (kWh)	65,861,867	66,518,557
Net Lifecycle Gas Savings (therm)	10,825,954	9,102,165
Total Resource Cost (TRC) Test – EEGA Workbook	1.5939	1.5241
Total Resource Cost (TRC) Test – E3 Calculator		2.7089
TRC Test Costs	$3,923,571	$3,923,571
TRC Test Benefits	$6,253,849	$5,979,917
TRC Test Net Benefits	$2,330,278	$2,056,346
Participant Test	7.1558	6.8327
Participant Test Costs	$2,275,185	$2,290,351
Participant Test Benefits	$16,280,673	$15,649,299
Participant Test Net Benefits	$14,005,488	$13,358,948

The net ex post Total Resource Cost (TRC) test benefit-cost ratio is 1.52 based on the Energy Efficiency Groupware Application (EEGA) Workbook.[1] The MICAP energy efficiency measures reduce air conditioning usage which contributes 33 percent to California's peak electricity demand.[2] The EEGA workbook doesn't value peak demand. The TRC benefit cost ratio is 2.7 based on the E3 calculator which does value the MICAP peak demand savings.[3]

The ex ante first-year savings are summarized in **Table 1.2**.

Table 1.2 Ex Ante First-Year Electricity and Gas Savings

Energy Efficiency Measure	Units Estimated	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/yr)	Net-to-Gross Ratio	Net Ex Ante Program Savings (kWh/y)	Net Ex Ante Program Savings (kW)	Net Ex Ante Program Savings (therm/yr)
Energy Star® CFL Torchieres	1,150	276	0.043		0.80	253,920	39.7	
Energy Star® Screw-In CFL 24 watt	18,000	111	0.037		0.80	1,598,400	529.9	
Energy Star® Screw-In CFL 20 watt	6,000	80	0.027		0.80	384,000	128.2	
Energy Star® Screw-In CFL 15 watt	6,000	66	0.022		0.80	316,800	104.6	
Basic HVAC Diagnostic FDZ3	1,250	438	0.442		0.89	487,275	491.7	
Basic HVAC Diagnostic FDZ2	150	211	0.200		0.89	28,169	26.7	
R-0 to R-30 Attic Insulation FDZ1	16,120	0.153	0.000159	0.256	0.89	2,197	2.3	3,677
R-0 to R-30 Attic Insulation FDZ2	73,140	0.467	0.000456	0.296	0.89	30,409	29.7	19,237
R-0 to R-30 Attic Insulation FDZ3	548,547	1.519	0.001578	0.289	0.89	741,506	770.5	140,974
R-0 to R-30 Attic Insulation FDZ4	145,076	0.190	0.000207	0.221	0.89	24,539	26.7	28,550
R-5 to R-30 Attic Insulation FDZ1	48,359	0.052	0.000054	0.117	0.89	2,255	2.3	5,042
R-5 to R-30 Attic Insulation FDZ2	219,419	0.160	0.000166	0.096	0.89	31,216	32.4	18,692
R-5 to R-30 Attic Insulation FDZ3	1,645,641	0.485	0.000504	0.109	0.89	710,271	738.0	159,023
R-5 to R-30 Attic Insulation FDZ4	435,229	0.060	0.000062	0.087	0.89	23,267	24.2	33,848
Energy Star® Thermostats FDZ1	18	267	-0.620	99	0.89	4,272	-9.9	1,588
Energy Star® Thermostats FDZ2	72	314	-0.614	108	0.89	20,095	-39.3	6,934
Energy Star® Thermostats FDZ3	540	382	-0.569	87	0.89	183,647	-273.2	41,812
Programmable Thermostats FDZ4	162	352	-0.709	103	0.89	50,708	-102.2	14,876
Duct Sealing FDZ1	18	107	0.197	34	0.89	1,719	3.2	548
Duct Sealing FDZ2	72	136	0.212	40	0.89	8,718	13.6	2,559
Duct Sealing FDZ3	540	270	0.295	32	0.89	129,823	141.8	15,165
Duct Sealing FDZ4	162	99	0.182	29	0.89	14,207	26.2	4,178
Water Heater Tank Insulation-Elec DHW	72	242	0.053	0	0.89	15,507	3.4	
Pipe Insulation-Elec DHW	36	92	0.020	0	0.89	2,948	0.6	
Faucet Aerators-Elec DHW	1,080	70	0.015	0	0.89	67,284	14.4	
Low-Flow Showerheads-Elec DHW	576	179	0.039	0	0.89	91,763	20.0	
Water Heater Tank Insulation	648			12	0.89			6,921
Pipe Insulation	324			5	0.89			1,442
Faucet Aerators	9,720			3	0.89			25,952
Low-Flow Showerheads	5,184			10	0.89			46,138
Energy Star® Thermostats FDZ5	108			122	0.89			11,689
Duct Sealing FDZ5	108			36	0.89			3,463
R-0 to R-30 Attic Insulation FDZ5	19,344			0.240	0.89			4,132
R-5 to R-30 Attic Insulation FDZ5	367,527			0.080	0.89			26,168
R-15 to R-30 Attic Insulation FDZ2	0				0.89			
R-15 to R-30 Attic Insulation FDZ3	0				0.89			
R-15 to R-30 Attic Insulation FDZ4	0				0.89			
Total	3,570,391					5,224,911	2,746	622,607

[1] Intergy Corporation. 2004. EEGA Workbook Validator (version 3.8). Prepared for the California Public Utilities Commission, San Francisco, Calif: Available online: http://eega.cpuc.ca.gov/.
[2] Brown, R.E. and Jonathan G. Koomey, 2002. Electricity Use in California: Past Trends and Present Usage Patterns, Review Draft, Lawrence Berkeley National Laboratory, LBNL-47992.
[3] E3: Energy and Environmental Economics, Inc. 2008. E3 Calculator. Energy and Environmental Economics, Inc.: San Francisco, Calif. 94104. Available online: http://www.ethree.com/cpuc_cee_tools.html.

The ex post first-year savings are summarized in **Table 1.3**. The EM&V study found first-year net ex post program savings of 6,682,098 ± 554,912 kWh per year, 2,934 ± 184 kW per year, and 572,704 ± 31,956 therms per year at the 90 percent confidence level. The net realization rates are 1.28 ± 0.08 for first-year kWh, 1.07 ± 0.06 for kW, and 0.92 ± 0.05 for first-year therms.

Table 1.3 Ex Post First-Year Electricity and Gas Savings

Energy Efficiency Measure	Units Installed	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)	Net-to-Gross Ratio	Net Ex Post Program Savings (kWh/y)	Net Ex Post Program Savings (kW)	Net Ex Post Program Savings (therm)
Energy Star® CFL Torchieres	1,606	443.5	0.071		0.85	605,422	96.9	
Energy Star® Screw-In CFL 24 watt	18,194	95.7	0.015		0.85	1,479,991	236.8	
Energy Star® Screw-In CFL 20 watt	25,268	83.8	0.013		0.85	1,799,840	288.0	
Energy Star® Screw-In CFL 15 watt	6,000	76.4	0.012		0.85	389,640	62.3	
Basic HVAC Diagnostic FDZ3	1,301	382.8	0.364		0.89	443,240	421.1	
Basic HVAC Diagnostic FDZ2	350	168.8	0.160		0.89	52,581	50.0	
R-0 to R-30 Attic Insulation FDZ1	0	0.153	0.000159	0.256	0.89			
R-0 to R-30 Attic Insulation FDZ2	25,065	0.524	0.000498	0.246	0.89	11,689	11.1	5,488
R-0 to R-30 Attic Insulation FDZ3	75,199	1.283	0.001219	0.282	0.89	85,867	81.6	18,873
R-0 to R-30 Attic Insulation FDZ4	75,199	0.388	0.000369	0.191	0.89	25,968	24.7	12,783
R-5 to R-30 Attic Insulation FDZ1	0	0.052	0.000054	0.117	0.89			
R-5 to R-30 Attic Insulation FDZ2	408,972	0.242	0.000230	0.091	0.89	88,084	83.7	33,123
R-5 to R-30 Attic Insulation FDZ3	1,952,532	0.493	0.000469	0.091	0.89	857,444	814.6	158,341
R-5 to R-30 Attic Insulation FDZ4	542,550	0.137	0.000130	0.084	0.89	66,153	62.8	40,561
Energy Star® Thermostats FDZ1	0	267	0.243	99	0.89			
Energy Star® Thermostats FDZ2	157	272.3	0.248	87	0.89	38,048	34.6	12,115
Energy Star® Thermostats FDZ3	729	518.1	0.492	94	0.89	336,148	319.3	60,988
Energy Star® Thermostats FDZ4	206	420.5	0.399	81	0.89	77,094	73.2	14,759
Duct Sealing FDZ1	0	107	0.197	34	0.89			
Duct Sealing FDZ2	128	201.6	0.183	25	0.89	22,966	20.9	2,859
Duct Sealing FDZ3	612	230.0	0.209	29	0.89	125,276	113.9	15,523
Duct Sealing FDZ4	205	120.7	0.110	18	0.89	22,022	20.0	3,284
Water Heater Tank Insulation-Elec	15	242.0	0.034		0.89	3,231	0.5	
Pipe Insulation-Elec DHW	1	92.0	0.013		0.89	82	0.0	
Faucet Aerators-Elec DHW	237	56.3	0.008		0.89	11,875	1.7	
Low-Flow Showerheads-Elec	119	183.0	0.026		0.89	19,382	2.7	
Water Heater Tank Insulation	964		0.000	12	0.89			10,296
Pipe Insulation	9		0.000	5	0.89			40
Faucet Aerators	13,739		0.000	4	0.89			44,020
Low-Flow Showerheads	7,729		0.000	13	0.89			86,879
Energy Star® Thermostats FDZ5	54	151.0	0.137	76	0.89	7,257	6.6	3,662
Duct Sealing FDZ5	115	38.8	0.035	15	0.89	3,971	3.6	1,505
R-0 to R-30 Attic Insulation FDZ5	119,667	0.504	0.000479	0.235	0.89	53,678	51.0	25,028
R-5 to R-30 Attic Insulation FDZ5	306,565	0.176	0.000167	0.078	0.89	48,020	45.6	21,282
R-15 to R-30 Attic Insulation FDZ2	5,094	0.079	0.000075	0.026	0.89	358	0.3	118
R-15 to R-30 Attic Insulation FDZ3	47,453	0.156	0.000148	0.026	0.89	6,588	6.3	1,098
R-15 to R-30 Attic Insulation FDZ4	3,548	0.057	0.000054	0.025	0.89	180	0.2	79
Total	3,639,582					6,682,098	2,934	572,704
90% Confidence Interval						554,912	184	31,956

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. The ex post net-to-gross ratio (NTGR) for compact fluorescent lamps

(CFLs) is 0.85.[4] The ex ante NTGR is 0.80 for CFLs. The NTGR for all other measures of 0.89 based on the Residential Contractor Program (consistent with the ex ante NTGR). The NTGR reflects what customers would have done in the absence of the program (i.e., 15% free riders for CFLs and 11% free riders for other measures).[5] The lifecycle electricity and gas savings are summarized in **Table 1.4**.

Table 1.4 Lifecycle Electricity and Gas Savings

Energy Efficiency Measure	Ex Ante Effective Useful Life (EUL)	Net Ex-Ante Lifecycle Program Savings (kWh)	Net Ex-Ante Lifecycle Program Savings (therm)	Ex Post Effective Useful Life (EUL)	Net Ex-Post Lifecycle Program Savings (kWh)	Net Ex-Post Lifecycle Program Savings (therm)	Net Lifecycle Realization Rate (kWh)	Net Lifecycle Realization Rate (therm)
Energy Star® CFL Torchieres	16	4,062,720		11	6,659,640		1.64	
Energy Star® Screw-In CFL 24 watt	8	12,787,200		6	8,879,946		0.69	
Energy Star® Screw-In CFL 20 watt	8	3,072,000		6	10,799,038		3.52	
Energy Star® Screw-In CFL 15 watt	8	2,534,400		6	2,337,840		0.92	
Basic HVAC Diagnostic FDZ3	10	4,872,750		10	4,432,403		0.91	
Basic HVAC Diagnostic FDZ2	10	281,685		10	525,812		1.87	
R-0 to R-30 Attic Insulation FDZ1	20	43,934	73,530	20				
R-0 to R-30 Attic Insulation FDZ2	20	608,181	384,734	20	233,786	109,755	0.38	0.29
R-0 to R-30 Attic Insulation FDZ3	20	14,830,111	2,819,477	20	1,717,350	377,469	0.12	0.13
R-0 to R-30 Attic Insulation FDZ4	20	490,788	570,996	20	519,354	255,662	1.06	0.45
R-5 to R-30 Attic Insulation FDZ1	20	45,099	100,841	20				
R-5 to R-30 Attic Insulation FDZ2	20	624,311	373,845	20	1,761,688	662,453	2.82	1.77
R-5 to R-30 Attic Insulation FDZ3	20	14,205,411	3,180,470	20	17,148,883	3,166,827	1.21	1
R-5 to R-30 Attic Insulation FDZ4	20	465,336	676,957	20	1,323,062	811,221	2.84	1.2
Energy Star® Thermostats FDZ1	11	46,991	17,463	11				
Energy Star® Thermostats FDZ2	11	221,046	76,272	11	418,533	133,261	1.89	1.75
Energy Star® Thermostats FDZ3	11	2,020,112	459,936	11	3,697,633	670,870	1.83	1.46
Energy Star® Thermostats FDZ4	11	557,786	163,640	11	848,039	162,348	1.52	0.99
Duct Sealing FDZ1	15	25,785	8,220	15				
Duct Sealing FDZ2	15	130,763	38,378	15	344,494	42,891	2.63	1.12
Duct Sealing FDZ3	15	1,947,345	227,475	15	1,879,146	232,851	0.96	1.02
Duct Sealing FDZ4	15	213,099	62,671	15	330,326	49,262	1.55	0.79
Water Heater Tank Insulation-Elec	10	155,074		10	32,307		0.21	
Pipe Insulation-Elec DHW	10	29,477		10	819		0.03	
Faucet Aerators-Elec DHW	10	672,840		10	118,754		0.18	
Low-Flow Showerheads-Elec	10	917,626		10	193,815		0.21	
Water Heater Tank Insulation	10		69,206	10		102,955		1.49
Pipe Insulation	10		14,418	10		401		0.03
Faucet Aerators	10		259,524	10		440,198		1.7
Low-Flow Showerheads	10		461,376	10		868,794		1.88
Energy Star® Thermostats FDZ5	11		128,581	11	79,828	40,284		0.31
Duct Sealing FDZ5	15		51,948	15	59,568	22,568		0.43
R-0 to R-30 Attic Insulation FDZ5	20		82,638	20	1,073,557	500,567		6.06
R-5 to R-30 Attic Insulation FDZ5	20		523,358	20	960,407	425,635		0.81
R-15 to R-30 Attic Insulation FDZ2	20			20	7,163	2,358		
R-15 to R-30 Attic Insulation FDZ3	20			20	131,767	21,961		
R-15 to R-30 Attic Insulation FDZ4	20			20	3,600	1,579		
Total		65,861,867	10,825,954		66,518,557	9,102,165	1.01	0.84
90% Confidence Interval					4,225,783	483,961		

[4] Itron, Inc. 2007. *2004-2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation.* prepared for Pacific Gas & Electric Company, Study I.D. PGE0214.01; 1115-04. Oakland, Calif: Itron, Inc. Available online: www.calmac.org.

[5] *Energy Efficiency Policy Manual*, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

The gross ex-ante lifecycle savings are 76,841 MWh and 12,163,993 therms. The net ex-post lifecycle savings are 66,519 ± 4,226 MWh and 9,102,163 ± 483,961 therms. The lifecycle ex-post net lifecycle kWh realization rate is 1.01 ± 0.06 and the net lifecycle therm realization rate is 0.84 ± 0.04.

The required energy impact reporting for 2004-05 programs is provided in **Table 1.5**.

Table 1.5 Required Energy Impact Reporting for 2004-2005 Programs

Program ID:		1082-04					
Program Name:		Moderate Income Attic Insulation Program					
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	6,193	6,682	3.186	3.333	699,558	572,704
2	2005	6,193	6,682	3.186	3.333	699,558	572,704
3	2006	6,193	6,682	3.186	3.333	699,558	572,704
4	2007	6,193	6,682	3.186	3.333	699,558	572,704
5	2008	6,193	6,682	3.186	3.333	699,558	572,704
6	2009	6,193	6,682	3.186	3.333	699,558	572,704
7	2010	6,193	3,013	3.186	2.642	699,558	572,704
8	2011	6,193	3,013	3.186	2.642	699,558	572,704
9	2012	3,319	3,013	2.233	2.642	699,558	572,704
10	2013	3,319	3,013	2.233	2.642	699,558	572,704
11	2014	2,541	2,482	1.607	2.107	609,162	431,469
12	2015	2,250	1,418	2.084	1.506	522,759	339,946
13	2016	2,250	1,418	2.084	1.506	522,759	339,946
14	2017	2,250	1,418	2.084	1.506	522,759	339,946
15	2018	2,250	1,418	2.084	1.506	522,759	339,946
16	2019	2,077	1,244	1.877	1.328	493,643	316,774
17	2020	1,759	1,244	1.827	1.328	493,643	316,774
18	2021	1,759	1,244	1.827	1.328	493,643	316,774
19	2022	1,759	1,244	1.827	1.328	493,643	316,774
20	2023	1,759	1,244	1.827	1.328	493,643	316,774
TOTAL		76,841	66,519			12,163,993	9,102,163

** 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 ex ante estimates and ex post accomplishments are due to the 16-year effective useful life (EUL) assumed for the Energy Star® CFL torchieres. The EUL value for this measure was reduced to 11 years based on light logger data. The 15W, 20W, and 24W Energy Star® CFL EUL values were reduced from 8 years to 6 years based on light logger data. The average ex post operating hours are 1,624 ± 298 hours/yr based on light logger data for 1,173 fixtures at 66 sites. The net ex post first-year gas savings are 572,704 ± 31,956 therms and this is 16% lower than the ex ante estimate.[6] The difference is largely due to lower ex post gas savings for attic insulation based on unavailability of R-0 to R-30 attic insulation measures (i.e., lack of attics without any insulation). MICAP assumed it would install 802,226 ft^2 of R-0 to R-30 attic

[6] 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.

insulation and 2,716,175 ft^2 of R-5 to R-30 insulation. The program actually installed 295,130 ft^2 of R-0 to R-30 (63.2% less than assumed) and 3,210,619 ft^2 of R-5 to R-30 insulation (18.2% more than assumed). The program also installed 56,095 ft^2 of R-15 to R-30 attic insulation. The program installed 3,561,844 ft^2 of attic insulation and exceeded its attic insulation goal by 1.2%.

Participant and non-participant process surveys were used to obtain general feedback and suggestions. Survey results indicate 85 percent of participants are satisfied with the program based on 624 survey responses to 35 questions from 70 randomly selected participants. Most participants expressed appreciation for measures installed by courteous technicians. Process survey responses indicated significant demand for the program with an overall satisfaction rating of 8.5 ± 0.1 out of 10 points. Participants indicated that they would like to see the program continue to serve customers throughout California. Non-participant survey results indicate 97 percent would have participated if they had known about the program and were eligible. 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.

- Increase attic insulation to R-38 and install radiant barriers to reduce solar heat gain to attics where ducts and cooling equipment are located to reduce cooling loads. MICAP installed 1 ft^2 of venting per 600 ft^2 of attic area. To further reduce cooling loads, attic venting should be increased to 1 ft^2 of venting per 300 ft^2 of attic area.
- Use a third party verification service provider to ensure that all measures are properly installed to increase savings, cost effectiveness, and reduce lost opportunities.
- Educate customers about comparable CFL replacements in terms of lumens. Offer more types of CFLs (i.e., color temperature, reflector, and dimmable, long-life cold-cathode) to increase savings and acceptance.
- Install occupancy sensors for lighting and plug loads and enable Energy Star® saving mode on LCD high-definition television sets.
- Install pressure-compensating low-flow showerheads and aerators to increase customer satisfaction and maintain consistent flow rates from 30 to 80 psig flowing pressure for showerheads and 30 to 60 psig flowing pressure for aerators.
- Capture pre-retrofit thermostat schedules in the database, provide simple instructions in various languages for Energy Star® thermostats, and consider placing a toll-free number on the thermostats for participants to call if they have any questions.
- Continue and expand the program throughout PG&E and offer more measures such as wall insulation, ceiling fans, whole house fans and high performance windows. Provide better advertising to increase participation including handouts or fliers from PG&E that tell customers about the program, funding source, and free services.
- Based on findings from this and other studies, hard-to-reach moderate income residential customers do not have sufficient capital or motivation to invest in improving the energy efficiency of their homes. To overcome these market barriers, MICAP should be continued and expanded to save energy and peak demand and reduce carbon dioxide emissions.

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 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 listed in **Table 2.1** including baseline information, energy efficiency measure information, measurement and verification approach, and the evaluation approach.

Table 2.1 Components of an EM&V Plan

Baseline Information ▪ Determine whether or not baseline data exist upon which to base energy savings measurement. Existing baseline studies can be found on the California Measurement Advisory Committee website (http://www.calmac.org/) and/or the California Energy Commission website (http://www.energy.ca.gov/). Detailed sources of baseline data should be cited. ▪ If baseline data do not exist, the implementer will need to conduct a baseline study (gather baseline energy and operating data) on the operation(s) to be affected by the energy efficiency measures proposed. ▪ If the baseline data do not exist and the implementer can show that a baseline study is too difficult, expensive or otherwise impossible to carry out prior to program implementation, the contractor should then provide evidence that baseline data can be produced or acquired during the program implementation. This process should then be detailed in the EM&V Plan.
Energy Efficiency Measure Information ▪ Full description of energy efficiency measures included in the program, including assumptions about important variables and unknowns, especially those affecting energy savings. ▪ Full description of the intended results of the measures.
Measurement and Verification Approach ▪ Reference to appropriate IPMVP option. ▪ Description of any deviation from IPMVP approach. ▪ Schedule for acquiring project-specific data
Evaluation Approach ▪ A list of questions to be answered through the program evaluation. ▪ A list of evaluation tasks/activities to be undertaken during the course of program implementation. ▪ A description of how evaluation will be used to meet all of the Commission objectives described above.

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 residential customers are provided in **Table 2.2**.

Table 2.2 Existing Baseline Studies

1	*Measure Incentives and Cost Effectiveness for the California Residential Contractor Program*, prepared for SDG&E, SCE, PG&E, and SCG, prepared by Robert Mowris & Associates, 1999, 2000, and 2001.
2	*Deemed Savings Estimates for the Summer Initiative Program*, prepared for SDG&E, SCE, PG&E, and SCG, prepared by Itron and Robert Mowris & Associates, San Diego, CA, 2001.
3	*Deemed Energy Savings for the Residential Standard Performance Contract Program*, prepared for Pacific Gas and Electric Company, prepared by Robert Mowris & Associates, 1998.
4	*2001 DEER Update Study, Final Report*, prepared for the California Energy Commission, Contract Number 300-99-008, prepared by XENERGY Inc., Oakland, California, August, 2001.
5	*Filing of Pacific Gas and Electric Company Requesting Approval of Proposed Energy Efficiency Programs and Budgets as Part of 2004-05 Energy Efficiency Program Selection Process Required by Rulemaking 01-08-028,* December 2003.
6	*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, 2003.
8	*Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation.* prepared for Pacific Gas & Electric Company, Study I.D. PGE0214.01; 1115-04. Oakland, Calif: Itron, Inc. Available online: www.calmac.org
9	*Energy Efficiency Policy Manual*, prepared by California Public Utilities Commission, 2001-2004.
10	*California Statewide Residential Sector Energy Efficiency Potential Study*, Study ID #SW063, Prepared for Pacific Gas & Electric Company San Francisco, California, Prepared by KEMA-XENERGY Inc., Oakland, California, April 2003.
11	*2005 Database for Energy Efficiency Resources (DEER) Update Study,* page 7-40, prepared for Southern California Edison, prepared by Itron, Inc., Vancouver, Washington 2005.
12	*California Statewide Residential Appliance Saturation Study (RASS)*, Volume 2, Contract 300-00-004, Prepared for the California Energy Commission. Prepared by KEMA-XENERGY, Itron, RoperASW. Sacramento, California, 2004.

Baseline cooling and heating Unit Energy Consumption (UEC) data for residential customers are provided in **Table 2.3**. Miscellaneous baseline UEC data are provided in **Table 2.4**. These values are from studies listed in **Table 2.2**. The baseline space cooling and heating UEC values are used to calibrate the 2004-05 DEER residential prototypes using participant utility billing data for 68 sites, eQuest (i.e., DOE-2.2) simulations, detailed site audits, and thermostat schedules.

Table 2.3 Baseline Cooling and Heating Unit Energy Consumption (UEC) Data

			Ceiling R-0		Ceiling R-5		Ceiling R-30	
CEC FDZ	CEC CZ	Ex Ante Roof Area	Cooling kWh	Heating therm	Cooling kWh	Heating therm	Cooling kWh	Heating therm
2	12	1,216	1,767	663	1,393	420	869	214
3	11	1,216	4,624	565	3,367	346	1,979	235
4	4	1,216	1,039	486	900	343	453	241
5	3	1,216	1,493	579	1,028	407	774	207

Table 2.4 Miscellaneous Baseline Unit Energy Consumption (UEC) Data

End Use	Baseline	Source
Water Heating UEC therm/yr	193	RASS Study 11, Table 2.2
Water Heating UEC kWhyr	3,079	RASS Study 11, Table 2.2
Lighting Indoor UEC kWh/yr	1,288	RASS Study 11, Table 2.2

Estimates of energy consumption by domestic water heating end use, distribution loss, and tank loss are shown in **Table 2.5**. These values are combined with field measurements to develop annual energy savings estimates for water heater measures.

Table 2.5 Single-Unit Water Heater Energy Consumption by End Use[7]

End Use or Standby Loss	Electric Water Heater Relative Energy Consumption	Gas Water Heater Relative Energy Consumption
Shower	26%	23%
Tub	10%	9%
Sink	10%	9%
Clothes washer	18%	16%
Dishwasher	8%	7%
Pilot Loss	-	13%
Distribution Loss	16%	13%
Tank Loss	12%	10%
Total	100%	100%

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.

2.2.1 Measure Assumptions and Intended Results

Baseline and energy efficiency measure assumptions provided by BO Enterprises in their PIP are shown in **Table 2.6**.[8] The EM&V study evaluated these values based on field measurements and statistical analyses of collected data (i.e., on-site inspections and surveys).

[7] *Water Conservation in California*, Bulletin 198-84, California Department of Water Resources, Sacramento, CA, July 1984. *Supply Curves of Conserved Energy: A Tool for Least-Cost Energy Analysis*, A. Meier, T. Usibelli, Proceedings of Energy Technology Conference, Government Institutes Inc., Rockville, MD, pp. 1264-1265, March 1986. *Residential Hot Water Use Patterns*, D. Stevenson, Canadian Electrical Association, Report #111U268, Montreal, July 1983. *Water Heater Innovations*, Progressive Builder, Howard Geller, pp. 24-26, September 1985.

[8] *Moderate Income Comprehensive Attic Program: A Residential Retrofit Local Program for Hard-To-Reach Single Family PG&E Customers.* Prepared by BO Enterprises with technical assistance from RLW Analytics. 2003.

Table 2.6 Baseline and Energy Efficiency Measure Assumptions

Description	Baseline Assumption	Measure Assumption	Annual Hours of Operation	Efficiency Improvement
Attic Insulation	≤R-11	R-30	n/a	20% cooling and 30% heating
Duct Test & Seal	20-30% Leakage	10-15% Leakage	n/a	10-20% leakage reduction
Basic HVAC Diagnostic Tune-up	Incorrect refrigerant charge and airflow dirty air filter and condensing coil	Correct RCA. Clean air filter and clean condensing coil	n/a	10-17% efficiency improvement
Energy Star® Programmable T-Stat	None	Energy Star Settings	n/a	8% cooling, 9% heating
Water Saving Showerhead-Gas	3.0 gpm @80 psi	2.2 gpm @80 psi	n/a	0.8 gpm reduction @80 psi
Water Saving Showerhead-Electric	3.0 gpm @80 psi	2.2 gpm @80 psi	n/a	0.8 gpm reduction @80 psi
Water Saving Faucet Aerators-Gas	2.5 gpm @80 psi	2.0 gpm @80 psi	n/a	0.5 gpm reduction @80 psi
Water Saving Faucet Aerators-Electric	2.5 gpm @80 psi	2.0 gpm @80 psi	n/a	0.5 gpm reduction @80 psi
WH Blankets-Gas	Internal No Blanket	Add R-8	n/a	33% tank loss reduction
WH Blankets-Electric	Internal No Blanket	Add R-8	n/a	33% tank loss reduction
Pipe Insulation	None	5 feet both R-4	n/a	3.3% annual WH savings
Energy Star® CFL Torchiere (55 W)	150-300 W	55 W	n/a	95-245 W reduction
Energy Star® CFL Screw-in (24 W)	100 W	24 W	n/a	76 W reduction
Energy Star® CFL Screw-in (20 W)	75 W	20 W	n/a	55 W reduction
Energy Star® CFL Screw-in (15 W)	60 W	15 W	n/a	45 W reduction

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. Ex ante savings for each measure are based on calibrated DOE-2 simulations performed by RLW Analytics Inc., and/or the 2001 DEER Update Study (Study 4, **Table 2.2**). The study evaluated the ex ante measure savings and assumptions and developed ex post savings values for each measure. Proper installation of energy efficiency measures was verified during on-site inspections.

Attic Insulation

Attic insulation involves installing R-30 or greater blown-in insulation into uninsulated attics or attics with existing insulation less than R-11. The program installed attic ventilation of 1 ft^2 net free venting per 600 ft^2 of attic insulation using mushroom, eyebrow, or eave vents.[9] Ex ante savings are assumed to be on average 20% for cooling and 30% for heating.

HVAC Diagnostic Tune-up

HVAC diagnostic tune-up involves cleaning condensing coils, replacing air filters, and checking and correcting refrigerant charge and airflow (RCA) on central air conditioning units and central heat pump units. Proper installation was verified using RCA Verification software and random site inspections of work performed by EPA-certified refrigerant technicians.[10] Detection of leaky Schrader valves was performed with leak detection equipment and leaky Schrader valves were replaced with new valves using core repair tools. Brass Schrader valve caps with secondary "O" ring seals were installed on each job. Several studies show an efficiency loss of 10-20% for overcharging and 20% for undercharging.[11]

[9] MICAP installed 1 ft^2 net free venting per 600 ft^2 of attic insulation using mushroom, eyebrow, or eave vents per the California Conventional Home Weatherization Installation Standards.

[10] EPA Certified Refrigerant Technicians as required by 40CFR part 82 subpart F.

[11] *National Energy Savings Potential from Addressing HVAC Installation Problems*, Chris Neme, Vermont Energy Investment Corporation, John Proctor, Proctor Engineering, Steve Nadel, ACEEE, prepared for US Environmental

Duct Test & Seal

Duct test and seal involves sealing both supply and return ducts to a leakage reduction of 60 cfm/ton or 14% of measured total system flow at 25 Pascal pressure (supply and return). The assumed baseline is 29% duct leakage going to 15% for a 14% reduction or 60 cfm/ton. Duct sealing performance was measured at a random sample of sites with duct pressurization equipment. Proper installation was verified by examining the materials used to seal the ducts including use of mastic and or UL-listed metal or butyl tape.

Energy Star® Thermostat

Energy Star® programmable thermostat replaces an existing manual thermostat. The Energy Star® thermostat is setup from 78F to 85F from 9AM to 6PM during summer weekdays while occupants are away. The unit is setback from 78F to 65F during winter nights while occupants are sleeping. Ex ante savings are assumed to be 8% for cooling and 9% for heating from the DEER database (see Study 4, **Table 2.2**).

Low-flow Showerhead (2.5 gpm)

Low-flow showerheads replace non-conserving 3.0 gpm or greater units at a flowing pressure of 80 psi (pounds per square inch). Low-flow showerheads are rated at 2.5 gpm or less at a flowing pressure of 80 psi. Savings are based on engineering estimates and EM&V studies and pre- and post-retrofit flow rates. Low-flow showerheads are assumed to reduce water flow by 17% and savings are from the DEER database (see Study 4, **Table 2.2**).

Low-flow Faucet Aerator (2.0 gpm)

Low-flow faucet aerators involve replacing non-conserving 2.5 gpm or greater units at a flowing pressure of 80 psi. Low-flow faucet aerators are rated at 2.0 gpm or less at a flowing pressure of 80 psi. Low-flow aerators are assumed to reduce water flow by roughly 20% and savings are from the DEER database (see Study 4, **Table 2.2**).[12]

Water Heater Insulation

Water heater insulation (R-8) is applied to water heaters with fittings that are dry and in good shape. The anode, relief valve, and control must be left exposed for routine maintenance. Water heater insulation reduces tank losses by about 33% based on empirical studies and savings are from the DEER database (see Study 4, **Table 2.2**).

Pipe Insulation

Pipe insulation is applied continuously to the first 5 feet of pipe from the tank on both hot and cold water pipes unless prevented by clearance and installation requirements.[13] This will reduce

Protection Agency, March 1998. *Field Measurements of Air Conditioners with and without TXVs*, Mowris, R., Blankenship, A., Jones, E., Proceedings of 2004 ACEEE Summer Study on Energy Efficiency in Buildings, Forthcoming August 2004.

[12] The following studies are referenced for water heater measures. *Residential Water Heating—Energy Conservation Alternatives*, M. Perlman, Ontario Hydro, 1991. *Domestic Water Heating—Summary Research Findings for Conventional Systems*, J. R. Biemer, C. D. Auburg, C. W. Ek, , pp. J-3 to J-10, Conservation in Buildings: A Northwest Perspective, 19-22 May, 1985.

[13] The California Conventional Home Weatherization Installation Standards require 3 inches of clearance from the flue to install pipe insulation on gas water heaters and at least one foot of continuous exposed pipe to install pipe

distribution losses caused by thermal siphoning on each pipe. Distribution losses represent approximately 16% of the annual electric UEC and 13% of the annual gas UEC. Pipe wrap reduces distribution losses by about 21% and ex ante savings are from the DEER database (see Study 4, **Table 2.2**).

Energy Star® Lighting Measures

Savings from Energy Star® CFLs and torchieres are from the DEER database and secondary research conducted by RLW Analytics. Energy savings data relied on five variables: 1) number of lamps/fixtures; 2) location (i.e., bedroom, kitchen, etc) of lamps/fixtures; 3) hours of operation; 4) Watts consumed by pre-existing lamp/fixture; and 5) Watts consumed by replacement lamp/fixture.

2.3 Measurement and Verification Approach

The measurement and verification (M&V) approach is based on the *International Performance Measurement & Verification Protocols* (IPMVP) defined **Table 2.7**.[14] On-site measurement and verification activities and surveys were performed for a statistically significant random sample of participating customers. Ex post energy savings for each measure were determined using the appropriate IPMVP Option. Statistical analyses are used to extrapolate energy and peak demand savings at the sample level to the program level. On-site data collection efforts verified baseline and measure assumptions by taking measurements and collecting data at customer sites.

insulation on electric water heaters. Gas water heaters generally do not meet the 3 inch clearance requirement and many electric heaters already have pipe insulation installed or do not have one foot of exposed pipe to insulate. Electric water heaters also have low saturation (approximately 9% based on the 2005 RASS Study). Therefore, pipe insulation has limited feasibility and availability.

[14] See *International Performance Measurement & Verification Protocols*, DOE/GO-102000-1132, October 2002.

Table 2.7 IPMVP M&V Options

M&V Option	Savings Calculation	Typical Applications
Option A. Partially Measured Retrofit Isolation Savings are determined by partial field measurement of energy use of systems to which a measure was applied, separate from site energy use. Measurements may be either short-term or continuous. Partial measurement means some but not all parameters may be stipulated, if total impact of possible stipulation errors is not significant to resultant savings.	Engineering calculations using short term or continuous post-retrofit measurements or stipulations.	Showerhead/aerator pre- and post-retrofit flow rates are measured and unit energy savings are based on stipulated deemed savings times the ratio of average ex post to ex ante flow rates.
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	For CFLs electricity use is measured with a Watt meter to verify pre- and post-retrofit power. Hours of operation are estimated using light loggers or participant interviews.
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 or conditional demand analysis.	Weather-sensitive measure energy savings are based on utility billing data for 12-month base year and minimum 12-month 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 calibrated to model actual energy performance measured in the facility.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.	Project affecting many systems where pre- or post data are unavailable. Utility meters measure pre- or post-retrofit energy use and savings are based on calibrated simulations.

The following ex ante cost effectiveness inputs used to develop the program were evaluated:

- Electricity kWh Savings;
- Peak demand kW Savings (although not tied to the TRC);
- Therm savings;
- Gross Incremental Measure Cost (Gross IMC);
- Effective Useful Life (EUL); and
- Net to Gross Ratio (NTGR).

BO Enterprises used three sources of information to develop the workbook inputs for the measures offered by the program. For measures using deemed savings the study verified the accuracy of deemed parameters. For inputs taken directly from the CPUC Energy Efficiency Policy Manual pertaining to EUL and Net to Gross Ratio, the study reviewed inputs for accuracy and applicability to the respective tables in the CPUC Energy Efficiency Policy Manual (i.e., Tables 4.1 and 4.2). For MICAP measures such as attic insulation and lighting measures, deemed savings are unavailable and eQUEST (i.e., DOE-2) modeling and secondary research are used to develop savings, with review of ex ante savings assumptions and methods to determine if additional analyses were necessary.

2.3.1 M&V Approach for Load Impact Evaluation

Gross ex post savings for each measure is 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. The **sample mean savings** estimates are 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., kW, kWh/yr, therm/yr).

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

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

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

Where,

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

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

The standard error, se_i**, of the measure sample mean** is calculated using **Equation 3, Equation 4** or both depending on the measure.[15]

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

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

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

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

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

Where,

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

[15] The standard error for all measures will be calculated based on the proportion of measures found properly installed from the on-site surveys. In addition, the standard error of the mean savings will also be calculated for measures where weighted average savings for each climate zone are available. These two standard errors will then be combined to characterize the statistical precision of the sample mean as an estimator of the population mean. The population total will be 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*, Chapter 13: Sampling, prepared for the CPUC, prepared by Hall, N., Barata, S., Chernick, P., Jacobs, P., Keating, K., Kushler, M., Migdal, L., Nadel, S., Prahl, R., Reed, J., Vine, E., Waterbury, S., Wright, R. February 2004.

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

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

Where,

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

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

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

Net savings are calculated as gross savings times the CPUC-accepted net-to-gross ratios from the CPUC EEPM. **Net annual savings** for year 1 through "x" and **net lifecycle savings** (i.e., kWh and therm) are calculated using the measure effective useful lifetime (EUL) from the CPUC Energy Efficiency Policy Manual. The study checked with other residential evaluations to review prior net-to-gross survey procedures to obtain defensible and consistent net-to-gross factors that are specific to the program as implemented.

A description of the measurement and verification approach for each measure is provided in **Table 2.8**. IPMVP Options A, B, C, and D were used to evaluate energy and peak demand savings for the program. Measurements were short-term, and some, but not all parameters were stipulated, as long as the total impact of possible stipulation errors was not significant to the resultant savings.

Table 2.8 Measurement and Verification Approach for MICAP Measures

Measure	IPMVP Option	Measurement and Verification Approach
Attic Insulation	A, C, D	Evaluated energy savings for the sample based on verification of proper installation and measurements of pre- and post-retrofit insulation thickness and R-value. Developed ex post savings using billing analyses and calibrated eQUEST simulations.
Attic Vents	N/A	Verify proper installation (this is not an energy savings measure).
Duct Seal	A, C, D	Evaluated energy savings for the sample based on verification of proper sealing methods and measurements of pre and post-retrofit duct leakage with duct pressurization equipment. Developed ex post savings using billing analyses and calibrated eQUEST simulations.
AC Diagnostic Tune-up	A, C, D	Evaluated energy savings for the sample based on field measurements of pre- and post-retrofit temperature split, superheat or subcooling. Developed ex post savings using billing analyses and calibrated eQUEST simulations.
Energy Star® Thermostats	A, C, D	Evaluated energy savings for the sample based on verification of proper installation and participant interviews to obtain pre-retrofit cooling and heating thermostat schedules. Developed ex post savings using billing analyses and calibrated eQUEST simulations.
Low-Flow Aerators and Showerheads	A, B	Evaluated energy savings for the sample based on field measurements of pre- and post-retrofit flow rates compared to ex ante assumptions.
Water Heater Blankets	A, B	Evaluated energy savings for the sample based on verification of pre- and post-retrofit R-value and proper installation compared to ex ante assumptions.
Water Heater Pipe Wrap	A	Evaluated energy savings for the sample based on verification of pre- and post-retrofit R-value and proper installation compared to ex ante assumptions.
Energy Star® CFL	A, B	Evaluated energy savings for the sample based on verification of pre and post-retrofit wattage and participant reported hours of operation and lighting logger data compared to usage factors from other studies.
Energy Star® CFL Torchieres	A, B	Evaluated energy savings for the sample based on verification of pre and post-retrofit wattage and participant reported hours of operation and lighting logger data compared to usage factors from other studies.
Energy Education	N/A	Participant surveys regarding linkage between installed measures, energy savings, retention of energy education information

Field measurement equipment tolerances are shown in **Table 2.9**.

Table 2.9 Field Measurement Equipment Tolerances

Field Measurement	Measurement Equipment	Tolerances
Temperature in degrees Fahrenheit (°F) of return and supply wetbulb and drybulb and outdoor condenser entering air	4-channel temperature data loggers with 10K thermisters. Wetbulb and drybulb temperatures were checked with sling psychrometers.	Data logger: ± 0.1°F Thermisters: ± 0.2°F Sling psychrometer: ± 0.2°F (wetbulb and drybulb)
Pressure in pounds per square inch (psi) of vapor and suction line	Compound pressure gauge for R22 and R410a.	Refrigerant pressure: ± 2 % for R22 and ± 3 percent for R410a
Temperature (°F) of vapor and suction lines	Digital thermometer with clamp-on insulated type K thermocouples.	Digital thermometer: ± 0.1°F Type K thermocouple: ± 0.1% °F
Temperature (°F) of actual and required superheat and subcooling	Digital thermometer with clamp-on insulated type K thermocouples.	Digital thermometer: ± 0.1°F Type K thermocouple: ± 0.1% °F
Airflow in cubic feet per minute (cfm) across air conditioner evaporator coil	Digital pressure gauge and fan-powered flow hood, flow meter pitot tube array, and electronic balometer.	Fan-powered flowhood: ± 3% Flow meter array: ± 7% Electronic balometer: ± 4%
Ounces (oz.) of refrigerant charge	Digital electronic charging scales.	Electronic scale: ± 0.5 ounces or ± 0.1%
Power in kilowatts (kW) of air conditioners or CFLs	True RMS 4-channel power data loggers and 4-channel power analyzer.	Data loggers, CTs, PTs: ± 1% Power analyzer: ± 1%
Duct Leakage in cfm at 25 Pascal (Pa)	Digital pressure gauge, controller, fan, extension duct, and flow conditioner.	Fan flow: ± 3%
Building envelope leakage in cfm at 50 Pa and Effective Leakage Area (ELA) in square inches.	Digital pressure gauge, controller, fan, and blower door.	Air leakage and ELA: ± 3%
Flow rate in gallons per minute (gpm) and flowing pressure (psi) of showerheads or aerators	Flow meter and flowing pressure gauge. Handheld flow device.	Flow rate (0.5 to 15 gpm): ± 7% Flowing Pressure (0 to 160 psi): ± 7% Micro-Wier (0 to 4 gpm): ± 1%
Light loggers (hours of operation)	Digital time-of-use meter.	On/Off: ± 1 minute/month

2.3.2 Sampling Plan

The statistical sample design approach for the load impact and process evaluations involved selecting a random sample of customers from the program 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 proposed sample design was based on statistical survey sampling methods to select a sample of participants to meet or exceed the California Evaluation Framework or CADMAC Protocols.[16] Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of

[16] Hall, N., Barata, S., Chernick, P., Jacobs, P., Keating, K., Kushler, M., Migdal, L., Nadel, S., Prahl, R., Reed, J., Vine, E., Waterbury, S., Wright, R. 2004. *The California Evaluation Framework*, Appendix to Chapter 7: 191-195. Uncertainty Calculation. San Francisco, Calif.: California Public Utilities Commission. 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% at the 90% 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.

all program participants and to evaluate the statistical precision of the results.[17] Selecting participants for the sample was guided by the statistical sampling plan.

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

Eq. 8 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% 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.[18]

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

Where,

$n_{FPC\,i}$ = Sample size for measure "i" with finite population correction.

Similar measures were grouped together to reduce the overall sample size requirements necessary to achieve the desired level of confidence and yield the greatest accuracy at the lowest cost. The statistical sample sizes for MICAP are shown in **Table 2.10**.

[17] 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.
[18] Ibid.

Table 2.10 Statistical Sample Size for MICAP Measures

Measure Description	Ex Ante Units	Proposed EM&V Sample	Ex Post Installed Units	EM&V Units Inspected	Ex Post Coefficient of Variation (Cv)	Ex Post Relative Precision (r)
Energy Star® CFL Torchieres	1,150	64	1606	37	0.9	0.042
Energy Star® Screw-In CFL 24 watt	18,000	68	18194	166	0.9	0.042
Energy Star® Screw-In CFL 20 watt	6,000	68	25268	468	0.9	0.042
Energy Star® Screw-In CFL 15 watt	6,000	68	6000	573	0.9	0.042
R-0 to R-30 Attic Insulation FDZ5	16,120	373	119667	624	0.11	0.007
R-0 to R-30 Attic Insulation FDZ2	73,140	1,654	25065	2,575	0.11	0.004
R-0 to R-30 Attic Insulation FDZ3	548,547	12,459	75199	7,006	0.11	0.002
R-0 to R-30 Attic Insulation FDZ4	241,794	5,496	75199	5,592	0.11	0.002
R-5 to R-30 Attic Insulation FDZ5	48,359	1,094	306565	1,400	0.11	0.005
R-5 to R-30 Attic Insulation FDZ2	219,419	4,989	408972	9,753	0.11	0.002
R-5 to R-30 Attic Insulation FDZ3	1,645,641	37,376	1952532	46,027	0.11	0.001
R-5 to R-30 Attic Insulation FDZ4	725,381	16,460	542550	16,624	0.11	0.001
AC Diagnostic Tune-up FDZ3	1,250	60	1301	60	0.21	0.040
AC Diagnostic Tune-up FDZ2	150	8	350	15	0.21	0.040
Energy Star® Thermostats FDZ5	18	2	54	2	1.65	0.384
Energy Star® Thermostats FDZ2	72	5	157	8	1.65	0.384
Energy Star® Thermostats FDZ3	540	41	729	20	1.65	0.384
Energy Star® Thermostats FDZ4	270	20	206	20	1.65	0.384
Duct Sealing FDZ5	18	2	115	2	0.62	0.121
Duct Sealing FDZ2	72	5	128	8	0.62	0.121
Duct Sealing FDZ3	540	41	612	41	0.62	0.121
Duct Sealing FDZ4	270	20	205	20	0.62	0.121
Water Heater Tank Insulation-Elec DHW	72	35	15	37	N/A	N/A
Pipe Insulation-Elec DHW	36	24	1	1	N/A	N/A
Water Saving Faucet Aerators-Elec DHW	1,080	64	237	201	0.2	0.027
Water Saving Showerheads-Elec DHW	576	61	119	116	0.22	0.032
Water Heater Tank Insulation	648	62	964	37	0.12	0.024
Pipe Insulation	324	56	9	1	N/A	N/A
Water Saving Faucet Aerators	9,720	68	13739	201	0.2	0.027
Water Saving Showerheads	5,184	68	7729	116	0.22	0.032
Participant Surveys	6,000	68	6570	70	N/A	N/A
Non-Participant Surveys		68	1606	68	N/A	N/A

A sample size of 68 was used for most measures assuming coefficient of variation (Cv) of 0.5 and relative precision of 0.1 to achieve the desired 90 percent confidence.[19] The Cv for some measures is greater than 0.5, but the budget was insufficient to increase the sample size to reduce the Cv. For measures implemented across multiple climate zones, the sample size is proportional to the number of measures. The sample is 68 for AC diagnostic tune-up allocated across two climate zones with a sample of 60 sites in demand forecasting zone 3 (1,250 measures) and sample of 15 sites in zone 2 (150 measures). For attic insulation the sample is based on 1,175 ft^2 of attic insulation per home for a total of 68 homes.

2.3.3 M&V Approach for Process Evaluation

The evaluation approach involved designing and implementing process surveys to measure participant satisfaction, and obtain suggestions to improve the program's services and procedures. Process surveys, on-site inspections, and field measurements were used to guide the

[19] The proposed sample size is adjusted based on finite population correction.

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 process evaluation examined how to install a comprehensive package of measures for each customer within the constraints of the program. Interview questions assessed how the program influenced awareness of linkages between efficiency improvements and bill savings and increased comfort for customers. A sample of 70 participants and 68 non-participants were asked process questions. The participant and non-participant surveys are provided in the **Appendices**. Participants were asked why and how they decided to participate in the program. Non-participants were asked why they chose not to participate. This was done to identify reasons why program marketing efforts were not successful with some customers as well as to identify additional hard-to-reach market barriers (i.e., incentives or other inducements to achieve greater participation). The process survey evaluation includes a summary of what works, what doesn’t work, and the level of need for the program. The evaluation identified the rejection rate/acceptance rate and size of the rejecter pool. This information was used to define if there were issues that need to be addressed. On-going feedback was provided based on installation quality. Half of the participant surveys were conducted after the 1st half of the program and a memo report of findings was provided to inform potential on-going program process improvements. The same instrument was used for the 2nd half, and the final evaluation report provides results the study.

2.4 Evaluation Approach

The evaluation approach included:

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

2.4.1 List of Questions to be Answered by the Study

The following list of questions will be answered by the study.

1. **Are measures being installed properly?**
   The study answered this question by conducting 70 participant surveys and by performing 1,832 verification inspections at a random sample of 158 participant sites. Participants indicated that measures were properly installed as indicated by the rating of 8.6 ± 0.4 on a scale of 1 to 10 regarding the quality of work performed by MICAP technicians. Light loggers were installed at 70 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-six (66) were successfully downloaded to monitor hours of operation on 1244 fixtures. Data loggers at four (4) sites 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. **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 performing on-site measurements at participant sites of attic insulation, duct leakage, refrigerant charge, showerhead/aerator flow rates, lighting

wattage, and lighting hours of usage. The study verified that water heater tank insulation and pipe insulation are properly installed at a random sample of customer sites. The study evaluated baseline UEC values and ex ante energy savings estimates using on-site measurements and inspections, engineering analysis, billing data and building energy simulations (i.e., IPMVP Options A, C, and D). The 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 158 participant sites to determine if the ex ante measure assumptions are appropriate and relevant.[20]

3. **Are the ex ante energy and peak demand savings estimates per measure appropriate and relevant?**
   The study answered this question by comparing the baseline and measure assumptions using on-site measurements for a random sample of customer sites. Ex ante and ex post energy and peak demand savings for each measure were evaluated using IPMVP Options A, B, C, and D. Ex post estimates of savings are provided for each measure.

4. **Is the ex ante net-to-gross ratio (NTGR) appropriate and relevant to this "hard-to-reach" single family energy savings program?**
   The study used the CPUC-approved 0.85 NTGR value for CFLs and 0.89 NTGR for other measures per Table 4.2 of the CPUC Energy Efficiency Policy Manual (page 23).

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

6. **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).

7. **Are there some customers who choose not to participate in the program?**
   The study answered this question by conducting telephone interviews with non-participating single family customers. 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 you decided not to install similar measures such as attic insulation, duct sealing, air conditioner tune-ups, Energy Star® thermostats, compact fluorescent lamps, water saving showerheads and aerators, water heater blankets and pipe wrap?
   3. Would you have participated if the program income eligibility requirements allowed you to participate?

[20] *Energy Efficiency Policy Manual*, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

4. Would you have participated if you knew the program installed free energy efficiency measures in your home?

8. 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 MICAP provided energy efficiency services to 6,570 moderate income residential customers and overall participant satisfaction with the program was 85 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 97 percent of non-participants would have participated if they knew the program installed free energy efficiency improvements in homes, indicating a continuing need for the program.

9. 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 duct sealing, AC diagnostic tune-up, thermostats, CFLs, water saving showerheads, or other measures and educates customers on the value of these and other measures. Based on process survey responses, 76 percent of interviewed customers shared program information with 4.1 times as many people (53 participants shared information with 215 people). Approximately 33 percent of these people (i.e., 72) decided to install similar low-cost measures or participate in the MICAP. The program helped expand impacts beyond the participant group to a larger group through direct installation of MICAP measures. The multiplier effect for the program is estimated at 34 percent.[21] 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 friends or neighbors about the benefits of duct sealing, AC diagnostic tune-up, thermostats, CFLs, water saving showerheads, or other measures offered in the program?
2. With how many people have you shared this information in the last 12 months?
3. About how many of these people have installed any of these measures?

[21] Spillover of 88 percent is calculated based on 215 people adopting at least one spillover measure based on information shared by a group of 53 participants who adopted twelve measures (i.e., 215 × (1÷ 12) ÷ 53 = 0.34).

2.4.2 List of Tasks Undertaken by the Study

The following four tasks will be undertaken by the study.

Task 1. Conduct Project Initiation Meeting

The project initiation meeting was held via teleconference. The meeting refined the objectives and methods for the EM&V work, clarified pertinent issues, discussed data requirements, and discussed the detailed work plan and schedule for project tasks.

Task 2. Prepare EM&V Research Plan

The EM&V Plan contained a detailed description of all activities required to complete the study to meet the CPUC requirements.

Task 3. Perform EM&V Work

The EM&V work included collecting required data and analyzing the data to determine the impacts of the program. The impact evaluation is based on the MICAP database, on-site EM&V inspections at 158 sites, measurements, and billing data. Load impacts for each measure in the program are based on data collected during the on-site visits including on-site performance measurements; audit data; billing analysis; engineering analyses and/or calibrated simulations. Sampling procedures are defined in Section 2. The process evaluation is based on participant and non-participant process survey instruments for 70 participants and 68 non-participants to meet the 90/10 confidence level. On-going feedback will be based upon installation quality. Therefore, half of the participant surveys were conducted after the 1st half of the program and a memo report of findings was provided to inform potential on-going program process improvements. Then the same instrument was used for the 2nd half, and the final evaluation report includes results from all respondents. Prior to conducting non-participant (non-qualifier) surveys, the evaluation identified the rejection rate/acceptance rate and size of the non-qualifier pool. This information is as important as the survey responses to define if there is an issue that needs to be addressed. Interviews evaluated energy educational efforts. The process evaluation identified what works, what doesn’t work, and the level of need for the program as well as recommendations to improve the program. Statistical analyses wee used to extrapolate measurements of baseline and measure assumptions (i.e., duct leakage reduction, etc.) from the sample level to the program population. Ex post energy and peak demand savings for each measure were determined using IPMVP Option A, B, C, and D. Statistical analyses are used to extrapolate energy and peak demand savings at the sample level to the program level. This task included an assessment of the relative precision of program-level energy and peak demand savings. Analysis of process evaluation telephone survey data included a summary of what works, what doesn’t work, and customer satisfaction. Market assessments were performed to evaluate whether or not there is a continuing need for the program

Task 4. Prepare and Report EM&V Activities and Results

Progress, draft, and final reports included a description of the study methodology and all deliverables as per the CPUC EEPM. The reports provide results of the impact evaluation including gross and net energy and peak demand savings for each measure and the program as well as results.

2.4.3 How Study meets CPUC EEPM Objectives

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

- **Measure the level of energy and peak demand savings achieved.**
  The study met this objective by performing detailed on-site inspections for a statistically significant sample of 158 participants to gather pre-and post-installation measurements for energy efficiency measures that are installed under the program. On-site pre- and post-measurements are used to assess deemed kW, kWh and therm savings. Sites in the statistical sample include spot measurements of attic insulation levels, duct leakage, refrigerant charge, showerhead/aerator flow rates, lighting wattage and lighting hours of operation. EM&V efforts included gathering enough information and measurements to develop savings estimates to assess deemed kW, kWh, and therm savings. Statistical analyses are used to extrapolate kW, kWh, and therm 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 assumptions used to calculate deemed savings.

- **Measure cost-effectiveness.**
  The study met this objective by developing ex post energy and peak demand savings for each measure. Ex post measure savings and implementation costs are used to develop ex post Total Resource Cost (TRC) test values for each measure using the CPUC cost effectiveness worksheets. The ex post TRC is 1.524 using the EEGA workbook and the TRC is 2.71 using the E3 Calculator that properly values kW savings. The ex post participant test is 6.83.

- **Provide up-front market assessments and baseline analysis.**
  The study met this objective by performing a market assessment and baseline analysis including an evaluation of the baseline unit energy consumption values for space cooling and heating, water heating, and lighting. The telephone survey interviews included questions about market barriers to energy efficiency and the success of the program in meeting the needs of hard-to-reach moderate-income residential customers.[22]

- **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 are installed properly. Results of on-site inspections are used to provide ongoing feedback and corrective or constructive guidance regarding implementation of the program. This included any necessary improvements to the installation efforts or procedures. Inspections also documented that all activities are being completed as per the contract requirements.

- **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 telephone surveys of participants and non-participants.

[22] The CPUC definition of residential 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), income (less than 400% of federal poverty guidelines), housing type (i.e., mobile home or multi-family), geographic (i.e., outside San Francisco Bay Area, Sacramento, Los Angeles Basin or San Diego), or home ownership (i.e., renter split incentives barrier).

- **Assess the overall levels of performance and success of the program.**
  The study provided ex post energy and peak demand savings at the 90 percent confidence level as per the CADMAC Protocols. The study determined participant satisfaction and ways to improve the program. Some 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 moderate-income residential customers 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 and the E3 calculator. The overall ex post TRC is 1.524 and this was 4.3 percent lower than the PIP TRC of 1.5939. The program treated 6,570 moderate income residential customers with 3,561,844 ft^2 of attic insulation, 49,462 CFLs, compact fluorescent lamps (CFLs), 1,606 CFL torchieres, 1,651 HVAC tune-ups, 1,060 duct seals, 12,978 efficient faucet aerators, 7,848 efficient showerheads, 979 water heater blankets, 10 pipe insulations, and 1,146 Energy Star® thermostats. In-person interviews were conducted with 70 participants. Telephone surveys were conducted with 68 non-participants. 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 97 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 (PIP) ex ante goals were to reach 6,000 residential customers in the PG&E service area and directly install 3,518,402 square feet of attic insulation and 51,630 energy efficiency measures, and conduct follow-up activities to achieve energy savings of 5,224,911 first-year kWh, 2,746 kW, 622,607 first-year therms, 65,861,867 lifecycle kWh and 10,825,954 lifecycle therms. The program exceeded its measure installation goals by 50% and electricity first-year and lifecycle savings goals by 28%, but fell short by 8% on first-year and 16% on lifecycle gas savings goals (as shown in **Table 3.1**). The program installed 3,561,844 square feet of attic insulation and 77,738 energy efficiency measures at 6,570 moderate income residential customers. Ex post accomplishments were verified by checking the tracking database, randomly inspecting 91,364 square feet of attic insulation and 1,763 energy efficiency measures at 158 customer sites (90 more than anticipated and budgeted), installing light loggers on 1,244 fixtures at 69 sites, evaluating billing data for 58 sites, and conducting surveys of participants, non-participants, and non-contacts.

Table 3.1 Ex Ante Goals and Ex Post Accomplishments

Description	Program Implementation Plan Ex Ante Goal	Ex Post Accomplishment
Total Direct Install Measures		
Attic Insulation	3,518,402	3,561,844
AC Diagnostic	1,400	1,651
Duct Seal	900	1,060
Aerators	10,800	13,978
Showerhead	5,760	7,848
Energy Star® CFL Torchiere	1,150	1,606
Water Heater Blanket	720	979
Pipe Insulation	360	10
Energy Star® CFL (15, 20, 24W)	30,000	49,462
Energy Star® Thermostat	900	1,146
Moderate Income Energy Education and Direct Installations	6,000	6,570
Net Annual Electricity Savings (kWh/yr)	5,224,911	6,682,098
Net Demand Savings (kW)	2,746	2,934
Net Annual Therm Savings (therm/yr)	622,607	572,704
Net Lifecycle Electricity Savings (kWh)	65,861,867	66,518,557
Net Lifecycle Gas Savings (therm)	10,825,954	9,102,165
Total Resource Cost (TRC) Test – EEGA Workbook	1.5939	1.5241
Total Resource Cost (TRC) Test – E3 Calculator		2.7089
TRC Test Costs	$3,923,571	$3,923,571
TRC Test Benefits	$6,253,849	$5,979,917
TRC Test Net Benefits	$2,330,278	$2,056,346
Participant Test	7.1558	6.8327
Participant Test Costs	$2,275,185	$2,290,351
Participant Test Benefits	$16,280,673	$15,649,299
Participant Test Net Benefits	$14,005,488	$13,358,948

The net ex post Total Resource Cost (TRC) test benefit-cost ratio is 1.52 based on the Energy Efficiency Groupware Application (EEGA) Workbook.[23] The MICAP energy efficiency measures reduce air conditioning usage which contributes 33 percent to California's peak electricity demand.[24] The EEGA workbook doesn't value peak demand. The TRC benefit cost ratio is 2.7 based on the E3 calculator which does value the MICAP peak demand savings.[25]

The ex ante first-year savings are summarized in **Table 3.2**.

[23] Intergy Corporation. 2004. EEGA Workbook Validator (version 3.8). Prepared for the California Public Utilities Commission, San Francisco, Calif: Available online: http://eega.cpuc.ca.gov/.
[24] Brown, R.E. and Jonathan G. Koomey, 2002. Electricity Use in California: Past Trends and Present Usage Patterns, Review Draft, Lawrence Berkeley National Laboratory, LBNL-47992.
[25] E3: Energy and Environmental Economics, Inc. 2008. E3 Calculator. Energy and Environmental Economics, Inc.: San Francisco, Calif. 94104. Available online: http://www.ethree.com/cpuc_cee_tools.html.

Table 3.2 Ex Ante First-Year Electricity and Gas Savings

Energy Efficiency Measure	Units Estimated	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/yr)	Net-to-Gross Ratio	Net Ex Ante Program Savings (kWh/y)	Net Ex Ante Program Savings (kW)	Net Ex Ante Program Savings (therm/yr)
Energy Star® CFL Torchieres	1,150	276	0.043		0.80	253,920	39.7	
Energy Star® Screw-In CFL 24 watt	18,000	111	0.037		0.80	1,598,400	529.9	
Energy Star® Screw-In CFL 20 watt	6,000	80	0.027		0.80	384,000	128.2	
Energy Star® Screw-In CFL 15 watt	6,000	66	0.022		0.80	316,800	104.6	
Basic HVAC Diagnostic FDZ3	1,250	438	0.442		0.89	487,275	491.7	
Basic HVAC Diagnostic FDZ2	150	211	0.200		0.89	28,169	26.7	
R-0 to R-30 Attic Insulation FDZ1	16,120	0.153	0.000159	0.256	0.89	2,197	2.3	3,677
R-0 to R-30 Attic Insulation FDZ2	73,140	0.467	0.000456	0.296	0.89	30,409	29.7	19,237
R-0 to R-30 Attic Insulation FDZ3	548,547	1.519	0.001578	0.289	0.89	741,506	770.5	140,974
R-0 to R-30 Attic Insulation FDZ4	145,076	0.190	0.000207	0.221	0.89	24,539	26.7	28,550
R-5 to R-30 Attic Insulation FDZ1	48,359	0.052	0.000054	0.117	0.89	2,255	2.3	5,042
R-5 to R-30 Attic Insulation FDZ2	219,419	0.160	0.000166	0.096	0.89	31,216	32.4	18,692
R-5 to R-30 Attic Insulation FDZ3	1,645,641	0.485	0.000504	0.109	0.89	710,271	738.0	159,023
R-5 to R-30 Attic Insulation FDZ4	435,229	0.060	0.000062	0.087	0.89	23,267	24.2	33,848
Energy Star® Thermostats FDZ1	18	267	-0.620	99	0.89	4,272	-9.9	1,588
Energy Star® Thermostats FDZ2	72	314	-0.614	108	0.89	20,095	-39.3	6,934
Energy Star® Thermostats FDZ3	540	382	-0.569	87	0.89	183,647	-273.2	41,812
Energy Star® Thermostats FDZ4	162	352	-0.709	103	0.89	50,708	-102.2	14,876
Duct Sealing FDZ1	18	107	0.197	34	0.89	1,719	3.2	548
Duct Sealing FDZ2	72	136	0.212	40	0.89	8,718	13.6	2,559
Duct Sealing FDZ3	540	270	0.295	32	0.89	129,823	141.8	15,165
Duct Sealing FDZ4	162	99	0.182	29	0.89	14,207	26.2	4,178
Water Heater Tank Insulation-Elec DHW	72	242	0.053	0	0.89	15,507	3.4	
Pipe Insulation-Elec DHW	36	92	0.020	0	0.89	2,948	0.6	
Faucet Aerators-Elec DHW	1,080	70	0.015	0	0.89	67,284	14.4	
Low-Flow Showerheads-Elec DHW	576	179	0.039	0	0.89	91,763	20.0	
Water Heater Tank Insulation	648			12	0.89			6,921
Pipe Insulation	324			5	0.89			1,442
Faucet Aerators	9,720			3	0.89			25,952
Low-Flow Showerheads	5,184			10	0.89			46,138
Energy Star® Thermostats FDZ5	108			122	0.89			11,689
Duct Sealing FDZ5	108			36	0.89			3,463
R-0 to R-30 Attic Insulation FDZ5	19,344			0.240	0.89			4,132
R-5 to R-30 Attic Insulation FDZ5	367,527			0.080	0.89			26,168
R-15 to R-30 Attic Insulation FDZ2	0				0.89			
R-15 to R-30 Attic Insulation FDZ3	0				0.89			
R-15 to R-30 Attic Insulation FDZ4	0				0.89			
Total	3,570,391					5,224,911	2,746	622,607

The ex post first-year savings are summarized in **Table 3.3**. The EM&V study found first-year net ex post program savings of 6,682,098 ± 554,912 kWh per year, 2,934 ± 184 kW per year, and 572,704 ± 31,956 therms per year at the 90 percent confidence level. The net realization rates are 1.28 ± 0.08 for first-year kWh, 1.07 ± 0.06 for kW, and 0.92 ± 0.05 for first-year therms.

Table 3.3 Ex Post First-Year Electricity and Gas Savings

Energy Efficiency Measure	Units Installed	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)	Net-to-Gross Ratio	Net Ex Post Program Savings (kWh/y)	Net Ex Post Program Savings (kW)	Net Ex Post Program Savings (therm)
Energy Star® CFL Torchieres	1,606	443.5	0.071		0.85	605,422	96.9	
Energy Star® Screw-In CFL 24 watt	18,194	95.7	0.015		0.85	1,479,991	236.8	
Energy Star® Screw-In CFL 20 watt	25,268	83.8	0.013		0.85	1,799,840	288.0	
Energy Star® Screw-In CFL 15 watt	6,000	76.4	0.012		0.85	389,640	62.3	
Basic HVAC Diagnostic FDZ3	1,301	382.8	0.364		0.89	443,240	421.1	
Basic HVAC Diagnostic FDZ2	350	168.8	0.160		0.89	52,581	50.0	
R-0 to R-30 Attic Insulation FDZ1	0	0.153	0.000159	0.256	0.89			
R-0 to R-30 Attic Insulation FDZ2	25,065	0.524	0.000498	0.246	0.89	11,689	11.1	5,488
R-0 to R-30 Attic Insulation FDZ3	75,199	1.283	0.001219	0.282	0.89	85,867	81.6	18,873
R-0 to R-30 Attic Insulation FDZ4	75,199	0.388	0.000369	0.191	0.89	25,968	24.7	12,783
R-5 to R-30 Attic Insulation FDZ1	0	0.052	0.000054	0.117	0.89			
R-5 to R-30 Attic Insulation FDZ2	408,972	0.242	0.000230	0.091	0.89	88,084	83.7	33,123
R-5 to R-30 Attic Insulation FDZ3	1,952,532	0.493	0.000469	0.091	0.89	857,444	814.6	158,341
R-5 to R-30 Attic Insulation FDZ4	542,550	0.137	0.000130	0.084	0.89	66,153	62.8	40,561
Programmable Thermostats FDZ1	0	267	0.243	99	0.89			
Energy Star® Thermostats FDZ2	157	272.3	0.248	87	0.89	38,048	34.6	12,115
Energy Star® Thermostats FDZ3	729	518.1	0.492	94	0.89	336,148	319.3	60,988
Energy Star® Thermostats FDZ4	206	420.5	0.399	81	0.89	77,094	73.2	14,759
Duct Sealing FDZ1	0	107	0.197	34	0.89			
Duct Sealing FDZ2	128	201.6	0.183	25	0.89	22,966	20.9	2,859
Duct Sealing FDZ3	612	230.0	0.209	29	0.89	125,276	113.9	15,523
Duct Sealing FDZ4	205	120.7	0.110	18	0.89	22,022	20.0	3,284
Water Heater Tank Insulation-Elec	15	242.0	0.034		0.89	3,231	0.5	
Pipe Insulation-Elec DHW	1	92.0	0.013		0.89	82	0.0	
Faucet Aerators-Elec DHW	237	56.3	0.008		0.89	11,875	1.7	
Low-Flow Showerheads-Elec	119	183.0	0.026		0.89	19,382	2.7	
Water Heater Tank Insulation	964		0.000	12	0.89			10,296
Pipe Insulation	9		0.000	5	0.89			40
faucet Aerators	13,739		0.000	4	0.89			44,020
Low-Flow Showerheads	7,729		0.000	13	0.89			86,879
Energy Star® Thermostats FDZ5	54	151.0	0.137	76	0.89	7,257	6.6	3,662
Duct Sealing FDZ5	115	38.8	0.035	15	0.89	3,971	3.6	1,505
R-0 to R-30 Attic Insulation FDZ5	119,667	0.504	0.000479	0.235	0.89	53,678	51.0	25,028
R-5 to R-30 Attic Insulation FDZ5	306,565	0.176	0.000167	0.078	0.89	48,020	45.6	21,282
R-15 to R-30 Attic Insulation FDZ2	5,094	0.079	0.000075	0.026	0.89	358	0.3	118
R-15 to R-30 Attic Insulation FDZ3	47,453	0.156	0.000148	0.026	0.89	6,588	6.3	1,098
R-15 to R-30 Attic Insulation FDZ4	3,548	0.057	0.000054	0.025	0.89	180	0.2	79
Total	3,639,582					6,682,098	2,934	572,704
90% Confidence Interval						554,912	184	31,956

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. The ex post NTGR for ex post net-to-gross ratio (NTGR) for compact fluorescent lamps (CFLs) is 0.85.[26] The ex ante NTGR is 0.80 for CFLs. The NTGR for all other measures of 0.89 based on the Residential Contractor Program (consistent with the ex ante NTGR). The NTGR reflects what customers would have done in the absence of the program (i.e., 15% free riders for CFLs and 11% free riders for other measures).[27] The lifecycle electricity and gas savings are summarized in **Table 3.4**.

[26] Itron, Inc. 2007. *2004-2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation.* prepared for Pacific Gas & Electric Company, Study I.D. PGE0214.01; 1115-04. Oakland, Calif: Itron, Inc. Available online: www.calmac.org.

[27] *Energy Efficiency Policy Manual*, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

Table 3.4 Lifecycle Electricity and Gas Savings

Energy Efficiency Measure	Ex Ante Effective Useful Life (EUL)	Net Ex-Ante Lifecycle Program Savings (kWh)	Net Ex-Ante Lifecycle Program Savings (therm)	Ex Post Effective Useful Life (EUL)	Net Ex-Post Lifecycle Program Savings (kWh)	Net Ex-Post Lifecycle Program Savings (therm)	Net Lifecycle Realization Rate (kWh)	Net Lifecycle Realization Rate (therm)
Energy Star® CFL Torchieres	16	4,062,720		11	6,659,640		1.64	
Energy Star® Screw-In CFL 24 watt	8	12,787,200		6	8,879,946		0.69	
Energy Star® Screw-In CFL 20 watt	8	3,072,000		6	10,799,038		3.52	
Energy Star® Screw-In CFL 15 watt	8	2,534,400		6	2,337,840		0.92	
Basic HVAC Diagnostic FDZ3	10	4,872,750		10	4,432,403		0.91	
Basic HVAC Diagnostic FDZ2	10	281,685		10	525,812		1.87	
R-0 to R-30 Attic Insulation FDZ1	20	43,934	73,530	20				
R-0 to R-30 Attic Insulation FDZ2	20	608,181	384,734	20	233,786	109,755	0.38	0.29
R-0 to R-30 Attic Insulation FDZ3	20	14,830,111	2,819,477	20	1,717,350	377,469	0.12	0.13
R-0 to R-30 Attic Insulation FDZ4	20	490,788	570,996	20	519,354	255,662	1.06	0.45
R-5 to R-30 Attic Insulation FDZ1	20	45,099	100,841	20				
R-5 to R-30 Attic Insulation FDZ2	20	624,311	373,845	20	1,761,688	662,453	2.82	1.77
R-5 to R-30 Attic Insulation FDZ3	20	14,205,411	3,180,470	20	17,148,883	3,166,827	1.21	1
R-5 to R-30 Attic Insulation FDZ4	20	465,336	676,957	20	1,323,062	811,221	2.84	1.2
Energy Star® Thermostats FDZ1	11	46,991	17,463	11				
Energy Star® Thermostats FDZ2	11	221,046	76,272	11	418,533	133,261	1.89	1.75
Energy Star® Thermostats FDZ3	11	2,020,112	459,936	11	3,697,633	670,870	1.83	1.46
Energy Star® Thermostats FDZ4	11	557,786	163,640	11	848,039	162,348	1.52	0.99
Duct Sealing FDZ1	15	25,785	8,220	15				
Duct Sealing FDZ2	15	130,763	38,378	15	344,494	42,891	2.63	1.12
Duct Sealing FDZ3	15	1,947,345	227,475	15	1,879,146	232,851	0.96	1.02
Duct Sealing FDZ4	15	213,099	62,671	15	330,326	49,262	1.55	0.79
Water Heater Tank Insulation-Elec	10	155,074		10	32,307		0.21	
Pipe Insulation-Elec DHW	10	29,477		10	819		0.03	
Faucet Aerators-Elec DHW	10	672,840		10	118,754		0.18	
Low-Flow Showerheads-Elec	10	917,626		10	193,815		0.21	
Water Heater Tank Insulation	10		69,206	10		102,955		1.49
Pipe Insulation	10		14,418	10		401		0.03
faucet Aerators	10		259,524	10		440,198		1.7
Low-Flow Showerheads	10		461,376	10		868,794		1.88
Energy Star® Thermostats FDZ5	11		128,581	11	79,828	40,284		0.31
Duct Sealing FDZ5	15		51,948	15	59,568	22,568		0.43
R-0 to R-30 Attic Insulation FDZ5	20		82,638	20	1,073,557	500,567		6.06
R-5 to R-30 Attic Insulation FDZ5	20		523,358	20	960,407	425,635		0.81
R-15 to R-30 Attic Insulation FDZ2	20			20	7,163	2,358		
R-15 to R-30 Attic Insulation FDZ3	20			20	131,767	21,961		
R-15 to R-30 Attic Insulation FDZ4	20			20	3,600	1,579		
Total		65,861,867	10,825,954		66,518,557	9,102,165	1.01	0.84
90% Confidence Interval					4,225,783	483,961		

The gross ex-ante lifecycle savings are 76,841 MWh and 12,163,993 therms. The net ex-post lifecycle savings are 66,519 ± 4,226 MWh and 9,102,163 ± 483,961 therms. The lifecycle ex-post net lifecycle kWh realization rate is 1.01 ± 0.06 and the net lifecycle therm realization rate is 0.84 ± 0.04.

The required energy impact reporting for 2004-05 programs is provided in **Table 3.5**.

Table 3.5 Required Energy Impact Reporting for 2004-2005 Programs

Program ID:		1082-04					
Program Name:		Moderate Income Attic Insulation Program					
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	6,193	6,682	3.186	3.333	699,558	572,704
2	2005	6,193	6,682	3.186	3.333	699,558	572,704
3	2006	6,193	6,682	3.186	3.333	699,558	572,704
4	2007	6,193	6,682	3.186	3.333	699,558	572,704
5	2008	6,193	6,682	3.186	3.333	699,558	572,704
6	2009	6,193	6,682	3.186	3.333	699,558	572,704
7	2010	6,193	3,013	3.186	2.642	699,558	572,704
8	2011	6,193	3,013	3.186	2.642	699,558	572,704
9	2012	3,319	3,013	2.233	2.642	699,558	572,704
10	2013	3,319	3,013	2.233	2.642	699,558	572,704
11	2014	2,541	2,482	1.607	2.107	609,162	431,469
12	2015	2,250	1,418	2.084	1.506	522,759	339,946
13	2016	2,250	1,418	2.084	1.506	522,759	339,946
14	2017	2,250	1,418	2.084	1.506	522,759	339,946
15	2018	2,250	1,418	2.084	1.506	522,759	339,946
16	2019	2,077	1,244	1.877	1.328	493,643	316,774
17	2020	1,759	1,244	1.827	1.328	493,643	316,774
18	2021	1,759	1,244	1.827	1.328	493,643	316,774
19	2022	1,759	1,244	1.827	1.328	493,643	316,774
20	2023	1,759	1,244	1.827	1.328	493,643	316,774
TOTAL		76,841	66,519			12,163,993	9,102,163

** 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 16-year effective useful life (EUL) assumed for the CFL torchieres. The EUL value for this measure was reduced to 11 years based on light logger data. The 15W, 20W, and 24W CFL EUL values were reduced from 8 years to 6 years based on light logger data. The average ex post operating hours are 1,624 ± 298 hours/yr based on light logger data for 1,173 fixtures at 66 sites. The net ex post first-year gas savings are 572,704 ± 31,956 therms and this is 16% lower than the ex ante estimate.[28] The difference is largely due to lower ex post gas savings for attic insulation based on unavailability of R-0 to R-30 attic insulation measures (i.e., lack of attics without any insulation). The program assumed it would install 802,226 ft^2 of R-0 to R-30 attic insulation and 2,716,175 ft^2 of R-5 to R-30 insulation. The program actually installed 295,130 ft^2 of R-0 to R-30 (63.2% less than assumed) and 3,210,619 ft^2 of R-5 to R-30 insulation (18.2% more than assumed). The program also installed 56,095 ft^2 of R-15 to R-30 attic insulation. The program actually installed 3,561,844 ft^2 of attic insulation and exceeded its attic insulation goal by 1.2%.

[28] 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.

3.1.1 Verification Inspection Findings

Verification inspections were conducted for the study from May 2005 through February 2006. All measures were verified as properly installed consistent with the MICAP database. Results of the on-site verification inspections were used in the impact evaluation to estimate the overall energy savings. One hundred fifty-eight (158) on-site participant inspections were completed (90 more than anticipated and budgeted). Inspections at each site were conducted for the following measures: CFLs, showerheads, aerators, attic insulation, duct sealing, water heater blankets, Energy Star® programmable thermostats, and AC tune-ups. AC tune-ups were checked at 75 sites and 72 passed the inspection. Three units failed inspection: two were undercharged by 8%, and one was overcharged by 10%. These units were corrected. Further investigations determined that the technicians were not waiting long enough for the AC units to reach equilibrium before taking final "test-out" temperature measurements. On some AC units if the suction line temperature measurements are fluctuating, the technician must wait about 30 minutes for the unit to reach equilibrium before making the final "test-out" measurements. The technicians were trained on this procedure and no such problems were found afterwards. All AC units received Novent™ locking Schrader caps and labels to identify them as having Verified™ refrigerant charge and airflow. Seventy-one (71) HVAC duct systems were inspected. While the EM&V plan proposed more inspections for electric water heater measures, fewer of these measures were installed by the program so the EM&V sample for these measures is less than anticipated.

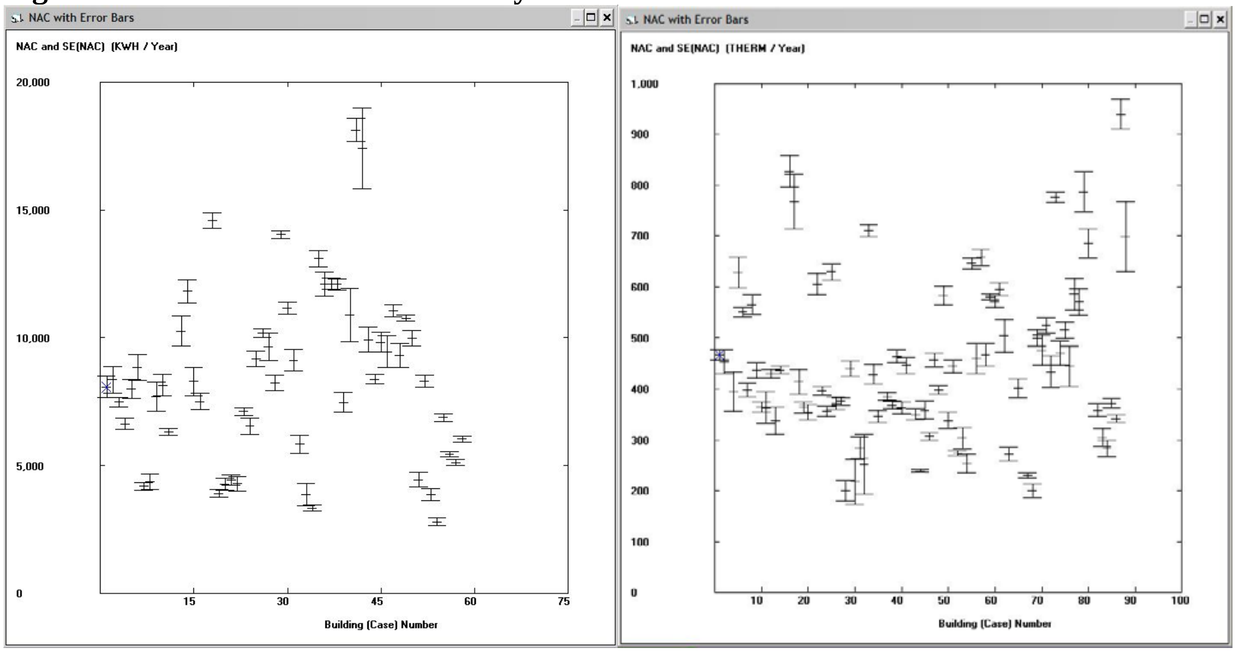
Light loggers were installed at 70 sites to measure hours of operation. Data loggers at four (4) sites were tampered with by the occupants and the data was lost. Lighting hours of operation are based on data from sixty-six (66) light loggers. Survey responses were used to evaluate thermostat settings before and after MICAP installed Energy Star® 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.

3.1.2 Load Impacts for All Measures Based on IPMVP Option C

Load impacts for all measures are evaluated using historical billing data and the PRInceton Scorekeeping Method (PRISM) consistent with IPMVP Option C. Two or three years of historical electric and gas billing data were obtained for a sample of 58 participant sites located in Stockton and Livingston (FDZ2, CZ 12), Yuba City, Marysville and Chico (FDZ3 and CZ11), Gilroy, Morgan Hill, and San Jose (FDZ4 and CZ4), and Union City (FDZ5 and CZ3). The billing data are in the PRISM statistical regression model to develop normalized energy savings (NEC) and normalized annual consumption (NAC) for electricity and natural gas (see **Figure 3.1**). The average PRISM cooling savings per site are 982 ± 361 kWh per year or 8.5 ± 3.3 % of the total kWh NAC. This is 12.7% higher than the ex ante electricity savings of 871 kWh per year per site.[29] The average PRISM heating savings per site are 94 ± 17 therm per year or 17.1 ± 2.7% of the gas NAC. This is 9.7% lower than the ex ante gas savings of 104 therm per year per site.[30]

[29] Ex ante savings of 871 kWh per year are based on 5,224,911 kWh per year divided by 6,000 sites (see Table 3.1).
[30] Ex ante savings of 104 therm per year are based on 622,607 therm per year divided by 6,000 sites (see Table 3.1).

Figure 3.1 PRISM NAC for Electricity and Natural Gas



3.1.3 Load Impacts for Weather Sensitive Measures Based on IPMVP Option D

Load impacts for weather sensitive measures are evaluated using calibrated eQuest building energy simulations consistent with IPMVP Options D. The weather sensitive measures include attic insulation, AC Diagnostic tune-ups, duct sealing, and Energy Star® thermostats. The eQUEST baseline simulations are calibrated to historical billing data (PRISM) and on-site audit data. The baseline cooling and heating UEC values are shown in **Table 3.6**. The average cooling UEC based on billing analysis is 2,445 ± 74 kWh per year and the average heating UEC is 320 ± 15 therm per year. The 2005 DEER Update Study provides an average UEC of 1,918 kWh per year and 368 therm per year. The average ex ante baseline UEC is 2,529 kWh per year and 359 kWh per year.

Table 3.6 Baseline Cooling and Heating Unit Energy Consumption (UEC)

			Billing Data		DEER 2005		Ex Ante R-5 Baseline	
CEC FDZ	CEC CZ	Ex Post % Savings	Cooling kWh	Heating therm	Cooling kWh	Heating therm	Cooling kWh	Heating therm
2	12	7.2%	2649	317	2,006	365	1,393	420
3	11	63.6%	3160	335	2,479	386	3,367	346
4	4	7.1%	1649	271	1,177	312	900	343
5	3	22.1%	591	328	524	378	1,028	407
Average			2,445	320	1,918	368	2,529	359

The eQUEST residential single family prototype is taken from the 2005 DEER Update Study (see **Figure 3.2**). The models were calibrated to average space cooling and heating UEC values from the billing data (i.e., PRISM) using Typical Meteorological Year (TMY) weather data for

CEC climate zones 3, 4, 11 and 12.[31] The baseline and Energy Star® thermostat schedules are shown in **Table 3.7**. The baseline thermostat schedule is the composite average schedule from the on-site inspections. The eQUEST building characteristics are shown in **Table 3.8**.

Figure 3.2 eQUEST Residential Single Family Prototype Based on 2005 DEER Study

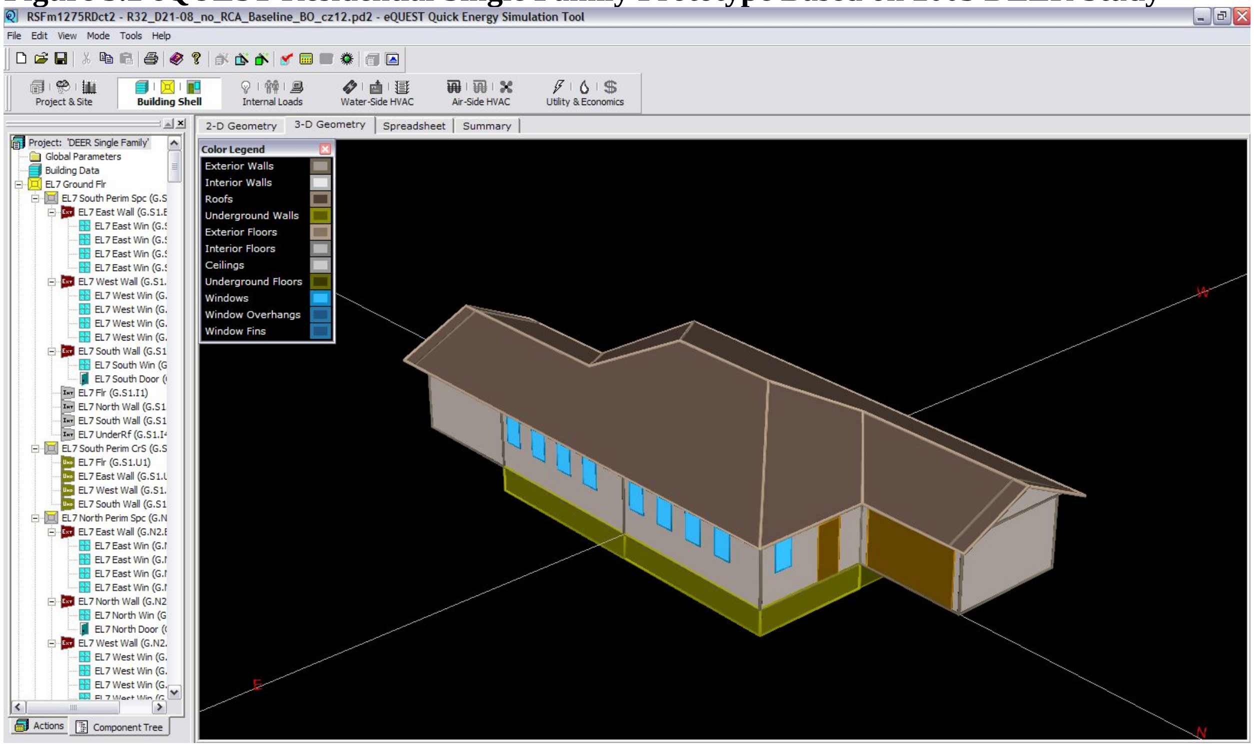


Table 3.7 Baseline and Energy Star Thermostat Schedules

	1-9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Baseline Cool	80	79	78	77	77	77	77	77	77	76	76	77	77	77	78	79
Baseline Heat	69	69	68	68	68	68	68	68	68	68	68	68	68	68	68	66
Energy Star® Cool	78	78	85	85	85	85	85	85	85	85	85	78	78	78	78	78
Energy Star® Heat	50	50	65	65	65	65	65	65	65	65	65	65	65	65	50	50

[31] *California Thermal Climate Zones*, California Energy Commission, 1516 9th St., Sacramento, CA 95814, 1992.

Table 3.8 DEER Residential Building Characteristics (DEER 2005)

Characteristic	Existing Vintage
Vintage	Pre-1978
Total Floor Area (ft^2)	1,212 ft^2
Average Floor Height	8 feet
Wall R-value [cavity only]	Total R-5.18 [R-1 cavity]
Wall Type	Wood Frame
Ceiling R-value [cavity]	Total R-6.71 [R-5 cavity]
Ceiling Area, total exterior (ft^2)	1,216 ft^2
Floor R-value [cavity]	Total R-5.51 (over Crawl Space)
Window-to-Floor Area Ratio	14%
Window u-value	1.23
Number of Panes	1
Occupancy (people)	3
Lighting Intensity (W/ft^2)	1.5 W/ft^2
Electric Internal Loads (W/ft^2)	0.91 W/ft^2
HVAC Zoning	Single zone
Heating System Type	Gas furnace
Heating Capacity (kBtu/hr-unit)	50 kBtuh
Heating System Efficiency	0.70
Cooling System Type	Split
Cooling Capacity, tons (kBtu/hr-unit)	2.5 tons (30 kBtuh)
Cooling System SEER	8.5 SEER
Design Air (cfm/ft^2)	0.9 cfm/ft^2

3.1.4 Load Impacts for Attic Insulation

Load impacts for Attic Insulation are based on field inspections of 89,601 ft^2 of insulation at 69 participant sites and calibrated eQUEST simulations consistent with IPMVP Option D. Attic insulation was installed (i.e., blown-in) to improve the overall insulation level to above R-30. The program installed attic ventilation of 1 ft^2 net free venting per 600 ft^2 of attic insulation using mushroom, eyebrow, or eave vents.[32] Increased attic ventilation will reduce attic temperatures and cooling loads in summer and save energy, but this was not modeled in eQUEST so the savings for attic insulation are conservative. The average measured ex post R-value is 33.69 ± 0.8. The ex ante and ex post unit savings per square foot (ft^2) are shown in **Table 3.9**.

[32] Per the California Conventional Home Weatherization Installation Standards.

Table 3.9 Attic Insulation Ex Ante and Ex Post Electricity and Gas Savings per ft^2

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
R-0 to R-30 Attic Insulation FDZ1	0.153	0.000159	0.256	N/A	N/A	N/A
R-0 to R-30 Attic Insulation FDZ2	0.467	0.000456	0.296	0.524 ± 0.054	0.000498 ± 0.000051	0.246 ± 0.025
R-0 to R-30 Attic Insulation FDZ3	1.519	0.001578	0.289	1.283 ± 0.132	0.001219 ± 0.000125	0.282 ± 0.029
R-0 to R-30 Attic Insulation FDZ4	0.190	0.000207	0.221	0.388 ± 0.040	0.000369 ± 0.000038	0.191 ± 0.020
R-0 to R-30 Attic Insulation FDZ5	0	0	0.240	0.504 ± 0.052	0.000479 ± 0.000049	0.235 ± 0.024
R-5 to R-30 Attic Insulation FDZ1	0.052	0.000054	0.117	N/A	N/A	N/A
R-5 to R-30 Attic Insulation FDZ2	0.160	0.000166	0.096	0.242 ± 0.025	0.000230 ± 0.000024	0.091 ± 0.009
R-5 to R-30 Attic Insulation FDZ3	0.485	0.000504	0.109	0.493 ± 0.051	0.000469 ± 0.000048	0.091 ± 0.009
R-5 to R-30 Attic Insulation FDZ4	0.060	0.000062	0.087	0.137 ± 0.014	0.000130 ± 0.000013	0.084 ± 0.009
R-5 to R-30 Attic Insulation FDZ5	0	0	0.080	0.176 ± 0.018	0.000167 ± 0.000017	0.078 ± 0.008
R-15 to R-30 Attic Insulation FDZ2	0	0	0	0.079 ± 0.008	0.000075 ± 0.000008	0.026 ± 0.003
R-15 to R-30 Attic Insulation FDZ3	0	0	0	0.156 ± 0.016	0.000148 ± 0.000015	0.026 ± 0.003
R-15 to R-30 Attic Insulation FDZ4	0	0	0	0.057 ± 0.006	0.000054 ± 0.000006	0.025 ± 0.003

Differences between ex ante and ex post first-year savings are due to using eQUEST prototype models from the 2005 DEER Update Study rather than DOE-2 models from the 2001 Update DEER Study. The ex ante goal for attic insulation is 3,518,402 ft^2 and the study verified 3,561,844 ft^2 of attic insulation. The net-to-gross ratio is 0.89 and the effective useful lifetime is 20 years. The total net ex ante savings are 1,565,658 first-year kWh, 1,626 kW, and 439,342 first-year therms. The total net ex post savings are 1,135,310 ± 100,483 first-year kWh, 1,182 ± 96 kW and 316,774 ± 19,837 first-year therms at the 90 percent confidence level. The net ex ante lifecycle savings are 31,313,170 kWh and 8,786,846 therms. The net ex post lifecycle savings are 24,880,617 ± 2,011,105 kWh and 6,335,485 ± 389,388 therms. The difference between net ex ante and ex post savings are due to unavailability of R-0 to R-30 attic insulation measures (i.e., lack of attics without any insulation). The program assumed it would install 802,226 ft^2 of R-0 to R-30 attic insulation and 2,716,175 ft^2 of R-5 to R-30 insulation. The program actually installed 295,130 ft^2 of R-0 to R-30 (63.2% less than assumed) and 3,210,619 ft^2 of R-5 to R-30 insulation (18.2% more than assumed). The program also installed 56,095 ft^2 of R-15 to R-30 attic insulation and exceeded its attic insulation goal by 1.2%.

3.1.5 Load Impacts for HVAC Diagnostic Tune-ups

Load impacts for HVAC diagnostic tune-ups are based on field inspections of 38 units, software verification of 919 units and calibrated eQUEST simulations consistent with IPMVP Option D. AC diagnostic tune-up involves chemical condensing coil cleaning, replacing air filters, and checking and correcting refrigerant charge and airflow (RCA) on central air conditioning units and central heat pump units. Proper installation was verified using RCA Verification software and random site inspections of work performed by EPA-certified refrigerant technicians. Detection of leaky Schrader valves was performed with leak detection equipment and leaky Schrader valves were replaced with new valves using core repair tools. Brass Schrader valve caps with secondary "O" ring seals were installed on each job. The average ex post refrigerant charge adjustment for 919 units is 10.1 ± 1.1% of the factory charge. The average temperature split improvement in terms of increased cooling capacity was 7 ± 3.1% from the combination of new air filters, clean coils, and proper refrigerant charge. The ex ante and ex post unit savings are shown in **Table 3.10**.

Table 3.10 AC Diagnostic Tune-up Ex Ante and Ex Post Electricity Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Basic HVAC Diagnostic FDZ3	438	0.442		382.8 ± 41.5	0.364 ± 0.039	
Basic HVAC Diagnostic FDZ2	211	0.200		168.8 ± 18.3	0.160 ± 0.017	

The ex ante goal for HVAC diagnostic tune-up attic insulation is 1,400 units and the study verified 1,651 units. The net-to-gross ratio is 0.89 and the effective useful lifetime is 10 years. The total net ex ante savings are 515,444 first-year kWh and 518 kW. The total net ex post savings are 495,821 ± 54,370 first-year kWh and 471 ± 52 kW at the 90 percent confidence level. The net ex ante lifecycle savings are 5,154,435 kWh. The net ex post lifecycle savings are 4,958,215 ± 543,701 kWh. The difference between net ex ante and ex post savings are due to using the eQUEST prototype models from the 2005 DEER Update Study rather than DOE-2 models from the 2001 Update DEER Study. The program exceeded the AC diagnostic tune-up installation goal by 18%.

3.1.6 Load Impacts for Duct Sealing

Load impacts for duct sealing are based on field inspections of 69 units, software verification of 919 units and calibrated eQUEST simulations consistent with IPMVP Option D. Duct testing and sealing involves sealing both supply and return ducts to an ex ante leakage reduction of 60 cfm/ton or 14% of measured total system flow at 25 Pascal pressure (supply and return). The ex ante baseline is 29% duct leakage going to 15% for a 14% reduction or 60 cfm/ton. Duct sealing performance was measured at a random sample of sites with duct pressurization equipment. Proper installation was verified by examining the materials used to seal the ducts including use of mastic and or UL-listed metal or butyl tape. The average ex post duct leakage reduction measured at 69 sites was 9.8 ± 1.2% of total system airflow based on 400 cubic feet per minute per ton of cooling capacity. The verified pre-duct leakage for 958 sites is 20.8 ± 0.5% and the post-duct leakage is 10.9 ± 0.2% with an average duct leakage reduction of 9.9 ± 0.4%. These pre-and post-leakage values were used in the eQUEST simulations to model the duct sealing measure. The ex ante and ex post unit savings are shown in **Table 3.11**.

Table 3.11 Duct Sealing Ex Ante and Ex Post Electricity Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Duct Sealing FDZ1	107	0.197	34	N/A	N/A	N/A
Duct Sealing FDZ2	136	0.212	40	201.6 ± 13.4	0.183 ± 0.0122	25 ± 5.83
Duct Sealing FDZ3	270	0.295	32	230.0 ± 15.3	0.209 ± 0.0138	29 ± 6.62
Duct Sealing FDZ4	99	0.182	29	120.7 ± 8.0	0.110 ± 0.0073	18 ±4.18
Duct Sealing FDZ5			36	38.8 ± 2.6	0.035 ± 0.0023	15 ± 3.41

The ex ante goal for duct sealing is 900 units and the study verified 1,060 installed measures. The net-to-gross ratio is 0.89 and the effective useful lifetime is 15 years. The total net ex ante savings are 154,466 first-year kWh, 185 kW, and 25,913 first-year therms. The total net ex post savings are 174,236 ± 9,651 first-year kWh, 158 ± 9 kW, and 23,171 ± 4,224 first-year therms at the 90 percent confidence level. The net ex ante lifecycle savings are 2,316,991 kWh and 388,692 therms. The net ex post lifecycle savings are 2,613,534 ± 144,762 kWh and 347,571 ±

63,366 therms. The difference between net ex ante and ex post savings are due to using the eQUEST prototype models from the 2005 DEER Update Study rather than DOE-2 models from the 2001 Update DEER Study. The program exceeded the duct sealing installation goal by 18%.

3.1.7 Load Impacts for Energy Star® Thermostat

Load impacts for Energy Star® thermostats are based on field inspections of 68 units and calibrated eQUEST simulations consistent with IPMVP Option D. Energy Star® thermostats replace the existing manual thermostat. The programmable thermostat is setup from 78F to 85F from 9AM to 6PM during summer weekdays while occupants are away. The unit is setback from 78F to 65F during winter nights while occupants are sleeping. If occupants adjust thermostat settings, then the Energy Star® unit will go back to its pre-defined energy conserving settings within 24 hours to ensure persistence of energy savings. Thermostat settings were measured at a random sample of sites to establish the pre-retrofit thermostat schedule (see **Table 3.7**). The baseline and Energy Star® thermostat schedules were used in the eQUEST simulations to model the measure. The ex ante and ex post unit savings are shown in **Table 3.12**.

Table 3.12 Energy Star® Thermostats Ex Ante and Ex Post Electricity Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Energy Star® Thermostats FDZ1	267	-0.620	99	N/A	N/A	N/A
Energy Star® Thermostats FDZ2	314	-0.614	108	272.3 ± 89.9	0.248 ± 0.082	87 ± 28.6
Energy Star® Thermostats FDZ3	382	-0.569	87	518.1 ± 171	0.492 ± 0.162	94 ± 31
Energy Star® Thermostats FDZ4	352	-0.709	103	420.5 ± 138.8	0.399 ± 0.132	81 ± 26.6
Energy Star® Thermostats FDZ5			122	151.0 ± 49.8	0.137 ± 0.045	76 ± 25.1

The ex ante goal for Energy Star® thermostats is 900 units and the study verified 1,146 installed measures. The net-to-gross ratio is 0.89 and the effective useful lifetime is 11 years. The total net ex ante savings are 258,721 first-year kWh, -425 kW, and 76,899 first-year therms. The total net ex post savings are 458,548 ± 128,701 first-year kWh, 434 ± 122 kW, and 91,524 ± 23,722 first-year therms at the 90 percent confidence level. The net ex ante lifecycle savings are 2,845,936 kWh and 845,891 therms. The net ex post lifecycle savings are 5,044,033 ± 1,415,707 kWh and 1,006,762 ± 260,944 therms. The difference between net ex ante and ex post savings are due to using the eQUEST prototype models from the 2005 DEER Update Study rather than DOE-2 models from the 2001 Update DEER Study. The program assumed it would install 900 units. The program exceeded the Energy Star® thermostat installation goal by 27%.

3.1.8 Load Impacts for Energy Star® CFLs and CFL Torchieres

Load impacts for Energy Star® CFLs and Energy Star® CFL torchieres are based on field inspections of 1,244 fixtures at 70 participant sites, and lighting logger measurements of 1,173 fixtures at 66 sites consistent with IPMVP Option B. The MICAP ex ante estimate of operating hours is 1,250 hours per year. The average ex post operating hours are 1,624 ± 298 hours/yr based on the light logger data. The ex ante and ex post unit savings are shown in **Table 3.13**.

Table 3.13 Energy Star® CFLs and Torchieres Ex Ante and Ex Post Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Energy Star® CFL Torchieres	276	0.043		443.5 ± 81.5	0.071 ± 0.0130	
Energy Star® Screw-In CFL 24 watt	111	0.037		95.7 ± 17.6	0.015 ± 0.0028	
Energy Star® Screw-In CFL 20 watt	80	0.027		83.8 ± 15.4	0.013 ± 0.0025	
Energy Star® Screw-In CFL 15 watt	66	0.022		76.4 ± 14	0.012 ± 0.0023	

The ex ante goal for Energy Star® CFLs and CFL torchieres is 31,150 units and the study verified 51,068 installed measures. The ex ante net-to-gross ratio is 0.80, but the ex post NTGR is 0.85.[33] The ex ante effective useful lifetime is 16 years for torchieres and 8 years for CFLs. The ex post EUL is 11 years for CFL torchieres and 6 years for screw-in CFLs.[34] The total net ex ante savings are 2,553,120 first-year kWh and 802 kW. The total net ex post savings are 4,274,892 ± 527,395 first-year kWh and 684 ± 84 kW at the 90 percent confidence level. The net ex ante lifecycle savings are 22,456,320 kWh. The net ex post lifecycle savings are 28,676,464 ± 3,386,656 kWh. The difference between net ex ante and ex post savings are due to different annual hours of operation based on light logger data. The program exceeded the total CFL installation goal by 64%.

3.1.9 Load Impacts for Low-Flow Showerheads

Load impacts for low-flow showerheads were evaluated based on field measurements of pre- and post-retrofit flow rates of 116 units, ex ante assumptions, engineering estimates and EM&V studies per IPMVP Option A and B. Low-flow showerheads replace non-conserving 3.0 gpm or greater units at a flowing pressure of 80 psi (pounds per square inch). Low-flow showerheads are rated at 2.5 gpm or less at a flowing pressure of 80 psi. Pre- and post-retrofit measurements of flow rates (gpm) and flowing pressure (psi) were made with flow meters as per ASME A112.18.1/CSA B125.1-2005. These measurements were checked using a micro weir. The average pre-retrofit showerhead flow rate was 2.8 ± 0.177 gpm at 52.9 ± 3.5 psi flowing pressure and the average post-retrofit flow rate was 2.0 ± 0.03 gpm at 65.4 ± 1.3 psi flowing pressure. The ex post savings are based on the average 28.6% reduction in flow rate and the average percentage of usage attributable to showering (i.e., 23% for gas and 26% for electric water heating) multiplied times the baseline water heating UEC of 193 therms per year for gas and 3,079 kWh per year (RASS Study 11, **Table 2.2**). The ex ante and ex post unit savings are shown in **Table 3.14**.

Table 3.14 Low-flow Showerheads Ex Ante and Ex Post Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Low-Flow Showerheads			10			13 ± 0.8
Low-Flow Showerheads-Elec DHW	179	0.039		183.0 ± 11.9	0.026 ± 0.002	

[33] Itron, Inc. 2007. *2004-2005 Statewide Residential Retrofit Single-Family Energy Efficiency Rebate Evaluation.* prepared for Pacific Gas & Electric Company, Study I.D. PGE0214.01; 1115-04. Oakland, Calif: Itron, Inc. Available online: www.calmac.org.

[34] CFL torchieres have an EUL of 11 years based on 18,000 hours divided by 1,624 hours per year (9,000 hours per lamp MICAP provided an extra lamp for each CFL torchiere). Screw-in CFLs have an EUL of 6 years based on 10,000 hours per lamp divided by 1,624 hours per year.

The ex ante goal for low-flow showerheads is 576 units with electric water heaters and 5,184 units with gas water heaters. The study verified 119 units with electric water heaters and 7,729 units with gas water heaters. The ex ante net-to-gross ratio is 0.89 and the ex ante effective useful lifetime is 10 years. The total net ex ante savings are 91,763 first-year kWh, 20 kW and 46,138 first-year therms. The total net ex post savings are 19,382 ± 1,416 first-year kWh, 2.7 ± 0.2 kW and 46,138 ± 6,183 first-year therms per year at the 90 percent confidence level. The net ex ante lifecycle savings are 917,626 kWh and 461,376 therms. The net ex post lifecycle savings are 193,815 ± 14,161 kWh and 868,794 ± 61,832 therms. The difference between net ex ante and ex post savings are due to different measured flow rates and baseline assumptions. The program exceeded the total low flow showerhead installation goal by 36%.

3.1.10 Load Impacts for Low-Flow Aerators

Load impacts for low-flow aerators were evaluated based on field measurements of pre- and post-retrofit flow rates of 201 units, ex ante assumptions, engineering estimates and EM&V studies per IPMVP Option A and B. Low-flow aerators replace non-conserving 2.5 gpm or greater units at a flowing pressure of 80 psi (pounds per square inch). Low-flow aerators are rated at 2.0 gpm or less at a flowing pressure of 80 psi. Pre- and post-retrofit measurements of flow rates (gpm) and flowing pressure (psi) were made with flow meters as per ASME A112.18.1/CSA B125.1-2005. These measurements were checked using a micro weir. The average pre-retrofit aerator flow rate was 2.5 ± 0.115 gpm at 58.3 ± 2.5 psi flowing pressure and the average post-retrofit flow rate was 1.9 ± 0.01 gpm at 66.3 ± 0.7 psi flowing pressure. The ex post savings are based on the average 24% reduction in flow rate and the average percentage of usage attributable to sinks (i.e., 9% for gas and 10% for electric water heating) multiplied times the baseline water heating UEC of 193 therms per year for gas and 3,079 kWh per year (RASS Study 11, **Table 2.2**). The ex ante and ex post unit savings are shown in **Table 3.15**.

Table 3.15 Low-flow Aerators Ex Ante and Ex Post Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Low-Flow Aerators			3			4 ± 0.8
Low-Flow Aerators-Elec DHW	70	0.015	0	56.3 ± 3.7	0.008 ± 0.001	

The ex ante goal for low-flow aerators is 1,080 units with electric water heaters and 9,720 units with gas water heaters. The study verified 237 units with electric water heaters and 13,739 units with gas water heaters. The ex ante net-to-gross ratio is 0.89 and the ex ante effective useful lifetime is 10 years. The total net ex ante savings are 67,284 first-year kWh, 14.4 kW and 25,952 first-year therms. The total net ex post savings are 11,875 ± 877 first-year kWh, 1.7 ± 0.1 kW and 44,020 ± 2,748 first-year therms per year at the 90 percent confidence level. The net ex ante lifecycle savings are 672,840 kWh and 259,524 therms. The net ex post lifecycle savings are 118,754 ± 8,769 kWh and 440,198 ± 27,478 therms. The difference between net ex ante and ex post savings are due to different measured flow rates and baseline assumptions. The program exceeded the total low flow aerator installation goal by 29%.

3.1.11 Load Impacts for Water Heater Insulation

Load impacts for water heater tank insulation were evaluated based on inspections and stipulated values per IPMVP Option A. Water heater insulation (R-8) is applied to water heaters with fittings that are dry and in good shape. The anode, relief valve, and control must be left exposed for routine maintenance. The study inspected 32 sites where MICAP installed R-7 water heater insulation. The ex ante and ex post unit savings are shown in **Table 3.16**.

Table 3.16 Water Heater Tank Insulation Ex Ante and Ex Post Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Water Heater Tank Insulation			12			12 ± 1.2
Water Heater Tank Insul.-Elec DHW	242	0.053	0	242 ± 24.2	0.053 ± 0.003	

The EM&V study used the stipulated savings. The ex ante goal for water heater insulation is 72 electric water heaters blankets and 648 gas water heater blankets. The study verified 15 electric water heater blankets and 964 gas water heater blankets. The ex ante net-to-gross ratio is 0.89 and the ex ante effective useful lifetime is 10 years. The total net ex ante savings are 15,507 first-year kWh, 3.4 kW and 6,921 first-year therms. The total net ex post savings are 3,231 ± 363 first-year kWh, 0.5 ± 0.1 kW and 10,296 ± 1,157 first-year therms per year at the 90 percent confidence level. The net ex ante lifecycle savings are 155,074 kWh and 69,206 therms. The net ex post lifecycle savings are 32,307 ± 3,630 kWh and 102,955 ± 11,568 therms. The program exceeded the total water heater tank insulation goal by 36%.

3.1.11 Load Impacts for Water Heater Pipe Insulation

Load impacts for water heater pipe insulation were evaluated based on inspections and stipulated values per IPMVP Option A. Water heater pipe insulation (R-4) is applied to water heaters with fittings that are dry and in good shape. The anode, relief valve, and control must be left exposed for routine maintenance. The study inspected 4 sites where MICAP installed R-4 pipe insulation. The ex ante and ex post unit savings are shown in **Table 3.17**.

Table 3.17 Water Heater Pipe Insulation Ex Ante and Ex Post Savings

Energy Efficiency Measure	Gross Ex-Ante Unit Savings (kWh/y)	Gross Ex-Ante Unit Savings (kW)	Gross Ex-Ante Unit Savings (therm/y)	Gross Ex-Post Unit Savings (kWh/y)	Gross Ex-Post Unit Savings (kW)	Gross Ex-Post Unit Savings (therm)
Water Heater Pipe Insulation			5			5 ± 0.5
Water Heater Pipe Insul.-Elec DHW	92	0.020	0	92 ± 9.2	0.020 ± 0.001	

The EM&V study used the stipulated savings. The ex ante goal for pipe insulation is 36 units on electric water heaters and 324 units on gas water heaters. The study verified 1 unit on an electric water heater and 9 units on gas water heaters. The ex ante net-to-gross ratio is 0.89 and the ex ante effective useful lifetime is 10 years. The total net ex ante savings are 2,948 first-year kWh, 0.6 kW and 1,442 first-year therms. The total net ex post savings are 82 ± 9 first-year kWh and 40 ± 5 first-year therms per year at the 90 percent confidence level. The net ex ante lifecycle savings are 29,477 kWh and 14,418 therms. The net ex post lifecycle savings are 819 ± 92 kWh and 401 ± 45 therms. The program installed 97% less pipe insulation than the ex ante goal. MICAP was unable to meet the ex goal for pipe insulation due to the California Conventional

Home Weatherization Installation Standards which require 3 inches of clearance from the flue to install pipe insulation on gas water heaters and at least one foot of continuous exposed pipe to install pipe insulation on electric water heaters. Gas water heaters generally do not meet the 3 inch clearance requirement and many electric heaters already have pipe insulation installed or do not have one foot of exposed pipe to insulate. Electric water heaters also have low saturation (approximately 9% based on the 2005 RASS Study). Therefore, pipe insulation has limited feasibility and availability.

3.2 Process Evaluation Results

Process evaluation recommendations are based on process surveys conducted in-person with 70 participants and 68 non-participants (i.e., non-qualifiers). 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 residential customers 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 – 85 percent satisfaction rating (i.e., average score of 8.5 ± 0.1 out of 10 points).
   - Courteous and Professional Crew – 89 percent satisfaction rating (i.e., 8.9 ± 0.3 out of 10 points).
   - Timeliness (i.e., work scheduled and completed on time) – 99 percent satisfaction rating (average reported time per installation 125 ± 3 minutes).
   - Increased Understanding of Link between Energy Efficiency, Savings, and Comfort - 78 ± 4 percent, indicating MICAP energy education efforts are generally doing a good job.

2. **Are customers satisfied with measures offered or installed by the program?**
   Customers were satisfied with measures as indicated by the following ratings.
   - 90 percent of customers are still using the measures installed by the program (i.e., 63 out of 70 surveyed customers were still using all installed measures). Four customers replaced showerheads, two customers reported a CFL that burned out, and one customer reported a breaking a CFL.
   - 88 percent of customers were satisfied with measures offered or installed by the program ((i.e., average score of 8.8 ± 0.2 out of 10 points).

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.
   - 83 ± 2 percent usefulness rating.
   - 83 ± 2 percent presentation rating.
   - 86 ± 2 percent accuracy rating.
   - 78 ± 4 percent rating of program increasing understanding of the linkage between energy efficiency, bill savings, and comfort.
   - 100 percent of participants indicated that neighbors would benefit from 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.[35]
   - 100 percent of participants were outside major metropolitan areas (i.e., San Francisco, Sacramento).
   - Average conditioned floor area is 1,341 ft^2 ± 50 ft^2.
   - Average number of occupants per home is 4 ± 0.4.
   - 96% owned the home and 4% are renters.
   - 100 percent spoke English well enough to understand and answer the questions.
   - Participants had the following primary languages: 46% Spanish, 46% English, 6% Vietnamese, and 2% Cambodian.
   - Average participant household income is $25,871 ± $4,202.

5. **Do participants have any suggestions to improve the program?**
   83 percent of participants provided comments or suggestions to improve the program.
   - 82% offered suggestions of praise such as "great program, everything was great! I would highly recommend this program to everyone I know." Many customers said they would like to see the program continue and expand throughout PG&E. "Continue funding this program. It is wonderful!"
   - 14% said their utility bills went down. "Big reduction in my utility bill." "Since the service my bills have been lower than they have been in years."
   - 10% said the program would benefit from better advertising. Four customers found out about the program by word of mouth. Three customers suggested official handouts or fliers from PG&E that told the customer about the program, funding source, and free services.
   - 4% of customers suggested training technicians to be careful when installing blown-in insulation to make sure insulation does not enter the home through the access door.
   - 10% suggested offering more measures such as wall insulation, ceiling fans, and high performance windows.
   - 6% said the CFLs were either not bright enough or too bright and 6% replaced low-flow showerheads with old units because low-flow showerheads didn't provide enough flow.

[35] The CPUC definition of residential 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), income (less than 400% of federal poverty guidelines), housing type (i.e., mobile home or multi-family), geographic (i.e., outside San Francisco Bay Area, Sacramento, Los Angeles Basin or San Diego), or home ownership (i.e., renter split incentives barrier).

- One customer said the Energy Star thermostat was confusing and hard to read and one customer said they had proper clearance for water heater blanket, but it wasn't installed.

6. **Did participants share information with friends or neighbors about the benefits of measures offered by the program (i.e., multiplier effects)?**
   Based on process survey responses, 76 percent of interviewed customers shared program information with 4.1 times as many people (53 participants shared information with 215 people). Approximately 33 percent of these people (i.e., 72) decided to install similar measures or participate in the MICAP. The program helped expand impacts beyond the participant group to a larger group through direct installation of MICAP measures. The multiplier effect for the program is estimated at 34 percent.[36] 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.
   - 83 percent of participants said they and would like to see the program continue to serve moderate income residential customers and expand to other communities in California.
   - 97 percent of non-participants would have participated if they knew the program installed no-cost energy efficiency improvements at homes like theirs.
   - 3 percent of non-participants would not have participated in the program.

2. **Why have customers chosen not to participate (i.e., market barriers)?**
   - 100% of non-participants would have participated if they met the MICAP income eligibility requirement (i.e., regulatory market barrier). 83% (i.e., 56 out of 68) had incomes below the guidelines and 17% had incomes above the guidelines.
   - 7% didn't participate due to not knowing about the program (i.e., information costs).
   - 6% were renters and did not own the building (i.e., misplaced or split incentive).

   Most non-participants didn't participate simply because they did not meet the income guidelines. 100% of the customers surveyed said they would have participated if the program income eligibility requirements allowed them to. Other cited barriers to participation include information costs and misplaced or split incentives. 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).

[36] Spillover of 88 percent is calculated based on 215 people adopting at least one spillover measure based on information shared by a group of 53 participants who adopted twelve measures (i.e., 215 × (1÷ 12) ÷ 53 = 0.34).

3. **Do non-participants have any suggestions to improve participation?**
   All non-participants provided suggestions to improve participation.
   - 84% of non-participants requested modifying the income requirements. 13% requested lowering the income eligibility guidelines, 9% requested raising the income guidelines, and 79% requested changing or eliminating the income guidelines. Typical responses include:
     - "Give services to poor families, especially poor families with small children. They need it the most."
     - "Get rid of the silly income guidelines."
     - "Target unemployed families first."

4. **What are the non-participant hard-to-reach demographics?**
   Non-participants had the following hard-to-reach demographics.
   - 88% of non-participants are owners and 12% are renters.
   - 100 % of participants were outside major metropolitan areas (i.e., San Francisco, Sacramento).
   - Average number of occupants per home is 3.9 ± 0.4.
   - 88% owned the home and 12% are renters.
   - 100 % spoke English well enough to understand and answer the questions.
   - Non-participants had the following primary languages: 62% English, 32% Spanish, 2% Vietnamese, 2% Vietnamese, and 2% Cambodian.
   - Average income of non-participants is $29,721 ± $5,053.

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. Increase attic insulation to R-38 to increase energy and peak demand savings.

2. Install radiant barriers to reduce peak air conditioning demand and reduce attic temperatures which can reach 140°F on hot days. The program installed attic ventilation of 1 ft^2 net free venting per 600 ft^2 of attic insulation using mushroom, eyebrow, or eave vents to reduce cooling loads. To further reduce cooling loads, the attic venting should be increased to 1 ft^2 net free venting per 300 ft^2 or install solar-powered attic fans.

3. Use a third party verification service provider to ensure that all measures are properly installed to increase savings, cost effectiveness, and reduce lost opportunities.

4. Educate customers about comparable CFL replacements in terms of lumens. Offer more types of CFLs (i.e., color temperature, reflector, and dimmable, long-life cold-cathode) to increase savings and acceptance.

5. Install pressure-compensating low-flow showerheads and aerators to increase customer satisfaction and maintain consistent flow rates from 30 to 80 psig flowing pressure for showerheads and 30 to 60 psig flowing pressure for aerators.
6. Capture pre-retrofit thermostat schedules in the database, provide simple instructions in various languages for Energy Star® thermostats, and consider placing a toll-free number on the thermostats for participants to call if they have any questions.
7. Install occupancy sensors for lighting and plug loads and enable Energy Star® saving mode on LCD high-definition television (HDTV) sets.
8. MICAP captured lighting hours of operation and this data was used to install CFLs in fixtures with the highest potential usage and savings. This data should be linked to CFL savings reported in the database. Capturing more information in the tracking database will improve energy and peak demand savings estimates.
9. Install more blocking around attic access panel to allow blocking to be a few inches above insulation depth to prevent insulation from falling into homes when access panel is opened.
10. Participants provided the following suggestions to improve the program.
    - Continue and expand the program throughout PG&E and offer more measures such as wall insulation, ceiling fans, whole house fans and high performance windows.
    - Provide better advertising to increase participation including handouts or fliers from PG&E that tell customers about the program, funding source, and free services.
    - Train technicians to be careful when installing blown-in insulation.

3.2.3.2 Recommendations for Training

MICAP technicians were professional, courteous, well trained, and equipped to implement the program. Train technicians to educate customers about comparable CFL replacements in terms of lumens. Customers suggested training technicians to be careful when installing blown-in insulation to make sure insulation does not enter the home through the access door. Train technicians to install low-flow showerheads that provide satisfactory flow rates to customers. Training technicians on proper installation procedures and materials especially for attic insulation will reduce complaints associated with attic insulation accidentally blowing into conditioned space. Consider providing simple instructions in various languages for Energy Star® thermostats and consider placing a toll-free number on the thermostats for participants to call if they have any questions. When the MICAP retrofits are completed the homes will have less air conditioning loads. Train technicians to inform customers about installing smaller air conditioners to reduce peak demand.

3.2.3.3 Recommendations for Database

The MICAP 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 HVAC diagnostic tune-up measurements as well as operational hours for lighting fixtures based on customer interviews. MICAP captured lighting hours of operation and this data was used to install CFLs in fixtures with the highest potential usage and savings. This data should be linked to CFL savings reported in the database. Capturing more information in the tracking database will improve energy and peak demand savings estimates. Also capture pre-retrofit thermostat schedules for customers who receive Energy Star® 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 Recommendations for Income Eligibility Guidelines

Revise the income guidelines to not only serve more hard-to-reach customers, but also to be more consistent with other PGC-funded programs serving similar hard-to-reach customers. The MICAP implementation plan eligibility "income range starts at the LIEE cap, generally 175% of the Federal Poverty guidelines or 200% for seniors, and ranges, on a sliding scale determined by number of household members, up to 400% of Federal Poverty Guidelines."[37] The 2004 Federal Poverty Guidelines are provided in **Table 3.18**.

Table 3.18 2004 Federal Poverty Guidelines

Size of Family Unit	48 Contiguous States and D.C.	Alaska	Hawaii
1	$9,310	$11,630	$10,700
2	$12,490	$15,610	$14,360
3	$15,670	$19,590	$18,020
4	$18,850	$23,570	$21,680
5	$22,030	$27,550	$25,340
6	$25,210	$31,530	$29,000
7	$28,390	$35,510	$32,660
8	$31,570	$39,490	$36,320
For each additional person add	$3,180	$3,980	$3,660

SOURCE: Federal Register, Vol. 69, No. 30, February 13, 2004, pp. 7336 7338.http://aspe.hhs.gov/poverty/04poverty.shtml

The MICAP income eligibility guidelines are shown in **Table 3.19**.

Table 3.19 MICAP Eligibility Lower and Upper Limits Guidelines

Size of Family Unit	MICAP Minimum Income Guidelines	MICAP Minimum Income Guidelines for Seniors and Disabled	MICAP Maximum Income Allowed
1	$23,400	$26,800	$53,600
2	$23,400	$26,800	$53,600
3	$27,500	$31,500	$63,000
4	$33,100	$37,900	$75,800
5	$38,700	$44,300	$88,600
6	$44,300	$50,700	$101,400
For each additional person, add	$5,600	$6,400	$12,800

The CPUC definition of "moderate-income" is "…all levels less than 400% of Federal Poverty Guidelines." MICAP is currently turning away 3 hard-to-reach households (all below 200%) for every enrollment. The problem is low-income families rejected by MICAP might not receive any service for years and possibly decades. According to BO Enterprises, referrals to LIEE aren't effective since the referrals exceed weekly maximum by 300 percent. Should equity protect hard-to-reach customers who have contributed to public goods surcharge funds from exclusion from MICAP because they are too poor? This shouldn't represent a conflict between LIEE and

[37] See page 14 of the Moderate Income Comprehensive Attic Program implementation plan.

MICAP since all the LIEE providers are MICAP subcontractors for their respective county territories. Since up to 18% unemployment exists in the area and the typical LIEE allocation is 300 low-income units per year, low-income eligible households will never become scarce. Other non-LIEE Energy Efficiency programs by utilities and third parties serve low-income households. If MICAP can provide services to both LIEE and non-LIEE customers, then fewer hard-to-reach customers will be turned away and the program will be more successful in reaching a larger cross section of PG&E hard-to-reach customers who desperately require energy efficiency services to save energy and reduce their bills.

3.2.3.4 Recommendations for Attic Insulation

Increase attic insulation to R-38 to improve energy and peak demand savings. Attic temperatures can reach 140°F on hot summer days which will increase cooling loads even in homes with R-30 attic insulation. Install radiant barriers and attic ventilation to reduce attic temperatures on hot summer days and reduce peak air conditioning demand. The program installed attic ventilation of 1 ft^2 net free venting per 600 ft^2 of attic insulation using mushroom, eyebrow, or eave vents to reduce cooling loads. To further reduce cooling loads, the attic venting should be increased to 1 ft^2 of venting per 300 ft^2 or install solar-powered attic fans. Explain the benefits of attic insulation and radiant barriers to customers. Benefits include reducing air conditioning energy use and reducing cooling capacity (i.e., size) of the air conditioner when replaced on burn-out.

3.2.3.5 Recommendations for HVAC Diagnostic Tune-up

Before and after performing HVAC diagnostic tune-up services such as installing clean air filters, cleaning condensing coils, or adjusting refrigerant charge, measure and record the air conditioner temperature split across the evaporator coil prior. At each step in the HVAC diagnostic tune-up procedure, measure and record air temperatures, refrigerant temperatures and pressures, and refrigerant added or removed. Measure and record air conditioner temperature split across the evaporator coil after performing all HVAC diagnostic tune-up services. This information will provide documentation regarding the improvement in air conditioner cooling capacity and efficiency for the customer and the program.

3.2.3.6 Recommendations for Duct Sealing

Provide target leakage reduction values for customers and provide stickers and information about benefits such as reduced energy bills, improved comfort, and better indoor air quality.

3.2.3.7 Recommendations for Energy Star® Thermostats

Some participants didn't understand how to operate or program the Energy Star® thermostats Technicians should properly explain Energy Star® 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. Energy Star® thermostats should include instructions for the technicians to follow when programming the thermostat for both cooling and heating and all old and new settings should be documented in the tracking database. The Energy Star® temperature schedules are stored in ROM so they are maintained even if occupants reprogram the thermostat or it is without power.

3.2.3.8 Recommendations for CFLs and CFL Torchieres

MICAP captured lighting hours of operation and this data was used to install CFLs in fixtures with the highest potential usage and savings. This data should be linked to CFL savings reported in the database. Some customers complained that the CFLs were not bright enough. Check to make sure CFLs provide enough light for customers and improve acceptance and retention. If not, install higher Wattage CFLs. Explain the benefits of operating the dimmable CFL torchieres at lower light levels to save energy.

3.2.3.9 Recommendations for Low-Flow Showerheads

Some customers complained that the installed low-flow showerheads didn't provide enough flow. Check to make sure low-flow showerheads provide enough flow for customers. Provide pressure-compensating low-flow showerheads that deliver greater force at lower flow rates to improve customer satisfaction. Offer customers at least three different types of pressure-compensating low-flow showerheads (including hand-held) to maintain consistent flow rates (no greater than 2.5 gpm) from 30 to 80 psig flowing pressure and improve acceptance and retention.

3.2.3.10 Recommendations for Low-Flow Aerators

Some customers complained that the installed low-flow aerators didn't provide enough flow especially in kitchen sinks. Check to make sure low-flow aerators provide enough flow for customers. Provide pressure-compensating low-flow aerators specifically designed for kitchens and vanities that are satisfactory to customers to maintain consistent flow rates (no greater than 2.2 gpm) from 30 to 60 psig flowing pressure.

3.2.3.11 Recommendations for Water Heater Insulation

One customer said they had proper clearance for water heater blanket, but it wasn't installed. MICAP should evaluate the use of high R-value (i.e., R-14) low-emissivity (low-e) reflective closed-cell foam insulation for water heaters to overcome clearance issues (if compatible with the California Conventional Home Weatherization Installation Standards and ASTM E84, ASTM C534, UL723, NFPA255, UL181A-P, or UL-181B-FX).

3.2.3.12 Recommendations for Pipe Insulation

As noted above, MICAP should evaluate the use of low-emissivity (low-e) reflective closed-cell foam insulation for pipes to overcome clearance issues (if compatible with the California Conventional Home Weatherization Installation Standards and ASTM E84, ASTM C534, UL723, NFPA255, UL181A-P, or UL-181B-FX).

3.2.3.13 Other Cost Effective Measures to Consider

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

1. Increase attic insulation to R-38 to increase energy and peak demand savings.
2. Install radiant barriers to reduce peak air conditioning demand and reduce attic temperatures which can reach 140°F on hot days. The program installed attic ventilation of 1 ft^2 net free venting per 600 ft^2 of attic insulation using mushroom, eyebrow, or eave vents to reduce cooling loads. To further reduce cooling loads, the attic venting should be increased to 1 ft^2 net free venting per 300 ft^2 or install solar-powered attic fans.

3. Offer more types of CFLs including low mercury (<1 mg/lamp), cold-cathode (i.e., instant on and 25,000 hour life), warm-white 2700K and full-spectrum 5100K color temperatures, reflector CFLs (R30, R40, PAR30, PAR38), and fully-dimmable CFLs to increase savings, acceptance and persistence of CFL savings.
4. Offer at least three types of pressure compensating low-flow showerheads (including at least one hand-held) to maintain consistent flow rates from 30 to 80 psig flowing pressure and provide more choices for customers to improve acceptance and retention.
5. Offer at least two types of pressure compensating low-flow aerators (including at least one for kitchen sinks rated at 2.2 gpm at 60 psi) to maintain consistent flow rates from 30 to 60 psig flowing pressure.
6. 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 MICAP database for verification.
7. Evaluate the use of low-emissivity reflective closed-cell foam insulation for water heater tanks and pipes and to overcome clearance issues For pipes insulate on the first 1 to 5 feet of the hot pipe coming out of the storage tank and the first 1 to 5 feet going into the storage tank or the first major bend as per California Energy Commission standards.
8. Install occupancy sensors for lighting and plug loads and enable Energy Star® saving mode on LCD high-definition television (HDTV) sets. Most HDTVs are shipped with the Energy Star® saving mode disabled. Savings are 40W to 170W or 88 to 370 kWh per year per HDTV. Energy Star® saving mode also extends HDTV lamp life.
9. Participating customers suggested offering more measures such as wall insulation, ceiling fans, whole house fans and high performance windows.
10. Combing condenser coil fins where appropriate will improve airflow across the condenser.
11. 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. 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 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.

Appendix A: Process Survey Instrument
BO Enterprises #1082-04 MICAP

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 MICAP 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.
2. **Non-participants** must be an owner or renter of a home in the local utility service area who was unaware of the program, ineligible, or decided not to allow program measures to be installed at their home (see non-participant survey at end).

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 the MICAP customer file information (for participants).
2. Make sure you understand what the MICAP 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 BO Enterprises Moderate Income Comprehensive Attic Program #1082-04. The program provided free energy efficiency services for your home. Funding for the program came from ratepayers under the auspices of the California Public Utilities Commission. Would you mind spending 15 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 BO Enterprises Moderate Income Comprehensive Attic Program #1082-04. The program provided free energy efficiency services for your home. Funding for the program came from ratepayers under the auspices of the California Public Utilities Commission. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program installed free energy efficiency measures in homes such as attic insulation, duct sealing, air conditioner tune-ups, Energy Star® thermostats, compact fluorescent lamps, water saving showerheads and aerators, water heater blankets and pipe wrap. Would you mind spending 5 minutes to answer a few questions?

MICAP PARTICIPANT SURVEY #______

Customer ______________________________ **Site** ___________________________________ **Unit** ______

Address _______________________________ **City**_____________________________________ **ZIP** ______

Technicians ____________________________ **Installation Date** ___________**Surveyor Initials** _______

Phone Number________________________ **PG&E Account Number**____________________________

Participant Survey

1. Do you remember a BO Enterprises crew installing free energy efficiency measures in your home?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer
2. How would you rate the program marketing information on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
3. How would you rate the attitude of 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
4. How would you rate the quality of work performed on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
5. How would you rate the responsiveness of the program to your questions and concerns on a scale from 1 to 10?
   ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
6. Was the work scheduled and completed within a reasonable timeframe?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer
7. How long was the technician in your home?
   ___ 1 hr ___2 hrs ___3 hrs ___4 hrs ___>4 hrs **98** Don't Know **99** Refused to Answer
8. Did the crew walk you through your home and provide energy saving tips?
   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

   Please tell me one of the tips they provided? ____
9. How would you rate the usefulness of energy educational services 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 presentation of energy educational services on a scale from 1 to 10?
    ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
11. How would you rate the accuracy of energy educational services on a scale from 1 to 10?
    ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
12. How would you rate the bill savings you are receiving on a scale from 1 to 10?
    ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
13. How would you rate the program in terms of increasing your understanding of the link between energy efficiency, bill savings, and comfort?
    ___ Response (**1 is low and 10 is high**) **98** Don't Know **99** Refused to Answer
14. 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? ____
15. Were any measures not installed (i.e., showerheads, aerators, CFLs, etc.)?
    ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

    Please list measures not installed? ____
16. 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

How would you rate your satisfaction with the measures installed at your home on a scale of 1 to 10?

Question	Measure Installed	Satisfaction Rating
18	Attic Insulation	Low **1 2 3 4 5 6 7 8 9 10** High
19	Duct Test & Seal	Low **1 2 3 4 5 6 7 8 9 10** High
20	AC Diagnostic Tune-up	Low **1 2 3 4 5 6 7 8 9 10** High
21	Energy Star Programmable Thermostat	Low **1 2 3 4 5 6 7 8 9 10** High
22	Water Saving Showerhead	Low **1 2 3 4 5 6 7 8 9 10** High
23	Water Saving Faucet Aerators	Low **1 2 3 4 5 6 7 8 9 10** High
24	WH Blankets	Low **1 2 3 4 5 6 7 8 9 10** High
25	Pipe Insulation	Low **1 2 3 4 5 6 7 8 9 10** High
26	Energy Star CFL Screw-in (15 W)	Low **1 2 3 4 5 6 7 8 9 10** High
27	Energy Star CFL Screw-in (20 W)	Low **1 2 3 4 5 6 7 8 9 10** High
28	Energy Star CFL Screw-in (24 W)	Low **1 2 3 4 5 6 7 8 9 10** High
29	Energy Star CFL Torchiere (55 W)	Low **1 2 3 4 5 6 7 8 9 10** High

30. Have you shared information with any of your friends or neighbors about the benefits of duct sealing, AC diagnostic tune-up, thermostats, CFLs, water saving showerheads, or other measures offered in the program?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

With how many people have you shared this information in the last 12 months? __________________________

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

31. Do you know any other neighbors or friends who would benefit from this program (name/address)?___________

____

LIGHTING

All Incandescent ❐ Some Fluorescent or CFLs ❐ 50-50 Incand./Fluorescent ❐ Most Fluorescent ❐
Kitchen Lighting: Incand. Fluorescent **Outside Lighting:** Incand. Fluorescent **Incand. Torchieres?** Y N

32. Please complete the following form for the compact fluorescent lamps installed by BO Enterprises.

CFL Location (from BO form)	Type	Qty	Hrs/d	12-6PM	Old Lamp	CFL	ASC	EM&V	Cust
1.			hrs		W	W			
2.			hrs		W	W			
3.			hrs		W	W			
4.			hrs		W	W			
5.			hrs		W	W			
6.			hrs		W	W			
7.			hrs		W	W			
8.			hrs		W	W			
9.			hrs		W	W			
10.			hrs		W	W			

Type: 1 = Inside CFL; 2 = Outside CFL; 3 = Hardwired Inside; 4 = Common CFL; 5 = Hardwired Common

DEMOGRAPHIC INFORMATION AND COMMENTS

33. Please provide the following demographic information?
____Age Owner Renter ___# Occupants ________Language _______Annual Household Income **99** Refused

34. 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). ____

____

35. Please sign the attached PG&E billing information release form.
___ **1** (Yes) ___ **2** (No)

THERMOSTAT AND HVAC SYSTEM

Energy Star® Programmable T-stat Make: _____________ Model #:___________(T-stat Reading:_____°F, EM&V Check:_____°F)

	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
Old Cool																								
Energy Star Cool	82	82	82	82	82	82	78	78	85	85	85	85	85	85	85	85	85	85	78	78	78	78	82	82
Old Heat																								
Energy Star Heat	62	62	62	62	62	62	70	70	62	62	62	62	62	62	62	62	62	62	70	70	70	70	62	62

Attic Insulation

	R-Value
Pre-Retrofit	
Post-Retrofit	

HVAC System	Done 3 yrs?	Manufacturer	Model Number	Age	Capacity	Refrigerant	Multiplier	Est. Airflow	Meas. Airflow	Meas. EER
AC or Heat Pump	Yes/no				tons	oz.	x 340 =	cfm	cfm	
Furnace (Gas or Elec)					kBtuh		x 18.5 =	cfm	cfm	

Proper Airflow (All Systems)	1. Return Wet-Bulb Temp.	2. Return Dry-Bulb Temp.	3. Supply Dry-Bulb Temp	4. Req'd Supply Dry-Bulb (Calculator)	5. Temp. Diff. = #3 - #4 (within -3 to +3F)
Pre-Measurement					
Post-Measurement					

Airflow Adjustment (check)			
New Air Filter		0 New Return Duct	
Open Registers		Fix Broken Duct	
Increase Fan Speed		Clear Obstructions	

Superheat Method (non-TXV Systems)	1. Return Wet-Bulb Temp.	2. Outdoor Air Temp.	3. Req'd Superheat (Calculator)	4. Measured Vapor Pressure	5. Measured Vapor Temp.	6. Evap. Sat. Temp	7. Actual Superheat = #5 - #6	8. SH-Diff. = #7 - #3 (within -5 to +5F)	Refrigerant +/- (ounces)
Pre-Measurement				psi					oz
Post-Measurement				psi					oz

Subcooling Method (TXV Systems)	1. Required Subcooling (Manufacturer Data)	2. Measured Liquid Line Pressure	3. Condenser Saturation Temp	4. Measured Liquid Line Temp.	5. Actual Subcooling = #3 - #4	6. SC-Diff. = #5 - #1 (within -3 to +3F)	Refrigerant +/- (ounces)
Pre-Measurement		psi					oz
Post-Measurement		psi					oz

Distribution: Floor Supply Ceiling Supply Floor Return Wall Return Single-Return Closet Return

DUCT SYSTEM

***Measure reference pressure at supply register closest to supply plenum. Indicate supply register room.**

Duct Sealing Method (check)	Register Sealing Method (Check)	Initial Leakage	Final Leakage	Total Leakage Reduction (Initial – Final)
Mastic:	Face Sealed:	cfm Pa	cfm Pa	cfm @ 25 Pa
Mesh Tape:	Lap Sealed:	cfm @ 25 Pa	cfm @ 25 Pa	cfm/ton @ 25 Pa
UL-Tape:	Joint Sealed:	% of total @25 Pa	% of total @25 Pa	cfm/ton @ 25 Pa
Aerosol Sealant:	Other:	Flow Ring (circle): 1 2 3	Flow Ring (circle): 1 2 3	*Supply Register Room:

WATER HEATER

Fuel Type: Natural Gas Electric **Storage Volume (gallons):** 30 40 50 Other: __________
Energy Factor (EF): _________ **Insulating Blanket?** Y N **Pipe Insulation?** Inlet – Y N Outlet – Y N
Manufacturer:___________ **Model #**_________ **Condition:** Satisfactory Undependable Failed **Age:** _______

Water Heater Blanket, Pipe Insulation, Showerhead, Aerator

Measure	Qty.	Old	New
Showerhead		gpm	gpm
Faucet Aerator		gpm	gpm
Water Heater Blanket		R-value	-value
Pipe Insulation		ft	ft

SHELL / INSULATION

Front Faces: N NE E SE S SW W NW N **Shading** (Carport, Trees): Front Back Left Right
Ceiling R-value (R 3.5/in.)**:** ____ **Wall R-Value:** ____ **Floor R-Value:** ____ **Roof Reflectivity** (Cool Roof?)**:** _____

POOL / SPA

Heater Type: Natural Gas Electric **Cover?** Pool – Y N **Spa** – Y N **Heating Timer?** Y N

WINDOWS

Window Area to Floor Area: Average (15%) ❒ **Below Ave.** (10%) ❒ **Above Ave.** (20%) ❒ **Expansive** (>20%) ❒
Window Type: Single-Pane Dual-Pane Low-E Aluminum Wood Vinyl **Shading:** Awnings Interior-Shades

APPLIANCES

Refrigerator Mfr: ______________ **Model:** ____________________ **Volume (cu.ft.):** ______ **Age:** ________
Dishwasher Mfr: _______________ **Model:** ____________________ **Age:** _______
Range/Oven: Natural Gas Electric **Mfr:**______________________ **Model:** ________________ **Age:** ________
Cooktop (if separate): Natural Gas Electric **Mfr:** ________________ **Model:** _________________ **Age:** _______
Clothes Washer Mfr: ________________ **Model:** _________________ **Age:** _______
Clothes Dryer: Natural Gas Electric **Mfr:** ____________________ **Model:** __________________ **Age:** ________

I certify under penalty of perjury that the information contained in this report is complete and accurate to the best of my knowledge.

EM&V Inspector Name (Print)____

EM&V Inspector Signature_____________________________ **Date**______________

Agreed & Accepted by Customer Name (Print)________________________________

Customer Signature__________________________________ **Date**________________

MICAP NON-PARTICIPANT PROCESS SURVEY #___

Customer_______________________________ **Site** ____________________________________ **Unit** ______

Address_________________________________ **City** _______________________________________**ZIP** ______

Technicians______________________________ **Installation Date**__ _________**Surveyor Initials** ______

Phone Number________________________ **PG&E Account Number**____________________________

Non-Participant Survey

I am conducting a survey regarding the BO Enterprises Moderate Income Comprehensive Attic Program #1082-04. The program installed free energy efficiency measures in homes such as attic insulation, duct sealing, air conditioner tune-ups, Energy Star® thermostats, compact fluorescent lamps, water saving showerheads and aerators, water heater blankets and pipe wrap. Funding for the program came from ratepayers under the auspices of the California Public Utilities Commission. You didn't participate in the program, but your feedback will help us evaluate and improve the program. Would you mind spending 5 minutes to answer a few questions?

1. What reasons are there for not participating and how might conditions be revised to motivate participation? (Read list – Multiple answers are okay.)

1 Didn't qualify due to MICAP income requirements. ____Household Size ___ Age $_____Household Income

Size of Family Unit	Minimum Income Guidelines	Minimum Guidelines for Seniors and Disabled	Maximum Income Allowed
1-2	$23,400	$26,800	$53,600
3	$27,500	$31,500	$63,000
4	$33,100	$37,900	$75,800
5	$38,700	$44,300	$88,600
6	$44,300	$50,700	$101,400
Each Additional Person	$5,600	$6,400	$12,800

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

3 Lack of time or unable to be home for crew to perform work (i.e., hassle cost).
Would you have participated if someone else you know (i.e., a neighbor or friend) could have been present at your home while the American Synergy crew did their work?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

4 Would you have participated if the program provided services at other times?
___ Evenings ___ Saturdays ___Sundays **98** Don't Know **99** Refused to Answer

5 Other ____

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

2. Why have you decided not to install similar measures such as attic insulation, duct sealing, air conditioner tune-ups, Energy Star® thermostats, CFLs, water saving showerheads and aerators, water heater blankets and pipe wrap?

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

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

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

3. Would you have participated if the program income eligibility requirements allowed you to participate?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

4. Would you have participated if you knew the program installed free energy efficiency measures in your home?
___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

5. Please provide the following demographic information?
____Age Owner Renter ___# Occupants ________Language _______Annual Household Income **99** Refused to Answer

6. 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). ____