Comprehensive Hard-to-Reach Mobile Home Energy Savings Program Evaluation, Measurement and Verification Report

Final Report

CPUC Contract #1275-1276

Prepared For

American Synergy Corporation, &
Cal-UCONS

Prepared By

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With Assistance From

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1. Executive Summary

The primary goals of a program evaluation are (1) to provide an independent assessment of the program's effects and (2) to offer recommendations for improving the program design and implementation practices for a more cost-effective delivery of the targeted load impact reductions. For the 2004-05 Comprehensive Hard-to-Reach Mobile Home Energy Savings Program designed and implemented by American Synergy Corporation (ASC) and Cal-UCONS, Alternative Energy Systems Consulting (AESC) was selected as the program evaluator. The evaluation followed the guidelines laid out in the Energy Efficiency Policy Manual Version 2. Herein presented are a summary of the CPUC approved evaluation plan (Section 2), results of the billing simulation (Section 3.1), measure-level savings analysis (Section 3.2), process evaluation findings (Section 4), and final conclusions and recommendations (Section 5).

For hard-to-reach residential customers living in mobile homes, the ASC and Cal-UCONS program provided education and no-cost installation of the following measures:

- Duct Test and Seal,
- AC Diagnostic and Tune-up,
- Programmable Thermostat,
- Faucet Aerator,
- Water Saving Showerhead,
- Compact Fluorescent Lamp,
- Blower Door Test & Seal, and
- Electric Water Heater Timer.

The program targeted mobile home customers in the Southern California Edison (SCE) and Southern California Gas Company (SCG) service areas. Unlike in 2002-03, the program was not offered in PG&E territory and some measures were dropped from the program, specifically hot water pipe and tank insulation.

The ex ante program goals were to serve 4,000 mobile home customers and directly install 34,807 measures for SCE and 18,125 measures for SCG. Additional funding was later provided by SCG to serve 1,000 additional customers. In the end, the program served 6,499 mobile home customers: 39,529 measures were installed for SCE and 19,391 measures were installed for SCG. Based on ex ante savings assumptions, the program exceeded its energy reduction goals for both utilities. However, adjusting for the results of the verification inspections and assuming ex post unit savings based on the most recent literature, the program ex post accomplishments for both electricity and natural gas were significantly lower than expected, due primarily to lower savings for Programmable Thermostats and Compact Fluorescent Lamps (CFLs). The following tables present gross and net savings for four different scenarios: (1) ex ante projected savings, (2) ex ante recorded savings, (3) ex post savings based on installation verification only, and (4) ex post savings based on installation verification and revised deemed savings from the most recent literature.

Table E.1 summarizes projected first year ex ante load impact goals. The net ex ante first year estimates are 2,728.7 kW, 6,982,743 kWh/yr, and 481,401 Therms/yr.

Table E.1: First Year Ex Ante Load Impacts Projected

Description	SCE Qty.	SCG Qty.	Gross Ex Ante (kW)	Gross Ex Ante (kWh/yr)	Gross Ex Ante (Therms/yr)	NTGR	Net Ex Ante (kW)	Net Ex Ante (kWh/yr)	Net Ex Ante (Therms/yr)
Duct Test and Seal	3,250	4,100	682.5	783,250	196,800	0.89	607.4	697,093	175,152
AC Diagnostic and Tune-up	3,250	0	1,007.5	568,750	0	0.89	896.7	506,188	0
Programmable Thermostat	3,000	3,500	450.0	768,000	231,000	0.89	400.5	683,520	205,590
Facuet Aerator	0	5,500	0.0	0	27,500	0.89	0.0	0	24,475
Showerhead	0	5,000	0.0	0	85,000	0.89	0.0	0	75,650
Energy Star CFL's - Exterior	3,932	0	78.6	1,289,696	0	0.89	70.0	1,147,829	0
Energy Star CFL's - Interior	9,000	0	180.0	891,000	0	0.89	160.2	792,990	0
Energy Star Hardwire CFL's - Exterior	2,457	0	49.1	805,896	0	0.89	43.7	717,247	0
Energy Star Hardwire CFL's - Interior	3,000	0	60.0	297,000	0	0.89	53.4	264,330	0
Common Area Energy Star CFL's - Ex.	1,966	0	157.3	695,964	0	0.89	140.0	619,408	0
Common Area Energy Star CFL's - Int.	1,229	0	98.3	435,926	0	0.89	87.5	387,974	0
Common Area ES Hardwire CFL's - Ext.	2,457	0	196.6	869,778	0	0.89	174.9	774,102	0
Common Area ES Hardwire CFL's - Int.	1,229	0	98.3	435,926	0	0.89	87.5	387,974	0
Blower Door Test and Seal	25	25	2.5	3,500	600	0.89	2.2	3,115	534
Electric Water Heater Timers	12	0	5.2	1,092	0	0.89	4.6	972	0
Total	34,807	18,125	3,065.9	7,845,779	540,900		2,728.7	6,982,743	481,401

Table E.2 summarizes the recorded accomplishments based on ex ante deemed savings. The first year recorded net ex ante savings are 3,037.7 kW, 7,244,790 kWh/yr, and 499,588 Therms/yr.

Table E.2: First Year Ex Ante Load Impacts Recorded

Description	SCE Qty.	SCG Qty.	Gross Ex Ante (kW)	Gross Ex Ante (kWh/yr)	Gross Ex Ante (Therms/yr)	NTGR	Net Ex Ante (kW)	Net Ex Ante (kWh/yr)	Net Ex Ante (Therms/yr)
Duct Test and Seal	4,531	4,539	951.5	1,091,971	217,872	0.89	846.8	971,854	193,906
AC Diagnostic and Tune-up	3,305	0	1,024.6	578,375	0	0.89	911.8	514,754	0
Programmable Thermostat	3,338	3,301	500.7	854,528	217,866	0.89	445.6	760,530	193,901
Facuet Aerator	0	5,901	0.0	0	29,505	0.89	0.0	0	26,259
Showerhead	0	5,644	0.0	0	95,948	0.89	0.0	0	85,394
Energy Star CFL's - Exterior	2,581	0	51.6	846,568	0	0.89	45.9	753,446	0
Energy Star CFL's - Interior	12,622	0	252.4	1,249,578	0	0.89	224.7	1,112,124	0
Energy Star Hardwire CFL's - Exterior	2,843	0	56.9	932,504	0	0.89	50.6	829,929	0
Energy Star Hardwire CFL's - Interior	4,168	0	83.4	412,632	0	0.89	74.2	367,242	0
Common Area Energy Star CFL's - Ex.	2,618	0	209.4	926,772	0	0.89	186.4	824,827	0
Common Area Energy Star CFL's - Int.	2,525	0	202.0	895,618	0	0.89	179.8	797,100	0
Common Area ES Hardwire CFL's - Ext.	724	0	57.9	256,296	0	0.89	51.5	228,103	0
Common Area ES Hardwire CFL's - Int.	266	0	21.3	94,350	0	0.89	18.9	83,972	0
Blower Door Test and Seal	6	6	0.6	840	144	0.89	0.5	748	128
Electric Water Heater Timers	2	0	0.9	182	0	0.89	0.8	162	0
Total	39,529	19,391	3,413.1	8,140,214	561,335		3,037.7	7,244,790	499,588

Table E.3 summarizes first year ex post load impacts using contracted (i.e., ex ante) engineering estimates with installation verification only. The net ex post first year load impacts are 2,697.2 kW, 6,268,637 kWh/yr, and 439,916 Therms/yr. The subsequent first year net realization rates are 0.89 for kW, 0.87 for kWh, and 0.88 for Therms.

Table E.3: First Year Ex Post Load Impacts
(w/ contracted (i.e., ex ante) deemed savings and installation verification only)

Description	SCE Qty.	SCG Qty.	Gross Ex Ante (kW)	Gross Ex Ante (kWh/yr)	Gross Ex Ante (Therms/yr)	NTGR	Net Ex Ante (kW)	Net Ex Ante (kWh/yr)	Net Ex Ante (Therms/yr)
Duct Test and Seal	4,531	4,539	861.7	988,955	197,318	0.89	767.0	880,170	175,613
AC Diagnostic and Tune-up	3,305	0	912.8	515,280	0	0.89	812.4	458,599	0
Programmable Thermostat	3,338	3,301	440.3	751,395	191,572	0.89	391.8	668,742	170,499
Facuet Aerator	0	5,901	0.0	0	25,035	0.89	0.0	0	22,281
Showerhead	0	5,644	0.0	0	80,219	0.89	0.0	0	71,395
Energy Star CFL's - Exterior	2,581	0	37.9	621,968	0	0.89	33.8	553,552	0
Energy Star CFL's - Interior	12,622	0	179.1	886,400	0	0.89	159.4	788,896	0
Energy Star Hardwire CFL's - Exterior	2,843	0	49.4	810,873	0	0.89	44.0	721,677	0
Energy Star Hardwire CFL's - Interior	4,168	0	78.2	387,161	0	0.89	69.6	344,573	0
Common Area Energy Star CFL's - Ex.	2,618	0	188.5	834,095	0	0.89	167.8	742,344	0
Common Area Energy Star CFL's - Int.	2,525	0	202.0	895,618	0	0.89	179.8	797,100	0
Common Area ES Hardwire CFL's - Ext.	724	0	57.9	256,296	0	0.89	51.5	228,103	0
Common Area ES Hardwire CFL's - Int.	266	0	21.3	94,350	0	0.89	18.9	83,972	0
Blower Door Test and Seal	6	6	0.6	840	144	0.89	0.5	748	128
Electric Water Heater Timers	2	0	0.9	182	0	0.89	0.8	162	0
Total	39,529	19,391	3,030.6	7,043,413	494,287		2,697.2	6,268,637	439,916

Table E.4 summarizes the ex ante recorded and ex post verified, on-site installation verification only, net lifecycle load impacts. The recorded net ex ante lifecycle savings are 75,060,571 kWh and 7,904,446 Therms. Based on the ex ante deemed savings and on-site inspection results, the verified net ex post lifecycle savings are 66,084,073 kWh and 7,007,781 Therms. The lifecycle ex post net lifecycle kWh realization rate is 0.88 and the net lifecycle Therm realization rate is 0.89. The SCE ex post cost-effectiveness is 2.10 for the total resource cost (TRC) test and 12.26 for the participant test. The SCG ex post cost effectiveness was 2.28 for the TRC test and 13.28 for the participant test.

Table E.4: Ex Ante and Ex Post Lifecycle Load Impacts
(w/ ex ante deemed savings and installation verification only)

Description	SCE			SCG		
	Proposed Ex Ante Goals	Recorded Ex Ante Goals	Verified Ex Post Goals	Proposed Ex Ante Goals	Recorded Ex Ante Goals	Verified Ex Post Goals
Mobile Home Customers Served	4,000	6,511	6,511	4,000	6,511	6,511
Measures Installed	34,807	39,529	39,529	18,125	19,391	19,391
Energy Education	4,000	4,776	4,776	4,000	4,776	4,776
Demand Savings (kW)	2,729	3,038	2,697	0	0.0	0
Annual Electricity Savings (kWh/yr)	6,982,739	7,244,785	6,268,637	0	0.0	0
Annual Therm Savings (therms/yr)	0	0.0	0	481,401	499,588	439,916
Lifecycle Electricity Savings (kWh)	75,612,386	75,060,571	66,084,073	0	0.0	0
Lifecycle Gas Savings (therms)	0	0.0	0	7,593,480	7,904,446	7,007,781
TRC Test Costs	$1,483,247	$1,474,207	$1,474,207	$949,384	$938,052	$938,052
TRC Test Benefits	$3,534,622	$3,526,169	$3,091,223	$2,323,626	$2,414,678	$2,136,512
TRC Test Net Benefits	$2,051,376	$2,051,963	$1,617,017	$1,374,242	$1,476,626	$1,198,460
Total Resource Cost (TRC) Test	2.38	2.39	2.10	2.45	2.57	2.28
Participant Test Costs	$677,601	$730,284	$730,284	$434,655	$482,914	$482,914
Participant Test Benefits	$10,036,848	$10,017,864	$8,953,060	$6,917,297	$7,157,251	$6,412,938
Participant Test Net Benefits	$9,359,248	$9,287,580	$8,222,776	$6,482,642	$6,674,337	$5,930,023
Participant Test	14.81	13.72	12.26	15.91	14.82	13.28

The on-site inspection results confirmed that the program was providing energy efficiency services to the participants targeted in the program's implementation plan. However, the billing simulation results were not showing the expected savings. It was clear that the difference between the billing simulation results and the ex ante engineering estimates could not be explained by the on-site installation inspections alone. The next question considered was, "Were the measure-level deemed savings estimates too high?" To answer that question, the measure-level engineering calculations and assumptions were evaluated.

Based on the analysis and literature review, it was determined that erroneous assumptions related to the Programmable Thermostat and CFL installations were the likely cause of the discrepancy between the expected and verified energy savings. In 2004, the methodology for calculating Programmable Thermostats changed. The latest research showed that, when accounting for behavioral changes, in some climate zones energy consumption may actually increase as a result of installing Programmable Thermostats (Reeves & Hirsch, 2004). This impact was not anticipated by ASC, Cal-UCONS, or the CPUC when funding was approved for this program. Also, the assumed CFL demand reduction and hours of operations were higher than findings from the most recent CFL Metering Study (KEMA-XENERGY, 2005). When accounting for these discrepancies the expected savings estimates per mobile home are more consistent with the billing simulation results.

Table E.5 summarizes first year ex post load impacts with the installation verification and revised deemed savings. The net ex post first year load impacts are 2,683.3 kW, 3,236,038 kWh/yr, and 138,422 Therms/yr. The subsequent first year net realization rates are 0.88 for kW, 0.45 for kWh, and 0.28 for Therms.

Table E.5: First Year Ex Post Load Impacts (w/ installation verification and revised deemed savings)

Description	SCE Qty.	SCG Qty.	Gross Ex Ante (kW)	Gross Ex Ante (kWh/yr)	Gross Ex Ante (Therms/yr)	NTGR	Net Ex Ante (kW)	Net Ex Ante (kWh/yr)	Net Ex Ante (Therms/yr)
Duct Test and Seal	4,531	4,539	1,448.6	718,121	90,437	0.89	1,289.2	639,127	80,489
AC Diagnostic and Tune-up	3,305	0	1,370.3	870,120	0	0.89	1,219.6	774,406	0
Programmable Thermostat	3,338	3,301	0.0	-387,647	-40,304	0.89	0.0	-345,006	-35,871
Facuet Aerator	0	5,901	0.0	0	25,035	0.89	0.0	0	22,281
Showerhead	0	5,644	0.0	0	80,219	0.89	0.0	0	71,395
Energy Star CFL's - Exterior	2,581	0	0.0	130,882	0	0.89	0.0	116,485	0
Energy Star CFL's - Interior	12,622	0	35.6	415,695	0	0.89	31.7	369,968	0
Energy Star Hardwire CFL's - Exterior	2,843	0	0.0	218,187	0	0.89	0.0	194,186	0
Energy Star Hardwire CFL's - Interior	4,168	0	13.2	154,160	0	0.89	11.7	137,203	0
Common Area Energy Star CFL's - Ex.	2,618	0	0.0	629,530	0	0.89	0.0	560,281	0
Common Area Energy Star CFL's - Int.	2,525	0	133.8	586,154	0	0.89	119.1	521,677	0
Common Area ES Hardwire CFL's - Ext.	724	0	0.0	247,347	0	0.89	0.0	220,139	0
Common Area ES Hardwire CFL's - Int.	266	0	12.0	52,429	0	0.89	10.7	46,661	0
Blower Door Test and Seal	6	6	0.6	840	144	0.89	0.5	748	128
Electric Water Heater Timers	2	0	0.9	182	0	0.89	0.8	162	0
Total	39,529	19,391	3,014.9	3,635,998	155,530		2,683.3	3,236,038	138,422

Table E.6 summarizes the ex ante recorded and ex post verified, with installation verification and revised deemed savings, net lifecycle load impacts. The final verified net ex post lifecycle savings are 31,116,757 kWh and 2,009,759 Therms. The lifecycle ex post net lifecycle kWh realization rate is 0.41 and the net lifecycle Therm realization rate is 0.25. The revised ex post cost-effectiveness calculations assumed no electricity or natural gas savings for the Programmable Thermostat measure. The revised SCE ex post cost-effectiveness is 1.00 for the TRC test and 4.31 for the participant test. The revised SCG ex post cost-effectiveness estimates are 0.71 for the TRC test and 3.01 for the participant test.

Table E.6: Ex Ante and Ex Post Lifecycle Load Impacts (w/ installation verification and revised deemed savings)

Description	SCE			SCG		
	Proposed Ex Ante Goals	Recorded Ex Ante Goals	Verified Ex Post Goals	Proposed Ex Ante Goals	Recorded Ex Ante Goals	Verified Ex Post Goals
Mobile Home Customers Served	4,000	6,511	6,511	4,000	6,511	6,511
Measures Installed	34,807	39,529	39,529	18,125	19,391	19,391
Energy Education	4,000	4,776	4,776	4,000	4,776	4,776
Demand Savings (kW)	2,729	3,038	2,683	0	0	0
Annual Electricity Savings (kWh/yr)	6,982,739	7,244,785	3,236,038	0	0	0
Annual Therm Savings (therms/yr)	0	0	0	481,401	499,588	138,422
Lifecycle Electricity Savings (kWh)	75,612,386	75,060,571	31,116,757	0	0	0
Lifecycle Gas Savings (therms)	0	0	0	7,593,480	7,904,446	2,009,759
TRC Test Costs	$1,483,247	$1,474,207	$1,709,971	$949,384	$938,052	$1,107,243
TRC Test Benefits	$3,534,622	$3,526,169	$1,711,232	$2,323,626	$2,414,678	$790,229
TRC Test Net Benefits	$2,051,376	$2,051,963	$1,261	$1,374,242	$1,476,626	-$317,014
Total Resource Cost (TRC) Test	2.38	2.39	1.00	2.45	2.57	0.71
Participant Test Costs	$677,601	$730,284	$1,303,291	$434,655	$482,914	$938,250
Participant Test Benefits	$10,036,848	$10,017,864	$5,613,971	$6,917,297	$7,157,251	$2,820,822
Participant Test Net Benefits	$9,359,248	$9,287,580	$4,310,680	$6,482,642	$6,674,337	$1,882,572
Participant Test	14.81	13.72	4.31	15.91	14.82	3.01

Also, the evaluation team contacted 300 participants as part of the process survey and asked them questions related to customer satisfaction, habitation, awareness of energy efficiency, and demographics. In all areas, from customer service in the field to overall program appeal, participants gave high marks to the program. Based on the customer responses, it is apparent that the program increased participant awareness of the benefits of the energy efficiency measures offered by the program. In particular, almost half of participants were unaware of the energy benefits of duct testing and sealing, and AC diagnostics and tune-ups. Also, a survey of the managing program staff was conducted. As had been observed in the field, ASC's staff was very enthusiastic about helping customers reduce their energy consumption and costs.

1.1. Key Findings

The evaluator's key findings are the following:

- The activities of the implementer were consistent with the program's implementation plan. Based on field verification only, the first year net realization rates were 0.89 for kW, 0.87 for kWh, and 0.88 for Therms. The observed discrepancies had more to do with retention (i.e., equipment removal, equipment failure, and performance test repeatable) and less to do with implementation.
- Customer satisfaction with the program was high. On a scale of 1 to 10, the program received a 9.4 for courteousness and professionalism of field technicians, and a 9.0 for overall program performance.
- Hard-to-reach residential customers were the primary recipient of the program's energy efficiency services. Specifically, 67.7% of the participants were 60 years of age or older and approximately 45.1% of the customer's were low income.
- An increase in customer awareness of energy efficiency was achieved. The percentage of participants who became aware of an energy conservation measure as a result of the

program is as follows: 21.4% of Programmable Thermostats; 17.9% for Low Flow Faucets: 30.4% for Water Saving Showerheads; 31.9% for Compact Fluorescent Lighting; 40.2% for AC Diagnostic and Tune-up; and 43.5% for Duct Test and Seal.

- Some customers (29%) complained about their Programmable Thermostat, of which a third (9.6%) reported removing it. The most common complaints were they were too difficult to program, they did not work properly, or they simply preferred the old thermostat.
- The ex ante deemed savings for the Programmable Thermostat installations overestimated the program impact. The ex ante saves estimates were 0.150 kW, 256 kWh/yr, and 66 Therms/yr. These estimates were based on DOE-2 building estimates and did not account for changes in behavior. Current research has found that in some climate zones programmable thermostats can actually increase energy consumption (Reeves & Hirsch, 2004).
- Some customers (7.2%) commented that the screw-in CFL installations did not provide adequate lighting. As a result, they were removed or relocated to areas of lower usage.
- The ex ante deemed savings for the CFL installations overestimated the program impact. The ex ante demand savings was 80 Watts per lamp. Depending on the installation type, interior or exterior and mobile home or common area, ex ante energy savings per installation ranged from 72 to 355 kWh/yr. Based on field observations, the demand savings realization rates for mobile home installations ranged from 0.00 to 0.16, and for common area installations they ranged from 0.00 to 0.66. The kilowatt-hour savings realization rates for mobile homes installations ranged from 0.15 to 0.37, and for common area installations they ranged from 0.56 to 0.97. See Section 3.2.6, Tables 3.13 and 3.15.
- The primary challenge to implementation was marketing. Park manager's with whom there was not existing relationship or participant referral were suspicious of direct marketing efforts by the program implementer.
- The billing simulation results showed that the program energy impacts were well below expectations, except for the domestic water heater measures. However, at savings estimates below 5% of the overall energy consumption, the EZ Sim billing simulation models did not have the resolution to distinguish the measure-level energy savings from the statistical noise. Unless there is substantial evidence that overall energy savings impact per customer will exceed 5% of the baseline energy consumption, billing simulation models should not be utilized for residential energy efficiency program evaluations.

1.2. Recommendations

The evaluator's recommendations are the following:

- Do not offer Programmable Thermostats in future programs.
- Use the 2004-05 DEER Update Study (Itron, 2005) to estimate future HVAC ex ante savings.
- Target weather sensitive (i.e., HVAC) measures by climate zone to improve the program performance.
- Use the most recent CFL Metering Study (KEMA, 2005) for future CFL ex ante savings.
- Install CFLs with equal or higher lumen output. One of the most common reasons for removing an installed CFL was the lower light level.

- Make sure all CFLs are installed by ASC technicians and consider installing CFLs in hard to reach, high use fixtures.
- Mark Compact Fluorescent Lamps so that they can easily be distinguished from those installed before or after the program.
- Conduct follow-up phone surveys in the months immediately following the installations to ensure there were no problems with the installed measures.
- Work with local utility representatives to coordinate program marketing efforts. Increasing personal contacts, both face-to-face and over the telephone, between utility staff and customers has been reported as a factor in increasing program participation (Nadel, 1994). General utility customer service personnel should be made aware of third party programs so that customer inquiries can be properly addressed.
- For futures program evaluations, whole building analysis (Option C) with 15-minute sub-metering in both individually metered and master metered parks should be considered. If the evaluation budget is a limiting factor, verification should be based on the most recent and accurate engineering savings estimates and on-site installation verification.

The CPUC's reporting tables are the most important deliverable of the study because they forecast the energy impact of this program from 2004 through 2023. These tables are why the study is funded and are the closing items of the Executive Summary. As previously stated, discrepancies between the projected and confirmed savings are a result of installation verification findings and overly optimistic ex ante deemed savings. Table E.7 presents the program's impact assuming the contracted ex ante deemed savings are accurate. These numbers give an indication of how effectively the program was implemented. Table E.8 presents the program's impact assuming evaluated ex post deemed savings based field observations and literature review. These numbers give the best estimate of the program's actual energy impacts.

Table E.7: Sum Of Energy Impacts for This 2004-2005 Program
(w/ contracted (i.e., ex ante) deemed savings and installation verification only)

Program IDs:	1275-04 and 1276-04							
Program Name:	Mobile Home HTR							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings**	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004	7,846	6,269	3.07	2.70	540,900	439,916
	2	2005	7,846	6,269	3.07	2.70	540,900	439,916
	3	2006	7,846	6,269	3.07	2.70	540,900	439,916
	4	2007	5,424	4,176	2.73	2.32	540,900	439,916
	5	2008	5,424	4,176	2.73	2.32	540,900	439,916
	6	2009	5,424	4,176	2.73	2.32	540,900	439,916
	7	2010	5,424	4,176	2.73	2.32	540,900	439,916
	8	2011	4,533	3,387	2.55	2.16	540,900	439,916
	9	2012	4,533	3,387	2.55	2.16	540,900	439,916
	10	2013	4,533	3,387	2.55	2.16	540,900	439,916
	11	2014	3,960	2,927	1.54	1.34	427,800	346,112
	12	2015	3,960	2,927	1.54	1.34	427,800	346,112
	13	2016	3,960	2,927	1.54	1.34	427,800	346,112
	14	2017	3,960	2,927	1.54	1.34	427,800	346,112
	15	2018	3,960	2,927	1.54	1.34	427,800	346,112
	16	2019	3,192	2,258	1.09	0.95	196,800	175,613
	17	2020	783	880	0.68	0.77	196,800	175,613
	18	2021	783	880	0.68	0.77	196,800	175,613
	19	2022	783	880	0.68	0.77	196,800	175,613
	20	2023	783	880	0.68	0.77	196,800	175,613
	TOTAL	**2004-2023**	84,958	66,084			8,532,000	7,007,781

Table E.8: Sum Of Energy Impacts for This 2004-2005 Program
(w/ installation verification and revised (i.e., ex post) deemed savings)

Program IDs:	1275-04 and 1276-04							
Program Name:	Mobile Home HTR							
	Year	**Calendar Year**	**Gross Program-Projected MWh Savings**	**Net Evaluation Confirmed Program MWh Savings**	**Gross Program-Projected Peak MW Savings**	**Evaluation Projected Peak MW Savings**	**Gross Program-Projected Therm Savings**	**Net Evaluation Confirmed Program Therm Savings**
	1	2004	7,846	3,236	3.07	2.68	540,900	138,422
	2	2005	7,846	3,236	3.07	2.68	540,900	138,422
	3	2006	7,846	3,236	3.07	2.68	540,900	138,422
	4	2007	5,424	2,038	2.73	2.56	540,900	138,422
	5	2008	5,424	2,038	2.73	2.56	540,900	138,422
	6	2009	5,424	2,038	2.73	2.56	540,900	138,422
	7	2010	5,424	2,038	2.73	2.56	540,900	138,422
	8	2011	4,533	1,668	2.55	2.53	540,900	138,422
	9	2012	4,533	1,668	2.55	2.53	540,900	138,422
	10	2013	4,533	1,668	2.55	2.53	540,900	138,422
	11	2014	3,960	892	1.54	1.31	540,300	44,618
	12	2015	3,960	892	1.54	1.31	427,800	44,618
	13	2016	3,960	892	1.54	1.31	427,800	44,618
	14	2017	3,960	892	1.54	1.31	427,800	44,618
	15	2018	3,960	892	1.54	1.31	427,800	44,618
	16	2019	3,960	892	1.54	1.31	196,800	80,489
	17	2020	783	639	0.68	1.29	196,800	80,489
	18	2021	783	639	0.68	1.29	196,800	80,489
	19	2022	783	639	0.68	1.29	196,800	80,489
	20	2023	783	639	0.68	1.29	196,800	80,489
	TOTAL	**2004-2023**	85,726	30,772			8,644,500	2,009,759

2. EM&V Plan

The following section provides specifics related to (2.1) EM&V objectives, (2.2) the selected measurement and verification options, (2.3) billing simulation, (2.4) onsite inspections and (2.5) data collection.

2.1. Objectives

The evaluation plan includes the following relevant research requirements and objectives specified in the Energy Efficiency Policy Manual Version 2.

- Measure the level of energy and peak demand savings achieved;
- Evaluate program cost-effectiveness;
- Provide up-front market assessments and baseline analysis;
- Provide ongoing feedback, and corrective and constructive guidance regarding the implementation of programs;
- Measure indicators of the effectiveness of specific programs, including testing of the assumptions that underlie the program theory and approach;
- Assess the overall levels of performance and success of programs; and
- Help to assess whether there is a continuing need for the program.

Understanding both the implementation plan of the program as well as the underlying theory of the program is essential to developing the most appropriate evaluation.

2.2. Measurement and Verification Approach

The measurement and verification approach employs the ratio estimator method using data collected and analyzed according to the *International Performance Measurement & Verification Protocols* (IPMVP) Option A (stipulated savings) and Option D (calibrated simulation). General descriptions of the IPMVP Options are:

- Option A - Stipulated Savings - Verify equipment performance (Watts, kW/ton)
- Option B - Measured/Stipulated - Verify equipment performance by conducting short-term monitoring to calibrate end-use estimation tool.
- Option C - Whole Building Analysis (hourly or monthly) – Verify savings by conducting utility billing analysis.
- Option D - Calibrated Simulation Model – Verify savings by calibrating whole building simulation model.

The ratio estimator method produces what is called a realization rate. A realization rate is estimated for each measure and end use. More specifically, this rate is defined as the verified savings divided by the ex ante savings for the same measures (Equation-1).

$$R_v = \frac{\bar{y}_v}{\bar{x}_v} \qquad \text{(EQ-1)}$$

where,

$R_v =$ Ratio or realization rate based on verification study.

$\bar{x}_v =$ Sample mean savings for all original, ex ante savings estimates in the sample.

$\bar{y}_v =$ Sample mean savings for all verification-based, ex post savings estimates in the sample.

The final total savings estimate is calculated as (Equation-2):

$$\hat{Y} = R_v \times \hat{X} \qquad \text{(EQ-2)}$$

where,

$R_v =$ Ratio or realization rate based on verification study.

$\hat{X} =$ Total ex ante savings for population of measure records in the program database for the specified end-use.

$\hat{Y} =$ Total ex post savings for end-use population of measure in the program database.

Common conditions that affect energy use are weather and occupancy. Changes to these conditions may affect equipment operations. Adjustments may be positive or negative. Adjustments include weather changes or other variables. Savings are deemed to be statistically valid if the M&V results for the sample and program are within the 90 percent confidence interval.

2.3. Billing Simulation

The evaluators chose billing simulation (Option D)[1], rather than billing analysis (Option C), because results from 2002-03 mobile home evaluation raised concern that the variability of residential customer usage may render the billing analysis results inconclusive, thus providing no additional verification to the deemed values established in the previous study. Specific reasons for not using billing analysis include:

- The results of the previous program's billing analysis are inconclusive.
- The California Evaluation Framework recommends that for energy savings that are 10% or less of the total usage that the impact be determined using engineering calculations (page 94, Feb 2004 version). The savings from the previous program are purportedly in the 5% to 10% range.

[1] Billing simulation differs from building simulation in that the emphasis is more on interpreting billing patterns and less on creating a virtual model of the building. The EZ Sim billing simulation model operates with average monthly utility bill data instead of hourly data and simple weather data – i.e., just daily average temperature. But unlike standard billing analysis, it is also based on building physics, not a statistical curve-fit, so the user can change a physical parameter to evaluate its impact on energy consumption. EZ Sim has been referred to as Option-C and Option-D. The Federal Energy Management Program (FEMP) refers to it as a billing analysis tool in Part 3 of their M&V Training Course for Super ESPC Projects (FEMP 2004). Where as, a Northwest Energy Efficiency Alliance study (Pacific Consulting Services 1999) endorsed the model as an industry recognized alternative, to DOE-2 building simulation, for performance verification of small and medium commercial buildings. To date, no decision by IPMVP has been made regarding the appropriate classification of this tool.

- Billing analysis requires a thorough understanding of the customer's energy use patterns in order to account for various factors to make the necessary adjustments. For the mobile home customers this information is not always available.
- Many mobile home customers can be considered a part of the low income group. Evaluators have recently tried to use billing analysis for low income programs with little success.
- Although adequate, the proposed budget is not large enough attempt multiple evaluation methods, or switch methods part way through the program. Therefore, at the onset of the program, a method believed to yield conclusive results was selected.

The analysis was be performed by Stellar Processes using their EZ Sim - Billing Simulation Tool. Efforts were be made to collect data for 150 sites, an attrition rate of 33% is assumed. In the final analysis, a total of 70 treated mobile homes were modeled. An additional 50 mobile homes were analyzed as a control group.

The proposed billing simulation used customer billing data to calibrate the model. A much greater sample size will be analyzed than was used in the previous evaluation. Benefits of using EZ Sim are:

- Ties together whole building bills and a simplified engineering simulation - user can quickly "tune" the engineering model to match the bills.
- No complicated software - use standard spreadsheet as basis.
- Minimal set of inputs - model will run using standard assumptions, but can be updated to include site-specific details when they are available.
- Use of real-time, local weather (not average weather data) that can be readily obtained.
- Option to change physical parameters using typical engineering values, such as standard equipment ratings, which allows for modeling of conservation measures.
- Savings estimates that are calibrated to match the actual usage.

The simulation process is two-fold. First, the calibration matches the model to pre and post consumption (bills) at the whole house level. At this point, the savings are defined at the whole-house level – that is, the sum of the savings is known. The only contribution of the model is that of weather normalization, as would be the case with PRISM or other statistical models.

The next step is to consider how the individual measures contribute to the sum. This is where the model is helpful because it allows physical parameters to be specified corresponding to the measures implemented. Different measures show up with different "signatures". For example, a water heater timer or CFLs would be manifest as a reduction in the non-seasonal baseload. A Programmable Thermostat would show up as a change in the effective balance temperature. An improvement in air conditioning would be apparent as a change that only affects cooling. In the process of calibration, the model would set up with the anticipated changes but then the parameters would be adjusted to best match the actual post consumption.

The impacts of those measures with different "signatures" are easily separated. In some cases, measures cannot be separated. For example, water heater timer and CFLs would both be evident as a baseload change without any clear separation. However, the sum of these impacts would be known. The modeler and auditor must review site characteristics in order to decide the best explanation for any difference from the expected impacts.

The modeling tool assists by keeping track of the implications of any physical parameters. Thus, a measured improvement in duct efficiency can be applied to the actual amount of heating and cooling in order to quantify the impact of that specific measure.

2.4. On-site Inspections

The on-site inspections of 150 mobile homes involved monitoring installation procedures and measurement and verification activities practiced by the program implementer. The sites were randomly selected by the EM&V team, not the implementer. An AESC engineer, with EPA certification, accompanied the ASC field manager during their regular quality control (QC) site inspections. The duct testing and AC testing was performed by ASC, while the EM&V inspector was present. In order to perform these measurements the following equipment was employed:

- Energy Conservatory Duct Blaster™ duct pressurization testing equipment to measure duct leakage (cfm) and duct pressure (Pascal);
- Refrigerant Gauges to measure refrigerant charge pressures and saturation temperatures;
- Fluke Digital Temperature Sensor to measure dry bulb temperature; and
- Sling Psychrometric to measure dry bulb temperature.

A mobile home survey was completed during each on-site inspection. This information was input into the billing simulation model. For the lighting replacement measures, short-term monitoring was considered. However, it was determined that the evaluation budget could not support the cost of installing, retrieving and analyzing light loggers for an adequate sample to challenge any previous statistics.

In general, peak kW impacts will be stipulated based on standard engineering principals, accepted deemed savings, billing simulation analysis, field observations and/or other relevant studies. As mentioned above, the cost of light logging makes measuring peak demand savings cost prohibitive. Similar cost and accuracy constraints apply to the other program measures.

2.5. Data Collection

Data was collected from three sources. The first was data provided by the program administrators, including information on all of the measures and projects, along with administrative data such as incentive paid, administrative costs and program data required for the analysis. The second data source was customer surveys, a random sample of 300 participants was selected to measure such things as program satisfaction and elicit ideas for improving the program. The third data source was onsite inspection to verify measure implementation, to gather data on the measures, and conduct interviews with the program participants. The measure verification data included such items as verifying the number of lighting fixtures installed, equipment nameplate data, spot measurements, and other data mainly related to the installation of new equipment or retrofitting of existing equipment.

3. Impact Evaluation Summary

The bid instructions for this solicitation directed parties to use the 2001 DEER Update Study. This database specifies energy efficiency measure estimates for single family and multi-family applications. For measures not identified in this database, ex ante savings and cost estimates were derived through the use of other public energy efficiency data and the implementation team's actual experience working with mobile homes projects.

Table 3.1 summarizes the CPUC approved measure savings, equipment useful life (EUL), net-to-gross ratio (NTGR), and unit costs.

Table 3.1: Contracted Measure-Level Savings, EUL, NTGR and Unit Cost

Measure	SCE Unit Goals	SCE Unit Cost	SCG Unit Goals	SCG Unit Cost	SCG Unit Goals (added)	SCG Unit Cost (added)	Ex Ante kW	Ex Ante kWh/yr	Ex Ante Therms /yr	EUL	NTGR
Duct Test and Seal	3,250	$33.86	4,100	$62.89	850	$117.26	0.210	241	48	20	0.89
AC Diagnostic and Tune-up	3,250	$62.00	0	$0.00	0	$0.00	0.310	175	0	10	0.89
Programmable Thermostat	3,000	$33.15	3,500	$17.85	500	$29.38	0.150	256	66	15	0.89
Facuet Aerator	0	$0.00	4,500	$5.86	1,000	$3.04	0.000	0	5	10	0.89
Showerhead	0	$0.00	4,000	$12.45	1,000	$7.36	0.000	0	17	10	0.89
Energy Star CFL's - Exterior	3,932	$9.65	0	$0.00	0	$0.00	0.020	328	0	3	0.89
Energy Star CFL's - Interior	9,000	$9.65	0	$0.00	0	$0.00	0.020	99	0	7	0.89
Energy Star Hardwire CFL's - Exterior	2,457	$36.10	0	$0.00	0	$0.00	0.020	328	0	16	0.89
Energy Star Hardwire CFL's - Interior	3,000	$36.10	0	$0.00	0	$0.00	0.020	99	0	16	0.89
Common Area Energy Star CFL's - Ext.	1,966	$9.70	0	$0.00	0	$0.00	0.080	354	0	3	0.89
Common Area Energy Star CFL's - Int.	1,229	$9.70	0	$0.00	0	$0.00	0.080	354.7	0	3	0.89
Common Area ES Hardwire CFL's - Ext.	2,457	$36.10	0	$0.00	0	$0.00	0.080	354	0	16	0.89
Common Area ES Hardwire CFL's - Int.	1,229	$36.10	0	$0.00	0	$0.00	0.080	354.7	0	16	0.89
Blower Door Test and Seal	25	$34.07	25	$63.28	0	$0.00	0.100	140	24	10	0.89
Electric Water Heater Timers	12	$108.40	0	$0.00	0	$0.00	0.430	91		10	0.89
Totals	34,807		16,125		3,350						

This program originally targeted climate zones 9, 10, and 15, with the projected savings being average values for these climate zones. By the end of the program, ASC technicians had serviced mobile homes in climate zones 6, 8, 9, 10, 14 and 15. The following sections provide a description of each measure, original engineering assumptions used by ASC and Cal-UCONS, current deemed savings reported in the 2004-05 DEER Update Study, and the results of the on-site inspections and billing simulation models.

3.1. Billing Simulation

The billing simulation analysis focused on a sample of 70 projects completed in 2004 and 2005. The study also included analysis of approximately 50 control group sites. Little evidence of the expected overall savings impact was found. For most end-use types, the participant's energy usage was not significantly different from the control group. Only the gas water heating measures showed savings that were statistically significant. Tables 3.2 through 3.4 summarize the results of the gross savings, control group changes, and net savings (gross minus control group).

Table 3.2: Summary of Billing Simulation Results, Gross Savings

Variable	Mean	Standard Deviation	90% CL Lower	90% CL Higher	t-test	Significance (2-tailed)
Electric HVAC (kWh/yr)	130	1,001	-67	327	1.08	ns
CFL Lights (kWh/yr)	18	815	-143	178	0.18	ns
Total Savings (kWh/yr)	147	1,054	-60	355	1.17	ns
Gas HVAC (Therm/yr)	-3	73	-18	11	-0.36	ns
Gas DHW (Therm/yr)	18	42	10	26	3.62	P>.99
Total Savings (Therm/yr)	15	90	-3	32	1.35	ns

Table 3.3: Summary of Billing Simulation Results, Control Group Changes

Variable	Mean	Standard Deviation	90% CL Lower	90% CL Higher	t-test	Significance (2-tailed)
Electric HVAC (kWh/yr)	167	810	-22	355	1.46	ns
CFL Lights (kWh/yr)	-92	551	-220	36	-1.18	ns
Total Savings (kWh/yr)	75	1,226	-210	360	0.43	ns
Gas HVAC (Therm/yr)	-3	61	-17	12	-0.30	ns
Gas DHW (Therm/yr)	-2	20	-7	2	-0.80	ns
Total Savings (Therm/yr)	-5	62	-19	10	-0.54	ns

Table 3.4: Summary of Billing Simulation Results, Net Savings

Variable	Mean	Standard Deviation	90% CL Lower	90% CL Higher	t-test	Significance (2-tailed)
Electric HVAC (kWh/yr)	-37	927	-176	102	-0.22	ns
CFL Lights (kWh/yr)	109	718	2	217	0.82	ns
Total Savings (kWh/yr)	72	1129	-97	242	0.35	ns
Gas HVAC (Therm/yr)	-1	69	-11	10	-0.04	ns
Gas DHW (Therm/yr)	20	35	15	26	3.06	P>.99
Total Savings (Therm/yr)	19	80	7	31	1.29	ns

3.1.1. Background and Methodology

The impact evaluation process seeks to identify the savings due to the specific energy conservation measures by review of the pre- and post-retrofit energy consumption. A billing simulation model (EZ Sim) was used to estimate energy savings. The model uses historical billing information to produce estimates of long-term energy savings. The model differs from statistical regression models in that it is based on a simulation of the building physics. Its use also enables examination of the energy savings on a measure-by-measure basis. When reviewing a single measure, the model is not different from a statistical approach. However, the model has an advantage in being able to model variation in consumer behavior, such as vacations or manual scheduling.

The model includes a set of calculations based on performance curves that duplicate DOE-2 results for commercial buildings[2,3]. EZ Sim's methodology, however, is very different from DOE-2's. While DOE-2 produces detailed hourly simulations, EZ Sim computes monthly energy consumption based on average daily temperatures, equipment, and operations. Thus, it is quick and relatively easy to conduct the model runs. Furthermore, EZ Sim is explicitly designed to calibrate to consumption records and actual weather data, while DOE-2 is difficult to calibrate and adjust to local weather conditions. Savings are computed as the difference in energy consumption between the two models (pre- and post-retrofit) when operated under "typical" weather conditions. This modeling procedure is necessary to make a fair comparison when weather, hours of operation, or other site conditions might have changed. Note that this approach calibrates directly to energy consumption but does not address demand impact.

The initial study group consisted of 99 treated cases and 59 comparison or "control group" cases. The comparison cases were drawn from customers that participated in the 2006-08 mobile home program in order to avoid potential selection bias. Due to incomplete consumption records, the final study group consisted of 70 treated cases and 50 comparison cases. In 8 of the treated cases and 5 of the comparison cases, the simulations were calibrated to electricity consumption only because gas records were not available. Treated cases were reviewed for changes in their consumption before and after their treatment date – this means that the dividing date between pre- and post-treatment was not the same in all cases. For the comparison cases, the calendar year 2004 was taken as the "pre-treatment" period for purposes of analysis. In all cases, there were 12 months of observations pre and post.

3.1.2. Billing Simulation Results

Results from the simulation analysis show little evidence of savings. Figures 3.1 and 3.2 show the relative magnitude of the actual and ex ante expected savings by measure category and fuel type. Units of savings are annual kWh for electricity and annual Therms for natural gas. The "whiskers" show upper and lower 90% confidence limits based on the observed variance in the

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[2] The simulation model was benchmarked against DOE-2 in the PacifiCorp's 1992-95 evaluation of the EF Commercial Program and approved by their Evaluation Steering Committee as an alternative to DOE-2 for commercial building simulations.

[3] In addition to its design and application for commercial buildings, this model has also been used in two previous residential studies. One was a load impact study for mobile home evaporative cooler maintenance improvements (LaPalme, 2006). The other was a residential heat pump study conducted in the Pacific Northwest (Baylon et al., 2005). In the latter study it is reported that the EZ Sims models typically fit to the bills with an R^2 of 95%.

treated sample. Savings were much less than anticipated; leading one to wonder if an underlying trend in consumption might be obscuring the observations. Therefore, a control group was analyzed to determine if an underlying trend in consumption was obscuring the results.

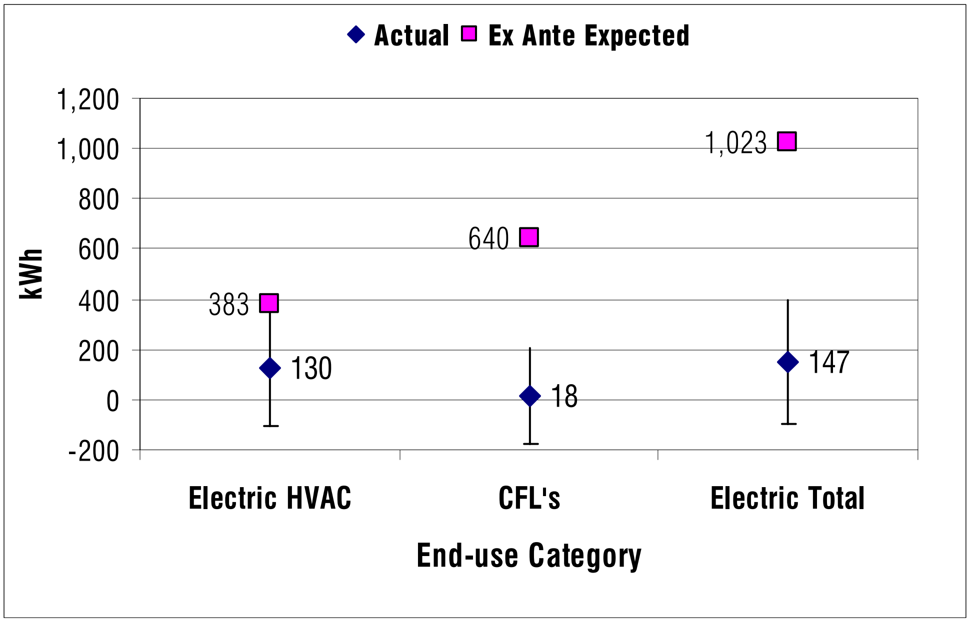

Figure 3.1: Actual and Ex Ante Expected Electricity Savings

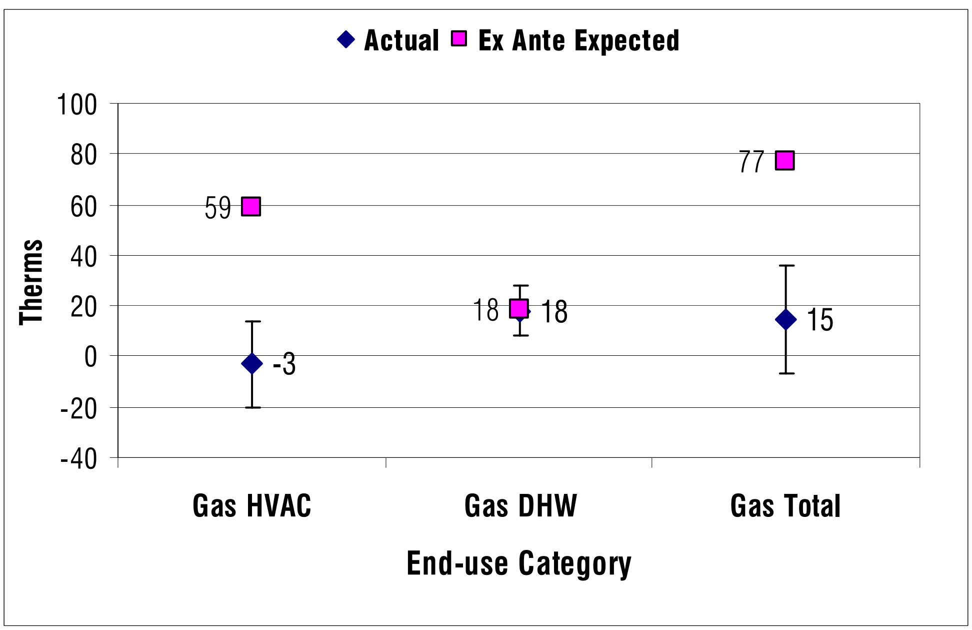

Figure 3.2: Actual and Ex Ante Expected Gas Savings

Figures 3.3 and 3.4 show savings from the analysis for both the treated and control group cases. As one might expect, the control group did not show changes in consumption that were statistically significant. There is some indication that there was less HVAC consumption and more lighting consumption in the second year. However, the differences were not statistically different from zero. For both groups, the changes in consumption are within the confidence limits due to “noise” or variance within the participants.

As in all statistical analyzes, the level of variability in the data dictates how much confidence can be placed on the results. In other words, could the “expected” savings occur but be buried within the statistical “noise”? The answer is no – the statistical method is sufficiently robust to be able to state that the “expected” level of savings did not occur except for the gas DHW measures.

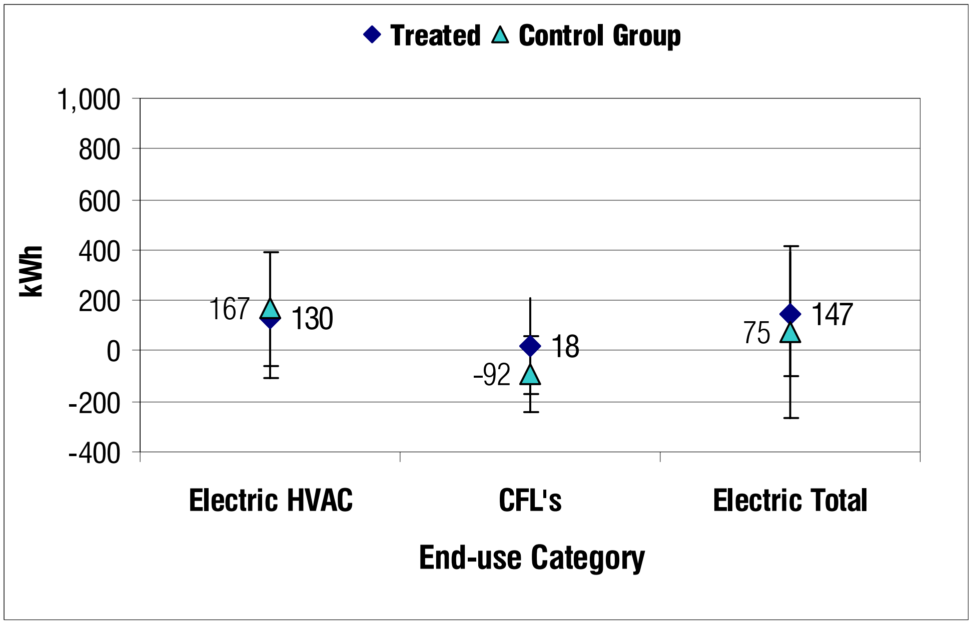

Figure 3.3: Treated and Control Group Electricity Savings

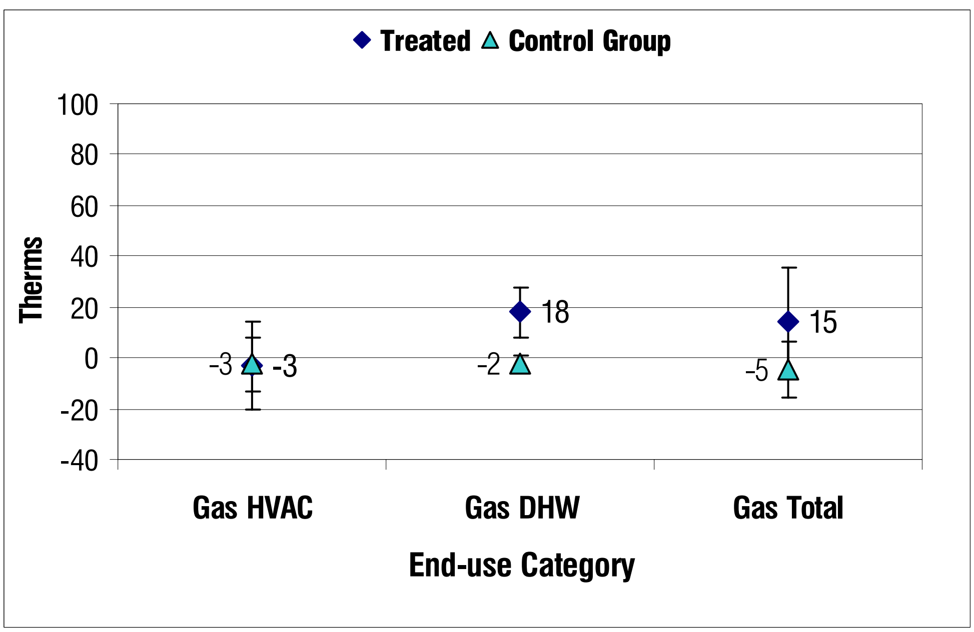

Figure 3.4: Treated and Control Group Gas Savings

It should be noted that the billing simulation, site inspections, and customer surveys were biased toward individually metered mobile home parks. The program participants in master metered parks may represent a subpopulation with different measure performance and/or behavioral characteristics.

3.1.3. Billing Simulation Findings

In general, only the gas hot water measure savings could be verified using billing simulation. These measures, low flow Faucet Aerators and Water Saving Showerheads, achieved savings very close to what was expected. For the other measures, savings were not statistically distinguishable from zero. Inclusion of a control group added methodological rigor but did not change the results. Therefore, while informing us of degree of the overall program savings impact, these results do not provide an accurate estimate of the measure-level savings.

In this analysis, the inability to detect statistically significant energy savings for most measures had more do with the relative size of the verified savings (e.g., reduction in overall electrical consumption) and less to do with the reliability of the billing simulation model. For example, from the sample analyzed, the expected overall electrical savings was approximately 15% of the base year. The 2001 IPMVP guidelines state that to use whole building analysis savings should be greater than 10% of the base year. The estimated gross kilowatt-hours savings from this analysis was only 2.2%, with a 90% upper confidence limit of only 5.4%.

It is clear from these results that billing simulation is not a viable verification approach for mobile homes using only monthly utility data, unless there is greater certainty a priori that the actual savings will surpass the 10% base year minimum. Other billing analysis approaches involving sub-metering may provide better results, but will come with a much higher cost. If the verification budget is a limiting factor accurate engineering estimates and on-site verification may be the only viable approach to estimate the overall program savings. The latter approach was used for another 2004-05 statewide program evaluation (Aloha Systems, 2006) where residential AC diagnostics and tune-ups were implemented.

Even though it can be deduced that the program did not have the overall impact anticipated, it is not clear how each measure performed and what energy savings estimates should be used in the future. Research has found that for residential retrofit programs it is not uncommon for impact evaluation results to be between 15 and 50% of the engineering estimates (Nadel & Keating, 1991). Common causes for these discrepancies are the following: (a) erroneous assumptions in the engineering estimates; (b) complex interactions which were not modeled in the engineering estimates; (c) “take-back” effects; (d) quality control problems during measure installation, commissioning, and maintenance; and (d) greater than expected adoption of conservation measures by non-participating customers, which lowers the net savings attributable to the program. Section 3.2 further investigates the cause(s) of the divergence between the ex ante engineering estimates and the billing simulation results.

3.2. Measure-Level Savings

This section details the field observations and literature review as they relate to the measures offered by the program. Both ex ante and ex post deemed savings are presented. For the weather sensitive measures, ASC and Cal-UCONS based the ex ante deemed savings on the 2001 DEER Update Study, which is limited to single and multi-family dwellings. These and other deemed savings were originally used in the 2002-03 Comprehensive Hard-to-Reach Mobile Home Energy Savings Programs and rolled over without adjustment into the 2004-05 program. The ex post deemed savings are based on on-site installation verification, the latest CFL Metering Study, and the 2004-05 DEER Update Study, which includes energy savings estimates for mobile homes. One major change to DEER is how energy savings are estimated for Programmable Thermostats. The impact of this change is significant and discussed in greater detail in the subsequent section covering this measure.

3.2.1. Duct Test and Seal

Duct system leakage in homes can result in heating and cooling losses to unconditioned spaces, reduced system efficiency and increased fan usage. Because these leaks are invisible, most go undetected and untreated. Studies have shown that the potential energy savings for a typical home is around 17% (Neme, Proctor, & Nadel, 1999). In addition to the energy savings this measure offers additional non-energy benefits such as improved comfort and air quality, reduced maintenance costs, and increased equipment life.

To help deliver this energy efficiency service to the mobile home sector, ASC and Cal-UCONS committed to conducting Duct Test and Seal for 3,250 customers. SCG later provided funding for an additional 850 customers, increasing their goal to 4,100 customers. The technicians were given two leak reduction targets - 15% of the measured system flow at 25 Pascal pressure (supply and return) or 60 CFM per ton.

The contracted savings for this measure are 0.21 kW, 241 kWh/yr and 48 Therms/yr. These are the same ex ante savings used in the 2002-03 Comprehensive Hard-to-Reach Mobile Home Energy Savings Program. Table 3.5 summarizes ex ante and ex post savings.

Table 3.5: Duct Test and Seal Estimates

Savings	Peak Demand (kW)	Electric (kWh/yr)	Gas (Therm/yr)
Ex Ante	0.21	241	48
Ex Post	0.32	158	20
Realization Rate	1.51	0.66	0.42

As part of the verification work, onsite inspections on a random sample of the Duct Test and Seal installations were conducted. An ASC technician retested the post installation leakage level to further demonstrate that the work had been completed per the program specifications. The assumption was if the post-retrofit was correct then the reported baseline leakage should also be correct. The quality assurance test procedures were consistent with the Minneapolis Duct Blaster® Operation Manual. Of the 53 duct retested, 4 sites were found to have leakage levels closer to the reported baseline leakage than to the reported post leakage levels. The resulting installation verification rate is 0.92.

For the remaining 49 sites, the average reported post leakage was 240 CFM (±42), and the average verified post leakage was 215 CFM (±29). There is no statistically significant difference between these estimates at 90% confidence; therefore, with installation verification adjustments, the recorded estimates were accepted as accurate. From the program database, the recorded average baseline leakage was 468 CFM (±7), and the recorded post leakage was 217 CFM (±7). Based on the leakage target of 60 CFM per ton and an average air conditioner size was 3.76 tons, the overall program goal was an average post leakage of at least 226 CFM, which was achieved.

Table 3.6: DT&S Implementation Distribution

Climate Zone	Distribution
Long Beach – 6	7.5%
El Toro – 8	7.5%
Burbank – 9	5.7%
Riverside – 10	15.1%
China Lake – 14	50.9%
El Centro – 15	13.2%
Total	100.0%

The site implementation distribution is presented in Table 3.6. The regional distribution exceeded the programs original scope. The participant's location is significant because this measure is weather sensitive. The 2004-05 DEER Update Study was used to recalculate the estimated energy savings, which are 0.35 kW, 175 kWh/yr, and 22 Therms/yr. After adjusting for the installation verification results, the ex post savings become 0.32 kW, 158 kWh/yr, and 20 Therms/yr.

3.2.2. AC Diagnostic and Tune-up

AC Diagnostic and Tune-up element of the program saves energy by checking and correcting the refrigerant charge and airflow on central air conditioning units. Studies have shown typical efficiency (EER) improvements ranging from 7% to 20% (Siegel & Wray, 2006). In extreme cases, savings can be as high as 48%. EPA-certified refrigerant technicians performed the AC diagnostic tune-up. They also replaced leaky Schrader valves.

The ex ante savings estimates were based on DOE-2.2 simulations and assumed that proper charge and proper airflow would improve the air conditioner Energy Efficiency Ratio (EER) by roughly 13%, which was based on the average measured savings from seven field studies (Mowris, Blankenship, & Jones, 2004). These field studies show an efficiency loss of 10-20% for overcharging and 20% for undercharging. Assuming an equal distribution of over- and undercharging the average efficiency loss is approximately 13%. The same studies showed an average efficiency loss of 7% for improper airflow across the air conditioning coil. The average combined loss from both problems is approximately 17% ASC only took credit for 13% savings to be conservative. Table 3.7 summarizes ex ante and ex post savings.

Table 3.7: AC Diagnostic and Tune-Up Estimates

Savings	Peak Demand (kW)	Electric (kWh/yr)
Ex Ante	0.310	175
Ex Post	0.414	264
Realization Rate	1.34	1.51

The results of the onsite inspection showed that the majority (89%) of the AC Diagnostic and Tune-up measures were not installed correctly. This is the same percentage found in the prior program evaluation (Morris, Blankenship, and Jones 2004). Of the 55 tested, 49 were found to have an acceptable refrigerant charge. The technician's target was a ±2°F superheat differential; even though, refrigerant charge is considered acceptable with a ±5°F superheat differential. Since the end of 2005 and for the current mobile home program, ASC has been using an automated testing and data collection system (eScan) to monitor technician performance and improve measure quality.

**Table 3.8:
AC Diagnostic and Tune-Up
Implementation Distribution**

Climate Zone	Distribution
Long Beach – 6	7.5%
El Toro – 8	7.5%
Burbank – 9	5.7%
Riverside – 10	15.1%
China Lake – 14	50.9%
El Centro – 15	13.2%
Total	100.0%

Table 3.8 shows the location of AC Diagnostic and Tune-up measures. This data, with house vintage and square footage, is required to estimate the energy savings using the 2004-05 DEER Update Study. The resulting deemed savings are 0.465 kW and 296 kWh/yr. Adjusting for the percentage of implementations that did not pass the inspection brings the ex post savings estimates to 0.414 kW and 263 kWh/yr.

3.2.3. Programmable Thermostat

The Programmable Thermostat ex ante savings estimates were based on the 2001 DEER Update Study. The contracted ex ante savings claims are 0.150 kW, 256 kWh/yr, and 66 Therms/yr. In the field, the inspector verified that 88% of the recorded Programmable Thermostats were still in operation. Those that could not be found had been removed by the customer or a returning ASC technician. Customer's had many complaints about this measure. Often they were unhappy with the temperature setpoint schedule but did not understand how to reset it. Table 3.9 summarizes ex ante and ex post savings.

Table 3.9: Programmable Thermostat Estimates

Savings	Peak Demand (kW)	Electric (kWh/yr)	Gas (Therm/yr)
Ex Ante	0.150	256	66
Ex Post	0.000	-116	-12
Realization Rate	0.00	0.00	0.00

As with the preceding measures, savings were recalculated using the 2004-05 DEER Update Study. It was discovered that the average estimated savings from the recorded installations was negative for both electricity and gas. It turns out that for the 2004-05 DEER Update Study the calculation methodology was revised and based on a statistical analysis of occupant's behavior (Reeves & Hirsch, 2004). The behavioral data used in this analysis compares how homeowners use different thermostat types for heating and cooling throughout the day. The latest Low Income Energy Efficiency Study (West Hill Energy & Computing, 2005) also found negative savings from this measure. Increased energy consumption from Programmable Thermostats is one explanation for the lower HVAC energy savings observed in the billing simulation results.

3.2.4. Faucet Aerator

Faucet Aerator energy savings were based on assumed pre- and post-retrofit flow rates of 3.5 gpm and 2.2 gpm, respectively. This is a flow reduction of roughly 37%. The ex ante energy savings are 5 Therms/yr for gas water heaters. This is the same deemed savings used in the 2002-03 program. Both ex ante and ex post measure savings are summarized in Table 3.10.

Table 3.10:
Faucet Aerator Savings Estimates

Savings	Gas (Therms/yr)
Ex Ante	5.0
Ex Post	4.2
Realization Rate	0.85

Seventy eight (78) Faucet Aerator installations were inspected. From this sample, 66 installations were confirmed. The other participants reported receiving the Faucet Aerators, but either removed or never installed them. Therefore, the ex post realization rate is 0.85 and the ex post savings is 4.6 Therms/yr. The program estimates are supported by the billing simulation and literature review. The combined realization rate for savings related to the domestic water heater was 1.17. The LIEE Impact Study (2005) reports savings ranging from 0.6 to 4.0 Therms/yr.

3.2.5. Water Saving Showerhead

Water Saving Showerhead savings were based on engineering estimates and M&V studies. Non-conserving showerheads use greater than 3.5 gpm and low flow showerheads use 2.5 gpm. The ex ante estimate energy savings is 17 Therms per low flow showerhead. Table 3.11 summarizes ex ante and ex post savings.

Table 3.11:
Water Saving Showerheads Estimates

Savings	Gas (Therm/yr)
Ex Ante	17
Ex Post	15
Realization Rate	0.89

In the field, seventy nine (79) Water Saving Showerhead installations were inspected. From this sample, 70 were confirmed. The other participants reported receiving the showerhead, but either removed or never installed them. Adjusting for the field verification findings, the ex post savings is 15 Therms/yr.

The 2004-05 DEER does not estimate energy savings for low flow showerheads in mobile homes. Single family installations are estimated. The estimated savings for this dwelling type ranges from 7 to 9 Therms/yr per installation. The LIEE study (2005) reported savings range from 2 to 22 Therms/yr.

3.2.6. Lighting Measures

Compact fluorescent lights typically replace incandescent bulbs. Although CFL's have a much higher initial cost than incandescent bulbs, they are an exceptional bargain in the long run, with typical paybacks of less than one year[4]. The general calculation for estimating lighting savings is as follows:

$$kWh_{saved} = Qty. \times Hours \times (kW_{pre} - kW_{post})$$

Energy savings for lighting measures are provided for interior and exterior Energy Star CFLs and interior Hardwired Energy Star fixtures. Savings can be calculated accurately if the above variables are known. The proposed ex ante assumed hours of operation for lighting in different space types are summarized in Table 3.12. Proposed and approved ex ante savings for typical fixtures installed in the program are shown in Tables 3.13 and 3.14.

Table 3.12: Lighting Operating Hours by Space Type

Space Type	Hours or Operation
Indoor Common Area	8,760
Indoor Special Use Common	4,380
Indoor Dwelling Unit	1,428
Exterior Dwelling Units	4,380
Exterior Common Area	4,380

Table 3.13: Ex Ante Lighting Savings Proposed

Measure	Pre Watts	Post Watts	Est. Runtime (hrs/yr)	EUL (years)	Peak Savings (kW)	Electric Savings (kWh/yr)
Energy Star CFL – Interior	60	15	1,428	7	0.08	72
Energy Star CFL - Interior	100	25	1,428	7	0.08	128
Energy Star Hardwire Fixture CFL - Interior	120	30	1,428	16	0.08	264
Energy Star CFL – Exterior	100	25	4,380	7	0.08	328
Energy Star Hardwire CFL – Exterior	80	20	4,380	16	0.08	328
Energy Star Interior CFL – Common	100	25	8,760	7	0.08	355

[4] Retrieved December 15, 2006 from the World Wide Web: http://www.energydesignresources.com/

Table 3.14: Ex Ante Lighting Savings Approved

Measure	EUL (years)	Peak Savings (kW)	Electric Savings (kWh/yr)
Energy Star CFL - Exterior	3	0.02	328
Energy Star CFL - Interior	7	0.02	99
Energy Star Hardwire CFL - Exterior	16	0.02	328
Energy Star Hardwire CFL - Interior	16	0.02	99
Common Area Energy Star CFL - Exterior	3	0.08	355
Common Area Energy Star CFL - Interior	3	0.08	355
Common Area ES Hardwire CFL - Exterior	16	0.08	355
Common Area ES Hardwire CFL - Interior	16	0.08	355

Table 3.15 summarized the reported and verified CFL installations (i.e., inspection ratio). The discrepancies were a result of (1) CFL failure, (2) CFL removal, and (3) CFL receipt without installation. Some participants did complain about the low light levels of the CFLs. As a result, some CFL's were relocated to fixtures of lower usage or removed.

The ex ante savings estimates for the exterior and interior mobile home CFL installations were overestimated. Accepting the ex ante savings estimates and the results on the onsite data collection, one would expected the billing simulation results to be around 80% of the reported amount. However, the erroneous assumptions overestimate both the baseline wattage and annual hours of operation. The results of the billing simulation were significantly lower than the ex ante estimates. The estimated realization rate was 17% with the control group. All of the sites included in the billing analysis are mobile homes; therefore, common area estimates did not influence the results.

We've concluded that the CFL assumptions are the second source of error, following the Programmable Thermostats, that significantly contribute to the gap separating the ex ante savings estimates and the billing simulation results. When the ex post engineering estimates and accounted for the verified installation rate, the billing simulation results and engineering estimates are much more agreeable. Table 3.15 summarizes ex post savings assumptions.

Table 3.15: Ex Post Savings Estimates

Measure	Pre Watts / Fixture	Post Watts / Fixture	Hrs / Day	Installation Ratio	Peak Savings (kW)	Realization Rate	Electric Savings (kWh/yr)	Realization Rate
Energy Star CFL - Exterior	79	18	3.1	0.73	0.000	0.00	51	0.15
Energy Star CFL - Interior	70	17	2.4	0.71	0.004	0.14	33	0.33
Energy Star Hardwire CFL - Exterior	91	13	3.1	0.87	0.000	0.00	77	0.23
Energy Star Hardwire CFL - Interior	75	30	2.4	0.94	0.003	0.16	37	0.37
Common Area Energy Star CFL - Exterior	79	18	12.0	0.90	0.000	0.00	240	0.68
Common Area Energy Star CFL - Interior	70	17	12.0	1.00	0.053	0.66	232	0.65
Common Area ES Hardwire CFL - Exterior	91	13	12.0	1.00	0.000	0.00	342	0.97
Common Area ES Hardwire CFL - Interior	75	30	12.0	1.00	0.045	0.56	197	0.56

3.2.7. Blower Door Test and Seal

The ex ante deemed savings are 0.100 kW, 140 kWh/yr, and 24 Therms/yr. The program goal was to implement 25 blower door test and seal measures. ASC recorded six installations. The overall contribution to the ex post savings was less than 0.1% for both electricity and natural gas. No sites with this measure were included in the billing simulation. Table 3.16 summarizes ex ante and ex post savings.

Table 3.16: Blower Door Test and Seal Estimates

Savings	Peak Demand (kW)	Electric (kWh/yr)	Gas (Therm/yr)
Ex Ante	0.100	140	24
Ex Post	0.100	140	24
Realization Rate	1.00	1.00	1.00

3.2.8. Water Heater Time Clock

The ex ante deemed savings are 0.430 kW and 91 kWh/yr. The program goal was to install 12 electric water heater timers. ASC recorded two installations. The overall contribution to the ex post savings was less than 0.1% for both electricity and natural gas. No sites with this measure were included in the billing simulation. Table 3.17 summarizes ex ante and ex post savings.

Table 3.17: Water Heater Time Clock Estimates

Savings	Peak Demand (kW)	Electric (kWh/yr)
Ex Ante	0.430	91
Ex Post	0.430	91
Realization Rate	1.00	1.00

3.2.9. Measure-Level Findings

In combination, the ex ante engineering estimates for the Programmable Thermostat and CFL installations significantly overestimated the sum of the program energy impacts. For the Programmable Thermostats, the 2001 DEER estimates did not account for the changes in human behavior. Also, the research and field observations show lower baseline demand and hours of operation for the lighting retrofits than had been assumed. Simply replacing the ex ante savings with the post ante savings brings the expected savings much closer to the actual gross billing simulation results. The differences are presented in Figures 3.5 and 3.6.

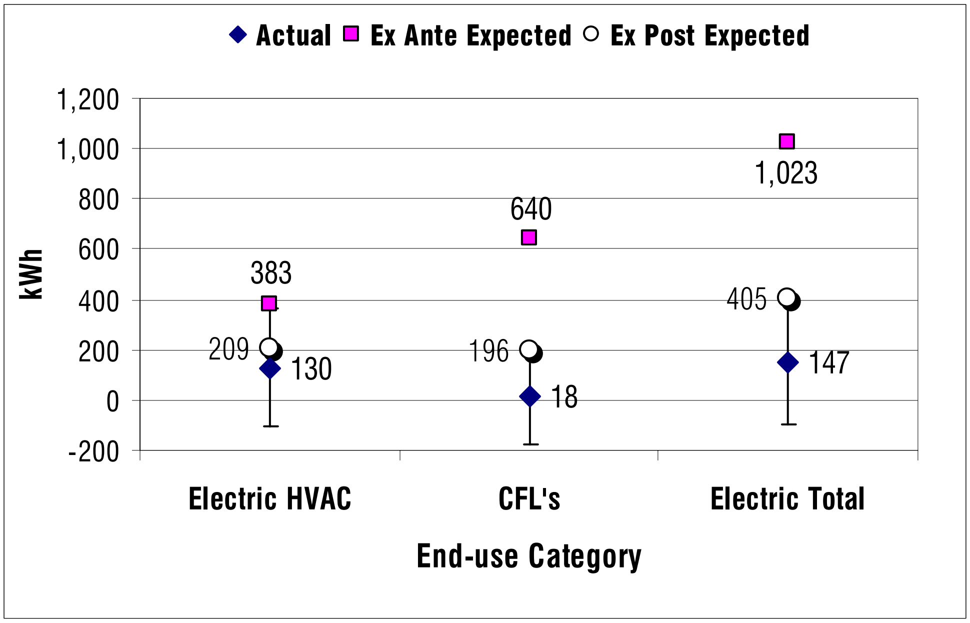

Figure 3.5: Actual, Ex Ante, and Ex Post Electricity Savings

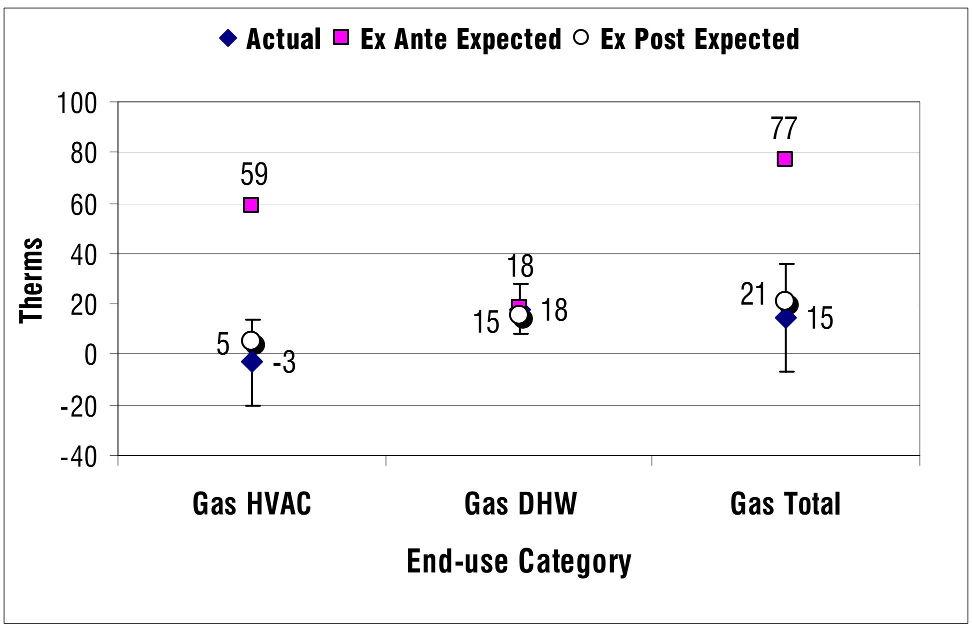

Figure 3.6: Actual, Ex Ante, and Ex Post Gas Savings

4. Process Evaluation

The process evaluation consisted of surveying 300 participants and six (6) program implementers. Copies of both survey instruments are included in the appendix. The exclusion of non-participants in the process evaluation was justified because there were budgetary constraints, a prior non-participant process evaluation was completed in the last three program cycles, and the program did not changed significantly.

4.1. Participant Surveys

The participant surveys investigated (1) customer satisfaction, (2) habitation, (3) awareness of energy efficiency measures, and (4) demographic characteristics.

4.1.1. Customer Satisfaction

In general, the ASC technicians received high marks for their services. Table 4.1 summarizes the average customer response to numerous customer satisfaction questions. The most consistent complaints were that the Programmable Thermostats were too difficult to use and some of the screw-in CFL installations did not provide adequate lighting. Better training to use the Programmable Thermostats was a common suggestion for improvement. Also, customer recommended that ASC conduct follow-up phone surveys in the months immediately following the installations to ensure there were no problems with the installed measures.

Table 4.1: Customer Satisfaction Results

Category	Ranking
Courteousness and Professionalism of Field Technicians	9.4
Overall Program Performance	9.0
Program's Impact on Increasing Awareness of Energy Efficiency	8.1
Energy Savings Tips	7.7

Approximately 68.6% of the participant surveyed reported sharing information about the benefits offered in the program with their friends or neighbors.

4.1.2. Habitation

Table 4.2 summarizes the typical habitation characteristics of the program participants. This information was used to estimate the ex post energy savings. The 2004-05 DEER Database provides engineering estimates in unit terms. Common units are savings per 1,000 square feet and savings per ton of cooling capacity.

Table 4.2: Habitation Results

Category	Parameter
Year Round Residences	99%
Average Years at Current Address	16 years
Mobile Home Owners	97%
Average Number of Occupants	1.75
Average Mobile Home Size	1,341 ft^2
Average AC Cooling Capacity	3.76 tons

4.1.3. Awareness

To determine how the program impacted customer awareness, participants were asked if they recalled energy conservation measures that were completed as a result of your participation in the program. If they remembered the event, they were asked if they were aware this measure could save energy before participating in the program. For all measures there appears to have been a significant increase in customer awareness. Table 4.3 summarizes the results of the measure awareness survey.

Table 4.3: Measure Awareness Results

Measure	Aware of Measure Prior to Program		
	Yes	Some-what	No
Programmable Thermostat	75.6%	3.1%	21.4%
Low Flow Faucet	74.4%	7.7%	17.9%
Water Saving Showerhead	64.3%	5.2%	30.4%
Compact Fluorescent Lamps	59.6%	8.5%	31.9%
AC Diagnostic and Tune-up	56.1%	3.7%	40.2%
Duct Test and Seal	51.9%	4.6%	43.5%
Average	66.0%	5.6%	28.4%

Participants were also asked some general questions about their awareness of ENERGY STAR products and other energy conservation programs, and inquired as to how they learned about this program.

Forty-six percent (46%) of the customer were aware of ENERGY STAR. Only 30% of the customers reported knowing about other energy conservation or energy efficiency programs, outside of this program.

How participants learned about the program is presented in Table 4.4. Based on this data, approximately half of the marketing was direct and the other half was indirect. For future marketing, approximately 53% of the program participants have access to the internet. However, the amount of time spent online is unknown.

Table 4.4: Program Marketing Results

Media	%
Community Association	36.3%
Letter or Call from ASC	35.0%
Word of Mouth	16.7%
Outreach Presentation	6.8%
Other	5.1%
Total	100.0%

4.1.4. Demographic Characteristics

These demographic characteristics are assumed to be representative of all participants. However, for the billing simulation model, this study had to steer toward utility customer with individually metered accounts. Efforts were made to collect utility data from master metered parks but with little success. Table 4.5 shows the typical mobile home vintages for the participants included in the program evaluation.

Table 4.5: Mobile Home Vintage Distribution

Building Vintage	%
Built before 1978	3.3%
Built between 1978 and 1992	23.7%
Built between 1993 and 2001	38.8%
Built between 2002 and 2005	34.3%
Built on or after 2006	0.0%
Total	100.0%

Table 4.6 shows the approximate age distribution. The data shows that the majority of participants are at or near retirement.

Table 4.6: Age Distribution Results

Age Bracket	Distribution
17 years or younger	7.2%
18 and 59	25.1%
60 or over	67.7%
Total	100.0%

Table 4.7 shows the approximate annual household income from all sources in 2005, before taxes. The data shows that approximately 92.3% of the participants are below the median income, which in Riverside County is currently $51,417. SCE's current threshold for low income households with one or two members is $28,600. Therefore, approximately 45.1% of the participant would be considered low income customers. However, this is likely a conservative estimate because the evaluators were forced to focus their data collection efforts on individually metered sites. The presumption is master metered parks tend to house residents with lower incomes.

Table 4.7: Income Distribution Results

Income Bracket	Distribution
Under $15,000	2.1%
$15,000 to less than $20,000	9.9%
$20,000 to less than $25,000	29.2%
$25,000 to less than $30,000	3.9%
$30,000 to less than $40,000	30.0%
$40,000 to less than $50,000	17.2%
$50,000 to less than $75,000	1.3%
$75,000 to less than $100,000	6.4%
$100,000 to less than $150,000	0.0%
Total	100.0%

4.2. Implementation Surveys

The evaluators surveyed the program managers to get their perspective of the program benefits, implementation challenges, best practices, measure performance, and general recommendations for improvements. The program managers surveyed have been working for ASC for at least 6 some, some as many as 20 years. The level of experience and expertise in the field and office is a critical element of any successful program.

The most important program benefits noted were helping the customer's reduce their energy cost and providing non-energy related services. According to the program manager, "We have provided a much needed service to many low and semi low income people that are struggling to get by. A lot are on fixed income and are just above the assistance level of most agencies. ASC's approach to providing energy conservation services to this sector of the population communicates a positive image of the utility as a company that looks out for the interest of their customers."

The foremost implementation challenge conveyed was marketing. ASC requested additional support from SCE and SCG for marketing the program to customers and park managers who have no prior experience with ASC. One of the barriers to participation was convincing participants of the program's legitimacy and intentions. Research has shown that personal contact, both face-to-face and over the phone, between utility staff and customers is one of the factors that contribute to high program participation (Nadel, Miriam, & Jordan, 1994). There were instances where a customer or park manager called the utility's help line and they were told by the operator that they had never heard of ASC or their program.

In 2005, ASC was one of the first to test and implement the latest automated data tracking and quality control system (eScan) developed by Honeywell-Enalsys Corp. The system digitally records temperature, humidity, pressure, and air flow with wireless sensors. The simultaneous measurement of all system parameters increases the accuracy of the field diagnostics, which should result in increase measure performance. After the field work is completed, the data is uploaded to the internet where it is processed and analyzed to verify the quality of the measure implementation. To meet their needs, ASC worked with Honeywell-Enalsys and The Energy Conservatory to develop a module for the Duct Test and Seal measure. All field technicians are using this system in the 2006-08 mobile home program. In March of 2006, the California Energy Commission approved this system for use in a third party quality control program[5].

ASC reported considerable problems with the Programmable Thermostats and recommended that they be dropped from the program. Older customers had a hard time programming them and often requested that an ASC technician return to the home to reprogram or remove the unit.

General recommendations from ASC are greater flexibility in implementing measures (i.e., give the people what they want), work to increase saturation, and coordinate marketing efforts with the utilities. One field manager noted that some monthly customer energy bills in master metered parks seemed to be significantly higher than expected without apparent reason.

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[5] The HomeEnalasys' Third Party Quality Control Program was created by the California Energy Commission to help develop a market that provides independent, cost-effective, and accurate verification of energy efficient equipment and measures.

5. Conclusions

This section presents the major findings and recommendations of the program evaluation. It begins with a summary of the measurement and verification results, and is followed by a discussion of the discrepancies between the ex ante and published savings estimates. Finally, the report closes with ex post net impacts, and recommendations for future program improvements and/or studies.

The results of the measurement and verification activities are the following:

- The onsite inspections demonstrated that the majority (71.5%) of the measure installations were installed per the program's specifications as reported to the CPUC. This discrepancy between reported and verified installations had more to do with retention (i.e., equipment removal, equipment failure, and performance test repeatable) and less to do with implementation. Still, to enhance the measure performance and program quality control, ASC has automated their testing and data collection procedures. For their 2006-08 program, they are utilizing Honeywell-Enalasys eScan technology.

- The evaluator found high customer satisfaction with the program. On a scale of 1 to 10, the program received a 9.4 for courteousness and professionalism of field technicians, and a 9.0 for overall program performance. Approximately 68.6% of the participants talk to their friends and neighbors about the benefits of the program. It was not uncommon during the post installation inspection for customers to ask about participating in the next ASC program.

- The customer survey and onsite inspections revealed that the program was reaching the hard-to-reach population specified in the program design[6]. Specifically, 67.7% of the participants were 60 years of age or older and approximately 45.1% of the customer's were low income. Also, it was determined that the program was having a positive impact on customer awareness of energy efficiency. The percentage of participants who became aware of an energy conservation measure as a result of the program is as followings: 21.4% of Programmable Thermostats; 17.9% for Low Flow Faucets: 30.4% for Water Saving Showerheads; 31.9% for Compact Fluorescent Lighting; 40.2% for AC Diagnostic and Tune-up; and 43.5% for Duct Test and Seal.

- The billing simulation showed that the net impact of the program was below expectations. For the sample analyzed, only the domestic hot water measures showed statistically significant savings. At the ex ante savings estimates, which were approximately 15% of the total site energy consumption for the mobile homes analyzed, the billing simulation model employed is a viable measurement and verification approach for estimating measure-level savings. However, with the post ante savings at or below 5% of the annual energy consumption the ability of the billing simulation model to distinguish between the

[6] The Energy Efficiency Policy Manual Version 2 defines "residential hard-to-reach" customers as those who do not have easy access to program information or generally do not participate in energy efficiency programs due to a language, income, housing type, geographic, or home ownership (split incentives) barrier. These barriers are defined as: (1) primary language spoken is other than English; and/or (2) customers who fall into the moderate income level (income levels less than 400% of federal poverty guidelines); and/or (3) multi-family and mobile home tenants; and/or (4) residents of areas other than the San Francisco Bay Area, San Diego, Los Angeles Basin or Sacramento; and/or (5) renters.

savings and the statistical noise is diminished. To improve on the billing simulation models, in an effort to more accurately evaluate the measure-level savings, additional sampling and field inspections were required. Unfortunately, such an undertaking was beyond the scope and budget of this report.

Given that the verified program accomplishments and observed discrepancy between actual (billing simulation) and expected (ex ante engineering estimates) load impacts, the next step was to compare the ex ante measure savings estimates to the most recent literature. From this investigation, two measures stood out - Programmable Thermostats and CFL installations. The specific discoveries are the following:

- The ex ante deemed savings of the Programmable Thermostat significantly overestimated the impact of the program. ASC and Cal-UCON based there ex ante savings on the 2001 DEER Update Study. However, the estimation methodology used by DEER has since changed. Rather than just looking at engineering estimates, the analysis included the results of a 2004 SCE study (Reeves & Hirsch, 2004) commissioned to evaluate the impact of behavioral changes associated with this measure. The study concluded that in many climate zones the installation of Programmable Thermostats actually increases energy consumption. These statistics were used in conjunction with computer simulation to revise the savings estimates in the 2004-05 DEER Update Study.

- The CFL ex ante savings are significantly higher than those found in the latest measure and program studies (KEMA, 2005 and LIEE, 2005). Both the baseline wattage and hours of usage were overestimated. The greatest discrepancies were with the mobile home retrofits, not the common area installations. The ex post measure savings were based on the KEMA report (2005), which investigated CFL's hours of usage and installation patterns. The study provides runtime estimates by location, fixture type, and control type. The overall kilowatt-hour realization rate for the CFL installations is 0.43. Also, summer coincident demand savings were, but should not be, claimed for fixtures that typically operate off peak – i.e., porch lighting and mobile home park street lighting.

In summary, the evaluators found that the program implementation was consistent with its design. Based on the contracted (i.e., ex ante) engineering estimates with installation verification only, the net ex post first year load impacts are 2,697.2 kW, 6,268,637 kWh/yr, and 439,916 Therms/yr. The subsequent first year net realization rates are 0.89 for kW, 0.87 for kWh, and 0.88 for Therms. However, erroneous assumptions resulted in unattainable projections of the program's load impacts. The effect of these factors reduced the total first year net savings to 2,683.3 kW, 3,236,038 kWh/yr, and 138,422 Therms/yr. The associated net realization rates are 0.88 for kW, 0.45 for kWh, and 0.28 for Therms.

Based on the evaluation field observations and research, the following program improvements are recommended:

- Target weather sensitive (i.e., HVAC) measures by climate zone. For example, the AC Diagnostic and Tune-up energy savings in Palm Desert (climate zone 15) is approximately five times greater than Rosemead (climate zone 8), and approximately twenty times greater than Torrance (climate zone 6).
- Use the most recent CFL Metering Study (KEMA, 2005) for future CFL ex ante savings. The report provides verified hours of operation by room type for residential lighting. The average hours of usage reported in the study is 2.3 hours per day. The study also reports

original incandescent wattages and typical CFL replacement wattages, and CFL peak diversity factors. Also, do not claim demand savings for fixtures that operate during off peak hours.

- Make sure all CFLs are installed by ASC technicians. Also consider installing CFLs in hard to reach fixtures since these are difficult for elderly citizens to reach and are often used more frequently than floor or table lamps.
- Mark Compact Fluorescent Lamps with a small sticker so that they can easily be distinguished from those installed before or after the program. Often it was difficult to identify the program fixtures given the variety of fixture types used. A similar practice is currently being implemented for the AC Diagnostic and Tune-up installations.
- Install CFLs with equal or higher lumen output. One of the most common reasons for removing an installed CFL was the lower light level. For example, replacing a 75 Watt table lamp with a 13 Watt CFL reduces the lighting output by approximately 25%.
- Conduct follow-up phone surveys in the months immediately following the installations to ensure there were no problems with the installed measures.
- Coordinate with local utility representatives to overcome marketing barriers that limit the program's reach. Personal contact between utility staff and customers (i.e., residents or mobile home park managers) has been cited as an important factor for increasing program participation (Nadel, Miriam, & Jordan, 1994).
- For futures program evaluations, whole building analysis (Option C) with sub-metering in both individually metered and master metered parks should be considered. At the percent reduction in whole building energy consumption at or below 5%, inferred by the billing simulation results and supported by the revised ex post deemed savings estimates, the EZ Sim billing simulation model does not have the necessary resolution to accurately quantify measure-level savings. If the evaluation budget is a limiting factor, verification should be based on the most recent and accurate engineering savings estimates and on-site installation verification.

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Appendix A: Sample Design

There are both process and impact evaluation objectives for this evaluation, each with slightly different sample size requirements. The sampling objectives are to estimate (1) certain participant population parameters such as customer satisfaction and (2) a realization rate for the major end uses implemented by program participants. It is assumed that approximately 4,000 mobile home residents will participate in the program. The desired relative precision for each of the two objectives is 10% at the 90% level of confidence.

A stratified random sampling approach was selected. Such a design produces a much smaller bound on the error of estimation than would be produced by a simple random sample of the same size. Strata will be defined using the Dalenius-Hodges technique (see Appendix A for the methodological details). The realizations rates for the sample of participants within each stratum were used to adjust the population of savings within each stratum.

Using equation 1, it was estimated that the sample of 300 would provide accurate estimates of such things as participant satisfaction at the 90/10 level of precision.

$$n_0 = \frac{z^2 \sigma^2}{d^2} \qquad (1)$$

where,

n_0 = required sample size without the finite population correction
t = critical value z associated with a certain level of confidence
d = desired level of accuracy
σ = is the standard deviation

When the sample is a substantial proportion (greater than 10 percent) of the population size, a finite population correction (fpc) factor can be used. This correction is calculated using Equation 2:

$$\mathrm{n} = \frac{\mathrm{n}_0}{1 + (\mathrm{n}_0/\mathrm{N})} \qquad (2)$$

where, N is the size of the population.

Note that for some measures and programs, a fpc correction was made that allowed for the use of somewhat smaller samples.

The sample size for on-site investigations was chosen to meet the need for reasonable statistical confidence and precision. The sample size was chosen to meet the targeted confidence level of 90 percent with an allowable relative error of 10 percent (Levy and Lemeshow, 1999) using the equation below.

$$n = \frac{z^2 \times N \times (V_x^2 + V_y^2 - 2\rho_{xy} \times V_x V_y)}{z^2 \times (V_x^2 \times V_y^2 - 2\rho_{xy} \times V_x V_y) + (N-1)\varepsilon^2} \quad (3)$$

where

z= the standard normal deviate for the given confidence level, specified as 1.645 for the 90 percent confidence

N= the population of projects

V_x^2 = the square of the coefficient of variation for x defined as $\frac{[(N-1)/N]s_x^2}{\hat{\bar{x}}^2}$ where s_x^2 is the variance of x and $\hat{\bar{x}}^2$ is the square of the estimated mean of x

V_y^2 = the square of the coefficient of variation for y defined as $\frac{[(N-1)/N]s_y^2}{\hat{\bar{y}}^2}$ where s_y^2 is the variance of y and $\hat{\bar{y}}^2$ is the square of the estimated mean of y

ρ_{xy} = assumed simple correlation between x and y (assumed to be 0.60)

ε^2 = the square of allowable relative error in the estimate of the ratio (0.075)

The sample size of 150, assuming a coefficient of variation of 0.75 and a simple correlation between x and y of 0.60, meets 90/09 level of confidence and precision.

Appendix B: Participant Survey Questions

Customer:____
Index#:___________________

Surveyor:____
Date:____________________

Program Satisfaction

S1. When the *AMERICAN SYNERGY* technicians came to your home, did they arrive on time and properly identify themselves?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

S2. How would you rate the crew in terms of being courteous and professional on a scale from 1 to 10?

01____RESPONSE (1 is low and 10 is high) 88____REFUSED 99____DON'T KNOW

S3. Was the work scheduled and completed within a reasonable timeframe?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

S4. Did the crew walk you through your home and provide Energy Savings Tips?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

IF YES, ASK FOLLOWING QUESTION

Please tell me one of the tips they provided? ______________________________________

S5. How would you rate the Energy Savings Tips on a scale of 1 to 10?

01____Response (1 is low and 10 is high) 88____REFUSED 99____DON'T KNOW

S6. To the best of your knowledge was everything installed correctly?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

S7. How would you rate the overall service you received on a scale from 1 to 10?

01____Response (1 is low and 10 is high) 88____REFUSED 99____DON'T KNOW

S8. How would you rate the program in terms of increasing your understanding of energy efficiency on a scale of1 to 10?

01____Response (1 is low and 10 is high) 88____REFUSED 99____DON'T KNOW

S9. Have you shared information with any of your friends or neighbors about the benefits offered in the program?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

S10. Do you have any suggestions to improve the program? ______________________________

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

If so, please provide the suggestion(s):

1. ______________________________

Habitation

H1. Do you live at this residence year round? (MUST LIVE AT ADDRESS AT LEAST 9 MONTHS OUT OF THE YEAR TO CODE AS "YES")

01____YES 02____NO 77____OTHER 88____REFUSED 99____DON'T KNOW

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Code: 0 = Unoccupied; 1 = Occupied

H2. When did you move to this address?

01________MONTH 02___________YEAR 77____OTHER 88____REFUSED 99____DON'T KNOW

H3. Do you own or rent the home?

01___Own 02___Rent 77____OTHER 88____REFUSED 99____DON'T KNOW

Recollection of Energy Efficiency Retrofits

It is our understanding that your energy survey was conducted in (INSERT MONTH FROM SAMPLE) of 2004. I'm going to read a list of energy conservation measures that were completed as a result of your participation in the program.

EEM	Database Code	Measure	a. Recall						b. Aware					
			01 -Yes	02- Some-what	03- No	77- Other	88- Refusal	99-Don't Know	01- Yes	02- Some-what	03- No	77- Other	88- Refusal	99- Don't Know
1	A/C	AC Diagnostic Tune-up												
2	D/S	Duct Test and Seal												
3	CFL	Compact Fluorescent												
4	Showerhead QTY	Water Saving Showerhead												
5	Faucet QTY	Low Flow Faucets												
6	WHTimer QTY	Water Heater Clocks												
7	WHType	Water Heating Measures												
8	TSQTY	Programmable Thermostats												

R1a. Do you recall these measures being installed?

IF "NO", "DON'T KNOW", OR "REFUSED" SKIP TO R2

R1b. **Before participating in the program**, were you aware these measures could save energy?

R9. Have (will) any of these measures be removed or disabled?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

Please explain why the measure(s) was removed:____

Awareness

A1. ENERGY STAR is a label or symbol applied to or associated with energy efficient appliances and products. Have you ever seen or heard of ENERGY STAR?

01____Yes 02____No 88____REFUSED 99____DON'T KNOW

A2. Over the years, the electric utilities and others have offered a variety of energy conservation programs. Not counting the program we have been talking about, are you aware of any other energy conservation or energy efficiency programs?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

A3. How did you learn about this program? [Don't read, check all that apply]

01____Community association
02____Word of mouth
03____A letter/call from [AMERICAN SYNERGY]
04____Outreach presentation [AMERICAN SYNERGY]
05 ____Other, specify:_______________

Internet Access

W1. Do you have access to the Internet?

01____YES 02____NO 88____REFUSED 99____DON'T KNOW

W2. From where do you have access to the Internet? [DON'T READ, CHECK ALL THAT APPLY]

01____HOME
02____OFFICE
03____LIBRARY
04____FRIEND'S/NEIGHBOR'S HOUSE
05____OTHER, SPECIFY______________________

Demographics Characteristics

D1. In what year was your home built?

________________YEAR 88____REFUSED 99____DON'T KNOW

D2. Was it built . . . [If unsure about the year]?

1____Withing Last 6 years (since 2000)
2____Between 1990 and 1999
3____Between 1980 and 1989
4____Between 1970 and 1979
5____Between 1960 and 1969
6____Between 1950 and 1960
7____Between 1940 and 1949
8____Before 1940
88____REFUSED
99____DON'T KNOW

D3. How many square feet of living space do you now have?

_________SQUARE FEET 88____REFUSED 99____DON'T KNOW

D4. Is it . . . [If unsure about the square footage]

01____Less Than 800
02____800 to less than 1,000
03____1,000 to less than 1,250
04____1,250 to less than 1,500
05____1,500 to less than 1,750
06____1,750 to less than 2,000
07____2,000 to less than 2,250
08____2,250 to less than 2,750
09____2,750 to less than 3,000
10____3,000 to less than 3,500
11____3,500 to less than 4,000
12____Or over 4,000
88____REFUSED
99____DON'T KNOW

D5. How many people live at this residence?

_______NUMBER OF PEOPLE 88____REFUSED 99____DON'T KNOW

D6. In terms of the ages of these residents

a. How many are 17 years or younger? ______
b. How many are between 18 and 59? ______
c. How many are 60 or over? ______
88____REFUSED
99____DON'T KNOW

D7. What is the approximate annual household income from all sources in 2005, before taxes? This information will be kept confidential.

01____Under $15,000
02____$15,000 to less than $20,000
03____$20,000 to less than $25,000
04____$25,000 to less than $30,000
05____$30,000 to less than $40,000
06____$40,000 to less than $50,000
07____$50,000 to less than $75,000
08____$75,000 to less than $100,000
09____$100,000 to less than $150,000
10____Over $150,000
88____REFUSED
99____DON'T KNOW

D8. What is the highest level of education you have completed?

01____Less than High School
02____Some High School
03____High School Graduate
04____Trade or Technical School
05____Some College
06____College Graduate
07____Some Graduate School
08____Graduate Degree
88____REFUSED
99____DON'T KNOW

D9. Which of the following best describes your racial or ethnic background?

01____Hispanic
02____African American
03____Caucasian
04____Asian American
05____Native American
06____Multi-racial
77____OTHER (PLEASE SPECIFY:______________________________)
88____REFUSED
99____DON'T KNOW

Appendix C: Implementation Survey

AD1. Please describe your role in the 2004/2005 program – i.e., title, responsibilities, etc.? How long have you been working for AMERICAN SYNERGY or Cal-UCONS in the field of energy efficiency?

AD2. From your perspective, what are the most important benefits of the 2004/2005 program? Please provide anecdotal examples that highlight these benefits?

AD3. From your perspective, what were some of the implementation challenges in the 2004/2005 program – i.e., marketing, measure installation, program management, EM&V, etc.? What are your recommendations for overcoming these challenges?

AD4. What type of quality control practices are in place in 2004/2005? What more could be done in this area?

AD5. Which measures were most problematic in 2004/2005? Please a provide a brief description of the problem(s) and your recommendation(s) for overcoming it.

AD6. Are there any energy conservation measures that you believe should be added to or removed from the program offerings? Please explain why this measure(s) should be added or removed.

AD7. In general, what changes do you recommend to improve the program performance, as it relates to increasing participation, customer satisfaction, measure installation, equipment, data management and/or administrative efficiency?