Moderate Income Comprehensive Energy Efficiency Program Evaluation

Robert Mowris, Verified, Inc., Olympic Valley, CA
Ean Jones, Verified, Inc., Olympic Valley, CA

Abstract

Evaluation results are provided for a moderate income comprehensive whole building energy efficiency program implemented in California. Evaluation software was used to verify proper installation, support coordination of the program, and as a tracking and accounting management tool. The program goals were to serve 6,000 residential customers and directly install 326,870 square meters of attic insulation (50% penetration) and 51,630 energy efficiency measures to achieve net energy savings of 5.2 first-year GWh, 2.75 MW, 65.7 first-year TJ, 65.9 lifecycle GWh and 1,142 lifecycle TJ. The program exceeded its measure installation goals by 50% and electricity savings goals by 28%, but fell short by 8% on first-year and 16% on lifecycle gas savings. Accomplishments were verified by randomly inspecting 8,488 square meters of attic insulation and 1,763 energy efficiency measures at 158 customer sites, installing light loggers on 1,244 fixtures at 69 sites, evaluating billing data for 58 sites, and conducting surveys of participants and non-participants. Net savings are based on pre and post-retrofit utility billing data, light logger data, previous studies, and building simulations calibrated to normalized billing data. Survey results indicate 85% of participants are satisfied with the program. Ninety seven percent of non-participants would have participated if they had known about the program and were eligible. Three out of four moderate income households did not meet the income eligibility requirements and could not participate in the program. Non participants did not have sufficient financial resources to pay a contractor to improve the energy efficiency of their homes.

Introduction

According to the US Energy Information Agency there are 113.6 million residential housing units in the United States and 51.2 million or 45.1% are moderate income households with total annual income less than $40,000 per year (USEIA 2009). The annual energy used by moderate income households in the United States is approximately 4.7 Exajoules (EJ) or 42.7% of total residential energy use. The breakdown of moderate income end use energy consumption is shown in **Figure 1**. The potential savings from energy efficiency improvements varies from 25 to 75 percent depending on end use (Rufo 2002).

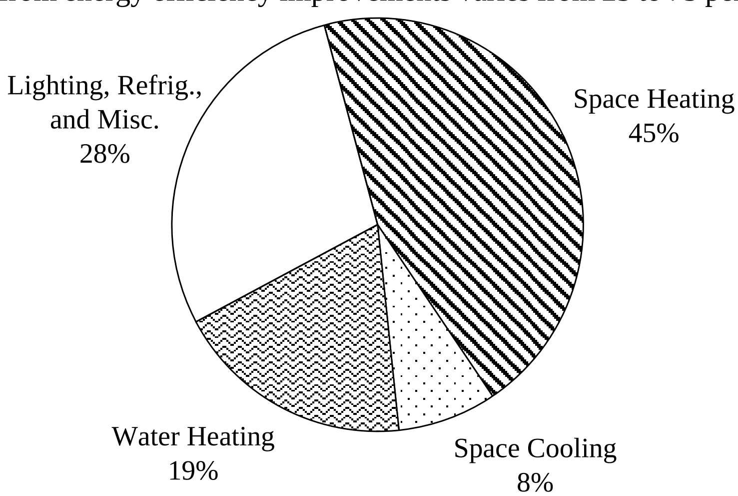

Figure 1. Moderate Income End Use Energy Consumption (Source (USEIA 2005)

This paper presents findings from an evaluation, measurement, and verification (EM&V) study of a Moderate Income Comprehensive Attic Insulation Program (MICAP) implemented in Northern California by BO Enterprises, Inc. (Mowris 2008). The program goal was to offer energy efficiency services to moderate income customers who are between 175% and 400% of the Federal Poverty Guidelines in terms of annual household income. The MICAP income eligibility starts at 175% of the Federal Poverty guidelines or 200% for seniors, and ranges, on a sliding scale determined by number of household members, up to 400% of Federal Poverty Guidelines. The 2004 Federal Poverty Guidelines are provided in **Table 1**.

Table 1. 2004 Federal Poverty Guidelines

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

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

The MICAP income eligibility guidelines are shown in **Table 2**.

Table 2. MICAP Eligibility Lower and Upper Limits Guidelines

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

The California Public Utilities Commission (CPUC) definition of "moderate-income" is "…all income levels less than 400% of Federal Poverty Guidelines." Three out of four moderate income households who wanted to participate in MICAP did not meet the income eligibility requirements for the program (all were below 200%). Low-income families rejected by MICAP might not receive energy efficiency services for years and possibly decades. According to the implementation contractor, referrals to the utility Low Income Energy Efficiency (LIEE) programs aren't effective since the referrals exceed weekly maximum by 300 percent. Should equity protect hard-to-reach customers who have contributed to public goods surcharge funds from exclusion from MICAP because they are too poor? This shouldn't represent a conflict between LIEE and MICAP since all the LIEE providers are MICAP subcontractors for their respective county territories. Since up to 18% unemployment exists in the area and the typical LIEE allocation is 300 low-income units per year, low-income eligible households will never become scarce. Other non-LIEE Energy Efficiency programs by utilities and third parties serve low-income households. If the MICAP can provide services to both LIEE and non-LIEE customers, then fewer hard-to-reach customers will be ineligible for services and the program will be more successful in reaching a larger cross section of customers who desperately require energy efficiency services to save energy and reduce their bills.

The MICAP installed 330,906 m^2 of attic insulation and 77,738 energy efficiency measures at 6,570 moderate income customers to reduce energy used for heating, cooling, water heating, and lighting. Ex post accomplishments were verified by conducting random inspections of energy efficiency measures installed at 158 customer sites. Light loggers were installed at 69 sites to measure hours of operation. Load impact findings are presented based on calibrated building energy simulations and electric and gas utility billing data for 58 sites. Process evaluation recommendations are provided based on interviews with 70 participants and 68 non-participants.

Description of Energy Efficiency Measures

The program installed ten energy efficiency measures as described in **Table 3**. Estimated ex ante savings are from the Database for Energy Efficiency Resources (Itron 2005).

Table 3. Energy Efficiency Measure Description and Ex Ante Savings

Measure	Description	Ex Ante Savings
Attic Insulation	For 50% of participants, R-30 or greater attic insulation was blown-in to uninsulated attics or attics with existing insulation less than R-11	20 to 30% for cooling and heating
Energy Star® Compact Fluorescent Lamp (CFL)	Replaces incandescent lamp with similar lumen CFL	75%
Energy Star® CFL Torchiere	Replaces incandescent floor lamp torchiere with CFL	75%
HVAC Diagnostic Tune-up	Clean condensing coils, new air filters, correct refrigerant charge and airflow on central air conditioners and heat pumps	10 to 20%
Duct Test and Seal	Pressurize supply and return ducts and seal with UL-approved mastic or tape. Reduce leakage 10 to 40% at pressure of 25 Pa	5 to 20%
Energy Star® Programmable Thermostat	Replace manual thermostat with programmable thermostat having summer setup from 25.6C to 29.4C from 9AM to 6PM during weekdays and winter setback from 25.6F to 18.3C.	8% cooling and 9% heating
Water Efficient Showerheads	Replace >9.5 liter per minute (lpm) with 7.6 lpm flowing at 550 kPa pressure	20% of flow and 6.5% of end use
Water Efficient Aerators	Replace >9.5 liter per minute (lpm) with 7.6 lpm flowing at 550 kPa pressure	20% of flow and 2% of end use
Water Heater Tank Insulation	Install R-8 insulation blanket on tank	6% of end use
Pipe Insulation	Install R-4 pipe insulation on cold and hot water pipes at tank up to first bend	2.5% of end use

Evaluation Approach

The EM&V approach is based on the *International Performance Measurement & Verification Protocols* (USDOE 2002). On-site measurement and verification inspections and surveys were conducted for a statistically significant random sample of participants. Ex post energy savings for each measure were determined using the appropriate IPMVP Option defined in **Table 4**.

Table 4. IPMVP EM&V Options

EM&V Option	Savings Calculation	Typical Applications
Option A. Partially Measured Retrofit Isolation Stipulated savings are based on partial or short-term field measurement of energy use of systems to which a measure is applied, separate from site energy use.	Engineering calculations using short term post-retrofit measurements or stipulations.	Pre and post values are measured and energy savings are based on stipulated savings times the ratio of average ex post to ex ante values.
Option B. Retrofit Isolation Savings are determined by field measurement of the energy use of systems to which the measure is applied; separate from the energy use of the facility.	Engineering calculations using short term or continuous measurements	Electricity use is measured to verify pre- and post-retrofit power. Hours of operation are estimated using light loggers or stipulated values.
Option C. Whole Facility Savings are determined by measuring energy use at the whole facility level based on billing data.	Analysis of utility meter or sub-meter data using comparison or regressions.	Weather-sensitive energy savings are based on utility billing data for pre and post retrofit period.
Option D. Calibrated Simulation Savings are determined through simulation of the energy use of the whole facility calibrated to hourly, monthly, or annual data (utility or site data).	Energy use simulation, calibrated with hourly, monthly utility billing data and/or end-use metering.	Energy savings are based on calibrated simulations using pre and post utility billing data.

A description of the measurement and verification approach for each measure is provided in **Table 5**. IPMVP Options A, B, C, and D were used to evaluate energy and peak demand savings. Measurements were short-term, and some, but not all parameters were stipulated, as long as the total impact of possible stipulation errors was not significant to the resultant savings.

Table 5. Measurement and Verification Approach for MICAP Measures

Measure	IPMVP Option	Measurement and Verification Approach
Attic Insulation	A, C, D	Evaluated energy savings for the sample based on verification of proper installation and measurements of pre- and post-retrofit insulation thickness and R-value. Ex post savings based on calibrated eQUEST simulations.
Duct Seal	A, C, D	Evaluated energy savings for the sample based on verification of proper sealing methods and measurements of pre and post-retrofit duct leakage with duct pressurization equipment. Ex post savings based on calibrated eQUEST simulations.
AC Diagnostic Tune-up	A, C, D	Evaluated energy savings for the sample based on field measurements of pre- and post-retrofit refrigerant charge and airflow adjustments (i.e., temperature split, superheat, subcooling). Ex post savings based on calibrated eQUEST simulations.
Energy Star® Programmable Thermostat	A, C, D	Evaluate energy savings for sample based on verification of proper installation and participant interviews to obtain pre-retrofit cooling and heating thermostat schedules. Ex post savings based on calibrated eQUEST simulations.
Showerhead/Aerator	A, B	Evaluated energy savings based on field measurements of pre- and post-retrofit flow rates compared to ex ante assumptions.
Water Heater Blanket	A, B	Evaluated energy savings for the sample based on verification of pre- and post-retrofit R-value and proper installation compared to ex ante assumptions.
Water Heater Pipe Insulation	A	Evaluated energy savings for the sample based on verification of pre- and post-retrofit R-value and proper installation compared to ex ante assumptions.
Energy Star® CFL	A, B	Evaluated energy savings for the sample based on verification of pre and post-retrofit wattage and participant reported hours of operation and lighting logger data compared to usage factors from other studies.
Energy Star® CFL Torchiere	A, B	Evaluated energy savings for the sample based on verification of pre and post-retrofit wattage and participant reported hours of operation and lighting logger data.

Statistical analyses are used to extrapolate energy and peak demand savings at the sample level to the program level. On-site data collection included inspections, field measurements, and process surveys to verify measure installations, investigate operational characteristics, and develop recommendations to improve the program. Process surveys included questions to evaluate retention of energy education information provided to participants by the program as well as questions to evaluate customer satisfaction and the program delivery.

Approximately 158 participants were randomly selected for on-site audits to measure energy efficiency performance, quality, and persistence of installed measures. The on-site inspections included verification and pre- and post-measurements for the energy efficiency measures. Load impacts for weather-sensitive measures are based on field measurements, engineering analysis, historical billing data (Fels 1995), and eQuest/DOE-2.2 building simulations calibrated to utility data (Hirsch 2002). Load impacts for CFLs are based on wattages of old incandescent lamps versus new CFLs and hours of operation based on participant-reported information and lighting loggers installed at a random sample of sites. Load impacts for showerheads and aerators are based on deemed savings times the ratio of the ex ante assumed flow rate divided by the ex post average measured flow rate. Load impacts for pipe insulation and water heater blankets are based on deemed savings and the proportion of verified measures found during field inspections.

Load Impacts for All Measures Based on IPMVP Option C

Load impacts for all measures are evaluated using historical billing data and the PRInceton Scorekeeping Method (PRISM) consistent with IPMVP Option C (Fels 1995). At least two years of historical electric and gas billing data were obtained for a sample of 58 participant sites. The billing data are evaluated in the PRISM statistical regression model to develop normalized energy savings (NEC) and normalized annual consumption (NAC) for electricity and natural gas (see **Figure 2**). The average PRISM cooling savings per site are 982 ± 361 kWh per year or 8.5 ± 3.3 % of the total kWh NAC. This is 12.7% higher than the ex ante electricity savings of 871 kWh per year per site.[1] The average PRISM heating savings per site are 9.9 ± 1.8 GJ per year or 17.1 ± 2.7% of the gas NAC. This is 10% lower than the ex ante gas savings of 11 GJ per year per site.[2]

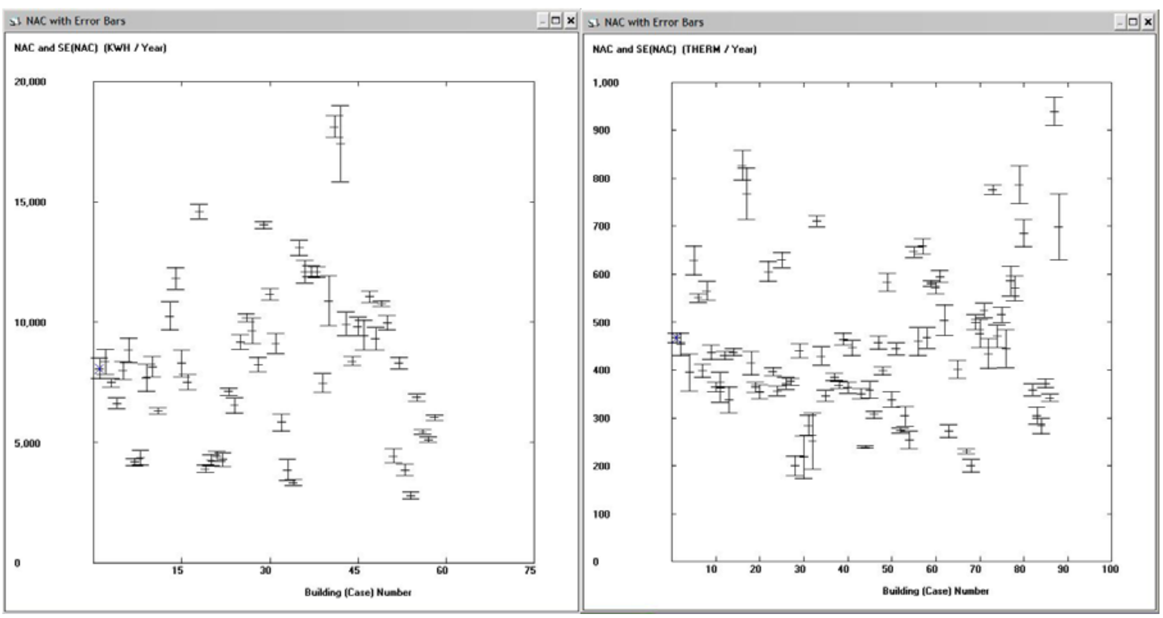

Figure 2. PRISM Normalized Annual Consumption for Electricity and Natural Gas

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

Load impacts for weather sensitive measures are evaluated using calibrated eQuest building

1 Ex ante savings of 871 kWh per year are based on 5,224,911 kWh per year divided by 6,000 sites.
2 Ex ante savings of 10.4 GJ/year are based on 62,261 GJ per year divided by 6,000 sites.

energy simulations consistent with IPMVP Options D (Hirsch 2002). The weather sensitive measures include attic insulation, HVAC Diagnostic tune-ups, duct sealing, and Energy Star® thermostats. The eQUEST baseline simulations are calibrated to historical billing data and on-site data. The baseline cooling and heating Unit Energy Consumption (UEC) are shown in **Table 6**. The average cooling UEC based on billing analysis is 2,445 ± 74 kWh per year and the average heating UEC is 33.8 ± 1.6 GJ per year. The 2005 DEER Update Study provides an average UEC of 1,918 kWh per year and 38.8 GJ per year. The average ex ante baseline UEC is 2,529 kWh per year and 37.9 GJ per year.

Table 6. Baseline Cooling and Heating Unit Energy Consumption

CEC	CEC	Ex Post	Billing Data		DEER 2005		Ex Ante R-5 Baseline	
Forecast Zone	**Climate Zone**	**% Savings**	**Cooling kWh**	**Heating GJ**	**Cooling kWh**	**Heating GJ**	**Cooling kWh**	**Heating GJ**
2	**12**	7.2%	2649	33.4	2006	38.5	1393	44.3
3	**11**	63.6%	3160	35.3	2479	40.7	3367	36.5
4	**4**	7.1%	1649	28.6	1177	32.9	900	36.2
5	**3**	22.1%	591	34.6	524	39.9	1,028	42.9
Average			2445	33.8	1918	38.8	2529	37.9

The eQUEST residential single family prototype is taken from the 2005 DEER Update Study (see **Figure 7**). The models were calibrated to average space cooling and heating UEC values from the billing data (i.e., PRISM) using Typical Meteorological Year (TMY) weather data for CEC climate zones 3, 4, 11 and 12 (CEC 1993). The baseline and Energy Star® thermostat schedules are shown in **Table 7**. The baseline thermostat schedule is the average schedule from the on-site inspections. The eQUEST building characteristics are shown in **Table 8**.

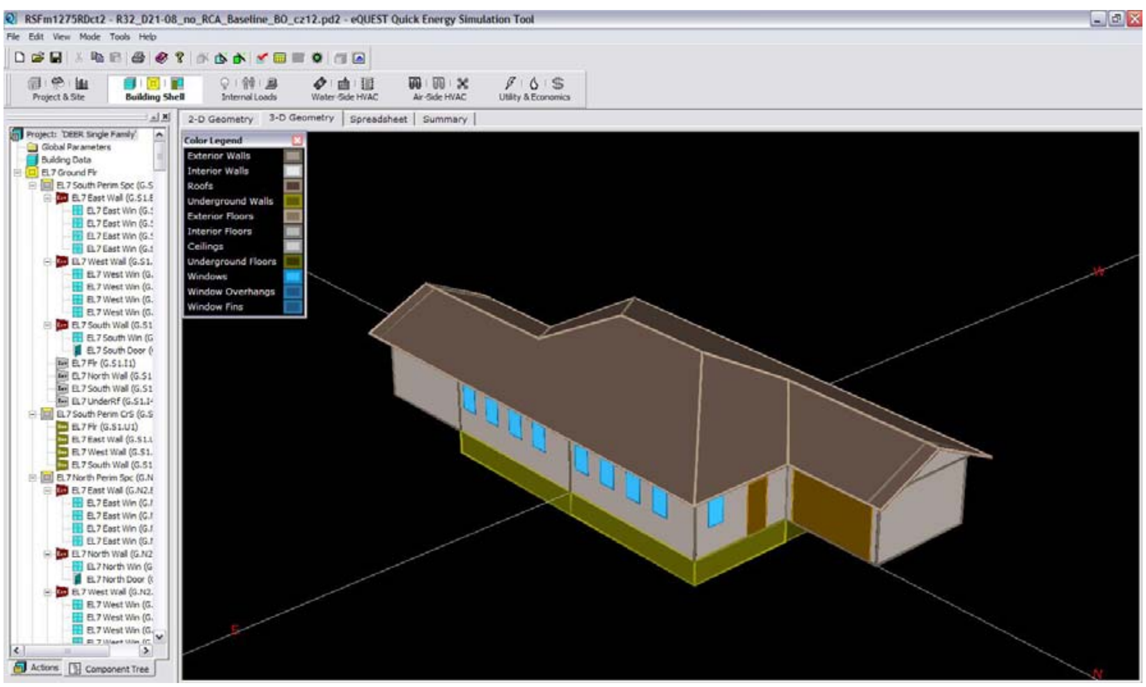

Figure 7. eQUEST Residential Single Family Prototype Based on 2005 DEER Study

Table 7. Baseline and Energy Star Thermostat Schedules (°C)

	Hours per day															
Description	**1-9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Baseline Cool	27	26	26	25	25	25	25	25	25	24	24	25	25	25	26	26
Baseline Heat	21	21	20	20	20	20	20	20	20	20	20	20	20	20	20	19
Energy Star® Cool	26	26	29	29	29	29	29	29	29	29	29	26	26	26	26	26
Energy Star® Heat	10	10	18	18	18	18	18	18	18	18	18	18	18	18	10	10

Table 8. Residential Building Prototype Characteristics (DEER 2005)

Characteristic	**Existing Vintage**
Vintage	Pre-1978
Total Floor Area (ft^2)	112.6 m^2
Average Floor Height	2.4 m
Wall R-value [cavity only] (Km^2/W)	Total R-0.912 [R-1 cavity]
Wall Type	Wood Frame
Ceiling R-value [cavity] (Km^2/W)	Total R-1.182 [R-5 cavity]
Ceiling Area, total exterior (ft^2)	113 m^2
Floor R-value [cavity] (Km^2/W)	Total R-0.97 (over Crawl Space)
Window-to-Floor Area Ratio	14%
Window u-value (W/m^2K)	6.98
Number of Panes	1
Occupancy (people)	3
Lighting Intensity (W/ft^2)	16.1 W/m^2
Electric Internal Loads (W/ft^2)	9.8 W/m^2
HVAC Zoning	Single zone
Heating System Type	Gas furnace
Heating Capacity (kW-unit)	14.65 kW
Heating System Efficiency	0.70
Cooling System Type	Split
Cooling Capacity, (kW-unit)	8.79 kW
Cooling System SEER	8.5 SEER
Design Air (l/m^3)	274.4 l/m^3

The calibrated eQuest simulations and engineering analyses yield average ex post savings per site of 943 ± 78 kWh per year, 0.486 ± 0.03 kW and 11.2 ± 0.63 GJ per year. This represents 8.2 ± 0.7 % of the total kWh NAC. This is 8.2% higher than the ex ante electricity savings of 871 kWh per year per site. The heating savings per site are 20.5 ± 1.1% of the gas NAC. This is 7.7% higher than the ex ante gas savings of 10.4 GJ per year per site. These savings are comparable to results obtained using PRISM.

Summary of EM&V Load Impact Findings

The program ex ante goals were to reach 6,000 residential customers in the Northern California investor-owned utility service area, perform an energy audit, directly install 326,860 square meters of attic insulation and 51,630 energy efficiency measures, and conduct follow-up activities to achieve net ex ante energy savings of 5,224,911 first-year kWh, 2,746 kW, 65,689 first-year GJ, 65,861,867 lifecycle kWh and 1,142,203 lifecycle GJ. The program exceeded its measure installation goals by 50% and electricity savings goals by 28%, but fell short by 8% on first-year and 16% on lifecycle gas savings goals as shown in **Table 9**. The program installed 330,895 square meters of attic insulation and 77,738 energy efficiency measures at 6,570 moderate income residential customers. Ex post accomplishments were verified by checking the tracking database, randomly inspecting 8,488 square meters of attic insulation and 1,763 energy efficiency measures at 158 customer sites (90 more than anticipated and budgeted), installing light loggers on 1,244 fixtures at 69 sites, evaluating billing data for 58 sites, and conducting surveys of participants, non-participants, and non-contacts.

Table 9. Ex Ante Goals and Ex Post Achievement

Description	**Ex Ante Goal**	**Ex Post Achievement**
Total Direct Install Measures		
Attic Insulation (m^2)	326,860	330,895
AC Diagnostic	1,400	1,651
Duct Seal	900	1,060
Aerators	10,800	13,978
Showerhead	5,760	7,848
Energy Star® CFL Torchiere	1,150	1,606
Water Heater Blanket	720	979
Pipe Insulation	360	10
Energy Star® CFL (15, 20, 24W)	30,000	49,462
Energy Star® Thermostat	900	1,146
Moderate Income Energy Education and Direct Installations	6,000	6,570
Net Annual Electricity Savings (kWh/yr)	5,224,911	6,682,098
Net Demand Savings (kW)	2,746	2,934
Net Annual Therm Savings (GJ/yr)	65,689	60,424
Net Lifecycle Electricity Savings (kWh)	65,861,867	66,518,557
Net Lifecycle Gas Savings (GJ)	1,142,203	960,333
Total Resource Cost (TRC) Test – EEGA Workbook	**1.59**	**1.52**
Total Resource Cost (TRC) Test – E3 Calculator		**2.71**
Participant Test	**7.16**	**6.83**

The net ex post Total Resource Cost (TRC) test benefit-cost ratio is 1.52 based on the CPUC Energy Efficiency Groupware Application (EEGA) Workbook (Intergy 2004). The energy efficiency measures reduce air conditioning usage which contributes 33 percent to California's peak electricity demand (Brown 2002). The EEGA workbook doesn't include peak demand avoided costs. The TRC benefit cost ratio is 2.7 based on the E3 calculator which includes the peak demand avoided costs (E3 2004).

The EM&V study found first-year net ex post program savings of 6,682,098 ± 554,912 kWh per year, 2,934 ± 184 kW per year, and 60,424 ± 3,372 GJ per year at the 90 percent confidence level. The net realization rates are 1.28 ± 0.08 for first-year kWh, 1.07 ± 0.06 for kW, and 0.92 ± 0.05 for first-year GJ. The gross ex-ante lifecycle savings are 76,841 MWh and 1,283,374 GJ. The net ex-post lifecycle savings are 66,519 ± 4,226 MWh and 960,333 ± 51,061 GJ. The lifecycle ex-post net lifecycle kWh realization rate is 1.01 ± 0.06 and the net lifecycle therm realization rate is 0.84 ± 0.04.

Differences between ex ante estimates and ex post accomplishments are due to the 16-year effective useful life (EUL) assumed for the Energy Star® CFL torchieres. The EUL value for this measure was reduced to 11 years based on light logger data. The 15W, 20W, and 24W Energy Star® CFL EUL values were reduced from 8 years to 6 years based on light logger data. The average ex post operating hours are 1,624 ± 298 hours/yr based on light logger data for 1,173 fixtures at 66 sites. The net ex post first-year gas savings are 60,424 ± 3,372 GJ and this is 16% lower than the ex ante estimate.3 The difference is largely due to lower ex post gas savings for attic insulation based on unavailability of R-0 to R-30 attic insulation measures (i.e., lack of attics without any insulation). The program implementers assumed they would install 74,527 m^2 of R-0 to R-30 attic insulation and 252,333 m^2 of R-5 to R-30 insulation. The program actually installed 27418 m^2 of R-0 to R-30 (63.2% less than assumed) and 298,267 m^2 of R-5 to R-30 insulation (18.2% more than assumed).

---

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

The program also installed 5,211 m^2 of R-15 to R-30 attic insulation. The program installed 330,895 m^2 of attic insulation and exceeded its attic insulation goal by 1.2%.

Process Evaluation Demographics and Findings

The average MICAP participant household income was \$25,871 ± \$4,202, and 96% owned their home with average conditioned floor area of 1,341 ft^2 ± 50 ft^2. The average number of occupants per home is 3.9 ± 0.4. The average energy efficiency retrofit cost was \$597 to \$1224 per home depending on the number of measures installed (including marketing, administration, materials, installation, and evaluation costs). Approximately 2,660 homes received all of the comprehensive measures including R-30 (5 cm) of blown-in cellulose attic insulation, Energy Star® programmable thermostats, air conditioning tune-ups, duct sealing, low-flow showerheads, low-flow aerators, compact fluorescent lamps, water heater blankets, and pipe insulation.

Participant and non-participant process surveys were used to obtain general feedback and suggestions. Survey results indicate 85 percent of participants are satisfied with the program based on 624 survey responses to 35 questions from 70 randomly selected participants. One hundred percent of participants expressed appreciation for the program since they did not have sufficient capital to invest in improving the energy efficiency of their homes. Process survey responses indicated significant demand for the program with an overall satisfaction rating of 8.5 ± 0.1 out of 10 points. Participants indicated that they want the program to continue serving moderate income customers throughout California. Non-participant survey results indicate 97 percent would have participated if they had known about the program and were eligible. Most indicated better advertising would have helped. Three out of four moderate income households did not meet the income eligibility requirements and could not participate in the program. Survey results of non participants indicated that they did not have sufficient financial resources to pay a contractor to improve the energy efficiency of their homes.

Process survey results, on-site verification inspections, and field measurements were used to guide the overall process evaluation in terms of investigating operational characteristics of the program and developing specific recommendations to help make the program more cost effective, efficient, and operationally effective. The most important process recommendations are as follows.

- Increase attic insulation to R-38 and install radiant barriers to reduce solar heat gain to attics where ducts and cooling equipment are located to reduce cooling loads. The program installed 0.0929 m^2 of venting per 55.7 m^2 of attic area. To further reduce cooling loads, attic venting should be doubled.
- Educate customers about comparable CFL replacements in terms of lumens. Offer more types of CFLs (i.e., color temperature, reflector, dimmable, long-life) to increase savings and acceptance.
- Install occupancy sensors for lighting and plug loads and enable Energy Star® saving mode on LCD high-definition television sets.
- Install pressure-compensating WaterSense™ low-flow showerheads and aerators to increase customer satisfaction and maintain consistent flow from 140 to 550 kPa flowing pressure.
- Capture pre-retrofit thermostat schedules in the database, provide simple instructions in various languages for Energy Star® thermostats, and consider placing a toll-free number on the thermostats for participants to call if they have any questions.
- Continue and expand the program throughout California and offer more measures such as wall insulation, ceiling fans, whole house fans and high performance windows. Provide better advertising to increase participation including handouts or fliers from the utility that tell customers about the program, funding source, and free services.
- Three out of four moderate income households did not meet the income eligibility requirements and could not participate in the program. Non participants did not have sufficient financial resources to pay a contractor to improve the energy efficiency of their homes. The program should be continued

and expanded to serve more moderate income customers, save energy and peak electricity demand, and reduce carbon dioxide emissions.

Conclusions

The EM&V study verified the installation of 330,895square meters of attic insulation and 77,738 energy efficiency measures at 6,570 moderate income residential customers. The study found first-year net ex post program savings of 6,682,098 kWh per year, 2,934 kW per year, and 60,424 GJ per year at the 90 percent confidence level. The program exceeded its measure installation goals by 50% and its electricity savings goals by 28%, but fell short by 8% on first-year and 16% on lifecycle gas savings goals. The ex post first-year gas savings are 16% lower than the ex ante estimate based on lower gas savings for attic insulation due to unavailability or lack of attics without insulation. Although the program installed less R-0 to R-30 attic insulation, the program installed 326,870 square meters of attic insulation and exceeded its attic insulation goal by 1.2%. The program achieved a 50% attic insulation penetration rate which is 5.5 times greater than the average 9% attic insulation penetration rate for California's Low-Income Energy Efficiency programs. Likewise, measure installations exceeded goals by 50% with 77,738 energy efficiency measures verified instead of the proposed 52,630. If not for the initial over-estimation of empty attics, the program would have exceeded all program goals. The average energy efficiency retrofit cost was $597 to $1224 per home depending on the number of measures installed including overhead for marketing, administration, materials, installation, and evaluation. The program total resource cost test ratio is 2.7 including the avoided costs of peak demand savings. Survey results indicate 85 percent of participants are satisfied with the program. Survey responses indicated significant demand for the program with an overall satisfaction rating of 8.5 +/- 0.1 out of 10 points. Participants indicated that they would like the program continued to serve customers throughout California. Ninety seven percent of non-participants would have participated if they had known about the program and were eligible. Three out of four moderate income households did not meet the income eligibility requirements and could not participate in the program. Non participants did not have sufficient financial resources to pay a contractor to improve the energy efficiency of their homes. The program should be continued and expanded to serve more moderate income customers, save energy and peak electricity demand, and reduce carbon dioxide emissions.

References

Brown, R.E. and Jonathan G. Koomey, 2002. Electricity Use in California: Past Trends and Present Usage Patterns, Review Draft, Lawrence Berkeley National Laboratory, LBNL-47992.

California Energy Commission. 1992. California Thermal Climate Zones. Sacramento, CA.

Energy and Environmental Economics, Inc. (E3). 2008. E3 Calculator. San Francisco, Calif. 94104. Available online: http://www.ethree.com/cpuc_cee_tools.html.

Fels, M., Kissock, K., Marean, M., Reynolds, C. 1995. PRInceton Scorekeeping Method (PRISM) Advanced Version 1.0 User's Guide. Princeton University Center for Energy and Environmental Studies. Princeton, NJ.

Hirsch, J. J. 2002. eQuest and DOE-2.2 Building Energy Simulation Program. Version 3.37, Copyright J.J. Hirsch. Camarillo, California.

Intergy Corporation. 2004. EEGA Workbook Validator (version 3.8). Prepared for the California Public Utilities Commission, San Francisco, Calif: Available online: http://eega.cpuc.ca.gov/.

Itron, Inc., 2005. 2005 Database for Energy Efficiency Resources (DEER) Update Study, prepared for Southern California Edison, prepared by Itron, Inc., Vancouver, Washington. Available online: www.deerresources.com.

Mowris, R., Jones, E. 2008. Evaluation, Measurement, and Verification Report for the Moderate Income Comprehensive Attic Insulation Program #1082-04, prepared for the California Public Utilities Commission, prepared by Robert Mowris & Associates, Olympic Valley, Calif. Available online: http://www.calmac.org.

M. Rufo, F. Coito. 2001. California's Secret Energy Surplus: The Potential For Energy Efficiency. Prepared for the Energy Foundation and The Hewlett Foundation. Prepared by Xenergy, Inc., Oakland, CA. Available inline: http://www.ef.org/documents/Secret_Surplus.pdf.

United States Department of Energy (USDOE). 2002. *International Performance Measurement & Verification Protocols: Concepts and Options for Determining Energy and Water Savings. Volume I.* DOE/GO-102000-1132. Washington, D.C.: United States Department of Energy.

United States Energy Information Agency (USEIA). 2005. Residential Energy Consumption Survey. Washington, D.C.: http://205.254.135.7/consumption/residential/data/2005/index.cfm#summary.

United States Energy Information Agency (USEIA). 2009. Residential Energy Consumption Survey. Washington, D.C.: http://205.254.135.7/consumption/residential/data/2009/.