

# **Evaluation Measurement and Verification Report for the Efficient Affordable Housing Program #255-02**

**Study ID: HMG0001.01**

## **FINAL REPORT**

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## TABLE OF CONTENTS

1. Executive Summary .....	1
2. Required CPUC Objectives and Components .....	5
2.1 Baseline Information .....	5
2.2 Energy Efficiency Measure Information .....	7
2.2.1 Measure Assumptions and Intended Results .....	8
2.2.2 Description of Energy Efficiency Measures .....	8
2.3 Measurement and Verification Approach .....	8
2.3.1 M&V Approach for Load Impact Evaluation .....	9
2.3.2 Sampling Plan .....	11
2.3.3 M&V Approach for Process Evaluation .....	12
2.4 Evaluation Approach .....	12
2.4.1 List of Questions Answered by the Study .....	12
2.4.2 List of Tasks Undertaken by the Study .....	14
2.4.3 How Study meets CPUC EEPM Objectives .....	15
3. EM&V Findings .....	16
3.1 Load Impact Results .....	17
3.1.1 Verification Inspection Findings .....	19
3.1.2 PRISM Baseline Analyses for all Sites .....	27
3.1.3 DOE-2.2 Building Energy Simulation Models .....	27
3.1.3 Load Impact Results at Flanders Pointe .....	29
3.1.4 Load Impact Results at Midway-Capri .....	30
3.1.4 Load Impact Results at Orange Tree .....	31
3.2 Process Evaluation Results .....	32
3.2.1 Participant Survey Results for the 2 <sup>nd</sup> Tier Utility Allowance .....	33
3.2.2 Non-Participant Survey Results for the 2 <sup>nd</sup> Tier Utility Allowance .....	33
3.2.3 Process Evaluation Results for EAH Incentives .....	34
3.2.4 Non-Participant Survey Results for EAH Incentives .....	35
3.2.5 Process Evaluation Recommendations .....	36
Appendix A: 2 <sup>nd</sup> Tier UA Process Survey Instrument .....	38
Participant Survey (2 <sup>nd</sup> Tier Utility Allowance Program) .....	39
Non-Participant Survey (2 <sup>nd</sup> Tier Utility Allowance Program) .....	40
Appendix B: Incentives Process Survey Instrument .....	41
Participant Survey (EAH Incentives Program) .....	42
Non-Participant Survey (EAH Incentives Program) .....	44
Appendix C: On-Site Data Collection Form .....	45



# 1. Executive Summary

This report provides the Evaluation, Measurement, and Verification (EM&V) findings for the Heschong Mahone Group (HMG) Efficient Affordable Housing (EAH) Program. The HMG program addressed market and regulatory barriers by providing educational information and incentives to residential multifamily property owners and housing authorities. To qualify for incentives participating housing authorities and Section 8 property owners were required to achieve minimum levels of energy savings for heating, cooling, and water heating determined through one of two energy efficiency improvement options:

- 1) Achieve a 20% reduction compared to existing conditions; or
- 2) Achieve a 10% reduction compared to the 2001 energy code (which is deemed to be at least a 20% reduction for existing buildings).

For both options, the program related savings are calculated as the difference between ex-post and ex-ante conditions. The study was conducted at the request of the California Public Utilities Commission (CPUC). The study was managed by HMG under the auspices of the CPUC. It was funded through the public goods charge (PGC) for energy efficiency and is available for download at [www.calmac.org](http://www.calmac.org).

The program implementation plan goals, ex ante program estimates, and ex post accomplishments are shown in **Table 1.1**.

**Table 1.1 Ex Ante Goals and Ex Post Accomplishments for the EAH Program**

Description	Program Implementation Plan Goal	Ex Ante Program Estimate	Ex Post Accomplishment
Multi-Family Incentives	160	202	202
Workshops	4	4	4
Media Placements	4	4	11
Housing Authorities Adopting 2 <sup>nd</sup> Tier UA	5	3	3
MF Housing Units Adopting 2 <sup>nd</sup> Tier UA (rough estimate of potential for 3 housing authorities)	n/a	10,000 <sup>1</sup>	2,431 (reported)
Annual Electricity Savings (kWh/yr)	242,478	438,528	43,576
Demand Savings (kW)	50	1,152	52
Annual Therm Savings (therms/yr)	11,038	19,968	11,744
Lifecycle Electricity Savings (kWh)	2,667,258	6,577,920	835,416
Lifecycle Gas Savings (therms)	121,418	299,520	236,533
<b>Total Resource Cost (TRC) Test</b>	<b>0.11</b>	<b>0.84</b>	<b>0.22</b>
TRC Test Benefits	\$154,737	\$400,059	\$106,541
TRC Test Costs	\$1,397,706	\$476,909	\$476,763
TRC Test Net Benefits	-\$1,242,969	-\$76,850	-\$370,222
<b>Participant Test</b>	<b>-41.52</b>	<b>4.76</b>	<b>1.96</b>
Participant Test Benefits	\$154,737	\$612,074	\$231,709
Participant Test Costs	-\$3,726	\$128,640	\$118,051
Participant Test Net Benefits	\$158,463	\$483,434	\$113,657

<sup>1</sup> Ex ante estimate of 10,000 MF units is an estimate of spillover potential and not a specific goal for the program.

The program succeeded in providing energy efficiency incentives at 202 apartments, and influenced the City of Norwalk, the City of Anaheim and the County of Riverside to adopt the 2<sup>nd</sup> Tier Utility Allowance (UA). A total of 2,431 apartment units were reported as adopting the 2<sup>nd</sup> Tier Utility Allowance based on 2,100 units reported by the City of Anaheim from two sites, and 323 units reported by the County of Riverside from four sites.<sup>2</sup> Ex post accomplishments were verified by randomly checking the tracking database with on-site measurements, inspections, and telephone surveys.

First year gross ex ante unit and program load impacts are summarized in **Table 1.2**. First year and lifecycle net ex ante load impacts are summarized in **Table 1.3**. First year net ex-ante program impacts are 548,160 kWh per year, 1,440 kW, and 24,960 therms per year. Lifecycle net ex ante program impacts are 6,577,920 kWh and 299,520 therms.

**Table 1.2 First Year Gross Ex Ante Unit and Program Load Impacts**

Description	Ex Ante Qty.	Gross Ex Ante Unit Savings (kWh/yr)	Gross Ex Ante Unit Savings (kW)	Gross Ex Ante Unit Savings (therm/yr)	Gross Ex Ante Program Savings (kWh/yr)	Gross Ex Ante Program Savings (kW)	Gross Ex Ante Program Savings (therms/yr)
EAH MF Incentives	160	3,426	9	156	548,160	1,440	24,960

**Table 1.3 First Year and Lifecycle Net Ex Ante Load Impacts**

Description	Ex Ante Net-to-Gross Ratio	Net Ex Ante Program Savings (kWh/yr)	Net Ex Ante Program Savings (kW)	Net Ex Ante Program Savings (therm/yr)	EUL	Net Ex Ante Lifecycle Savings (kWh)	Net Ex Ante Lifecycle Savings (therm)
EAH MF Incentives	0.8	438,528	1,152	19968	15	6,577,920	299,520

The program provided incentives for installation of the following energy efficiency measures in 202 multi-family buildings: R30 attic insulation at 161 apartments; 9.8 EER room air conditioners at 50 apartments; solar sunscreens on 52 apartments; central water heater pipe insulation on 5 central water heaters/boilers; and R12 water heater blankets for 41 apartments.<sup>3</sup> First year gross ex post unit and program load impacts are summarized in **Table 1.4**, and first year and lifecycle net ex post load impacts are summarized in **Table 1.5**. The EM&V gross ex-post program load impacts are 48,962 ± 15,357 kWh per year, 57.9 ± 18.2 kW, and 13,196 ± 5,304 therms per year. The ex post net-to-gross ratio (NTGR) is 0.89.<sup>4</sup> The EM&V net ex-post program load impacts are 43,576 ± 13,668 kWh, 51.5 ± 16.2 kW, and 11,744 ± 4,721 therms per

<sup>2</sup> The City of Anaheim and County of Riverside were unwilling to disclose contact information or the locations for the 2,423 multifamily apartments participating in their 2<sup>nd</sup> Tier UA. Therefore, these sites were not verified as participating.

<sup>3</sup> Energy savings per apartment for weather-sensitive measures are based on DOE-2.2 simulations calibrated to cooling and heating unit energy consumption (UEC) values. The cooling and heating UEC values were developed using PRISM based on three years of historical billing data. Electric billing data was obtained for 106 apartments and gas billing data was obtained for 9 apartments. It was relatively to obtain electric billing data since only meter numbers were required. It was more difficult to obtain gas billing data, since signed release forms from current occupants were required and most occupants were unwilling to sign the utility billing data release forms.

<sup>4</sup> The NTGR is used to estimate free-riders, that is, program participants who would have undertaken the activity, regardless of whether or not there was an energy efficiency program promoting that activity. The NTGR factor represents the net program load impact divided by the gross program load impact. This factor is applied to gross program savings to determine the program’s net impact. See the *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

year at the 90 percent confidence level. The EM&V study lifecycle load impacts are 835,416 ± 262,927 kWh and 236,533 ± 96,000 therms per year at the 90 percent confidence level.

**Table 1.4 First Year Gross Ex Post Unit and Program Load Impacts**

Description	Ex Post Qty.	Gross Ex Post Unit Savings (kWh/yr)	Gross Ex Post Unit Savings (kW)	Gross Ex Post Unit Savings (therm/yr)	Gross Ex Post Program Savings (kWh/yr)	Gross Ex Post Program Savings (kW)	Gross Ex Post Program Savings (therms/yr)
EAH MF Incentives	202	242	0.29	65	48,962	57.9	13,196

**Table 1.5 First Year and Lifecycle Net Ex Post Load Impacts**

Description	Ex Post Net-to-Gross Ratio	Net Ex Post Program Savings (kWh/yr)	Net Ex Post Program Savings (kW)	Net Ex Post Program Savings (therm/yr)	EUL	Net Ex Post Lifecycle Savings (kWh)	Net Ex Post Lifecycle Savings (therm)
EAH MF Incentives	0.89	43,576	51.5	11,744		835,416	236,533

First year and lifecycle realization rates are shown in **Table 1.6**. The EM&V ex-post first year net realization rates are 0.10 ± 0.03 for kWh/yr, 0.04 ± 0.01 for kW, and 0.59 ± 0.24 for therms. The ex post lifecycle net realization rates are 0.13 ± 0.04 for kWh and 0.79 ± 0.32 for therms.

**Table 1.6 First Year and Lifecycle Net Realization Rates**

Description	Ex Post First Year Net Realization Rate kWh/yr	Ex Post First Year Net Realization Rate kW	Ex Post First Year Net Realization Rate therm/yr	Ex Post Lifecycle Net Realization Rate kWh	Ex Post Lifecycle Net Realization Rate therm
EM&V EAH Program	0.10	0.04	0.59	0.13	0.79

The program implementation plan cost effectiveness goals were 0.11 for the Total Resource Cost (TRC) test and -41.52 for the Participant Test (PT). The ex ante program estimated TRC was 0.84 and the PT was 4.76. The EM&V ex post TRC is 0.22 and the PT is 1.96.<sup>5</sup> The program included an information-only market transformation (MT) element (i.e., 2<sup>nd</sup> Tier Utility allowance) and an energy savings element (i.e., incentives). Approximately 25.8 percent of the program budget was used for the MT element, so the adjusted ex post TRC is 0.29 and the PT is 2.61. The difference between ex post and ex ante TRC is largely due to HMG using the CEC Title 24 approved methodologies which substantially overestimate energy use of these buildings (see 4<sup>th</sup> bullet below and page 5).

Process surveys were conducted with participants and non-participants to evaluate the 2<sup>nd</sup> Tier UA (census of 3 participants and 10 non-participants). Survey results indicate 100 percent of participants were satisfied with the program. Non-participant survey results indicate housing authority managers would have participated if they had been building new complexes (i.e. lack of eligibility) or simply had more time to get the paperwork together for HMG. No on-site inspections were performed because the housing authority managers would not disclose the locations of the complexes or builders that are participating in the program. Specific recommendations to help make the program more cost effective, efficient, and operationally effective are drawn from the process survey results.

<sup>5</sup> Cost effectiveness calculations are based on the CPUC 2002-2003 Program Implementation Plan Workbook for HMG, see HMG255CD02\_Q2\_2004\_SCG.xls and HMG255CD02\_Q2\_2004\_SCE.xls.

Process surveys were conducted with participants and non-participants to evaluate the EAH Incentive program (census of 3 participants and 3 non-participants). EAH survey results indicate 93 percent of participants were satisfied with the program based on telephone surveys with participating property managers. Non-participant survey results indicate property managers would have participated if they simply had more time to fill out all of the paperwork required to participate in the program. Process survey results, on-site 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 process recommendations are as follows.

- As a condition for participating in the 2<sup>nd</sup> Tier UA program, housing authorities should be required to disclose contact information for participating developers who upgrade their buildings. This information is necessary to evaluate, measure, and verify participation and program savings. The program implementer should be required to maintain a tracking database with this information and make this data available to their EM&V contractor and the CPUC. The database should contain housing authority information, participating management company/developer contact information, all existing or planned multifamily apartment sites that might be included in the program, and measure information by location (i.e., description, costs, savings, etc.).
- Better advertising at housing authority meetings would increase participant understanding and appreciation of program. Advertising should explain how the housing authority managers can take advantage of utility allowance energy efficiency improvements offered by the program.
- While the 2<sup>nd</sup> Tier UA program provided useful information to housing authority managers at the meetings and over the telephone, it might also help to consider providing a simple energy education pamphlet to housing authority managers to clearly explain the link between energy efficiency, utility bills, energy savings, and comfort.
- HMG provided RMA with Micropas savings estimates for the three sites that received incentives. The Micropas space cooling savings were 3 to 10 times greater than the cooling unit energy consumption based on billing data and 8 to 29 times greater than the calibrated DOE-2.2 evaluation savings. The Micropas computer program is a compliance tool for the CEC Alternative Calculation Method under the Title 24 Building Energy Efficiency Standards for new construction. Micropas can be used for existing buildings if it is calibrated to site-specific billing data or average cooling, heating, and water heating unit energy consumption (UEC) values. Calibrating the energy savings methodology will avoid potential problems of overestimating energy savings and recommending measures that are potentially non-cost effective. HMG should consider using a more accurate energy savings methodology based on billing data or use the DEER database for estimating savings. Southern California Edison (SCE) will provide billing data from meter numbers with signed confidentiality agreement forms.
- Although the program was designed to promote space heating, space cooling, and water heating measures consistent with Title-24, this focus will result in lost opportunities for cost effective energy efficient lighting and appliance measures for multi-family occupants and property owners. Future programs should be more comprehensive and include market



intervention strategies (i.e., energy educational information) or incentives to promote energy efficient lighting, appliances (refrigerators, dishwashers, fans), and equipment (such as clothes washers). The following measures should be considered: air conditioner refrigerant charge and airflow tune-ups; water heater or boiler controllers; efficient showerheads and aerators; Energy Star programmable thermostats; and lowering hot water temperatures. These measures will increase savings, cost effectiveness, and reduce lost opportunities.

**Section 2** describes how the EM&V study addresses the required CPUC Energy Efficiency Policy Manual objectives, including baseline information, energy efficiency measure information, measurement and verification approach, and the evaluation approach. **Section 2** also includes equations used to develop energy and peak demand savings, sample design, methods used to verify proper installation of measures, and methods used to perform field measurements.

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

**Appendix A** provides the participant and non-participant survey instruments for the 2<sup>nd</sup> Tier UA Program. **Appendix B** provides the participant and non-participant survey instruments for the EAH Incentive Program. **Appendix C** provides the audit data collection form.

## **2. Required CPUC Objectives and Components**

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

### **2.1 Baseline Information**

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

**Table 2.1 Existing Baseline Studies for Multifamily Homes**

1	<i>Filing of Southern California Gas Company Requesting Approval of Proposed Energy Efficiency Programs and Budgets as Part of the 2002 Energy Efficiency Program Selection Process Required by Rulemaking 01-08-028, December 14, 2001.</i>
2	<i>2001 DEER Update Study, Final Report, prepared for the California Energy Commission, Contract Number 300-99-008, prepared by XENERGY Inc., Oakland, California, August, 2001.</i>
3	<i>Voluntary Existing Residential Baseline Values for Single Family, Multifamily, and Mobile Homes, prepared for the CPUC R. 01-08-028, prepared by Robert Mowris and Associates, January 7, 2002.</i>
4	<i>Deemed Savings Estimates for the Summer Initiative Program, prepared for SDG&amp;E, SCE, PG&amp;E, and SCG, prepared by Regional Economic Research and Robert Mowris &amp; Associates, San Diego, CA, 2001.</i>

**Table 2.1 Existing Baseline Studies for Multifamily Homes**

5	1996-1997 Residential Appliance Efficiency Incentives Program 4th-Year Program Load Impact and Measure Retention Study for the 2nd Program Year, Program ID No. D-9308-116, Prepared for Southern California Gas Company, prepared by Energx Controls, Inc. and Occidental Analytical Group, 2001.
6	<i>Analysis of the 1999 Residential Survey</i> , prepared for Southern California Gas Company, prepared by Business Economic Analysis Research, 1999.
7	<i>Market Segment Analysis based on the 1991 Residential Weatherization Survey</i> , prepared by Business Economic Analysis Research and RER, prepared for Southern California Gas Company, 1992.
8	<i>Energy Use and DSM Measure Impacts in Prototypical Buildings: Interim Report for Task 2, Characterization of the Residential Building Stock in California</i> , prepared by ITEM Systems, Berkeley, CA, prepared for the California Energy Commission, July 1992.
9	<i>Integration of Billing and Metering Data</i> , prepared for the California Demand Side Management Advisory Committee: The Subcommittee on Modeling Standards for End Use Consumption and Load Impact Models, prepared by Pacific Consulting Services, 1320 Solano Avenue, Suite 203, Albany, CA 94706, December 1994.

Existing baseline Unit Energy Consumption (UEC) data for multifamily homes from other studies are provided in **Table 2.2** for the following climate zones where measures were installed:<sup>6</sup>

- CEC Climate Zone 8 – Tustin and Garden Grove (Flanders Pointe and Orange Tree); and
- CEC climate zone 10 – Perris (Midway Capri) Riverside County.

**Table 2.2 Baseline UEC Values for Multifamily Homes From Other Studies**

End Use per Unit Other Studies	Anaheim Climate Zone 8	Riverside Climate Zone 10	Source
Space Heat UEC therm/yr	124	201	2001 DEER Study 3, <b>Table 2.2</b>
Space Cool UEC kWh/yr	786	1,687	2001 DEER Study 3, <b>Table 2.2</b>
Central Water Heat UEC therm/yr (pipes in building)	190	190	SCG Study 1, <b>Table 2.2</b>
Central Water Heat UEC therm/yr (pipes underground)	357	357	Occidental Analytical Group Study 10, <b>Table 2.2</b> <sup>7</sup>
Single Water Heating UEC therm/yr-unit	153	153	BEAR Study 6, <b>Table 2</b>

The EM&V study used the baseline UEC values shown in **Table 2.2** as the basis for developing savings estimates for this study.<sup>8</sup> New baseline UEC values shown in **Table 2.3** were developed for the study based on participant utility billing data and eQuest (i.e., DOE-2.2) simulations based on detailed site audits and pre-retrofit self-reported thermostat schedules for space heating and space cooling. The new baseline values for space heating and water heating are reasonably close to the existing baseline values.

<sup>6</sup> Baseline cooling UECs are from Table 5-15, Commission Target Values for Air Conditioning UECs, *2001 DEER Update Study*, page 5-28. The *2001 DEER Update Study* did not indicate if the target values are for MF apartments, and MF cooling UECs provided elsewhere in the study were significantly higher than these values.

<sup>7</sup> Multifamily central water heater UEC of 357 therm/yr-unit is based on two years of pre- and post-retrofit utility billing analysis for 24,900 multifamily units with water heater controllers installed. Energy savings were 77.6 therm/yr-unit. Study 5, Table 2, *1996-1997 Residential Appliance Efficiency Incentives Program 4th-Year Program Load Impact and Measure Retention Study for the 2nd Program Year*, Program ID No. D-9308-116, Prepared for Southern California Gas Company, prepared by Energx Controls, Inc. and Occidental Analytical Group, 2001.

<sup>8</sup> No CEC target values for cooling UECs were available for climate zone 15. The central water heater UEC was evaluated using billing data and the study found a UEC of 201.7 therm/yr-apt. This is 6 percent higher than the lower UEC from existing studies.

**Table 2.3 New Baseline UEC Values for Multifamily Homes for this Study**

End Use per Unit This Study	Flanders Pointe CZ 8	Orange Tree CZ 8	Midway Capri CZ 10	Source
Space Heat UEC therm/yr	120	120	113	Participant Billing Data
Space Cool UEC kWh/yr	513	693	857	Participant Billing Data
Central Water Heat UEC therm/yr	202	202	202	Participant Billing Data

Baseline estimates of water heater energy consumption by end use, distribution loss, and tank loss are shown in **Table 2.4**. The relative energy consumption for each end use illustrates savings available from measures installed by the program.

**Table 2.4 Central Water Heater Energy Consumption<sup>9</sup> by End Use**

End Use or Standby Loss	Gas Water Heater Relative Energy Consumption %
Shower (low for efficient showerheads and high for inefficient)	13 to 23
Tub	10
Sink (low for efficient aerators and high is for inefficient)	9 to 16
Clothes Washer	10
Dishwasher	5
Pilot Loss	13
Distribution Loss (low for recirculation pipes inside building and high range for recirculation pipes in ground)	30 to 50
Tank Loss	10

Note: Sum of high range values is greater than 100 percent indicating higher UEC than 100% low range which includes water saving showerheads and aerators.

## 2.2 Energy Efficiency Measure Information

The EAH program did not provide incentives for specific measures. Therefore, no specific ex ante energy efficiency measure information were available. To qualify for incentives participating housing authorities and Section 8 property owners must have achieved minimum levels of energy savings for heating, cooling, and water heating determined through one of two energy efficiency improvement options:

- 1) Achieve a 20% reduction compared to existing conditions; or
- 2) Achieve a 10% reduction compared to the 2001 energy code (which is deemed to be at least a 20% reduction for existing buildings).

For both options, the program related savings are calculated as the difference between ex-post and ex-ante conditions.

In addition, the EAH also provided educational information to Section 8 housing authorities to facilitate changes in utility allowance rules to include a mechanism whereby Section 8 housing

<sup>9</sup> These values are averages taken from the following studies: *Water Conservation in California*, Bulletin 198-84, California Department of Water Resources, Sacramento, CA, July 1984. *Supply Curves of Conserved Energy: A Tool for Least-Cost Energy Analysis*, A. Meier, T. Usibelli, Proceedings of Energy Technology Conference, Government Institutes Inc., Rockville, MD, pp. 1264-1265, March 1986. *Residential Hot Water Use Patterns*, D. Stevenson, Canadian Electrical Association, Report #111U268, Montreal, July 1983. *Water Heater Innovations*, Progressive Builder, Howard Geller, pp. 24-26, September 1985.

owners will be able to recoup their investments in energy efficiency. The goal was an immediate benefit to owners for their efficiency investments, while assuring tenants also receive benefits of increased comfort and lower total housing burden (rent + utilities). This change was intended to provide lasting benefits that will encourage efficient affordable housing even if the EAH program (and the associated direct incentive) eventually went away.

### 2.2.1 Measure Assumptions and Intended Results

The HMG proposal and PIP contained no specific ex ante measure information and no measure assumptions other than the minimum 20% improvement in energy efficiency. The EM&V study assessed pre- and post-retrofit conditions for participating customer sites and developed EM&V ex post measure assumptions. This was accomplished through the use of engineering and statistical analyses of data collected during the study (i.e., billing data and on-site inspections). Ex post energy savings were developed for each site using ex post baseline and measure assumptions determined in the study.

The intended ex ante and ex post load impact results for HMG local program #255-02 are shown in **Table 2.5**.

**Table 2.5 Intended Ex Ante and Ex Post Load Impact Results**

Program	Utility	Net kWh/yr	Net kW	Net therm/yr	Net Lifecycle kWh	Net Lifecycle therm
Ex Ante HMG #255-02	SCE	219,264	576	9,984	3,288,960	149,760
Ex Ante HMG #255-02	SCG	219,264	576	9,984	3,288,960	149,760
Ex Post HMG #255-02	SCE	21,788	25.8	5,872	417,708	118,266
Ex Post HMG #255-02	SCG	21,788	25.8	5,872	417,708	118,266

### 2.2.2 Description of Energy Efficiency Measures

The EAH program provided no descriptions of energy efficiency measures. Energy efficiency measures were examined by the EM&V study. Proper installation of energy efficiency measures were verified during the on-site inspections.

## 2.3 Measurement and Verification Approach

The measurement and verification approach for the study was based on *International Performance Measurement & Verification Protocols* (IPMVP) Option A (post-installation inspections or partially measured retrofit isolation) and Option D (calibrated simulation). The four IPMVP Options are defined in **Table 2.6**.<sup>10</sup>

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<sup>10</sup> See *International Performance Measurement & Verification Protocols*, DOE/GO-102000-1132, October 2000.

**Table 2.6 IPMVP M&V Options**

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

### 2.3.1 M&V Approach for Load Impact Evaluation

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

1. Attic insulation, solar sunscreens, and high efficiency room air conditioners savings were evaluated using IPMVP Option C (i.e., whole-facility billing data) and Option D (i.e., calibrated simulations).
2. Pipe insulation and water heater blankets were evaluated using IPMVP Option A (i.e., partially measured retrofit isolation or verified pre- and post-retrofit R-values and stipulated or deemed savings).

**Gross ex post savings** for each measure were calculated based on information or measurements collected in the statistical random sample of on-site inspections, stipulated values, billing data analyses, and calibrated DOE-2.2 energy simulations. **Sample mean savings estimates** were calculated using **Equation 1**.

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

Where,

$\bar{y}_i$  = Mean savings for measure “i” in the sample (e.g., kWh, therm).

$n_i$  = Number of measures “i” in the sample.

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

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

Where,

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

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

**The standard error,  $se_i$ , of the measure sample mean was calculated using Equation 3, Equation 4 or both depending on the measure.<sup>11</sup>**

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

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

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

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

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

Where,

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

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

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

Where,

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<sup>11</sup> The standard error for all measures was calculated based on the proportion of measures found properly installed from the on-site surveys. In addition, for measures where weighted average savings for each climate zone were available, the standard error of the mean savings was also calculated. These two standard errors were then combined to characterize the statistical precision of the sample mean as an estimator of the population mean. The population total was estimated by multiplying both the sample mean and the corresponding combined error bound by the number of units in the population as per sampling procedures from *The California Evaluation Framework*, prepared for the CPUC and Project Advisory Committee, prepared by TecMarktWorks Framework Team, Chapter 13: Sampling, February 2004.

$N_{p_i}$  = Number of “i” measures in the entire program population.

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

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

Net savings were calculated as gross savings times the CPUC-accepted 0.89 net-to-gross ratio.

### 2.3.2 Sampling Plan

The sampling plan was used to verify measure installation as well as to estimate ex-post energy savings. The statistical sample design involved selecting a random sample of multifamily apartments from the program participant population. Samples were selected to obtain a reasonable level of precision and accuracy at the 90 percent confidence level per CPUC Energy Efficiency Policy Manual (EEPM). The sample design was based on statistical survey sampling methods to select a sample of participants to meet the CADMAC Protocols.<sup>12</sup> Sampling methods were used to analyze the data and extrapolate mean savings estimates from the sample measurements to the population of all program participants and to evaluate the statistical precision of the results.<sup>13</sup>

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

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

Where,

$n_i$  = Required sample size for measure “i”,

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

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

$C_{vi}$  = Coefficient of variation,  $\frac{S_i}{\bar{y}_i}$ , for measure “i.”

For small populations, the sample size was corrected using the finite population correction (FPC) equation as follows.<sup>14</sup>

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<sup>12</sup> See Table 5c, Protocols for the General Approach to Load Impact Measurement, page 14, Evaluation design decisions related to sample design were determined by the following protocols: if the number of program participants is greater than 200 for residential programs, a sample must be randomly drawn and be sufficiently large to achieve a minimum precision of plus/minus 10 percent at the 90 percent confidence level, based on total annual energy use. A minimum of 200 for residential programs must be included in the analysis dataset for each applicable end-use. *Protocols and Procedures for Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs*, as adopted by the California Public Utilities Commission Decision 93-05-063, Revised March 1998.

<sup>13</sup> Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

<sup>14</sup> Ibid.

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

Where,

$n_{FPCi}$  = Sample size for measure “i” with finite population correction.

The preliminary and actual statistical sample sizes for the EM&V study are shown in **Table 2.7**.

**Table 2.7 Statistical Sample Size for the EM&V Study**

Measure Description	Ex Ante Units	Proposed Sample	Preliminary Cv	Ex Post Units	Actual Sample	Actual Cv	Relative Precision
Flanders Pointe	n/a	10	0.50	82	40	1.17	0.25
Midway-Capri	n/a	5	0.50	40	25	1.27	0.26
Orange Tree	n/a	10	0.50	80	41	0.94	0.19
EAH Incentives	n/a	n/a	0.50	3	6-Census	0.13	0.09
2 <sup>nd</sup> Tier Utility Allowance Survey	n/a	n/a	0.50	2	12-Census	0.26	0.17
<b>Total</b>	<b>160</b>	<b>25</b>	<b>n/a</b>	<b>202</b>	<b>106</b>	<b>n/a</b>	<b>n/a</b>

Note: EAH incentives had 3 participants and 3 non-participants. The 2<sup>nd</sup> Tier UA had 2 participants and 10 non-participants.

### 2.3.3 M&V Approach for Process Evaluation

The M&V approach for the process evaluation involved designing and implementing participant and non-participant surveys to evaluate participant satisfaction, and to obtain suggestions to improve the program's services and procedures. Survey questions assessed how the program influenced awareness of linkages between efficiency improvements and bill savings and increased comfort for tenants. In terms of the 2<sup>nd</sup> Tier Utility Allowance program, all managers from participating housing authorities and 10 non-participating housing authority managers were surveyed over the telephone. For the EAH Incentive program, all participating and non-participating property managers were surveyed over the telephone. The participant and non-participant surveys for the 2<sup>nd</sup> Tier UA program are provided in Appendix A. The participant and non-participant surveys for the EAH Incentive program are provided in Appendix B. Participants were asked why and how they decided to participate in the program. Non-participants were asked why they chose not to participate in order to identify reasons why program marketing efforts were not successful as well as to identify additional hard-to-reach market barriers (i.e., incentives or other inducements to achieve greater participation). Analysis of process evaluation survey data includes a summary of what works, what doesn't work, and if there is a continuing need for both of the programs.

## 2.4 Evaluation Approach

The evaluation approach included:

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

### 2.4.1 List of Questions Answered by the Study

The study answered the following list of questions.

1. Are measures being installed properly?



The study answered this question by performing 40 inspections at a random sample of participant sites. In addition, billing analysis for 106 sites provided additional verification that measures were installed properly. These efforts provided useful information in developing recommendations regarding proper measure installation (see **Section 3.2.3**).

**2. Are the ex ante energy savings estimates per measure appropriate and relevant?**

The study answered this question by evaluating the baseline UEC values and ex ante energy savings estimates using on-site measurements and inspections, engineering analysis, building energy simulations, and billing data (i.e., IPMVP Options A, C, and D). Existing baseline UEC values were evaluated and refined, and ex post savings estimates are provided for each measure based on research performed for this study.

**3. Are the total program savings estimates accurate?**

The study answered this question by developing ex post energy savings for the program at the 90 percent confidence level as per CADMAC Protocols.

**4. Are customers satisfied with the program implementation and with the measures that were offered and installed by the program?**

The study answered this question by summarizing customer satisfaction survey responses for housing authority managers and property managers. Participant satisfaction was found to be very high (see **Sections 3.2.1 and 3.2.3**).

**5. Are there some customers who choose not to participate in the program?**

The study answered this question by conducting telephone interviews with 10 non-participating housing authority managers for the 2<sup>nd</sup> Tier HA program and all non-participating property managers for the EAH program. The following questions were included:

1. What were the reasons for not participating and how might the program be revised to motivate participation?
2. What barriers tend to reduce or restrict participation?
3. What percent of the MF market are affected by each of these barriers?

**6. Is there a continuing need for the program?**

The study answered this question by evaluating ex post savings and responses from the telephone process surveys of participants and non-participants for both the 2<sup>nd</sup> Tier UA and the EAH Incentive programs.

## 2.4.2 List of Tasks Undertaken by the Study

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

### **Task 1. Project Initiation Meeting**

The project initiation meeting refined the research objectives and methods, clarified pertinent issues, discussed data requirements, and discussed the detailed work plan and scheduled the project tasks.

### **Task 2. EM&V Plan**

The EM&V plan contained a detailed description of all activities required to complete the study.

### **Task 3. Data Collection Procedure**

The data collection procedure reviewed available load impact studies and the HMG program tracking data to determine what aspects of the evaluation needed new data collection. An EM&V data collection plan was developed for each EAH participant site based on information provided by HMG.

### **Task 4. Sample Design**

A statistical sample design was used to select a sample of customers or projects from the participant populations. Samples were selected to obtain a reasonable level of precision and accuracy at the 90 percent level per CPUC Energy Efficiency Policy Manual (EPPM). The load impact evaluation involved three participant sites. However, other participants might have been influenced by the program to improve energy efficiency based on changes to utility allowances (i.e., housing authorities) or changes in awareness of linkages between efficiency improvements and increased income and resale valuation (i.e., property owners). The sampling design was adjusted as the project was completed (several participants opted out of the program but they were interviewed as non-participants).

### **Task 5. Data Collection**

For the impact evaluation on-site audits were performed at 3 sites that received incentives (including 202 apartments) to verify energy efficiency measure installations and gather sufficient information to develop detailed and calibrated building energy simulations to quantify kW, kWh, and therm savings for each site. For the process evaluation interviews were conducted with 3 housing authority participants and 3 property owner participants to identify what works, what doesn't work, and the level of need for the program. Interviews were also conducted over the telephone with 10 non-participating housing authority managers and 3 non-participating property owners. For the EAH Incentive program, all participating and non-participating property managers were surveyed over the telephone. In-depth housing authority interviews assessed how the program influenced utility allowance practices. We were unable to verify utility allowance changes due to not having contact information for participating developers. Non-participating housing authorities were interviewed during the evaluation process and these interviews included questions to evaluate why they chose not to participate. Structured surveys were conducted with participating Section 8 property owners to obtain information about their satisfaction with the program.

### **Task 6. Data Analyses**

For the impact evaluation the data analyses included developing detailed and calibrated building energy simulations to quantify kW, kWh, and therm savings for each site. Statistical analysis methods were used to extrapolate these savings to the program as a

whole. For the process evaluation the results of the telephone and in-depth surveys were analyzed to identify what works, what doesn't work, and the level of need for the program. Analysis of in-depth housing authority interviews assessed how the program influenced utility allowance practices. Analysis of interviews included an assessment of market barriers to energy efficiency, participant satisfaction, and suggestions to improve the program.

**Task 7. Progress/Feedback, Draft, and Final Reports**

The progress reports provided preliminary impact evaluation results (i.e., cost effectiveness) as well as a process evaluation results. Feedback reports provided on-going feedback and guidance to HMG on EM&V findings that might improve the program process and procedures. Draft and final reports included a description of the study methodology and all deliverables as per the CPUC EEPM.

**Task 8. Project Management**

Project management included management of all personnel required to complete the study, consistent and timely communication, issue resolution, and periodic reporting.

**2.4.3 How Study meets CPUC EEPM Objectives**

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

▪ **Measure the level of energy savings achieved.**

The study met this objective by performing detailed on-site visits for a statistically significant sample of participants to gather pre-and post-installation measurements for energy efficiency measures installed under the program. Sites in the statistical sample included verification of all measures including: attic insulation depth; room air conditioner make, model, capacity, and efficiency rating; solar sunscreen shading coefficients; and water heater pipe and blanket insulation. EM&V efforts included gathering enough information and measurements to develop savings estimates for each measure and number of apartments served by the program. Statistical analyses were used to extrapolate energy savings at the sample level to the program level. This step included an assessment of the relative precision of program-level savings, mean savings estimates, standard deviations, and confidence intervals. This analysis included an assessment of all major assumptions used to calculate deemed savings.

▪ **Measure the cost-effectiveness.**

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

▪ **Provide up-front market assessments and baseline analysis.**

The study met this objective by performing a simple market assessment and baseline analyses including an evaluation of the baseline unit energy consumption values. Telephone survey interviews included questions about market barriers to energy efficiency and the success of the program in meeting the needs of hard-to-reach customers.<sup>15</sup>

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<sup>15</sup> The CPUC definition of residential hard-to-reach customers are those who do not have easy access to program information or generally do not participate in energy efficiency programs due to language (i.e., primary language non-English), income (less than 400% of federal poverty guidelines), housing type (i.e., mobile home or multi-

- **Provide ongoing feedback and corrective or constructive guidance regarding the implementation of programs.**

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

- **Measure indicators of the effectiveness of the programs, including testing of the assumptions that underlie the program theory and approach.**

The study met this objective by performing a process evaluation of the program including telephone surveys of participants and non-participants.

- **Assess the overall levels of performance and success of the program.**

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

- **Help to assess whether there is a continuing need for the program.**

The study met this objective by assessing overall cost effectiveness and the number of multi-family apartments treated by the program. Ex post measure savings and implementation costs were used to develop ex post Total Resource Cost (TRC) test values for the program using the CPUC cost effectiveness worksheets. The overall ex post TRC was 0.22 and this was 74 percent lower than the ex ante 0.84 TRC value. The program provided incentives for installation of the following energy efficiency measures in 202 multi-family buildings: R30 attic insulation at 161 apartments; 9.8 EER room air conditioners at 50 apartments; solar sunscreens on 52 apartments; central water heater pipe insulation on 5 central water heaters/boilers; and R12 water heater blankets for 41 apartments. This represents roughly 0.005 percent of the total 3,962,986 multifamily apartments in California. Participant and non-participant surveys were conducted with housing authority and property managers. Surveys assessed how the program influenced awareness of linkages between efficiency improvements, bill savings, and increased comfort for tenants. The study also identified what works, what doesn't work, and the level of need for the program.

### 3. EM&V Findings

This section provides load impact results (i.e., gross and net energy savings) for the program and for each measure. This section also provides the process evaluation results for the EAH Incentives and 2<sup>nd</sup> Tier Utility Allowance (UA) programs. Process survey results, on-site inspections, and field measurements were used to guide the overall process evaluation in terms

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family), geographic (i.e., outside San Francisco Bay Area, Sacramento, Los Angeles Basin or San Diego), or home ownership (i.e., renter split incentives barrier).

of investigating operational characteristics of the program and developing specific recommendations to help make the program more cost effective, efficient, and operationally effective. Process evaluation recommendations are provided regarding what works, what doesn't work, and the continuing need of the program.

### 3.1 Load Impact Results

The program implementation plan goals, ex ante program estimates, and ex post accomplishments are shown in **Table 3.1**. The program succeeded in providing energy efficiency incentives at 202 apartments, and influenced the City of Norwalk, the City of Anaheim and the County of Riverside to adopt the 2<sup>nd</sup> Tier Utility Allowance (UA). A total of 2,431 apartment units were reported as adopting the 2<sup>nd</sup> Tier Utility Allowance based on 2,100 units reported by the City of Anaheim from two sites, and 323 units reported by the County of Riverside from four sites.<sup>16</sup> Ex post accomplishments were verified by randomly checking the tracking database with on-site measurements, inspections, and telephone surveys.

**Table 3.1 Ex Ante Goals and Ex Post Accomplishments for the EAH Program**

Description	Program Implementation Plan Goal	Ex Ante Program Estimate	Ex Post Accomplishment
Multi-Family Incentives	160	202	202
Workshops	4	4	4
Media Placements	4	4	11
Housing Authorities Adopting 2 <sup>nd</sup> Tier UA	5	3	3
MF Housing Units Adopting 2 <sup>nd</sup> Tier UA (rough estimate of potential for 3 housing authorities)	n/a	10,000 <sup>17</sup>	2,431 (reported)
Annual Electricity Savings (kWh/yr)	242,478	438,528	43,576
Demand Savings (kW)	50	1,152	52
Annual Therm Savings (therms/yr)	11,038	19,968	11,744
Lifecycle Electricity Savings (kWh)	2,667,258	6,577,920	835,416
Lifecycle Gas Savings (therms)	121,418	299,520	236,533
<b>Total Resource Cost (TRC) Test</b>	<b>0.11</b>	<b>0.84</b>	<b>0.22</b>
TRC Test Benefits	\$154,737	\$400,059	\$106,541
TRC Test Costs	\$1,397,706	\$476,909	\$476,763
TRC Test Net Benefits	-\$1,242,969	-\$76,850	-\$370,222
<b>Participant Test</b>	<b>-41.52</b>	<b>4.76</b>	<b>1.96</b>
Participant Test Benefits	\$154,737	\$612,074	\$231,709
Participant Test Costs	-\$3,726	\$128,640	\$118,051
Participant Test Net Benefits	\$158,463	\$483,434	\$113,657

First year gross ex ante unit and program load impacts are summarized in **Table 3.2**. First year and lifecycle net ex ante load impacts are summarized in **Table 3.3**. First year net ex-ante program impacts are 548,160 kWh per year, 1,440 kW, and 24,960 therms per year. Lifecycle net ex ante program impacts are 6,577,920 kWh and 299,520 therms.

<sup>16</sup> The City of Anaheim and County of Riverside were unwilling to disclose contact information or the locations for the 2,423 multifamily apartments participating in their 2<sup>nd</sup> Tier UA. Therefore, these sites were not verified as participating.

<sup>17</sup> Ex ante estimate of 10,000 MF units is an estimate of spillover potential and not a specific goal for the program.

**Table 3.2 First Year Gross Ex Ante Unit and Program Load Impacts**

Description	Ex Ante Qty.	Gross Ex Ante Unit Savings (kWh/y)	Gross Ex Ante Unit Savings (kW)	Gross Ex Ante Unit Savings (therm/yr)	Gross Ex Ante Program Savings (kWh/yr)	Gross Ex Ante Program Savings (kW)	Gross Ex Ante Program Savings (therms/yr)
EAH MF Incentives	160	3,426	9	156	548,160	1,440	24,960

**Table 3.3 First Year and Lifecycle Net Ex Ante Load Impacts**

Description	Ex Ante Net-to-Gross Ratio	Net Ex Ante Program Savings (kWh/yr)	Net Ex Ante Program Savings (kW)	Net Ex Ante Program Savings (therm/yr)	EUL	Net Ex Ante Lifecycle Savings (kWh)	Net Ex Ante Lifecycle Savings (therm)
EAH MF Incentives	0.8	438,528	1,152	19968	15	6,577,920	299,520

The program provided incentives for installation of the following energy efficiency measures in 202 multi-family buildings: R30 attic insulation at 161 apartments; 9.8 EER room air conditioners at 50 apartments; solar sunscreens on 52 apartments; central water heater pipe insulation on 5 central water heaters/boilers; and R12 water heater blankets for 41 apartments.<sup>18</sup> First year gross ex post unit and program load impacts are summarized in **Table 3.4**, and first year and lifecycle net ex post load impacts are summarized in **Table 3.5**. The EM&V gross ex-post program load impacts are 48,962 ± 15,357 kWh per year, 57.9 ± 18.2 kW, and 13,196 ± 5,304 therms per year. The ex post net-to-gross ratio (NTGR) is 0.89.<sup>19</sup> The EM&V net ex-post program load impacts are 43,576 ± 13,668 kWh, 51.5 ± 16.2 kW, and 11,744 ± 4,721 therms per year at the 90 percent confidence level. The EM&V study lifecycle load impacts are 835,416 ± 262,927 kWh and 236,533 ± 96,000 therms per year at the 90 percent confidence level.

**Table 3.4 First Year Gross Ex Post Unit and Program Load Impacts**

Description	Ex Post Qty.	Gross Ex Post Unit Savings (kWh/y)	Gross Ex Post Unit Savings (kW)	Gross Ex Post Unit Savings (therm/yr)	Gross Ex Post Program Savings (kWh/yr)	Gross Ex Post Program Savings (kW)	Gross Ex Post Program Savings (therms/yr)
Flanders R30 Attic	41	288	0.3	59	11,808	13.9	2,419
Flanders Sunscreens	52	107	0.1	-25	5,564	6.8	-1,300
Flanders Pipe Insul	5	0	0.0	5	0	0.0	25
Midway R30 Attic	40	312	0.4	93	12,480	14.8	3,720
Midway WH Blkt	41	0	0.0	12	0	0.0	492
Orange R30 Attic	80	207	0.2	98	16,560	19.4	7,840
Orange 9.5EER AC	50	51	0.1	0	2,550	3.0	0
<b>Total</b>					<b>48,962</b>	<b>57.9</b>	<b>13,196</b>

<sup>18</sup> Energy savings per apartment for weather-sensitive measures are based on DOE-2.2 simulations calibrated to cooling and heating unit energy consumption (UEC) values. The cooling and heating UEC values were developed using PRISM based on three years of historical billing data. Electric billing data was obtained for 106 apartments and gas billing data was obtained for 9 apartments. It was relatively to obtain electric billing data since only meter numbers were required. It was more difficult to obtain gas billing data, since signed release forms from current occupants were required and most occupants were unwilling to sign the utility billing data release forms.

<sup>19</sup> The NTGR is used to estimate free-riders, that is, program participants who would have undertaken the activity, regardless of whether or not there was an energy efficiency program promoting that activity. The NTGR factor represents the net program load impact divided by the gross program load impact. This factor is applied to gross program savings to determine the program's net impact. See the *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

**Table 3.5 First Year and Lifecycle Net Ex Post Load Impacts**

Description	Ex Post Net-to-Gross Ratio	Net Ex Post Program Savings (kWh/yr)	Net Ex Post Program Savings (kW)	Net Ex Post Program Savings (therm/yr)	EUL	Net Ex Post Lifecycle Savings (kWh)	Net Ex Post Lifecycle Savings (therm)
Flanders R30 Attic	0.89	10,509	12.4	2,153	20	210,182	43,058
Flanders Sunscreens	0.89	4,952	6.0	-1,157	15	74,279	-17,355
Flanders Pipe Insul	0.89	0	0.0	22	11	0	245
Midway R30 Attic	0.89	11,107	13.2	3,311	20	222,144	66,216
Midway WH Blkt	0.89	0	0.0	438	11	0	4,817
Orange R30 Attic	0.89	14,738	17.3	6,978	20	294,768	139,552
Orange 9.5EER AC	0.89	2,270	2.7	0	15	34,043	0
<b>Total</b>	<b>0.89</b>	<b>43,576</b>	<b>51.5</b>	<b>11,744</b>		<b>835,416</b>	<b>236,533</b>

First year and lifecycle realization rates are shown in **Table 3.6**. The EM&V ex-post first year net realization rates are  $0.10 \pm 0.03$  for kWh/yr,  $0.04 \pm 0.01$  for kW, and  $0.59 \pm 0.24$  for therms. The ex post lifecycle net realization rates are  $0.13 \pm 0.04$  for kWh and  $0.79 \pm 0.32$  for therms.

**Table 3.6 First Year and Lifecycle Net Realization Rates**

Description	Ex Post First Year Net Realization Rate kWh/yr	Ex Post First Year Net Realization Rate kW	Ex Post First Year Net Realization Rate therm/yr	Ex Post Lifecycle Net Realization Rate kWh	Ex Post Lifecycle Net Realization Rate therm
EM&V EAH Program	0.10	0.04	0.59	0.13	0.79

The program implementation plan cost effectiveness goals were 0.11 for the Total Resource Cost (TRC) test and -41.52 for the Participant Test (PT). The ex ante program estimated TRC was 0.84 and the PT was 4.76. The EM&V ex post TRC is 0.22 and the PT is 1.96.<sup>20</sup> The program included an information-only market transformation (MT) element (i.e., 2<sup>nd</sup> Tier Utility allowance) and an energy savings element (i.e., incentives). Approximately 25.8 percent of the program budget was used for the MT element, so the adjusted ex post TRC is 0.29 and the PT is 2.61. The difference between ex post and ex ante TRC is largely due to HMG using the CEC Title 24 approved methodologies which substantially overestimate energy use of these buildings.

Verification inspection findings and detailed load impact results for measures installed at Flanders Pointe, Midway-Capri, and Orange Tree Apartments are provided in the following sections.

### 3.1.1 Verification Inspection Findings

Two pre-retrofit inspections and two post-retrofit verification inspections were conducted for the study. RMA inspectors completed the first pre-retrofit inspections in July 2003, and HMG personnel were present during these inspections. The second set of pre-retrofit inspections was completed in October 2003. The first set of post-retrofit verification inspections was completed in May 2004, and the second set of post-retrofit inspections was completed in June of 2004. A final set of inspections was performed in late June 2004 to gather SCE meter numbers to obtain billing data to establish baseline values for the load impact evaluation.

<sup>20</sup> Cost effectiveness calculations are based on the CPUC 2002-2003 Program Implementation Plan Workbook for HMG, see HMG255CD02\_Q2\_2004\_SCG.xls and HMG255CD02\_Q2\_2004\_SCE.xls.

For the impact evaluation RMA planned to perform pre- and post-retrofit verification inspections at the sites that received incentives to verify energy efficiency measure installations and gather sufficient information to develop calibrated building energy simulations to quantify kW, kWh, and therm savings for each site (as per Task 5 of the CPUC-approved EM&V plan).

During the on-site inspections, RMA measured or obtained the following information.

1. Building envelope leakage using a blower door.
2. Duct leakage using a duct blaster (some buildings didn't have ducts so this wasn't necessary at every site).
3. Air conditioner airflow using a flow meter or a duct blaster.
4. Air conditioner kW input using a 3-phase power meter.
5. Return/supply dry-bulb and wet-bulb temperatures using thermistors and dataloggers.
6. Water flow rates using a flow meter.
7. Appliance kW usage using a plug-in data logger.
8. Building envelope insulation, window characteristics, shading, conditioned floor area, floor plan, and elevations of the buildings.
9. Hours of operation, thermostat set-point temperatures, and schedules.
10. Furnace, water heater, or boiler make, model, and efficiency.
11. Utility billing data (signed customer release forms or meter numbers).

The above information was used to:

- Develop baseline pre-retrofit energy usage from billing data and accurate energy and peak demand load impacts;
- Provide ongoing feedback and corrective or constructive guidance regarding implementation of the program or improvements regarding programs policies or procedures; and
- Assess measures that might or might not be included in the program in order to evaluate what works, what doesn't work, and the level of need for the program.

The following findings and recommendations are based on information obtained from the verification inspections.

- Kitchens, bathrooms, and common areas at all of the apartments had inefficient incandescent and fluorescent lighting such as T12 fluorescent lamps with magnetic ballasts.
- Most apartments had inefficient refrigerators and dishwashers. Some of the apartments were undergoing complete interior and exterior rehabilitation and the appliances were being replaced. Energy Star refrigerators, dishwashers, and clothes washers might have been cost effective measures to consider for the program.
- Showerheads and aerators flow rates at all apartments were relatively high and could have been retrofitted with energy and water efficient showerheads and aerators.
- Water heater controllers were installed at Flanders Pointe under another program. Controllers are a cost effective measure for the program to consider in the future.
- Thermostats for space heating and cooling at Midway and space heating at Flanders Pointe and Orange Tree could have been upgraded to Energy Star programmable thermostats.
- Although the program was designed to promote space heating, space cooling, and water heating measures consistent with Title-24, this focus will result in lost opportunities for cost effective energy efficient lighting and appliance measures for multi-family occupants and



property owners. Future programs should be more comprehensive and include market intervention strategies (i.e., energy educational information) or incentives to promote energy efficient lighting, appliances (refrigerators, dishwashers, fans), and equipment (such as clothes washers). Also consider air conditioner refrigerant charge and airflow tune-ups, water heater or boiler controllers, Energy Star programmable thermostats, and lowering hot water temperatures since these measures will increase savings, cost effectiveness, and reduce lost opportunities.

- HMG provided RMA with Micropas savings estimates for the three sites that received incentives. The Micropas space cooling savings were 3 to 10 times greater than the cooling unit energy consumption based on billing data and 8 to 29 times greater than the calibrated DOE-2.2 evaluation savings. The Micropas computer program is a compliance tool for the CEC Alternative Calculation Method under the Title 24 Building Energy Efficiency Standards for new construction.<sup>21</sup> Micropas can be used for existing buildings if it is calibrated to site-specific billing data or average cooling, heating, and water heating unit energy consumption (UEC) values. Calibrating the energy savings methodology will avoid potential problems of over estimating energy savings and recommending measures that are potentially non-cost effective. HMG should consider using a more accurate energy savings methodology based on billing data or use the DEER database for estimating savings. Southern California Edison (SCE) will provide billing data from meter numbers with signed confidentiality agreement forms.

**3.1.1.1 Findings from the First Set of Pre-Retrofit Inspections**

On July 25, 2003, RMA personnel, Robert Mowris and Anne Blankenship, conducted on-site field measurements of two room air conditioners (RAC) at unit #48, of Flanders Point Apartments, 15520 Tustin Village Way, Tustin, CA. This work was requested by HMG, as part of our EM&V efforts to provide ongoing feedback under Task 5, Data Collection, and Task 7, Progress/Feedback Reports.

Field measurements were made with an Alnor Model APM151 Balometer. Temperature data was recorded using a 4-channel Dent Instruments, Ultralite Temperature Data Logger. Drybulb and wetbulb thermistors were calibrated with a Bacharach mercury sling psychrometer. Electric power data was recorded using a Dent Instruments, ElitePro True RMS data logger and calibrated with a Summit Technology PS3000 PowerSight monitor. Room air conditioner efficiency measurements for Flanders Point Apartments are provided in **Table 3.7**.

**Table 3.7. Measurements of Room Air Conditioner Efficiency at Flanders Pointe**

Description	Rated EER 95°F OD	Rated Capacity (Btuh)	Rated kW	Measured EER 80°F OD	Measured Capacity (Btuh)	Measured kW	Notes
Old Friedrich 8912G10	8.9	12,800	1.444	12.4	15,200	1.225	53 min. of data
New Amana AAC141SRA	9.8	13,800	1.408	14.1	16,400	1.162	62 min. of data

Based on the EM&V field measurements, the extrapolated in-situ efficiency for the old Friedrich unit is 8.6 EER (close to the 8.9 EER rating). RMA also performed a preliminary on-site

<sup>21</sup> California Energy Commission (CEC). *2001 Energy Efficiency Standards*. Report CEC P400-01-024. June 1, 2001. Sacramento, Calif.: California Energy Commission.

inspection of unit #48 to assess EM&V data collection requirements. RMA also captured the make, model, and capacity information from the central water heaters at the site.

**3.1.1.2 Findings from the Second Set of Pre-Retrofit Inspections**

On the 13<sup>th</sup> and 14<sup>th</sup> of October 2003, Anne Blankenship and Ean Jones collected data from two apartment units at each of three Efficient Affordable Housing Program participant apartment complexes.

1. Jeffery-Lynn Apartments at 1330 Cerritos Avenue in Anaheim.
2. Flanders Pointe Apartments at 15520 Tustin Village Way in Tustin.
3. Orange Tree Apartments at 13906 and 13930 Taft Street in Garden Grove.

Pre-retrofit data are shown in **Tables 3.8** and **3.9**. Where possible, RMA chose units that had different floor plans, aspects, and/or were on different levels. The measurements taken at each unit (whenever applicable) were: Floor area, window area, forced-air unit (FAU) airflow, duct leakage, envelope leakage (infiltration), water usage of showerheads and aerators, and thermostat indoor temperature reading versus actual indoor temperature. RMA also recorded the existing make, model, and age of appliances; window aspect and type; building vintage and construction materials; insulation type of floor, ceiling and walls; HVAC system ratings; domestic water heating type and rated efficiency; thermostat scheduled for heating and cooling; and existing lighting location, type, usage, and wattage.

**Table 3.8 Pre-Retrofit Data - FAU Airflow, Duct Leakage and Infiltration**

Apartment Complex	Apt. #	Floor Area (ft <sup>2</sup> )	FAU Airflow (cfm)	Duct Leakage (cfm @ 25 Pa)	Infiltration EOA (in <sup>2</sup> )	CFM50
Jeffery-Lynne	A	891	773	71	628	4673
Jeffery-Lynne	B	891	696	134	477	3563
Flanders Pointe	31	663	No FAU	No Ducts	242	1806
Flanders Pointe	44	663	No FAU	No Ducts	188	1386
Orange Tree	4	915	919	79	296	2240
Orange Tree	2	900	525	103	390	2941

**Table 3.9 Pre-Retrofit Data - Showerhead and Aerator Flow Rates**

Apartment Complex	Apt. #	Static pressure	Showerhead	Bathroom Aerator	Kitchen Aerator
Jeffery-Lynne	A	n/a	n/a	n/a	n/a
Jeffery-Lynne	B	n/a	n/a	n/a	n/a
Flanders Pointe	31	79 psi	2.2 GPM @ 75 psi	2.3 GPM @ 77 psi	2.2 GPM @ 77 psi
Flanders Pointe	44	79 psi	3.0 GPM @ 61 psi	1.9 GPM @ 78 psi	2.2 GPM @ 76 psi
Orange Tree	4	61 psi	7.0 GPM @ 35 psi	2.0 GPM @ 56 psi	1.7 GPM @ 59 psi
Orange Tree	2	61 psi	2.5 GPM @ 60 psi	1.9 GPM @ 55 psi	2.1 GPM @ 53 psi

**3.1.1.2.1 Jeffery-Lynn Apartments (Non-Participant)**

Jeffery-Lynne Apartments has 40 units. This site was not a participant. At the time of inspections all utilities were turned off and each apartment was vacant in preparation for renovation. Unit A had windows facing north and west. Unit B had windows facing north and east. RMA found the two units to have no shell insulation, one adiabatic wall, and to be constructed of wood, with a concrete floor. The units were ground floor single-level with a floor area of 891 ft<sup>2</sup> and window area of 184 ft<sup>2</sup>. The windows were single pane with aluminum frames and had no interior or exterior shades. The complex was built in 1968. Both units had a very high amount of infiltration mainly due to no sealing around poorly cut flue holes for the FAU and stove, no

dampers in either the bathroom or range exhaust fans, and no weather-stripping or caulking around any floor or wall penetrations.

At apartment A the FAU airflow was 773 cfm, and duct leakage was 71 cfm at 25 Pa (9.2 %). The unit had infiltration of 4,673 cfm and Effective Orifice Area (EOA) of 628 in<sup>2</sup> at a pressure of 50 Pa. There were no showerheads or aerators found in the unit. The water heater for that side of the building (3 units) was 80 gallons. There were two 40 watt and nine 60 watt incandescent bulbs in the apartment along with two 40 watt T12 fixtures in the kitchen with magnetic ballasts.

At apartment B the FAU airflow was 696 cfm and duct leakage was 134 cfm at 25 Pa (19.3%). The unit had infiltration of 3,563 cfm and EOA 477 in<sup>2</sup> at a pressure of 50 Pa. There were no showerheads or aerators in the unit. The individual water heater for that unit was 40 gallons. There were six incandescent 75 watt bulbs and four 13 watt CFLs in the unit.

### **3.1.1.2.2 Flanders Pointe Apartments**

Flanders Pointe Apartments has 82 units. Both apartments were vacant, single-level, and had a floor area of 663 ft<sup>2</sup> and window area of 143 ft<sup>2</sup>. Apartment #31 was on the ground floor with windows facing north and south. Apartment #44 was on the second floor of the two story building and also had north and south facing windows. RMA found the units to have no shell insulation, two adiabatic walls, and concrete and wood construction. Apartment #3 had a concrete floor and apartment #44 had an adiabatic wood floor. The windows were single pane with aluminum frames and had interior shades. Both units had wall mounted air conditioners and furnaces with no duct system. The complex was built in 1964.

Apartment #31 had infiltration of 1806 cfm and EOA of 242 in<sup>2</sup> at 50 Pa. The static water pressure of the unit was 79 psi. The showerhead was measured at 2.2 gpm at 75 psi. The bathroom aerator was measured at 2.3 gpm at 77 psi. The kitchen aerator was measured at 2.2 gpm at 77 psi. The room temperature was measured at 78° F whereas the thermostat read a room temperature of 73° F. The water heating for that unit was a Teledyne Laars boiler with a 119 gallon storage tank used for 18 units. There were nine 35 watt and one 60 watt incandescent bulbs in the unit along with four 40 watt T12 fixtures in the kitchen.

Apartment #44 had infiltration of 1386 cfm and EOA of 188 in<sup>2</sup> at 50 Pa. The static water pressure of the unit was 79 psi. The showerhead was measured at 3.0 gpm at 61 psi. The bathroom aerator was measured at 1.9 gpm at 78 psi. The kitchen aerator was measured at 2.2 gpm at 76 psi. The room temperature was measured at 73° F whereas the thermostat read a room temperature of 66° F. The water heating for that unit was a 100 gallon Reliance water heater used for 10 units. There were nine 35 watt and one 60 watt incandescent bulbs in the unit along with four 40 watt T12 fixtures in the kitchen.

### **3.1.1.2.3 Orange Tree Apartments**

Orange Tree Apartments has 80 units. Apartment #4 at 13930 Taft St. had windows facing north and east. Apartment #2 at 13906 Taft St. had windows facing east and west. RMA found the two units to have no shell insulation, two adiabatic walls, and to be constructed of wood, with a concrete floor. The units were ground floor single-level with a floor area of 915 ft<sup>2</sup> and window area of 138 ft<sup>2</sup> for apartment #4 and a floor area of 900 ft<sup>2</sup> and window area of 203 ft<sup>2</sup> for

apartment #2. The windows were single pane with aluminum frames and had interior shades. The complex was built in 1963.

Apartment #4 had FAU airflow of 919 cfm and duct leakage was 79 cfm at 25 Pa (8.6%). The infiltration was 2240 cfm and EOA was 296 in<sup>2</sup> at 50 Pa. The static water pressure was 61 psi. The showerhead was measured at 7.0 gpm at 35 psi. The bathroom aerator was measured at 2.0 at 56 psi. The kitchen aerator was measured at 1.7 gpm at 59 psi. The individual water heater for the unit was 40 gallons. There were three 35 watt, eight 65 watt, and one 100 watt incandescent bulbs along with three 23 watt CFLs.

Apartment #2 had FAU airflow of 525 cfm and duct leakage was 103 cfm (19.6%). The infiltration was 2941 cfm and EOA was 390 in<sup>2</sup> at 50 Pa. The static water pressure of the unit was 61 psi. The showerhead was measured at 2.5 gpm at 60 psi. The bathroom aerator was measured at 1.9 at 55 psi. The kitchen aerator was measured at 2.1 gpm at 53 psi. The individual water heater for the unit was 40 gallons. There were four 25 watt, six 30 watt, one 40 watt, and two 60 watt incandescent bulbs along with five 23 watt CFLs.

**3.1.1.3 Findings from the First Post-Retrofit Inspections**

On the 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> of May 2004, Anne Blankenship and Ean Jones performed post-retrofit verification inspections at three apartment complexes that received incentives from the Efficient Affordable Housing Program.

1. Flanders Pointe Apartments at 15520 Tustin Village Way in Tustin.
2. Orange Tree Apartments at 13906 and 13930 Taft Street in Garden Grove.
3. Midway-Capri Apartments at 120 Midway in Perris.

The measures shown in **Table 3.10** were verified during the first set of post-retrofit inspections.

**Table 3.10 Post-Retrofit Verified Measures**

Site	Apts.	Reported Apts.	Verified Applicable Apts.	Reported Measures	Verified Characteristics
Flanders Pointe	82	82	41	R30 Attic Insulation	R30 to R47 (9.1" to 14")
Flanders Pointe	82	82	52	Solar Sunscreen	Shading Coefficient 0.16
Flanders Pointe	82	80	5	R4 Pipe Insulation	R4 on 5 central water heaters or boilers
Flanders Pointe	82	80	0	Room AC Rehab	Manager reported regular AC maintenance
Midway-Capri	40	40	40	R30 Attic Insulation	R30 to R59 (9.1" to 18")
Midway-Capri	40	40	40	R12 WH Blanket	R12 WH Blanket
Orange Tree	80	80	80	R30 Attic Insulation	R30 to R49 (9.1" to 15")
Orange Tree	80	50	29	9.8 EER Room AC	9.5 EER Room AC (GE AJCS10ACBM1)

**3.1.1.3.1 First Verification Inspections at Flanders Pointe Apartments**

Verification inspections at Flanders Pointe Apartments found attic insulation only applicable to the 41 second story units. Solar sunscreens were verified on windows at 52 units. Pipe insulation was verified on 5 central water heaters.



**Fig. 3.1 Flanders without Attic Insulation**



**Fig. 3.2 Flanders R30 Attic Insulation**



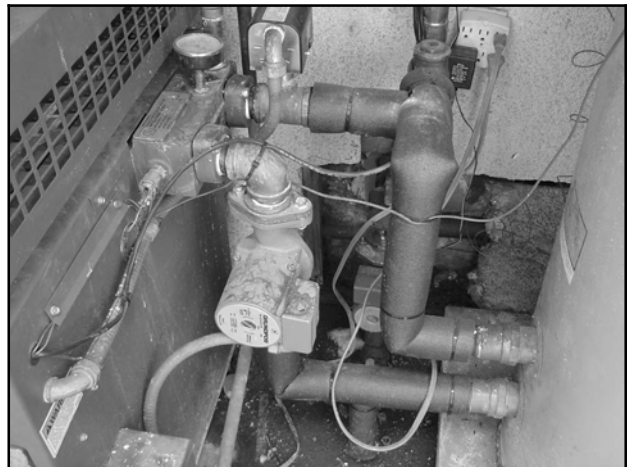
**Fig. 3.3 Flanders Pointe Solar Sunscreens**



**Fig. 3.4 Sunscreen Shading Coefficient**



**Fig. 3.5 Flanders No Pipe Insulation**



**Fig. 3.6 Flanders Pipe Insulation**

### 3.1.1.3.2 First Verification Inspections at Midway-Capri Apartments

Verification inspections at Midway-Capri Apartments found attic insulation and R12 water heater blankets applicable to 40 units (as reported).



Fig. 3.7 Midway-Capri R30 Attic Insulation



Fig. 3.8 Midway-Capri R12 WH Blankets

### 3.1.1.3.3 First Verification Inspections at Orange Tree Apartments

Verification inspections at Orange Tree Apartments found attic insulation at 80 units (as reported). The 9.8 EER room air conditioners were verified as 9.5 EER and only 29 were installed out of the 50 that were reported as installed.



Fig. 3.9 Orange Tree R30 Attic Insulation



Fig. 3.10 Orange Tree 9.5 EER RAC

### 3.1.1.4 Findings from the Second Post-Retrofit Inspections

On the 8<sup>th</sup> of June 2004, Anne Blankenship and Ean Jones performed post-retrofit verification inspections at Orange Tree Apartments to verify installation of the remaining 9.5 EER room air conditioners. The measures shown in **Table 3.11** were verified during the second set of post-retrofit inspections. The second verification inspections at Orange Tree Apartments found 9.5 EER installed at all 50 apartments (as reported).

**Table 3.11 Post-Retrofit Verified Measures**

Site	Apts.	Reported Apts.	Verified Apts.	Reported Measures	Verified Characteristics
Orange Tree	80	50	50	9.8 EER Room AC	9.5 EER Room AC (GE AJCS10ACBM1)

**3.1.1.5 Findings from the Final Post-Retrofit Inspections**

On the 28<sup>th</sup> of June 2004, Anne Blankenship and Ean Jones performed final post-retrofit verification inspections at Flanders Pointe, Midway-Capri, and Orange Tree Apartments to gather SCE utility meter numbers in order to obtain historical billing data. Meter numbers were obtained for all 202 apartments at all three apartment sites.

**3.1.2 PRISM Baseline Analyses for all Sites**

Three years of historical electric billing data was obtained for a sample of 106 participant sites and historical gas billing data was obtained for 9 participant sites. This data was analyzed using the PRinceton Scorekeeping Method (PRISM) to develop normalized annual consumption (NAC) and cooling and heating unit energy consumption (UEC) values. Load impacts for all measures were evaluated using the DOE-2.2 building energy simulation program calibrated to UEC values developed using PRISM. Average NAC values and average space cooling and heating UEC values for each site are shown in **Table 3.12**. The 90 percent confidence intervals are also provided. The confidence intervals indicate a relatively high coefficient of variation due to some customers who use very little cooling or heating.

**Table 3.12 Average NAC and UEC Values for Participating Apartments**

Site	Electric Billing Data Sample	CEC Climate Zone	Electric NAC (kWh/y)	Cooling UEC (kWh/y)	Gas Billing Data Sample	Therm NAC (therm/y)	Heat UEC (therm/y)
Flanders	40	8	3,256	513 ± 159	n/a	373	120 ± 53
Orange Tree	41	8	4,171	693 ± 170	5	373	120 ± 53
Midway Capri	25	10	3,213	857 ± 364	4	270	113 ± 38

**3.1.3 DOE-2.2 Building Energy Simulation Models**

Load impacts for space cooling and heating measures are based on field inspections, on-site audits, and DOE-2.2 building energy simulation models calibrated to UEC data developed using PRISM based on three years of historical billing data.<sup>22</sup> The load impact approach is consistent with IPMVP Option D. The eQuest model for Flanders Pointe Apartments is shown in **Figure 3.11**. The models for Midway-Capri and Orange Tree were similar with the exception of being one-story. The model was calibrated using average baseline space cooling and heating UEC values and Typical Meteorological Year (TMY) weather data for CEC climate zone 8.<sup>23</sup> After calibrating to CEC climate zone 8, the model was used to evaluate savings for weather sensitive measures with input assumptions based on the verification inspections. The DOE-2 building

<sup>22</sup> DOE-2.2 eQuest building performance simulation program version 3.37, [www.energydesignresources.com](http://www.energydesignresources.com), James J. Hirsch, 2003. TMY weather data for Los Angeles climate zone 9 from *California Thermal Climate Zones*, California Energy Commission, 1516 Ninth St., Sacramento, CA 95814, 1992.

<sup>23</sup> *California Thermal Climate Zones*, California Energy Commission, 1516 Ninth St., Sacramento, CA 95814, 1992.

characteristics for Flanders Pointe, Midway-Capri, and Orange Tree Apartments are provided in Table 3.13.

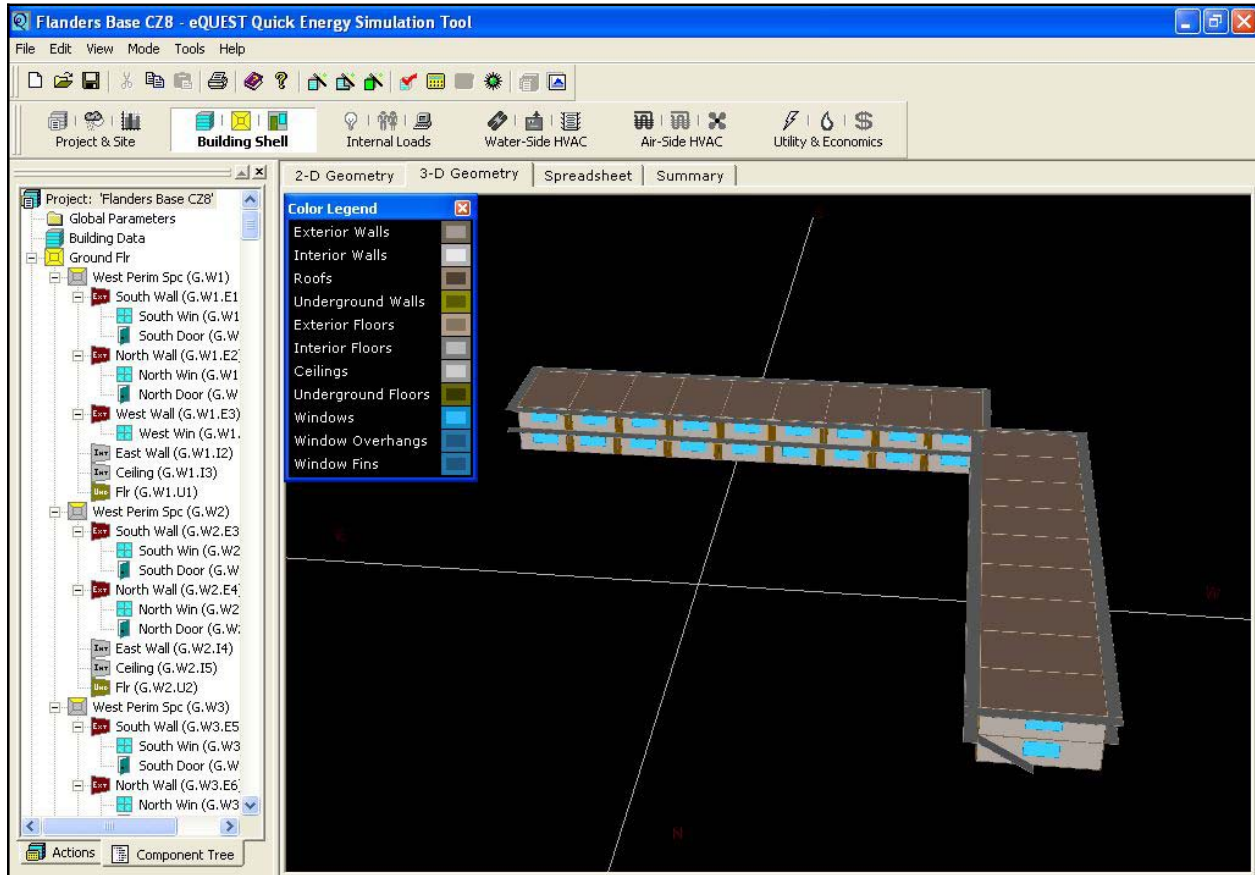


Figure 3.11 Flanders Pointe eQuest (DOE-2.2) Building Energy Simulation Model

Table 3.13 DOE-2.2 Input Characteristics for Flanders, Midway, and Orange Tree

Characteristic	Flanders Pointe	Midway-Capri	Orange Tree
Total Floor Area (sf)	62,954	35,040	75,830
Total Units	82	40	80
Floors	2	1	1
Model Unit Floor Area (sf)	663	876	948
Average Ceiling Height	8	8	8
Wall R-value [cavity only]	None [0]	None [0]	None [0]
Wall Type	Wood, Concrete	Wood, Concrete	Concrete Block
Ceiling R-value [cavity]	None [0]	17.2 [11]	17.2 [11]
Ceiling Area, total exterior (sf)	663 (upstairs)	876	948
Hallway Area per Floor (sf)	n/a	n/a	n/a
Floor R-value [cavity]	Concrete Slab or Wood	Concrete Slab	Concrete Slab
Door Area (sf)	20.1	40.2	40.2
Door R-Value	2	2	2
Window-to-Floor Area Ratio	0.216	0.23	0.226
Air Changes per Hour (ELA)	0.9 [0.0023 ELA]	0.9 [0.0023 ELA]	0.89 [0.0022 ELA]
Window u-value	1.03	1.03	1.03
Number of Panes	1	1	1
Occupancy (people)	2	2	2
Lighting Intensity (W/sqft)	0.36	0.4	0.4



**Table 3.13 DOE-2.2 Input Characteristics for Flanders, Midway, and Orange Tree**

Characteristic	Flanders Pointe	Midway-Capri	Orange Tree
Electric Internal Loads (W/sqft)	0.54	0.37	0.4
Internal Loads (Btu/hr-sqft)	6.0	4.6	n/a
Heating Setpoint/Setback (F)	70/65	70/60	70/60
Cooling Setpoint/Setforward (F)	79/off	82/off	79/off
HVAC Zoning	Single zone	Single zone	Single zone
Heating System Type	Gas furnace	Gas furnace	Gas furnace
Heating Capacity (kBtu/hr-unit)	24.5	40	31
Supplemental Heat Cap. (kBtu/hr)	n/a	n/a	n/a
Heating System Efficiency	0.75	0.75	0.75
Cooling System Type	Room AC	Packaged	Room AC
Cooling Capacity (kBtu/hr-unit)	9.8	24	10.2
Cooling System EER	8.9	8.6	8.5
Design Air (cfm/sqft)	0.63	0.4	0.97

### 3.1.3 Load Impact Results at Flanders Pointe

Load impacts for R30 attic insulation and solar sunscreen measures at Flanders Pointe are based on field inspections, detailed audits, billing data analyses, and calibrated DOE-2.2 energy simulations consistent with IPMVP Option D. Load impacts for water heater pipe insulation are based on verification inspections and the 2001 DEER Update Study consistent with IPMVP Option A. Pre- and post-retrofit field inspections were performed and the inspections verified proper installation of all measures. First year ex post unit load impacts for measures installed at Flanders Pointe are provided in **Table 3.14**. Since all of these measures were previously offered under the Statewide Residential Contractor Program, the net-to-gross ratio is 0.89.<sup>24</sup> First year ex post site load impacts are shown in **Table 3.15**. Net first year ex post savings are 15,461 ± 4,782 kWh/year and 18.4 ± 5.7 kW for space cooling, 996 ± 436 therm/year for space heating, and 22 ± 5 therm/year for water heating. Solar sunscreens produce negative space heating savings due to reduced solar gain in winter.

**Table 3.14 First Year Gross Ex Post Unit Load Impacts for Measures at Flanders Pointe**

Description	Space Cooling Usage kWh/yr	Space Cooling Usage kW	Space Heating Usage therm/yr	Water Heating Usage therm/yr	Gross Ex Post Unit Savings kWh/yr	Gross Ex Post Unit Savings kW	Gross Ex Post Unit Savings therm/yr
Baseline	513	1.45	120	203	n/a	n/a	n/a
R30 Attic Insulation	225	1.11	61	n/a	288	0.34	59
Solar Sunscreens	118	0.98	86	n/a	107	0.13	-25
Pipe Insulation				198			5

HMG provided savings estimates for Flanders based on the Micropas computer program, and these values are provided at the bottom of **Table 3.15**. The Micropas savings were evaluated and the cooling savings were 19 times greater than the ex post savings and 8 times greater than the ex post cooling UEC. The HMG Micropas space heating savings were 2 times greater than the ex post savings.

<sup>24</sup> The ex post NTGR is 0.89 based on the Residential Contractor Program applicable to rebate measures, see *Energy Efficiency Policy Manual*, Version 3, Chapter 4, Table 4.2, page 19, prepared by the California Public Utilities Commission, 2003.

**Table 3.15 First Year Ex Post Site Load Impact for Measures at Flanders Pointe**

Description	Apts.	Gross Ex Post Electric Savings kWh/yr	Gross Ex Post Electric Savings kW	Gross Ex Post Gas Savings therm/yr	Net to Gross Ratio	Net Ex Post Electric Savings kWh/yr	Net Ex Post Electric Savings kW	Net Ex Post Gas Savings therm/yr
R30 Attic Insulation	41	11,808	13.94	2,419	0.89	10,509	12.4	2,153
Solar Sunscreens	52	5,564	6.76	-1,300	0.89	4,952	6.0	-1,157
R4 Pipe Insulation	5			25	0.89	0	0.0	22
<b>Total Ex Post</b>		<b>17,372</b>	<b>20.70</b>	<b>1,144</b>		<b>15,461</b>	<b>18.4</b>	<b>1,018</b>
HMG Micropas		338,025		1,910				
HMG/Ex Post Ratio		19		2				

Lifecycle ex post site load impacts are shown in **Table 3.16** Net ex post lifecycle electricity savings for Flanders Pointe Apartments are 284,462 ± 87,991 kWh and 25,948 ± 11,296 therms.

**Table 3.16 Lifecycle Ex Post Site Load Impacts for Measures at Flanders Pointe**

Description	EUL	Gross Ex Post Lifecycle kWh	Gross Ex Post Lifecycle therm	NTGR	Net Ex Post Lifecycle kWh	Net Ex Post Lifecycle therms
R30 Attic Insul	20	236,160	48,380	0.89	210,182	43,058
Solar Sunscreens	15	83,460	-19,500	0.89	74,279	-17,355
R4 Pipe Insulation	11		275	0.89	0	245
<b>Total</b>		<b>319,620</b>	<b>29,155</b>	<b>0.89</b>	<b>284,462</b>	<b>25,948</b>

### 3.1.4 Load Impact Results at Midway-Capri

Load impacts for R30 attic insulation at Midway-Capri are based on field inspections, detailed audits, billing data analyses, and calibrated DOE-2.2 energy simulations consistent with IPMVP Option D. Load impacts for R12 water heater blankets are based on verification inspections and the 2001 DEER Update Study consistent with IPMVP Option A. Pre- and post-retrofit field inspections were performed and the inspections verified proper installation of all measures. First year ex post unit load impacts for measures installed at Midway-Capri are provided in **Table 3.17**. Since all of these measures were previously offered under the Statewide Residential Contractor Program, the net-to-gross ratio is 0.89. First year ex post site load impacts are shown in **Table 3.18**. Net first year ex post savings are 11,107 ± 4,723 kWh/year and 13.2 ± 5.6 kW for space cooling, 3,311 ± 1,128 therm/year for space heating, and 438 ± 101 therm/year for water heating.

**Table 3.17 First Year Gross Ex Post Unit Load Impacts for Measures at Midway-Capri**

Description	Space Cooling Usage kWh/yr	Space Cooling Usage kW	Space Heating Usage therm/yr	Water Heating Usage therm/yr	Gross Ex Post Unit Savings kWh/yr	Gross Ex Post Unit Savings kW	Gross Ex Post Unit Savings therm/yr
Baseline	857	2.79	113	203	n/a	n/a	n/a
R30 Attic Insulation	545	2.42	20	n/a	312	0.37	93
R12 WH Blanket				191			12

HMG provided savings estimates for Midway-Capri based on the Micropas computer program, and these values are provided at the bottom of **Table 3.18**. The Micropas savings were evaluated and the cooling savings were 8 times greater than the ex post savings and 3 times greater than the ex post cooling UEC. The HMG Micropas space heating savings were 3.4 times less than the ex post savings.

**Table 3.18 First Year Ex Post Site Load Impact for Measures at Midway-Capri**

Description	Apts.	Gross Ex Post Electric Savings kWh/yr	Gross Ex Post Electric Savings kW	Gross Ex Post Gas Savings therm/yr	Net to Gross Ratio	Net Ex Post Electric Savings kWh/yr	Net Ex Post Electric Savings kW	Net Ex Post Gas Savings therm/yr
R30 Attic Insulation	40	12,480	14.80	3,720	0.89	11,107	13.2	3,311
R12 WH Blanket	41			492	0.89	0	0.0	438
<b>Total Ex Post</b>		<b>12,480</b>	<b>14.80</b>	<b>4,212</b>		<b>11,107</b>	<b>13.2</b>	<b>3,749</b>
HMG Micropas		102,321		1,215				
HMG/Ex Post Ratio		8		0.29				

Lifecycle ex post site load impacts are shown in **Table 3.19**. Net ex post lifecycle electricity savings for Midway-Capri Apartments are 222,144 ± 94,455 kWh and 71,033 ± 23,659 therms.

**Table 3.19 Lifecycle Ex Post Site Load Impacts for Measures at Midway-Capri**

Description	EUL	Gross Ex Post Lifecycle kWh	Gross Ex Post Lifecycle therm	NTGR	Net Ex Post Lifecycle kWh	Net Ex Post Lifecycle therms
R30 Attic Insul	20	249,600	74400	0.89	222,144	66,216
R12 WH Blanket	11		5412	0.89	0	4,817
<b>Total</b>		<b>249,600</b>	<b>79,812</b>	<b>0.89</b>	<b>222,144</b>	<b>71,033</b>

### 3.1.4 Load Impact Results at Orange Tree

Load impacts for R30 attic insulation and 9.5 EER room air conditioners at Orange Tree are based on field inspections, detailed audits, billing data analyses, and calibrated DOE-2.2 energy simulations consistent with IPMVP Option D. Pre- and post-retrofit field inspections were performed and the inspections verified proper installation of all measures. First year ex post unit load impacts for measures installed at Orange Tree are provided in **Table 3.20**. Since all of these measures were previously offered under the Statewide Residential Contractor Program, the net-to-gross ratio is 0.89. First year ex post site load impacts are shown in **Table 3.21**. Net first year ex post savings are 17,008 ± 4,163 kWh/year and 19.9 ± 4.9 kW for space cooling, and 6,978 ± 3,052 therm/year for space heating.

**Table 3.20 First Year Gross Ex Post Unit Load Impacts for Measures at Orange Tree**

Description	Space Cooling Usage kWh/yr	Space Cooling Usage kW	Space Heating Usage therm/yr	Water Heating Usage therm/yr	Gross Ex Post Unit Savings kWh/yr	Gross Ex Post Unit Savings kW	Gross Ex Post Unit Savings therm/yr
Baseline	693	1.20	120	203	n/a	n/a	n/a
9.5 EER RAC	486	0.96	22	n/a	207	0.24	98.00
R12 WH Blanket	435	0.90	22		51	0.06	

HMG provided savings estimates for Orange Tree based on the Micropas computer program, and these values are provided at the bottom of **Table 3.21**. The Micropas savings were evaluated and the cooling savings were 29 times greater than the ex post savings and 10 times greater than the ex post cooling UEC. The HMG Micropas space heating savings were 1.2 times greater than the ex post savings.

**Table 3.21 First Year Ex Post Site Load Impact for Measures at Orange Tree**

Description	Apts.	Gross Ex Post Electric Savings kWh/yr	Gross Ex Post Electric Savings kW	Gross Ex Post Gas Savings therm/yr	Net to Gross Ratio	Net Ex Post Electric Savings kWh/yr	Net Ex Post Electric Savings kW	Net Ex Post Gas Savings therm/yr
R30 Attic Insulation	80	16,560	19.41	7,840	0.89	14,738	17.3	6,978
9.5 EER RAC	50	2,550	2.99	0	0.89	2,270	2.7	0
<b>Total Ex Post</b>		<b>19,110</b>	<b>22.40</b>	<b>7,840</b>		<b>17,008</b>	<b>19.9</b>	<b>6,978</b>
HMG Micropas		551,943		9,070				
HMG/Ex Post Ratio		29		1.2				

Lifecycle ex post site load impacts are shown in **Table 3.22**. Net ex post lifecycle electricity savings for Orange Tree Apartments are 328,811 ± 80,480 kWh and 139,552 ± 61,045 therms.

**Table 3.22 Lifecycle Ex Post Site Load Impacts for Measures at Orange Tree**

Description	EUL	Gross Ex Post Lifecycle kWh	Gross Ex Post Lifecycle therm	NTGR	Net Ex Post Lifecycle kWh	Net Ex Post Lifecycle therms
R30 Attic Insul	20	331,200	156800	0.89	294,768	139,552
9.5 EER RAC	15	38,250	0	0.89	34,043	0
<b>Total</b>		<b>369,450</b>	<b>156,800</b>	<b>0.89</b>	<b>328,811</b>	<b>139,552</b>

### 3.2 Process Evaluation Results

The process surveys were used to evaluate participant satisfaction and obtain suggestions to improve the program's services and procedures. Interview questions assessed how the program influenced awareness of linkages between efficiency improvements, bill savings, and increased comfort for the residents. Participants were asked why and how they decided to participate in the program. Non-participants were asked why they chose not to participate. The surveys identified reasons why program marketing efforts were not successful with non-participants as well as to identify additional hard-to-reach market barriers. The process survey instruments for the 2<sup>nd</sup> Tier UA are provided in Appendix A. The process survey instruments for the EAH Incentive program are provided in Appendix B.

### 3.2.1 Participant Survey Results for the 2<sup>nd</sup> Tier Utility Allowance

Process evaluation recommendations for the 2<sup>nd</sup> Tier UA are based on process surveys conducted over the telephone with three housing authority (HA) managers (census). According to the interviewed HA managers, there were 2,423 participating apartment units with a potential for 3,923 participating units if all current new construction projects in the City of Norwalk (1,500 units) decided to participate. The 2<sup>nd</sup> Tier UA participant process survey results are summarized to answer the following questions from the CPUC-approved EM&V plan.

#### 1. Are participating HA managers satisfied with services and information provided by the program?

Participant satisfaction was very high as indicated by the following survey responses, though more educational materials could be provided.

- Overall Satisfaction with Program – 100% satisfaction rating (i.e., average score of 10.0 out of 10 points).
- Courteous and Professional Crew – 100% satisfaction rating.
- Increased Understanding of Link between Energy Efficiency, Savings, and Comfort – 43% indicating property owner energy education efforts could be improved.
- Program’s Usefulness – 100% satisfaction rating.
- Program’s Presentation – 100% satisfaction rating.

#### 2. Do participating HA managers have any suggestions to improve the program?

HA managers did not have any suggestions to improve the program.

#### 3. Did HA managers share information with business associates about the benefits of the UA program (i.e., multiplier effects)?

- Each participating HA manager shared information with an average of 34 business associates about the benefits of measures offered by the program at the Southern California Finance Officers Group meeting.

#### 4. What are the tenant hard-to-reach demographics?

Tenant demographics were verified as “hard-to-reach” as indicated by the following results.

- According to the HA managers, all of the participating complexes are multi-family properties. The Riverside County HA stated there are 323 apartments participating in the UA program. The City of Anaheim HA said that 2,100 apartment units are participating in the UA program. The City of Norwalk HA indicated a potential of 1,500 apartments to participate in the program, although none of the sites have decided to participate yet.
- According to the HA managers, the average number of occupants is 3 per apartment.
- According to the housing authority managers, the tenants speak a variety of primary languages (i.e., Spanish, English, Chinese, Vietnamese and Korean).

### 3.2.2 Non-Participant Survey Results for the 2<sup>nd</sup> Tier Utility Allowance

Process evaluation recommendations for the 2<sup>nd</sup> Tier UA are based on process surveys conducted over the telephone with the managers of 10 non-participating HA (census). Non-participant process survey results are summarized to answer the following questions from the CPUC-approved EM&V plan.

#### 1. Is there a continuing need for the program?

- 30% of non-participants are planning to consider UA revisions in the foreseeable future.
- All non-participants considering UA revisions would consider making energy efficiency improvements part of the UA.

**2. Why have customers chosen not to participate (i.e., market barriers)?**

- 30% are not building any new complex at this time.
- 30% didn't participate due to lack of time or scheduling problems (i.e., hassle cost).
- 20% didn't participate because they felt that the program wasn't right for their HA.
- 20% have yet to decide whether or not their HA is going to participate.

Most non-participants didn't participate because their HA is not considering any new complexes at this time or the HA didn't have time to consider the program. The most often cited barriers to participation include lack of eligibility, hassle costs, and performance uncertainty. Although difficult to quantify, it appears that a large segment of the multi-family market is affected by each of these barriers.

**3. Do non-participants have any suggestions to improve participation?**

- One of the non-participants requested more information about the program.

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

Non-participants had the following hard-to-reach demographics.

- 100% of non-participants manage housing authorities.
- The primary language spoken by the tenants is English, followed by Spanish and Vietnamese.
- According to the non-participants, the average number of affordable multi-family apartments managed by each HA is 3,166 with an average of 2.43 tenants per apartment.

### **3.2.3 Process Evaluation Results for EAH Incentives**

Process evaluation recommendations for the EAH incentive program are based on process surveys conducted over the telephone with all three participating apartment managers (census). EAH incentive program participant process survey results are summarized to answer the following questions from the CPUC-approved EM&V plan.

**1. Are participating property managers satisfied with services or information provided by the program?**

Participant satisfaction is very high as indicated by the following survey responses.

- Overall Satisfaction with Program – 93% satisfaction rating (i.e., average score of 9.3 out of 10 points).
- Courteous and Professional Crew – 93% satisfaction rating (i.e., 9.3 out of 10 points).
- Timeliness (i.e., customer felt that rebate was paid within a reasonable timeframe) – 100% satisfaction rating. The average reported number of weeks between submitting application and receiving rebate 2.0 weeks.
- Increased Understanding of Link between Energy Efficiency, Savings, and Comfort – 70% indicating property manager energy education efforts could be improved.
- Program's Usefulness – 93% satisfaction rating.
- Program's Presentation – 87% satisfaction rating.

**2. Are participating property managers satisfied with measures installed by the program?**

Customer satisfaction with measures is very high as indicated by the following responses.

- 100% of property managers stated that they are still using all measures installed by the program.
- 67% of managers were “very pleased with the program’s results”.
- 33% of managers stated that the program was easy to understand.

**3. Do participants have any suggestions to improve the program?**

- None of the participating managers had any suggestions to improve the program.

**4. Did property owners share information with business associates about the benefits of measures offered by the program (i.e., multiplier effects)?**

- All property managers surveyed shared information with an average of 20 business associates about the benefits of measures offered by the program.

**5. What are the participant hard-to-reach demographics?**

Participant demographics were verified as “hard-to-reach” as indicated by the following results.

- A total of 202 apartments in 3 complexes were affected by the program.
- An average of 2.48 occupants resides in each of the units.
- 20% of participating apartments meet the hard-to-reach criteria of being located outside the Los Angeles basin (i.e., Perris).
- About 50% of the tenants spoke Spanish as their primary language.
- About 50% of the tenants spoke English as their primary language.

### **3.2.4 Non-Participant Survey Results for EAH Incentives**

Process evaluation recommendations for the EAH incentive program are based on process surveys conducted over the telephone with all three non-participating apartment managers or project coordinators (census). Non-participant process survey results are summarized to answer the following questions from the CPUC-approved EM&V plan.

**1. Is there a continuing need for the program?**

The following responses indicate a continuing need for the program.

- 67% of non-participants stated that they will be making improvements to their buildings in the foreseeable future and would consider making energy efficiency improvements if incentives were available.

**2. Why have customers chosen not to participate (i.e., market barriers)?**

- 100% didn’t participate due to lack of time or scheduling problems with finishing all of the required paperwork to participate in the program. The cited barrier to participation is hassle costs.

**3. Do non-participants have any suggestions to improve participation?**

- Non-participants had no suggestions to improve their participation in the program.

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

Non-participants had the following hard-to-reach demographics.

- The primary language spoken by the tenants is Spanish, followed by Chinese and then English.
- On average, eleven Section 8 properties are managed by each non-participant, ten of which are located outside of the LA Basin.
- There is an average of 3 occupants per unit.

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

### **3.2.5 Process Evaluation Recommendations**

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

#### **3.2.5.1 General Program Recommendations for the 2<sup>nd</sup> Tier UA**

1. All housing authorities participating in the 2<sup>nd</sup> Tier UA program should be informed that in order to properly evaluate the program, it is necessary that the contractors installing the building upgrades be contacted and surveyed. The contractors should be asked what upgrades are being installed at what location. It is necessary that the installation receipts and documents be available for viewing in order to verify the housing authority's participation in the 2<sup>nd</sup> Tier UA program.
2. Better advertising at housing authority meetings would increase participant understanding and appreciation of program parameters. Advertising should explain how the housing authority managers can take advantage of utility allowance energy efficiency improvements offered by the program.
3. While the 2<sup>nd</sup> Tier UA program provided useful information to housing authority managers at the meetings and over the telephone, it may also help to consider providing a simple energy education pamphlet to housing authority managers to clearly explain the link between energy efficiency, utility bills, energy savings, and comfort.

#### **3.2.5.2 General Program Recommendations for the EAH Incentive Program**

1. While the EAH program did provide useful information to participating property managers about energy efficiency improvement options for their apartment complexes, it would be helpful to consider providing a simple energy education pamphlet to all participating multi-family tenants and property owners to clearly explain the link between energy efficiency, utility bills, energy savings, and comfort.
2. Better advertising through the telephone, email, mail, or newspapers will increase apartment manager participation and appreciation of program parameters. Advertising should explain how multi-family property managers can take advantage of the energy efficiency benefits offered by the EAH program.

#### **3.2.5.3 Recommendations for Estimating Energy Savings (EAH and 2<sup>nd</sup> Tier)**

HMG should consider using a more accurate energy savings methodology based on billing data or use the DEER database for estimating savings. This recommendation is based on the evaluation of Micropas savings estimates provided for three sites that received incentives. The



Micropas space cooling savings were 3 to 10 times greater than the cooling unit energy consumption based on billing data and 8 to 29 times greater than the calibrated DOE-2.2 evaluation savings. The Micropas computer program is a compliance tool for the CEC Alternative Calculation Method under the Title 24 Building Energy Efficiency Standards for new construction.<sup>25</sup> Micropas can be used for existing buildings if it is calibrated to site-specific billing data or average cooling, heating, and water heating unit energy consumption (UEC) values. Calibrating the energy savings methodology will avoid potential problems of over-estimating energy savings and recommending measures that are potentially non-cost effective. Southern California Edison (SCE) will provide billing data from meter numbers with signed confidentiality agreement forms.

### 3.2.5.4 Recommendations to Avoid Lost Opportunities for Savings

1. Although the program was designed to promote space heating, space cooling, and water heating measures consistent with Title-24, this focus will result in lost opportunities for cost effective energy efficient lighting and appliance measures for multi-family occupants and property owners.
2. Future programs should be more comprehensive and include market intervention strategies (i.e., energy educational information) or incentives to promote energy efficient lighting, appliances (refrigerators, dishwashers, fans), and equipment (such as clothes washers).
3. The following measures should be considered: air conditioner refrigerant charge and airflow tune-ups; water heater or boiler controllers; efficient showerheads and aerators; Energy Star programmable thermostats; and lowering hot water temperatures. These measures will increase savings, cost effectiveness, and reduce lost opportunities.

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<sup>25</sup> California Energy Commission (CEC). *2001 Energy Efficiency Standards*. Report CEC P400-01-024. June 1, 2001. Sacramento, Calif.: California Energy Commission.

# Appendix A: 2<sup>nd</sup> Tier UA Process Survey Instrument

## Interview Instructions for 2<sup>nd</sup> Tier Utility Allowance (UA) Process Survey

### 1. Purpose

The purpose of the Process Survey is to evaluate market barriers to energy efficiency and questions to determine what works, what doesn't work, participant satisfaction, and suggestions for improvement in the program's services and procedures. Complete 10 to 20 participant and 10 non-participant surveys. The HMG local program seeks to influence energy efficiency improvements at approximately 10,000 multifamily housing units through changing housing authority utility allowance practices in Riverside, San Bernardino, Ventura, and Long Beach.

### 2. Selection of Respondent

Process surveys will be randomly selected to include surveys from housing authorities. Interviews will be conducted with participants, interested non-participants, and uninterested non-participants. In-depth housing authority interviews will assess how the program influenced utility allowance practices. Verification of utility allowance changes will be performed using schedules for 2001, 2002 and 2003.

1. **Participants** must be the person responsible for participating in the 2<sup>nd</sup> Tier Utility Allowance.
2. **Non-participants** must be a housing authority who chose not to participate in the program (see non-participant survey at end).

### 3. How to Start a Survey

Complete the following steps to start one of these surveys:

1. Review HMG customer file information (for participants).
2. For 2<sup>nd</sup> Tier Utility Allowance participants make sure you understand what information HMG provided and whether or not the Housing Authority is participating in the 2<sup>nd</sup> Tier Utility Allowance before initiating the visit or call.
3. Participant Survey Introduction.  
**Say:** "Hello! My name is [\_\_\_\_\_], and I am conducting a survey regarding the 2<sup>nd</sup> Tier Utility Allowance. The program provided information about the 2<sup>nd</sup> Tier Utility Allowance. Funding for the program came from the California Public Utilities Commission. Would you mind spending 10 to 20 minutes to answer a few questions to help us evaluate and improve the program?"
4. Non-participant Survey Introduction.  
**Say:** "Hello! My name is [\_\_\_\_\_], and I am conducting a survey regarding the HMG 2<sup>nd</sup> Tier Utility Allowance Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program provided information about the 2<sup>nd</sup> Tier Utility Allowance. Would you mind spending 10 minutes to answer a few questions to help us evaluate and improve the program?"

HMG 2<sup>nd</sup> Tier Utility Allowance Participant Survey

# \_\_\_\_\_

Business \_\_\_\_\_ Name \_\_\_\_\_ Title \_\_\_\_\_

Address \_\_\_\_\_ City \_\_\_\_\_ ZIP \_\_\_\_\_

Phone Number \_\_\_\_\_ Survey Date \_\_\_\_\_ Surveyor Initials \_\_\_\_\_

Participant Survey (2<sup>nd</sup> Tier Utility Allowance Program)

- 1. Do you remember receiving information about the 2<sup>nd</sup> Tier Utility Allowance Program?
2. How did you learn about the 2<sup>nd</sup> Tier Utility Allowance Program?
3. Did you decide to EAH beyond Title 24 standards due to the 2nd Tier UA, MF Energy Star Rebate Program, or both?
4. If both programs influenced you, which program had more influence: the 2<sup>nd</sup> Tier UA or the Utility Program?
5. Would property owners have built their projects to higher energy efficiency standards without the 2nd Tier UA?
6. How many apartments will be upgraded with improvements based on your participation in the 2nd Tier UA?

Please answer the following questions on a scale of 1 to 10, with 1 being lowest rating and 10 being highest.

- 7. How would you rate the 2<sup>nd</sup> Tier Utility Allowance Program overall on a scale from 1 to 10?
8. How would you rate the 2<sup>nd</sup> Tier UA staff in terms of being professional on a scale from 1 to 10?
9. How would you rate the 2<sup>nd</sup> Tier UA staff in terms of being courteous and helpful on a scale from 1 to 10?
10. How would you rate the 2<sup>nd</sup> Tier Utility Allowance Program in terms of usefulness on a scale from 1 to 10 (i.e., usefulness of information regarding energy efficiency for your housing authority)?
11. How would you rate the 2<sup>nd</sup> Tier Utility Allowance Program in terms of presentation on a scale from 1 to 10 (i.e., way information was advertised or delivered to you)?
12. How would you rate the 2<sup>nd</sup> Tier Utility Allowance Program in terms of increasing your understanding of the linkage between energy efficiency and utility bill savings?
13. Have you shared information about the benefits of the 2<sup>nd</sup> Tier Utility Allowance Program?
14. Please provide the following demographic information?
15. Do you have any suggestions to improve the program?

**HMG 2<sup>nd</sup> Tier Utility Allowance Non-Participant Survey** # \_\_\_\_\_

Business \_\_\_\_\_ Name \_\_\_\_\_ Title \_\_\_\_\_

Address \_\_\_\_\_ City \_\_\_\_\_ ZIP \_\_\_\_\_

Phone Number \_\_\_\_\_ Survey Date \_\_\_\_\_ Surveyor Initials \_\_\_\_\_

**Non-Participant Survey (2<sup>nd</sup> Tier Utility Allowance Program)**

I am conducting a survey regarding HMG 2<sup>nd</sup> Tier Utility Allowance Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program provided information about the 2<sup>nd</sup> Tier Utility Allowance for your Housing Authority. Would you mind spending 10 minutes to answer a few questions to help us evaluate and improve the program?

1. Are you a Housing Authority manager?  
\_\_\_ **1** (Yes)      \_\_\_ **2** (No—Ask for someone else or **STOP**—Thank you and Goodbye) **98** DK **99**  
Refused
2. How many properties are included in your jurisdiction?  
\_\_\_ **1** (one) \_\_\_ **2** (2 to 4) \_\_\_ **3** (5 to 9) \_\_\_ **4** (10 to 19) \_\_\_ **5** (20 to 29) \_\_\_ **6** (30 to 39) \_\_\_ **7** (40 or more) **99** Refused
3. Please tell me why you choose not to participant in the 2<sup>nd</sup> Tier Utility Allowance Program? (Read list – Multiple answers are okay.)
  - 1** Didn't know about the program (i.e., information cost).
  - 2** Didn't understand energy savings benefits of the program (i.e., performance uncertainty).
  - 3** Don't care because other utilities (i.e., sewer, water, garbage) are more important (i.e., misplaced or split incentive).
  - 4** Didn't have time to consider the program or understand efficiency issues (i.e., hassle cost).

**4a** Would you have participated if someone else you know (i.e., an employee) had taken time to help you participate (i.e., learn about 2<sup>nd</sup> Tier Utility Allowance)?

\_\_\_ **1** (Yes)      \_\_\_ **2** (No)      **98** Don't Know      **99** Refused to Answer
- 5** Other \_\_\_\_\_ **98** Don't Know **99** Refused to Answer
4. Would you have participated if the program had better marketing, design, implementation, delivery and follow-up efforts?  
\_\_\_ **1** (Yes) \_\_\_ **2** (No)      **98** Don't Know      **99** Refused to Answer
5. Are you planning to consider Utility Allowance revisions in the foreseeable future?  
\_\_\_ **1** (Yes) \_\_\_ **2** (No, Skip to Q3)      **98** Don't Know      **99** Refused to Answer
6. If "yes or DK," would you consider making energy efficiency improvements part of the Utility Allowance?  
\_\_\_ **1** (Yes) \_\_\_ **2** (No)      **98** Don't Know      **99** Refused to Answer
7. Please provide the following demographic information?  
\_\_\_\_\_ Language(s)      \_\_\_\_\_ # Affordable MF buildings      \_\_\_\_\_ # MF units      \_\_\_\_\_ #MF tenants **98** DK **99**  
Refused
8. Do you have any suggestions that might have helped you participate in the program?  
\_\_\_ **1** (Yes)      \_\_\_ **2** (No)      **98** Don't Know      **99** Refused to Answer  
If so, please provide the suggestion(s). \_\_\_\_\_  
\_\_\_\_\_

## Appendix B: Incentives Process Survey Instrument

### Interview Instructions for EAH Incentives Process Survey

#### 1. Purpose

The purpose of the Process Survey is to evaluate market barriers to energy efficiency and ask questions to determine what works, what doesn't work, participant satisfaction, and suggestions for improvement in the program's services and procedures. Complete 2 or 3 participant and 2 to 10 non-participant surveys. The HMG local program provided energy efficiency incentives for 2 or 3 sites with roughly 162-202 affordable housing units in the SCE and SCG service areas.

#### 2. Selection of Respondent

Process surveys will be selected to include surveys from housing authorities and Section 8 property owners. Interviews will be conducted with participants, interested non-participants, and uninterested non-participants.

3. **Participants** must be the person responsible for participating in the Section 8 property owner incentive program.
4. **Non-participants** must be a Section 8 multi-family property owner who chose not to participate in the program (see non-participant survey at end).

#### 3. Two Types of Sites

This survey will be used for two types of sites:

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

#### 4. How to Start a Survey

Complete the following steps to start one of these surveys:

5. Review HMG customer file information (for participants).
6. For incentive program participants, make sure you understand what HMG provided incentives for prior to initiating the visit or call.
7. Participant Survey Introduction.  
**Say:** "Hello! My name is [\_\_\_\_\_], and I am conducting a survey regarding the Efficient Affordable Housing Program. The program provided incentives for space cooling, space heating and/or water heating measures for your multifamily property. Funding for the program came from the California Public Utilities Commission. Would you mind spending 10 to 20 minutes to answer a few questions to help us evaluate and improve the program? If no, gently remind them that their participation requires a survey to evaluate their participation.
8. Non-participant Survey Introduction.  
**Say:** "Hello! My name is [\_\_\_\_\_], and I am conducting a survey regarding the HMG Efficient Affordable Housing Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program provided incentives for space cooling, space heating and water heating measures for multifamily properties. Would you mind spending 10 to 20 minutes to answer a few questions to help us evaluate and improve the program? If no, thank them and hang up.

## HMG EAH Incentives Participant Survey

# \_\_\_\_\_

Business \_\_\_\_\_ Name \_\_\_\_\_ Title \_\_\_\_\_

Address \_\_\_\_\_ City \_\_\_\_\_ ZIP \_\_\_\_\_

Phone Number \_\_\_\_\_ Survey Date \_\_\_\_\_ Surveyor Initials \_\_\_\_\_

### Participant Survey (EAH Incentives Program)

1. Did your company receive (or apply) for an incentive from the Efficient Affordable Housing (EAH) Program?  
\_\_\_ 1 (Yes) \_\_\_ 2 (No) If no ask to speak with someone else 98 Don't Know 99 Refused to Answer

2. How many properties do you manage that have Section 8 tenants?  
\_\_\_ 1 (one) \_\_\_ 2 (2 to 4) \_\_\_ 3 (5 to 9) \_\_\_ 4 (10 to 19) \_\_\_ 5 (20 to 29) \_\_\_ 6 (30 to 39) \_\_\_ 7 (40 or more) 99 Refused

3. How did you learn about the Efficient Affordable Housing (EAH) Incentive Program?  
\_\_\_ 1 (other property owner) \_\_\_ 2 (EAH presentation) \_\_\_ 3 (HMG or EAH website) \_\_\_ 4 (local housing authority)  
\_\_\_ 5 (Contractor) \_\_\_ 6 (Other) describe \_\_\_\_\_ 98 DK 99 Refused

4. Was the incentive processed and paid within a reasonable timeframe?  
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer

5. How long did it take to get your incentive after you submitted your "Proof of Completion?"  
\_\_\_ 1 wk \_\_\_ 2 wks \_\_\_ 3 wks \_\_\_ 4 wks \_\_\_ >4 wks 98 Don't Know 99 Refused to Answer

*Please answer the following questions on a scale of 1 to 10, with 1 being lowest rating and 10 being highest.*

6. How would you rate the EAH Incentive Program overall service on a scale from 1 to 10?  
\_\_\_ Response (1 is low and 10 is high) 98 Don't Know 99 Refused to Answer

7. How would you rate the EAH staff in terms of being professional on a scale from 1 to 10?  
\_\_\_ Response (1 is low and 10 is high) 98 Don't Know 99 Refused to Answer

8. How would you rate the EAH staff in terms of being courteous and helpful on a scale from 1 to 10?  
\_\_\_ Response (1 is low and 10 is high) 98 Don't Know 99 Refused to Answer

9. How would you rate information you received from the EAH Incentive Program in terms of usefulness on a scale from 1 to 10 (i.e., usefulness of information regarding energy efficiency for your building[s])?  
\_\_\_ Response (1 is low and 10 is high) 98 Don't Know 99 Refused to Answer

10. How would you rate the EAH Incentive Program in terms of presentation on a scale from 1 to 10 (i.e., way program information was advertised or delivered to you)?  
\_\_\_ Response (1 is low and 10 is high) 98 Don't Know 99 Refused to Answer

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

12. To the best of your knowledge were all the energy efficiency measures installed correctly?  
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer

If no, please describe measures not installed properly or if not satisfied with measures. \_\_\_\_\_

13. Is your property still using the measures that were installed?  
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer

Please list measures not used and why not? \_\_\_\_\_

**HMG EAH INCENTIVES PARTICIPANT SURVEY (cont'd) # \_\_\_\_\_**

14. Have you shared information with any of your business associates about the benefits of the EAH incentive program?

\_\_\_ 1 (Yes)      \_\_\_ 2 (No)      98 Don't Know    99 Refused to Answer

If yes, with how many others (people in your company) or other businesses have you shared this information in the last 12 months? \_\_\_\_\_

About how many of these people have installed any of these measures? \_\_\_\_\_

Please provide the name and phone number of these other businesses. \_\_\_\_\_

\_\_\_\_\_

15. Please provide the following demographic information about your Section 8 property.

\_\_\_\_\_ Language(s)    \_\_\_ Outside LA Basin    \_\_\_ # MF Units    \_\_\_ # Tenants    98 DK    99 Refused

16. Do you have any suggestions to improve the program? (Only ask property owners)

\_\_\_ 1 (Yes)      \_\_\_ 2 (No)      98 Don't Know    99 Refused to Answer

If so, please provide the suggestion(s). \_\_\_\_\_

\_\_\_\_\_

17. Please list all measures that were installed (i.e., make, model, efficiency, and # apartments served?)

#	Measure	Manufacturer	Model	Rated Eff.	EM&V Eff.	# Apts.	Notes

18. Would you mind providing your gas or electric billing information so we can estimate your savings?

\_\_\_ 1 (Yes)      \_\_\_ 2 (No)      98 Don't Know    99 Refused to Answer

(If they say yes, please ask them to fax their billing data or ask permission for a utility billing data release form).

SoCalGas Acct # \_\_\_\_\_

Edison Acct. # \_\_\_\_\_

Month	Gas (therms)	Electricity (kWh)	Notes
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			

Be sure to add *“Thank you for your time.”*

HMG EAH Incentives Non-Participant Survey

# \_\_\_\_\_

Business \_\_\_\_\_ Name \_\_\_\_\_ Title \_\_\_\_\_

Address \_\_\_\_\_ City \_\_\_\_\_ ZIP \_\_\_\_\_

Phone Number \_\_\_\_\_ Survey Date \_\_\_\_\_ Surveyor Initials \_\_\_\_\_

Non-Participant Survey (EAH Incentives Program)

Surveys will be randomly selected to include at least 10 surveys from non-participants. I am conducting a survey regarding the Efficient Affordable Housing (EAH) Program that was funded by the California Public Utilities Commission in 2002 and 2003. You didn't participate in the program, but your feedback will help us evaluate and improve the program. The program provided incentives for space cooling, space heating and water heating measures for your property. Would you mind spending 10 to 20 minutes to answer a few questions to help us evaluate and improve the program?

- 1. Do you own or manage Section 8 Affordable Housing?
\_\_\_ 1 (Yes) \_\_\_ 2 (No-STOP-Thank you and Goodbye) 98 Don't Know 99 Refused
2. How many properties do you manage that have Section 8 tenants?
\_\_\_ 1 (one) \_\_\_ 2 (2 to 4) \_\_\_ 3 (5 to 9) \_\_\_ 4 (10 to 19) \_\_\_ 5 (20 to 29) \_\_\_ 6 (30 to 39) \_\_\_ 7 (40 or more) 99 Refused
3. Please tell me why you choose not to participant in the program? (Read list - Multiple answers are okay.)
1 Didn't know about the program (i.e., information cost).
2 Didn't understand energy savings benefits of the program (i.e., performance uncertainty).
3 Don't care because renters pay utility bills or bills are paid with utility allowance (i.e., renter-misplaced or split incentive).
4 Didn't have time to consider the program or understand efficiency issues (i.e., hassle cost).
4a Would you have participated if someone else you know (i.e., an employee) had taken time to help you participate (i.e., apply for an EAH incentive)?
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer
5 Company couldn't participate for budgetary reasons.
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer
6 Program was fully subscribed. \_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer
7 Other \_\_\_\_\_ 98 Don't Know 99 Refused to Answer
4. Would you have participated if the program had better marketing, design, implementation, delivery and follow-up efforts? \_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer
5. Are you planning to make any improvements to your building in the foreseeable future?
\_\_\_ 1 (Yes) \_\_\_ 2 (No, Skip to Q3) 98 Don't Know 99 Refused to Answer
6. If "yes or DK," would you consider making energy efficiency improvements if incentives were available?
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer
7. Please provide the following demographic information?
\_\_\_\_\_ Language(s) \_\_\_\_\_ Section 8? \_\_\_\_\_ Outside LA Basin \_\_\_\_\_ # MF Units \_\_\_\_\_ # Tenants 98 DK 99 Refused
8. Do you have any suggestions that might have helped you participate in the program (Only ask property owners)?
\_\_\_ 1 (Yes) \_\_\_ 2 (No) 98 Don't Know 99 Refused to Answer
If so, please provide the suggestion(s). \_\_\_\_\_



## Appendix C: On-Site Data Collection Form

# EM&V Report for the HMG Efficient Affordable Housing Program #255-02

Customer \_\_\_\_\_ Apartment Complex \_\_\_\_\_ Apt. # \_\_\_\_\_

Address \_\_\_\_\_ City \_\_\_\_\_ ZIP \_\_\_\_\_

Phone \_\_\_\_\_ Vintage \_\_\_\_\_ Windows Face: N NE E SE S SW W NW N

Floor Area \_\_\_\_\_ Window Area \_\_\_\_\_ Type: Single Double Low-e Aluminum Wood Vinyl Window Shading: Interior Exterior

Ceiling: Concrete Wood Walls: Concrete Wood Floor: Concrete Wood

Ceiling R-Value: Adiabatic R0 R11 R19 R30 R38 Adiabatic Walls: \_\_\_\_\_ Wall R-Value: R0 R11 R19 Floor R-Value: Adiabatic R0 R11 R19

HVAC System	Manufacturer	Model Number	Rated Efficiency	Output Capacity	Refrig	Multiplier	Airflow	Age
AC or Heat Pump			SEER/HSPF	Tons	oz.	x 340 =	cfm	
Furnace/Hydronic			AFUE	kBtuh		x 18.5 =	cfm	

DUCTS (circle) Supply: Floor Ceiling Return: Floor Ceiling Wall Single

Ducts	Duct Leakage	Flow Ring
Pre	0 cfm @ Pa	None 1 2 3
Post	cfm @ Pa	None 1 2 3

Infiltration	EOA50	CFM50
Pre		
Post		

Thermostat (Thermostat Reading: \_\_\_\_\_ °F, EM&V Check: \_\_\_\_\_ °F)

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

Showerheads and Aerators (Static Pressure \_\_\_\_\_ psi)

Measure	Rated Old	EM&V Old	Bucket Old	Rated New	EM&V New	Bucket New
Showerhead #1	Gpm @ psi	Gpm @ psi	gpm ( sec)	gpm @ psi	gpm @ psi	gpm ( sec)
Showerhead #2	Gpm @ psi	Gpm @ psi	gpm ( sec)	gpm @ psi	gpm @ psi	gpm ( sec)
Aerator #1	Gpm @ psi	Gpm @ psi	gpm ( sec)	gpm @ psi	gpm @ psi	gpm ( sec)
Aerator #2	Gpm @ psi	Gpm @ psi	gpm ( sec)	gpm @ psi	gpm @ psi	gpm ( sec)

Water Heater Controller

Measure	Manufacturer	Model Number	# Apt. Units	Operational (Yes/No)	Hot Water Supply (°F)	Recirculation Return (°F)	Cold Water Mix (°F)
WH Controller							

Central Boiler or Water Heater

Measure	Manufacturer	Model Number	Storage (Gallons)	Input kBtuh	Output kBtuh
Boiler					
Water Heater					

Individual Water Heater

Measure	Manufacturer	Model Number	Storage (Gal)	WH Blanket	Pipe Insul. (In/Out)	EF	FTC Use	Age
Water Heater								

Existing Lighting

Location	Type	Qty	Hrs/d	12-6PM	Incand.	CFL	HMG	EM&V	Cust
1.			hrs		W	W			
2.			hrs		W	W			
3.			hrs		W	W			
4.			hrs		W	W			
5.			hrs		W	W			
6.			hrs		W	W			
7.			hrs		W	W			
8.			hrs		W	W			
9.			hrs		W	W			
10.			hrs		W	W			

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

Demographic information

Age	Owner	Renter	# Occupants	Language	Annual Household Income	Refused

I certify under penalty of perjury the information contained in this EM&V form is complete and accurate to the best of my knowledge.

EM&V Inspector Name (Print) \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_\_

**FLOOR PLAN DRAWING:**

