Customer Energy Efficiency Program
Measurement and Evaluation Program

IMPACT EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 RESIDENTIAL NEW CONSTRUCTION PROGRAM

PG&E Study ID Number: 386

March 1, 1998

Measurement and Evaluation
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IMPACT EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 RESIDENTIAL NEW CONSTRUCTION PROGRAM

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Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs," as adopted by California Public Utilities Commission Decision 93-05-063, revised January, 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, and 96-12-079.

This study measured the gross and net energy savings at the whole building level for a total of 3,960 homes who qualified for rebates in 1996 under the shared savings portion of the PG&E Residential New Construction Program, also referred to as the Comfort Home Program.

Methodology

On-site surveys were conducted for 155 participant and 160 nonparticipant homes to collect information about the structure and factors affecting end use energy consumption. Duct tests were conducted on a subset of 158 sites to provide data on the efficiency of the air distribution systems. Builders associated with the surveyed homes were then interviewed via the telephone to collect information about their building practices and the effect of the PG&E Program on their installations of efficient technologies.

An engineering analysis utilizing on-site survey data was used to develop initial estimates of as-built and reference energy consumption (defined as energy use at Title 24 compliance efficiencies) for each home in the study. Micropas building simulations were used to develop the space conditioning loads. Non-space-conditioning algorithms, based on customer appliance holdings and reported usage levels, were used to develop loads for other end uses.

Next, statistical models were used to calibrate engineering results to customer bills and develop gross savings estimates. These models, referred to as SAE (Statistically Adjusted Engineering) models, use regression equations to relate actual billed consumption to engineering estimates of consumption. Weather variables are included in the equations to account for differences between bill energy use that relates to actual weather and engineering estimates that rely on normal weather.

Net Program savings were developed using three different approaches: statistical modeling, simple comparisons of participants and nonparticipants, and builder self-report data. The statistical model, referred to as an efficiency choice model, was used only for the space conditioning end use. In this approach, differences in site energy efficiency are related to Program participation, site characteristics and builder characteristics. The model isolates the component of energy efficiency that is attributable to the Program while controlling for other. Final net savings estimates were based on: (1) the efficiency choice analysis for the heating and cooling end uses, and (2) builder self-report data for the cooking and clothes drying end uses.

Study Results

The results of the evaluation are summarized in the following table.

	Gross Savings	Gross Realization Rate	Net-to-Gross Ratio[1]	Net Savings	Net Realization Rate
EX ANTE					
kW	2,952		0.93	2,760	
kWh	4,736,338		0.85	4,021,958	
Therms	76,757		1.34	103,087	
EX POST					
kW	2,546	0.86	1.07	2,718	0.98
kWh	4,265,650	0.90	0.74	3,169,694	0.79
Therms	-41,576	-0.54	-1.34	55,882	0.54

[1] The net-to-gross method used for this study did not separate out free-ridership and spillover.

Regulatory Waivers and Filing Variances

No regulatory waivers filed.
There were no E-Table variances.

IMPACT EVALUATION OF PACIFIC GAS AND ELECTRIC COMPANY'S 1996 RESIDENTIAL NEW CONSTRUCTION PROGRAM

PG&E STUDY ID NUMBER: 386

Final Report

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March 1, 1998

LIST OF TABLES

LIST OF FIGURES

1 EXECUTIVE SUMMARY

This report presents final impact evaluation results for the PG&E 1996 Residential New Construction Program. Both gross and net Program impacts were developed for electric consumption (kWh), electric demand (kW) and natural gas consumption (therms). The evaluation approach was designed to meet the requirements of the Measurement and Evaluation Protocols. Engineering estimates of energy impacts for a sample of Program participants and a nonparticipant control group were statistically calibrated to billed energy use, and then were compared against each other to provide estimates of net Program Savings.

1.1 PROGRAM DESCRIPTION

The PG&E Residential New Construction Program, referred to as the PG&E Comfort Home Program, provides financial incentives to builders who construct energy-efficient homes that exceed Title 24 standards. Energy efficiency measures addressed in this evaluation were installed in Program years 1993 through 1996 and were rebated in calendar year 1996 under the shared savings portion of the Program. The Program focuses on homes built in California Energy Commission (CEC) climate zones 11, 12, and 13 and on four key energy efficiency measures (in addition to Title 24 compliance):

- high efficiency air conditioning (11.5 SEER or better);
- efficient duct systems installed to PG&E's Program standards;
- natural gas cooking; and
- natural gas dryer stubs.

A total of 3,960 homes qualified for rebates in 1996 under the shared savings portion of the Program. These homes cover Comfort Home program years 1993 through 1996. For 1993 and 1994, builders could choose which measures to install in their homes and were rebated accordingly. For 1995 and 1996, installation of all four key measures by the builder of a development was a mandatory condition for Program participation. Table 1-1 shows the frequency of measure installations in the 3,960 qualifying homes. As the table indicates, all four of the key measures are installed in the vast majority of Program homes. Measures for the lighting and water heating end uses represent a very small portion of Program accomplishments and are carry-overs from the 1993 program year.

For the 3,960 shared savings homes rebated in 1996, PG&E had initially estimated net first year savings to be: 4.1 GWh, 2.7 MW, and 0.1 million therms.

Table 1-1
Measures Installed in Comfort Home Program Homes

Measures Installed	Frequency	Percent
Efficient AC	3,893	98.3
Enhanced duct installations	3,551	89.7
Code enforcement	3,694	93.3
Gas cooking	3,417	86.3
Gas drying	3,304	83.4
CFLs	296	7.5
Efficient Furnaces	203	5.1
Efficient Water Heaters	66	1.7

1.2 EVALUATION APPROACH

The primary objectives of the residential new construction impact evaluation project were to:

- assess the gross annual energy and demand savings for installed program measures; and
- assess the net energy impacts due to the Program;

Secondary objectives were to:

- analyze differences between evaluation results and PG&E-estimated impacts;
- investigate, explain, and estimate market spillover effects.

The impact evaluation utilized multiple approaches to assess both gross and net impacts. The methodology provides impact results that are consistent with the Measurement and Evaluation (M&E) Protocols (Protocols). Key components of the evaluation include:

- development of sample design used to select 155 homes built by Program builders and an additional sample of 160 nonparticipating homes for the study;
- data collection involving on-site surveys of homes and telephone surveys of builders;
- engineering analysis of home energy consumption at the end use level, including the use of Micropas simulations to determine estimates of space conditioning usage;
- statistical calibration of initial engineering estimates to customer bills using an SAE (Statistically Adjusted Engineering) approach; and
- a free-ridership analysis that analyzed participant and nonparticipant energy efficiency using three alternative methods: (1) a simple comparison of energy efficiency in participant and nonparticipant homes; (2) a decision analysis model that compares participants and nonparticipants while controlling for nonprogram factors; and (3) a self report free-ridership analysis that gauges what portion of increased participant efficiency is attributable to the Program.

Program tracking data and PG&E billing data were utilized to develop a sample frame of participant homes with adequate billing histories to support the statistical billing analysis used in the study. A comparable group of nonparticipants was developed using the PG&E billing system, including information on meter set dates and dates when the customer was first served at a given residential premise.

On-site surveys were then conducted for a sample of selected homes to collect detailed structure, equipment, and operations data. Duct blaster tests were performed at a subset of 158 sites to provide data on the efficiency of the air distribution systems for use in analyzing savings attributable to enhanced duct installation procedures. Builders associated with the surveyed homes were then interviewed to collect information about the effect of the PG&E Program on their building practices.

Engineering analysis and simulations were conducted to determine energy impacts relative to a baseline (set at Title 24 compliance levels) for both participant and nonparticipant homes. After statistical calibration of engineering results to bills using a regression approach, participant and nonparticipant efficiencies were compared to arrive at net Program Savings. Builder-reported data was also used to assess what action may have been taken in the absence of the Program.

1.3 KEY FINDINGS

Evaluation estimates of Program Impacts, relative to PG&E's initial estimates, are summarized in Table 1-2. Overall, the Program is estimated to be saving 2,718 kW, 3,196,694 kWh, and 55,882 therms on an annual basis. Approximately 99% of PG&E ex ante kW savings, 79% of the ex ante kWh savings and 54% of the ex ante therm savings are being realized. Ninety-percent confidence intervals are ± 27% for net kW impacts, ± 44% for net kWh impacts, and ± 21% for net therm impacts.

Table 1-2
Summary of Program Impacts

	Gross Savings	Gross Realization Rate	Net-to-Gross Ratio[1]	Net Savings	Net Realization Rate
EX ANTE					
kW	2,952		0.93	2,760	
kWh	4,736,338		0.85	4,021,958	
Therms	76,757		1.34	103,087	
EX POST					
kW	2,546	0.86	1.07	2,718	0.98
kWh	4,265,650	0.90	0.74	3,169,694	0.79
Therms	-41,576	-0.54	-1.34	55,882	0.54

[1] The net-to-gross method used for this study did not separate out free-ridership and spillover.

In order to gain an additional understanding of Program performance, end use level impacts are discussed next. As Figures 1-1 and 1-2 show, the HVAC end use comprises the largest component of Net Program Savings. Cooling savings, due primarily to installation of efficient air conditioners and enhanced duct installation, comprises almost two-thirds of Program electric savings. Heating savings, from enhanced duct installations and a combination of other measures including code enforcement, accounts for essentially all of the positive gas savings.

Figure 1-1
Distribution of Evaluation Net kWh savings

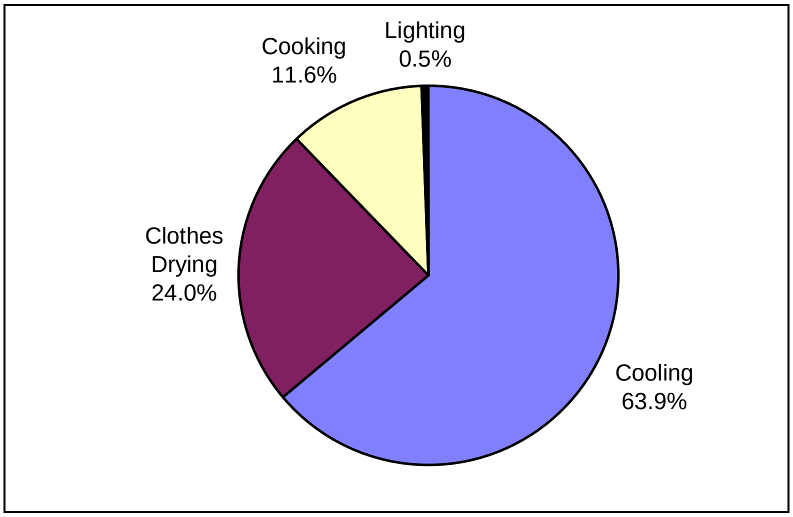
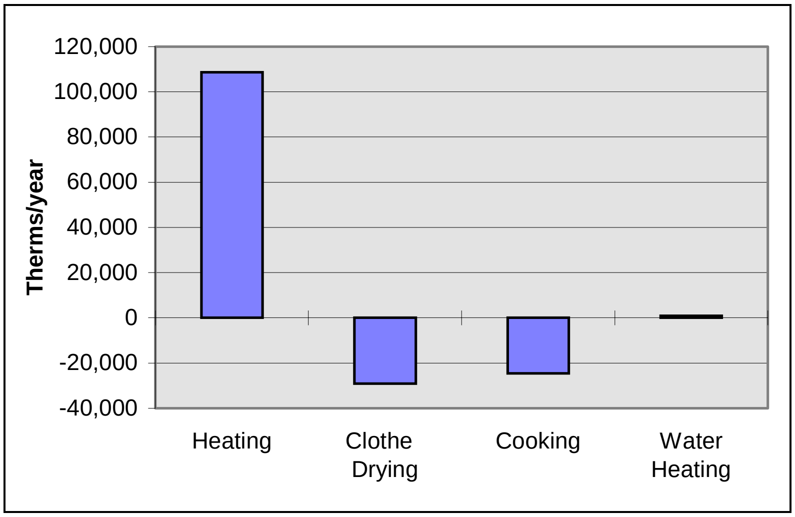


Figure 1-2
Evaluation Net Therm Savings



HVAC

Heating and cooling impacts are presented and compared to PG&E estimates in Table 1-3. As the table indicates, evaluation net impacts are just over 70% of PG&E estimates for energy consumption (kWh and therms) 103% of the PG&E estimate for peak demand (kW). Gross HVAC impacts for the evaluation are generally lower than PG&E estimates, offset somewhat by higher evaluation net-to-gross ratios. In general, impacts for the enhanced duct installation measures fall short of expectations for both cooling and heating. A primary factor driving this result is the relatively high level of nonparticipant duct efficiency. This factor may be driven by Program spillover as there is some evidence that more builders are utilizing improved duct installation procedures. The other main HVAC measure, high efficiency air conditioners, is achieving expected savings.

Evaluation net-to-gross ratios are based on the results of an efficiency choice model that compares participant efficiency against nonparticipant efficiency while factoring out the affects of nonprogram factors (such as house size, number of levels in the home, and type of home – production or custom). The evaluation net-to-gross ratios exceed one, providing evidence of Program spillover.

Table 1-3
HVAC Impacts

	Gross Savings	Gross Realization Rate	Net-to-Gross Ratio	Net Savings	Net Realization Rate
EX ANTE					
kW	2,595		0.98	2,534	
kWh	2,790,174		0.98	2,723,813	
Therms	156,968		0.99	155,371	
EX POST					
kW	2283	0.88	1.14	2,597	1.03
kWh	1,781,809	0.64	1.14	2,026,661	0.74
Therms	75,202	0.48	1.44	108,663	0.70

Clothes Drying

Impacts of the gas clothes drying element of the program are presented in Table 1-4. A major reason gross impacts from the evaluation are high relative to ex ante levels is that PG&E discounts gross impacts to reflect the fact that only a fraction of homeowners install gas dryers despite the availability of gas dryer plugs in the laundry area. The evaluation found that 52% of participant homes had gas drying versus the PG&E estimate of 35%. The other major difference in gross savings is a higher evaluation estimate of clothes dryer energy consumption.

The low evaluation net-to-gross ratios result because only 46% of surveyed builders indicate that they would not have installed gas dryer plugs without the program. Overall, evaluation results for this measure exceed PG&E *ex ante* estimates.

Table 1-4
Gas Clothes Drying Impacts

	Gross Savings	Gross Realization Rate	Net-to-Gross Ratio	Net Savings	Net Realization Rate
EX ANTE					
kW	38		0.74	28	
kWh	693,840		0.74	513,442	
Therms	-23,128		0.74	-17,115	
EX POST					
kW	175	4.64	0.46	81	2.91
kWh	1,636,285	2.36	0.46	759,237	1.48
Therms	-62,749	2.71	0.46	-29,115	1.70

Gas Cooking

Table 1-5 presents gas cooking measure impacts. Lower than expected net energy impacts are based on two factors: a lower estimated net-to-gross ratio for the evaluation and different assumptions about the efficiency of gas cooking relative to electric cooking that lower the electric cooking impacts. Net-to-gross ratios, based on builder-reported data are significantly lower than the PG&E assumption. In addition, PG&E's assumed gas-to-electric conversion factors are much larger that those used in the evaluation. Evaluation impacts are based on a relative gas efficiency/electric efficiency ratio of 0.51, derived from U.S. Department of Energy cooking efficiency estimates published in the E-SOURCE Residential Appliances Technology Atlas.

Table 1-5
Impacts from Gas Cooking Measures

	Gross Savings	Gross Realization Rate	Net-to-Gross Ratio	Net Savings	Net Realization Rate
EX ANTE					
kW	318		0.62	197	
kWh	1,230,580		0.62	762,959	
Therms	-58,319		0.62	-36,158	
EX POST					
kW	87	0.27	0.45	39	0.20
kWh	825,812	0.67	0.45	367,488	0.48
Therms	-55,265	0.95	0.45	-24,593	0.68

2 STUDY DESIGN

2.1 OVERVIEW

This section presents an overview of the evaluation analysis method used for this project and a description of the sample design. The study methodology is discussed in more detail in succeeding sections of this report.

2.2 METHODOLOGY

Figure 2-1 provides an overview of the evaluation project design. To begin the project, a sample of participant homes was extracted from the PG&E Program tracking system. A matching nonparticipant sample was then extracted from the PG&E billing system.

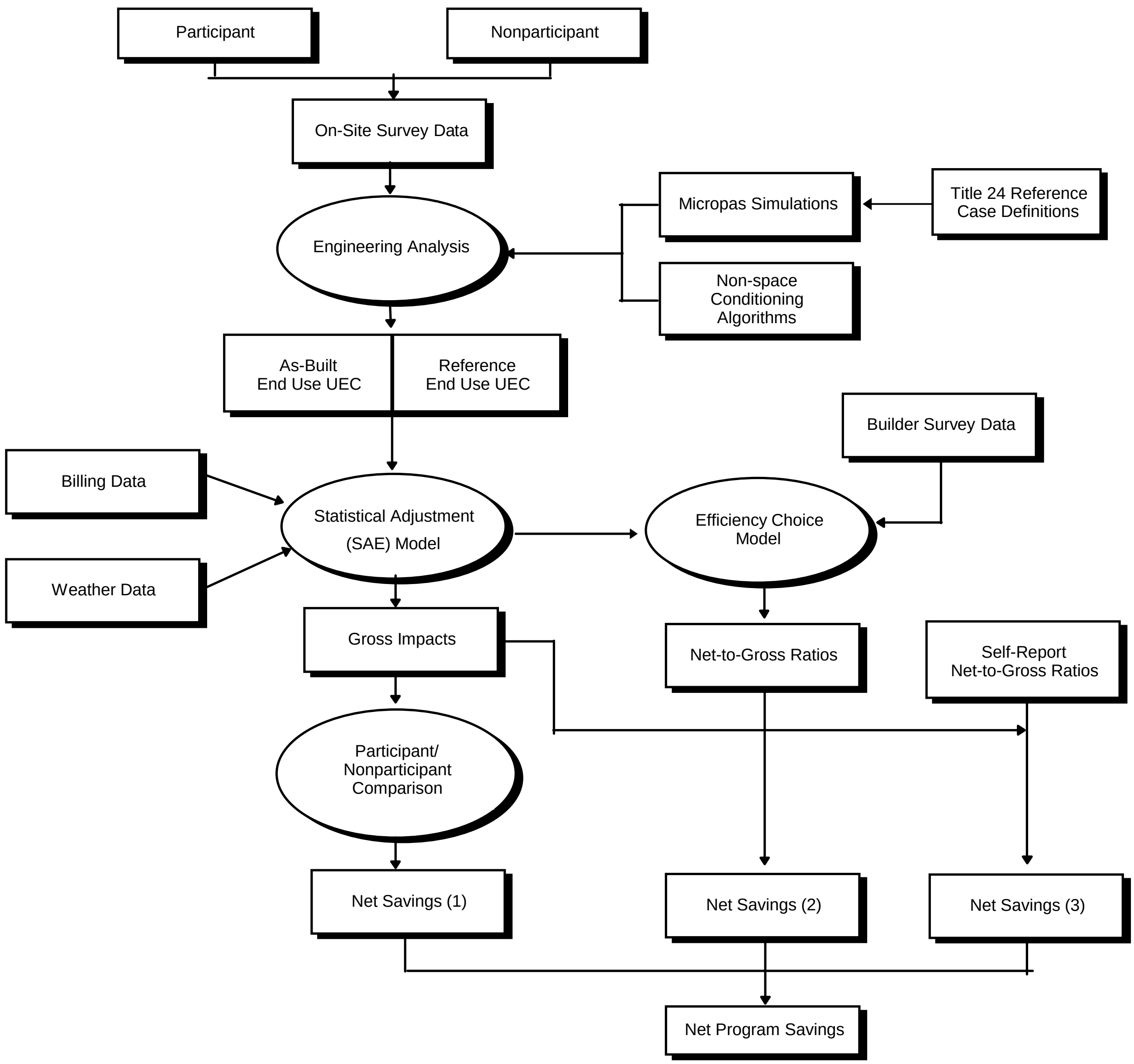
On-site surveys were conducted for 155 participant and 160 nonparticipant homes to collect information about the structure and factors affecting end use energy consumption. Duct tests were conducted on a subset of 158 sites to provide data on the efficiency of the air distribution systems. Builders associated with the surveyed homes were then interviewed via the telephone to collect information about their building practices and the effect of the PG&E Program on their installations of efficient technologies.

An engineering analysis utilizing on-site survey data was used to develop initial estimates of as-built and reference energy consumption (defined as energy use at Title 24 compliance efficiencies) for each home in the study. Micropas building simulations were used to develop the space conditioning loads. Non-space-conditioning algorithms, based on customer appliance holdings and reported usage levels, were used to develop loads for other end uses.

Next, statistical models were used to calibrate engineering results to customer bills and develop gross savings estimates. These models, referred to as SAE (Statistically Adjusted Engineering) models, use regression equations to relate actual billed consumption to engineering estimates of consumption. Weather variables are included in the equations to account for differences between bill energy use that relates to actual weather and engineering estimates that rely on normal weather.

Finally, net Program savings were developed using three different approaches: statistical modeling, simple comparisons of participants and nonparticipants, and builder self-report data. The statistical model, referred to as an efficiency choice model, was used only for the space conditioning end use. In this approach, differences in site energy efficiency are related to Program participation, site characteristics and builder characteristics. The model isolates the component of energy efficiency that is attributable to the Program while controlling for other

Figure 2-1
New Construction Evaluation Project Overview



factors. Net savings results from each approach were carefully reviewed and integrated to provide the most appropriate measure of net savings.

2.3 SAMPLING PLAN

This section presents the sampling plan used to select homes for inclusion in the impact evaluation study group. The goals of the sample design are:

1. to provide a representative sample of participating homes and a comparable sample of nonparticipating homes for inclusion in the engineering and statistical impact analyses; and
2. to comply with the sample size and relative precision requirements of the M&E Protocols.

Because calibration to billing data is an important component of the analysis, all customers were screened for adequate billing histories before inclusion in the study. The remainder of this section describes the screening of customers for data adequacy and the development of the sample.

2.3.1 Sampling Frames

Initial sampling frames for participants and nonparticipants are as follows:

- participant homes: homes that were built under the Program and were rebated in 1996 under the shared savings option; this group contains homes that were included in Program applications during program years 1993, 1994, 1995, and 1996, a total of 3,960 homes;
- nonparticipant homes: single family homes with meter set dates after December 31, 1994, located in the same PG&E meter route areas as participating homes.

Before the sample was developed, customers identified above were screened for data adequacy. This screening process is discussed below.

Participant Screening

The following process was used to screen participating homes:

1. all Program homes under the shared savings option with incentive payment dates in 1996 were selected from the tracking system;
2. a limited number of homes identified as multifamily homes were excluded;
3. remaining homes were matched to the PG&E billing system data using the PG&E Control number;
4. home addresses in the tracking system were matched against service addresses from the billing system and homes with matched addresses were retained;
5. homes were screened for adequate billing data (consistent read dates, billed usage greater than zero, and meter reads dating back to at least November 1996), and "good" homes were retained;
6. finally, homes identified as "multifamily" in the PG&E billing system were dropped.

The participant screening process is summarized in Table 2-1. Overall, 2,506 homes with adequate billing data were available after the screening process.

Table 2-1
Participant Screening Summary

	Remaining Homes	Screened Homes
Total homes with 1996 Shared Savings rebates	3,960	
Single family homes, per tracking system	3,928	32
Homes matched to the billing system	3,844	84
Tracking system address, service address match	3,596	248
Homes with adequate billing data	2,558	1,038
Single family homes, per billing system	2,506	52

To facilitate the on-site surveys, several remote areas with limited program activity were dropped from the study. These areas included: cities north of Chico, the areas around Grass Valley, Auburn, Lincoln, Dinuba, and Madera. After exclusion of these areas, 2,402 homes remained available for on-site surveys.

Tables 2-2 and 2-3 compare the 3,690 homes that received rebates in 1996 with the screened homes available for on-site surveys. As Table 2-2 shows, the distributions of homes across Program application year are similar, with the exception of 1996. This can be expected as 1996 year homes were more likely to be screened out due to insufficient billing data. Table 2-3 shows that measure distributions in the screened homes are very similar to the population.

Table 2-2
Comparison of Participant Population to Screened Homes, by Program Year

	All Homes		Screen Homes	
Program Year	Frequency	Percent	Frequency	Percent
1993	223	5.6	97	4.0
1994	2,522	63.7	1,709	70.8
1995	608	15.4	379	15.7
1996	607	15.3	228	9.4
Total	3,960	100.0	2,402	100.0

Table 2-3
Comparison of Participant Population to Screened Homes, by Measures Installed

	All Homes		Screened Homes	
Measures Installed	Frequency	Percent	Frequency	Percent
Efficient AC	3,893	98.3	2,402	100.0
Improved ducts	3,551	89.7	2,149	89.5
Code enforcement	3,694	93.3	2,274	94.7
Gas cooking	3,417	86.3	2,140	89.1
Gas drying	3,304	83.4	1,984	82.6
CFLs	296	7.5	210	8.7
Other	203	5.1	88	3.7

Nonparticipant Screening

Nonparticipant screening was conducted using the PG&E billing system as follows:

1. all identified participants were screened out (using the PG&E Control number);
2. all homes with meter-set-dates and dates-on-premise prior to 1995 were screened out;
3. all single-family, individually-metered homes located on the same PG&E meter route (first 5 characters of the PG&E account number) were retained; and
4. remaining sites were screened for adequacy of billing data.

Using this screening process, 4,923 nonparticipant homes were selected. After additional geographical screening (similar to the participants) and further matching of nonparticipants to participants by PG&E meter route, a total of 2,057 nonparticipant homes remained available for on-site surveys.

2.3.2 Sample Design

To comply with the M&E Protocols, studies utilizing on-site data collection require minimum participant and nonparticipant sample sizes of 150 each. For this study, sample size goals of 159 participants and 159 nonparticipant were established to allow for some attrition due to factors such as problematic billing data and contradictory or incomplete survey results.

In addition, the project design called for “duct blaster” duct testing at 150 sites. We targeted duct testing for 60 participant sites (slightly over one third of the participant sample) and 106 nonparticipant sites (two thirds of the nonparticipant sample). Fewer duct tests were specified for participant homes than nonparticipant homes due to an expected higher variation in duct efficiency among nonparticipant homes.

A cluster sampling technique was chosen as the most efficient technique for the on-site surveys. This technique ensures that sampled sites are “clustered” in areas that are scheduled for surveys by the same surveyor on a given day. The geographically diverse sample segmentation used in the cluster approach also ensured that the final sample of surveyed homes contained variation by builder, home type, and home size.

To implement the sample design, using the cluster sampling technique, the available homes were divided into geographical nodes (areas that could be reached by a single surveyor in a given day). In several cities, initial nodes were further disaggregated by PG&E meter route in order to better match participant and nonparticipant homes. Next, a random sample of 53 participants was drawn. This sample of participants determined how many surveys would be conducted in a given node. For each participant selected in a node, a total of six surveys would be conducted (3 participant and 3 nonparticipant). Overall, 34 nodes were target for surveys, providing a random and diverse sample.

2.4 COMPLETED SURVEYS

Table 2-4 shows the distribution of available sites, targeted surveys, and completed surveys by CEC climate zone. As the table indicates, completed surveys match up reasonably well with initial targets. In limited cases, targets were adjusted to facilitate the survey schedule. The nonparticipant sample was matched relatively closely with the participants. Sample disposition reports are provided in Appendix B.

Table 2-4
Summary of Targeted and Completed Surveys

Participants						
			Survey		Duct Test	
CEC Climate Zone	Population	Available	Target	Complete	Target	Complete
11	658	368	24	28	10	11
12	2,296	1,317	84	81	32	33
13	1,006	717	51	46	18	15
Total	3,960	2,402	159	155	60	59
Nonparticipants						
			Survey		Duct Test	
CEC Climate Zone		Available	Target	Complete	Target	Complete
11		274	24	29	16	14
12		1,001	84	86	56	55
13		782	51	45	34	30
Total		2,057	159	160	106	99

2.4.1 Coverage of Rebated Measures

Table 2-5 compares rebated program measures in the survey group with measures in the program population. Overall, the sample mirrors the population reasonably well in terms of rebated measures. Given the limited penetration of measures in the water heating and lighting end uses, these end uses were not focused on for the evaluation.

Table 2-5
Rebated Measure Comparison for Population and Surveyed Homes

	Population		Surveyed Homes	
	# Homes	Percent	# Homes	Percent
Efficient AC	3,893	98%	155	100%
Improved Ducts	3,551	90%	140	90%
Code Enforcement	3,694	93%	146	94%
Efficient Furnaces	203	5%	7	5%
Gas Cooking	3,417	86%	131	85%
Gas Dryer Stubs	3,304	83%	127	82%
CFLs	296	7%	14	9%
Efficient Water Heaters	66	2%	0	0%

Table 2-6 compares average ex ante estimates for the population and the sample of surveyed homes. As the table shows, average impacts are similar for most measures; however, average cooking savings estimates for the sample are somewhat larger that for the population.

Table 2-6
Average Ex Ante Gross Savings Estimates for Population and Surveyed Homes

	Population		Surveyed Homes	
	kWh	Therms	kWh	Therms
Efficient AC	343	-	338	-
Improved Ducts	364	33	369	32.8
Code Enforcement	44	8.8	44	8.4
Efficient Furnaces	-	33.6	-	25.2
Gas Cooking	360	-17.1	402	-20.3
Gas Dryer Plugs	210	-7	212	-7.1
CFLs	74	-	78	-
Efficient Water Heaters	-	18.7	-	-

2.4.2 Nonparticipant Reassignment

Based on results of the on-site survey, it was determined that a number of homes classified as nonparticipants had actually participated in the Program in other years that were not covered by the evaluation. Although the nonparticipant screening process was designed to eliminate participant homes before selection of the available nonparticipant group, it became clear that homes that had participated in past program years were not removed from the nonparticipant pool.

Using information from the on-site survey, the builder survey, and Program tracking for 1994 and 1995, an analysis was performed to reassign affected nonparticipants into a third sample category of prior Program participants. First, a "nonparticipant" dataset was developed that was comprised of the following:

- any surveyed home where the owner believed they lived in a Comfort Home (61 homes),
- any home where the PG&E Control number matched a Control number in prior-year tracking dataset (32),
- and homes associated with one particular builder who claimed to have built only Comfort Homes over the past three years and another particular builder who identified two nonparticipant homes as Comfort Homes (a total of 4 homes).

Second, this group, comprised of 71 homes (after netting out overlap from the three screening methods), was reviewed in light of energy efficiency installations. Six homes that were identified by homeowners as being Comfort Homes were determined to be nonparticipants. Overall, 65 homes were reassigned into the prior-participant group, leaving a final sample of 95 nonparticipants.

For the evaluation analysis, all three customer groups (participants, nonparticipants, and prior-participants) were included in the engineering and SAE analyses to provide the maximum number of observations for the calibration of engineering results to customer bills. The prior-participant group was excluded from the net-to-gross analysis, because this group would confound efficiency comparisons between participants and true nonparticipants.

2.5 BUILDER SURVEYS

Interviews were targeted towards builders of all homes that received on-site surveys. For participating homes, the PG&E tracking data provided information about who built the home and the appropriate contact person. For nonparticipants, builders were identified using information provided by the homeowner and information provided by PG&E new construction representatives. Overall, 61 builder surveys were completed, accounting for 219 of the 315 homes that received on-site surveys. A sample disposition report is provided in Appendix B.

2.6 ANALYSIS SAMPLE SIZES

A summary of the number of homes available for surveys and included in the various stages of the project analysis is provided in Table 2-6. Gas model sample size was limited because customers without gas bills (electric-only customers) were not screened out of the participant sample frame; otherwise, excluding electric-only customers may have introduced bias into the study. Efficiency choice model sample sizes and self-report sample sizes were limited by the availability of builder surveys.

Table 2-7
Homes Surveyed and Included in the Analysis

	Participants	Prior Participants	Nonparticipants	Total
Participant Population	3960			
Screened Sites Available for Surveys	2,402	2,057		4,459
On-site Surveys	155	65	95	315
Duct Tests	155	65	95	315
Builder Surveys[1]	110 (39)	53 (27)	56 (22)	219 (61)
Electric SAE Model	155	65	95	315
Gas SAE Model	137	57	88	282
Electric Efficiency Choice Model	110		56	166
Gas Efficiency Choice Model	96		54	150
Self Report NTG Analysis	105			105

[1] Number of builders are included in parentheses. Builder counts do not sum to total because of overlap of builders in the three categories.

2.7 EXPANSION WEIGHTS

In order to generalize study impacts to the Program population, expansion weights were developed using ex ante impact estimates from the Program tracking system. Weights were calculated by CEC climate zone (*z*), fuel type (*f*), and end use (*e*) as follows:

$$Weight_{z,f,e} = \frac{\sum_{N} Impacts_{z,f,e}}{\sum_{n} Impacts_{z,f,,e}}$$

where *N* indicates all homes in the participant population, and *n* indicates homes in the study.

3 DATA COLLECTION

3.1 OVERVIEW

The data requirements for the new construction evaluation and sources of data are discussed in this section. Key data elements used in the impact analysis include the following:

- program tracking data,
- billing data,
- weather data,
- on-site survey data,
- telephone builder survey data, and
- secondary source data.

3.2 PROGRAM TRACKING DATA

Program data was provided by PG&E in electronic format. A number of data elements useful for the evaluation were included in the datasets, including:

- identification of rebated homes,
- Program measures installed in those homes and the expected savings, and
- builders associated with each home.

The tracking data matched up well with the PG&E filed savings in terms of number of units and net-therm savings. Electric savings (kW and kWh) varied slightly from reported figures.

3.3 BILLING DATA

Billing data for the statistical impact analysis was pulled from the PG&E mainframe during the second half of November 1997. The datasets used for the analysis are the “Elec Fix” and “Gas Fix” datasets maintained by PG&E’s rate department. For each home, data are available for the last 12 read cycles for the following key billing analysis components:

- energy use (kWh, therms),
- meter read dates, and
- the number of days in the read cycle.

Additional billing system data (from the “Demog” file) used in the sample design and on-site recruitment process included:

- customer account number,
- customer name,

- service address, and
- residential class (single family vs. multifamily, individual meter vs. master meter).

Billing system data were linked to tracking data using the PG&E Control number identifier.

Table 3-1 summarized collected billing data by key participation group. As the table indicates, the nonparticipants tend to use more energy than the participants. (However, as shown below in Table 3-2, nonparticipants also tend to live in larger homes.)

Table 3-1
Average Annual Energy Consumption

	Participants	Prior Participants	Nonparticipants
kWh	7,906	7,969	8,774
Therms	453	432	517

3.4 WEATHER DATA

Two weather data sources were used for the study:

- *average year* weather data for each of the three CEC climate zones in the study (zones 11, 12, and 13) that comes from typical meteorological year (TMY) data developed by the CEC for Title 24 compliance use; and
- *actual weather* data that comes from a PG&E weather database containing 30-minute temperature and humidity data for 25 locations in the PG&E service area. This data goes back to 1983.

3.5 ON-SITE SURVEY DATA

On-site surveys of 315 new homes provide the primary data used for the study. The surveys support the building simulation, engineering, and statistical analyses that were used to develop gross kW, kWh and therm savings estimates for the Program. In addition, on-site data was used in the net-to-gross analysis, when combined with data from the telephone builders survey.

Data collected in the on-site survey include building shell data, equipment/appliance data, customer demographic data, and equipment usage patterns. Several questions were included in the survey to address customer awareness of energy efficiency and awareness of the PG&E energy efficiency programs. For 158 of the surveyed sites, “duct blaster” duct testing was conducted. These tests measure the efficiency of a home’s ducts with respect to leakage. The equipment used for this study was the Minneapolis Duct Blaster Systems’ Series B units with DG-3 digital gauges.

3.5.1 Survey Instrument

The on-site survey instrument was developed to capture both detailed engineering *and* household behavior information for all major end uses. Capturing discretionary customer behavior patterns (e.g., for thermostat setpoints and schedules, showers/week, meals/week, laundry loads/week, etc.) is important to developing accurate end use consumption estimates and related program measure impacts. The on-site survey instrument for this project was designed to address each of the key issues listed below.

1) The instrument had to enable the collection of all data necessary to perform the specific analyses required. For this project, the key analytic considerations were:

- Data were required provide evidence and documentation of as-built energy efficiency levels. In particular, it was necessary to collect equipment nameplate data, building shell characteristics (insulation R-values, infiltration levels, window characteristics, etc.), and duct characteristics.
- Data were required to provide all of the necessary inputs for the Micropas building simulation analyses, which in addition to the elements noted above included building geometry, shading, zoning, internal loads, equipment schedules, and construction characteristics.
- Data were required to support the non-space conditioning engineering algorithms for lighting, refrigerators, dishwashing, water heating, cooking, clothes drying, spas, pools, etc. In addition to the equipment data noted above, these algorithms required occupant behavior information such as number of showers, meals, loads of laundry, etc., per week.
- Data were required to support the net-to-gross and spillover analyses, including customer awareness of energy efficiency and increased efficiency practices at the home not directly related to the Program (that may have been instituted after the homeowner moved in and contributed to lower bills).

2) The survey instrument was designed for ease and efficiency of use by the surveyor. This promoted completeness, reduced potential errors, and maximized the cost-effectiveness of the data collection tasks.

3) The survey instrument was designed with an understanding of how the data would be entered into the survey database and how it would be used for the subsequent analyses.

4) The survey was designed with the homeowner in mind. It maintained an order and structure that helped the homeowner respond accurately to the questions, and it was designed to be as expeditious as possible to reduce the burden on the homeowner's time (maximum of 20 minutes for the homeowner questionnaire portion of the survey).

A copy of the on-site survey instrument is provided in Appendix A.

3.5.2 On-site Data Collection

The on-site data collection portion of the project consisted of a number of steps: survey instrument pre-testing, surveyor training, customer recruitment, and survey implementation (including survey database development). These steps are discussed below.

Survey Instrument Pre-Test

To ensure the survey instrument was easy to use and was providing the required data, the instrument was pretested by senior surveyors at three homes. No major modifications were made to the instrument. However, the allotted time for each survey was extended somewhat to allow for adequate on-site survey time.

Surveyor Training

Surveyor training was conducted in a three-level training session. Level one training consisted of a classroom session focusing on equipment and structure identification techniques and familiarization with the survey instrument. Level two consisted of a session on customer relations, interpersonal communication skills, and client sensitivity. Level three entailed in-field training.

Homeowner Recruitment and Incentives

Recruitment consisted of two activities. The first activity involved sending a project introduction letter to all potential homes for the survey. The letter helped the recruiting team establish credibility with the homeowner. The next activity involved contacting the homeowner by telephone to obtain general information and to schedule a convenient time for the survey. At this time we ensured that we have contacted the correct home and that the home had been built in the past few years. The telephone recruitment process included: (1) a brief project introduction (including reiteration of participation incentives discussed below), (2) obtaining general information about the home and occupants, (3) scheduling an appointment for the survey, and (4) providing a description of the type of information that would be gathered and the estimated survey duration.

A PC-based project tracking and reporting system was used in the field management of this project. Priority action notification, various sort filters, notation fields, and other mechanisms provided immediate and complete reports on the customer recruitment, surveying, and data management status by customer site and sample cell.

To facilitate customer participation in the projects, homeowners were offered cash incentives: $25 for a standard survey and $50 for a survey that included duct testing.

On-site Implementation

The data collection process will followed seven key steps: (1) collecting general building and dwelling type characteristics, (2) conducting a homeowner interview (collecting occupancy, thermostat/ equipment schedules, net-to-gross and spillover information), (3) collecting equipment, appliance, duct, and building shell data, (4) conducting a first-cut quality assessment (5) conducting a technical quality assessment, (6) performing accurate data entry, and (7) implementing statistical quality control checks.

Step one was performed when the homeowner was recruited for the survey. Basic information was collected on the dwelling type (i.e., standard tract, custom tract, or custom), approximate size of the home, number of stories, number of occupants, and the name of the survey contact. The recruiter also prepared the homeowner for the type of information to be collected.

Step two was performed at the customer's home. General information on the building was obtained from the homeowner and occupancy and energy usage schedules were gathered. Step three was to collect a thorough inventory of the building shell, duct, HVAC, and other appliances and equipment at the home. Other data that were then collected include building envelope characteristics (construction type, % glazing, shading, and fenestration levels), duct conditions (signs of leakage, gaps, general installation quality, length of ducts, insulation levels), appliance inventory, and miscellaneous loads such as spas or pools.

The next four steps of the data collection process insure high-quality data. Step four, the first-cut quality assessment phase involved a review of the completed survey to insure that the forms are filled out correctly and completely. Surveys that do not pass this process were returned to the surveyor for correction. Step five was a technical review of the survey data by a XENERGY engineer. During this review, the responses were checked for technical reasonableness. Step six consisted of accurate data entry, and in step seven, final quality control activity involved a data validation assessment of the collected and entered data using statistical procedures.

Nested Duct Blaster Tests

For a subsample of 158 homes, a "duct blaster" duct test was performed. For this test, the home's duct system was sealed off and the system was pressurized to 25 pascals. Reads from the duct blaster equipment indicate how much air leakage there is in the duct system.

The results of the duct blaster tests were used to develop duct efficiency estimates for the Program and non-Program homes.

3.5.3 Onsite Survey Results

Table 3-2 presents selected statistics developed from the on-site survey data. As the tables indicates nonparticipant homes tend to be somewhat larger and more expensive than participant homes. As expected, participant homes are more efficient. Participant homeowners earn slightly lower income than nonparticipants and were more interested in buying an energy efficient home. Awareness of the U.S. Environmental Protection Agency's The Energy Star New Home Program is generally low.

Table 3-2
Selected Statistics Developed from On-site Survey Data

	Participants	Prior Participants	Nonparticipants
Average House Price	$179,968	$154,846	$206,842
Part of a Subdivision	92.3%	90.8%	89.5%
Conditioned Square Footage	1,949	1,814	2,110
Number of Stories	1.4	1.3	1.4
Number of Rooms	6.5	6.5	6.7
Window-Floor Area Ratio	0.149	0.158	0.148
Ceiling R-value	34.9	35.1	32.0
Duct Leakage Flow CFM	144	141	187
AC SEER	12.35	12.91	11.00
Furnace AFUE	82.9	85.0	80.7
Number of Occupants	3.1	3.1	3.1
Average Annual Income	$68,010	$63,962	$72,863
Have College Degree	58.1%	43.1%	55.8%
Energy Effic. Important for Purchase	67.1%	72.3%	54.7%
Aware of Energy Star Program	2.6%	0.0%	1.1%

3.6 TELEPHONE SURVEY DATA

A survey of Program and non-Program builders was used to support the net-to-gross and spillover analyses. The survey was targeted to the builders of homes that received on-site surveys.

3.6.1 Survey Instrument

The survey instrument was designed to collect basic information about the builders, such as the size of their operations, the fraction of their homes that are built under the Program, the HVAC contractors they use, and the factors motivating them to build certain types of homes (energy efficient, low cost, customer comfort, etc.). Other key issues addressed in the survey instrument are determination of:

- the Program effect on measures installed by participants,
- the Program effect on measures installed in nonparticipant homes (nonparticipant spillover),
- spillover of non-Comfort Home measures *within* participant homes,
- changes in builders' awareness of measures, changes in builders' knowledge of measures, changes in builders' decision-making processes, etc., and
- effects on code compliance.

A copy of the telephone survey instrument is provided in Appendix A.

3.6.2 Survey Pretest

The builder survey instrument was pretested to ensure that it is understandable by the respondent and that it is providing the right data for the analyses. Three pretests were conducted by XENERGY analysts and the ordering of the participant self-report net-to-gross questions was revised to make the survey flow better.

3.6.3 Telephone Survey Implementation

Locating and contacting the appropriate builder decision maker was a significant component of the survey. There was often only one person who was qualified to complete the survey in each builder office, and more often than not, this person was seldom around. Once the builder was contacted, it was important to maintain their interest in the survey in order to get a complete set of responses. Use of analysts who were familiar with the PG&E Program and residential building practices improved the survey response rates and the quality of the collected data.

3.6.4 Telephone Survey Results

Tables 3-3 through 3-9 present selected results from the telephone survey of builders. Key findings include:

- the sample of builders was fairly evenly split between small builders and large builders;
- on average, participant builders were smaller;
- most builders average home selling price in under $200,000;
- most builders concentrate on building entry-level and mid-range homes;
- almost all builders were aware of the Comfort Home Program;
- PG&E was the primary source of their awareness; and
- less than 20% of the builders knew of the Environmental Protection Agency's Energy Star New Home Program - only one builder indicated that they currently plan to participate in the program.

Table 3-3
Distribution of Number of Homes Built: 1994-1996

	Number of Builders	Percent of Builders
Under 100	15	25%
100-199	9	15%
200-299	7	11%
300-499	4	7%
500-999	15	25%
1000 or more	11	18%

Table 3-4
Average Number of Homes Built: 1994-1996

	Average Number of Homes
Builders of Participant Homes	589
Builders of Nonparticipant Homes	1,105

Table 3-5
Distribution of Average Home Prices

Price Range	Percent of Builders
Under $125,000	12%
$125,000-149,999	17%
$150,000-174,999	20%
$175,000-199,999	14%
$200,000-249,999	12%
$250,000-299,999	3%
$300,000-499,999	14%
$500,000 or higher	8%

Table 3-6
Types of Homes Built

	Percent of Builders
Entry Level	56%
Mid Level	82%
Luxury	20%

Does not sum to 100% due to overlap

Table 3-7
Aware of the PG&E Comfort Home Program?

	Percent of Builders
Yes	95%
No	5%

Table 3-8
First Source of Comfort Home Program Awareness

	Percent of Builders
Approached by PG&E	57%
Saw PG&E Literature	7%
Other Builder/Subcontractor	12%
General Knowledge	12%
Don't Recall	12%

Table 3-9
Aware of EPA Energy Star New Home Program?

	Percent of Builders
Yes	18%
No	82%

3.7 SECONDARY SOURCE DATA

Secondary source data used for the study mainly consisted of load shape data, PG&E appliance saturation data, and equipment efficiency data.

3.7.1 Load Shape Data

The primary use of load shape data was to disaggregate energy savings into time-of-use impacts. Data for this analysis came from two sources:

1. PG&E's ongoing end-use research projects (for cooking and clothes drying); and
2. air conditioner metering data from the previous new construction program evaluation (data collected from June through October of 1993).

Figures 3-1 through 3-3 present the load shapes used for the analysis.

In addition to time-of-day fractions shown in Figures 3-1 through 3-3, the load shape was used to develop allocation factors to separate average daily usage into weekday, weekend, and peak day usage. The type-of-day distinction was required to provide impact estimates by PG&E costing period. Daily usage factors are presented in Table 3-10.

Figure 3-1
Air Conditioning Load Shapes

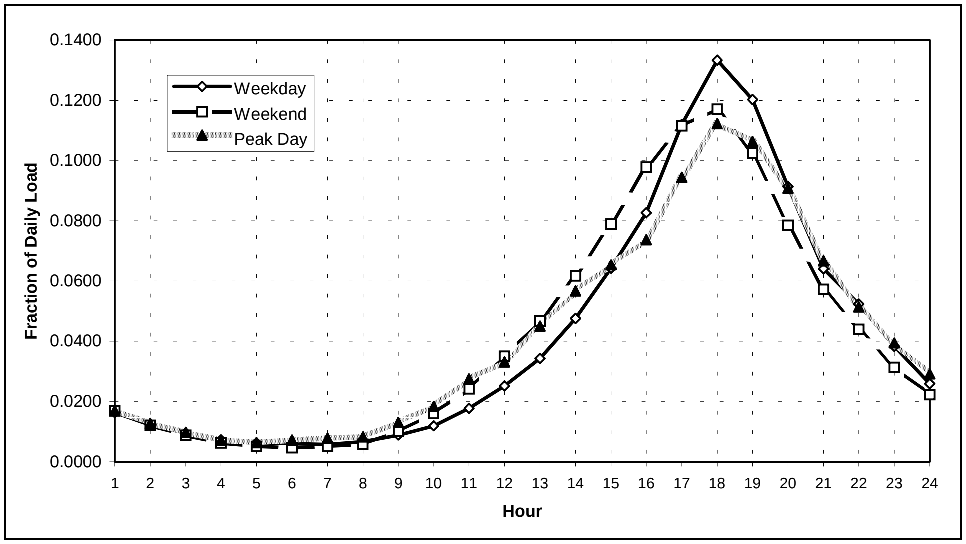


Figure 3-2
Clothes Drying Load Shapes

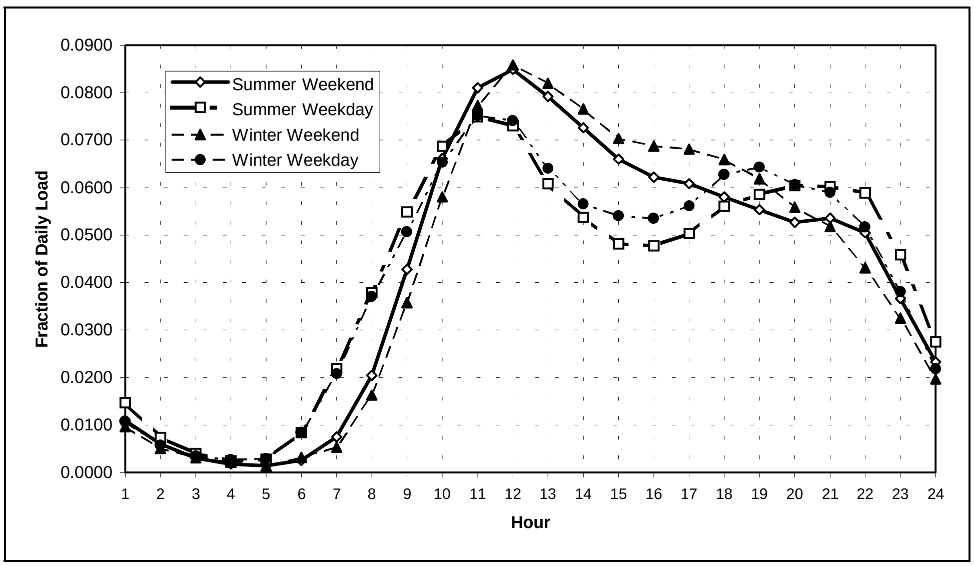


Figure 3-3
Cooking Load Shapes

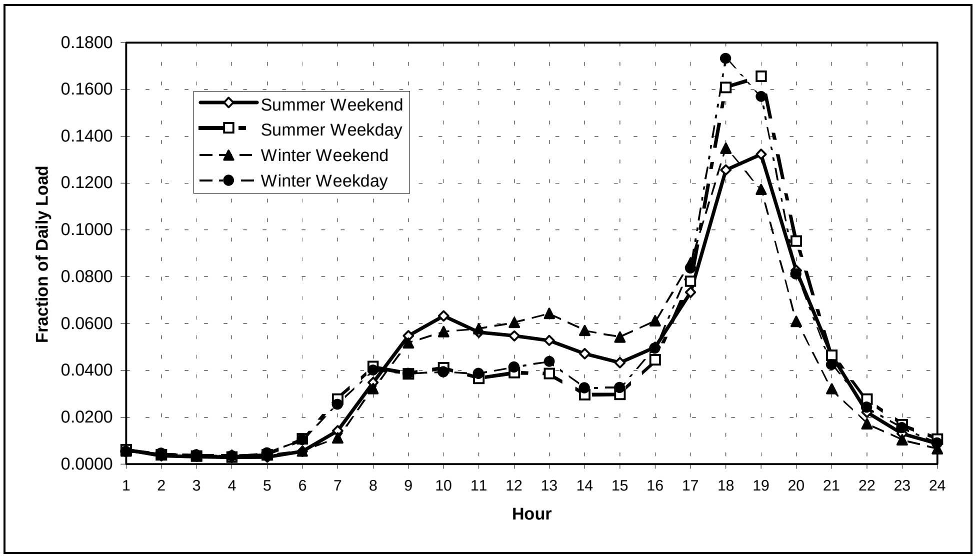


Table 3-10
Daily Usage Factors - Using Loadshape Data

	Daily kWh from Load Shape Data	Fraction of Average Daily Use
Cooling		
Summer Weekday	5.192	0.927
Summer Weekend	6.620	1.182
Summer Peak Day[1]	17.426	3.112
Clothes Drying		
Summer Weekday	1.535	0.935
Summer Weekend	1.909	1.163
Winter Weekday	1.939	0.918
Winter Weekday	2.546	1.205
Cooking		
Summer Weekday	0.736	0.961
Summer Weekend	0.839	1.097
Winter Weekday	0.887	0.939
Winter Weekday	1.088	1.152

[1] Based on an average of the 5 peak usage weekdays covered by the load shape data.

3.7.2 Other Data

Other secondary source data that was used in the project include: (1) the most recent PG&E residential appliance saturation survey (RASS) to assess the reasonableness of net impacts calculated for gas cooking and gas clothes drying measures, and (2) various equipment literature and efficiency databases that were used to identify the energy efficiency ratings of key appliances.

4 ENGINEERING ANALYSIS

4.1 OVERVIEW

Engineering calculations utilize the information about the homes gathered during the on-site survey to calculate end-use energy consumption. Estimates of end-use energy consumption were calculated for all buildings in the study under two scenarios: as-built and reference. The reference case calculations were used to calculate gross energy savings relative to a fixed reference point (Title 24 standards) for both program participant and nonparticipant buildings.

In order to develop site-by-site savings estimates for each program component, the following two types of engineering analyses were employed:

1. building simulation modeling and associated analysis for space conditioning measures; and
2. engineering equations for non-space conditioning measures.

In addition, an analysis of secondary source data was utilized to develop allocation factors to assign impacts to the appropriate time-of-use periods. A description of each approach is presented below, followed by a section presenting engineering analysis results.

4.2 SPACE CONDITIONING USAGE

Site-specific building simulations were utilized to develop estimates of space cooling and space heating energy usage for both as-built and reference scenarios. The Micropas building simulation model was used for the analysis. Micropas is one of the most popular methods used to assess Title 24 compliance in new residential homes, and therefore, this approach is consistent with the requirements of the M&E Protocols (Table C-7) that call for use of a “Building Simulation Model approved by the CEC to set Title 24 building standards.”

One of the major elements of the PG&E Program being evaluated involved enhanced duct installation procedures. The analysis of duct impacts was developed outside the Micropas model using the ASHRAE Standard 152P: Method. Duct analysis results (in the form of distribution system efficiency) were then combined with Micropas load calculations and system efficiency parameters to develop space conditioning energy usage estimates for each home in the study. An overview of the energy consumption calculation and energy savings approach are presented next, followed by a description of the load simulation process and the duct efficiency analysis.

4.2.1 Energy Consumption Calculations

Because Micropas does not internally model cooling, heating, and duct system efficiencies, energy usage for cooling and heating was calculated externally for each site as follows:

$$Energy_i = \frac{load_i}{systeff_i \times ducteff_i} \times conv_i \qquad (1)$$

where:

$Energy_i$	=	energy (kWh or therms) for end use i (cooling or heating)
$load_i$	=	Micropas load estimate in kBtus for cooling or heating
$systeff_i$	=	system efficiency for cooling (SEER) or heating (AFUE)
$ducteff_i$	=	duct efficiency (fraction between 0.0 and 1.0)
$conv_i$	=	conversion factor to translate from kBtu to kWh or therms

System efficiencies were obtained from the on-site survey

4.2.2 Energy Savings Calculations

The engineering estimates of energy savings, above the Title 24 reference, were determined by subtracting “as-built” energy usage from reference energy usage. Using Equation 1 above, as-built energy usage reflects the as-built loads from Micropas, the actual system efficiencies (SEER and AFUE), and the calculated duct efficiencies. Reference energy use reflects the Micropas reference loads, standard system efficiencies (10 SEER and 0.78 AFUE), and reference duct efficiencies (based on the nonparticipant average for cooling and heating). Given the parameters of Equation 1, HVAC savings can be broken out into duct savings, air conditioner savings, and other savings.

Recent studies have shown that the default duct efficiencies applied external to load calculations in Micropas (and also published in the CEC compliance manual) tend to overstate actual duct efficiency. The effect of this overstatement may be that both participant and nonparticipant “as-built” duct systems show lower efficiencies than the default Micropas efficiencies. This effect may lower gross Program savings relative to an artificially efficient reference case (although net impacts that rely on differences between participants and nonparticipants will not be affected). In lieu of this problem, the “reference” duct efficiencies were adjusted to reflect more realistic values using the average nonparticipant duct efficiencies for heating and cooling (shown in Table 4-4).

Two sets of Micropas simulations were developed for the analysis, one set using compliance thermostat schedules and another set using customer-reported thermostat schedules.

Customer-reported schedule loads were used:

1. in the SAE analysis to develop calibration coefficients for the engineering results, and
2. in the gross savings analysis for development of gross measure impacts.

Compliance schedule loads were used:

1. to assess compliance with Title 24 energy budgets, and

2. in the net savings analysis to determine net impacts through a comparison of participant and nonparticipant efficiencies.

The compliance schedule loads were used in the net savings analysis because they eliminated behavioral differences between participants and nonparticipants, therefore, enhancing the effectiveness of the nonparticipants as a control group for the participants.

4.2.3 Loads Simulation Process

Building geometry information from the on-site surveys were used to create computer simulation models of every home in the study. These Micropas simulations yielded the heating and cooling load estimates for the homes that were later used to calculate total energy use. This section describes the process taken to obtain the heating and cooling loads.

The first step was to review the paper surveys and the electronic survey database. This database includes such survey information as the heating and cooling thermostat setpoints and the location of the home. The paper surveys show physical dimensions of structure.

Next, a new database was created and populated with takeoffs from the survey drawings of the areas of walls, floors, ceilings, windows, and skylights. Other site data taken from the surveys includes the building orientation (azimuth), the climate zone, and the attributes for each of the construction types. These attributes describe the building element with u-value, mass properties, and shading coefficient.

A VisualBasic program was written to pull this geometric data out of the new database and the thermostat setpoint data from the initial survey database to create four Micropas input files for each site, referred to as cases A through D:

A. actual geometry with actual schedules
B. actual geometry with compliance schedules
C. standard geometry with actual schedules
D. standard geometry with compliance schedules

For each simulation of the A and B cases, Micropas generates a reference input file that has a standard geometry. This file is normally used for determining compliance. In this case, the standard geometry section created by Micropas is copied into the A and B files to create the C and D cases.

The monthly heating and cooling loads are extracted from the Micropas output files. The load data are then used to calculate energy consumption.

4.2.4 Duct Efficiency Analysis

The Micropas model does not specifically address duct efficiency. Rather, default efficiencies, reflecting CEC and ASHRAE assumptions, are assigned to a home based on home type (single-story vs. Multi-story) and duct location (attic, crawlspace). The same duct efficiencies are used for “proposed design” and compliance scenarios.

To assess duct efficiency for the evaluation, a separate duct efficiency model based on the ASHRAE 152 Forced Air Calculation was used. The model was developed by Ian Walker and Mark Modera of LBL to better determine actual duct efficiencies utilizing site-specific data. Inputs to the model include:

- duct insulation levels;
- duct blaster test results;
- house size; and
- duct dimensions and locations.

Duct Blaster Basics

Forced air distribution systems can have a significant impact on the energy consumed in residences. It is common practice to place such duct systems outside the conditioned space, typically in attics, crawlspaces and garages. This results in the loss of energy by air leakage and conduction. In cases where the ducts are located in the conditioned space, air lost from the ducts helps condition the space, so it is not a loss.

There are several diagnostic procedures, which are used to perform quantitative leakage measurements. The most often recommended method is the “Duct Blaster Method”. The procedure is performed using a calibrated air flow measurement system called a “duct blaster”. It consists of the following major components: a fan, a digital pressure measurement gauge, a fan speed controller and a flexible extension duct. The duct blaster system chosen for the study is manufactured by the Energy Conservatory in Minneapolis, and meets the flow calibration specifications of the standards. It is capable of moving up to 1,350 CFM against 50 Pa of back pressure and has a flow accuracy of +/-3%.

Pressurization Test Procedure

Duct leakage is measured by first connecting the duct blaster system to the ducts at either a central return grill or at the air handler access door. After sealing off all the supply and return registers, and combustion or ventilation air inlets, the duct blaster is used to pressurize the entire duct system to a standard testing pressure. The duct pressure at which the test is conducted is representative of the average actual duct operating pressure and is typically predetermined by the program test protocol (e.g. 25 Pa or 50 Pa). The air flow needed to generate the test duct pressure (reference pressure) is measured by a calibrated pressure gauge connected to the fan. Once the reference pressure is established and maintained, it is then possible to measure the fan pressure needed to pressurize the duct system to the reference pressure. This pressure reading is converted to CFM and represents the measurement of total duct leakage (in CFM) at the duct reference pressure. The total duct leakage value consists of leakage to the outside of the conditioned space plus leakage to the inside.

Duct Leakage Results Utilization

Once the total duct leakage is recorded it is possible to utilize the "ASHRAE Standard 152P: Method of Test for Determining the Design and Seasonal Efficiency of Residential Thermal Distribution Systems 1997" to provide an estimate of the efficiency of thermal distribution systems. The calculation procedure requires inputs, which include information about the supply and the return duct location, the ambient conditions, duct surface area, duct insulation level, heating and cooling system capacities and system fan flow. The results provide seasonal thermal distribution system efficiencies for both heating and cooling systems that are used in computing energy consumption.

Duct Efficiency Modeling Assumptions

To determine the efficiency of the studied residential thermal distribution systems, XENERGY used a spreadsheet-based computer program developed by the Lawrence Berkeley National Laboratory (LBNL). The program is based entirely on the most recent version of ASHRAE Standard 152P: Method of Test For Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, August 1997.

The spreadsheet is split into INPUT data, CALCULATED parameters and the OUTPUT Parameters. The INPUT data is the data required to perform the calculations. These data come from measurements and observations in actual buildings, building plans and default values. The CALCULATED parameters are calculated from the INPUT data and represent intermediate information required to determine the duct efficiencies. The OUTPUT Parameters are Delivery Effectiveness and Distribution System Efficiency and are given for heating and cooling, under both design and seasonal conditions.

Input Parameters

A host of input data are required for the LBNL duct model. Some data were collected during the on-site surveys while others were calculated based on surveyed data or assumed from standard practice and ASHRAE protocols. In addition, standard CEC climate data are utilized for weather-related inputs. The following table lists each input and its source. For a more detailed explanation of each input, see Appendix C.

Table 4-1
Duct Efficiency Model Input Parameters

Parameter	Surveyed	Calculated or Lookup[1]	Assumed
Conditioned Floor Area, and House Volume	✓		
Supply & Return Duct Surface Areas		✓	
Fraction of Ducts in Conditioned Space			✓
Supply & Return Duct R-values	✓		
Thermostat Setpoint, Heating & Cooling	✓		
Heating & Cooling Design Temperatures		✓	
Design Wetbulb Temperature		✓	
Indoor Wetbulb Temperature		✓	
Attic Solar Gain Reduction [y/n]	✓		
Equipment Heating & Cooling Capacity	✓		
Heating & Cooling Fan Flow		✓	
Heating & Cooling Supply & Return Duct Leakages	✓		
Duct Thermal Mass Correction	✓		
Equipment Efficiency Correction	✓		
Is The Attic Vented?	✓		
Is There A Thermostatic Expansion Valve?		✓	
Is Heating System A Heat Pump?	✓		

[1]Calculated values are based on survey data or lookup part numbers in Manufacturer's literature.

Duct Efficiencies for Non-tested Homes

Since duct test results are available for only about half of the homes included in the study, efficiency estimates were required for the remaining homes. For the homes with duct tests, efficiency results were correlated to factors such as house size and dimensions, duct characteristics, and program participation using regression analysis. The duct leakage variable from the duct tests was deliberately left out of the equations, because this variable was not available for the remaining homes that duct efficiency estimates were required for. The regression equations were used to impute duct efficiencies for homes without duct test results. Equations for cooling-related efficiencies are presented in Table 4-2, and equations for heating-related efficiencies are presented in Table 4-3. Separate equations were developed for the participant, prior-participant, and nonparticipant groups. Overall, the statistical properties of the regression equations are marginal (modest R^2 and t-statistics below 2.0); however, the estimated parameters appear to be reasonable. Since the regression equations are essentially used to adjust the average duct efficiencies to reflect physical attributes that vary by home, it was determined that use of the equations to estimate duct efficiencies for site without duct tests was preferable to applying simple averages across participant groups.

Table 4-2
Duct Cooling Efficiency Regression Parameters

Variable	Participants		Prior Participants		Nonparticipants	
	Parameter	t-statistic	Parameter	t-statistic	Parameter	t-statistic
Intercept	0.7524	32.3	0.7429	22.7	0.7562	26.2
Number of levels in home	0.0308	2.8	0.0037	0.3	0.0206	1.7
Insulation above standard	0.0270	1.2	-0.0018	0.0	0.0600	2.5
Number of rooms in home	-0.0063	-1.5	-0.0018	-0.4	-0.0061	-1.3
Return duct in conditioned space	0.0552	2.3	0.0370	1.4	0.0235	0.8
Climate zone 11 indicator	-0.0094	-0.7	0.0232	1.5	-0.0106	-0.5
Climate zone 12 indicator	0.0196	1.8	0.0359	2.6	-0.0072	-0.6
Number of observations	56		39		57	
Adjusted R^2	0.3379		0.2059		0.1494	

Table 4-3
Duct Heating Efficiency Regression Parameters

Variable	Participants		Prior Participants		Nonparticipants	
	Parameter	t-statistic	Parameter	t-statistic	Parameter	t-statistic
Intercept	0.7832	22.5	0.7558	21.5	0.7882	21.5
Number of levels in home	0.0407	2.5	0.0103	0.7	0.0079	0.5
Insulation above standard	0.0372	1.1	0.0199	0.5	0.0774	2.5
Number of rooms in home	-0.0086	-1.4	0.0010	0.2	-0.0042	-0.7
Return duct in conditioned space	0.0695	2.0	0.0290	1.0	0.0279	0.7
Climate zone 11 indicator	-0.0272	-1.4	-0.0162	-1.0	-0.0155	-0.6
Climate zone 12 indicator	0.0156	1.0	0.0166	1.1	-0.0278	-1.9
Number of observations	56		39		56	
Adjusted R^2	0.2484		0.1966		0.1081	

Average duct leakage and duct efficiency estimates are presented in Table 4-4. As the table indicates, the participants performed better than the nonparticipants both in terms of duct leakage (lower) and duct efficiency (higher). Duct efficiency differences between participants and nonparticipants were statistically significant at the 99% confidence level. Duct efficiencies for the prior participant group were similar to the participant efficiencies (and not statistically different at the 90% confidence level). As expected, the average duct efficiencies were lower than the efficiencies used in the compliance model.

Table 4-4
Duct Efficiency Parameters

	Participants	Prior Participants	Nonparticipants	Average	Compliance Value
Duct leakage, cfm	144	141	187		
Duct leakage, cfm/sf	0.081	0.074	0.100		
Cooling efficiency	0.768	0.762	0.741	0.759	0.860
Heating efficiency	0.794	0.786	0.756	0.781	0.873

4.3 DEVELOPMENT OF ENGINEERING-BASED ESTIMATES FOR NON-SPACE CONDITIONING

Building simulation models do not generally provide any advantageous capabilities in modeling non-space conditioning end uses such as refrigeration, water heating, cooking, clothes drying, spas, and pools. As a result, it is more efficient to determine the reference and as-built consumption of these other end uses using stand alone engineering models that can be calculated directly off of the customer survey data. The key to accurate estimation of the non-space conditioning end uses is capturing customer behavior. Water heating, cooking, dryer, spa, and pool usage are all driven by occupant behavior. We will use the customer survey data to develop unique non-space conditioning end use estimates for each home in the study. These estimates will then enter the statistical model in the same manner as the building simulation results. Table 4-5 shows some of the site-specific factors that affect key end uses.

Table 4-5
Site Factors Influencing End Use Consumption

End Use	Influencing Factors
Refrigerators/Freezers	Type, Size, Age, Location
Television	Number of Sets, Hours of Use
Cooking	Number of Residents, Number of Meals, Microwave Use
Lighting	Number of Residents, Square Footage, Number of Rooms
Laundry	Number of Residents, Number of Loads
Water Heating	Number of: Residents, Showers, Meals, Wash Loads
Pool/Spa	Pump Size, Reported Usage, Use of Heaters

4.3.1 Equivalent kWh Usage for Cooking and Clothes Drying

In addition to direct engineering calculations of electric usage for cooking and clothes drying for use in the SAE analysis, equivalent cooking and clothes drying estimates were developed from gas usage estimates using the following conversions:

$$Equivalent\_kWh = Therms \times \frac{100{,}000}{3{,}413} \times \frac{GasEfficiency}{ElectricEfficiency} \qquad (2)$$

Where relative gas-efficiency-to-electric-efficiency ratios of 0.51 for cooking and 0.89 for clothes dryer were developed from U.S. Department of Energy information provided in the E-SOURCE Residential Appliances Technology Atlas, October 1994 Edition.

The equivalent kWh usage estimates (after SAE calibration) are used for calculation of Program electric impacts due to the installation of gas cooking and clothes drying measures. For these measures that influenced the installation of gas appliances instead of electric appliances , electric savings impacts are positive while gas savings impacts are negative (reflecting a reduction in electric use and an increase in gas use). This approach of using equivalent kWh usage estimates was taken so that Program impacts would reflect behavioral patterns associated with the impacted homes.

4.4 TIME OF USE ALLOCATION

Allocation factors were developed to assign annual energy savings to PG&E cost periods using the load shapes discussed in Section 3 together with monthly space conditioning usage profiles from the Micropas simulation analysis. Allocation factors, expressed as a percent of annual energy use, are presented in Table 4-6.

Table 4-6
Time of Use Allocation Factors - Relative to Annual Usage

		Summer Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak
Cooling	Peak kW	0.001282	0.001848	0.000893	0.000000	0.000000
	kWh	0.3128	0.2383	0.4402	0.0048	0.0039
Heating	Therms	0.0126			0.9874	
Cooking	Peak kW	0.000105	0.000391	0.000065	0.000446	0.000044
	kWh	0.1187	0.1423	0.1901	0.3082	0.2407
	Therms	0.4511			0.5489	
Clothes Drying	Peak kW	0.00011	0.00013	0.00013	0.00020	0.00002
	kWh	0.0938	0.1340	0.2130	0.2888	0.2705
	Therms	0.4407			0.5593	

4.5 SUMMARY OF ENGINEERING RESULTS

Results of the engineering analysis are summarized in this subsection. First, compliance with Title 24 allowance budgets are addressed. Next, space conditioning energy usage and energy efficiency impacts are presented. Finally, unit energy consumption (UEC) values developed from the on-site survey and the non-space conditioning algorithms are shown.

4.5.1 Title 24 Budget Compliance

Table 4-3 presents Title 24 compliance calculation averages based on the Micropas simulation results that utilized compliance thermostat schedules and duct efficiencies. For participants and prior participants, the air conditioner SEER level was set to 10 in order to approximate budget compliance prior to Program effects. As the table indicates, participants were below budget by 2.3% on average, prior to accounting for the effects of increased air conditioner efficiencies. The table also shows that nonparticipants were, on average, lower than the Title 24 budgets by about 4.3%. For all groups, budget compliance is realized primarily through the water heating end use. This is not surprising, given an almost negligible cost different between efficient and standard water heaters (0.60+ EF water heaters versus 0.54 EF water heaters).

Table 4-7
Title 24 Compliance Calculations - kBtu/ft2-yr

	End Use	As-built	Budget	Difference
Participants @ SEER=10	Space Heating	12.05	12.00	-0.05
	Space Cooling	11.22	10.22	-1.00
	Water Heating	10.62	12.47	1.85
	Total	33.89	34.69	0.80
Prior Participants @ SEER=10	Space Heating	13.04	12.53	-0.51
	Space Cooling	11.60	10.20	-1.40
	Water Heating	11.21	13.09	1.88
	Total	35.85	35.82	-0.03
Nonparticipants @ Actual	Space Heating	12.25	12.12	-0.13
	Space Cooling	10.10	10.09	-0.01
	Water Heating	10.46	12.08	1.62
	Total	32.81	34.29	1.48

4.5.2 Space Conditioning

Average space conditioning consumption and impacts, based on the engineering analysis, are presented in Table 4-8. For comparison purposes, usage based on Micropas compliance schedules are presented alongside usage based on customer-reported schedules. Nonparticipant results are also shown. Results are unweighted simple averages of study sites. Key findings include:

- average results using compliance schedules differ somewhat from results using reported schedules, especially for space heating; also, variation across homes is much greater when using the reported schedules;
- engineering estimates of gross savings for space conditioning are 284 kWh and 18.3 therms;
- "as-built" usage for nonparticipants is not much lower than baseline usage;
- duct savings for nonparticipants are, by design, near zero;
- positive participant savings for ducts and air conditioning are somewhat offset by negative savings in other areas - primarily involving the building envelope;
- nonparticipants also show negative "other" savings;
- negative "other" savings are consistent with budget compliance results shown in Table 4-7, where participants exceed the cooling budget before factoring efficient air conditioning and nonparticipant just meet budget despite averaging a SEER of 11;
- negative "other" savings for space heating is partially compensated for by increased furnace efficiency.

Table 4-8
Average per Home Engineering Results (Unweighted) - Space Conditioning

	Compliance Schedules		Reported Schedules	
	Participants	Nonparticipants	Participants	Nonparticipants
Cooling - kWh/year				
Baseline Cooling	2,162	2,283	2,105	2,300
As-built Cooling	1,867	2,257	1,820	2,271
Total Savings	296	26	284	29
Duct Savings	77	-4	76	-11
AC Savings	450	223	429	217
Other Savings	-232	-193	-220	-177
Heating - Therms/year				
Baseline Heating	267.1	281.5	342.6	371.5
As-built Heating	251.7	282.6	324.3	371.9
Total Savings	15.4	-1.1	18.3	-0.4
Duct Savings	13.5	-1.9	15.7	-4.3
Furnace Savings	16.9	9.6	23.1	12.7
Other Savings	-14.9	-8.7	-20.5	-8.8

4.5.3 Other End Uses

Engineering estimates of UECs (unit energy consumption) for non-space conditioning end uses is presented in Table 4-9. Results are simple unweighted averages of study sites. Appliance saturations are also presented to provide an indication of how many homes the UEC estimates are based on. In general, the UECs appear reasonable in light of other published usage estimates.

Table 4-9
Engineering Estimates of Non-space Conditioning Unit Energy Consumption
(Unweighted Average of Participants and Nonparticipants)

Electric End Uses	kWh/year	Saturation
Water Heating	2,077	0.003
Refrigeration	1,078	1.000
Freezers	744	0.184
Televisions	425	1.000
Stovetops	283	0.197
Ovens	205	0.460
Microwave Ovens	150	0.981
Lighting	1,365	1.000
Clothes Drying	958	0.540
Clothes Washing	109	0.994
Dish Washing	155	0.962
Pools	1,670	0.152
Spas	1,952	0.124
Miscellaneous	1,424	1.000
Gas End Uses	**Therms/year**	**Saturation**
Water Heating	184	0.990
Stovetops	20	0.800
Ovens	19	0.540
Clothes Drying	39	0.451
Pool Heating	212	0.025
Spa Heating	134	0.044
Gas Fireplace	12	0.444

As discussed in Section 4.3, Program electric impacts for cooking and clothes drying are imputed from participant gas usage estimates using appropriate conversion factors. Table 4-10 shows gas UECs and the associated equivalent-electric UECs for the participants. These results are simple unweighted averages before applying the SAE adjustments discussed in the next section of this report. As Table 4-10 shows, the participants tend to use their cooking and clothes drying equipment somewhat less than average.

Table 4-10
Gas and Equivalent-electric Cooking and Clothes Drying UECs
(Unweighted Participant Average)

End Uses	Therms/year	Equivalent kWh/year
Stovetops	19.8	296
Ovens	13.6	203
Clothes Drying	36.4	950

5 STATISTICAL CALIBRATION AND GROSS IMPACTS

5.1 OVERVIEW

This section presents the method used to statistically calibrate engineering usage and savings estimates to customer bills. Model results, including calibration coefficients and their statistical precision, are presented. Application of the calibration coefficients to engineering savings estimates is also shown, and calibrated estimates of gross program savings are presented.

5.2 STATISTICAL CALIBRATION OF ENGINEERING RESULTS

For the statistical analysis portion of this project, an SAE (statistically adjusted engineering) approach was utilized. Regression models were specified using engineering estimates of end-use energy consumption (discussed in Section 4) to estimate monthly energy usage (from bills) for the surveyed sample of homes.

The SAE modeling approach has some distinct advantages over simpler conditional demand models that use binary end use and program indicator variables interacted with other survey data. The SAE models impose an engineering-based structure to the regression model, making it easier to delineate energy usage among the various end uses. This structure is especially important for addressing multicollinearity among gas space heating and water heating that occurs because almost all homes utilize gas for both of these end uses. In addition, by providing engineering structure to program savings estimates, the SAE models are better able to identify measure savings that can get lost in the “noise” of purely statistical models.

Key SAE model inputs include billing data, weather data, and end-use consumption estimates (UECs) from the engineering analysis portion of the project (all developed on a monthly basis and expressed in use per day). The key outputs are calibration coefficients that can be applied to the engineering results to provide realized usage and savings estimates. The adjustment coefficients are often referred to as realization rates because they relate realized usage and savings to the initial engineering savings estimates.

5.2.1 Model Specification

The SAE model is based on the fact that the total energy use in a home is equal to the sum of energy use across all of the end uses. The basic form of the SAE model is:

$$Energy_{it} = \sum_{j=1}^{n} (\beta_j \times AB\_ENGIN_{jit}) + \varepsilon_{it} \qquad (2)$$

Where:

Energy	=	Billed electric or gas use for customer *i*, in period *t*
AB_ENGIN	=	As-built engineering estimates of energy use for end-use *j*, for customer *i*, in period *t*
β	=	Estimated adjustment parameters
ε	=	Error term

If the *AB_ENGIN* values are perfectly accurate, all of the parameters β would be equal to one and the error term would be zero. If a parameter value is greater than one, this implies that the engineering estimates are too low on average. The engineering estimates are too high on average if the parameter value is less than one. The further the parameter estimate is from one, the larger the error in the engineering estimate

Next, for the end uses of interest, the basic SAE model can be modified, by decomposing the engineering estimates into two components, base case use (*BASE_ENGIN*) and the difference between base-case use and as-built use (*BASE_ENGIN - AB_ENGIN*):

$$Energy_{it} = \sum_{j=1}^{n} [\alpha_j \times BASE\_ENG_{jit} - \beta_j \times (BASE\_ENGIN - AB\_ENGIN)_{jit} + \varepsilon_{it}] \qquad (3)$$

As it applies to this evaluation *BASE_ENGIN* is energy use under Title 24 standards and (*BASE_ENGIN - AB_ENGIN*) represents energy savings over the standards that occur for both participants and nonparticipants. The addition of the term α in equation (3) indicates that the adjustment parameters can be allowed to vary between the base-case usage estimate (adjustment parameter α) and the energy savings estimate (adjustment parameter β). Using this equation, realized savings are estimated as:

$$Realized\ Gross\ Savings_{jit} = \beta_j \times (BASE\_ENGIN_{jit} - AB\_ENGIN_{jit}) \qquad (4)$$

β_j in equation (4) is referred to as the realization rate, the fraction of gross engineering savings realized in customer bills. Sometimes modeling limitations preclude the estimation of separate adjustment for savings and base-case usage. This is especially true when savings are small relative to total end-use consumption or when savings are highly correlated with total end-use consumption. In these instances equation (2) is utilized instead of equation (3) and the same realization rate parameter is estimated for both the base case usage and the savings.

Cooking and Clothes Drying Impacts

In addition to the development of realized savings for HVAC measures that are determined by the difference between baseline and as-built use, the evaluation also requires impact estimates for measures promoting gas cooking and gas clothes drying. For these end uses, separate realization rates were developed in the gas SAE model. These realization rates are then applied to engineering estimates of gas cooking and clothes drying consumption to determine realized gross impacts. As discussed in Section 4, equivalent electric impacts are then derived from the gas impact estimates.

5.2.2 SAE Model Results

Specific variables that were used in the electric and gas SAE models are presented next, along with the estimated equations.

Electric Model

In specifying the electric SAE model, monthly electric usage (expressed on a kWh per day basis) was modeled as a function of the following variables (developed from the engineering analysis and also expressed on a kWh per day basis):

1. base-case cooling usage (reflecting Title 24 compliance usage, 10 SEER air conditioner efficiency, and average nonparticipant duct efficiency of 0.741);
2. high efficiency air conditioner savings due to increased efficiency above 10 SEER;
3. duct savings based on the difference between site duct efficiency and the nonparticipant average of 0.741)
4. other cooling savings based on differences between compliance and as-built envelope construction;
5. pool and spa electric usage; and
6. electric usage from all other end uses.

All space cooling variables were interacted with the ratio of actual-to-normal cooling degree days (65 degree base) to account for differences between billed consumption that reflect actual weather and the engineering cooling estimates that reflect normal weather. When developing realized impact estimates, the actual-to-normal degree day ratios are set to one, thereby providing impact under normal weather conditions. Finally, the coefficient for the air conditioner savings variable was restricted to be equal, but in the opposite direction, to the base cooling usage estimate [i.e., AC-parameter = - (base-cooling-parameter]. This restriction was made for two reasons: first, savings for air conditioner efficiency improvements should be proportional to loads; and second, there was a high degree of multicollinearity between the base usage estimate and the air conditioner savings estimate making it difficult to get an accurate estimate for the air conditioner adjustment coefficient.

The electric model was estimated using a generalized least squares procedure to correct for autocorrelation (the correlation of model residuals over time for each home). Autocorrelation is a typical problem in time-series analyses, and its presence was confirmed by the examination of site-specific Durbin-Watson statistics that were generally outside the acceptable range. Eighteen outlier observations (with studentized t-statistic greater than 4 in absolute value) were removed from the final model.

The electric model results are presented in Table 5-1. As the table indicates, all variables have the appropriate signs (savings variables have negative coefficients indicating a reduction in usage) and are statistically significant at very high confidence levels. The adjusted R^2 is reasonable for these types of models. The coefficients for base-case cooling and efficient AC variables indicate that engineering results for these components are, on average, somewhat high. The duct savings coefficient of -2.094 indicates the engineering estimate of duct savings is only about half of the realized estimate. "Other" cooling savings appear to be significantly overestimated in the engineering analysis as demonstrated by the low realization coefficient of -0.276. Realization rates for the other end uses are close to 1.0, indicating at good fit between the engineering estimates and billed usage.

Table 5-1
Electric SAE Model, Dependent Variable: Billed Consumption

Variable	Parameter Estimate	t-statistic
Base case cooling use	0.842	60.8
Efficient AC savings	-0.842	-60.8
Duct savings	-2.094	-9.7
Other cooling savings	-0.276	-6.1
Pool/Spa use	1.019	22.5
Other end use consumption	1.059	78.3
Number of observations	3,762	
Adjusted R^2	0.7634	

Possible explanations of the low "other" savings parameter were developed from a review of the building simulation results. Recall from Section 4 that other cooling savings were negative, indicating that building envelopes tended to be less efficient that Title 24 reference values. Key factors that were likely to lead to an underestimate of building envelope efficiency include the window and wall insulation levels:

- Windows: assumed U-values for the study are the CEC defaults for reported construction types (as defined in the Title 24 compliance manual); a limited comparison of assumed U-values against values contained in PG&E program files indicated that the assumed U-values may exceed actual U-values by 10%-15%. Based on builder survey results that indicate no major differences in window installation practices between participants and nonparticipants, this effect can probably be assumed to be systematic across all study sites.
- Walls: in many cases, reported wall insulation R-values were below the Title 24 standard and experience has indicated that surveyors often underestimate wall insulation levels due to the difficulty of examining installed construction material without damaging the structure or alarming the occupant.

Also note for the "other" cooling savings coefficient that despite its low value, it still has the appropriate sign and is statistically significant. This fact means that although, on average, the engineering analysis may have overestimated the difference between as-built and reference building envelope efficiency, it is still likely that as-built envelopes are less efficient than the Title 24 reference values.

Gas Model

The gas SAE model specification is similar to the electric model. Monthly gas consumption, on a therm per day basis, is modeled as a function of:

1. base case heating usage (reflecting Title 24 compliance usage, 0.78 AFUE furnace efficiency, and average nonparticipant duct heating efficiency of 0.756);
2. high efficiency furnace savings due to increased efficiency above 0.78 AFUE;
3. duct savings based on the difference between site duct efficiency and the nonparticipant average of 0.756);
4. other heating savings based on differences between compliance and as-built envelope construction;
5. cooking gas usage;
6. clothes drying gas usage; and
7. gas usage from all other end uses.

All space heating variables were interacted with the ratio of actual-to-normal heating degree days (65 degree base), and similar to the electric model, the coefficient for the furnace savings variable was restricted to be equal, but in the opposite direction, to the base heating usage estimate. The gas model was also estimated using a generalized least squares procedure to correct for autocorrelation. As with the electric model outlier observations were examined; however, no outliers were removed from the final model. The model that excluded outliers had coefficients for cooking and clothes drying that increased substantially (to the 1.5 range), returning cooking and clothes drying usage estimates that were deemed less reasonable than the model with all observations. Multicollinearity between the cooking, clothes drying, and other end use-variables was detected and could lead to the instability of the cooking and clothes drying parameter estimates.

The gas model results are presented in Table 5-2. All variables have the appropriate signs and are statistically significant at high confidence levels. The adjusted R^2 is similar to that of the electric model. The coefficients for base case heating and efficient furnace variables indicate that engineering results for these components require an adjustment to 88% of the original engineering estimate. The duct savings coefficient of -0.54 and the “other” heating savings coefficient of -0.49 indicate the engineering estimates are about twice as high as the realized estimates. The engineering-based cooking estimate is adjusted downward by about 30% and the clothes drying estimate is adjusted upward by about 15%. The lower t-statistics for the cooking and clothes drying variables may be partially due to the multicollinearity discussed above.

Table 5-2
Gas SAE Model, Dependent Variable: Billed Consumption

Variable	Parameter Estimate	t-statistic
Base case heating use	0.881	79.4
Efficient furnace savings	-0.881	-79.4
Duct savings	-0.542	-3.4
Other savings	-0.491	-5.8
Cooking use	0.708	2.3
Clothes drying use	1.148	3.7
Other end use consumption	0.950	24.5
Number of observations	3,377	
Adjusted R^2	0.7477	

5.3 CALIBRATED LOADS AND GROSS IMPACTS

Program level gross impacts are calculated by applying the SAE adjustments to site-level engineering estimates of usage and savings and then weighting up participant site-level results to Program totals using the expansion weights discussed in Section 2. Gross impact results are discussed next.

5.3.1 Space Conditioning Impacts

Gross impacts for the space conditioning end uses are presented in Table 5-3. All impacts are measured relative to Title 24 standards. Cooling impacts are estimated to be 450 kWh per home and 1,781,809 kWh for the Program. Heating impacts are estimated to be 19.0 therms per home and 75,202 therms for the Program. Note for space heating, the furnace savings include impacts for all furnaces with efficiencies above 0.78 AFUE. In many cases, increased furnace efficiency may be used by builders to offset deficiencies in building envelop efficiency (as noted by the negative “other” heating savings).

Table 5-3
Gross Program HVAC Impacts

Cooling	Average kWh	Total kWh
Baseline Cooling	1,720	
As-built Cooling	1,270	
Total Savings	450	1,781,809
Duct Savings	166	657,839
AC Savings	347	1,374,791
Other Savings	-63	-250,821
Heating	Therms/home	Total therms
Baseline Heating	305.9	
As-built Heating	286.9	
Total Savings	19.0	75,202
Duct Savings	8.4	33,236
Furnace Savings	20.7	82,148
Other Savings	-10.1	-40,182

Table 5-4 compares evaluation gross impacts with PG&E *ex ante* estimates. In general evaluation results are lower than PG&E estimates. In reviewing results, one should keep in mind that a comparison of gross impacts is not always very useful, especially when reviewing the results for "code enforcement" and "other" savings. The key to evaluating these types of measures is to compare participant impacts relative to nonparticipants. Such a comparison is really only meaningful at the end use level since there are trade-offs among measures in complying with Title 24 and in constructing a home that is energy efficient. Nonetheless, a few observations can be made concerning gross impacts: first, the air conditioner measure is achieving what is expected in terms of gross impacts; and second, the duct efficiency measures are not producing expected savings either for cooling or heating. Nonparticipant duct efficiencies are not that much lower than participant efficiencies.

Table 5-4
Comparison of Gross HVAC Impacts to PG&E ex ante Estimates

	Evaluation	PG&E *ex ante*	Realization Rate
Cooling	kWh/year		
Total Savings	1,781,809	2,790,174	0.64
Duct Savings	657,839	1,293,369	0.51
AC Savings	1,374,791	1,334,996	1.03
Code Enforcement		161,809	
Other Savings	-250,821		
Heating	Therms/year		
Total Savings	75,202	156,968	0.48
Duct Savings	33,236	115,198	0.29
Furnace Savings	82,148	6,814	
Code Enforcement		32,357	
Other Savings	-40,182	2,599	

5.3.2 Clothes Drying and Cooking

Cooking and clothes drying impacts are presented in Table 5-5. These impacts are the calibrated gas usage estimates and equivalent electric usage estimates for homes in the sample that received rebates for gas cooking and clothes drying measures. Results are weighted to the participant population using the expansion weights described in Section 2. Average savings differ from UECs reported at the end of Section 4 because impacts are weighted averaged over all participant homes.

Table 5-5
Gross Program Impacts for Gas Clothes Drying and Cooking Measures

	Average		Total	
	Therms	kWh	Therms	kWh
Clothes Drying	-15.8	413	-62,749	1,636,285
Stovetop	-9.2	138	-36,580	546,604
Oven	-4.7	71	-18,685	279,209
Cooking Total	-13.9	209	-55,265	825,813

Evaluation gas clothes drying and cooking impacts are compared to PG&E estimates in Table 5-6. Evaluation clothes dryer impacts are much higher than PG&E estimates. This reflects the relatively high penetration of gas dryers in rebated participant homes in the study (52%). PG&E rebates builders who install gas dryer stubs in the wash area but assumes only a fraction of the homeowners (35%) will install gas dryers. These impacts are incorporated into the tracking system as lower gross impacts rather than through a lower net-to-gross ratio. Evaluation cooking therm impacts are similar to PG&E's estimates; however, evaluation kWh impacts are much lower. For both clothes drying and cooking, it appears that PG&E is assuming different gas-to-electric conversion factors than those determined by the evaluation (and based on efficiency comparisons from the E-SOURCE Appliance Technology Atlas).

Table 5-6
Comparison of Gross Clothes Drying and Cooking Impacts to PG&E ex ante Estimates

	Evaluation		PG&E ex ante		Realization Rate	
	Therms	kWh	Therms	kWh	Therms	kWh
Clothes Drying	-62,749	1,636,285	-23,128	693,840	2.71	2.36
Cooking	-55,265	825,813	-58,319	1,230,580	0.95	0.67

5.3.3 Other End Uses

Two end uses covered by the Program were not included in the evaluation: water heating and lighting. Impacts for these end uses were small. For these end uses, the Program tracking estimate for savings was assumed to be correct.

Table 5-7
Savings for Measures Not Evaluated Based on Tracking System Data

	kWh	kW	Therms
Lighting	21,744	1.057	-
Water Heating	-	-	1,236

5.3.4 Gross Impacts by Costing Period

Using the allocation factors developed from load shape data and discussed in Section 4, impacts were calculated for the PG&E costing periods. Results are presented in Table 5-8.

Table 5-8
Gross Impacts by PG&E Costing Period

	PG&E Costing Period				
	Summer Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak
kWh Impacts					
Cooling	557,418	424,529	784,347	8,480	7,034
Clothes Drying	153,428	219,224	348,525	472,496	442,612
Cooking	98042	117533	156956	254540	198741
Lighting	4,136	3,940	6,550	3,785	3,332
Total	813,024	765,226	1,296,378	739,301	651,719
kW Impacts					
Cooling	2283.4	3292.9	1590.6	0	0
Clothes Drying	175.1	215.0	216.1	332.7	32.7
Cooking	86.7	322.5	53.9	368.6	36.3
Lighting	1.1	1.7	0.7	0.5	0.1
Total	2,546.3	3,832.1	1,861.3	701.8	69.1
Therm Impacts					
Heating	949			74,253	
Clothes Drying	-27,656			-35,093	
Cooking	-24,931			-30,334	
Water Heating	618			618	
Total	-51,020			9,444	

5.3.5 Gross Impact Confidence Intervals

Using statistical output from the SAE models, confidence intervals were developed by end use. Program-level confidence intervals are calculated as the sum of the end use intervals. Results are shown in Table 5-9.

Table 5-9
Gross Impact Confidence Intervals

	Point Estimate	90% Confidence Interval			80% Confidence Interval		
		Percent	Lower bound	Upper bound	Percent	Lower bound	Upper bound
kWh Impacts							
Cooling	1,781,809	±19%	1,440,986	2,122,632	±15%	1,516,610	2,047,008
Clothes Drying	1,636,285	±44%	908,802	2,363,768	±35%	1,070,219	2,202,351
Cooking	825,812	±72%	235,177	1,416,447	±56%	366,230	1,285,394
Lighting	21,744	±0%	21,744	21,744	±0%	21,744	21,744
Total	4,265,650	±39%	2,606,709	5,924,591	±30%	2,974,802	5,556,498
Peak kW Impacts							
Cooling	2,283.4	±19%	1,846.6	2,720.2	±15%	1,943.5	2,623.3
Clothes Drying	175.1	±44%	97.3	252.9	±35%	114.5	235.7
Cooking	86.7	±72%	24.7	148.7	±56%	38.4	135
Lighting	1.1	±0%	1.1	1.1	±0%	1.1	1.1
Total	2,546.3	±23%	1,969.6	3,122.9	±18%	2,097.6	2,994.9
Therm Impacts							
Heating	75,202	±43%	42,647	107,757	±34%	49,871	100,533
Clothes Drying	-62,749	±44%	-34,851	-90,647	±35%	-41,041	-84,457
Cooking	-55,265	±72%	-15,739	-94,791	±56%	-24,509	-86,021
Water Heating	1,236	±0%	1,236	1,236	±0%	1,236	1,236
Total	-41,576	±84%	-6,706	-76,446	±65%	-14,443	-68,709

6 NET SAVINGS ANALYSIS

6.1 OVERVIEW

The calculation of net savings involves determining the portion of realized gross savings that is attributable to the Program. In this study, three approaches to estimating net savings were investigated and integrated to provide the most appropriate estimate of net savings for the Program. The three approaches are:

1. Self-report estimates based on participant builder survey data of what they would have done in the absence of the Program;
2. A simple comparison of participant and nonparticipant efficiency levels; and
3. An efficiency choice model-based comparison of participant and nonparticipant efficiencies to correct for endogeneity of savings and program participation.

A discussion of each of the net savings approaches is provided next followed by a summary of the results. Then the issue of program spillover is addressed. Findings from the builder survey regarding spillover are presented and impacts on net savings are discussed. Finally, program net savings are presented and compared to PG&E ex ante estimates.

6.2 SELF-REPORT NET-TO-GROSS ANALYSIS

The self-report net-to-gross analysis was used to estimate free-ridership ratios based on builder responses to survey questions. Following is a brief review of the survey questions used to assess free-ridership, followed by a description of the free-ridership ratio assignment.

6.2.1 Free-Ridership Survey Results

Three key survey questions were used in the assignment of free-ridership. Tables 6-1 through 6-3 tabulate builder responses to these questions.

Table 6-1 shows the results of the questions about how the builders first learned about high efficiency air conditioning and enhanced duct installation procedures. The table shows that a large fraction of builders (42%) were introduced to efficient air conditioning by PG&E, and over 70% learned about enhanced duct installation from PG&E.

Table 6-1
Source of Builder Information for Efficient Air Conditioners and Enhanced Duct Installation

Source of Information	Efficient AC	Enhanced Duct Installation Procedures
From PG&E representative	36%	64%
From PG&E Literature	6%	7%
From other builders or sub-contractors	34%	18%
From architect or designer	2%	0%
From manufacturers' rep or literature	2%	2%
From trade literature	9%	2%
Other	11%	7%

* Results do not include missing responses

Table 6-2 presents the ranking of PG&E rebates among various factors influencing the builder to install program measures. Other factors included in the importance ranking were: information from program literature, past experience with the measures, information from vendors or designers, home buyers' request for measures, and meeting Title 24 compliance budgets. As the table indicates, PG&E rebates were important factors for the efficient air conditioner and enhanced duct efficiency measures, but less important for the gas appliance measures.

Table 6-2
Ranking of PG&E Rebates Among Reasons for Installing Program Measures

	Program Measure			
	High SEER AC	Enhanced Duct Installation	Gas Cooking	Gas Dryer Stubs
Rebates ranked first	56%	54%	34%	38%
Rebates ranked second	5%	5%	18%	18%
Rebates ranked third	5%	5%	7%	7%
Not ranked 1st, 2nd or 3rd	34%	36%	41%	38%

Table 6-3 shows a tabulation of builder responses regarding likely measure installation practices without the rebates. The responses show that most builders say that they would not have installed the HVAC measures but would have still included the gas appliance measures.

Table 6-3
Likelihood of Measure Installation Without Rebates

	Program Measure			
	High Efficiency AC System	Enhanced Duct Installation	Gas Cooking	Gas Dryer Stubs
Definitely would have done it anyway	2%	7%	40%	31%
Probably would have done it anyway	21%	7%	36%	38%
Probably would not have done it anyway	43%	33%	12%	17%
Definitely would not have done it anyway	29%	48%	5%	7%
Don't Know	5%	5%	7%	7%

6.2.2 Self-Reported Free-Ridership Ratios

Using the survey results described above, free-ridership ratios were calculated. The approach is described below, followed by the free-ridership results.

Self-Reported Free-Ridership Ratios

First, initial free-ridership ratios were developed based on builders' stated intentions about what they would have done in the absence of the Program rebates. Table 6-4 shows the ratio assignment used for this study.

Table 6-4
Initial Free-ridership Ratio Assignment Based on Stated Intentions

Install Measures Without Program?	Free-Ridership Ratio
Definitely would install anyway	1.00
Probably would install anyway	0.67
Probably would not install anyway	0.33
Definitely would not install anyway	0.00

Next, a set of consistency checks were implemented to adjust the initial free-ridership ratio based on questions regarding the source of the builders' knowledge of efficiency measures and the builders' importance ranking of the rebate in their decision to install measures. The consistency checks are important because simple self-report net-to-gross studies tend to produce biased results; respondents often give themselves credit for installing program measures despite being significantly influenced by the Program. The consistency checks used for this study are shown in Table 6-5.

Table 6-5
Self-report Consistency Checks

Consistency Check	Assigned Free-ridership Probability Limit
If customer first heard of efficient AC and ducts from PG&E	Maximum of 50%
If PG&E rebates were most important reason for installing Program measures	Maximum of 33%
If PG&E rebates were not one of the top three reasons for installing Program measures	Minimum of 67%

6.2.3 Self-Report Results

Using the approach outlined above, free-ridership ratios were assigned to each participant builder who responded to the survey. Weighted averages of the results were then developed and are presented in Table 6-6. Weights were based on the number of homes associated with each builder, estimated savings for each home, and the site expansion weights (described in Section 2). Implied net-to-gross ratios (*NTGR*s) are calculated as one minus the free-ridership ratio.

Table 6-6
Self-report Free-ridership and Implied Net-to-Gross Ratios

	Without Consistency Checks		With Consistency Checks	
Measure	Free-Ridership Ratio	Implied NTGR	Free-Ridership Ratio	Implied NTGR
Efficient AC	0.292	0.708	0.266	0.734
Enhanced Ducts	0.269	0.731	0.218	0.782
Gas Cooking	0.667	0.333	0.555	0.445
Gas Dryer Stubs	0.631	0.369	0.536	0.464

As Table 6-6 shows free-ridership is lowest and implied *NTGR*s are highest for the air conditioner and duct measures. Free-ridership ratios decrease somewhat, and implied *NTGR*s increase somewhat, when the consistency checks are included. The result is due to a number of builders (between 5 and 10, depending on the measure) indicating that they would probably have installed the measure without the rebate but also stated that the rebate is the most important factor influencing their decision to install the measure. For these builders, the free-ridership ratio was adjusted downward from 0.67 to 0.33. One builder indicated that they would probably not install measures without the rebate, but did not rank rebates as an important installation factor. The free-ridership ratios were increased from 0.33 to 0.67 for this builder.

6.3 Simple Efficiency Comparison

The first step in the efficiency comparison analysis is to define energy efficiency improvements for participants and nonparticipants using components of the gross savings developed in Section 5 of this report. For this analysis, efficiency improvements are defined as realized savings divided by calibrated base case usage. Using the impacts developed in the engineering analysis (using compliance thermostat schedules) and the calibration coefficients developed in the SAE analysis cooling and heating efficiencies are calculated for each home in the study as follows:

$$CoolingEfficiency = \frac{0.842 \times ACSavings + 2.094 \times DuctSavings + 0.276 \times OtherSavings}{0.842 \times BaseCoolingUse} \qquad (1)$$

$$HeatingEfficiency = \frac{0.881 \times FurnaceSavings + 0.542 \times DuctSavings + .491 \times OtherSavings}{0.881 \times BaseHeatingUse} \qquad (2)$$

Next a comparison of participant and nonparticipant efficiency improvements is used to calculate net-to-gross ratios (*NTGR*s) as follows:

$$NTGR_{Cooling,Heating} = \frac{(Participant\_Efficiency - Nonparticipant\_Efficiency)}{Participant\_Efficiency} \qquad (3)$$

The *NTGR* then can be multiplied by the gross realized savings to provide estimates of net savings.

For the clothes drying and cooking measures, efficiency changes are not the major focus. Instead, increases in the penetration of gas appliances is the major target of the program. For these measures, the *NTGR* is developed by comparing appliance saturations for participants (who received rebates for cooking and drying) and nonparticipants as follows:

$$NTGR_{Drying,Cooking} = \frac{(Participant\_Gas\_Saturation - Nonparticipant\_Gas\_Saturation)}{Participant\_Gas\_Saturation} \quad (4)$$

*NTGR*s based on the simple comparisons are presented in Table 6-7. The space conditioning *NTGR*s are in the 0.75 - 0.80 range while the gas appliance *NTGR*s are very low. Further investigation of these ratios indicates than the low values are primarily due to the rather high saturation of gas appliances in the nonparticipant sample.

Table 6-7
Net-to-Gross Ratios Based on Efficiency and Saturation Comparisons

	Participant Efficiency	Nonparticipant Efficiency	Difference	NTGR
Cooling	0.26170	0.06580	0.19590	0.749
Heating	0.06300	0.01260	0.05040	0.800
	Participant Saturation	Nonparticipant Saturation	Difference	NTGR
Clothes Drying	0.5238	0.4737	0.0501	0.096
Stovetop	0.8986	0.7368	0.1617	0.180
Oven	0.6304	0.4947	0.1357	0.215

Table 6-8 compares evaluation gas saturations with comparable numbers from PG&E's most recent Residential Appliance Saturation Survey. As the table indicates, both participant *and* nonparticipant homes in this study show much higher penetrations of gas appliances versus other groups.

Table 6-8
Comparison of Evaluation Gas Saturations to PG&E Residential Appliance Saturation Survey (RASS) Results

End Use	Current Study		Comparable RASS Numbers - After Adjusting Out Other Fuels			
	Participants	Nonparticipants	Single Family	Newest Homes	Central Valley	Elec & Gas Areas
Clothes Drying	0.524	0.474	0.331	0.302	0.190	0.375
Stovetop	0.899	0.737	0.414	0.498	0.364	0.439
Oven	0.630	0.495	0.352	0.379	0.331	0.385

One factor that may contribute to the relatively high nonparticipant gas saturations is that the nonparticipant homes are generally larger and more expensive than the participant homes (see Section 3, Table 3-3). Since gas cooking and the availability gas dryer stubs are considered premium features in a home, the inadvertent selection of a higher-end nonparticipant group for the study may bias the gas measure *NTGR*s downwards.

Another factor that could be contributing to the higher nonparticipant saturations is spillover. The RASS estimates shown in Table 6-8 reflect, for the most part, data collected prior to the implementation of the gas appliance portion of the Program (the Newest Homes category reflects homes built between 1989 and 1994). Part of the increase in gas saturations between the RASS period and the current Program period may reflect a general change in builder practices as a result of Program influences.

The simple comparison approach outline above is consistent with the Protocols in that it utilizes differences between participants and nonparticipants to develop net savings. To the extent that the nonparticipant sample group provides a good control group for the participants, this approach will provide a fairly accurate estimate of net savings. However, variations in the groups can introduce bias.

6.4 Efficiency Choice Modeling

There are a number of reasons why participants and nonparticipants may differ, thus limiting the accuracy of the simple comparison technique described above. Differences may be due to:

- random effects, such as the size of the homes included in the sample (in square footage) or the number of stories in the home (as discussed above);
- systematic effects, such as the tendency of the program to focus marketing efforts on certain types of builders; and
- self-selection bias resulting from participating builders self selecting themselves into the program.

The efficiency choice modeling approach can help to correct for differences between participants and nonparticipants in the calculation of net savings. This approach uses data collected for the engineering and load impact regression models and additional data collected during the survey of participant and nonparticipant builders to estimate a multi-equation efficiency choice (decision analysis) model.

The efficiency choice model is estimated using two types of equations: a binary discrete choice equation of program participation, and a regression equation to explain efficiency improvement. The general form of these equations is:

$$Participation = f_1\left(Efficiency, INC, MKT, DEC, SITE\right) \quad (5)$$

$$Efficiency = f_2\left(Participation, INC, MKT, DEC, SITE\right) \quad (6)$$

where

Efficiency	= efficiency improvements as calculated in equations (1) and (2) above
Participation	= a binary variable indicating program participation
INC	= a variable representing the incentive rate facing builders

MKT	= a set of market conditions facing builders
DEC	= a set of features relating to decision-making at the site
SITE	= a set of site characteristics

As the above equations (5) and (6) indicate, there is an endogeneity problem as both *Participation* and *Efficiency* enter into both equations. Program participation is expected to affect home efficiency but, in addition, builders who are likely to increase their homes' efficiency are also more likely to participate in the program.

The general approach to estimating the above system of equations is to use a two-stage process. First, a participation decision model is estimated using only the exogenous variables (excluding the *Efficiency* variable). Second, results of the participation model are included in the *Efficiency* regression model to help correct for self-selection bias. For this study, selectivity correction terms, known as Mills ratios, that are a function of the estimated probability of participation are included as explanatory variables in equation (6) in addition to the binary *Participation* variable.

The discrete choice participation model for this project is specified as a logit model with the following functional form:

$$Prob[Part] = \frac{e^{\beta' z}}{(1 + e^{\beta' z})} \tag{7}$$

where:

Prob[Part]	= probability that a customer participates in the Program
z	= vector of independent variables explaining customer participation
β	= vector of parameters

The dependent variable in the estimated equation takes on the value of “1” for participant homes and “0” otherwise. The model is estimated using Maximum Likelihood Estimation (MLE). Table 6-9 presents results of the participation model. Most of the variables in the model are reasonably significant (t-statistics close to 2.0 or more in absolute terms) and the log likelihood ratio is fairly high for this type of model.

Table 6-9
Participation Decision Model
Dependent Variable: Program Participation

Variable	Parameter Estimate	t-statistic
Intercept	2.335	1.7
Number of residents in home	-0.336	-1.6
Homeowner has a college education	0.700	1.5
Energy efficiency was an important home purchase factor	0.716	1.6
Builder only builds production homes	1.109	2.0
Builder only builds custom homes	-2.002	-1.9
Energy efficiency ranked 1st or 2nd in construction approach	2.346	2.6
Quality ranked 1st in construction approach	-0.595	-1.3
Builder constructs luxury homes	-0.951	-1.8
Builder believes buyers are willing to pay for energy efficiency	-1.984	-3.1
Builder believes energy efficiency improves home salability	2.087	3.3
Number of homes builder built in 1994-96 period	-0.119	-4.1
Climate zone 11 indicator	-0.617	-0.9
Climate zone 12 indicator	0.696	1.3
Number of observations	166	
Log likelihood ratio	0.3399	

Using the results of the participation decision model, two Mills ratios are calculated using the following formulas:

Mills Ratio one (MR1): For participants:

$$\mathrm{MR1} = -\left[\frac{(1-\boldsymbol{P})\times\ln(1-\boldsymbol{P})}{\boldsymbol{P}} + \ln(\boldsymbol{P})\right]$$

For nonparticipants:

$$\mathrm{MR1} = \frac{\boldsymbol{P}\times\ln(\boldsymbol{P})}{1-\boldsymbol{P}} + \ln(1-\boldsymbol{P}) \qquad (8)$$

Mills Ratio two (MR2):

$$\mathrm{MR2} = \mathrm{MR1}\times\mathrm{Part} \qquad (9)$$

Where ***P*** equals the estimated participation probability and ***Part*** is a binary variable equal to 1.0 for participants and 0.0 for nonparticipants.

The Mills ratios are then included in the efficiency regression model to control for self selection bias. The cooling and heating efficiency models are presented in Table 6-10.

Table 6-10
Cooling and Heating Efficiency Models
Dependent Variable: Efficiency Relative to Base Case Usage

	Cooling Efficiency		Heating Efficiency	
Variable	Parameter Estimate	t-statistic	Parameter Estimate	t-statistic
Intercept	-0.089766	-1.56	-0.024414	-0.68
Participation indicator	0.311329	8.26	0.090874	4.07
Mills Ratio 1	-0.040178	-2.37	-0.011407	-1.14
Mills Ratio 2	-0.000571	-0.02	-0.005590	-0.30
Home size (sq. ft.)	0.000027	1.19	0.000012	0.85
Number of levels in home	0.095792	3.52	0.027883	1.67
Home not part of a subdivision	0.049693	1.27	0.010429	0.44
Number of residents in home	-0.005896	-0.60	-0.008271	-1.39
Energy efficiency ranked 1st or 2nd in construction factors	-0.090452	-2.50	-0.060194	-2.20
Builder only builds production homes	-0.035403	-1.37	-0.000027	0.00
Climate zone 11 indicator	-0.126062	-3.66	0.013101	0.60
Climate zone 12 indicator	-0.065411	-2.24	-0.053793	-2.90
Number of observations	166		150	
Adjusted R2	0.4611		0.1969	

Once the efficiency choice model was estimated, it was used to estimate what the participant comparison efficiency improvement should be for the net-to-gross calculations (assuming absence of the program) by simulating the *Efficiency* equation, Equation (6) and Table 6-10, over participants while setting the value of the *Participation* variable to zero. Setting the participation to zero impacts the Participation indicator and Mills Ratio 2 variables shown in Table 6-10.

The modified net-to-gross calculation is [see Equation (3) for the simple calculation]:

$$NTGR = \frac{(Participant\_Efficiency - Participant\_Base\_Efficiency)}{Participant\_Efficiency} \quad (10)$$

where the Participant_Base_Efficiency variable is the estimated value from Equation (6) after removing the effects of program participation.

The *NTGR*s are calculated and applied to gross savings estimates on a site-specific basis to determine net savings for each participant home. Results are then weighted up to population totals to provide estimates of net Program savings for the space conditioning end use. Program *NTGR*s for space conditioning are calculated by dividing net savings by gross savings.

Results of the efficiency choice modeling effort are summarized in Table 6-11.

Table 6-11
Net-to-Gross Ratios Based on the Efficiency Choice Model

	Participant Efficiency	Adjusted Participant Efficiency	Difference	NTGR
Cooling	0.26170	-0.03596	0.29766	1.137
Heating	0.06300	-0.02803	0.09103	1.445

Since the estimation of Equations (5) and (6) utilizes differences between participants and nonparticipants, in addition to the impacts of Program participation, to quantify changes in efficiency improvements, the efficiency choice approach is entirely consistent with the M&E Protocols.

6.5 NET-TO-GROSS INTEGRATION

Results of the three net savings approaches implemented above are summarized by end use in Table 6-12. A comparison of the methods reveals:

- Cooling and heating *NTGR*s from the efficiency choice model are higher than the *NTGR*s from the self report and simple comparison methods, which are similar. The efficiency choice model accounts for differences between the participants and nonparticipants, adjusts for self-selection bias, and is more likely to incorporate spillover effects than either of the other two methods.
- Clothes drying and cooking *NTGR*s from self reports are much higher than *NTGR*s from the simple comparison method.
- It is quite possible that differences between the participant and nonparticipant groups may result in a downward bias in the simple comparison results, relative to the self report and efficiency choice methods as discussed below.

Table 6-12
Summary of Different Net-to-Gross Ratios

	NTGR by Analysis Method		
	Self Report	Simple Comparison	Efficiency Choice Model
Cooling	0.750	0.749	1.137
Heating	0.782	0.800	1.445
Clothes Drying	0.464	0.096	-
Cooking	0.445	0.191	-

Table 6-13 presents a comparison of average house price, house size, and annual income for participants and nonparticipants. Nonparticipants tend to have higher income and live in larger, more expensive homes. These factors tend to offset some of the effects of the Program when viewed from the perspective of the simple comparison net-to-gross analysis:

- the more expensive homes can be associated with higher quality construction, leading to higher levels of energy efficiency for cooling and heating;

- additional home features such as gas cooking and the presence of gas dryer stubs are more likely to be seen in higher priced homes; and
- homeowners with higher incomes are probably more likely to purchase gas dryers as the first cost hurdle for gas is not as important.

Because of these factors, cooling and heating *NTGR*s from the efficiency choice model and clothes drying and cooking *NTGR*s from the self report method were deemed most appropriate to use in computing net savings for the program. The final *NTGR*s used in developing net Program savings are summarized in Table 6-14.

Table 6-13
Comparison of Participant and Nonparticipant Home and Occupant Attributes

	Participants	Nonparticipants	% Difference
Average House Price	$179,968	$206,842	15%
Conditioned Square Footage	1,949	2,110	8%
Average Annual Income of Occupants	$68,010	$72,863	7%

Table 6-14
Final Net-to-Gross Ratios used to Estimate Net Savings

	Final *NTGR*
Cooling	1.137
Heating	1.445
Clothes Drying	0.464
Cooking	0.445

6.6 SPILLOVER

Both the simple efficiency comparison and the efficiency choice modeling approaches discussed above account for participant spillover because total end savings (Program-related and otherwise) are included in the analysis. However, nonparticipant spillover (where the Program has induced builders to install efficiency measures in nonparticipant homes) is not captured, particularly in the simple comparison analysis. In fact, nonparticipant spillover counts against the Program by narrowing the efficiency difference between participants and nonparticipants.

As part of the builder survey, spillover issues were explored. Eighteen of the 38 builders who had built homes outside of the Comfort Home Program during the 1994-1996 period indicated that the Program influenced their decision to install energy efficiency measures outside of the Program. Half of these builders claimed the Program had a significant influence on their decisions, while the remainder indicated the Program had influenced their decision “somewhat.”

Using builder-supplied data, nonparticipant spillover was quantified use the following equation:

$$NPSpillover = \%Affected \times \%Homes \times \%Savings \times ProgEffect \quad (11)$$

where:

%Affected	=	Percent of builders who built homes outside of the Program and who said the Program influenced their decision to improve efficiency in nonprogram homes
%Homes	=	Percent of nonprogram homes in which they stated that measures were installed
%Savings	=	Percent savings for each measure
ProgEffect	=	1.0 if the Program significantly influence their decision and 0.5 otherwise

As part of the survey, builders provided two types of efficiency improvement information regarding nonprogram homes: (1) the percent of homes in which they installed specific measures, and (2) the average improvement above Title 24 that they built to.

Using this data, two separate approaches were used to quantify spillover effects. First, a bottom-up estimate was developed on a measure-specific basis, using builder-supplied data on percent of nonprogram homes in which measures were installed and a percent savings estimate for each measure. Savings percents used are as follows:

- Efficient air conditioning: 17% (increase from 10 SEER to 12 SEER);
- Duct improvement: 10% for air conditioning, 3% for heating (based on the realized gross participant savings estimates shown in Section 5);
- Increased ceiling insulation: 9% for air conditioning, 6% for heating (based on an increase from R-38 to R-49 levels and Micropas analysis); and
- Premium efficiency windows: 1% for air conditioning, 12% for heating (based on a decrease in U-values from 0.65 to 0.52 and Micropas analysis);

A second approach combined the *%Homes* and *%Savings* terms in Equation (11) into a single estimate: the average percent improvement in efficiency (above Title 24) that nonprogram homes were built to. This estimate was supplied by builders as part of the survey.

Results from Equation (11) were applied to the specific nonparticipant homes in the study to determine the average improvement in nonparticipant efficiency attributable to the Program. Results are presented in Table 6-15.

Table 6-15
Average Program-related Efficiency Improvement in Nonprogram Homes

Spillover quantification approach	Enduse	Program-related efficiency improvement
Measure specific	Cooling	0.0076
	Heating	0.0024
Improvement over Title 24	Cooling	0.0106
	Heating	0.0106

To integrate the spillover estimates into the net-to-gross analysis, the simple participant-nonparticipant comparison equation [Equation (3)] was modified as follows:

$$NTGR'_{Cooling,Heating} = \frac{Participant\_Efficiency - (Nonparticipant\_Efficiency - NPSpillover) + NPSpillover}{Participant\_Efficiency} \quad (12)$$

Now, instead of counting against the Program *NTGR*, nonparticipant spillover contributes to it. The overall effect is twice the estimate of spillover. Table 6-16 presents revised simple-comparison *NTGR*s, for the two sets of nonparticipant spillover estimates shown in Table 6-15. The limited use of spillover estimates causes the simple-comparison *NTGR*s to move towards the estimated developed in the efficiency choice model.

Table 6-16
Revised Simple-Comparison Net-to-Gross Ratios Incorporating Nonparticipant Spillover

	a	b	c	(a-b)/a	(a-b+2c)/a
	Participant Efficiency	Nonparticipant Efficiency	NP Spillover	Initial NTGR	Revised NTGR
Measure-specific Nonparticipant Spillover Calculation					
Cooling	0.26170	0.06580	0.0076	0.749	0.807
Heating	0.06300	0.01260	0.0024	0.800	0.876
Improvement over Title 24 Nonparticipant Spillover Calculation					
Cooling	0.26170	0.06580	0.0106	0.749	0.830
Heating	0.06300	0.01260	0.0106	0.800	1.137

6.7 NET PROGRAM IMPACTS

For space conditioning end uses, net impacts are calculated on a site-specific basis, then are expanded up to Program totals using the appropriate expansion weights. For the clothes drying and cooking end uses, the self-report *NTGR*s are applied to the Program-level gross impacts identified in Section 5 of this report. Net impact results are discussed next.

6.7.1 Space Conditioning Impacts

Net impacts for the space conditioning end uses are presented in Table 6-17. All impacts are calculated on a site-specific base, then weighted up to Program totals. Net cooling impacts are estimated to be 512 kWh per participating home and 2,026,661 kWh for the Program. Heating impacts are estimated to be 27.4 therms per home and 108,663 therms for the Program.

Table 6-17
Net Program HVAC Impacts

	Average	Total
Cooling Savings - kWh/year	512	2,026,661
Heating Savings - Therms/year	27.4	108,663

Table 6-18 compares evaluation net impacts with PG&E *ex ante* estimates. The evaluation results are lower that PG&E estimates. However, the net realization rates are higher than the comparable gross realization rates (see Table 5-4) because the evaluation *NTGR*s exceed 1.0, while the PG&E *NTGR*s are just below 1.0 (0.99 for cooling and 0.98 for heating).

Table 6-18
Comparison of Net HVAC Impacts to PG&E ex ante Estimates

	Evaluation	PG&E *ex ante*	Realization Rate
Cooling Savings - kWh/year	2,026,661	2,723,813	0.74
Heating Savings - Therms/year	108,663	155,371	0.70

6.7.2 Clothes Drying and Cooking

Cooking and clothes drying impacts are presented in Table 6-19. These impacts are derived by applying the appropriate *NTGR*s from Table 6-14 to gross impacts (see Table 5-5).

Table 6-19
Net Program Impacts for Gas Clothes Drying and Cooking Measures

	Per Home		Total	
	Therms	kWh	Therms	kWh
Clothes Drying	-7.4	192	-29,115	759,236
Cooking	-6.2	93	-24,593	367,488

Evaluation clothes drying and cooking impacts are compared to PG&E estimates in Table 6-20. Net realization rates for these end uses are lower than comparable gross realization rates because the evaluation *NTGR*s (0.46 for clothes drying and 0.45 for cooking) are lower than the PG&E estimates (0.74 for clothes drying and 0.62 for cooking). Overall, net evaluation savings exceed PG&E estimates for clothes drying but are lower for cooking.

Table 6-20
Comparison of Net Clothes Drying and Cooking Impacts to PG&E ex ante Estimates

	Evaluation		PG&E ex ante		Realization Rate	
	Therms	kWh	Therms	kWh	Therms	kWh
Clothes Drying	-29,115	759,236	-17,115	513,442	1.70	1.48
Cooking	-24,593	367,488	-36,158	762,959	0.68	0.48

6.7.3 Other End Uses

For end uses not evaluated - water heating and lighting, default *NTGR*s of 0.75 were used, based on the default NTGR assumption in the M&E Protocols for miscellaneous program activity. Program impacts are summarized in Table 6-21.

Table 6-21
Net Savings for Measures Not Evaluated

	Total kWh	Total kW	Therms
Lighting	16,308	0.825	-
Water heating	-	-	927

6.7.4 Net Impacts by Costing Period

Using the allocation factors developed from load shape data and discussed in Section 4, net impacts were calculated for the PG&E costing periods. Results are presented in Table 6-22.

Table 6-22
Net Impacts by PG&E Costing Period

	PG&E Costing Period				
	Summer Peak	Summer Partial Peak	Summer Off Peak	Winter Partial Peak	Winter Off Peak
kWh Impacts					
Cooling	634,017	482,867	892,130	9,646	8,001
Clothes Drying	71,191	101,720	161,716	219,238	205,372
Cooking	43,629	52,302	69,846	113,271	88,440
Lighting	3,856	3,336	5,737	1,797	1,580
Total	752,693	640,225	1,129,429	343,952	303,393
kW Impacts					
Cooling	2,597.2	3,745.4	1,809.2	0.0	0.0
Clothes Drying	81.3	99.7	100.3	154.4	15.2
Cooking	38.6	143.5	24.0	164.0	16.1
Lighting	0.8	1.2	0.5	0.2	0.0
Total	2,717.9	3,989.8	1,934.0	318.6	31.3
Therm Impacts					
Heating	1,371			107,292	
Clothes Drying	-12,832			-16,283	
Cooking	-11,094			-13,499	
Water Heating	463			464	
Total	-22,092			77,974	

6.7.5 Net Impact Confidence Intervals

Net impact confidence intervals are provided in Table 6-23. Space cooling and heating confidence intervals are derived from the statistical output of the efficiency choice model. Confidence intervals for clothes drying and cooking are based on the estimated variance for gross impacts combined with the estimated variance for the estimated *NTGR*s. Program-level confidence intervals are calculated as the sum of the end use intervals.

Table 6-23
Net Impact Confidence Intervals

	Point Estimate	90% Confidence Interval			80% Confidence Interval		
		Percent	Lower bound	Upper bound	Percent	Lower bound	Upper bound
kWh Impacts							
Cooling	2,026,661	±24%	1,536,388	2,516,934	±19%	1,645,172	2,408,150
Clothes Drying	759,237	±66%	259,659	1,258,815	±51%	370,508	1,147,966
Cooking	367,488	±110%	-35,524	770,500	±85%	53,898	681,078
Lighting	16,308	±0%	16,308	16,308	±0%	16,308	16,308
Total	3,169,694	±44%	1,776,831	4,562,557	±34%	2,085,886	4,253,502
Peak kW Impacts							
Cooling	2,597.2	±24%	1,968.9	3,225.5	±19%	2,108.3	3,086.1
Clothes Drying	81.3	±66%	27.8	134.8	±51%	39.7	122.9
Cooking	38.6	±110%	-3.7	80.9	±85%	5.7	71.5
Lighting	0.8	±0%	0.8	0.8	±0%	0.8	0.8
Total	2,717.9	±27%	1,993.8	3,442.0	±21%	2,154.5	3,281.3
Therm Impacts							
Heating	108,663	±53%	51,002	166,324	±41%	63,796	153,530
Clothes Drying	-29,115	±66%	-9,957	-48,273	±51%	-14,208	-44,022
Cooking	-24,593	±110%	2,377	-51,563	±85%	-3,607	-45,579
Water Heating	927	±0%	927	927	±0%	927	927
Total	55,882	±21%	44,349	67,415	±16%	46,908	64,856

A SURVEY INSTRUMENTS

This appendix contains the survey instruments used for project data collection:

1. the onsite home survey; and
2. the telephone builder survey.

Onsite Home Survey

PG&E Residential New Construction Evaluation - On-site Survey

Confidential: All data collected on this form is confidential and may only be used for PG&E studies.

Home ID# CNTL

Surveyor	AUDNAME	Date	APPTDATE
Customer Name	CUSNAME		
Address	SERADDR		
City	SERCITY	Zip Code	SERZIP
Phone Number 1	PHONE1 (W) (H)		
Phone Number 2	PHONE2 (W) (H)		

Notes:

NOTES

Dwelling Characteristics

Dwelling Type

DWLTYPE

Age of Home

HSAGE

Number of Levels

NUMLVL

Estimated Conditioned Area, SF

SFCON

Estimated Unconditioned Area, SF

SFUNCON

Number of Bedrooms

BEDROOM

Total Number of Rooms (excluding hallways, bathrooms, basements, closets, and any rooms not used as living space)

NUMROOM

Weather-stripping around doors? (Y/N)

WTRSTDR

Dwelling Type Codes	
1. Single-Family Stand Alone	4. Mobile Home
2. Single-Family Attached	5. Other_________________________
3. Multi-Family	DWL5DESC

Walls

Wall Reference Number	WL1	B1	WL2	B2	WL3	B3	WL4	B4
WLREF Wall Construction Code		☐		☐		☐		☐
WLCNSTR1 Wall Siding Type Code		☐		☐		☐		☐
WLSDTYP1 Percent Wall Below Grade		☐☐☐		☐☐☐		☐☐☐		☐☐☐
WLPCBGD1 Wall Thickness, inches		☐☐		☐☐		☐☐		☐☐
WLTHCK1 Wall Insulation R-value		☐☐		☐☐		☐☐		☐☐
WLINSR1 Wall Percent Insulated		☐☐☐		☐☐☐		☐☐☐		☐☐☐
WLPCINS1 **WALL COLOR CODE**		☐		☐		☐		☐

(1-DARK, 2-MEDIUM, 3-LIGHT)

WLCOLOR1

Wall Construction Type Codes	*Wall Siding Type Codes*
1. No Exterior	1. Wood Siding
2. 2”X4” Wood Frame	2. Masonary Siding
3. 2”X4” Wood Frame w/ insul. sheet	3. Stucco\ Plaster
4. 2”X6” Wood Frame	4. Combination Wood / Masonary
5. 2”X4” Metal Frame	5. Metal Siding
6. 2”X6” Metal Frame	6. Vinyl
7. Concrete block	7. Other
8. Brick wall	
9. Other ___________________________	WLCNTS9D

Windows

	G1	G2	G3	G4
Window System Type WDREF1				
Window Type Code WDTYP1				
Number of Panes WDPAN1				
FRAME TYPE CODE WDFRM1				
Glazing Type Code WDGLZ11 WDGLZ12	___ , ___	___ , ___	___ , ___	___ , ___
Window NFRC ID # [2]				
OVERHANG TYPE [3] WDOVR1				
Interior Shading Code WDINSHD1				
EXTERIOR SHADING CODE WDEXSHD1				

Describe Ext. Shading (sunscreens, adjacent buildings, trees, etc.) ______________________________
WDSHDD1

____

____

Notes: 1. It is possible to enter a combination of glazing types.
Sample: [2,3] means tinted glass with low-e coating.
2. Located on the glazing (if available).
3. Code indicated on the overhang sketch.
4. Describe Ext. Shading, including dimensions and distance from the window.

Window Type Codes	*Glazing Type Codes*	*Frame Type Codes*	*Interior Shading Codes*	*Exterior Shading Codes*
1. Fixed	1.Clear Glass	1. Wood	0. None	0. None
2. Double Hung	2.Tinted Glass	2. Metal	1. Drapes	1.Building Structure
3. Casement	3.Reflective Glass/Film	3. Vinyl	2. Blinds	2.Tree(s) / Foliage
4. Sliding Pane	4.Low-E		3. Shutters	3. Fence
5. Skylight	5.Opaque		4. Roller shade	4. Other
6.Other (describe)	6.Gas-Filled		5. Other	

Windows

Window System Type G 5 | G 6 | G 7 | G 8

WDREF5
Window Type Code

WDTYP5
Number of Panes

WDPAN5
FRAME TYPE CODE

WDFRM5
Glazing Type Code ☐ , ☐

WDGLZ51 WDGLZ52
Window NFRC ID # [2]

OVERHANG TYPE [3]

WDOVR5
Interior Shading Code

WDINSHD5
EXTERIOR SHADING CODE

WDEXSHD5
Describe Ext. Shading (sunscreens, adjacent buildings, trees, etc.) ____________________

WDSHDD2

____

____

Notes: 1. It is possible to enter a combination of glazing types.
Sample: [2,3] means tinted glass with low-e coating.
2. Located on the glazing (if available).
3. Code indicated on the overhang sketch.
4. Describe Ext. Shading, including dimensions and distance from the window.

Window Type Codes	*Glazing Type Codes*	*Frame Type Codes*	*Interior Shading Codes*	*Exterior Shading Codes*
1. Fixed	1.Clear Glass	1. Wood	0. None	0. None
2. Double Hung	2.Tinted Glass	2. Metal	1. Drapes	1.Building Structure
3. Casement	3.Reflective Glass/Film	3. Vinyl	2. Blinds	2.Tree(s) / Foliage
4. Sliding Pane	4.Low-E		3. Shutters	3. Fence
5. Skylight	5.Opaque		4. Roller shade	4. Other
6.Other (describe)	6.Gas-Filled		5. Other	

Ceilings [1]

	C1	C2	C3
Ceiling Reference Code CEREF1			
Estimated Ceiling Area, SF CESQFT1			
Description CEDESC1			
Insulation			
Insulation Type Code CEINSTY1			
Insulation R-value CEINSRV1			
Insulation Thickness, inches CEINSTK1			
Percent Insulated, % CEINSPC1			
Describe Insulation Condition CEINSCN1			
Roof Exterior Color CERFCLR1			
Skylights (Y/N) CESKYLG1			
Window System Type CEWWDSYS1			

Notes: 1. Draw the ceiling outlines on the floor plan (pages8, 9) and identify with a proper code (e.g. C1, C2..).

Roof

RFSLOPE

Roof Slope

1. Almost Flat
2. Average Incline
3. Very Steep

Roof Insulation Type Codes
1. Mineral Wool/Fiber (batt)
2. Expanded Polystyrene
3. Expanded Polyurethane
4. Preformed Insulation
5. Other ____________________________
CEINOTR1

Floors

Floor Reference Code	F1	F2	F3
FLREF1			
Estimated Floor Area, SF	☐☐☐☐	☐☐☐☐	☐☐☐☐
FLSOFT1			
Floor Type Code	☐	☐	☐
FLTYP1			
Insulation R-Value	☐☐	☐☐	☐☐
FLINSRV1			
Raised Floor Only			
Crawl Space Height (ft.)	☐☐	☐☐	☐☐
FLRSHT1			
Crawl Space Wall	☐	☐	☐
FLRSTYP1			
Is Crawl Space Vented (Y/N)	☐	☐	☐
FLRSVNT1			
Crawl Space Wall Insulation	☐☐	☐☐	☐☐
FLRSWIN1			
Percent of the Floor Tiled or Vinyl	☐☐☐	☐☐☐	☐☐☐
FLTILPC1			
Percent of the Floor Carpeted	☐☐☐	☐☐☐	☐☐☐
FLCPTPC1			

Basement

BSMTCDTN

Is Basement Conditioned (Y/N) ☐

Notes: 1. Draw the floor outlines on the floor plan (pages 8, 9) and identify with a proper code (e.g. F1, F2..).

Crawl Space Wall Construction Type Codes	*Floor Type Code*
1. Framed	1. Raised floor
2. Concrete	2. Slab-on-grade
3. Other______________	3. Floor over Basement
FLRST51	4. Floor over Other Uncond. Spaces

Floor Plan Sketch

Notes: 1) Sketch the plan of each floor separately. 2) Include a Wall Reference Number for each wall. Example: [# B1]. (The Reference Number will be one and the same for the walls with one and the same construction characteristics). 2) Include the outer length of each wall. 3) Indicate North direction. 4) Draw the ceiling outlines with a red pencil and identify with a proper code. Example: [# C1]. 5) Draw the floor outlines with a green pencil and identify with a proper code. Example: [# F1].

First Floor

Second Floor

Floor Plan Sketch (cont.)

Notes: 1) Sketch the plan of each floor separately. 2) Include a Wall Reference Number for each wall. Example: [# B1]. (The Reference Number will be one and the same for the walls with one and the same construction characteristics). 2) Include the outer length of each wall. 3) Indicate North direction. 4) Draw the ceiling outlines with a red pencil and identify with a proper code. Example: [# C1]. 5) Draw the floor outlines with a green pencil and identify with a proper code. Example: [# F1].

Basement

Elevations Plan Sketch

Notes: 1) Sketch each elevation separately. 2) Mark Wall Reference Numbers as the walls appear on the elevation. Example: # B1. (The Reference Number will be one and the same for the walls with one and the same construction characteristics). 2) Include the wall height. 3) For each elevation show the windows location and mark the Window System Type (from p.12 Window System Sketch) and number of windows. Example: [(3) G1] means "three windows type G1".

Front

Back

Elevations Plan Sketch, (cont.)

Notes: 1) Sketch each elevation separately. 2) Mark Wall Reference Numbers as the walls appear on the elevation. Example: # B1. (The Reference Number will be one and the same for the walls with one and the same construction characteristics). 2) Include the wall height. 3) For each elevation show the windows location and mark the Window System Type (from p.12 Window System Sketch) and number of windows. Example: [(3) G1] means "three windows type G1".

Right

Left

Window System Sketch

Notes: 1) Sketch each different window system separately. 2) Show the dimensions including the frame.

Window System Type **G1**

Window System Type **G2**

Window System Type **G3**

Window System Type **G4**

Window System Sketch, (cont.)

Notes: 1) Sketch each different window system separately. 2) Show the dimensions including the frame.

Window System Type **G5**

Window System Type **G6**

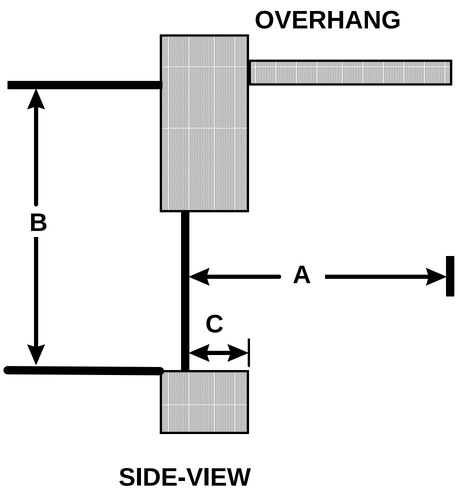
Window System Type **G7**

Window System Type **G8**

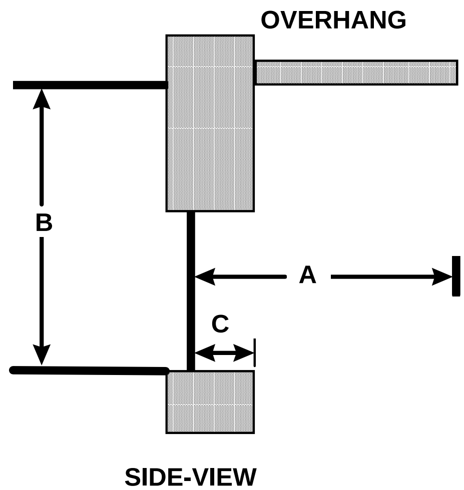
Overhang Sketch

Notes: 1) Show the dimensions A, B and C on sketches.

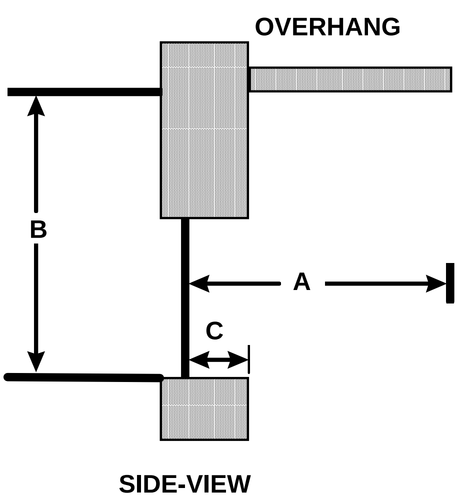
Overhang Type **S1**



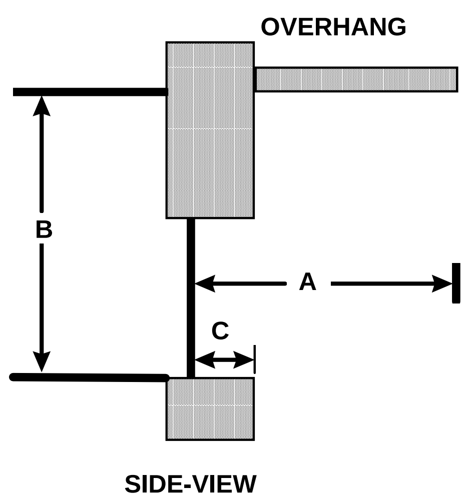
Overhang Type **S2**



Overhang Type **S3**



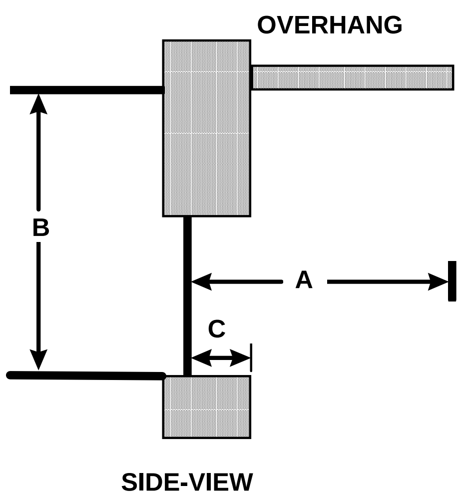
Overhang Type **S4**



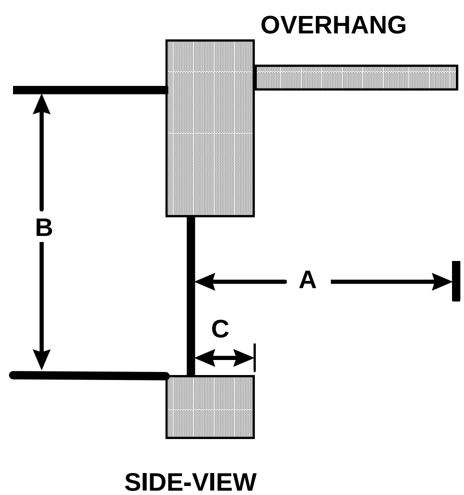
Overhang Sketch (cont.)

Notes: 1) Show the dimensions A, B and C on sketches.

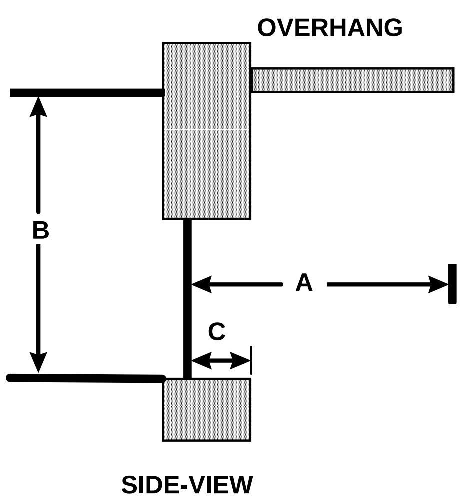
Overhang Type **S5**



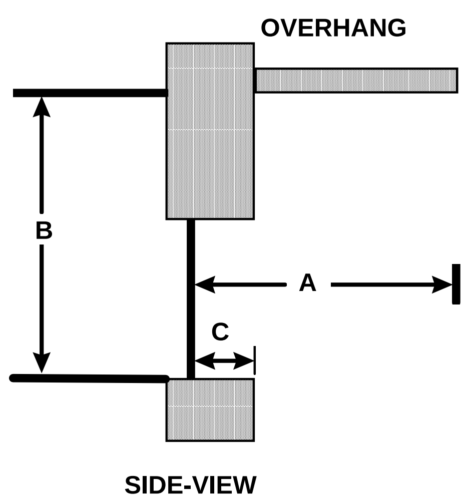
Overhang Type **S6**



Overhang Type **S7**



Overhang Type **S8**



Heating Systems

	System #1	System #2
System Type Code [1] HTSYS1		
Fuel Code HTFUEL1		
Quantity HTQTY1		
Use Code HTUSE1		
Age HTAGE1		
Programmable Thermostat (Y / N) HTPGTHM1		
Equipment Location Code HTLOCN1		
Manufacturer HTMANU1		
Model # HTMODL1		
Serial # HTSERL1		
Output (Btu) HTOBTU1		
Input (Btu) HTIBTU1		
Input (kW) HTIKW1		
Volts/ Phase/ Rated Amps (RLA) HTRLA1		
Auxiliary Heat, kW HTAUX1		
AFUE or HSPF or COP (circle one) HTTYP1		
Area serving (1st floor, 2nd floor, etc.) HTAREA		

Notes: 1) If System Type Code is 8, explain the usage pattern. Example: Gas furnace rarely used, fireplace - 4hr/day, portable electric heaters - 2 hr/day. HTNOTES

System Type Codes			
1.	DX Heat Pump	5.	Central Forced Air Packaged Unit --Gas Pack
2.	Central Forced Air Furnace	6.	Portable Heaters
3.	Electric Resistance Baseboard	7.	Fireplace/Wood Burning Stove
4.	Radiant Heater	8.	Combination/Addition of a secondary system

E = Electric	P = LPG	1. Often

1. Conditioned Space	3. Unconditioned Basement	5. Outside

Cooling Systems

	System #1	System #2
System Type Code CLSYS1		
Quantity CLQTY1		
Use Code CLUSE1		
Age CLAGE1		
Programmable Thermostat (Y / N) CLPGTHM1		
Outdoor Unit:		
Manufacturer CLOMANU		
Model # CLOMODL1		
Serial # CLOSERL1		
Indoor Fan Coil (if accessible):		
Manufacturer CLIMANU1		
Model # CLIMODL1		
Output (Btuh) CLOBTU1		
Input (kW) CLIKW1		
VOLTS/ PHASE/ RATED AMPS (R CLRLA1		
SEER or CLSEER1		
EER or CLEER1		
COP CLCOP1		

CLNOTES

System Type Codes
1. Central Forced Air System --AC only
2. Central Forced Air Packaged Unit --Gas Pack
3. Heat Pump
4. Window or Wall AC unit
5. Central Evaporative Cooler
6. Other

Fuel Codes		***Usage Codes***
E = Electric	P = LPG	1. Often
G = Natural Gas	O = Oil	2. Supplemental
W = Wood	S = Steam	3. Rarely Used
C = Coal	M = Other	4. Never Used

Ducts

DUCT TYPE
(0-none, 1-flexed, 2-sheet metal, 3-other)
DCTTYP

Duct Insulation R-value
DCTINSRV

Describe Duct Insulation Condition
(1- good, 2-fair, 3-poor)
DCTINSCN

Return air
(1- bend only, 2-ducted return, 3-none)
DCTRTAIR

Duct Location
Code and % of total duct surface area ,
DCTLOC1 DCTPCT1
Code and % of total duct surface area ,
DCTLOC2 DCTPCT2
Code and % of total duct surface area ,
DCTLOC3 DCTPCT3

Return duct located in conditioned space, %
DCTRTCP

Describe Duct Header (connection to AC unit)
DCTHDDS

Duct Location Codes	
1.	Conditioned space
2.	Vented attic space
3.	Vented crawl space
4.	Open space (or garage)
5.	Controlled ventilation crawl space
6.	Slab-on-grade

Thermostat Settings

Primary **cooling** system thermostat settings (F°) during July and August.

Time periods		Weekdays #1 Unit		Weekend #1 Unit		Weekday #2 Unit		Weekend #2 Unit
6 am to 10 am (morning)	CLTMWKM1		CLTMWEM1		CLTMWKM2		CLTMWEM2	
10 am to 6 pm (day time)	CLTMWKD1		CLTMWED1		CLTMWKD2		CLTMWKE1	
6 pm to 10 pm (evening)	CLTMWKE1		CLTMWEE1		CLTMWKE2		CLTMWEE2	
10 pm to 6 am (night time)	CLTMWKN1		CLTMWEN1		CLTMWKN2		CLTMWEN2	

Off = 99°

Primary **heating** system thermostat settings (F°) during December and January.

Time periods		Weekdays #1 Unit		Weekend #1 Unit		Weekday #2 Unit		Weekend #2 Unit
6 am to 10 am (morning)	HTTMWKM1		HTTMWEM1		HTTMWKM2		HTTMWEM2	
10 am to 6 pm (day time)	HTTMWKD1		HTTMWED1		HTTMWKD2		HTTMWKE1	
6 pm to 10 pm (evening)	HTTMWKE1		HTTMWEE1		HTTMWKE2		HTTMWEE2	
10 pm to 6 am (night time)	HTTMWKN1		HTTMWEN1		HTTMWKN2		HTTMWEN2	

Off = 50°

Refrigerators

		Type		Con Spc (Y/N)		Size Cu. Ft.		Watts		Age		Mnth/ Year Used
Unit 1	RFTYP1		RFCNSP1		RFSIZE1		RFWATT1		RFAGE1		RFUSE1	
Unit 2	RFTYP2											
Unit 3	RFTYP3											

Type codes:
1. Auto Defrost Side by Side
2. Auto Defrost Top / Bottom
3. Auto Defrost Single Door
4. Manaul Defrost Single Door

Freezers

		Type		Con Spc (Y/N)		Size Cu. Ft.		Watts		Age		Mnth/ Year Used
Unit 1	FZTYP1		FZCNSP1		FZSIZE1		FZWATT1		FZAGE1		FZUSE1	
Unit 2	FZTYP2											
Unit 3	FZTYP3											

Cooking

	Fuel (Elec/Gas/Prop)	Meals[1] /Week	Size (kW or kBtuh)
Oven Fuel (E/G/P)	KOVFUEL	KOVMEAL	KOVSIZE
Range Fuel (E/G/P)	KRGFUEL	KRGMEAL	KRGSIZE
Microwave Oven		KM_MEAL	KM_SIZE

Note: Enter the total number of meals. The maximum is 3 meals/day or 21 meals/week.

Television

Number of televisions	TVNUM	
Number of TV set hours per day (# TV * # Hours)	TVHRS	

Dishwasher

Use Electric Dishwasher (Y/N)	DSHELEC	
Uses energy saving cycle (Y/N)	DSHENRG	
Total loads per week	DSHTTLLD	
Number of loads weekdays between 10am - 6pm	DSHLDWKD	

Indoor Lighting

		Ind
Total Number of Bulbs (including Fluorescent bulbs)	IBLBNUM	
Number of Compact Fluorescent Bulbs (CFL)		
CFL hardwired	ICFLHARD	
CFL screw-in	ICFLSCRW	
Number of Fluorescent Tubes	IFLRNUM	

Outdoor Lighting

		Number		Operation, hr/day-bulb
Incandescent Bulbs	EINCNUM		EINCUSE	
Compact Fluorescent Bulbs (CFL)	ECFLNUM		ECFLUSE	
Security Lamps (Metal Halide/Mercury Vapor)	ESMHNUM		ESMHUSE	

Number CFLs that were installed when you move in ?

CFL hardwired	PCFLHARD	
CFL screw-in	PCFLSCRW	

Hot Water Heating

Make/Model	WHMODL		
Fuel Code	WHFUEL	Is Water Heater Located in conditioned	WHCONSP
Tank Capacity	WHCAP	Input Rating (kW or kBtuh)	WHINP
Temperature Setting	WHTEMP	Insulation Blanket (Y/N)	WHBLKT
Is there a Timeclock (Y/N)	WHTIME	Are the visible portion of the pipes wrapped w\ insulation (Y/N)	WHPIPE

Laundry

Use Clothes Washer (Y/N)	CW
Number of hot / warm water loads	CWHTWM
Use Clothes Dryer (Y/N)	CD
Clothes Dryer Fuel Code	CDFUEL
Is Dryer/Washer located in Cond.	CDCONSP
Number of dryer loads per week	CDLOAD
Gas Plug in Laundry Area (Y/N)	CDGAS

Fuel Codes	
E =	Electric
G =	Natural Gas
P =	LPG
S =	Solar
M =	Other

Pool

Swimming Pool (Y/N)	PL	☐		
Filter Pump				
Filter on timer (Y/N)	PLFPTIME	☐		
Filter hours per day (summer)	PLFPSHR	☐☐		
Filter hours per day (winter)	PLFPWHR	☐☐		
Filter pump size (kW) or (HP)	PLFPSZKW	☐☐ kW	☐☐ HP	PLFPSZHP
Pool Heater				
Heater Fuel Type Code[1]	PLHTFL1	☐ , ☐		PLHTFL2
Heater Capacity (kW) or (HP)	PLHTCPKW	☐☐ kW	☐☐ HP	PLHTCPHP
Heater Use (1-never, 2-seldom, 3-a lot, 4-always)	PLHTUSE	☐		

Note: [1]Indicate combination of fuel types. Sample: (G,S) means Gas and Solar. Describe the percent use allocated to each fuel type.

Spa

Spa or hot tub? (Y/N)	SP	☐		
Spa location (1-outdoor, 2-	SPLOCN	☐		
Spa uses per week	SPUSE	☐☐		
Filter				
Filter on timer? (Y/N)	SPFPTIME	☐		
Filter hours per day (summer)	SPFPSHR	☐☐		
Filter hours per day (winter)	SPFPWHR	☐☐		
Filter pump size (kW) or (HP)	SPSZKW	☐☐ kW	☐☐ HP	SPSZHP
Heater				
Spa Heater Fuel Type Code	SPHTFL1	☐	:	
If electric, ON continuously?	SPELON	☐		
If gas, hours ON before each	SPGSON	☐☐		
Heater ON, hours per week	SPHTSUSE	☐☐		
Heater ON, hours per week	SPHTWUSE	☐☐		

Fuel Codes			
E =	Electric	P =	LPG
G =	Natural Gas	O =	Oil
W =	Wood	S =	Steam
C =	Coal	M =	Other

A.1 RESIDENT QUESTIONNAIRE

1. Which of the following equipment or services are used in this home?

		Yes	No	(If Yes) **How Many**		**Equipment Use, hr/week**	
Home Office Equipment							
Personal computer	PC	☐	☐	PCNUM	____	PCUSE	____
Computer printer	PRN	☐	☐	PRNNUM	____	PRNUSE	____
Fax machine	FAX	☐	☐	FAXNUM	____	FAXUSE	____
Copier (other than fax)	CPR	☐	☐	CPRNUM	____	CPRUSE	____
Miscellaneous							
Heated H_2O Bed	H2O	☐	☐	H2ONUM	____	H2OUSE	____
Small Kitchen Appliances	SKT	☐	☐	SKTNUM	____	SKTUSE	____
Gas Fireplace	GFP	☐	☐	GFPNUM	____	GFPUSE	____
Kiln	KLN	☐	☐	KLNNUM	____	KLNUSE	____
Welding Equipment	WLD	☐	☐	WLDNUM	____	WLDUSE	____
Medical Equipment	MED	☐	☐	MEDNUM	____	MEDUSE	____
Well Pump	WLP	☐	☐	WLPNUM	____	WLPUSE	____
Other (list) ____________	OTR1	☐	☐	OTR1NUM	____	OTR1USE	____
Other (list)____________	OTR2	☐	☐	OTR2NUM	____	OTR2USE	____

2. Fan Uses in Summer?

		Don't Have	Rarely	Sometimes	Often
Portable Fans	PORTFAN	☐	☐	☐	☐
Ceiling Fans	CEILFAN	☐	☐	☐	☐
Attic Fan	ATTCFAN	☐	☐	☐	☐
Whole House Fan	WHHSFAN	☐	☐	☐	☐

3. How many people, including yourself, live in this home? OCCUP ☐☐

4. How many people living in your home are:

			Number
Preschool	(under 6)	PRESCHL	
School Age	(6-17)	SCHOOL	
Adult -	18-34	ADLT18	
	35-59	ADLT35	
	60-74	ADLT60	
	Over 74	ADLT74	

5. How many people occupy the home from 10 a.m. to 6 p.m. on typical weekdays?

		Number
Winter (Dec - Feb)	OCCWN	
Spring (Mar-May)	OCCSP	
Summer (Jun-Aug)	OCCSM	
Fall (Sep-Nov)	OCCFL	

6. Is your home used as a primary work location?
HOMEOFFC
1. Yes ☐
2. No ☐

7. Does someone occupy the home at least 10 months per year?
YRRESID
1. Yes ☐
2. No ☐

8. Did you vacation away from home at least one week this summer?
VACATION
1. Yes ☐
2. No ☐

9. Is the home part of a subdivision?
SUBDVSN
1. Yes ☐
2. No ☐

10. Name of the builder/developer who constructed the home:
BUILDER
____

11. Do you own or rent?
OWNRENT

1. Own ☐
2. Rent ☐

If you RENT then skip to Question 27

12. Approximate purchase price of home:

PRCPRICE

Under $100,000	1	☐
$100,000-$149,999	2	☐
$150,000-$199,999	3	☐
$200,000-$249,999	4	☐
$250,000-$299,999	5	☐
$300,000-$349,999	6	☐
$350,000-$399,999	7	☐
$400,000 or more	8	☐

13. Please rank the following factors important in the decision to buy your home, with 1 for the most important to 7 for the least important:

Price	PRCFCTR1	☐
Location	PRCFCTR2	☐
House Size	PRCFCTR3	☐
Appearance	PRCFCTR4	☐
Home Layout	PRCFCTR5	☐
Energy Efficiency	PRCFCTR6	☐
Schools	PRCFCTR7	☐

14. Was energy efficiency an important consideration in your home purchase decision?
NRGEFF

1. Yes ☐
2. No ☐

15. Is your home a PG&E Comfort Home?
CMFTHOME

1. Yes ☐
2. No ☐
3. Don't Know ☐

If Question **15** is answered **YES**, then answer Questions **16** and **17**:

16. What features of your home are energy efficient? EEFTR

____

____

17. Were you specifically looking to purchase a PG&E Comfort Home?
CHWANT

1. Yes ☐
2. No ☐

If Question **15** is answered **NO**, then answer Question **18**:

18. Are you aware of PG&E's California Comfort Home program that promotes energy efficient new homes?
CHAWARE

1. Yes ☐
2. No ☐

If Question **15** or Question **18** is answered **YES** (i.e., you are aware of PG&E Comfort Homes) then answer Question **19**:

19. How did you first learn about the PG&E Comfort Home?

PG&E	CHLEARN1	☐
Builder	CHLEARN2	☐
Realtor	CHLEARN3	☐
Advertisements	CHLEARN4	☐
Word-of-mouth5	CHLEARN5	☐
Other (list) ____________________	CHLEARN6	☐
CHLEARND		☐

20. Would you be willing to pay more for a new home with cost effective energy efficient features? (Cost effective energy efficient features usually produce savings on your energy bill that over time will pay for the higher costs of the home.)

PAYMORE

1. Yes ☐
2. No ☐

21. IF YES: How much more would you be willing to pay for a new home with cost effective energy efficient features?

PAYMORE1

- $0 .... 1 ☐
- $0-500 .... 2 ☐
- $501-1000 .... 3 ☐
- $1001-2000 .... 4 ☐
- $2001-3000 .... 5 ☐
- $3001-5000 .... 6 ☐
- $5001-10,000 .... 7 ☐
- Other (list) ______________ . 8 ☐

PAYMORED

22. Did you use any special energy efficient related loan packages to help with the financing of your new home?

1. Yes ☐
2. No ☐

EELOAN

23. IF YES: What type of package did you use? ______________________________

EELNDESC

24. IF NO: Were you aware that energy efficient loan packages were available?

EELNAVLB

1. Yes ☐
2. No ☐

25. During your efforts to purchase a new home, were you aware that some homes are built more energy efficient than others?

1. Yes ☐
2. No ☐

EEMORE

26. IF YES: From what source did you learn about the different levels of energy efficiency in new homes?

- Realtor — EEMRLRN1 ☐
- PG&E — EEMRLRN2 ☐
- New Home Advertising (Newspaper, Site Brochure) — EEMRLRN3 ☐
- Financial Institution — EEMRLRN4 ☐
- Other (list) ____________ — EEMRLRN5 ☐

EEMRLRND

27. Have you used PG&E rebate coupons in the purchase of any of the following:

27A. Natural gas clothes dryer .... 1. Yes ☐
REBCD 2. No ☐

27B. Energy efficient clothes washer.............. 1. Yes ☐
REBCW 2. No ☐

27C. Energy efficient refrigerator .... 1. Yes ☐
REBRF 2. No ☐

28. What is the highest education level for the head of the household:

EDUC

- Some high school .... 1 ☐
- High school graduate.. 2 ☐
- Some college/Junior college graduate .... 3 ☐
- College graduate .... 4 ☐
- Graduate degree .... 5 ☐

29. Approximate household income category:

INCOME

- Under $25,000 .... 1 ☐
- $25,000-$49,999 .... 2 ☐
- $50,000-$74,999 .... 3 ☐
- $75,000-$99,999 .... 4 ☐
- $100,000-$149,999 .... 5 ☐
- $150,000 or more .... 6 ☐

30. Have you heard of the Energy Star New Homes Program that is being provided through the U. S. Environmental Protection Agency?

ESTAR

1. Yes ☐
2. No ☐

31. IF YES: From what source did you learn about the different levels of energy efficiency in new homes?

Realtor	ESLRN1	☐
New Home Advertising (Newspaper, Site Brochure)	ESLRN2	☐
Financial Institution	ESLRN3	☐
Other (list) ______________________________	ESLRN4	☐

32. IF YES: Please describe what you know about this program:

ESDESC

____

____

____

____

END OF INTERVIEW, THANK YOU FOR PARTICIPATING

DUCT PRESSURE TESTING

Date	
Work Crew Names	
Address	

Fan Connection Location	ΔP_{duct}	Ring Number	Duct Leakage Flow, cfm
DPFANLCN	DPDELTAP	DPRING	DPLEAK

Air Handler Location (closet, attic, crawlspace, garage, etc.)	DPAHLOCN
Number of Supply Registers	DPSOPREG
Number of Return Registers	DPRETREG

Notes:

Telephone Builder Survey

Hello, my name is ____. I am calling on behalf of Pacific Gas & Electric as part of a research project. I have nothing to sell and will not ask for money. May speak with (INSERT NAME IF AVAILABLE)?

Hello, my name is ____. I am calling on behalf of Pacific Gas & Electric as part of a research project involving energy efficiency in newly constructed homes, including homes that were built under the PG&E Comfort Home Program. I have nothing to sell and will not ask for money. We would like to ask you a few questions about your company's knowledge and participation in the program and your company's use of building practices promoted by the program.

		Y	N
0. Am I speaking to the person who would make major construction decisions, including the decision to participate in PG&E's program?	0		

(If "NO") May I speak to that person? *If contact is not available, get name and phone number for callback.*

(If "YES) Record name and number and continue with survey.

0a. Name:____

0b. Position:____

0c. Phone Number:____

This survey will take approximately 10-15 minutes.

A.2 HOME CONFIRMATION:

Our records indicate that you built homes at the following addresses under the Comfort Home Program during the past few years. Can you confirm this?

ID #	Project Name - **PARTICIPANT HOMES**	Yes	No	DK

Our records (also) indicate that you built homes at the following addresses during the past few years, and that these homes were <u>not</u> part of the Comfort Home Program. Can you confirm this?

ID #	Project Name - **NON-PARTICIPANT HOMES**	Yes	No	DK

A.3 BUILDER FIRMOGRAPHICS

1. How many residential development projects did you build between 1994 and 1996? 1. ☐

2. In those developments, how many homes did you build (total, over 3 years)? 2. ☐

3. Of those homes, how may were single family and how many were multi family? (**NUMBER OR PERCENT**) - ***(Indicate percent with a "%".)***

   Single Family .... 3a. ☐

   Multi Family.. 3b. ☐

4. Of those homes, how many were custom homes and how many were production homes? (**NUMBER OR PERCENT**) - ***(Indicate percent with a "%".)***

   Custom (one-of-a- kind) 4a. ☐

   Production (multiple, with std., designs) 4b. ☐

5. What is the average price of the homes that you sell? 5. ☐

6. What type of home buyers are your homes generally targeted towards?

   First time buyers/entry level homes .... 6a. ☐

   "Move-up" buyers/mid level homes.. 6b. ☐

   Luxury home buyers/high end homes .... 6c. ☐

   Other; specify ____ 6d. ☐

A.4 COMFORT HOME PROGRAM

FOR BUILDERS WITH PARTICIPANT HOMES: ask 7a-7c and then skip to 8:

7a. Of the dwelling units that you built between 1994 and 1996, what percentage made use of the Comfort Home Program? 7a. ☐

7b. Did you make use of the Comfort Home program prior to 1994? 7b. Y ☐ N ☐

7c. Did you make use of the Comfort Home program this year, 1997? 7c. Y ☐ N ☐

SKIP TO Question 8

FOR BUILDERS WITH ONLY NON-PARTICIPANT HOMES LISTED: ask 7d-7g:

7d. Prior to this phone call, did you know about the Comfort Home Program? 7d. Y N DK

If 7d = yes, CONTINUE, OTHERWISE SKIP TO Q9

7e. Have you ever participated in the Comfort Home Program 7e. Y N DK

If 7e = yes, CONTINUE, OTHERWISE SKIP TO Q8

7f. Did you participate in the Program between 1994 and 1996? 7f. Y N DK

If 7f = yes, CONTINUE, OTHERWISE SKIP TO Q8

7g. What percentage of the dwelling units that you built between 1994 and 1996, made use of the Comfort Home Program? 7g.

FOR ALL BUILDERS WITH PARTICIPANT HOMES AND FOR ALL BUILDERS AWARE OF THE COMFORT HOME PROGRAM (question 7d = yes):

8. How did you first hear about the Comfort Home Program?

Approached by PG&E directly	8a.
Saw PG&E literature	8b.
Heard about program from other builder or sub contractor	8c.
Heard about program from architect or designer	8d.
Other ____________________	8e.

A.5 NON COMFORT HOME ENERGY EFFICIENCY

FOR PARTICIPANTS AND NON-PARTICIPANTS:

9. Excluding homes built through the Comfort Home Program, what best describes the homes you build relative to Title 24 Standards? **READ LIST**

Homes met standards	9a.
Homes exceeded Standards by about 5 to 10%	9b.
Homes exceeded Standards by 10 to 20%	9c.
Homes exceeded Standards by greater than 20%	9d.
Don't know, Refused, or Not Applicable **(DON'T READ)**	9e.

FOR BUILDERS WHO HAVE EVER PARTICIPATED IN THE COMFORT HOME PROGRAM (all participants, and any nonparticipants who answered yes to question 7e):

10. Which of the following statements best describes the homes you build outside of the Comfort Home Program? **READ FIRST TWO LINES OF LIST**

They contain HVAC equipment and construction characteristics similar to those in homes built under the Comfort Home Program.	10a.	
They contain HVAC equipment and construction characteristics chosen to comply with the Title 24 standards and nothing more.	10b.	
Don't know / Not applicable **(DON'T READ)**.	10c.	

I am going to ask you some questions about your use of specific energy efficiency measures over time.

For the following time periods, what percentage of the homes you built - ***outside of the PG&E Comfort Home Program*** - included the following high efficiency measures? (**QUERY AND FILL IN CHART**)

Q#		a	b	c	d	e	f
	Year	Included ACs with SEER above that used to comply with Title 24 Standards	Utilized enhanced HVAC duct installation procedures	Installed gas dryer stub	Installed gas cook top and/or range	Included insulation above that used to comply with Title 24 Standards	Installed premium efficiency windows
11.	1997						
12.	1994-96						
13.	1991-93						

FOR BUILDERS WHO HAVE EVER PARTICIPATED IN THE COMFORT HOME PROGRAM (all participants, and any nonparticipants who answered yes to question 7e):

14a. Did your participation in the Comfort Home Program influence your decision to install the energy efficiency measures in homes built ***outside*** of the Program?

Influenced decision significantly..	14a1	
Influenced decision somewhat..	14a2	
No significant influence	14a3	

If answer to question 14a is "no significant influence" then ask:

14b. What caused you to install the additional energy efficiency measures?

____

FOR BUILDERS WHO HAVE <u>EVER</u> PARTICIPATED IN THE COMFORT HOME PROGRAM (all participants, and any nonparticipants who answered yes to question 7e):

15a. For homes built under the Comfort Home Program, did you install additional energy efficiency measures ***not covered under the Program*** above those required to comply with Title 24 standards? If so, what measures were installed?

Premium efficiency windows (above standard double paned windows)	15a1	
Insulation levels above Title 24 compliance levels..	15a2	
High efficiency furnaces	15a3	
High efficiency water heaters...	15a4	
Efficient lighting technologies (T-8's, Hardwired CFLs, etc.)	15a5	
Other, specify: ___________________________________	15a6	

15b. Did your participation in the Comfort Home Program influence your decision to install the additional energy efficiency measures in the Program homes?

Influenced decision significantly..	15b1	
Influenced decision somewhat..	15b2	
No significant influence	15b3	

If question 15b answer is "no significant influence" then ask:

15c. What caused you to install the additional energy efficiency measures?

____

FOR PARTICIPANT <u>AND</u> NON-PARTICIPANTS:

16a. Do you think home buyers are generally willing to pay more for homes that are more energy efficient than Title 24 Standards? 16a Y N

16b. Do you think home energy efficiency is an important feature that makes it easier to sell homes? 16b Y N

17. I am going to read of list of factors that can affect new home construction and design. Please tell me which of these is most important from your experience (#1)? Least important (#6)? Next most important (#2)?

Construction costs	17a1	
Energy efficiency..	17a2	
Visual appearance of home	17a3	
Occupant comfort	17a4	
Quality of construction	17a5	
Appropriateness of design for a given location..	17a6	

A.6 PARTICIPANT BUILDER INFORMATION

***ONLY* FOR BUILDERS WITH PARTICIPATING HOMES *IN THE SAMPLE*, ask Questions 18, 19, 20, and 21 for applicable efficiency measures:**

How did you learn about HE Equipment?

18a. How did you first learn about AC units with SEER levels above Title 24 Standards?

From PG&E representative	18a1	
From PG&E literature	18a2	
From other builders or sub contractors	18a3	
From architect or designer	18a4	
From manufacturers' literature or reps	18a5	
From trade literature	18a6	
Other ______	18a7	

18b. How did you first learn about duct testing and enhanced installation procedures?

From PG&E representative	18b1	
From PG&E literature	18b2	
From other builders or sub contractors	18b3	
From architect or designer	18b4	
From manufacturers' literature or reps	18b5	
From trade literature	18b6	
Other ______	18b7	

Decision Influences

19a. From the following list, please rank the three most important reasons you installed the higher efficiency AC Systems, with 1 being the most important and 3 the third most important. (**READ LIST**)

PG&E Rebates	19a1	
PG&E advice or recommendations	19a2	
Equipment literature	19a3	
Past experience with energy efficiency equipment	19a4	
Information from vendors or designers	19a5	
Home buyers request high efficiency equipment	19a6	
Meeting the Title 24 energy budget	19a7	
Other ______	19a8	

19b. From the following list, please rank the three most important reasons you used enhanced duct installation procedures, with 1 being the most important and 3 the third most important. (**READ LIST**)

PG&E Rebates	19b1	
PG&E advice or recommendations	19b2	
Equipment literature	19b3	
Past experience with energy efficiency equipment	19b4	
Information from vendors or designers	19b5	
Home buyers request high efficiency equipment	19b6	
Other ______________________________	19b7	

19c. From the following list, please rank the three most important reasons you installed gas cooking equipment in your Comfort Homes, with 1 being the most important and 3 the third most important. (**READ LIST**)

PG&E Rebates	19c1	
PG&E advice or recommendations	19c2	
Equipment literature	19c3	
Past experience installing gas cooking equipment	19c4	
Information from vendors or designers	19c5	
Home buyers' request for gas cooking equipment	19c6	
Other ______________________________	19c7	

19d. From the following list, please rank the three most important reasons you installed gas dryer stubs in your Comfort Homes, with 1 being the most important and 3 the third most important. (**READ LIST**)

PG&E Rebates	19d1	
PG&E advice or recommendations	19d2	
Equipment literature	19d3	
Past experience with gas installations	19d4	
Information from vendors or designers	19d5	
Home buyers' request for gas drying capabilities	19d6	
Other ______________________________	19d7	

Importance of Rebates

20a. If the rebate had not been available, how likely is it that you would have installed the higher efficiency AC systems?

Definitely would have done it anyway	20a1	☐
Probably would have done it	20a2	☐
Probably would not have done it	20a3	☐
Definitely would not have done it	20a4	☐
Don't know	20a5	☐

20b. If the rebate had not been available, how likely is it that you would have conducted duct **testing**?

Definitely would have done it anyway	20b1	☐
Probably would have done it	20b2	☐
Probably would not have done it	20b3	☐
Definitely would not have done it	20b4	☐
Don't know	20b5	☐

20c. If the rebate had not been available, how likely is it that you would have conducted **enhanced duct installation procedures**?

Definitely would have done it anyway	20c1	☐
Probably would have done it	20c2	☐
Probably would not have done it	20c3	☐
Definitely would not have done it	20c4	☐
Don't know	20c5	☐

20d. If the rebate had not been available, how likely is it that you would have installed gas cooking in the same number of Comfort Homes?

Definitely would have done it anyway	20d1	☐
Probably would have done it	20d2	☐
Probably would not have done it	20d3	☐
Definitely would not have done it	20d4	☐
Don't know	20d5	☐

20e. If the rebate had not been available, how likely is it that you would have installed the dryer stubs?

Definitely would have done it anyway	20e1	☐
Probably would have done it	20e2	☐
Probably would not have done it	20e3	☐
Definitely would not have done it	20e4	☐
Don't know	20e5	☐

If Rebates are Discontinued

21a. If the rebates are discontinued, how likely is it that you will install higher efficiency AC systems in the future?

Definitely would	21a1	☐
Probably would	21a2	☐
Probably would not	21a3	☐
Definitely would not	21a4	☐
Don't know	21a5	☐

21b. If the rebates are discontinued, how likely is it that you will conduct duct **testing** in the future?

Definitely would	21b1	☐
Probably would	21b2	☐
Probably would not	21b3	☐
Definitely would not	21b4	☐
Don't know	21b5	☐

21c. If the rebates are discontinued, how likely is it that you will conduct **enhanced duct installations** in the future?

Definitely would	21c1	☐
Probably would	21c2	☐
Probably would not	21c3	☐
Definitely would not	21c4	☐
Don't know	21c5	☐

21d. If the rebates are discontinued, how likely is it that you will continue to install a gas cooking in the same percent of homes you build?

Definitely would	21d1	☐
Probably would	21d2	☐
Probably would not	21d3	☐
Definitely would not	21d4	☐
Don't know	21d5	☐

21e. If the rebates are discontinued, how likely is it that you will continue to install the same amount of gas dryer stubs?

Definitely would	21e1	☐
Probably would	21e2	☐
Probably would not	21e3	☐
Definitely would not	21e4	☐
Don't know	21e5	☐

A.7 HVAC Sub Contractors

		Y	N
22a. Do you work with a HVAC sub-contractor?	22a	☐	☐

If yes. Would you tell us who it is?

22b. Company Name:______________________________

22c. Contact:______________________________

22d. Phone Number:______________________________

23. Who does your HVAC **duct** work?

We do our own work	23a	☐
We use the sub contractor mentioned above	23b	☐
We use a different sub contractor - *get name and phone number*	23c	☐
Don't know/ Won't say	23e	☐

If Question 23 indicates "different sub contractor" for duct work:

24a. Company Name:______________________________

24b. Contact:______________________________

24c. Phone Number:______________________________

A.8 ENERGY STAR PROGRAM

25a. Have you heard of the Energy Star New Homes Program that is being provided through the U. S. Environmental Protection Agency? 25a [Y] [N]

25b. ***If 25a = Yes***: Do you know the requirements for participating in the Energy Star Program? 25b [Y] [N]

25c. ***If 25a = Yes***: Do you plan to participate in the Program? 25c [Y] [N] [DK]

25d. ***If 25c = No***: Why not?

____

____

THIS CONCLUDES THE SURVEY. THANK YOU FOR YOUR TIME.

B

SURVEY DISPOSITION REPORTS

On-Site Survey
Final Sample Disposition Report

	Total Sample	
	Frequency	Percent of Sample Contacted
NonParticipants		
Not Contacted	991	
Call Back	61	5.72%
Cancelled	37	3.47%
Not Qualified	25	2.35%
Refused	115	10.79%
Rescheduled	0	0.00%
Surveyed	160	15.01%
Unscheduled In Progress	426	39.96%
Wrong Number	242	22.70%
Total Contacted	1066	100.00%
Participants		
Not Contacted	1502	
Call Back	40	4.44%
Cancelled	20	2.22%
Not Qualified	6	0.67%
Refused	77	8.56%
Reschedule	1	0.11%
Surveyed	155	17.22%
Unscheduled In Progress	394	43.78%
Wrong Number	207	23.00%
Total Contacted	900	
Average Number of Calls Per Site	1.5	
NonParticipant	1.6	
Participant	1.4	

Builder Telephone Survey
Disposition Report

Total completes:	61
No telephone numbers available:	20
No response to calls:	11
Rejections	3
No answer	3
Subtotal:	17
Total:	98

C

DUCT MODEL PARAMETERS

The following assumptions were used in the ASHRAE Standard 152P: Method duct efficiency calculations.

Duct Model Input Parameters and Assumptions

Conditioned Floor Area, (ft^2)
The surveyor's estimate of the total conditioned floor area.

Supply Duct Surface Area, (ft^2)
The total surface area of the supply ductwork is determined based on the conditioned floor area of the building, using the following equation (ASHRAE 152P, eqn. 6.4):

$$A_{s,\,total} = 0.27\,A_{floor}$$

Return Duct Surface Area, (ft^2)
The total surface area of the return ductwork is determined based on the actual return duct surface area indicated on the survey form. In the cases when this survey datum is not available, the area is determined based on the conditioned floor area of the building using the following equation (ASHRAE 152P, eqn. 6.5):

$$A_{r,\,total} = 0.05\,N_{returns}A_{floor}$$

where

$N_{returns}$ is the number of return registers,
A_{floor} is the conditioned floor area.

Fractional supply/return duct location
This is the amount of the duct system in a given location expressed as a fraction of the total. The total includes interior ducts. For each of the supply and return, the sum of the fractions entered plus the fractions of the duct inside the conditioned space (which is not entered) must add to 1. The supply duct location options are: in attic, in garage, in unvented & uninsulated crawlspace, in unvented crawlspace with insulated building floor and crawlspace walls, in unvented crawlspace with insulated building floor, in vented & uninsulated crawlspace, in vented crawlspace with insulated building floor and crawlspace walls, in vented crawlspace with insulated building floor, in uninsulated basement, in basement with insulated walls, in basement with insulated ceiling, duct under slab and in exterior walls.

The fractional supply/return duct locations used in the models reflect the actual observations collected during the on-site survey. In the case of two-story houses, the duct location was assumed to be 70% in the attic and 30% in the conditioned space (ASHRAE 152P, table 6.1). In cases where there are no return ducts, the duct location for the return is entered the same as for the supply. This is necessary in order to calculate the appropriate thermal regain factor, because the thermal regain factor for the system is computed as an average of supply and return thermal regain factors.

Supply & Return Duct R values (hft^2F/Btu)
The models use the measured supply and return duct insulation R-values from the survey form.

Indoor Temperature, heating (F)
The surveyed heating system thermostat setting for December and January from the survey form.

Indoor Temperature, cooling (F)
The surveyed cooling system thermostat setting for July and August from the survey form.

Heating Design temperature at 97.5% and Cooling Design Temperature at 2.5%, ASHRAE, (F)
These site-specific values are taken from ASHRAE publication SPCDX, Climatic Data for Region X, Arizona, California, Hawaii and Nevada, 1982.

T wetbulb design, (F)
This value for the specific site location is taken from ASHRAE publication SPCDX, Climatic Data for Region X, Arizona, California, Hawaii and Nevada, 1982.

T wetbulb indoor, (F)
Determined from the psychometric chart, based on the cooling system thermostat setpoint.

Is there solar gain reduction in the attic? [Y/N]
Solar gain reduction is described in detail in (ASHRAE 152P, eqn. 6.4): If there is an appropriately installed radiant barrier, or a high reflectivity roof coating, or a barrel tiled roof, then these attics qualify for the solar gain reduction credit. The models use on-site data from the survey forms.

House Volume, (ft^3)
The total building volume is determined based on the conditioned floor area of the building and the measured ceiling height:

$$V_{total} = height * A_{floor}$$

Equipment Heating/Cooling Capacity, [Btu/hour]
The single speed equipment capacity or the higher capacity for two speed equipment; these are separate numbers for heating and cooling. The value is provided from the equipment name plate or from the manufacturers specification based on the model data. For cooling equipment, the convention is to enter values as negative.

Equipment Heating/Cooling Capacity, [Btu/hour], LOW
The lower capacity for two speed equipment. The value is provided from the equipment name plate or from the manufacturers specification based on the model data. Again, cooling is entered as a negative number.

Heating Fan Flow, (cfm)

The single speed heating fan flow or the higher heating fan flow for two speed equipment. The value is provided from the manufacturers specification of design fan system flow or is assumed equal to the calculated cooling fan flow. When using manufacturers rating, the 15% reduction indicated in the standard is applied.

Cooling Fan Flow, (cfm)
The single speed cooling fan flow or the higher cooling fan flow for two speed equipment. The value is calculated as a function of the cooling capacity of the system, (340 cfm per ton of cooling capacity).

$$Q_{ecool} = CoolCap / 12000 * 340$$

where

Q_{ecool} is the cooling fan flow, (cfm):

$CoolCap$ is the cooling capacity, Btu/h.

Heating Supply and Return Duct Leakages (cfm)
Assumed to be equal to the cooling supply and return duct leakages (cfm).

Cooling Supply duct leakage (cfm)
Duct leakage flow measured at the higher fan flow for two speed equipment is entered. Since this value represents the duct leakage flow to outside at operating conditions, it is assumed that 75% (a recommended value) of the measured leakage flow is lost to outside.

Cooling Return duct leakage (cfm)
Duct leakage flow calculated at the higher fan flow for two speed equipment is entered. If a return duct exists, it is assumed that 10% (a recommended value) of the measured total flow is lost to outside from the return ductwork.

Heating/Cooling Fan Flow, (cfm), LOW SPEED
The lower heating and cooling fan flows for two speed equipment. These values are calculated by prorating the design fan system flows using the ratio of capacities between lower and higher speeds.

Heating Supply/Return Duct Leakages (cfm), LOW SPEED
Assumed to be equal to the cooling supply and return duct leakages (cfm), LOW SPEED.

Cooling Supply duct leakage (cfm), LOW SPEED
Duct leakage flow measured at the higher fan flow for two speed equipment multiplied by the capacity ratio is entered. Since this value represents the duct leakage flow to outside at operating conditions, it is assumed that 75% (a recommended value) of the actually measured flow is lost to outside.

Cooling Return duct leakage (cfm), LOW SPEED

Duct leakage flow calculated at the higher fan flow for two speed equipment multiplied by the capacity ratio is entered. It a return duct exists, it is assumed that 10% (a recommended value) of the actually measured total flow is lost to outside from the return ductwork.

For Duct Thermal Mass Correction, enter F for flex duct or duct board, M for sheet metal. The actual duct construction is taken from the survey form.

For equipment efficiency correction, Enter 1 for ACCA manual D design, 2 without Manual D design. A value of 2 is always entered for no Manual D based design.

Enter 1 for single speed cooling/heating equipment, 2 for multispeed cooling/heating equipment. The actual cooling and heating equipment speed indices is entered.

For attics, enter V for vented, U for unvented. Actual observation is entered.

For cooling systems, Enter T for TXV control, O for other control. For cooling system control, a TXV is a thermostatic expansion valve. The other method of control is usually a simple orifice. These control systems differ in their ability to control the operation of the refrigerant cooling systems at different flows across the coil. The manufacturer's literature usually specifies which control method is used.

For heating systems, enter H for heat pump, O for other system. The observed system type is indicated.

Supply plenum dry bulb temperature for cooling systems, [F]. Since no flow temperature measurements were performed, the recommended value of 55F was assumed.

D

PROTOCOLS TABLES 6 AND 7

This appendix presents the CPUC Protocols: Table 6 and Table 7.

Table 6

M&E PROTOCOLS TABLE 6 — Residential New Construction Program

Designated Unit of Measurement: Home
ENDUSE: Whole Building

1. Average Participant Group and Average Comaprison Group		**Participant**	**Comparison**								
A. Pre-install usage:	Pre-install kW	na	na								
	Pre-install kWh	na	na								
	Pre-install Therms	na	na								
	Base kW	na	na								
	Base kWh	na	na								
	Base Therms	na	na								
	Base kW/ designated unit of measurement	na	na								
	Base kWh/ designated unit of measurement	na	na								
	Base Therms/ designated unit of measurement	na	na								
B. Impact year usage:	Impact Yr k	na	na								
	Impact Yr kWh	1,225,43	833,53								
	Impact Yr Therms	70,215	49,115								
	Impact Yr kW/designated unit	na	na								
	Impact Yr kWh/designated unit	7,906	8,774	**5. A. 90% CONFIDENCE LEVEL**				**5. B. 80% CONFIDENCE LEVEL**			
	Impact Yr Therms/designated unit	453	517	**LOWER BND**	**UPPER BND**	**LOWER BND**	**UPPER BND**	**LOWER BND**	**UPPER BND**	**LOWER BND**	**UPPER BND**
2. Average Net and Gross End Use Load Impact		**AVG GROSS**	**AVG NET**	**AVG GROSS**	**AVG GROSS**	**AVG NET**	**AVG NET**	**AVG GROSS**	**AVG GROSS**	**AVG NET**	**AVG NET**
	A. i. Load Impacts - kW	2,546.3	2,717.9	1,969.6	3,122.9	1,993.8	3,442.0	2,097.6	2,994.9	2,154.5	3,281.3
	A. ii. Load Impacts - kWh	4,265,65	3,169,69	2,606,70	5,924,59	1,776,83	4,562,55	2,974,80	5,556,49	2,085,88	4,253,50
	A. iii. Load Impacts - Therms	-41,57	55,882	-6,706	-76,44	44,349	67,415	-14,44	-68,70	46,908	64,856
	B. i. Load Impacts/designated unit - k	0.64	0.69	0.50	0.79	0.50	0.87	0.53	0.76	0.54	0.83
	B. ii. Load Impacts/designated unit - kWh	1,077	800	658	1,496	449	1,152	751	1,403	527	1,074
	B. iii. Load Impacts/designated unit - Therms	-10.5	14.1	-1.7	-19.3	11.2	17.0	-3.6	-17.4	11.8	16.4
	C. i. a. % change in usage - Part Grp - k	na	na	na	na	na	na	na	na	na	na
	C. i. b. % change in usage - Part Grp - kWh	na	na	na	na	na	na	na	na	na	na
	C. i. c. % change in usage - Part Grp - Therms	na	na	na	na	na	na	na	na	na	na
	C. ii. a. % change in usage - Comp Grp - k	na	na	na	na	na	na	na	na	na	na
	C. ii. b. % change in usage - Comp Grp - kWh	na	na	na	na	na	na	na	na	na	na
	C. ii. c. % change in usage - Comp Grp - Therms	na	na	na	na	na	na	na	na	na	na
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rat	0.86	0.98	0.67	1.06	0.68	1.17	0.71	1.01	0.73	1.11
	D.A. ii. Load Impacts - kWh, realization rate	0.90	0.79	0.55	1.25	0.38	0.96	0.63	1.17	0.44	0.90
	D.A. iii. Load Impacts - Therms, realization rat	-0.54	0.54	-0.09	-1.00	0.58	0.88	-0.19	-0.90	0.61	0.84
	D.B. i. Load Impacts/designated unit - kW, real rat	0.86	0.98	0.67	1.06	0.68	1.17	0.71	1.01	0.73	1.11
	D.B. ii. Load Impacts/designated unit - kWh, real rate	0.90	0.79	0.55	1.25	0.38	0.96	0.63	1.17	0.44	0.90
	D.B. iii. Load Impacts/designated unit - Therms, real rat	-0.54	0.54	-0.09	-1.00	0.58	0.88	-0.19	-0.90	0.61	0.84
3. Net-to-Gross Ratios		**RATIO**		**RATIO**	**RATIO**			**RATIO**	**RATIO**		
	A. i. Average Load Impacts - k	1.07		na	na			na	na		
	A. ii. Average Load Impacts - kWh	0.74		na	na			na	na		
	A. iii. Average Load Impacts - Therms	-1.34		na	na			na	na		
	B. i. Avg Load Impacts/designated unit of measurement - k	1.07		na	na			na	na		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.74		na	na			na	na		
	B. iii. Avg Load Impacts/designated unit of measurement - Therms	-1.34		na	na			na	na		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relativ to Base usage in Impact year - k	na		na	na			na	na		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relativ to Base usage in Impact year - kWh	na		na	na			na	na		
	C. iii. Avg Load Impacts based on % chg in usage in Impact year relativ to Base usage in Impact year - Thms	na		na	na			na	na		
4. Designated Unit Intermediate Dat				**PART GRP**	**PART GRP**			**PART GRP**	**PART GRP**		
	A. Pre-install average valu	na		na	na			na	na		
	B. Post-install average valu	na		na	na			na	na		
6. Measure Count Data		**NUMBER**									
	A. Number of measures installed by participants in Part Grou	See next page									
	B. Number of measures installed by all program participants in the 12 months of the program year	See next page									
	C. Number of measures installed by Comp Grou	na									
7. Market Segment Data											
	A. Distribution by CEC climate zone	See next page									

M&E PROTOCOLS TABLE 6 (CONTINUED)

6A/6B Measure Count Data				
	Participant Group		All Program Participants	
Measure	# Homes	Percent	# Homes	Percent
Efficient AC	155	100%	3,893	98%
Improved Ducts	140	90%	3,551	90%
Code Enforcement	146	94%	3,694	93%
Efficient Furnaces	7	5%	203	5%
Gas Cooking	138	89%	3,553	90%
Gas Dryer Plugs	127	82%	3,304	83%
CFLs	14	9%	296	7%
Effic Water Heaters	0	0%	66	2%
All Measures	155		3,960	

7A. Market Segment Data - Distribution by CEC Climate Zone				
	Participant Group		All Program Participants	
Measure	# Homes	Percent	# Homes	Percent
Climate Zone 11	28	18%	658	17%
Climate Zone 12	81	52%	2,296	58%
Climate Zone 13	46	30%	1,006	25%
All Climate Zones	155		3,960	

Table 7

D.1 OVERVIEW INFORMATION

D.1.1 Study Title and Study ID Number

Study Title: *Impact Evaluation of Pacific Gas and Electric Company's 1996 Residential New Construction Program*

Study ID No: 386

D.1.2 Program Year and Program Description

Program year: 1996

Program description: The PG&E Residential New Construction Program, referred to as the PG&E Comfort Home Program, provides financial incentives to builders who construct energy-efficient homes that exceed Title 24 standards. Energy efficiency measures addressed in this evaluation were installed in Program years 1993 through 1996 and were rebated in calendar year 1996 under the shared savings portion of the Program. The Program focuses on homes built in California Energy Commission (CEC) climate zones 11, 12, and 13 and on four key energy efficiency measures (in addition to Title 24 compliance): high efficiency air conditioning; enhance duct installations; natural gas cooking; and natural gas dryer stubs. A total of 3,960 homes qualified for rebates in 1996 under the shared savings portion of the Program.

D.1.3 End Uses Covered

Whole building

D.1.4 Methods and Models Used

To develop gross impacts, engineering estimates of impacts were first developed. The Micropas building simulation model was used to develop impacts for space conditioning and other engineering algorithms were used to estimate impacts for cooking and clothes drying. For space conditioning, impacts were defined as the difference between Title 24 compliance loads and as-build loads. For cooking and clothes drying, impacts were defined as total end use energy consumption for rebated homes.

Engineering results were calibrated to customer bills using an SAE (Statistically Adjusted Engineering) approach. For this approach, billed consumption was regressed against energy consumption for all end uses. The model's regression coefficients are interpreted as calibration factors because they are used to calibrate the engineering results to the customer bills.

For space conditioning, the calibrated engineering estimates of impacts for participants and nonparticipants were then compared using an efficiency choice model. In this model, efficiency (defined as the percent improvement above Title 24 compliance energy consumption) is modeled (using an econometric approach) as a function of program participation and other variables such as house size and builder characteristics. The model provides estimates of efficiency improvement attributable to the Program while factoring out confounding effects of other factors. The results of the efficiency choice model is an estimate of net savings.

For the cooking and clothes drying end uses, a self report approach was used to develop net savings using the results of a builder survey in which respondents were asked if they would have installed measures in the absence of the Program. Net-to-gross ratios developed from the self-report analysis were applied to gross savings in order to determine net savings.

D.1.5 Participant and Comparison Group Definition

- Participant group: homes built by participant builders that were rebated in 1996.
- Nonparticipant comparison group: single family homes that were built in the 1994-1996 period and were located in the same geographical area as the participant homes.

D.1.6 Analysis Sample Size

The analysis sample size was originally designed to be 155 participants and 160 nonparticipants. Initial analysis of survey results indicated that a number of nonparticipants were actually Program participants from prior Program years. After accounting for these prior participants final sample sizes were: 155 participants, 95 true nonparticipants, and 65 prior participants. All 315 sample points were used in the SAE analysis to develop calibration coefficients for the engineering impacts used for gross savings. Only the participants and true nonparticipants were used in the efficiency choice modeling to develop net savings.

The following tables summarizes the number of homes used in various stages of the analysis. Also note, monthly data was used in the SAE models - 3,762 observations were included in the electric model and 3,377 observations were included in the gas model.

	Participants	Prior Participants	Nonparticipants	Total
Participant Population	3960			
Screened Sites Available for Surveys	2,402	2,057		4,459
On-site Surveys	155	65	95	315
Duct Tests	155	65	95	315
Builder Surveys[1]	110 (39)	53 (27)	56 (22)	219 (61)
Electric SAE Model	155	65	95	315
Gas SAE Model	137	57	88	282
Electric Efficiency Choice Model	110		56	166
Gas Efficiency Choice Model	96		54	150
Self Report NTG Analysis	105			105

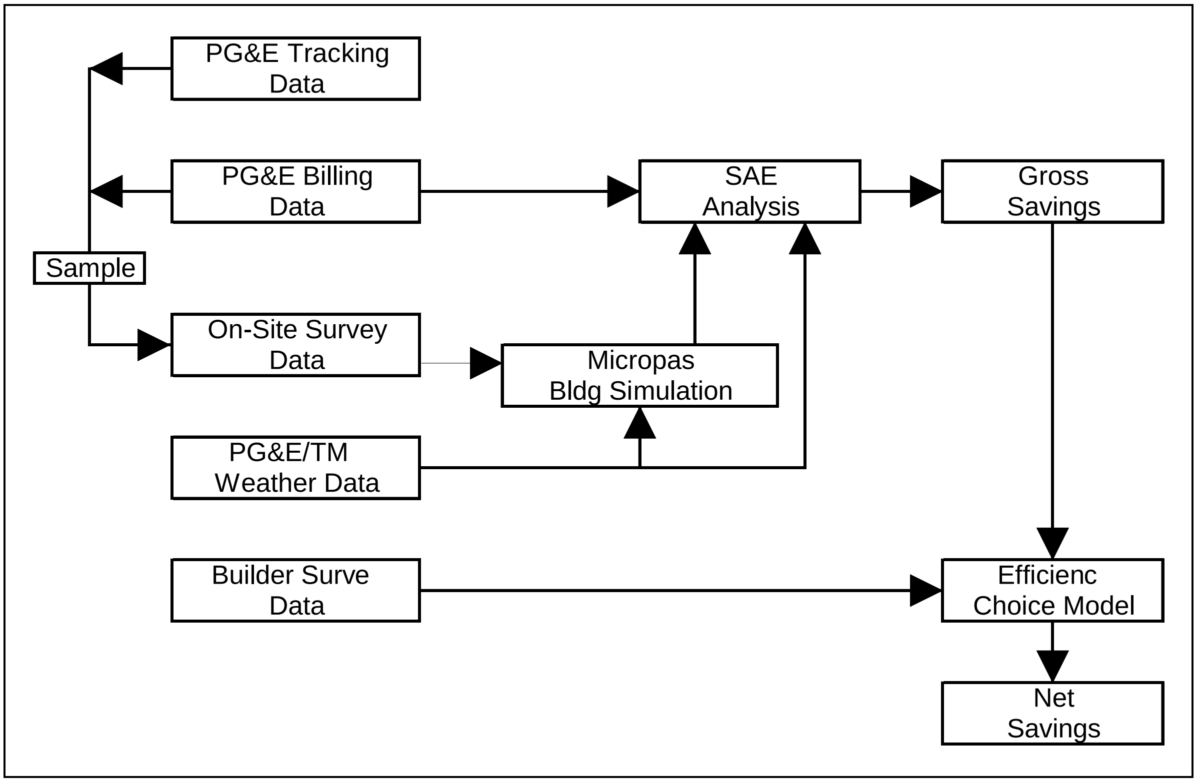
[1] Number of builders are included in parentheses. Builder counts do not sum to total because of overlap of builders in the three categories.

D.2 DATABASE MANAGEMENT

D.2.1 Flow Chart

The flow chart is presented in the following figure.

Data Flow Chart



D.2.2 Specific Data Sources

PG&E rebate tracking data:

PDETAIL.SD2	Measure level savings for each home
PDETAIL.SD2	Savings summarized to the home level
PGENTG.SD2	Assumed net-to-gross ratios by measure
VHOME96.SD2	List of addresses for 1996 participating homes
ELEYPGE.SD2	Additional participant data from hardcopy files

PG&E billing/weather data:

EBILL65.SD2	Electric billing data and matched weather data
GBILL65.SD2	Gas billing data and matched weather data

On-site survey data:

CLNSURV.SD2	Onsite survey dataset (see Appendix A survey instrument for variable descriptions)
BLDGEOM.XLS	Onsite survey data regarding building geometry, input by modelers; variable descriptions in GEOM-DB.DOC

Builder survey data:

BLDSRV.SD2	Survey data for each respondent
BLDID.SD2	File linking builder ID to home ID (the PG&E Control number)

Other data:

LSPGE.SD2:	PG&E cooking and clothes drying load shapes
CECZONE.SD2	CEC climate zone indicator for each home

Micropas input files (each file begins with the 7 digit ID number):

_______A.M45	Type A simulations, as built, customer reported schedules
_______B.M45	Type B simulations, as built, compliance schedules
_______C.M45	Type C simulations, compliance, customer reported schedules
_______D.M45	Type D simulations, compliance, compliance schedules

ASHRAE Standard 152 Duct Efficiency Calculations (each file begins with the 7 digit ID):

_______.XLS

Other created datasets:

NSENG.SD2	Non-space-conditioning engineering estimates of energy usage
DUCTEFF.SD2	Estimated duct efficiencies for homes with duct tests
DCLEFF.SD2	Cooling duct efficiencies for all homes
DHTEFF.SD2	Heating duct efficiencies for all homes
BLDSIM.SD2	Micropas simulation results
ENGIMPCS.SD2	Engineering energy usage using compliance schedules
ENGIMPRS.SD2	Engineering energy usage using reported schedules
ADJSAV.SD2	Adjusted engineering results using reported schedules
NETSAMP.SD2	List of final sites in the efficiency choice model
WEIGHT2.SD2	Site expansion weights

Analysis programs:

ENGMOD.SAS	Non-space-conditioning engineering module
NSPCENG.SAS	Runs ENGMOD.SAS for different daytypes a retains results
DUCTMODL.SAS	Develops regression equations to estimate duct efficiencies for all sites
BLDSIM.SAS	Combines Micropas results with duct and system efficiencies
ENGRSLT.SAS	Prints out selected results of BLDSIM.SAS calculations
ELESAE.SAS	Electric SAE model
GASSAE.SAS	Gas SAE model
WEIGHTS.SAS	Calculates site expansion weights
NTGSR.SAS	Self-report net-to-gross analysis
NTGMOD.SAS	Efficiency choice model and calculation of net impacts
LDSHAPE.SAS	Develops and applies allocation factors to provide impacts by cost period
SPILLOVR.SAS	Calculation of nonparticipant spillover from builder survey data

D.2.3 Data Attrition

The initial participant and nonparticipant screening described is in the following table.

	Remaining Homes	Screened Homes
Particiapnts		
Total homes with 1996 Shared Savings rebates	3,960	
Single family homes, per tracking system	3,928	32
Homes matched to the billing system	3,844	84
Tracking system address, service address match	3,596	248
Homes with adequate billing data	2,558	1,038
Single family homes, per billing system	2,506	52
Homes after removing several remote areas	2,402	104
Nonparticpants		
Homes with adequate bills, matched to participants by meter route	4,923	
Homes after additional geographical/proportional matching to participants	2,057	2,866

A sample disposition report for the on-site survey is presented in the following table.

	Frequency	% of Sample Contacted
Participants		
Not Contacted	1,502	
Call Back	40	4.4%
Cancelled	20	2.2%
Not Qualified	6	0.7%
Refused	77	8.6%
Reschedule	1	0.1%
Surveyed	***155***	***17.2%***
Unscheduled In Progress	394	43.8%
Wrong Number	207	23.0%
Total Contacted	900	100.0%
NonParticipants		
Not Contacted	991	
Call Back	61	5.7%
Cancelled	37	3.5%
Not Qualified	25	2.4%
Refused	115	10.8%
Rescheduled	0	0.0%
Surveyed	***160***	***15.0%***
Unscheduled In Progress	426	40.0%
Wrong Number	242	22.7%
Total Contacted	1,066	100.0%

The sample disposition report for the builder survey is presented in the following table.

Total completes:		61
No telephone numbers available:		20
No response to calls:	11	
Rejections	3	
No answer	3	
Subtotal - unsurveyed, with phone number:		17
Total:		98

D.2.4 Data Quality

PG&E tracking and billing audit data were matched using the PG&E Control number, a fixed number uniquely corresponding to a PG&E account. After matching, addresses from the tracking system were match against addresses from the billing system. A total of 248 sites were dropped from the study because the address did not match.

Each on-site survey was tracked using the PG&E Control number. During the on-site survey recruitment process, home occupants were asked if they lived in a new home; those who didn't were disqualified from the study. During the on-site survey, both participant and nonparticipant customers were asked if they lived Program homes. This information was used to reassign a number of initial nonparticipants into a prior-participant category.

Builders were associated with each survey by Control number. Weather data was assigned, based on CEC climate zone.

D.2.5 Data Collected Specifically for the Analysis but not Used

NA

D.3 SAMPLING

D.3.1 Sampling Procedures and Protocols

To comply with the M&E Protocols, studies utilizing on-site data collection require minimum participant and nonparticipant sample sizes of 150 each. For this study, sample size goals of 159 participants and 159 nonparticipant were established to allow for some attrition due to factors such as problematic billing data and contradictory or incomplete survey results.

It was decided that a cluster sampling technique would be most efficient for the on-site surveys. This technique ensures that sampled sites are "clustered" in areas that are scheduled for surveys by the same surveyor on a given day. The geographically diverse sample segmentation used in the cluster approach also will ensure that final sample of surveyed homes will contain variation by builder, home type, and home size.

To implement the sample design, using the cluster sampling technique, the available homes were divided into geographical nodes - areas that could be reached by a single surveyor in a given day. In several cities, initial nodes were further disaggregated by PG&E meter route in order to better match participant and nonparticipant homes. Next, a random sample of 53 participants was drawn. This sample of participants determined how many surveys would be conducted in a given node. For each participant selected in a node, a total of six surveys would be conducted (3 participant and 3 nonparticipant). Overall, 34 nodes were target for surveys, providing a random and diverse sample.

D.3.2 Survey Information

Survey instruments are presented in Appendix A of the report. See section B3 for response rates. Non-response bias was not addressed.

D.3.3 Statistical Descriptions

Descriptive statistics for key model variables are provided in the following tables.

Electric SAE Model

Group	Variable	N	Mean	Std Dev	Minimum	Maximum
Nonparticipants	kWh	1140	24.0317	14.0893	0.2903	94.3793
	Base case cooling use	1140	7.4267	10.0965	0.0000	60.3412
	Efficent AC savings	1140	0.6953	1.4784	0.0000	13.0478
	Duct savings	1140	-0.0329	0.5311	-5.2230	2.6887
	Other savings	1140	-0.6175	2.6160	-13.1172	12.0080
	Pool/Spa use	1140	1.7781	4.5235	0.0000	27.8501
	Other end use consumption	1140	15.7669	4.8426	6.9106	88.7447
Prior participants	kWh	780	21.8368	10.5289	2.5556	92.3793
	Base case cooling use	780	7.3145	9.7190	0.0000	45.8417
	Efficent AC savings	780	1.6142	2.3682	0.0000	16.9215
	Duct savings	780	0.1765	0.6895	-7.7478	3.1535
	Other savings	780	-0.7252	2.5694	-11.3996	6.6675
	Pool/Spa use	780	1.3581	2.8460	0.0000	13.4280
	Other end use consumption	780	15.2196	5.0453	6.8449	34.2159
Participants	kWh	1860	21.6607	11.4982	0.0313	75.4138
	Base case cooling use	1860	6.8082	8.7131	0.0000	37.9008
	Efficent AC savings	1860	1.3961	1.9818	0.0000	15.1555
	Duct savings	1860	0.2529	0.6415	-2.7888	6.4685
	Other savings	1860	-0.7768	2.6181	-18.3503	6.6785
	Pool/Spa use	1860	1.0648	2.9515	0.0000	23.4990
	Other end use consumption	1860	15.4308	4.2721	7.5508	38.7626

Gas SAE Model

Group	Variable	N	Mean	Std Dev	Minimum	Maximum
Nonparticipants	Therms	1053	1.4130	1.2591	0.0303	8.6667
	Base case heating use	1053	0.8057	1.1716	0.0000	7.5810
	Efficent furnace savings	1053	0.0275	0.0453	0.0000	0.5237
	Duct savings	1053	-0.0091	0.0638	-0.6593	0.3085
	Other savings	1053	-0.0209	0.1793	-0.9018	1.0566
	Clothes drying use	1053	0.0702	0.0584	0.0000	0.2912
	Other end use consumption	1053	0.0513	0.0674	0.0000	0.3374
	Cooking use	1053	0.5851	0.3609	0.1268	3.9636
Prior participants	Therms	683	1.1807	0.9549	0.0625	5.9677
	Base case heating use	683	0.6295	0.9972	0.0000	8.0128
	Efficent furnace savings	683	0.0522	0.0973	0.0000	0.6679
	Duct savings	683	0.0231	0.0565	-0.1222	0.3753
	Other savings	683	-0.0218	0.1401	-1.1610	0.4781
	Clothes drying use	683	0.0795	0.0647	0.0000	0.3257
	Other end use consumption	683	0.0376	0.0584	0.0000	0.2441
	Cooking use	683	0.5238	0.2374	0.1125	1.1473
Participants	Therms	1641	1.2364	1.0468	0.0333	9.5484
	Base case heating use	1641	0.7449	1.0250	0.0000	5.7413
	Efficent furnace savings	1641	0.0496	0.1076	0.0000	0.7301
	Duct savings	1641	0.0358	0.0927	-0.4402	0.9138
	Other savings	1641	-0.0464	0.1350	-0.9968	0.6565
	Clothes drying use	1641	0.0676	0.0412	0.0000	0.1724
	Other end use consumption	1641	0.0385	0.0597	0.0000	0.3230
	Cooking use	1641	0.5279	0.2516	0.1230	2.0114

Participation Decision Model

Group	Variable	N	Mean	Std Dev	Minimum	Maximum
Nonparticipants	Number of residents in home	56	3.27	1.21	1.00	7.00
	Homeowner has a college education	56	0.55	0.50	0.00	1.00
	Energy efficiency was an important home purchase factor	56	0.50	0.50	0.00	1.00
	Builder only builds production homes	56	0.68	0.47	0.00	1.00
	Builder only builds custom homes	56	0.11	0.31	0.00	1.00
	Energy efficiency ranked 1st or 2nd in construction approach	56	0.04	0.19	0.00	1.00
	Quality ranked 1st in construction approach	56	0.55	0.50	0.00	1.00
	Builder constructs luxury homes	56	0.38	0.49	0.00	1.00
	Builder believes buyers are willing to pay for energy efficiency	56	0.38	0.49	0.00	1.00
	Builder believes energy efficiency improves home salability	56	0.73	0.45	0.00	1.00
	Number of homes builder built in 1994-96 period	56	29.89	14.67	4.47	54.77
	Climate zone 11 indicator	56	0.18	0.39	0.00	1.00
	Climate zone 12 indicator	56	0.54	0.50	0.00	1.00
Participants	Number of residents in home	110	3.05	1.12	1.00	5.00
	Homeowner has a college education	110	0.65	0.48	0.00	1.00
	Energy efficiency was an important home purchase factor	110	0.65	0.48	0.00	1.00
	Builder only builds production homes	110	0.82	0.39	0.00	1.00
	Builder only builds custom homes	110	0.04	0.19	0.00	1.00
	Energy efficiency ranked 1st or 2nd in construction approach	110	0.16	0.37	0.00	1.00
	Quality ranked 1st in construction approach	110	0.37	0.49	0.00	1.00
	Builder constructs luxury homes	110	0.14	0.34	0.00	1.00
	Builder believes buyers are willing to pay for energy efficiency	110	0.38	0.49	0.00	1.00
	Builder believes energy efficiency improves home salability	110	0.87	0.33	0.00	1.00
	Number of homes builder built in 1994-96 period	110	21.93	10.41	1.00	48.99
	Climate zone 11 indicator	110	0.15	0.35	0.00	1.00
	Climate zone 12 indicator	110	0.58	0.50	0.00	1.00

Electric Efficiency Model

Group	Variable	N	Mean	Std Dev	Minimum	Maximum
Nonparticipants	Cooling Efficiency	56	0.0491	0.1852	-0.3293	0.4654
	Participation indicator	56	0.0000	0.0000	0.0000	0.0000
	Mills Ratio 1	56	-1.2771	1.0817	-5.5901	-0.0725
	Mills Ratio 2	56	0.0000	0.0000	0.0000	0.0000
	Home size (sq. ft.)	56	1927.0500	581.6472	892.0000	4116.0000
	Number of levels in home	56	1.4107	0.4964	1.0000	2.0000
	Home not part of a subdivision	56	0.1071	0.3121	0.0000	1.0000
	Number of residents in home	56	3.2679	1.2134	1.0000	7.0000
	Energy efficiency ranked 1st or 2nd in construction factors	56	0.0357	0.1873	0.0000	1.0000
	Builder only builds production homes	56	0.6786	0.4713	0.0000	1.0000
	Climate zone 11 indicator	56	0.1786	0.3865	0.0000	1.0000
	Climate zone 12 indicator	56	0.5357	0.5032	0.0000	1.0000
Participants	Cooling Efficiency	110	0.2723	0.1235	-0.0300	0.6425
	Participation indicator	110	1.0000	0.0000	1.0000	1.0000
	Mills Ratio 1	110	0.6208	0.5334	0.0092	2.5691
	Mills Ratio 2	110	0.6208	0.5334	0.0092	2.5691
	Home size (sq. ft.)	110	2011.2600	530.5300	1205.0000	3626.0000
	Number of levels in home	110	1.4364	0.5163	1.0000	3.0000
	Home not part of a subdivision	110	0.0636	0.2452	0.0000	1.0000
	Number of residents in home	110	3.0455	1.1202	1.0000	5.0000
	Energy efficiency ranked 1st or 2nd in construction factors	110	0.1636	0.3716	0.0000	1.0000
	Builder only builds production homes	110	0.8182	0.3875	0.0000	1.0000
	Climate zone 11 indicator	110	0.1455	0.3542	0.0000	1.0000
	Climate zone 12 indicator	110	0.5818	0.4955	0.0000	1.0000

Gas Efficiency Model

Group	Variable	N	Mean	Std Dev	Minimum	Maximum
Nonparticipants	Heating Efficiency	54	-0.0023	0.0822	-0.2035	0.1325
	Participation indicator	54	0.0000	0.0000	0.0000	0.0000
	Mills Ratio 1	54	-1.2951	1.0976	-5.5901	-0.0725
	Mills Ratio 2	54	0.0000	0.0000	0.0000	0.0000
	Home size (sq. ft.)	54	1915.3500	587.5621	892.0000	4116.0000
	Number of levels in home	54	1.4259	0.4991	1.0000	2.0000
	Home not part of a subdivision	54	0.1111	0.3172	0.0000	1.0000
	Number of residents in home	54	3.2593	1.2314	1.0000	7.0000
	Energy efficiency ranked 1st or 2nd in construction factors	54	0.0370	0.1906	0.0000	1.0000
	Builder only builds production homes	54	0.7037	0.4609	0.0000	1.0000
	Climate zone 11 indicator	54	0.1852	0.3921	0.0000	1.0000
	Climate zone 12 indicator	54	0.5556	0.5016	0.0000	1.0000
Participants	Heating Efficiency	96	0.0593	0.0817	-0.0916	0.2836
	Participation indicator	96	1.0000	0.0000	1.0000	1.0000
	Mills Ratio 1	96	0.6283	0.5291	0.0233	2.5691
	Mills Ratio 2	96	0.6283	0.5291	0.0233	2.5691
	Home size (sq. ft.)	96	2034.4000	506.4268	1205.0000	3626.0000
	Number of levels in home	96	1.4792	0.5022	1.0000	2.0000
	Home not part of a subdivision	96	0.0625	0.2433	0.0000	1.0000
	Number of residents in home	96	3.0521	1.1459	1.0000	5.0000
	Energy efficiency ranked 1st or 2nd in construction factors	96	0.0833	0.2778	0.0000	1.0000
	Builder only builds production homes	96	0.8125	0.3924	0.0000	1.0000
	Climate zone 11 indicator	96	0.1667	0.3746	0.0000	1.0000
	Climate zone 12 indicator	96	0.6458	0.4808	0.0000	1.0000

D.4 DATA SCREENING AND ANALYSIS

D.4.1 Outliers, Missing Data Points and Weather Adjustment

Outliers: Eighteen outlier observations, with studentized residuals greater that 4 in absolute value were removed from the electric SAE model. For the gas model, the same outlier screening was conducted, but no outliers were removed. The gas model that excluded outliers had coefficients for cooking and clothes drying that increased substantially (to the 1.5 range), returning cooking and clothes drying usage estimates that were deemed less reasonable than the model with all observations.

Missing data points: Sites with missing builder survey data were excluded from the efficiency choice model.

Weather adjustment: All space cooling variables in the electric SAE model were interacted with the ratio of actual-to-normal cooling degree days (65 degree base) to account for differences between billed consumption that reflect actual weather and the engineering cooling estimates that reflect normal weather. The same approach was used for space heating variables in the gas SAE model, but a heating degree day ratio was applied.

D.4.2 Control for the Effects of Background Variables

For the SAE models, engineering equations that incorporated customer behavior as well as site characteristics were used to control for differences between participants and nonparticipants. For the efficiency choice models, site-specific and builder-specific variables were included to account for factors that could lead to differences in energy efficiency in addition to Program participation.

D.4.3 Screening Data

See the database management and attrition discussion above.

D.4.4 Regression Statistics

Regression statistics are provided in the following tables.

Electric SAE Model, Dependent Variable: Billed Consumption

Variable	Parameter Estimate	t-statistic
Base case cooling use	0.842	60.8
Efficient AC savings	-0.842	-60.8
Duct savings	-2.094	-9.7
Other cooling savings	-0.276	-6.1
Pool/Spa use	1.019	22.5
Other end use consumption	1.059	78.3
Number of observations	3,762	
Adjusted R^2	0.7634	

Gas SAE Model, Dependent Variable: Billed Consumption

Variable	Parameter Estimate	t-statistic
Base case heating use	0.881	79.4
Efficient furnace savings	-0.881	-79.4
Duct savings	-0.542	-3.4
Other savings	-0.491	-5.8
Cooking use	0.708	2.3
Clothes drying use	1.148	3.7
Other end use consumption	0.950	24.5
Number of observations	3,377	
Adjusted R^2	0.7477	

Participation Decision Model
Dependent Variable: Program Participation

Variable	Parameter Estimate	t-statistic
Intercept	2.335	1.7
Number of residents in home	-0.336	-1.6
Homeowner has a college education	0.700	1.5
Energy efficiency was an important home purchase factor	0.716	1.6
Builder only builds production homes	1.109	2.0
Builder only builds custom homes	-2.002	-1.9
Energy efficiency ranked 1st or 2nd in construction approach	2.346	2.6
Quality ranked 1st in construction approach	-0.595	-1.3
Builder constructs luxury homes	-0.951	-1.8
Builder believes buyers are willing to pay for energy efficiency	-1.984	-3.1
Builder believes energy efficiency improves home salability	2.087	3.3
Number of homes builder built in 1994-96 period	-0.119	-4.1
Climate zone 11 indicator	-0.617	-0.9
Climate zone 12 indicator	0.696	1.3
Number of observations	166	
Log likelihood ratio	0.3399	

Cooling and Heating Efficiency Models
Dependent Variable: Efficiency Relative to Base Case Usage

	Cooling Efficiency		Heating Efficiency	
Variable	Parameter Estimate	t-statistic	Parameter Estimate	t-statistic
Intercept	-0.089766	-1.56	-0.024414	-0.68
Participation indicator	0.311329	8.26	0.090874	4.07
Mills Ratio 1	-0.040178	-2.37	-0.011407	-1.14
Mills Ratio 2	-0.000571	-0.02	-0.005590	-0.30
Home size (sq. ft.)	0.000027	1.19	0.000012	0.85
Number of levels in home	0.095792	3.52	0.027883	1.67
Home not part of a subdivision	0.049693	1.27	0.010429	0.44
Number of residents in home	-0.005896	-0.60	-0.008271	-1.39
Energy efficiency ranked 1st or 2nd in construction factors	-0.090452	-2.50	-0.060194	-2.20
Builder only builds production homes	-0.035403	-1.37	-0.000027	0.00
Climate zone 11 indicator	-0.126062	-3.66	0.013101	0.60
Climate zone 12 indicator	-0.065411	-2.24	-0.053793	-2.90
Number of observations	166		150	
Adjusted R^2	0.4611		0.1969	

D.4.5 Specification

See Section 5.2 of the report for a discussion of the SAE model. See 6.4 of the report for a discussion of the efficiency choice model.

Heterogeneity

Variations in energy use across customers was addressed through the use of engineering algorithms that took into account customer behavior as well as site characteristics.

Changes

Weather variables were included in the model as well as engineering usage estimates that contained seasonal variation.

Self-Selection

The efficiency choice model utilized participation decision equation to estimate the probability of participation as a function of site and builder variables. Mills ratio variables were developed from the predicted probability of participation and included in the cooling and heating efficiency models to account for self selection. bias.

Omitted Factors

NA

Interpretation as Net Impacts

In the efficiency choice model, participant and nonparticipant efficiency improvements over Title 24 compliance energy consumption are modeled as a function of program participation and other variables such as house size and builder characteristics. Differences between participant and nonparticipant efficiencies are captured in the program participation variable that is included in the model. The coefficient on this variable is the amount of efficiency improvement attributable to the Program. Thus, the result of the efficiency choice model is an estimate of net savings.

Other factors that can also cause differences in site-level efficiency are also included as model variables in order to factor out their confounding effects on the estimate of efficiency improvement due to the Program.

Since the estimation of efficiency choice model utilizes differences between participants and nonparticipants to quantify the impacts of Program participation on efficiency improvements, the efficiency choice approach is entirely consistent with Table 5 net impact guidelines in the M&E Protocols.

D.4.6 Error in Measuring Variables

Surveyor training and quality control procedures were utilized to minimize measurement error in on-site data collection.

D.4.7 Autocorrelation

For the SAE models, a generalized least squares procedure was used mitigate the effects of autocorrelation.

D.4.8 Heteroskedasticity

The SAE models were estimated on a use-per-day basis to mitigate the effects of varying billing cycles. No other attempt was made to address heteroskedasticity which usually not considered a problem in these types of residential analysis.

D.4.9 Collinearity

Multicollinearity between regression variables was reviewed using standard statistical output. For the gas SAE model, multicollinearity between the cooking, clothes drying, and other end use-variables was detected. Concerns about the impacts of multicollinearity influenced the choice not to remove outliers from the gas model. See Section D.1. above.

D.4.10 Influential Data Points

Studentized residuals were reviewed. Models were run without the largest outliers. Outliers were removed from the electric SAE model but not from the gas SAE model. See Sections D.1. and D.9. above.

D.4.11 Missing Data

See Section D.1.

D.4.12 Precision

Gross savings precision was based on standard errors of the regression parameters of the energy savings variables in the SAE models. For heating and cooling, net savings precision was based on the standard error of the regression parameters for the program savings variables in the electric and gas components of the efficiency choice model. For cooking and clothes drying, standard errors for the gas cooking and clothes drying variables in the SAE model were combined with standard errors of the self-report net-to-gross ratios to develop net saving precision.

D.5 DATA INTERPRETATION AND APPLICATION

D.5.1 Net Impacts

For space cooling and space heating the methods used in this study provide net impacts according to method 1a of Section E of Table 7. For cooking and clothes drying end uses net impacts were derived using method 1b of Section E of Table 7.

D.5.2 Rationale

See Sections 5 and 6 of the report for the rationale for the approach taken. Section 5.2 outlines the reason for using an SAE model to develop gross impacts. Section 6.4 presents the rationale for using an efficiency choice model to develop net impacts for cooling and heating. Section 6.5

presents rationale for the choice of a self-report net-to-gross method do determine net impacts of cooking and clothes drying.