EVALUATION, MEASUREMENT, AND VERIFICATION OF THE 2004 & 2005 CALIFORNIA STATEWIDE ENERGY STAR® NEW HOMES PROGRAM

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FINAL REPORT

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This study was funded through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org.

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RLW Analytics' California and New York team members contributed enthusiasm and dedication to the success of this evaluation: Clark Bernier, Justin Kjeldsen, Jarred Metoyer, Robert Kasman, Stacia Okura, Alea German, Amber Watkins, Eric Swan, Jason Meyer, Kevin Cracknell, Monica Hartlauer, Rima Gupta, Michael Holbrook, Ed Smyth, and Roger Wright. Thank you.

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Executive Summary

This document is the evaluation, measurement and verification (EM&V) report for the 2004 and 2005 California ENERGY STAR® New Homes Programs. California's Investor Owned Utilities Pacific Gas & Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Southern California Gas (SoCalGas) each implemented the ESH program in their respective service territories. This evaluation of the 2004 and 2005 ESH program is a study mandated by the California Public Utility Commission (CPUC) and the contract was managed by Pacific Gas and Electric. It was funded through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org. RLW Analytics (RLW) was the primary evaluation, measurement and verification contractor on this project. Skumatz Economic Research Associates (SERA) was responsible for the determination of the multifamily net to gross, the non-energy benefits (NEBS), and one version of the single family net to gross ratio included in this report.

ENERGY STAR® New Homes Program Overview

The California ENERGY STAR® New Homes Program (ESH Program) provides financial incentives, education, and marketing assistance to California builders who construct new residences that exceed the state's mandatory minimum energy efficiency standards. The program targets single family (SF) production builders and multifamily (MF) developers. Participating builders that exceed California's Title 24 residential standards by 15% or more receive cash incentives, in addition to training and marketing support.

Like any new construction program, the ESH program has a long project cycle, due to production times associated with construction of new homes. Program participants have 24 months from the time they are accepted into the Program to complete construction. The longevity of the Program is important to understand what is included in this evaluation. This evaluation only considers projects that were *completed within or prior to* 2004 or 2005, and *approved in* 2004 and 2005. A structure is considered "complete" when its construction is complete, and is considered "approved" when it has completed *and passed* all necessary post-construction C-HERS inspections required for program participation.

Evaluation Objectives

This study is the second impact evaluation conducted for the Statewide ESH program.[1] This study also includes a comprehensive process evaluation of the program. The primary goal of this evaluation is to provide gross and net impact savings estimates for the single family and multifamily components of the 2004 and 2005 ESH programs.

Three distinct approaches were attempted to evaluate the gross and net impacts resulting from the single family Program: an engineering-based "difference-of-differences" approach to estimating net savings, a survey-based net to gross estimation, and an econometric billing data analysis. A less rigorous evaluation method, termed the "simple gross", was used for measuring gross savings resulting from the multifamily

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[1] The first, *Evaluation, Measurement and Verification of the 2002 and 2003 California Statewide Energy Star New Homes Program Phase II Report*, can be found on the CALMAC website, www.calmac.org.

Program component. Survey data were collected from builders of multifamily projects for determining construction practices absent the Program and overall net Program effects.

There were several key data sources used by RLW to conduct this evaluation. The first data sources were the California Home Energy Efficiency Rating System (CHEERS) and the CalCERTS Registries. Registry data includes detailed building characteristics information for participant structures from Title-24 compliance documentation.

Another key data source used for this study was the 2004 Residential New Construction Baseline Study[2] (the baseline study). It is important to note that the baseline study grouped CEC climate zones into five Regional Market Share Tracking (RMST) climate zones. The study's prime contractor provided RLW with raw data collected by building surveyors, as well as structure-specific compliance software output generated in the process of conducting the baseline study.

RLW also conducted a metering study of single family and multifamily participants to determine annual gas and electric energy consumption of the three primary end-uses (i.e., space heating, space cooling, and water heating) that builders can affect through implementation of energy conservation measures at the time of construction. The meter data were compared to the annual energy usage output of Title 24 software programs using actual weather data. The end-use metering data were then used to "calibrate" the model consumption and subsequent savings for actual occupancy and energy usage.

For the billing analysis, billing usage data was acquired from each of the investor owned utilities (IOUs). Several thousand participant single family homes' billing data were collected covering an eighteen month period, where available. Billing usage data was also collected for the non-participant (baseline) homes. A demographic survey was conducted with a subset of participant and non-participant homes to supplement the billing analysis. The billing analysis results were not used to adjust the savings estimates for a few reasons: the sample sizes were relatively small, it was only performed for two climate zones where data were available, and the consumption estimates need to be validated through further research to fully understand behavior-adjusted end-use savings.

RLW obtained Program estimates of gas and electric savings from each investor owned utility, at the unit level. RLW required this information in order to determine the aggregate ex ante Program savings. Some background is provided as it is useful for understanding why RLW was required to calculate the ex ante savings.

Key Evaluation Findings

Program Participation

Table 1 shows the number of approved units by type and utility. The total number of dwelling units *completed within or prior to* 2004 or 2005, and *approved in* 2004 and 2005 was 52,349. Of these, there were a total of 31,113 single family ENERGY STAR Homes, with the remainder being multi-family units.

[2] 2004 California Residential New Construction Baseline Study (Itron, 2004).

Utility	2004-05 Dwelling Units			
	Single Family	Low Rise Multi-Family	High Rise	Total
PGE	12,309	2,758	269	15,336
SCE	13,297	2,791	504	16,592
SoCalGas	1,191	6,322	602	8,115
SDGE	4,316	7,257	733	12,306
Total	31,113	19,128	2,108	52,349

Table 1: Summary of Dwelling Units Completed

Ex ante and ex post energy savings were estimated based on *actual dwelling units approved* in calendar years 2004 and 2005, as shown in Table 1.

Net Program Energy Savings and Net Realization Rates

Total program net ex post electricity savings were 23,741,818 kWh and 25,504 kW and gas savings were 1,255,434 therms. These savings include all program participants: single family, multifamily low-rise and high-rise projects. SCE did not claim any ex ante gas savings, although the participants that they funded through their program did generate gas savings. Similarly, SoCalGas participant customers achieved electricity savings even though these savings do not impact SoCalGas directly. SoCalGas did claim their ex ante electricity savings. Therefore, realization rates could only be calculated when ex ante estimates were available. As explained in the introduction, ex ante values were calculated for "approved units" based on each utility's original per-dwelling-unit savings estimates. Ex ante and ex post calculation methods are described in chapters throughout this report. Utility electricity savings realization rates for single family, multifamily, and high-rise[3] projects are:

Utility	kWh			Therms			kW		
	Net Ex Ante	Net Ex Post	Realization Rate	Net Ex Ante	Net Ex Post	Realization Rate	Net Ex Ante	Net Ex Post	Realization Rate
PGE	3,786,119	7,241,155	1.91	1,457,778	634,533	0.44	4,170	7,686	1.84
SCE	14,038,346	12,694,362	0.90	NA	371,772	NA	17,980	13,730	0.76
SoCalGas	2,874,807	2,050,545	0.71	234,344	97,608	0.42	4,194	2,202	0.53
SDGE	5,139,179	1,755,755	0.34	242,489	151,521	0.62	8,141	1,886	0.23
Total	25,838,451	23,741,818	0.92	1,934,611	1,255,434	0.65	34,485	25,504	0.74

Table 2: Combined (SF, MF, and high-rise) Electricity and Gas Savings Realization Rates

RLW used a peak factor or an 'H-factor' approach to estimating coincident kW reduction. RLW used the same 'H-factor' values that were used by the utilities for program planning. The 'H-factor' values are documented in the impact methodology chapter. These 'H-factors' were applied to the ex-post net energy savings values by utility and building type (single family vs. multifamily) to obtain ex-post net kW savings. Note that

3 High Rise ex ante values were estimated by applying low-rise multifamily per unit savings estimates.

this method does not provide any independent verification of actual kW savings. RLW did not provide any verification of the "H-factor" under this contract[4].

Single Family Net to Gross (NTG)

The single family NTG results are shown in Table 3. The single family NTG results were derived using a "Difference of Differences" approach to estimating the net impact. Electricity NTG ratios vary widely across IOUs, from 0.85 to 1.54. The statewide electric NTG ratio is 1.23. This is consistent with the new construction baseline study used for the analysis, and is a direct result of less cooling savings than expected among non-participants.[5] That is, on average, non-participant homes do not meet Title 24 package D cooling energy budgets. In fact, the non-participant baseline study found that 27% of homes surveyed did not meet Title 24 energy requirements period.

Gas NTG ratios are more consistent across IOUs and Program years. The statewide gas NTG ratio is 0.40, implying high average free-ridership of 60%. This is a direct result of high naturally occurring "savings" in the two gas end-uses, heating and especially water heating.

Utility	kWh			Therms		
	Ex Post Gross Savings	Ex Post Net Savings	Net-to-Gross Ratio	Ex Post Gross Savings	Ex Post Net Savings	Net-to-Gross Ratio
PGE	4,644,067	7,173,746	1.54	1,167,600	589,615	0.50
SCE	10,338,359	12,483,162	1.21	1,009,965	336,516	0.33
SoCalGas	2,078,956	1,760,013	0.85	55,012	22,154	0.40
SDGE	1,506,207	1,396,234	0.93	300,772	71,301	0.24
TOTAL	18,567,589	22,813,155	1.23	2,533,350	1,019,586	0.40

Table 3: SF Electric (kWh) and Gas (Therms) Net to Gross Ratios

Multifamily and High Rise Net to Gross (NTG)

The multifamily NTG ratio was determined through telephone surveys, conducted by SERA. A single NTG ratio was estimated statewide for all utilities, for both fuel types, and both 2004 and 2005 program years. Although SERA did estimate market effects as part of this project, the policy rules for this cycle of programs do not permit the inclusion of spillover and market effects in the reported official results, therefore the NTG ratio used to compute net savings *only accounts for free ridership*.

Multifamily NTG_{MF}: 0.50

Details of the estimation methodology can be found in this report in the Impact Methodologies section.

However, if spillover and market effects could be fully accounted for, which would constitute savings net of the combined effects of free ridership and indirect spillover

[4] The CPUC agreed to a simplified ex-post kW calculation method during the planning stages of the study (December 1, 2006).

[5] As determined by the 2004 California Residential New Construction Baseline Study (Itron, 2004). Non-participant homes exceeded cooling budgets primarily in inland climate zones. Some homes made up the deficit with energy savings in other areas (heating or hot water), but the study found that 27% of homes surveyed were not Title 24 compliant. The compliance of another 30% could not be determined within the error bounds of the data collected.

effects (zero or positive effect on NTG), we might expect the NTG ratio to be as high as 0.63 (between 0.55 to 0.71) as explained by SERA in the appendix.

General Conclusions & Recommendations

The estimates of baseline usage that come from the compliance software may be overestimated for non-participants. There is no common or distinct difference in building characteristics between ES homes and non-participant homes. The only consistent finding was that over 90% of ES homes take modeled energy credits for two HERS measures: tight ducts (<6% leakage) and reduced air infiltration. It is entirely possible that some non-participant homes would have qualified for these energy credits, but did not take credit for them in their compliance model on account of testing costs. This would reduce the savings due to the program by decreasing the net to gross ratio.

The orientation of a home can significantly affect its space cooling and heating energy requirements. The percentage difference between the worst energy orientation and the average energy orientation ranged from 17% to 46%. This means that only recording the worst orientation or only recording the average of the orientations of a home in the registries can dramatically misstate savings of specific homes. The costs of recording the orientation of each surveyed home would not be prohibitive, especially relative to the benefit of more accurate records of program performance.

A new RNC baseline study should be performed. A new RNC baseline study should be performed before the 2006-08 RNC impact evaluation is performed. The baseline study should be representative of all CEC climate zones where new homes are being constructed. The selection of non-participants should be unbiased and representative of all non-participant new homes. The study should be designed at the outset as the baseline for the RNC evaluation, including a designated method for calculating net to gross by verifying as-built efficiencies and characteristics and ensuring that the appropriate data points are collected for inclusion in a billing or metering analysis.

The metered data indicate that the compliance software overestimate the amount of cooling, heating, and water heating energy consumed at a site, and hence overstate savings. Further exploration of this issue through billing data analysis, additional mining of the existing metered data, and added metering should be undertaken to verify the finding and understand the impact on compliance and overall residential consumption in the state.

The billing analyses performed for CZ8 and CZ12 indicates that participants use more electricity and fewer therms than non-participants. Controlling for housing characteristics as well as demographic information, ENERGY STAR® homes participants used more energy with the exception of CZ12 gas usage. The demographic question results all point to non-participants using more energy than participants, and even controlling for these variables, we see participants with higher usage.

Utilities should track participation information in a common database**.** The implementers need a statewide Program tracking system, other than the CHEERS and CalCERTS registries that ties a building plan to a payment amount and date. The registries are not an effective system for tracking Program information, especially as new C-HERS providers become active and begin working with participant builders.

Most high rise buildings took advantage of loopholes in Title-24 water heating requirements to achieve program compliance. These loopholes were closed with the October 2005 Title-24 update, but all high rise buildings completed in 04-05 (in this evaluation) entered the program under 2001 Title-24 while the loopholes were still open. While the 0.5 multifamily NTG ratio reflects some of this free-ridership, probably very few of these high rise buildings would have qualified for the ENERGY STAR® program without this loophole.

Studies should be conducted on the metering data to learn more about residential usage patterns for builder-affected end-uses. As a result of this study, we have collected one of the most extensive sets of residential end-use meter data ever collected in the state of California. This study has made one use of those data—revising the end-use estimates of the compliance models—but we have the ability, among other things, to build complete annual hourly load curves for each end-use with this data, and it would be a waste to see those data go unexplored.

Total Resource Cost Test

This evaluation does not include a test of measure or program cost-effectiveness. Although we would like to include a measurement of program cost effectiveness, this CPUC requirement is not feasible given the life cycle of the 2004-05 ESH Program. The evaluation protocols for this segment look at projects completed in the evaluation year. As an example, for the 2004-05 program evaluation we evaluated program year 2002, 2003 and 2004 projects, a hybrid participant population representing two different programs. Since some of the 2004-05 projects will not be completed until 2007 or even early 2008, RLW cannot know what the total number of completed projects will be, nor can we know the total energy savings. Without knowing the actual participation or total program savings, it would be a futile exercise to try and estimate program cost effectiveness. We suggest making this a requirement of the next program year evaluation, which should be able to look retrospectively at the evaluation results from previous years in order to calculate cost-effectiveness. We can however obtain a general picture of where the program is likely to end up based upon the realization rate for the projects completed in 2004-05.

The kWh realization rate is less than 1.0 for all IOUs except for PG&E. This is a result of the other three IOUs expecting 2.5 to 4.5 times more ex-ante savings *per unit* than PG&E. Table 4 presents the IOU projected (i.e., the TRC at the beginning of the program) and recorded (i.e., the TRC at the end of the program) TRC ratios from the final 2004-05 EEGA workbooks. The TRC benefit cost ratio in the Program Plans are based on the achievement of 100% of ex ante savings estimates.

Using PG&E as an example, the ex ante recorded TRC was forecasted to be 0.85, lower than the other TRC ratios estimated by the other IOUs. We have estimated the overall kWh realization rate for PG&E to be 1.9, which alone would push PG&E's program into the cost-effective range. However, PG&E's therm realization rate is less than 50%, which would bring down the TRC to the non cost-effective range.

For SCE, the TRC is recorded as 1.0. With a kWh realization rate of 90%, or achieved savings 10% less than SCE expected, the TRC would likely be slightly less than 1. For SoCalGas, the TRC is recorded as 1.87. With a kWh realization rate of 71% and a therm realization rate of 42%, the TRC would likely be less than 1. For SDGE, the TRC is recorded as 1.1. With a kWh realization rate of 34% and a therm realization rate of 62%, the TRC would be less than 1 and the program is not going to be cost-effective.

Total Resource Cost Test from EEGA		
Utility	**Projected**	**Recorded**
PGE	0.70	0.85
SCE	0.88	1.03
SoCalGas	1.16	1.87
SDGE	0.67	1.11

Table 4: IOU Total Resource Cost Test Results (Final EEGA Workbook)

Introduction

This measurement and verification (EM&V) report of the ENERGY STAR® New Homes Programs (ESH program) is a study mandated by the California Public Utility Commission (CPUC) and managed by Pacific Gas and Electric. It was funded through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org. RLW Analytics, Inc. (RLW) was the primary evaluation, measurement and verification contractor on this project. Skumatz Economic Research Associates (SERA) was responsible for determination of the multifamily net to gross, one of the single family net to gross ratios, and non-energy benefits (NEBS) included in this report.

ENERGY STAR® New Homes Program Overview

The California ENERGY STAR® New Homes Program provides financial incentives, education, and marketing assistance to California builders who construct new residences that exceed the state's mandatory minimum energy efficiency standards. The program targets single family production builders and multifamily developers. California's energy efficiency standards for residential and non-residential new buildings are set by the California Energy Commission (CEC) in the Title 24 energy code.[6] Since residential energy consumption is significantly affected by weather, Title 24 recognizes sixteen distinct climate zones within California as shown in Figure 1. The ESH program divides these sixteen climate zones into two groups: coastal and inland. Coastal climate zones are defined to be CEC climate zones 1-7, and inland climate zones are 8-16.

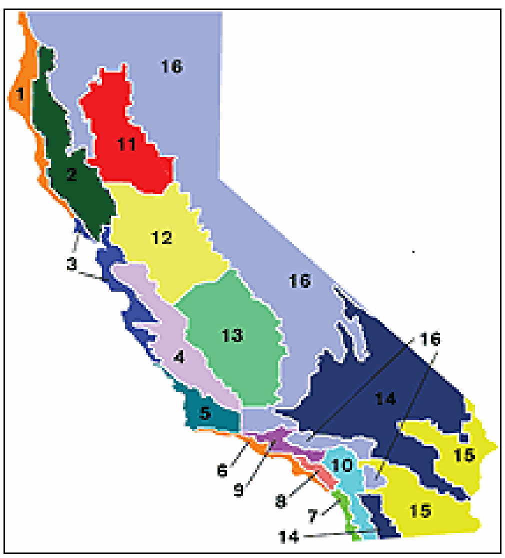

Figure 1: California Energy Commission 16 Climate Zones

6 http://www.energy.ca.gov/title24/

Participating builders that build structures that exceed California's Title 24 residential standards by 15% or more receive cash incentives, in addition to training and marketing support. Table 5 summarizes the dollar amount a builder received for each unit that met ESH program standards.

	SINGLE FAMILY				MULTIFAMILY			
	Inland		Coastal		Inland		Coastal	
Program Year	15% better	20% better	15% better	20% better	15% better	20% better	15% better	20% better
2004-05	500	700	400**	-	150*	-	150*	-

* Plus assistance ($50 for inspection, $40 design assistance for SCE/PGE)
** Not offered for SCE

Table 5: 2004-2005 Incentive Rates per Unit

Like any new construction program, the ESH program has a long life cycle, due to the long lead times associated with construction of new homes. Program participants have 24 months from the time they are accepted into the Program to complete construction. In some cases, program managers provide three month extensions to participants requesting additional construction time. For example, under the 2002 ESH program, builders were able to participate up until December 31, 2002, after which they had roughly 24 months to finish the projects. Thus, the final projects were allowed to be completed by December 31, 2004, or possibly later if time extensions were granted to any of the participant builders.

The longevity of the Program is important to understand what is included in this evaluation. As noted above, this evaluation only considers projects that were completed and approved[7] in 2004 and 2005.

[7] A structure becomes "approved" when its construction is complete and it has completed and passed all necessary C-Hers inspections.

Program Flow Overview

Figure 2 gives a brief description of the process of program participation and the connection between the various parties involved with the California ENERGY STAR® Program.

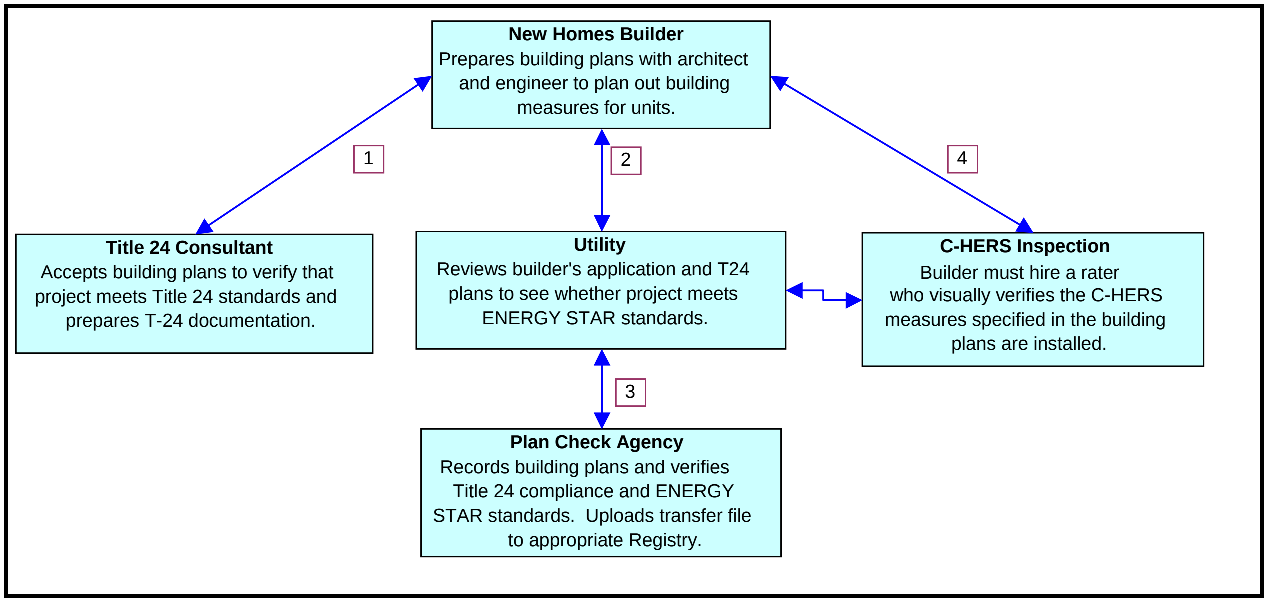

Figure 2: ENERGY STAR® Homes Program Compliance Process

Step 1: Once builders have the building designs prepared they submit the plans to Title 24 consultants who prepare the required compliance documentation. Title 24 requirements are California law, which include energy efficiency minimum requirements, and must be met by all builders, regardless of whether they intend to participate in the ENERGY STAR® Homes program or not.

Step 2: If builders want to participate in the ESH program, they must design a building that is more efficient than the minimum Title 24 requirements to meet Program requirements (at least 15% higher than minimum compliance margins). Builders must submit their building plans, Title 24 documentation, and a short application to the appropriate utility. At this stage, construction is usually in the planning and design, or early construction stage. If the utility approves the application, the ESH program reserves incentive funds for the builder based on the projected number of units approved.

Step 3: After the utility reviews and approves the builder's project(s), it submits the building plans to a plan check agency that confirm Title 24 and ESH program compliance. Once approved, the plan check agency uploads the Title 24 output file (called the "transfer file") to the CHEERS and CalCERTS registries.

Step 4: Once builders have actually constructed the homes, they must hire a HERS rater to verify HERS measures, if any, *and to verify all other design specifications specified in the Title 24 file including elements of the building envelope, fenestration and mechanical systems*. Verifications are completed via on-site inspection(s) and/or test(s) of the constructed unit. If a builder constructs multiple units of the same design, not every unit requires inspection, but a sample of units is inspected.

Each utility had somewhat different implementation methods for the program. However, major program elements such as program qualification levels and incentive levels were uniform statewide. These implementation differences are discussed further in the process evaluation chapter which discusses how the program is functioning, differences between utilities, identifies process weaknesses, and suggests opportunities for improvement.

California's Home Energy Rating System (HERS)

The California Energy Commission is required by Public Resources Code Section 25942 to establish regulations for a Home Energy Rating System (HERS) Program to certify home energy rating services in California. The goal of the program is to provide reliable information to differentiate the energy efficiency levels among California homes and to guide investment in cost-effective home energy efficiency measures.

The California HERS (C-HERS) Program includes field verification and diagnostic testing available through Commission-certified providers. The Energy Commission has a process for certifying HERS raters who perform third-party inspections to verify the presence and operational specifications of HERS measures used to gain compliance with Title 24 energy standards. Testing and verification protocols are summarized and located in both the Residential and Nonresidential Field Verification and Diagnostic Testing Regulations Manuals.

C-HERS measures are special energy efficiency measures that can be implemented by builders to achieve higher efficiency construction. To take credit for the measures, they must be inspected by a certified HERS rater. There were six C-HERS measures in effect during the 2004-2005 ESH program years (under the 2001 version of Title 24)[8], shown in Table 6.

C-HERS Measure	Rater Verification
Improved duct location (ducts in conditioned spaces)	Visual inspection
ACCA Manual D duct design and installation	Inspect/measure dimensions for compliance
Tight ducts, < 6% leakage	Duct leakage testing with duct blaster
Reduced air infiltration	Requires blower door testing and mechanical ventilation visual inspection if SLA is 3.0-1.5
TXV or proper refrigerant charge and airflow	Visual inspection for TXV, test for charge
Reduced duct surface area	Measure dimensions; requires ACCA Manual D duct design

Table 6: C-HERS Measures and Verification Method

Regulations establishing field verifications and diagnostic testing services administered by HERS providers became effective on June 17, 1999. The California Certified Energy

[8] Effective October 2005 an updated version of Title 24 was implemented in California, however all new construction covered in this report was completed in 2004 and 2005, and subject to 2001 Title 24 code.

Rating & Testing Services (CalCERTS) and the California Home Energy Efficiency Rating System (CHEERS) have been approved by the California Energy Commission (CEC) as HERS providers to oversee HERS raters providing Title 24 field verification and diagnostic testing. ENERGY STAR® Homes may include a number of C-HERS energy efficiency measures. All new or renovated homes that include C-HERS measures are contained in the Registries. Therefore, the Registries are databases of building and energy characteristics for homes with one or more C-HERS measures, and/or ENERGY STAR® homes. Again, the Registries are populated by extracting data from the Title 24 building file,[9] which is then uploaded to the appropriate Registry. Builders receive incentives from the utility once their homes pass the verification process.

Impact Evaluation Overview

This evaluation has taken more than four years from the beginning of planning to the writing of this report and has pulled data from program registries, compliance models, participant and non-participant surveys, on-site inspections, a year-long metering study, and weather data providers. Understanding the results that follow require understanding how the stages of analysis and how the various pieces of the evaluation fit together to produce the final findings.

Single Family Savings Estimation Overview

Tracking Gross savings estimates were calculated from the participant information stored in the CHEERS and CalCERTS registries. The gross savings estimates were functions of the compliance margin disaggregated into end-uses and summed by electricity and natural gas impacts.

Orientation and Inspection Adjusted Gross applied two ratios to adjust tracking gross savings for differences between the model results reported in the program tracking databases and surveyed as-built characteristics of the participant homes. The first ratio, the orientation ratio, adjusted for any discrepancy in the actual versus reported orientation of structures in the CalCERTS database. The second, the inspection ratios, were the results of any deviation between the site inspections of 110 structures and the compliance model building characteristics and the subsequent edits and runs of their Title 24 compliance models.

Ex Post Gross (meter adjustment) recalculated gross savings to account for the difference between compliance model estimates of usage and metered actual homeowner energy usage. This involved comparing a full year of end-use metered data from 101 sites to those sites' compliance model predictions when modeled under actual year weather conditions. The resulting ratios were used to adjust the adjusted gross savings to ex post gross savings.

Ex Post Net calculated net savings by using the ex post gross savings estimates of non-participants, adjusted using the same meter ratio derived for the participants, as a proxy for the savings that would have been achieved by participants in absence of the program. This analysis used the compliance model results compiled by the authors of the 2004 baseline study for the non-participant group, comparing it to participant ex

[9] A Title 24 building file, also known as a C-2R file, is an inspection report that qualifies the newly constructed home to comply with California's Title 24 standards.

post gross savings through the difference-of-differences analysis describe in the methodology section. This represents our best estimate of the actual savings attributed to the Program.

Billing Analysis was another approach used to obtain an estimate of program savings. Ultimately limited to two CEC climate zones, the billing analysis drew billing data and actual-year weather data together to produce regression-based estimates of program-induced savings. *Ultimately, the analysis was too limited to produce program savings estimates, but did serve as a useful guide for interpreting other results.*

Figure 3 shows an overview of the processes and analyses that were accomplished to arrive at final single family net and gross savings estimations.

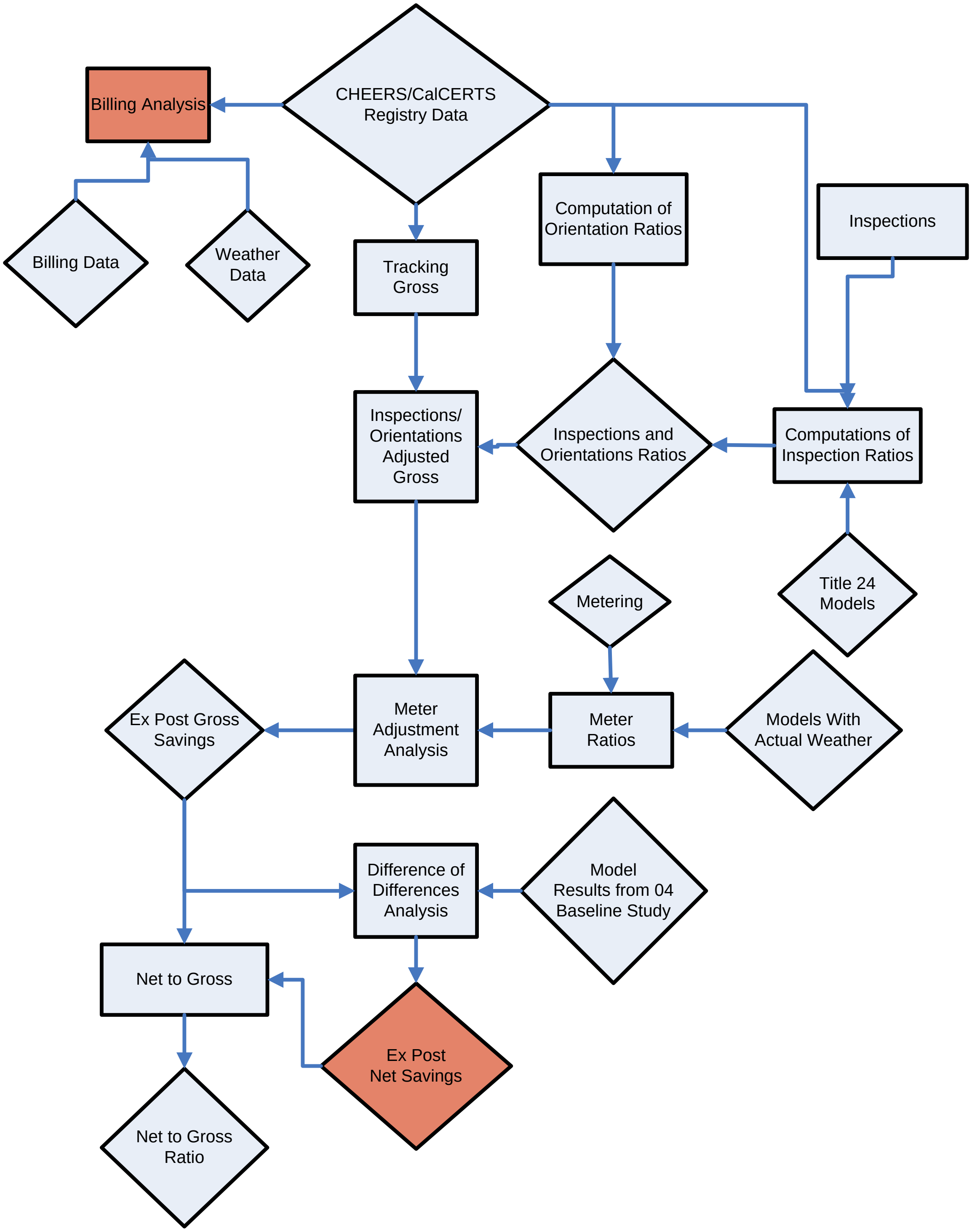

Figure 3: Single Family Gross and Net Energy Savings Calculation Flowchart

Low-Rise Multifamily Savings Estimation Overview

Tracking Gross savings estimates were calculated from the participant information stored in the CHEERS and CalCERTS registries. The gross savings estimates were functions of the compliance margin disaggregated into end-uses and summed by electricity and natural gas impacts.

Orientation Adjusted Gross adjusted tracking gross savings for differences between the model results reported in the program tracking databases and actual characteristics of the participant structures. The orientation ratio adjusted for any discrepancy in the actual versus reported orientation of structures in the CalCERTS database. There was no inspection ratio calculated or used for the multi family structures.

Ex-Post Gross (meter-adjusted) recalculated gross savings to account for the difference between compliance model estimates of usage and actual occupant energy usage. This involved comparing a full year of end-use metered data from 99 sites in 25 structures to those sites' compliance model predictions when modeled under actual year weather conditions. The resulting ratios were used to adjust orientation-adjusted gross savings to ex post gross savings.

Ex-Post Net was calculated using the net to gross ratio estimated by SERA to account for the difference between the model baseline and what would have been built in the absence of the program (taking free-ridership into account, but not spillover). The ex post gross savings estimate was multiplied by the net-to-gross ratio to yield the estimate of ex post net savings. This represents our best estimate of the actual savings attributed to the Program.

Figure 4 shows an overview of the processes and analyses that were accomplished to arrive at final multifamily net and gross savings estimations.

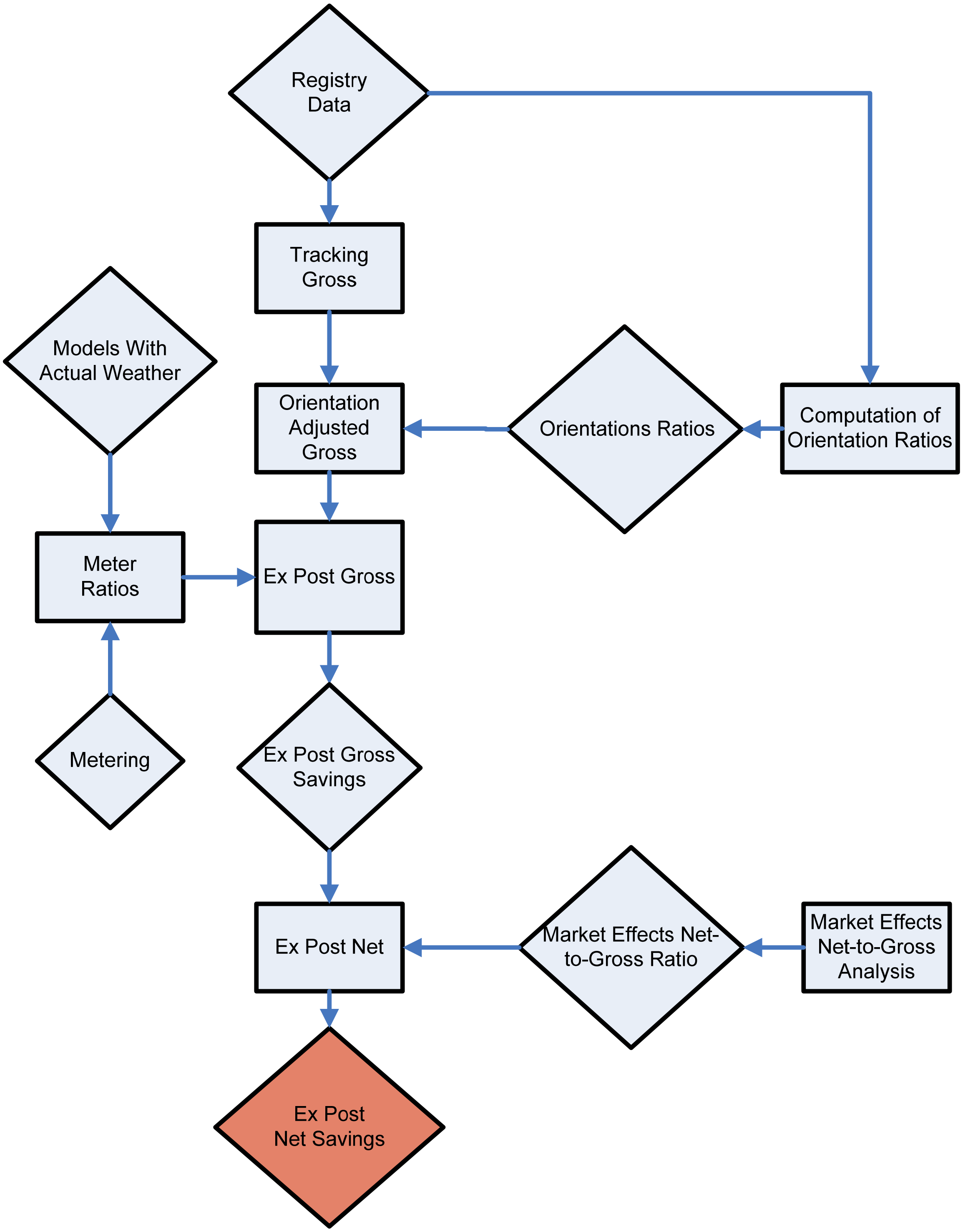

Figure 4: Multifamily Gross and Net Energy Savings Calculation Flowchart

Process Evaluation Objectives

The primary objectives of the process evaluation are to assess the level of success of the program and identify ways that it could be refined to increase its efficiency and value to the participants and the utilities. Results are expected to provide further direction on ways to streamline the program, increase the levels of energy and demand savings, and increase participant satisfaction.

These objectives were met by performing the following tasks:

- Develop a logic model of the program using materials provided by program implementation staff and staff interview information,
- Develop list of researchable questions that the process evaluation will seek to answer,
- Assess level of initial success,
- Identify ways for the program to increase the efficiency and value of the program to the stakeholders,
- Identify directions to streamline the program,
- Identify ways to increase levels of energy and demand savings achieved,
- Identify ways to increase all participant satisfaction,
- Assess whether there is a continuing need for the program.

The methodology behind the process evaluation and the resulting findings are discusses in subsequent chapters of this document.

Net Impacts Analysis Objectives

To fully assess the net attributable impacts of the program, Skumatz Economic Research Associates (SERA) conducted two analyses:

- **Net to gross analysis**: designed to analyze the direct and indirect energy efficiency and savings–related effects induced in the marketplace attributable to the Single family component of the California Statewide ENERGY STAR® New Homes Program
- **Non-energy benefits analysis**: designed to inventory and measure the "hard to measure" positive and negative non-energy effects (non-energy benefits in the literature) experienced due to the program, including effects for participants, the utilities, and society and the environment at large.

The California ENERGY STAR® New Homes program has important market transformation elements. It uses a combination of incentives and education to encourage builders to incorporate ENERGY STAR® appliances and recommended whole building design features that cause the building to exceed Title 24 energy standards by 15% or 20% or more. The program works to achieve this in several ways:

- Direct effects: The incentives and education are designed to encourage increased efficiency in a first generation of participating / rebated projects.
- Indirect Participant Effects: The experience and the education provided by the program are designed to help encourage participants to incorporate energy efficient design practices into succeeding projects (including non-participating projects).
- Indirect Market / Non-Participant Effects: In addition, the program's logic would postulate that even non-participant builders could be encouraged to incorporate more efficient practices into their projects because of the combined forces of:

- competition with other builders,
- demand in the market,
- indirect education on the benefits and costs, and on efficient design practices,
- incorporation of ENERGY STAR® homes elements into revised "standard practice" for buildings,[10] and
- increased availability (and potentially improved "price points") for energy efficient equipment in the marketplace.

However, the program may also succeed in attracting builders to the program that would have installed program measures or used program-encouraged practices even if the program had not been in place. These builders that receive program incentives (and are counted in program records) but do not add, in a net way, to the total amount of energy efficiency resulting in the marketplace, represent a "free rider" effect.

The SERA Net-To-Gross (NTG) analysis is designed to identify and measure those effects listed above – both the market effects (direct and indirect) and the free rider effects -- that occur, and provide a ratio that translates the gross savings measured based on program installations (figures from program records) into savings net of the combined effects of free ridership (generally a decrease) and indirect spillover effects (zero or positive effect).

Specifically, to provide information on the performance attributable to the program, the gross savings estimates developed through the impact evaluation need to be adjusted by the net to gross (NTG) ratio. This ratio is constructed to provide appropriate adjustment for the program's net effect – specifically, to estimate the impact of the program *above and beyond what would have happened without the program*.

Note that for the purposes of this study, **the indirect spillover effects estimated by SERA were not included in the computation of net savings**. The SERA NTG ratio that estimates the effects of free ridership was used to estimate multifamily net savings in this report. The SERA NTG ratio was not used to estimate the single family net savings that are presented in this report.

While the focus of traditional program evaluations – energy savings, awareness, market share and other metrics – provide direct indicators of program effects, a significant body of work has developed around recognizing and measuring net non-energy benefits (NEBs). NEBs include a variety of program impacts — positive and negative — that result from the program.[11] Strictly speaking, NEBs are "omitted program effects" – impacts attributable to the program, but often ignored in program evaluation work. After nearly a decade of research, more and more utilities and regulators are considering these effects.

In order to assess the NEBs associated with the California Statewide ENERGY STAR® program, Skumatz Economic Research Associates (SERA) developed a questionnaire directed at identifying NEBs accruing to Program participants and perceptions about NEBs from non-participants.

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[10] For participant and non-participant developers / builders

[11] Note that the literature has used the designation "non-energy benefits" although we examine both positive and negative impacts from energy efficiency measures. Although the conventional term NEB is used in this project, the name refers to "net" non-energy benefits.

Differences in Net to Gross Ratios

Comparing the meter-adjusted estimate of NTG from the Difference of Differences (DofD) approach to the SERA NTG ratio for the single family program, the meter-adjusted estimate of NTG from the DofD approach possibly overstates the NTG ratio. This can, in part, be due to the compliance credits that were not inspected in the baseline homes. SERA's NTG ratio is based on what the participant builders indicate they would have done in absence of the program. The DofD net-savings NTG ratio was estimated based on what the *compliance models* say non-participant builders did in absence of the program.

If non-participant builders were still building low-infiltration homes with low-leakage ductwork, then these baseline "savings" would not be reflected in the models. As such, the estimate of net savings based on the models would miss that these measures have a certain non-zero program-independent saturation. The SERA builder survey approach, on the other hand, may be better able identify this program-independent building quality as free ridership, and reduce the NTG ratio accordingly. Additional completed surveys of non-participants builders could confirm the lower NTG ratio. Additionally, a new baseline study that at the outset was designated to serve as the baseline for RNC programs would enable the evaluators to better quantify NTG. For this report, the single family NTG ratio presented in the ex post impact analysis results section is based upon the modeled non-participant net to gross ratio (DofD). These were computed at the end use and climate region level by utility and are based upon higher sample sizes than the SERA ratio.

Data Sources

RLW and SERA used numerous data sources to conduct this evaluation. This chapter discusses the data sources in the context of the each analysis in which the data were used.

Gross and Net Savings Analysis

CHEERS and CalCERTS Registry - detailed building characteristics information for participant structures, including Title-24 model output from the compliance documentation models

2004 Itron Residential New Construction Baseline Study – non-participant building characteristics and contact information including Title-24 model output from the compliance documentation models

EEGA workbooks - Program implementation estimates of unit-level gas and electric savings from each utility were obtained. RLW required this information in order to determine the ex-ante program savings.

Metering Analysis

IOU Plan Check Agency – Participants' Title 24 compliance models for use in modeling using actual-year weather

RLW Site Inspections – detailed inspection data for altering Title 24 models to reflect as-built characteristics of units

Western Regional Climate Center's Remote Access Weather Stations (RAWS) system – Hourly solar, temperature, precipitation, and wind speed data from RAWS sites throughout California, and temperature, precipitation, and wind speed data from major airports in the state

RLW End-use Meter Data – Cooling, heating, and water heating usage data collected over a one-year logging period from 101 single family sites and 99 units in 25 multi family sites.

Billing Analysis

California Home Energy Efficiency Rating System (CHEERS) Registry - detailed building characteristics information for participant structures

2004 Itron Residential New Construction Baseline Study – non-participant building characteristics and contact information

IOU Billing data – each of the investor owned utilities (IOUs) used address matching to provide 2003-2006 bills for participants and non-participants

Western Regional Climate Center – Daily temperature data from weather stations in CEC climate zones 8 and 12.

Process Evaluation

RLW interviewed utility program managers, CalCERTS registry staff, managers of firms contracted to review building plans, and design assistance contractors. Additionally, RLW worked with SERA to insert a number of process-related questions into the surveys that SERA was under contract to perform for the NEB and NTG analyses.

The tables below show the final interviewee list and counts and the completed survey counts for the process evaluation component:

Interview Respondents	Completed
Utility Staff	3
Registry Staff	1
Design Assistance Staff	1
Plan Check Consultants	1
TOTAL	**6**

Table 7: Interview Counts

Survey Respondents	Completed
Single Family Participating Builders	37
Single Family Non-Participating Builders	21
Multifamily Participating Builders	20
Multifamily Non-Participating Builders	8
Participating Homeowners	43
Non-Participating Homeowners	101
TOTAL	**230**

Table 8: Survey Counts

Net Effects Evaluation (SERA)

The information to support these analyses were gathered using detailed structured telephone interviews conducted with developers or builders of homes in the State of California who had constructed a building in 2004 or 2005.

Single Family Sample Design and Completions

The results of the calls for participating and non-participating builders and households are displayed in the Table below.

	Participant Builders	Non-Participant Builders	Participant Owners	Non-Participant Owners
Total Population	118	490	Collected by RLW	896
Non-viable Firms/Homes	40	229		431
Viable Population	78	Unknown; list included 261 viable firms		465
Completed Surveys(Respondents)	40	21	75	100
Disposition				
Unique Numbers	118	490		896
Number of Call	384	978		1318
Bad Numbers	30	167		6
Contacted	65	26		116
No Answer	17	12		656
Refusals	10	65		222
Wrong Number	15	20		78

Table 9: Single Family Completes

Multifamily Sample Design and Completions

In order to assess the State of California's ENERGY STAR® program for multifamily building development, samples of both participating and non-participating businesses were surveyed.

Source for Participant Sample: The participant sample was drawn from a database provided by RLW including the name, address, phone number, and contact information of each business. The sample consisted of firms that participated in the ENERGY STAR® program and been paid for the completion of their buildings in the years 2004 and 2005.

Participant Completions: We started with a list of 161 unique numbers. From this sample, 43 were unviable due to bad numbers that couldn't be remedied, failed qualifications, or single family construction only. Of the remaining 118 viable builder / developers that were participants in 2004-2005, only sixteen surveys could be completed, despite attempting five calls per business. Only four directly refused; the remainder was not available and/or never returned calls.

Sources for Non-Participant Sample: Non-participants were defined as multifamily builders, developers, or owners that had never participated or had not participated in 2004-2005. The non-participant sample was drawn from several locations.

- RLW Analytics provided a database with firms who had participated in the ENERGY STAR® Multifamily Home program in any one of the years since the program had been implemented. Those who had not participated in the years 2004 and 2005 were considered "non-participants" for that time frame. Recognizable duplicates in this sample were eliminated and the list was randomized.
- Non-participants were also drawn from a sample acquired through a search engine quest, using the key words "California Multifamily General Contractor." In contacting these businesses, an immediate screener was used to establish if they were involved in residential multifamily construction. The vast majority of the firms on this list were not involved in the necessary activity of building residential multifamily

constructions. If the firm was involved in such construction, then the interviewer began administering the survey.

- We also purchased a sample of businesses in California with relevant NAICS codes.

The total list of potential non-participant firms derived from these sources was 295. A total of 116 were non-viable due to failed qualifications, single family construction only, or bad / wrong numbers that could not be located, leaving 179 viable firms. There were 19 outright refusals, and several firms were identified as participants (and participant surveys were completed for some of these). Again, most failed to return multiple messages and were unavailable throughout at least five contact attempts.

Non-Participant Completions: The total non-participant sample could not be determined because there is no inventory of firms. Unless they refused or were otherwise removed from the list, each business was called at least five times. Certainly the six non-participant completes represent a relatively small portion of the non-participants for 2004-2005; however, non-participants in this year tended to be participants in other years. This complicated the identification and analysis of non-participant data.

Therefore, despite exhaustive efforts, a total of 22 surveys were completed, 16 with participants, and 6 with non-participants. The summary is presented in the following Table.

	2004-2005 Participants	**Non-Participants**
Total Population	161	295
Non-viable firms	43	116
Viable Population	118	Unknown; list included 179 viable firms
Completed Surveys (Respondents)	16	6
Disposition		
Unique Numbers	161	296
Number of calls	257	656
Bad numbers	14	4
Contacted	37	32
No answer	8	15
Refusals	4	19
Single Family Only	7	21
Wrong Number	6	18

Table 10: Multifamily Population and Completes

Impact Methodology

The ultimate goal of the impact analysis is to determine how much of an effect participating in the ENERGY STAR® Homes program had on energy savings. This section will look at two different approaches of measuring the difference between participant and non-participant homes. The first approach is called the Difference of Differences (DofD) where Data was used on the standard and proposed energy usages for all non-participant homes from the RNC baseline database. We compared the savings of the non-participants to the savings of the ENERGY STAR® participant homes. Their difference becomes the estimate of net savings.

The second approach that we looked at was a billing analysis comparison of single family homes. The billing analysis study used billing data from the utilities to compare the actual electricity and gas usage of participant ENERGY STAR® new homes to non-participant homes. In this analysis we looked to isolate the impact of program participation by controlling for housing characteristics and demographic differences. The billing analysis allowed us to compare the modeled results from the DofD analysis to actual energy usage.

Single Family

Ex-Ante Savings

Evaluation studies measure the actual energy impacts of a program and compare the results to the savings estimates provided by the program implementer. The implementer's estimate of savings is most often referred to as the "*ex* ante" value, while the evaluator's best estimate of savings is referred to as the "*ex* post". The ex ante estimate is important because it allows the evaluation results to be compared to something meaningful.

Each utility filed a Program Implementation Plan with the CPUC prior to receiving approval to implement the program. Included with those plans are Excel workbooks which estimate program energy and demand savings. The basis of those estimates is per unit energy and demand savings in conjunction with unit goals.

For program years 2004 and 2005 the utilities filed their final Annual Earning Assessment Proceeding (AEAP) report, which summarizes program accomplishments and total energy savings. The values included in the AEAP report often become the ex ante value used for program impact evaluation. The AEAP filed gross savings estimates were taken directly from the workbooks and are summarized in the 'Impact Results' section under 'Ex Ante Savings'.

However, RLW was not able to use the total AEAP energy saving values because, for this particular program, the AEAP energy savings values are only estimates and are inclusive of energy savings resulting from both completed *and* committed structures (project planned for completion at some future date) from 2004 and 2005.

The evaluation, on the other hand, considers realization of energy savings only for structures considered completed in 2004 or 2005 but may have actually been committed to the program in 2002 or 2003.[12] Therefore it was necessary for RLW to calculate the ex ante energy savings using only the total number of 'completed and approved' units, the per unit savings found in each utility's EEGA workbook, and the deemed 0.8 NTG ratio. Specifically:

> Ex ante savings used as denominator in net savings realization rate = (number of actual units *approved*) x (IOU per-unit gross savings estimate filed in EEGA workbook) x (0.8 NTG ratio).

RLW worked with each of the four implementers to obtain their planning estimates of savings for participant projects. The estimates often included different estimates for regional differences (coastal vs. inland) and compliance margin (15% vs. 20%). The total ex ante savings estimates used to compare the ex-post savings to and to compute net realization rates is based upon approved and completed structures.

Gross Savings

The starting point for energy savings analysis are the Tracking databases, CHEERS and CalCERTS, and the associated Gross Savings, defined as the difference between Standard (package D) and Proposed modeled energy consumption.[13]

The inclusion or exclusion of homes in the population has a dramatic effect on the total energy savings estimates; therefore a precise definition of the population is necessary. In accordance with CPUC policy, energy savings are counted in the year the savings are realized, which for this program translated into the year each home was *built and passed inspection*. Homes included in the population were:

1. Inspected in 2004 or 2005
2. Structure "status" was labeled "Approved" (i.e. passed inspection) in CHEERS data extract and lot status was labeled as "Passed" or "Passed – previously failed" in CalCERTS
3. The sponsoring utility name was PGE, SCE, SoCalGas, or SDGE
4. Plan type was not labeled as "Non ENERGY STAR® [14]

Note that when, or if, incentives were paid is not a criteria used to determine participation status.

A home was classified as either coastal or inland based on its CEC climate zone. Homes modeled (or built) in CEC climate zones 1-7 were classified as coastal, whereas homes modeled in CEC climate zones 8-16 were classified as inland. This inland/coastal classification was created by the ENERGY STAR® Homes program – not this evaluation.

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[12] For the purpose of the evaluation, "completed" was defined by the final C-HERS inspection date, designated in CHEERS by a date and "approved".

[13] "Standard" and "Proposed" are terms used by Title 24 energy modeling software. When a new home is modeled, it is compared to a "Standard" home's energy budget, which is determined by a set of prescriptive measures and characteristics (referred to as Package D) specific for that climate zone (e.g. insulation levels, air conditioner SEER, etc.). "Proposed" is the modeled energy consumption of the new home as designed. Gross energy savings is defined as the difference between Standard and Proposed.

[14] In addition, 10 homes from CalCERTS data extract were excluded from the population as they had 0 standard or proposed energy values reported in the data.

Simple Gross (Tracking) Savings

Calculating the Adjusted Gross Savings is a two step process: first the Gross Savings are calculated, and then they are adjusted to take into account differences in tracking databases, CHEERS and CalCERTS, and to reflect verification inspection findings. Gross Savings is defined as the difference between Standard (package D) and proposed modeled energy consumption, taken from the tracking databases,

Gross Savings of the ENERGY STAR® Homes = $\sum_{i=1}^{N_p} (S_{p_i} - P_{p_i}) SF_{p_i}$, where

S_p[15] = Participant CF-1R standard[16] energy use (kBTU/sf-yr)

P_p = Participant CF-1R proposed energy use (kBTU/sf-yr)

SF_p = Conditioned floor area of the home

N_p = total number of ENERGY STAR® Homes

This sum, Gross (Tracking) Savings, is not shown in this report.

Allocation of End Uses

The first step in the analysis was to determine which of the three end-uses should be included in the kWh and therm calculations for each of the plans. All cooling systems utilized electricity and consequently were used in the electricity (kWh) savings calculation. Because all single family hot water systems in the program utilized gas as the primary energy source, hot water savings were added to the therm reduction calculation. Finally, heating systems varied by each unit; consequently, heating savings from homes that utilized a heat pump were added to electricity savings and homes with a furnace were added to therm reductions. Standards for the three end-uses are set by Title 24 and often vary by climate zone.

The units reported in the model documentation were converted from source kBTU to kWh and therms using the following equations:

*kilowatt-hour (kWh) = Source kBtu / (3*3.412)*

therm = Source kBtu /100

Orientation Adjustments

The orientation of a home can significantly affect its space cooling and heating energy requirements, chiefly due to solar gain through windows. However, when ENERGY STAR® homes are built and entered into the tracking registries (CHEERS and CalCERTS) their actual orientations are not recorded. Instead, production builders design homes which are built in all possible orientations, usually dependent upon the layout of the streets in the development. To accommodate this style of planning and to satisfy the ENERGY STAR® Homes program requirements, builders model their homes in north,

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[15] The subscript p is used to denote Participants, and np is used for Non-Participants.

[16] "Standard" and "Proposed" are terms used by Title 24 energy modeling software. When a new home is modeled, it is compared to a "Standard" home's energy budget, which is determined by a set of prescriptive measures and characteristics specific for that climate zone (e.g. insulation levels, air conditioner SEER, etc.). "Proposed" is the modeled energy consumption of the new home as designed. Gross energy savings is defined as the difference between Standard and Proposed.

east, south, and west orientations to show that energy consumption meets minimum program requirements in all four "cardinal" orientations. Generally, the CHEERS registry contains the modeled energy consumption for each orientation, and the average was used to calculate the gross energy savings for each home.

The CalCERTS registry only contains modeled energy for the worst orientation, but clearly not all homes are actually built in the worst possible orientation. To adjust for this, the CHEERS data was used to estimate appropriate "average" orientation energy as a function of worst orientation energy, explained in Appendix A.

Inspection Adjustments

The tracking savings were adjusted using findings from actual inspection data of 2002-03 ENERGY STAR® homes. This adjustment was necessary to correct for the differences between planned and inspected single family building characteristics. Adjustments were made at the end-use level and the inland/coastal region level. See Appendix A (Adjustments to Gross Tracking Savings) for details.

Meter Adjustment

The metered data were collected and processed into usage figures as described in Appendix D, and then the data from each site were aggregated into annual usages by end use for each site. These were then compared to the end-use usages predicted by the MICROPAS and EnergyPro compliance software using real-weather adjusted models. Ratio analysis was then used to compute a metering-adjustment factor for each end-use in three climate zones: coastal, inland, and desert. These adjustment factors were then applied to the adjusted gross savings estimates from the orientation and inspection adjustments to produce the ex post gross program savings estimates.

Preparing the Modeling Results

Every single family and multifamily participant was modeled in either MICROPAS or EnergyPro Title 24 compliance software in order to qualify as an ENERGY STAR® Home. We obtained the model files for 110 single family homes and 25 multifamily projects as part of the 2002-2003 program evaluation's site inspections. Based on the inspections conducted for that study, RLW then adjusted the compliance models to reflect the structures actually found on site.[17] These adjusted models were used for the comparison runs in this study.

Real-Weather Adjustment of Models

MICROPAS and EnergyPro utilize CTZ2 weather data files developed by the CEC for each of California's sixteen climate zones to compute energy budgets for Title 24 simulations. The CTZ2 files were developed from historical data over the past 30 years and are representative of a typical climate year. However, RLW metered homes during 2005 and 2006, and there are significant weather variations from year-to-year that in turn have a significant impact on heating and cooling end-uses in the compliance models. Therefore, it was necessary to adjust the model outputs to account for the actual weather conditions during the metering period.

[17] The results of these inspections are discussed in detail in the 2002-2003 ENERGY STAR Homes program evaluation report.

To this end, RLW obtained hourly temperature, precipitation, wind speed, and solar radiation data from the Western Regional Climate Center's (WRCC) Remote Automatic Weather Station (RAWS) system. Additionally, RLW obtained hourly temperature, precipitation, and wind speed data from major metropolitan airports in California from the WRCC. For each single family and each multifamily site in the respective samples, we chose the nearest RAWS to provide hourly solar data, and the nearest RAWS and/or airport to provide temperature, wind, and precipitation data. For each site, a year of weather data (beginning with the day after meter installation) was extracted from the chosen weather files.

RLW obtained a custom weather-packing utility from Enercomp that transformed these weather files into a form compatible with custom MICROPAS runs. For MICROPAS-modeled sites, we were thus able to rerun the models with the site-specific weather file for the metering period. The output from these reruns was a compliance-model estimate of annual energy usage by end-use under the same weather conditions the houses experienced during end-use metering. For single family structures, these end-use estimates were then compared to the metered usages for the site. For multifamily units, the end-use usages of the structures at a site were totaled to produce an estimate of total site usage by end use.

For the 13 multifamily and 1 single family sites modeled in EnergyPro, RLW was unable to arrange for custom weather packing due to budget restrictions. An alternative method was devised to estimate the impact of changing these models from CTZ2 weather to actual-year weather. While processing the MICROPAS reruns, RLW realized that remodeled homes tended to have similar percentage changes in heating and cooling energy usage as homes remodeled using the weather data from the same RAWS/airport data combination. Based on this observation, we used MICROPAS models with custom weather files to estimate the percentage change in usage that the EnergyPro models would face. For each EnergyPro-modeled site, RLW chose a MICROPAS-modeled site that had the most similar building characteristics. Each of this site's MICROPAS models (ranging from 3-10) were then run in the climate zone the EnergyPro site was originally modeled in and then run again using the custom weather chosen for the site. The average percentage change of the models' heating and cooling energy budgets was then calculated and applied to the original EnergyPro usage estimates for the structures at the site. The multifamily results were then totaled by structure into site total usages by end-use for comparison with the metered data.

Results of Model Reruns

The impact of real-weather remodels on cooling and heating energy estimates varied greatly by climate zone, weather station, and metering period. Changing the weather had no impact on domestic hot water energy demand.

Figure 5 shows the relationship between the original MICROPAS cooling energy using the CEC climate zone data compared to the same homes modeled using the weather file corresponding to their location/metering period. Some homes use considerably more or less energy under real weather conditions than under their base historical-weather climate data. Most homes, however, moved a small amount to either side of the y=x line that denotes no change on remodeling. The large outliers on the upside are the three homes in climate zone 15 (the high southern desert), which MICROPAS predicted as having much higher cooling demand under real weather conditions than using CTZ2 data from climate zone 15. The outliers on the downside tended to be homes that were on the border between two climate zones, and thus saw significant changes to their energy budget when remodeled with weather data closer to their true location than the representative city of their climate zone.

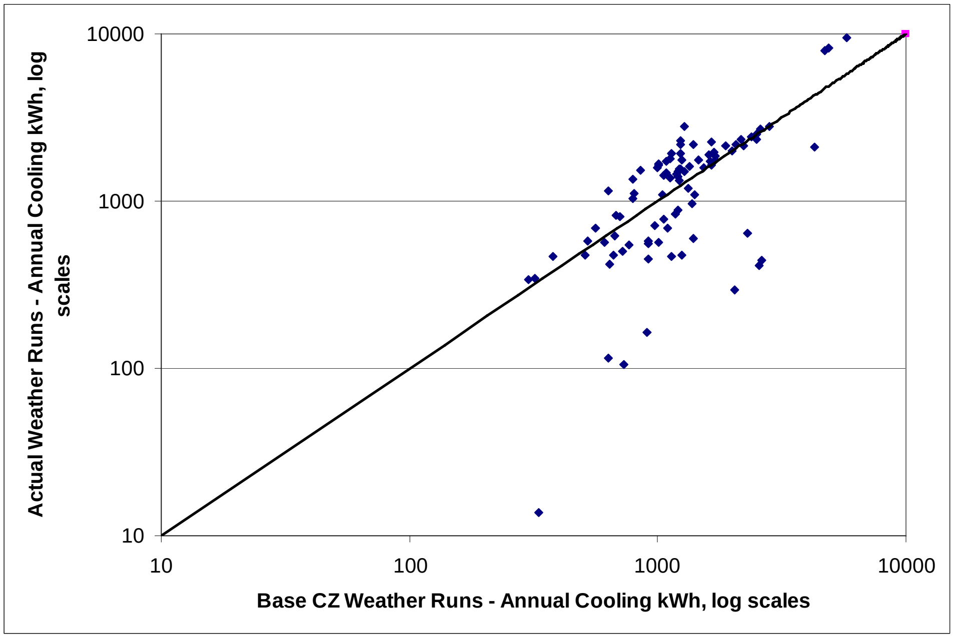

Figure 5: Base MICROPAS Cooling Results Compared to Real Weather Reruns

Heating usage estimates all tended to be higher under real weather conditions than using the base climate zone, as can be seen in Figure 6. In part this was due to a colder-than-average February and March 2006 across much of the state. Another key difference, however, was that the solar energy for the winter months tended to be higher in the CTZ2 weather files than in the real-year weather data obtained from the WRCC. Several individuals with experience in solar data have confirmed the solar numbers RLW used in the remodels, and it is thought that the data simply reflects a lower-than-average year for total winter solar gain due to it being one of the rainiest winters in recent history.

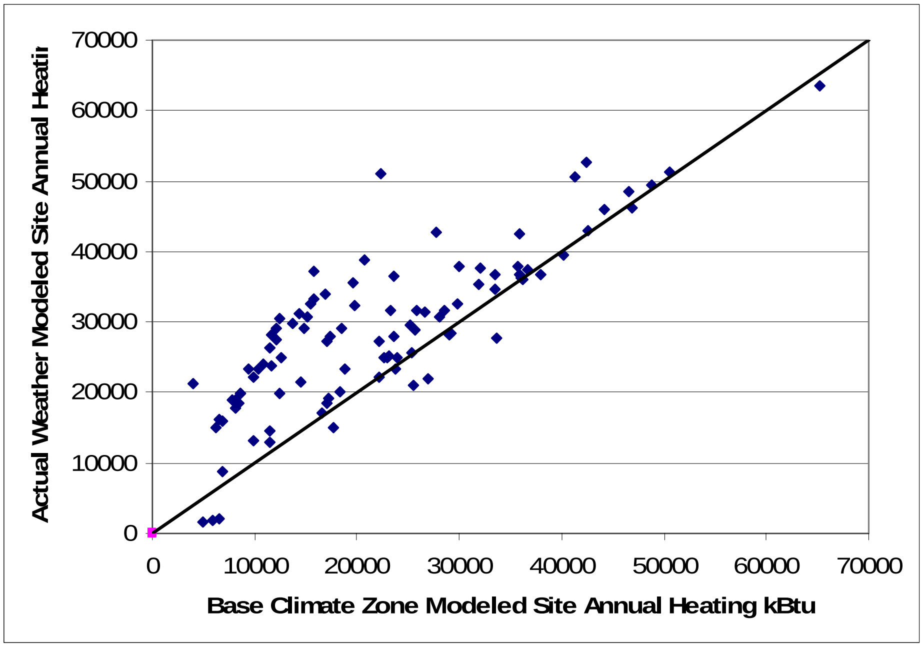

Figure 6: Base MICROPAS Results Compared to Real Weather Reruns, Source kBtu Heat Usage

Net Savings

Difference of Differences

Net Savings are the ultimate goal of the impact analysis. In this section, we combined all the previous results and applied the "difference-of-differences" analysis, the essence of which is to compare ENERGY STAR® Homes (participants) to standard construction practices (non-participants). The previous chapters were concerned with adjusted gross savings, defined as the difference between Standard (package D) and Proposed modeled energy consumption, adjusted for orientation, inspection results, and the results of the meter analysis. Net Savings are defined as the gross savings less naturally occurring savings (the natural savings of similar non-participants above Title-24). Data was used on the standard and proposed energy usages for all non-participant homes from the RNC baseline database. The proposed values were adjusted using the same meter-adjustment ratios derived for the participants. Meter-adjusted gross savings were calculated for each non participant home, and then compared to the savings of the ENERGY STAR® participant homes. Their difference becomes the estimate of net savings.

Net Savings = [Gross participant savings] – [meter-adjusted gross savings from the nonparticipant homes]

The complete calculation methodology can be found in Appendix B.

Coincident Demand (kW) Reduction

RLW did not originally propose to estimate an ex-post kW estimate for the program but we became aware of the CPUC's need for the kW estimate while performing the evaluation. Instead of verifying peak kW, we used a peak factor or an 'H-factor' approach to estimating coincident kW reduction. The 'H-factor' values that were used by the utilities for program planning were used in the evaluation and are presented in the following table. These 'H-factors' were applied to the ex-post net energy savings value to obtain ex-post net kW savings. This method does not provide any independent verification of actual kW savings. RLW did not provide any verification of the "H-factor" under this contract.

Utility	Type	MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	IOU Ex-Ante from EEGA		Final H-Factor Used in Evaluation
			GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	
PGE	SF	SF Whole House	0.37	342	0.001062
SCE	SF	SF Home	1.60	1,494	0.001081
SoCalGas	SF	52009-Single Family	1.40	1,018	0.001074
SDGE	SF	21007-Single Family	1.40	1,018	0.001074

Table 11: Single Family H-Factors

Effective Useful Life (EUL)

In order to correctly complete the lifetime savings Excel spreadsheet required by the CPUC, the first year savings must be forecast into the future based on an agreed effective useful life (EUL). The CPUC Policy Manual (August 2003) provides some EUL values to use for the 2004-2005 program measures and footnotes the genesis of these values.[18] See also p. 26 of September 25, 2000 CALMAC report prepared pursuant to Ordering Paragraph 9 of D.00-07-017]. The Policy Manual does not provide the EUL for a residential whole house measure, although it is present in Table 3 of Appendix C2 of the September 25, 2000 CALMAC report. The whole house energy use value in Appendix C2 is 19 years.

The residential new construction programs support integrated designs that reduce the whole house energy use. There are multiple energy efficient measures installed that synergistically interact to create the energy savings claimed by the program. We believe that to attempt to disaggregate the EUL and savings values based on the specific measures installed by each home may not be possible, and would not be appropriate.

This evaluation uses the 19 year EUL value that was determined previously. As such, the first year savings would be forecast 18 years into the future equal to the total number of homes with first year savings.

Net-to-Gross (SERA)

This section of the report focuses on the gross and net impact savings estimates for the Single family components of the 2004 and 2005 ENERGY STAR® New Homes Programs. To fully assess the net attributable impacts of the Single family component of the program, Skumatz Economic Research Associates (SERA) conducted two analyses:

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[18] *Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand Side Management (DSM) Programs (MA&E Protocols*).

- **Net to gross analysis**: designed to analyze the direct and indirect energy efficiency and savings–related effects induced in the marketplace attributable to the Single family component of the California Statewide ENERGY STAR® New Homes Program.
- **Non-energy benefits analysis**: designed to inventory and measure the "hard to measure" positive and negative non-energy effects (non-energy benefits in the literature) experienced due to the program, including effects for participants, the utilities, and society and the environment at large. The non-energy benefits analysis is presented in the appendix.

Overview of Data Collection Approach

The information to support these analyses were gathered using detailed structured telephone interviews conducted with developers or builders of Single family homes in the State of California who had constructed a Single family building in 2004 or 2005.

Survey Instrument

SERA developed the survey used for the participant and non-participant firms with input and comment from RLW Analytics, the PG&E project manager, and representatives from the other utilities. The survey instrument measured the Single family builder project background, awareness of and participation/non-participation in the ENERGY STAR® program, general practices, program influence, free-ridership (only in the case of participants), market effects, and non-energy benefits (NEBs).

Experienced personnel administered the survey via telephone. The customary practice called for a maximum of five attempts per record, at different times during business hours. When the appropriate person was contacted, participants were asked to focus on a Single family building project that had been built / developed between the years 2004 and 2005 and had participated in the ENERGY STAR® Homes program. Non-participants were also asked to focus on a Single family building project that had been built / developed between the years 2004 and 2005, but one that did *not* participate in the program.

Summaries of the topics included in the participant and non-participant surveys are presented in the following Table. The surveys are provided in the appendix.

Topics in Participant Interview Guide
Process: • Roles, type of project • Awareness of ESH program, sources of information, reasons for participating, barriers • Assessment of approval process, rater, use of consultant, and other steps • Program strengths and weaknesses • Assessment of impact on marketability Net-To-Gross (NTG) • Energy performance relative to standard construction, program influence in efficiency / performance • Free ridership / likelihood of installing equipment / equipment performance / efficiency changes compared to situation without program; estimated energy savings attributable to program • Related effects, behavioral changes due to installation of higher efficiency equipment through program

• Market effects within projects, by participants at other projects, and changes in efficiency and standard construction by non-participants attributable to the influence of the program (not included in net savings estimates) Non-energy benefits (NEBs) • Positive and negative impacts from program; value of individual NEB categories in relative terms • Overall total NEBs, positive and negative relative valuations via comparison, willingness to pay, and other measurement methods • Use of NEBs in "selling" the dwelling Firmographics and Attitudes • Changes in knowledge and attitude indicators • Number of employees, CA/non-CA share of work, number of homes built in CA, share by territory
Topics in Non-Participant Interview Guide
Process: • Roles, type of project • Awareness of ESH program, sources of information, reasons for NOT participating, barriers • Difficulty in meeting threshold efficiency levels in building • Use of Title 24 consultant Net-To-Gross (NTG) • Baseline energy savings relative to energy code, frequency their projects exceed Title 24 by 15%, relative efficiency level of their projects relative to Title 24 over time, normal building practices / efficiency level • Influence of ESH program on energy performance of projects • Cost differences for meeting / exceeding Title 24 • Role of awareness of ESH in likelihood of installing higher efficient equipment • Related effects, behavioral changes due to installation of higher efficiency equipment generally • Effects of ESH on non-participants / market place, if any (not included in net savings estimates) Non-energy benefits (NEBs) • Positive and negative impacts from installation of energy efficient equipment in SF, values of individual NEB categories in relative terms • Overall total NEBs, positive and negative relative valuations via comparison, willingness to pay, and other measurement methods • Use of NEBs in "selling" the dwelling Firmographics and Attitudes • Changes in knowledge and attitude indicators • Number of employees, CA/non-CA share of work, number of homes built in CA, share by territory

Table 12: Topics Addressed in SF Builder Participant and Non-Participant Interview Guides

Data from both participants and non-participants were used to estimate the NTG and NEB results.[19] The steps involved in these analyses are presented in the remainder of this chapter.

Sample Design and Completions for the Builder and Owner Samples

Sample lists for participating households were obtained from RLW. Sample lists for non-participating households were obtained from a list of non-participants from RLW, augmented with a purchased sample of newly constructed homes in the State of California.

Builder samples were drawn from several sources. One call list was supplied by Pacific Gas and Electric and contained a list of single family builders who had participated in the ENERGY STAR® program in 2004 to 2005. The list was randomized and calling proceeded. The builders were called a maximum of five times before the surveyors stopped calling them, unless the builders requested no more contact be made or refused to answer the survey. The other builder list contained a random selection of California Builders that SERA researchers purchased from an independent source. This list was separated into two categories; builders who generated over $2.5 million in revenue last year and those whose revenue was under $2.5 million but over $200 thousand. Approximately 80% of the non-participant builders called were from the larger revenue list and the others were from the smaller revenue list. A large number of the builders called did not qualify for the interview, many were not in the single family building industry and some had participated in ENERGY STAR® in 2004 to 2005. Therefore, a significant portion of this sample either did not qualify for the interview process or had bad numbers. Of the remaining builders, 65 refused to answer the survey.

Importance of Indirect / Market Effects for Programs

The ENERGY STAR® Homes Programs rely on indirect effects on the market and market actors to realize the bulk of the interim and longer-term program effects. A review of the ENERGY STAR® program logic identifies indirect activities, outputs, and outcomes including the following:

- Increased builder and public awareness of ENERGY STAR® Homes – including and beyond direct participants
- Educated market actors
- Promotion and advertising of ENERGY STAR® Homes
- More non-participating homes built to ENERGY STAR® Homes standards
- Increased product acceptance and demand for ENERGY STAR® products
- Increased availability of energy efficient goods, products, and services
- Enhanced home designs and home construction practices in the market, with product differentiation and profitability for builders
- Increased need for (and maturation of) ENERGY STAR® infrastructure, including builders, raters, etc.

Indirect effects are key to the design and success of a program such as ENERGY STAR® Homes. For this reason, it is critical to measure both:

[19] The process questions were analyzed by RLW and the results are presented elsewhere.

- the direct effects due to the program – that is, the energy efficiency actions by direct participants that were induced by the program, and
- the indirect and induced effects on participating actors beyond participating projects, and the energy efficiency changes induced in the market by the program, ideally including changes in energy efficiency of non-participating homes, changes in education and actions of non-participant market actors, changes in equipment availability, etc.

The first factor is reflected in the analyses of "free ridership" discussed in upcoming sections. The measurement work on "market effects" described in the following sections measure key elements of the induced and indirect effects. Both methods and results for these key elements of Net To Gross are discussed in the following sections.

Net-To-Gross Analysis

The Net-To-Gross (NTG) analysis is designed to identify and measure those effects listed above – both the market effects (direct and indirect) and the free rider effects -- that occur, and provide a ratio that translates the gross savings measured based on program installations (figures from program records) into savings net of the effects of free ridership (generally a decrease) and indirect spillover effects (zero or positive effect). *However, the net savings in this report do not take the market effect into account, they only include free rider effects.* To provide information on the performance attributable to the program, the gross savings estimates developed through the impact evaluation need to be adjusted by the net-to-gross (NTG) ratio. This ratio is constructed to provide appropriate adjustment for the program's net effect – specifically, to estimate the impact of the program *beyond what would have happened without the program*.

Key Caveats and Considerations

Analytical Approach

The NTG work can be more difficult for this program than for many other residential programs because the ENERGY STAR® Homes Program is not a single measure that is being rebated, but a set of design practices and measures that combined, lead to at least 15% savings beyond code. Gaining feedback on the savings and impacts compared to a similar project that didn't use these ENERGY STAR® elements necessarily requires an estimate compared to a hypothetical "similar" non- ENERGY STAR® project that doesn't exist.

In the detailed interviews that were conducted, attempts were made to talk with the most relevant decisionmaker(s). In addition, respondents were asked a variety of questions meant to understand behaviors and decisions relative to ENERGY STAR® elements. Also, as described below, corroborating information was asked in order to confirm responses and understand different nuances about the influences on decisions to incorporate ENERGY STAR® elements into the project. Finally, we talked to both participating and non-participating builders in order to get a better handle on baseline practices in the absence of the program. These efforts have been designed to provide reasonable estimates of the NTG ratio for the program, and the direct and indirect effects from the ENERGY STAR® activities undertaken as part of the Statewide Program. These estimates are important to identify the range of the impact that the program has had on energy efficiency in Single family buildings, above and beyond what would have occurred without the program.

Defining Net To Gross (NTG)[20]

Translating gross program-tracked energy and demand savings into just that share that can be specifically attributed to the program is a complex problem in evaluation. Net program impacts were calculated to account for the combination of two main effects:

- Net effect: a reduction in the gross effect for "free ridership", attempting to estimate that share of program savings that program participants would have achieved even without the influence of the program or its market interventions.
- Market effects: an additive adjustment to gross impacts, accounting for the indirect and induced effects from the program, including positive impacts and efficiency increases that the program may have on market actors and actions above and beyond direct program participants.

This evaluation did not include market effects in the net savings calculation.

Given that the evaluation is attempting to measure changes due to the program, and specifically effects above and beyond what would have happened without the program, free ridership (or net effects) is a key component.

- **Free ridership** addresses the set of program participants that would have purchased the energy efficient measure, or adopted the behavior, even without the influence of the program – that is, the program was not instrumental in the participant purchasing / installing the energy efficient measures or using advanced design. Given that the smallest this factor can be is zero, this factor always reduces the gross savings attributable to the program.

The Market Effects (ME) factor, on the other hand, attempts to measure the indirect and induced impacts that the program caused in the market through the indirect and Multiplier-type influences from the program. These indirect market effects are an especially important part of the program's intended effects, and derive from the array of market transformation activities undertaken in the Program. There are several components of these indirect and induced market effects:[21]

[20] For additional information on the approach and background, see: Sebold, et.al., "A Framework for Planning and Assesssing Publicly Funded Energy Efficiency", Study ID PG&E-SW040, March, 2001, referred to as "California Framework Study"; Skumatz, Lisa A., Ph.D., John Gardner, and Charles Bicknell (SERA), "Techniques for Getting the Most from an Evaluation: Review of Methods and Results for Attributing Progress, Non-Energy Benefits, Net to Gross, And Cost-Benefit, Proceedings of the EEDAL conference, Turin Italy, May 2005, and Skumatz, Lisa A., Ph.D., Dan Violette, and Rose Woods, "Successful Techniques For Identifying, Measuring, And Attributing Causality In Residential Programs", proceedings from the 2004 American Council for an Energy Efficient Economy (ACEEE), Summer Study, Asilomar, CA; ACEEE Washington DC.

[21] There can also be "Other" Market effects which can occur through several pathways. For example, manufacturers may change the efficiency of their products, and/or retailers and wholesalers may change the composition of their inventories to reflect the demand for more efficient goods created through an energy efficiency program. Another example might be new building codes or appliance standards adopted in part due to the demonstration of technologies through an energy efficiency program.

- **ME Component 1 / within-project effects**:[22] This term consists of additional energy efficiency measures installed or practices incorporated by the builder in a participating building – but not incentivized / included in the program – that were installed because of the influence of the program or the education / awareness provided by the program. These are energy efficient measures or design practices that are not included in the program records or accounted for in program savings computations.

- **ME Component 2 / outside project effects**:[23] This market effects component reflects additional (eligible and non-eligible) efficiency equipment and design features installed by participating builders / contractors in non-participating projects. The measures are not incentivized through the program. This factor accounts for the increase in efficient measures / practices adopted because of the influence of the program even without direct incentives. Indirect Effects: However, that experience and the education provided are designed to help encourage participants to incorporate energy efficient design practices into succeeding projects (including non-participating projects).

- **ME Component 3 / non-participant effects**:[24] This factor incorporates non-program measures purchased / installed by non-participants that were inspired to purchase the energy efficient measures or use the advanced practices because of program advertising or because more efficient measures are in the market due to program actions. Indirect Market Effects: In addition, the program's logic would postulate that even non-participant builders could be encouraged to incorporate more efficient practices into their projects because of the combined forces of:
  - ⇒ competition with other builders,
  - ⇒ demand in the market,
  - ⇒ indirect education on the benefits and costs, and on efficient design practices, and
  - ⇒ increased availability (and potentially improved "price points") for energy efficient equipment in the marketplace.[25]

NTG Formulae: Net program impacts were computed by applying adjustment factors for the effect of free riders and market effects to the gross savings estimates for the program. The basic equation for the Net-to-Gross (NTG) ratio is:

NTG ratio = (Net Factor) x (Market Effects Factor)

The net factor equals the attributed fraction of savings, or the value one minus those savings deemed to be free riders.

[22] For resource acquisition programs, the parallel to this term would be "inside project spillover".

[23] For resource acquisition programs, the parallel to this term would be "outside spillover".

[24] For resource acquisition programs, the parallel to this term would be "non-participant spillover".

[25] In this analysis, stocking behaviors and increased availability in that sense are measured only indirectly through non-participant effects.

Net Factor = [1 – (free ridership)]

The market effects factor is a combination of the three market effects components that may influence actions taken outside of the program. The market effects factor is the sum of one and the market effects components:

Market Effects Factor = [1 + (ME Component 1 + ME Component 2 + ME Component 3)]

NTG Data and Computations

The data were collected as part of the participant, and to some degree, the non-participant interviews conducted as part of the project.[26] The participant interviews provided direct data – self-reported – on free ridership, market effects, and baseline information. The non-participant surveys were used to provide information on non-participant market effects components and to provide context for standard practice.[27]

The results for individual attribution questions are provided in the following paragraphs. The computations were conducted and the information summarized below provides feedback on the major trends and results related to net-to-gross (NTG) and its component factors.

Computing Free Ridership Factors: The participant builder questionnaire(s) included several variations of the core question to ascertain the share of the energy savings counted by the program that can be attributed to the effects of the program. Variations providing indications as to free ridership values are summarized below:

If they had not participated in the program, the likelihood they would have installed <u>all</u> the same energy efficiency measures (Q-C2): 49.7%.

If they had not participated in the program, the likelihood they would have installed <u>some</u> of the same energy efficiency measures (Q-C2b): 66.4%

- Best estimate of the overall energy savings above Title 24 that were achieved due to the influence of the Program[28] : 32%, implying free ridership of 68%.

These responses imply the free ridership, not accounting for influencing factors, is between 50% and 68%.

To provide more robust information from participants about their decision-making (a key factor in free ridership), we asked corroborating information as well. This corroborating information we included follows:

[26] The survey development and the interviews were conducted by Skumatz Economic Research Associates, Inc. (SERA).

[27] Both survey instruments are included in the Appendices.

[28] The first two free ridership questions, which asked verbal responses with clarifications about the percentage range implied (e.g., definitely or almost definitely, greater than 90% likely) returned responses from almost all interviewees. For these questions, we coded the midpoint of the corresponding range as the response. Open ended numbers garnered fewer answers. Too few responses from “minimum” and “maximum” for this value; “best estimate” response average is provided here.

- Importance of program financial incentive in program participation (Q-B15): 21.5% said it was very important.
- Program influenced their decision to increase energy efficiency beyond code very much (Q-C1a): 24.1%.
- Program's importance in decision to design and build the project to exceed T24 by 15% - very important (Q-C6): 16.7%.
- Program led to increases in the efficiency level of equipment installed over that required to meet Title 24, with a list of nine end-use options (Q-D2). 70% reported the program having influenced more than two end uses.

Free ridership was computed by using the responses to the direct free ridership question battery, adjusted to take into consideration the results from the "corroborating factors". If the corroborating factors indicated the following, the lower free ridership values were selected.

- For those respondents that stated the program was "very important", but provided a high free ridership factor, the information was considered inconsistent.
- For those that stated the program had a high influence, bur provided a high free ridership value, the information was considered inconsistent.

Using these methods, we were able to derive a more robust estimate of free ridership, using combined responses from several questions. The computations resulted in an estimate of 46%-58% free ridership factor (0.46-0.58). This result indicates that perhaps half of the savings from program records may not be strictly attributable to the program.

Computing Market Effects / Indirect Factors: Three types of indirect market effects are traditionally attributable to market transformation programs. These estimates are derived as follows.[29]

- **ME1 - Within Project Market Effects:** This includes additional energy efficiency measures and design practices installed at the (participating) site that are not covered by the program but are installed because of the influence of the program. However, the comprehensive nature of the ENERGY STAR® program makes it difficult to identify any measures "outside" the program. Therefore, no market effects are attributed to this type of indirect influence.

- **ME2 - Outside Project Market Effects**: The program has an effect in influencing participants to carry over ENERGY STAR® measures and practices to other non-participant projects.

A total of about 32% of the participating builders indicated that the program had influenced their practices at buildings that had not gone through the program. The influence was felt on about 3.5 additional homes each, beyond those asked about in the survey. The respondents stated that the average building size for these other buildings

[29] The topics were addressed in three pieces: 1) whether the factor exists, 2) the share of savings from this effect as a multiple of the direct program savings, and 3) the share of these savings that were influenced by / due to the program.

was about 104% of the project size, and about 28-46% of these resulting savings were attributable to the program influence. This implies that for the energy savings from the Single family building (or home) participants, the influence from the program carried over to other buildings to produce about 32%-54% additional savings in spillover of this type (outside project spillover).

- **ME3 - Non-participant market effects**: The program can indirectly influence non-participant builders to upgrade their energy practices because of the influence of the program on the market. About 47% of participating builders believe this effect occurs. About 32% of non-participants interviewed believe this occurs.

This factor is one of the most difficult to estimate. Gathering information on the effects that the program has had on builders that have not directly participated in the program is difficult because the influence is indirect, and because attributing changes in practices specifically to the program is difficult to assign. To provide some level of feedback on this influence, we gathered data from both participants and non-participants. Generally, we would focus on non-participant feedback; however, we had a very small sample of non-participants, so we examined responses from both groups. Non-participants are generally replying about their own practices and influences; participants were asked about whether they believe non-participants have been influenced, or whether they spoke to them about modified practices.

Billing Analysis

During the 2002-03 ENERGY STAR® homes analysis, the lack of demographic information such as occupancy and income left RLW unable to resolve the question of negative program savings raised by the billing analysis. As a result, this year RLW conducted phone surveys of 212 participants and non-participants in climate zones 8 and 12 and conducted a variety of statistical tests to determine which of the multiple models specified would most accurately represent the data.

All of the analyses were pursued using multivariate regression models run in SAS using the backwards step-wise regression to eliminate the least significant variables. F-tests were performed on variables to insure that they could be dropped as a group as well as individually. The analysis used $p \leq 0.10$ as the threshold criteria for inclusion of explanatory variables in the models, meaning that for a variable to be considered significant in determining energy usage, there must be less than a 10% chance that the resulting coefficient could be different from zero based on purely random chance.

Eleven independent variables were ultimately defined and included in the preliminary analysis. In some cases, data were combined to create more meaningful sample sizes in the categories for analysis. For example, income data was originally collected in 5 groups of $25,000 increments. These were subsequently aggregated into three groupings of low, mid, and high, that had ranges of: less than $25,000, $25,000 to $75,000, and greater than $75,000.

Sample Overview

Table 13 shows a breakdown of participants and non-participants by climate zone. Climate zone 8 had a sample of 24 participant sites and 30 non-participant sites while climate zone 12 had 83 total participants and 75 non-participants. The sizes of the samples were determined from billing data availability and the success of the sample used for the phone survey. The sample frame for the surveys was a simple random sample of the sites for which we had billing data.

Climate Zone	Participant	Non-Participant	Total
8	24	30	54
12	83	75	158

Table 13: Number of Participants and Non participants by Climate Zone for Billing Analysis

Information for the survey was obtained through telephone calls conducted by RLW. Participant contact information was provided by the IOU's, whereas the non-participant contact information was provided by the authors of the 2004 baseline study.

The Regression Model

Our base regression model, Equation 1, looked at the effects of housing characteristics and the demographic survey questions on energy consumption. In order to conduct this analysis, we first needed to determine energy usage for each end use. The four IOUs used address matching to provide RLW with electric and gas monthly billing data from 2003-2006 for participants and non-participants in each climate zone. We calculated end-use values using the Princeton Scorekeeping Model (PRISM) to regress the electric and gas billing data against weather data to come up with average daily weather dependent and weather independent usage for each fuel type.[30] The weather dependent values represented AC electricity usage and heating gas usage. The weather independent values for electricity were not used in the analysis and the weather independent gas values represented mainly hot water heating, with some cooking and clothes drying.

The final model used for each climate zone and end use will be discussed in the billing analysis section of the impact analysis.

$$\begin{aligned}&Energy\ \ Usage = \beta_1(\,floor\ \ area\,) + \beta_2(\#\,stories\,) + \beta_3(\#\ fulltime\ \ adult\ \ residents\,) + \\ &\beta_4(\#\ fulltime\ \ children\ \ residents\,) + \beta_5(\#\,temp\ \ summer\ \ time\ adults\,) + \\ &\beta_6(\#\,temp\ \ summertime\ \ children\,) + \beta_7(\,Income\,) + \beta_8(\#\ home\ \ during\ \ summer\ \ day\,) + \\ &\beta_9(\#\ home\ \ during\ \ winter\ \ day\,) + \beta_{10}\ (participa\ nt) + \varepsilon\end{aligned}$$

Equation 1: Base Regression Model

Working from this full model we used a backwards regression approach in which we would eliminate variables that were shown to be statistically insignificant one at a time. Looking at the housing characteristic variables, we believed that floor area would be a large factor in the differences between houses, where energy usage would increase

[30] A detailed description of this methodology can be found in Appendix E.

systematically with the size of a house. Based on the results of the 02-03 study we expected multi stories houses would consume less energy than single story houses, for houses of similar floor areas.

Looking at the demographic variables, we expected that energy usage increased with each additional resident. To further analyze the relationship of occupancy we separated residents into adults (18 and over) and child (17 and under) so we could examine the difference between them. We expected to see that adults would have a larger impact on energy usage than children did, because adults generally use more household appliances than children. Another variable that we thought would have a substantial impact, especially on electric energy usage, was the number of summer time residents. This would represent the increase of energy usage, due to additional AC usage as well as appliances and lighting, the additional resident would use.

We also investigated the impact of the number of people home seasonally during the day. This was similar to the number of summer time residents in that it looked at the increased energy consumption as a result in changes in occupancy status. We hypothesized that having people home during the day would increase electricity usage during the summer and gas usage during the winter, due to cooling and heating respectively. We also thought that there would be another smaller increase in usage due to residents using household appliances and electronic devices during the day. During our analysis, we looked at the number of daytime residents as an ordinal variable, where we examined the impact that each additional resident on energy consumption. We also looked at the results of treating daytime residents as a dummy variable to determine if the presence of at least one daytime resident was more significant than the incremental impact of additional daytime residents. Through the backwards regression approach, we determined that treating the number of daytime residents as a dummy variable was never statistically significant.

The participation variable was a dummy variable that tracked whether or not a house was an ENERGY STAR® home. With this variable we could analyze the impact of program participation. We expected to see that program participants would use less energy than non-participant homes, in line with the net savings analyses.

Multifamily

Ex-Ante Savings

The approach to calculating the multifamily ex ante values is the same as the approach used for single family. RLW worked with each of the four implementers to obtain their estimates of energy savings for multifamily participant projects. The estimates were provided for both 2004 and 2005 program years, and often included different estimates for regional differences (coastal vs. inland) and compliance margin (15% vs. 20%).

Gross Savings

Similar to single family, the energy savings analysis of multifamily homes is based upon the Tracking databases of CHEERS and CalCERTS. The associated Gross Savings for multifamily homes is similarly defined as the difference between Standard and Proposed[31] modeled energy consumption.

The definition of an ENERGY STAR® Homes multifamily program participant is: multifamily structures in projects that were accepted into the ENERGY STAR® Homes Program, completed construction, and passed inspection all occurring in 04-05. Note that when, or if, incentives were paid is not a criteria used to determine participation status. As a result, we are using the CHEERS and CalCERTS databases to define the population of participant structures by filtering on most recent inspected Year (= 04 or 05), plan type (not labeled as "Non ENERGY STAR®") and Status (= approved or passed or passed but previously failed) for the four utilities PGE, SCE, SoCalGas, or SDGE.

Since Gross Savings is defined as the difference between Standard and Proposed modeled energy consumption,

Gross Savings of the ENERGY STAR® Homes = $\sum_{i=1}^{N_p}(S_{p_i} - P_{p_i})SF_{p_i}$, where

S_p[32] = Participant CF-1R standard energy use (kBTU/sf-yr)

P_p = Participant CF-1R proposed energy use (kBTU/sf-yr)

SF_p = Conditioned floor area of the home

N_p = Total number of multifamily structures

Details of Computing the Simple Gross

Similar to single family, we used the *Data* table in the CHEERS database and the SummaryInfo table from the CalCERTS database to compute values for energy savings.

The CHEERS data contains values for energy usage per square foot for heating, cooling, and water heating. It has one value for each possible orientation of the structure; north, south, east, or west. We computed the average of these orientations to arrive at a unique number for each type of end use. This number is the expected usage of the structure from the Micropas or EnergyPro models. For the baseline values for the energy usage per square foot for a structure, we used the CHEERS value called "standard." The average usages of the four orientations were compared to the standard to compute the energy savings for a structure.[33]

Unlike CHEERS, only the worst value of energy usage from the four plan orientations is reported in CalCERTS data extract. Similar to single family, the tracking savings

[31] "Standard" and "Proposed" are terms used by Title 24 energy modeling software. When a new home is modeled, it is compared to a "Standard" home's energy budget, which is determined by a set of prescriptive measures and characteristics specific for that climate zone (e.g. insulation levels, air conditioner SEER, etc.). "Proposed" is the modeled energy consumption of the new home as designed. Gross energy savings is defined as the difference between Standard and Proposed.

[32] The subscript p is used to denote Participants, and np is used for Non-Participants.

[33] In a small percentage of structures, we did not have values for all four orientations. Instead we used the 'PROPOSED' values for energy savings were reported in the CHEERS database. In these cases, we subtracted the 'Proposed' values from the 'Standard' in order to arrive at the energy savings for these structures.

computed from CalCERTS data were revised so that they represented energy savings from the average of all four orientations. Appendix A contains the details of this adjustment.

In order to differentiate the results by coastal and inland differences each home was classified as either coastal or inland using the CEC climate zone it was modeled in. Homes modeled (or built) in CEC climate zones 1-7 were classified as coastal, whereas homes modeled in CEC climate zones 8-16 were classified inland.

Structure ID in CHEERS database or Lot ID in CalCERTS database is a variable which can represent a dwelling unit, a building, or a group of buildings, depending on how the builder modeled the project. One recommendation of this report is that at least minimal uniformity in modeling be implemented to assist the program implementers and plan check agencies.

Meter Adjustment

As with the single family analysis, the gross savings estimates for the multifamily participants were adjusted to account for discrepancies between the actual, metered usage and the modeled predictions of end-use specific energy usage.

The multifamily models needed to be aggregated by site in order to be compared to the metering data. To calculate the predicted energy usage for a particular site, RLW multiplied each of the site's plan's usage by the number of buildings of that plan type at the site. To determine that number, we cross-referenced the CHEERS and/or CALCERTS registry database. RLW then added these products together to get the total predicted usage for all buildings at a site.

Likewise, the metered data from the units metered at each site needed to be weighted up to represent the total site. For each site, between three and four dwelling units worth of meter data were available to represent the site. Having measured the square footage of each metered unit during the site visits, we determined the total amount of metered floor area by adding the floor areas of each metered unit at a site. RLW then took the total square footage of the site (obtained from the CHEERS and/or CALCERT database) and divided by the total metered area, yielding the per-metered-square-foot weight. Each metered unit's usage was then weighted up by the square footage of the unit times this weight. The sum of these weighted metered usages gave the total site usage for each end use. Once both the modeled and metered data for multifamily sites was aggregated, they could be compared in the same way as the single family data.

Results of Model Reruns

The multifamily sites generally showed less sensitivity to the change from standard climate zone data to actual-year weather data. Figure 7 shows the impact on model estimates of cooling usage. A few high-usage sites' total demand dropped due to milder temperatures, while a few lower-usage sites' demand increased due to more sun and higher temperatures in their climate zone during the metering period. Overall, however, the conversion to actual-year weather had a relatively small impact on the cooling budgets of multifamily sites.

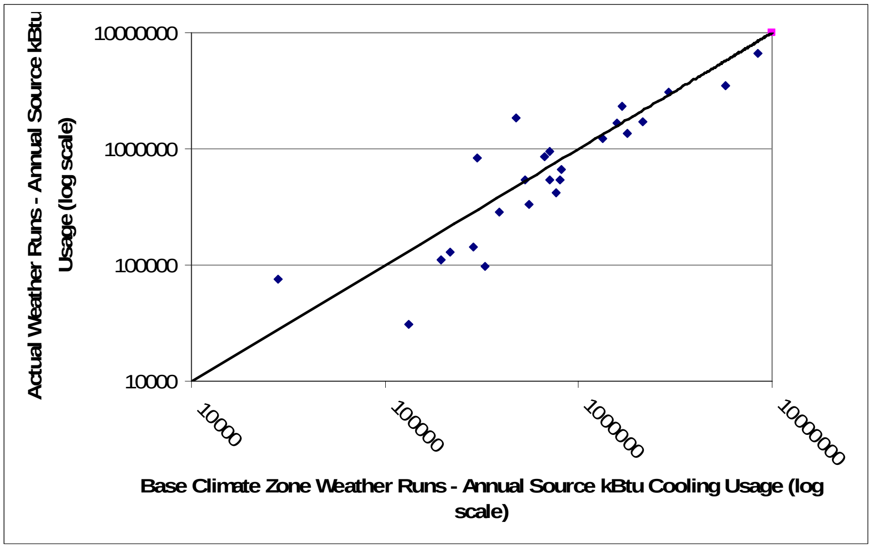


Figure 7: Base Model Results Compared to Real Weather Reruns, Source kBtu Cooling Usage

The impact on heating usage was slightly more pronounced on a percentage basis, as can be seen in Figure 8. There does not, however, appear to be the predominantly upward correction seen in the single family remodels. The heating remodels are about equally split between sites that increased and sites that decreased usage relative to baseline weather for their climate zone.

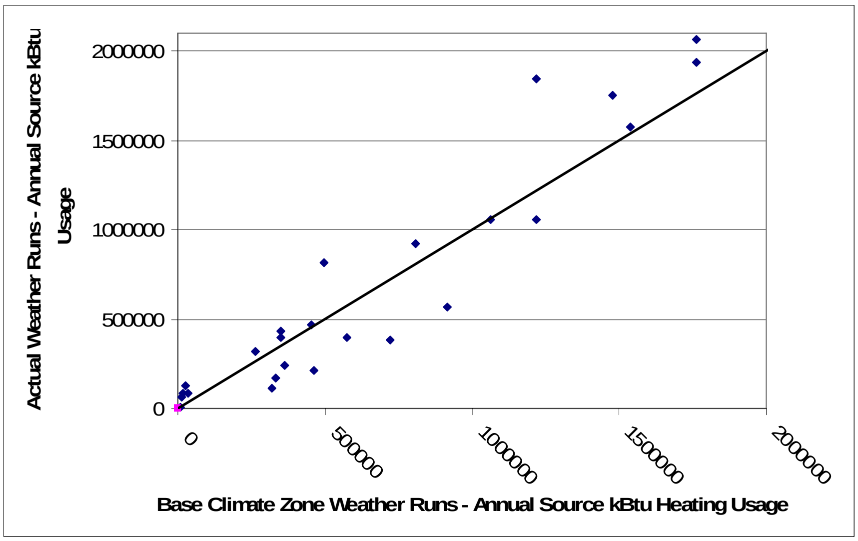


Figure 8: Base Model Results Compared to Real Weather Reruns, Source kBtu Heat Usage

Coincident Demand Reduction (kW)

As with single family, instead of verifying peak kW, we used an 'H-factor' approach to estimating coincident kW reduction where the utility planning 'H-factors' were applied to the kWh savings to obtain kW savings.

Utility	Type	MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	IOU Ex-Ante from EEGA: GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	IOU Ex-Ante from EEGA: GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	Final H-Factor Used in Evaluation
PGE	MF	MF Whole Building - 15% above T-24	0.22	218	0.001025
SCE	MF	MF Home 15%	0.35	311	0.001127
SoCalGas	MF	52007-Multifamily 15% Above AB970	0.51	367	0.001074
SDGE	MF	21006-Multifamily All Zones 15% Above AB970	0.51	367	0.001074

Table 14: Multifamily H-Factors

Net Savings (SERA)

The multifamily NTG ratio was determined through interviews conducted by SERA, resulting in a **NTG = 0.50 for all multifamily projects**. This ratio was applied to all gross energy savings estimates to arrive at our final estimates for net multifamily program savings. Market effects were not included in the net savings estimates; only free rider effects were included.

A billing analysis was not conducted for multifamily projects.

To fully assess the net attributable impacts of the multifamily component of the program, Skumatz Economic Research Associates (SERA) conducted two analyses:

- **Net to gross analysis**: designed to analyze the direct and indirect energy efficiency and savings–related effects induced in the marketplace attributable to the multifamily component of the California Statewide ENERGY STAR® New Homes Program
- **Non-energy benefits analysis**: designed to inventory and measure the "hard to measure" positive and negative non-energy effects (non-energy benefits in the literature) experienced due to the program, including effects for participants, the utilities, and society and the environment at large.

The data collection methodology and survey instrument design are similar to the methods and topics described in the single-family SERA net-to-gross methodology section.

Impact Results

Single Family Results

Ex-Ante Savings

For program years 2004 and 2005 the utilities filed their Annual Earning Assessment Proceeding (AEAP) report, which summarizes program accomplishments and total energy savings based upon program goals. The AEAP filed gross savings estimates were taken *directly* from the workbooks (with no format changes made) and are summarized in this section. The key estimates that this report evaluates are the per unit energy savings values.

PG&E

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
SF Whole House - Coastal - 15% above T-24	SF house	$400.00	$0.00	0.3690	343.58	133.53	$469.00	19	0.80	642
SF Whole House - Inland - 15% above T-24	SF house	$500.00	$0.00	0.3455	326.66	122.17	$469.00	19	0.80	5,777
SF Whole House - Inland - 20% above T-24	SF house	$700.00	$0.00	0.3673	341.96	163.70	$825.00	19	0.80	1,284

Table 15: PG&E SF Ex-Ante Estimates

SCE

Since SCE had two funding sources for this program, two program plans were filed, each with its own set of savings estimates.

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
SF Home 15% Inland	Dwelling	$500.00	$0.00	1.2500	1153	0	469	18	0.80	3,000
SF Home 20% Inland	Dwelling	$700.00	$0.00	1.6000	1494	0	825	18	0.80	1,000

Table 16: SCE SF Procurement Ex-Ante Estimates

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
SF Home 15% Inland	Dwelling	$500.00	$0.00	1.2500	1153	0	469	18	0.80	5,478
SF Home 20% Inland	Dwelling	$700.00	$0.00	1.6000	1494	0	825	18	0.80	2,720

Table 17: SCE SF PGC Ex-Ante Estimates

SoCalGas

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
52006-Single Family Inland 15% Above AB970	Home	$500.00	$0.00	1.1140	809	20	671	18	0.80	900
52009-Single Family Inland 20% Above AB970	Home	$700.00	$0.00	1.4016	1018	51	1741	18	0.80	500
52008-Single Family Coastal 15% Above AB970	Home	$400.00	$0.00	1.1140	809	-6	564	18	0.80	0

Table 18: SoCalGas SF Ex-Ante Estimates

SDG&E

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
21004-Single Family Coastal 15% Above AB970	Home	$400.00	$0.00	1.1140	809	-6	564	18	0.80	1,000
21005-Single Family Inland 15% Above AB970	Home	$500.00	$0.00	1.1140	809	20	671	18	0.80	2,250
21007-Single Family Inland 20% Above AB970	Home	$700.00	$0.00	1.4016	1018	51	1741	18	0.80	0

Table 19: SDG&E SF Ex-Ante Estimates

Program Population

The population of single family participant homes in 2004 and 2005 contained 31,113 unique single family dwelling units.

Utility	Inland	Coastal	Total
PGE	11,117	1,192	12309
SCE	13,145	152	13297
SoCalGas	1,191	0	1191
SDGE	1,256	3,060	4316
TOTAL	26,709	4,404	31113

Table 20: Population of Completed Single Family 04-05 Participant Homes

Single Family On-Site Verification Inspections

The 04-05 evaluation included on-site inspections of 50 single family ENERGY STAR® Homes to verify that as-built characteristics and associated energy savings matched the plans[34] as reported in the CHEERS and CalCERTS registries. The results of the 02-03 evaluation found that homes were often built somewhat differently than planned, but that average energy efficiency was slightly higher than planned. This result was not too surprising given that many aspects of construction plans are not thoroughly identified at the time of energy modeling, and Title 24 consultants often use minimum requirements in Title 24 models to gain compliance while providing the builder greatest flexibility at the time of construction and equipment selection. As a result it was determined not to

[34] ‘Plans’ refers to the Title 24 files submitted to the utility by the participant and approved by the utility. This data is then uploaded to the appropriate Registry’s database.

re-model the 04-05 homes since they were expected to closely resemble those in the 02-03 program. Key building characteristics (e.g. equipment types and efficiencies) were inspected and compared against planned characteristics to provide verification; the results are presented in this chapter.

Inspection Findings

The findings of the 04-05 on-site verifications revealed that, like the 02-03 findings, the homes were generally slightly more efficient than the original plans. There were many homes that had at least one characteristic different from the Title 24 documentation and some of the effects were lower energy efficiency. However, the net effect over the population was higher than planned energy efficiency.

The following graphs and tables show the results for key characteristics in residential energy use. Results are shown by home, although Home IDs have been suppressed. The number of homes shown differs because some homes have multiple systems or verification of a characteristic may not have been possible. In a few cases homes were found to have a different quantity of HVAC systems than were specified in the registry. It is difficult to conclusively state how this impacts the energy use for the home but since the efficiencies of the equipment did match the plans in each situation it is reasonable to assume the capacity of the system was appropriately sized to the home resulting in a negligible impact on energy use.

In nearly every case water heaters had an energy factor (EF) of .62 or higher. 2001 Title 24 standards, in effect for all of the homes completed in 04-05, specified water heater minimum requirements of EF $\geq$ .56 (for units with an input of 75,000 Btu or less). The average installed EF is better than Title 24 requirements, and better than the average planned EF. Only two of the inspected homes were found to have EFs lower than planned. One instantaneous water heater was specified in the sample of inspected homes, and was found to be installed as planned. The figure below does not show the inspection findings for the instantaneous water heater because their efficiency is measured in Recovery Efficiency -- not Energy Factor.

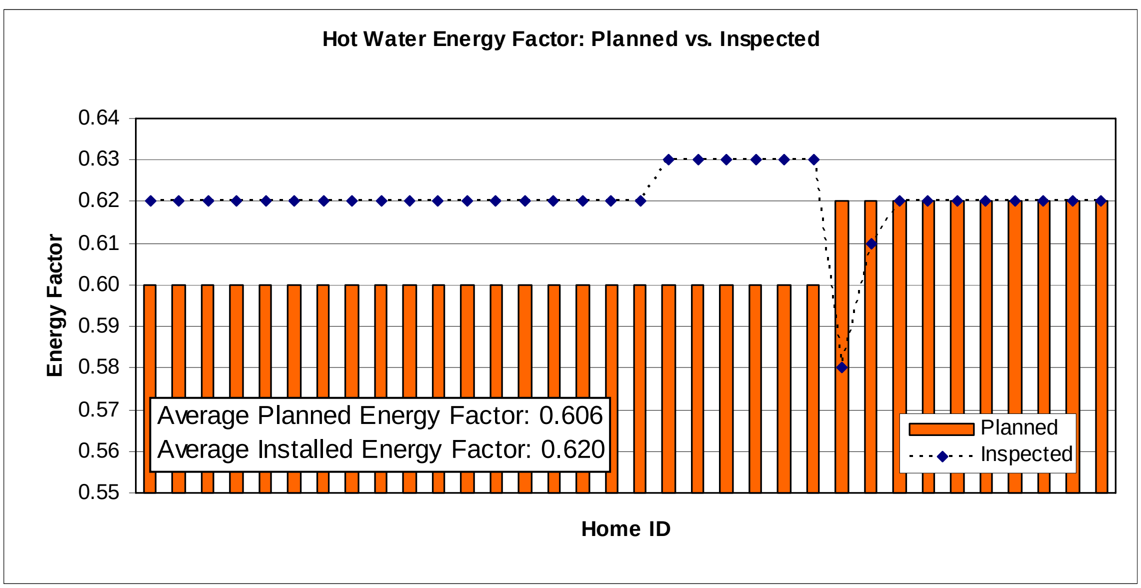


Figure 9: Planned vs. Inspected Water Heater Energy Factor

The figure below shows the SEER energy efficiency rating of cooling systems. Findings show that in every case where the SEER was verifiable, values were as planned or better. The average planned SEER was 10.56 and the average verified SEER was 11.05.

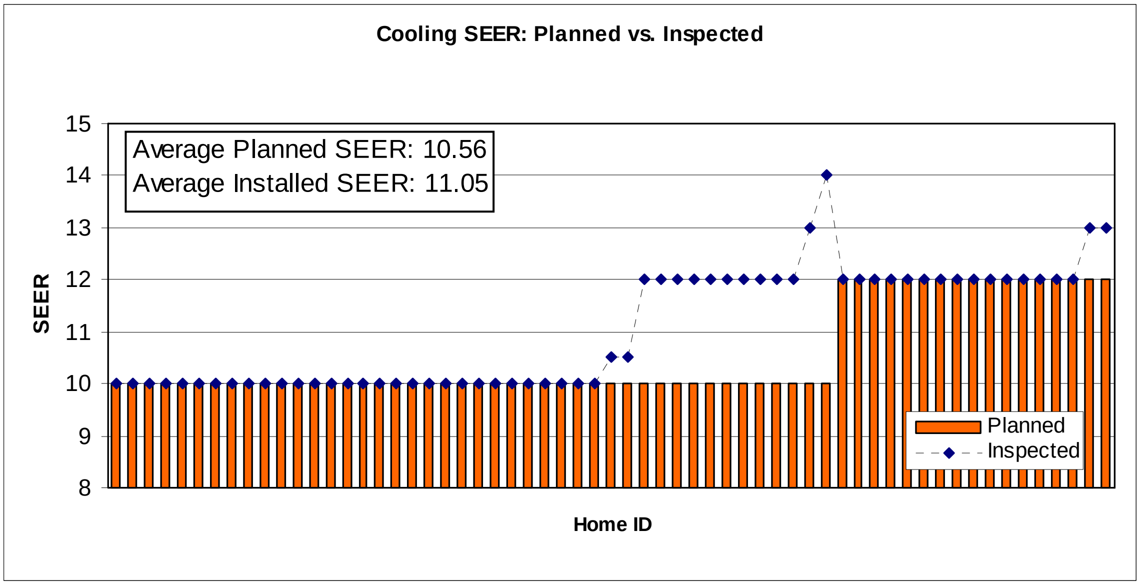


Figure 10: Planned vs. Inspected Cooling SEER

Windows play a key role in the energy efficiency of new construction. The following figure shows that despite slight variations in window square footages the average home receives slightly less window area than planned, which is expected to slightly increase efficiency. Unfortunately it was not possible to verify additional details of installed windows, such as U-value or SHGC, since these are not easily measurable in the field.

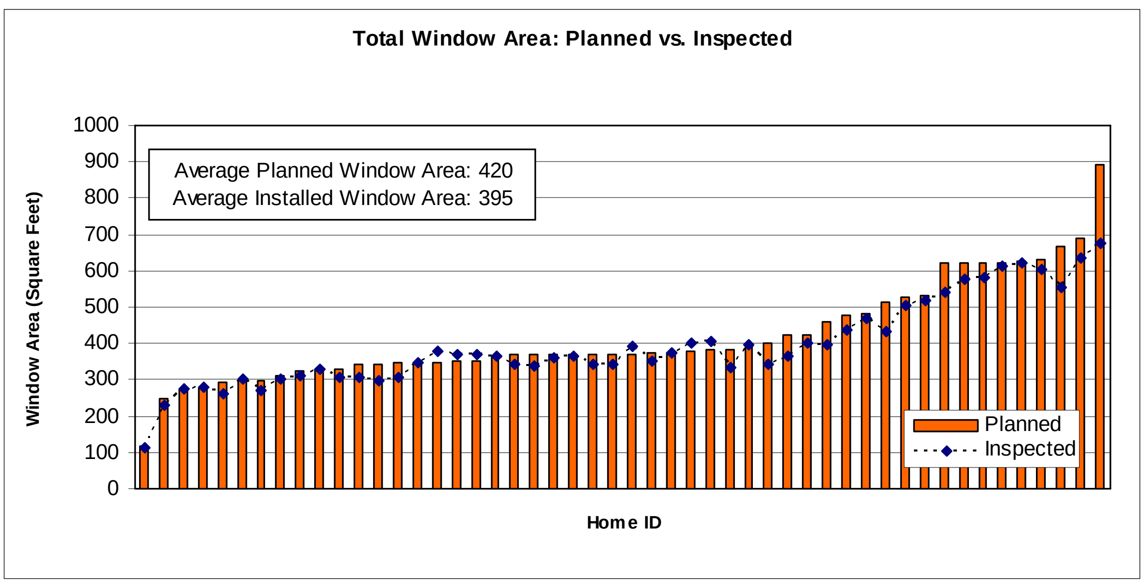


Figure 11: Planned vs. Inspected Total Window Area

The following table shows other inspected characteristics. The table shows some of the differences between the as planned and as-built characteristics discovered during the on-site inspections. For example, there were 4 sites where a radiant barrier was installed, when none was planned in the Title 24 model, making these homes slightly more efficient. Conversely, there were no cases where a radiant barrier was planned, but not installed. In all cases the inspections showed that the net effect of the verified building characteristics was either as planned, or more efficient than planned.

Measure	Planned	Inspected	Frequency	Net Energy Effect
TXV Valve	No	Yes	0	No Difference
	Yes	No	0	
Radiant Barrier	No	Yes	4	More Efficient
	Yes	No	0	
Attic R-value	Higher than plan		9	More Efficient
	Lower than plan		2	

Table 21: Planned vs. Inspected Measures (Thermal Expansion Valves (TXV), Radiant Barrier, Attic R-value)

These single family inspection findings correspond with the 02-03 evaluation's inspection findings. Though there are commonly construction differences that may make a particular home more or less efficient, the average as-built ENERGY STAR® home is slightly more efficient than planned.

Gross Savings

Orientation/ Inspection-Adjusted Gross Savings

Adjustments were made to the tracking gross savings based on the orientation ratios and inspection ratios described in Appendix A. The results of these adjustments are reported in Table 22.

Utility	kWh		Therms	
	Coastal	**Inland**	**Coastal**	**Inland**
PGE	381,992	4,985,343	149,160	1,614,445
SCE	126,128	12,717,202	6,060	1,528,460
SoCalGas	0	3,090,349	0	69,359
SDGE	474,555	879,031	235,426	139,677
Total	982,675	21,671,926	390,646	3,351,942

Table 22: Orientation/Inspection-Adjusted Gross Savings of Single Family 04-05 Participant Homes

Meter Adjustment

In the analysis of the metered data, RLW found that there were significant differences between the average usage predicted for a site through its compliance model and the end-use demand actually metered on site. We calculated meter adjustment factors and error bounds that were the estimated ratio of metered usage to model usage for each end use in each of three climate regions. These ratios were then applied to the orientation/inspection-adjusted estimates of gross savings to yield the ex post estimates of gross single family program savings.

Meter Adjustment Calculation

The aggregated annual meter data was matched up by end use to the estimated usages output by the MICROPAS reruns and adjusted EnergyPro runs for each site. As expected, the variation in actual usage was greater than the variation in modeled estimates—after all, the models are meant to represent a home under standardized usage conditions. Figure 12 shows the cooling metering results plotted against the cooling load predicted by the models.

Most of the sites have a metered usage less than the modeled usage, falling underneath the y=x line in the plot. There are a handful of sites that exhibited considerably higher annual usages than the models predicted. Some of these sites are standard sampling outliers; larger users that are statistically balanced out by smaller users in the sample. However, most of the 14 homes located in coastal climate zones lie above the line, indicating that, generally, coastal-dwellers used more AC energy than the compliance model indicated.

The three desert sites with high model-predicted cooling load used considerably less AC than the model predicted. This is to be expected, as it is in very hot climate zones that the impact of the models' constant thermostat set point is going to have the greatest impact on usage estimates.

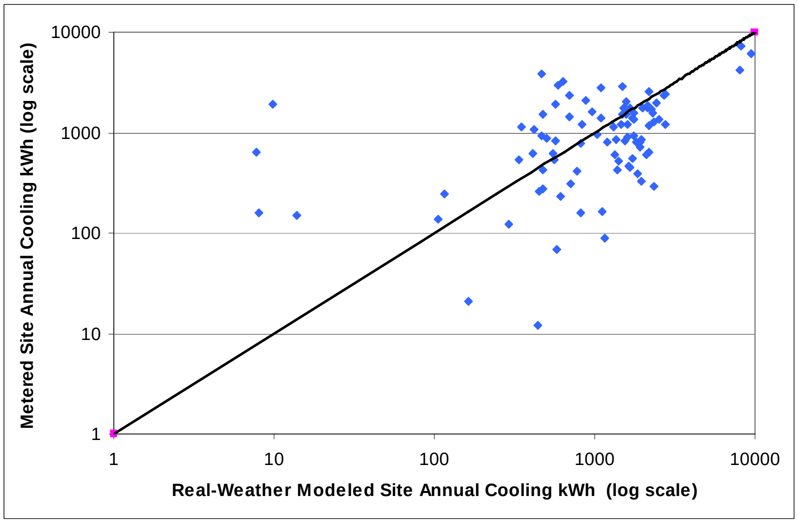


Figure 12: Single family Metered Annual kWh Cooling Compared to Modeled kWh Cooling

The heating results more consistently show that metered usage is less than the modeled usage. Figure 13 shows that just over a dozen sites logged usage greater than the amount the compliance model predicted for them. The rest of the sites fall below the y=x line, indicating that the model over predicted heating demand relative to what the homeowner actually used during the metering period.

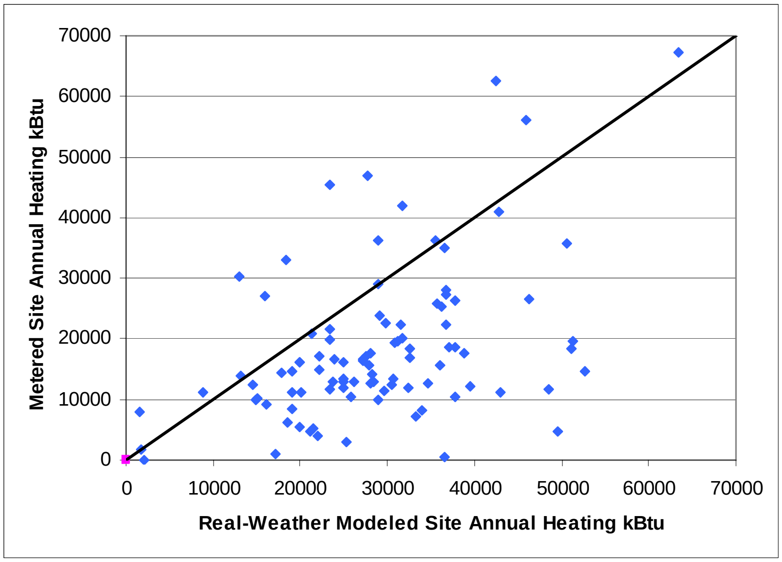


Figure 13: Single family Metered Annual kBtu Heating Compared to Modeled kBtu Heating

The greatest variation among the metered results vis-à-vis the modeled usages was seen in the hot water results. As Figure 14 shows, the models predicted between 19,000 and 30,000 kBtu for the homes, whereas actual metered usage ranged from just above 0 to 45,000 kBtu—with one home topping 60,000 kBtu. Despite the large spread, the majority of the homes showed metered usage less than the model-predicted annual usage. In fact, most of the homes had metered usage under 19,000 kBtu, the smallest model-predicted usage among our sample homes.

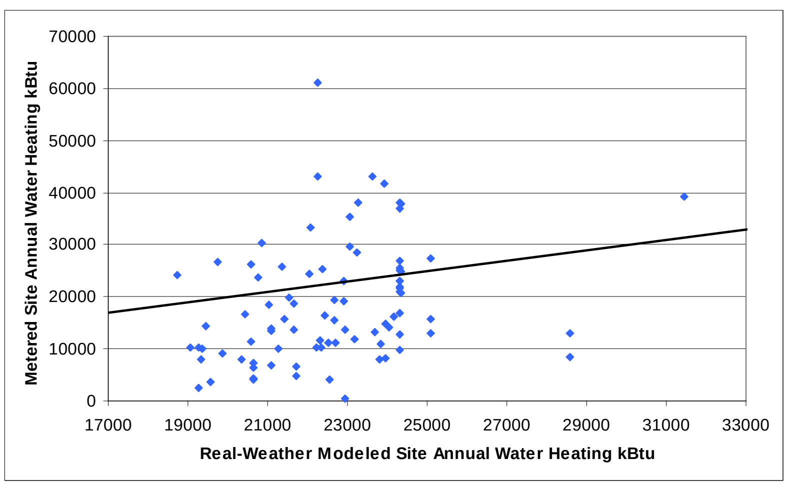


Figure 14: Single family Metered Annual Water Heating Compared to Modeled Water Heating

Meter Adjustment Factor Ratio Analysis

Due to the differences between the larger, desert-located cooling sites and the rest of the inland data and the difference between coastal and inland results seen in the data, we broke out the analysis into three climate zones: coastal (defined as in the rest of this report), inland (same as inland in the rest of this report, minus CEC climate zone 15), and desert (comprised of CEC climate zone 15). These distinctions were used throughout the single family portion of the metered-adjusted ratio analysis of the heating and cooling end uses. Since water heating is not weather-dependent in the compliance models, its adjustment factor was not separated out by climate zone.

For each climate-zone/end-use combination, we used stratified ratio estimation to weight our sample up to the 2004-2005 ENERGY STAR® Homes single family participant population and calculated the ratio of metered usage to real-weather modeled usage. The sample was projected up to the total population by CEC climate zone, such that each CEC climate zone's available sample sites for each end use were treated as a simple random sample of the participants in that climate zone. Once those weights were assigned to the sample homes, ratio estimation was used to calculate the adjustment factors reported in Table 23.

End Use	Climate	Sample n	Ratio Meter Usage to Modeled Usage	Relative Precision
AC	Coastal	14	1.752	49.0%
	Inland	72	0.797	14.3% *
	Desert	5	0.664	18.3% *
Heat	Coastal	14	0.589	28.9% *
	Inland	76	0.614	11.6% *
	Desert	6	0.837	25.3%
Hot Water	N/A	87	0.813	10.3% *

* Indicates statistically significantly different from ratio = 1

Table 23: Single family Meter Adjustment Factors by Climate Zone and End Use[35]

As was observed in the graphs of metered versus modeled energy usage, coastal cooling usage was, on average, 75.2% higher than modeled usage for coastal homes. Despite it's size, however, this ratio is not statistically significantly different from 1, and thus does not represent a statistically significant difference between coastal metered and modeled usage. The ratios for inland cooling and desert cooling, however, are both statistically significant, both having relative precisions under 20%. The inland homes, on average, used 79.7% of the cooling energy predicted by the models. The desert homes used 66.4% of the predicted energy. Overall, there is good statistical evidence that the compliance model overstates cooling energy demand for inland and desert single family homes.

The heating ratios reflect even greater overestimation of usage. Coastal metered usage was 58.9% of modeled projections while inland homes' usage was 61.4% of their models' estimates. Both results were statistically significant. Desert homes also used

[35] All relative precisions were computed at the 90% level of confidence. The relative precisions indicate what percentage of the estimates the error bounds represent. If the estimate plus or minus that error bound does not include 1, then the estimate is determined to be statistically different from 1.

less heating energy than modeled—83.7% less—but this difference was not statistically significant, owing to the small sample size of desert homes.

The hot water ratio also reflects the results shown in Table 23, showing an average metered usage of 81.3% of modeled usage across all homes at a 10% relative precision.

Meter Adjustment Impacts on End-use Shares

The metered data can also be looked at to see how it affects the proportion of builder-affected energy use that goes to each of the three major end-uses (heating, cooling, and water heating) compared to the end-use shares predicted by the modeling software. Figure 15 shows the proportion of energy,[36] aggregated across the single family metering sample) that goes to each of the end-uses according to the meter data (on the left) and the modeled data (on the right). The models predict that heating is the majority of usage, with cooling taking small 9% share. The metering results show that there actually much less heating energy usage and more cooling usage than predicted. The result is that cooling's share increases to 17% and heating's drops from 51% to 35% of total builder-affected energy usage.

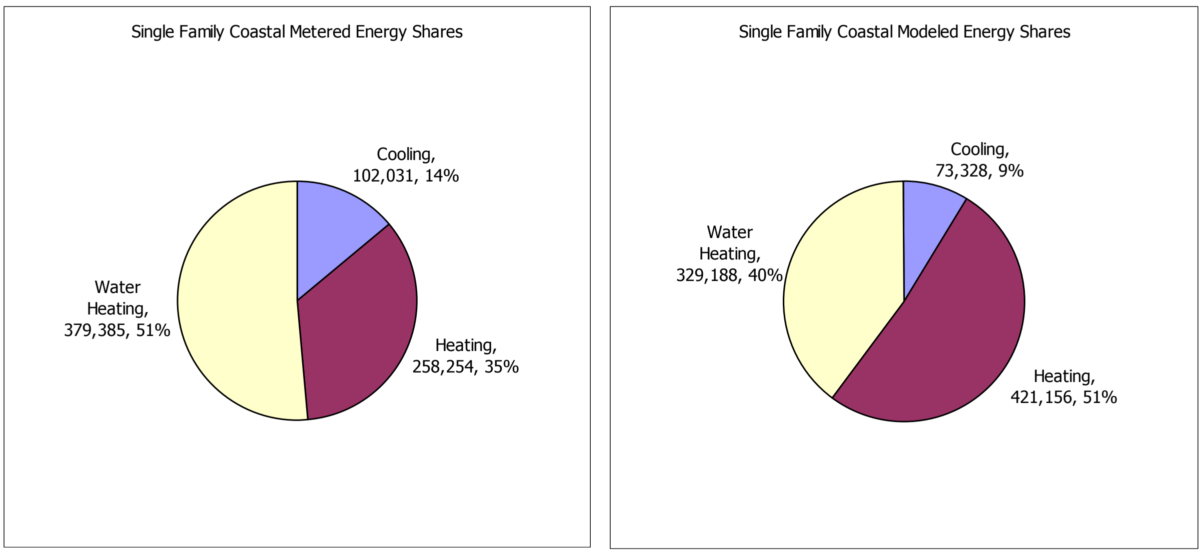
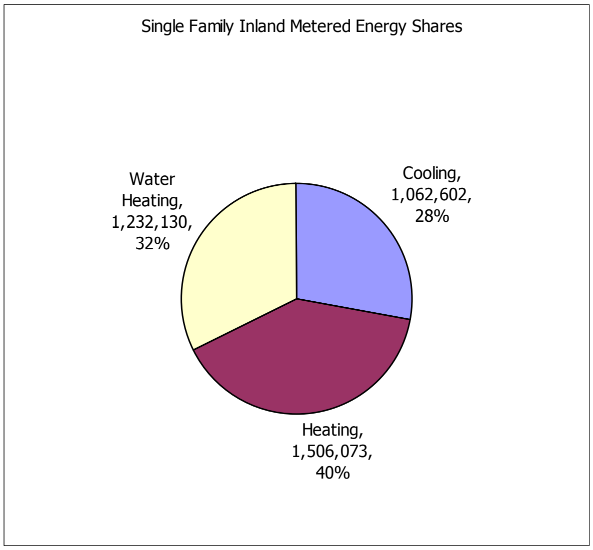


Figure 15: Single Family Metered vs. Modeled Energy Usage Shares, Coastal

The impacts on inland energy use share, Figure 16 are less pronounced, but still present. Water heating's share of energy usage is relatively constant, but metering indicates that homes use a higher share of cooling energy and a lower share of heating energy than indicated by the models.

[36] The end-use shares charts present all end-uses in source kBtu for ease of comparability between end uses.



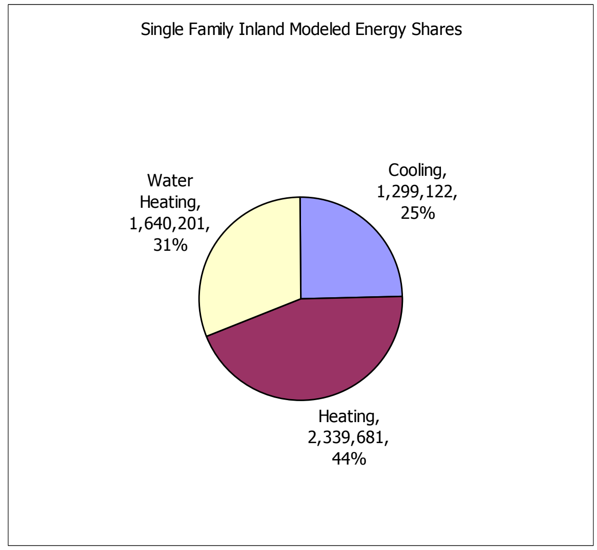


Figure 16: Single Family Metered vs. Modeled Energy Usage Shares, Inland

Meter-Adjusted Savings

The orientation/inspection-adjusted gross savings were broken down by utility and into coastal, inland, and desert so that the different ratios for the three climate zones could be applied. Table 24 shows how the ratios were applied for estimates of cooling savings by utility. The reported error bound includes the error both from the estimate of the meter-adjustment ratio and from the estimate of the inspection B-ratios. The tables for the calculations for the gross savings of other end uses are included in Appendix D.

Utility	Climate Zone	Inspection-Adjusted Gross	Meter Adjustment Factor	Ex Post Gross Savings	Error Bound
PGE	Coastal	381,992	1.752	669,313	349,429
	Inland	4,985,343	0.797	3,974,754	591,336
SCE	Coastal	126,128	1.752	220,998	115,377
	Inland	12,553,439	0.797	10,008,704	1,489,024
	Desert	163,764	0.664	108,657	20,341
SoCalGas	Inland	213,069	0.797	169,878	25,273
	Desert	2,877,279	0.664	1,909,078	357,390
SDGE	Coastal	474,555	1.752	831,500	434,102
	Inland	683,697	0.797	545,103	81,097
	Desert	195,334	0.664	129,604	24,263

Table 24: Single Family Cooling Meter-adjusted Savings (kWh) with Error Bounds

Ex Post Gross Single Family Program Savings

Based on these meter-adjusted net savings by end-use, RLW then recalculated the gross program savings by utility and by climate zone for the two fuel types. Table 25 shows the gross program savings after taking into account the meter adjustment factor. The inland savings amounts have all dropped relative to the orientation/inspection-adjusted gross savings estimates; coastal savings estimates have all increased. The per-unit savings for inland structures ranged from PGE's 358 kWh per year to SoCalGas's average 1,746 kWh/year/unit. Coastal savings were lower for SDGE, around 270 kWh/y/unit, but higher for both PGE and SCE; 562 and 1,454 kWh/year/unit respectively.

Utility	Inland				Coastal			
	Units	Ex Post Gross Savings	Error Bound	Gross Unit Savings	Units	Ex Post Gross Savings	Error Bound	Gross Unit Savings
PGE	11,117	3,974,754	591,336	358	1,192	669,313	349,429	562
SCE	13,145	10,117,361	1,489,163	770	152	220,998	115,377	1,454
SoCalGas	1,191	2,078,956	358,283	1,746	0	NA	NA	NA
SDGE	1,256	674,708	84,648	537	3,060	831,500	434,102	272
TOTAL	26,709	16,845,778	1,644,024	631	4,404	1,721,811	569,084	391

Table 25: Single Family Meter-adjusted Gross Program Electricity Savings (kWh)

Table 26 shows the impact of the meter-adjustment factors on program gross gas savings. All gas savings are lower than the orientation/inspection-adjusted gross savings. Using the overstated model estimates of usage as the sole estimator of savings over-estimated gas savings by some 20-30%. Per-unit inland savings ranged from SoCalGas's 45 therms/year to SCE's 114 therms/year savings. Savings were lower in the coastal regions, from 50 kWh/year/unit for SCE up to 82 kWh/year/unit in PGE's program.

Utility	Inland				Coastal			
	Units	Ex Post Gross Savings	Error Bound	Gross Unit Savings	Units	Ex Post Gross Savings	Error Bound	Gross Unit Savings
PGE	11,117	1,081,137	229,873	97	1,192	98,118	19,756	82
SCE	13,145	1,496,290	235,487	114	152	7,657	1,191	50
SoCalGas	1,191	53,184	7,246	45	0	NA	NA	NA
SDGE	1,256	102,401	15,986	82	3,060	167,751	26,090	55
TOTAL	26,709	2,733,012	329,551	102	4,404	273,527	32,748	62

Table 26: Single Family Meter-adjusted Gross Program Gas Savings (therms)

Net Savings

Difference of Differences

Table 27 shows electricity net to gross ratios; Table 28 shows natural gas net to gross ratios. Electricity NTG ratios vary widely across IOUs and region, from 0.32 to 1.67. <u>The statewide electric NTG ratio is .75 for the Coastal region, and 1.27 for Inland</u>, implying an overall negative free-ridership in the Inland region. This is consistent with the new construction baseline study used for the analysis, and is a direct result of negative naturally occurring cooling savings among non-participants in the Inland region.[37] That is, on average, non-participant homes do not meet Title 24 package D cooling energy budgets in the Inland region. In fact, the non-participant baseline study found that 27% of homes surveyed did not comply with Title 24 energy requirements. The NTG ratio for the Coastal region ranged from 0.32 to 0.82, implying there are some naturally occurring cooling savings for non-participants in the coastal areas. Note that

[37] As determined by the 2004 California Residential New Construction Baseline Study (Itron, 2004). Non-participant homes exceeded cooling budgets primarily in inland climate zones. Some homes made up the deficit with energy savings in other areas (heating or hot water), but the study found that 27% of homes surveyed were not Title 24 compliant. The compliance of another 30% could not be determined within the error bounds of the data collected.

there are significantly fewer new ENERGY STAR® Homes in the coastal region compared to the inland region, shown in Table 27 and Table 28.

Electricity (kWh)							
	Inland				Coastal		
Utility	Ex Post Gross Savings	Ex Post Net Savings	Net-to-Gross Ratio	Utility	Ex Post Gross Savings	Ex Post Net Savings	Net-to-Gross Ratio
PGE	3,974,754	6,622,261	1.67	PGE	669,313	551,485	0.82
SCE	10,117,361	12,412,735	1.23	SCE	220,998	70,427	0.32
SoCalGas	2,078,956	1,760,013	0.85	SoCalGas	NA	NA	NA
SDGE	674,708	727,800	1.08	SDGE	831,500	668,434	0.80
TOTAL	16,845,778	21,522,809	1.28	TOTAL	1,721,811	1,290,346	0.75

Table 27: kWh Impacts and Net to Gross Ratios By Climate Region[38]

Gas NTG ratios are a little more consistent across IOUs and climate regions. The statewide gas NTG ratio is 0.14 for Coastal region and 0.45 for Inland, implying high statewide weighted average free ridership of 58%. This is a direct result of high naturally occurring savings in the two gas end-uses, heating and especially water heating.

Gas (therms)							
	Inland				Coastal		
Utility	Ex Post Gross Savings	Ex Post Net Savings	Net-to-Gross Ratio	Utility	Ex Post Gross Savings	Ex Post Net Savings	Net-to-Gross Ratio
PGE	1,053,484	588,538	0.56	PGE	114,116	1,077	0.01
SCE	1,006,054	336,590	0.33	SCE	3,912	-74	(0.02)
SoCalGas	55,012	22,154	0.40	SoCalGas	NA	NA	NA
SDGE	95,741	28,194	0.29	SDGE	205,031	43,107	0.21
TOTAL	2,210,291	975,476	0.44	TOTAL	323,059	44,110	0.14

Table 28: Therm Impacts Net to Gross Ratios By Climate Region

To assign kBTU energy per home to kWh and therms savings it was necessary to assign fuel types to each end use. For single family projects it was assumed all space heating and water heating were natural gas fired, and that all cooling was electric. These assumptions are very reasonable and accurate for over 99% of all California single homes. (In a few cases space heating may have been electric, due to occasional usage of heat pumps; however this was extremely rare and would not have impacted the results.) The same assumptions were not made for multifamily projects, which were handled on a building-by-building basis.

Single Family Net Savings and Realization Rates

Single family net energy savings were calculated based on the actual number of homes completed in calendar years 2004 and 2005; there were 31,113 single family dwelling units. Ex ante estimates were calculated for each utility based on per unit savings estimates and the number of homes actually built in 2004 and 2005.[39] Ex post savings were estimated using the difference-of-differences (DofD) methodology, detailed in this report. The essence of this method is to compare ENERGY STAR® Homes (participants)

[38] The Gross Ex Post is the Adjusted Gross Savings, while the Net Ex Post is the difference-of-differences result.

[39] At the time utilities filed Program information with the CPUC, estimates were based on homes committed (approved applications) within a Program year – not constructed. Since that time, it was determined to conduct this evaluation based on homes actually constructed within a Program year. Due to this accounting change, it was necessary to calculate new ex ante estimates.

to standard construction practices (non-participants), determined from a non-participant new construction baseline study, to subtract out naturally occurring savings. The result is ex post (net) savings. Single family electricity savings and realizations rates for coastal and inland climate regions are presented in Table 29. In inland areas, net per-unit savings ranged from 579 kWh/year/unit in SDGE to 1,478 kWh/year/unit among SoCalGas's customers. Overall, the program produced an average 806 kWh/year/unit savings in inland climate zones. As expected, savings were lower in coastal climate zones, ranging from SDGE's 218 kWh/year/unit to 463 kWh/year/unit from both PGE and SCE's program. The overall program savings in coastal climate zones came to 293 kWh/year/unit.

Electricity (kWh)									
	Inland					Coastal			
Utility	Net Ex Ante	Net Ex Post Savings	Net Unit Savings	Realization Rate	Utility	Net Ex Ante	Net Ex Post Savings	Net Unit Savings	Realization Rate
PGE	2,929,935	6,622,261	596	2.26	PGE	327,638	551,485	463	1.68
SCE	13,218,550	12,412,735	944	0.94	SCE	NA	70,427	463	NA
SoCalGas	841,921	1,760,013	1,478	2.09	SoCalGas	0	NA	NA	NA
SDGE	812,883	727,800	579	0.90	SDGE	1,980,432	668,434	218	0.34
TOTAL	17,803,289	21,522,809	806	1.21	**TOTAL**	2,308,070	1,290,346	293	0.56

Table 29: Single Family Annual Electricity Savings & Realization Rates

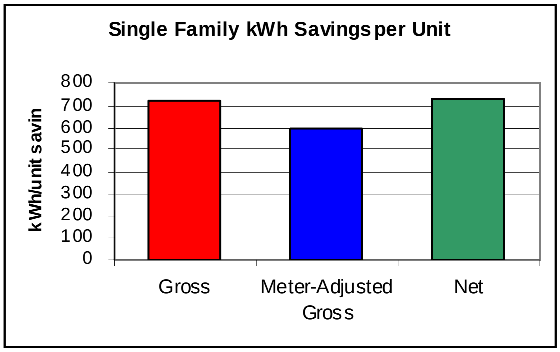
Single family gas savings and realization rates for coastal and inland climate regions are presented in Table 30. Net inland gas savings ranged from 19 therms per unit in SoGal Gas's program to 53 therms/year/unit for PGE. Overall inland program gas savings averaged 37 therms/year/unit. Net coastal gas savings were negative for SCE and ranged up to 14 therms/year/unit for SDGE. Overall coastal gas savings were 10 therms/year/unit.

Gas (therms)									
	Inland					Coastal			
Utility	Net Ex Ante	Net Ex Post Savings	Net Unit Savings	Realization Rate	Utility	Net Ex Ante	Net Ex Post Savings	Net Unit Savings	Realization Rate
PGE	1,153,676	588,538	53	0.51	PGE	127,330	1,077	0.9	0.01
SCE	NA	336,590	26	NA	SCE	NA	-74	-0.5	NA
SoCalGas	29,394	22,154	19	0.75	SoCalGas	0	NA	NA	NA
SDGE	19,694	28,194	22	1.43	SDGE	-13,709	43,107	14	-3.1
TOTAL	1,202,764	975,476	37	0.81	**TOTAL**	113,621	44,110	10	0.39

Table 30: Single Family Annual Gas Net Savings & Realization Rates

Savings Compared to Gross and Non-Meter-Adjusted Net

Figure 17 shows how the meter-adjusted gross savings estimates compare to the orientation/inspection-adjusted gross and net savings results reported above. For electricity, the negative cooling compliance margins of inland non-participants drove the net savings higher than the compliance-margin-based gross savings estimates. This compensated for the downward adjustment for the difference between metered usage and modeled usage, such that the final estimate of program electricity savings was very close to the original gross savings estimate.



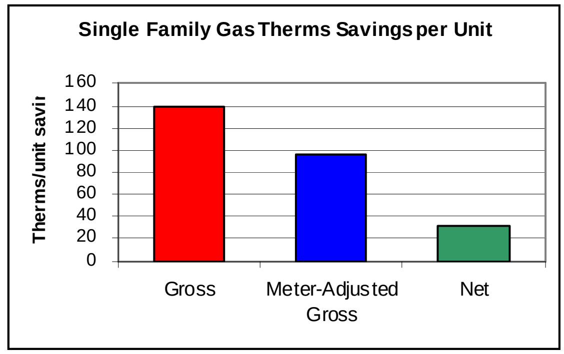


Figure 17: Single Family Per-unit Overall Estimated Savings, by Analysis

For gas savings, high heating and water heating compliance margins pushed the overall net gas savings well below the gross estimates. When adjusted downward for the metering adjustment and net savings, the total net program savings were roughly 25% of the non-meter-adjusted gross savings.

Breakdown of Usage Estimates

The results of the net savings analysis are presented in a different way in Figure 18. The total height of each bar represents the standard design, or Title 24 Package D energy use. Energy savings are divided into two parts – the naturally occurring savings, and the net savings calculated using the difference-of-differences method. All three end-uses consume roughly equal amounts of source energy statewide. In the single family population, water heating is always gas fueled and cooling always electric. Heating is natural gas fueled for over 99.5% of the homes.

Several results are evident:

- The ESH program's largest source of net energy savings for single family are derived from cooling, while the smallest are from water heating.
- Negative natural savings for cooling means that new non ENERGY STAR® Homes on average do not meet Title 24 cooling budget requirements, as determined by the baseline study (Itron, 2004). The fact that non participants are performing worse than code means that some of net electricity savings are attributable to the low performance of the baseline group.
- Significant naturally occurring (gas) savings are present for heating and water heating, translating to high gas free-ridership rates.
- The average as-proposed ENERGY STAR® home uses the most energy for water heating among the three end-uses. Most of the program savings in energy use come from heating and cooling.

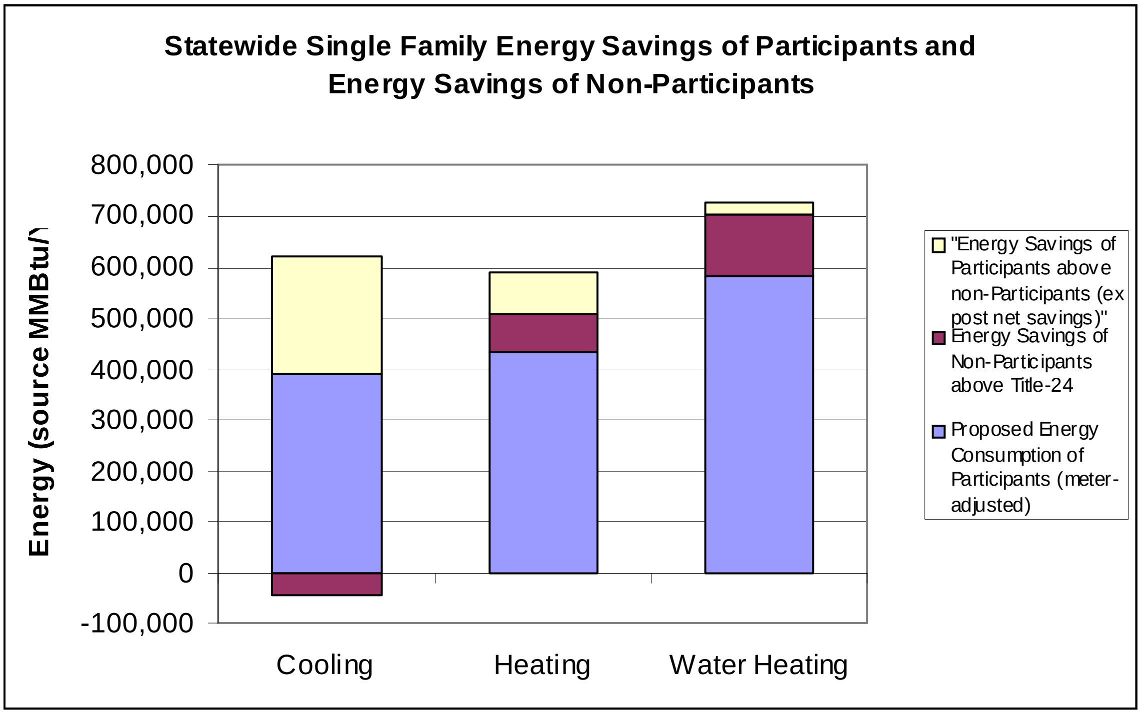


Figure 18: Statewide Single Family Net Energy Savings

(Total height of each bar represents Standard design Title 24 Package D energy use)

Net to Gross (SERA)

The derivation of estimates from non-participants is summarized below. The responses make it clear that the program has had an influence beyond that represented by participating builders. Additional discussion of the survey responses is located in Appendix F.

- For the buildings under discussion, we asked what energy efficiency level they were built, relative to code (Q-C1) The responses were that none were building higher than 15% better than code, 22% building about 15% better than code, 22% building better than code but less than 15% better than code (average about 9%), and 50% building just to code. None say they are building less than code .
- We asked whether the program influenced the energy efficiency building practices in their homes (C1b) and found that 73% said no, but 18% said their procedures were partially influenced by the program, and 9% said yes, the program did influence practices.
- When asked to characterize their efficiency levels for homes built in 2004/05 (C3), most said same as Title 24 (44%), 7% said much less than T24, 39% said somewhat more efficient than T24, 5.6% said slightly more efficient. Overall, this can be translated to baseline 2004-2005 building by non-participants at about 1.04% of Title 24.
- We asked what factors improved the efficiency level of the constructed homes (C4b). None reported that the program led them to decrease their efficiencies, but those that noted improvements in efficiency attributed the increases largely to Title 24. Their responses on drivers included: T24 (41%); market moving/customer demand

(19%), technology improvements (19%), green bldg program (13%), and the other mentions were fuel prices, and on-going learning by builders.

- When asked about their average energy efficiency level for construction of single family residents relative to code (C9), they reported the following: none reported building to less than code; 47% said they build just to code, and 41% said they build to energy efficiency levels greater than that required by code. For those above code, the average percent above code was 10.9%. Applying these percentages implies the market base is about 5.1% above code for non-participants. When asked if the ENERGY STAR® program had led to improvements in efficiency levels (D2), about 12% of those exceeding code attributed changes / increases to the program.
- We then asked about whether non-participant builders believed that non-participants have been influenced to exceed code due to program (E3). Almost a third (32%) believe this effect exists. We may then derive an estimate of the non-participant spillover as follows. The estimate of NP spillover might be estimated as energy efficiencies of 11% over T24 are occurring, representing 46% of the market. About 12% of this increase is influenced by or attributable to the program, which results in an estimate of perhaps a 0.6% increase in market wide efficiencies due to the program.

The difficulty occurs in identifying the factor to use to apply to the program's savings to represent this market-wide effect because it is unclear what share of total new construction market is represented by ENERGY STAR® homes. If it represents 5% of the market for new homes, then the NP spillover factor to be applied to ESH program would be a multiplier of 0.12 or if 10% of the market, the multiplier would be 0.06. We apply this range for the report.

The results of these computations are provided in the table below.

Net to Gross Results: The estimated Net to Gross Ratio is developed in the following table.

Source of Estimate		Indirect Market Effects			(1-Col A)	(1+Col B+C+D)	(E*F)
	A.	**B.**	**C.**	**D.**	**E.**	**F.**	**G.**
	Free Rider	Inside	Outside	Non-Partic.	Net factor	Market Factor	NTG Ratio
Household - Participant, non-participant, and control groups	0.46-0.58	0	0.32-0.54	0.06-0.12[40]	0.42-0.53	1.38-1.66	0.58-0.88

Table 31: Summary of NTG Elements and Computation of NTG Ratio

[40] Assumed ENERGY STAR® Homes represent 5-10% of the new construction market.

Billing Analysis

For this analysis we utilized regression analysis to determine what effect, if any, ENERGY STAR® Homes program participation had on a household's energy usage. We ran a regression for each of three building affected energy end uses—AC electric usage, heating gas usage, and non-heating gas usage—using utility-provided billing data and the results of our survey questions. We ran each of the three end-use regressions for climate zones 8 and 12 in order to isolate program participation. The final regressions for each climate zone are listed below. These regressions are the results of backwards regression analysis in which we dropped all variables that were not statistically significant from the original model listed in the impact methodology section. [41]

Model Results

Electricity Air Conditioning Usage

CEC Zone 8

Variable	Coefficient	Std Error	P value
Participant	96.64	497.5	0.8468
Floor Area	0.685	0.188	0.0007
R squared	0.2313		

Table 32: Climate Zone 8 AC Results

The coefficient on the participant variable indicates that ENERGY STAR® homes used 100 kWh/year more than their non-participant counterparts, though with a p-value of 0.84 we cannot make any definitive statement about the difference between participant and non-participant AC usage. The imprecision of this result could be due to the small sample size (49 total participants and non-participants). The coefficient on the floor area variable indicates that AC usage increases by 0.69 kWh/year for each additional square foot of floor area.

CEC Zone 12

Variable	Coefficient	Std Error	P value
Participant	252.69	153.73	0.1028
Floor Area	0.21	0.09	0.0186
# Fulltime Adult Residents	331.23	106.58	0.0023
# Summer Time Residents	670.24	157.12	<.0001
# Home During Summer Day	147.88	64.27	0.0231
R squared	0.3457		

Table 33: Climate Zone 12 AC Results

The coefficient on the participant variable indicates that ENERGY STAR® homes used 250 kWh/year more than a comparable non-participant. The participant result is

41 Because we were trying to isolate the effects of participation, the participant variable was still included in the regressions even when not statistically significant.

contrary to the findings in the net savings analysis. The p-value of 0.1028 shows that this result is significant at an 89% level of confidence, meaning that, even taking into account the demographic survey results, participants in climate zone 12 had more AC usage on average than non-participants. The coefficient on the floor area variables indicates that AC usage increases by 0.21 kWh/year for each additional square foot of floor area. The coefficient on the # Fulltime Adult Residents indicates each additional adult resident will increase AC energy usage by 330 kWh/year.

The coefficient on the summertime residents variable indicates 670 kWh/year increased usage for each additional summer time resident. The reason for this variable is that AC usage figures were calculated using the PRISM model. This model separates out all electricity usage that is weather dependent, mainly AC usage. If a resident is only present during the summer, when the weather is hot, the PRISM model will attribute all electricity this resident uses as AC usage. By using this demographic variable we are able to further isolate the effect of program participation on AC usage by removing the effect of these summer residents. The coefficient on the # Home During Summer Day variable indicates that each additional resident that is home during the day increases AC energy usage by 150 kWh/year.

Gas Heat Usage

CEC zone 8

Variable	Coefficient	Std Error	P value
Participant	49.97	24.70	0.0479
Floor Area	0.164	0.05	0.0034
Floor Area Squared	-0.000023	0.000008	0.0041
R squared	0.1752		

Table 34: Climate Zone 8 Gas Heat Results

The results for CEC 8 shows statistically significant, at the 95% level of significance, an additional usage of 50 therms/year for ENERGY STAR® homes participants compared to comparably sized non-participants, which is contrary to the net savings analysis findings. The coefficient on the Floor Area variables indicates that gas heat usage increased by 0.164 therms/year per square foot minus 0.000023 therms/year per square-foot squared—an indication that the heating usage impact of floor area flattens out as the size of the home increases.

CEC zone 12

Variable	Coefficient	Std Error	P value
Participant	-109.52	23.02	<.0001
Floor Area	0.08	0.012	<.0001
# Fulltime Adult Residents	32.66	15.04	0.0315
R squared	0.4244		

Table 35: Climate Zone 12 Gas Heat Results

The coefficient on the participant variable indicates that participants used 110 therms/year less than non-participants, which is in line with the net estimate of heating savings from the net savings analysis. The coefficient on the floor area variable indicates that gas heat usage increased by 0.08 therms/year per square foot. The coefficient on the # Fulltime Adult Residents variable indicates that each additional adult resident will increase gas heat usage by 32.66 therms/year.

Gas Non-heating Usage

CEC zone 8

Variable	Coefficient	Std Error	P value
Participant	71.73	68.04	0.2963
Floor Area	0.18	0.03	<.0001
# Fulltime Adult Residents	103.69	46.5	0.03
R squared	0.5304		

Table 36: Climate Zone 8 Gas Non-heating Results

The coefficient on the participant variable indicates participants used 70 therms/year more than non-participants for non-heating end uses (water heating, cooking, clothing dryers), though the p-value of 0.2963 means that we can not make a definitive conclusion about the result. The coefficient on the floor area variables indicates that gas heat usage increased by 0.18 therms/year per square foot. The coefficient on the # Fulltime Adult Residents variable indicates that each additional adult resident will increase non-heating gas usage by 100 therms/year

CEC zone 12

Variable	Coefficient	Std Error	P value
Participant	-17.30	20.03	0.3894
Floor Area	0.06	0.01	<.0001
# Fulltime Adult Residents	51.55	12.75	<.0001
# Fullltime Child Residents	40.34	7.59	<.0001
R squared	0.4931		

Table 37: Climate Zone 12 Gas Non-heating Results

The coefficient on the participant variable indicates that ENERGY STAR® homes used 17 therms/year less than their non-participant counterparts, however we can not make a definitive conclusion about this result due to the p-value of 0.39. The coefficient on the floor area variable indicates that each additional square foot increases gas non-heating usage by 0.06 therms/year. The coefficient on the # Fulltime Adult Residents variable indicates that each additional adult resident will increase gas non-heating usage by 50 therms/year. Similarly, the coefficient on the # Fulltime Child Residents variable indicates each additional child resident will increase gas non-heating usage by 40 therms/year.

Conclusions

End Uses with Savings

There was evidence that savings in gas heating and non-heating gas usage were seen in CEC climate zone 12. Figure 19 shows how the billing analysis estimate of heating savings, 109 therms per unit, compares to the estimates obtained in the gross, net, and meter-adjusted net analyses for climate zone 12. The fact that it is even greater than the model-base estimate of net savings is solid evidence of the program's success in creating realized gas savings for units in climate zone 12.

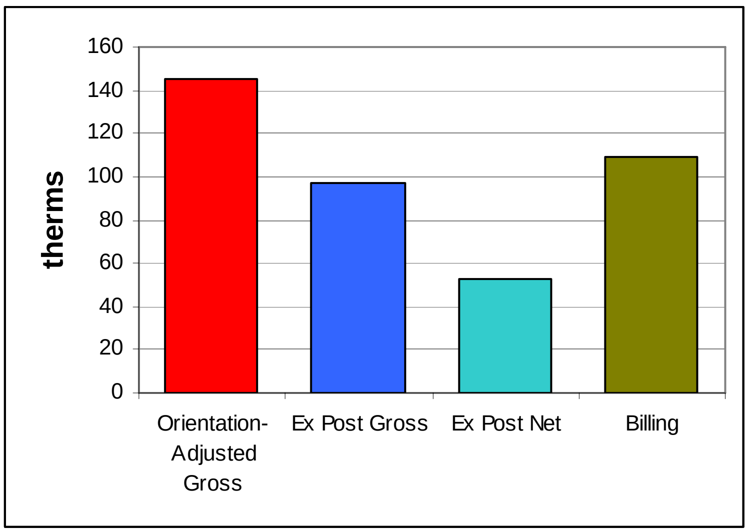


Figure 19: Per-unit Estimated Gas Savings in Climate Zone 12, by Analysis

End Uses Without Savings

Controlling for housing characteristics as well as demographic information, ENERGY STAR® homes participants used more energy with the exception of climate zone 12 gas usage. The demographic question results all indicate that non-participants would use more energy than participants, over and above any differences in their homes' physical characteristics. That we still see participants with higher usages in the regression results indicate that either there is a bias in the participant or non-participant samples or that participant homeowners are behaviorally inclined to use more heating, cooling, and water heating energy than non-participants.

Table 38 shows a comparison of net savings with significant results calculated from the billing analysis and net savings (calculated using the Difference-of-Differences method described in the report) adjusted by the metered-usage-to-modeled-usage ratios.

	End Use	Meter-adjusted Net Savings	Billing Analysis Net-Savings	Difference
CZ 8	Heating (therms)	-1	-50	49
CZ12	Cooling (kWh)	586	-253	839
	Heating (therms)	46	109	-63

Table 38: Net Saving Results Comparison

For Climate zone 8 the meter-adjusted heating net savings is -1 therm while the billing-base estimate of savings was -50 therms; the billing analysis indicates that there was 49 therms less savings per unit than seen in the net savings analysis.

Climate zone 12 showed an even larger difference between modeled and billing data for cooling energy usage of 828 kWh, with the meter-adjusted net savings of 586 kWh and billing-analysis net savings of -252 kWh. Figure 20 shows graphically how this results compares to the per-unit estimates of electricity savings in climate zone 12 under the gross, net, and meter-adjusted net analyses.

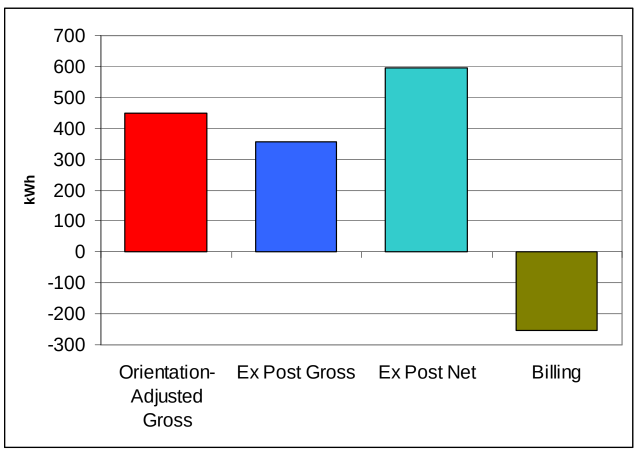


Figure 20: Per-unit Estimated kWh Savings in Climate Zone 12, by Analysis

These results indicate that model-based estimates of savings in electricity, at least within these two climate zones, are not necessarily realized in practice. Both regressions, after controlling for relevant demographic information, show that there is considerably more weather-dependent electricity usage among participants than non-participants.

This could be a result of self selection among participants; those with naturally higher energy usage habits have the most to gain from owning a more efficient home, and therefore may be more likely to purchase an ENERGY STAR® home. Another possible cause of this result could be the so-called snapback effect, where people use more energy *because* they live in a more efficient home and see a lower marginal cost to setting the thermostat to a more comfortable level or taking longer showers. These are not questions that can be answered in the present analysis, but raises questions that should be explored more fully if we are to best understand the impacts of future residential new construction programs.

It is also possible that the modeling approach missed some of the building-related savings actually experienced by non-participant homes—measures such as infiltration and tight ducts that were not tested for in the baseline study. Most likely it is a combination of these reasons. Either way, however, this result should be kept in mind in designing future residential new construction evaluations, as those will be the next best opportunity to get at and answer these questions.

Low Rise Multifamily Results

Ex-ante Savings

The AEAP filed gross savings estimates for 2004-05, which summarizes program accomplishments and total energy savings based upon program goals, were taken directly from the individual utility workbooks (no format changes were made) and are summarized in this section. The key estimates that this report evaluates are the per unit energy savings values.

PG&E

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
MF Whole Building - 15% above T-24	MF living unit	$150.00	$0.00	0.2237	218.26	73.00	$225.00	19	0.80	3,209
MF Design Assistance	MF living unit	$32.12	$0.00	0.0000	0.00	0.00	$0.00	0	0.80	3,209
MF Inspection Assistance	MF living unit	$50.00	$0.00	0.0000	0.00	0.00	$0.00	0	0.80	3,209

Table 39: PG&E MF Ex-Ante Estimates

SCE

Since SCE had two funding sources for this program, two program plans were filed, each with its own set of savings estimates.

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
MF Home 15%	Dwelling	$190.00	$0.00	0.3506	311	0	225	18	0.80	3,600

Table 40: SCE MF Procurement Ex-Ante Estimates

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
MF Home 15%	Dwelling	$240.00	$0.00	0.3506	311	0	225	18	0.80	4,540

Table 41: SCE MF PGC Ex-Ante Estimates

SoCalGas

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
52007-Multifamily 15% Above AB970	Home	$150.00	$0.00	0.5050	367	37	51	18	0.80	8,000

Table 42: SoCalGas MF Ex-Ante Estimates

SDG&E

MEASURE / ACTIVITY NAME Provide Measure Descriptions in Proposal Narrative	UNIT DEFINITION	FINANCIAL INCENTIVE PER UNIT	INSTALLATION, SERVICE, AND REPAIR LABOR COSTS PER UNIT	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)	GROSS IMC	EUL	NTG	UNIT GOALS
21006-Multifamily All Zones 15% Above AB970	Home	$150.00	$0.00	0.5050	367	37	51	18	0.80	4,100

Table 43: SDG&E MF Ex-Ante Estimates

Program Population

The population of low rise multifamily homes in 2004 and 2005 contains 2,825 unique structures. The distribution of these multifamily structures, by utility and climate region, is presented in Table 44.

Utility	Coastal	Inland	Total
PGE	171	204	375
SCE	62	96	158
SCG	80	548	628
SDGE	1,349	315	1,664
Total	1,662	1,163	2,825

Table 44: Population of Completed 04-05 Low Rise Multifamily Structures

These 2,825 structures are associated with 157 unique projects. The distribution of these projects, by utility and coastal/inland climate region, is presented in the table below.

Utility	Coastal	Inland	Total
PGE	14	19	33
SCE	7	14	21
SCG	8	39	47
SDGE	37	19	56
Total	66	91	157

Table 45: Population of Projects Associated with Completed 04-05 Low Rise Multifamily Structures

Multifamily On-Site Verification Inspection

Of the 157 low rise multifamily projects a total of 23 were inspected.[42] The inspected sites had a total of 98 plans[43], since there were multiple plans associated with almost all of the projects. A sample of these plans was inspected at each project, primarily based upon availability and access.

The findings of the 02-03 evaluation found very little variation in the compliance margins of the planned versus inspected multifamily sites, and no adjustments to the tracking savings estimates were made in 02-03. Based on the 02-03 results, RLW and the CPUC determined in order to better use evaluation resources, no remodeling of multifamily sites would be conducted for the 04-05 evaluation.

The 04-05 on-site inspections focused on verifying the efficiency of equipment to confirm that the same general trends had carried over from the previous evaluation. The on-site inspection methodology was similar to the methods used for the single family inspections. Heating, cooling, and water heating equipment efficiencies were verified against values recorded in the registries. In addition, conditioned floor area, volume, and window square footage were also verified against registry data. These parameters were found to match the plans (within 10%) except for three inspections.

Equipment efficiencies were found to have more variation than in 02-03, as shown below. However, the differences were approximately balanced as both better and worse, again indicating the average efficiency is approximately matched to the planned efficiency. Based on the increased variation, it is suggested future evaluations consider remodeling if a similar approach is used.

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[42] One low rise site had to be dropped when the site contact accidentally arranged the inspection at a non-ESH complex.

[43] The meaning of “plans” for multifamily projects is variable. For single family, a plan represents a single family home. Due to the flexibility of Title 24 modeling software, a multifamily plan can represent a dwelling unit, a multifamily structure, or a group of structures.

ID	Heating Efficiency Tracking	Heating Efficiency Verified	Heating Efficiency Type	Heating System Type	Cooling Efficiency Tracking	Cooling Efficiency Verified	DHW EF - Tracking	DHW EF - Verified
Home ID's Suppressed	7.0	7	HSPF	HPSplit	12	12	RE 0.82	N/O
	0.80	0.81	AFUE	Hydronic	10	12	DHW 0.61	Boiler 0.85
	7.8	7.8	HSPF	HPSplit	10	10	0.00	Inst 0.81
	0.75	0.78	AFUE	Hydronic	10	10	0.62	0.60
	0.75	0.75	AFUE	Hydronic	10	10	0.61	0.61
	0.75	0.78	AFUE	Hydronic	10	10	0.60	0.60
	0.76	0.75	AFUE	Hydronic	10	10	0.62	0.62
	0.75	0.75	AFUE	Hydronic	10	10	0.54	0.54
	No EF	0.70	AFUE	Hydronic	10	10	0.58	0.60
	0.75	0.75	AFUE	Hydronic	10	10	0.60	0.62
	0.78	0.75	AFUE	Hydronic	10	10	0.62	0.62
	0.79	0.75	AFUE	Hydronic	10	10	0.61	0.62
	6.8	N/O	HSPF	Room HP	10.66	N/O	DHW 0.62	Boiler 0.82
	0.78	0.75	AFUE	Hydronic	No cooling	No cooling	0.56	0.59
	0.80	0.76	AFUE	Hydronic	No cooling	No cooling	0.59	0.58
	0.82	0.74	AFUE	Hydronic	12	12	0.63	0.62
	No EF	N/O	AFUE	Hydronic	11	N/O	0.62	0.55
	7.8	N/O	HSPF	HPSplit	12.5	12	0.53	0.58
	No EF	N/O	AFUE	Hydronic	12	12	0.61	0.62
	No EF	0.80	HSPF	HPSplit	10	10	0.64	0.62
	0.80	0.80	AFUE	FAU	No cooling	No cooling	0.62	0.62
	0.80	N/O	AFUE	FAU	No EF	10	0.60	N/O
	0.80	N/O	AFUE	FAU	10	11	0.60	N/O

EF - Energy factor
No EF - No efficiency recorded in tracking
RE - Recovery efficiency
N/O - Not observable
DHW - Standard domestic hot water heater
Boiler - Central boiler
Inst - Instantaneous hot water heater

Table 46: Multifamily Equipment Efficiency Inspection Findings

Summary of Key Results

The multifamily on-site inspections revealed that, on average, there was not a significant difference between planned and inspected energy efficiency. Based on the current inspection results, it was determined the tracking database modeled energy values can be considered reasonably accurate, and no adjustments to the tracking savings estimates are necessary.

Gross Savings

Both CHEERS and CalCERTS tracking databases report all modeled energy in source kBTU. The calculation of gross tracking savings for multifamily homes is similar to that for single family. The orientation ratios were calculated to adjust the CALCERTS sites and applied to the tracking gross estimates to yield the adjusted gross savings. Table 47 presents the gross kWh savings (from cooling and electric heating) of completed 2004-05 multifamily dwelling units by utility. Table 48 shows the gross gas savings, which include gas-fired heating and water heating. Note that dwelling units are presented in this section, but the sample was selected by multifamily complex since the compliance models were often modeled at the building level.

Utility	Inland		Coastal	
	Dwelling Units	Orientation-adjusted Gross Savings	Dwelling Units	Orientation-adjusted Gross Savings
PGE	1773	426,312	985	118,337
SCE	1988	636,575	803	137,954
SoCalGas	5968	1,631,100	354	63,922
SDGE	1609	348,519	5,648	786,919
TOTAL	11,338	3,042,506	7,790	1,107,131

Table 47: Gross Electricity Savings of Completed 04-05 Multifamily Dwelling Units (kWh)

Utility	Inland		Coastal	
	Dwelling Units	Orientation-adjusted Gross Savings	Dwelling Units	Orientation-adjusted Gross Savings
PGE	1773	122,449	985	77,758
SCE	1988	120,320	803	38,912
SoCalGas	5968	323,766	354	19,254
SDGE	1609	109,006	5,648	360,618
TOTAL	11,338	675,541	7,790	496,542

Table 48: Gross Gas Savings of Completed 04-05 Multifamily Dwelling Units (therms)

Meter Adjustment

In the analysis of meter data, RLW found that there were significant differences between the average usage predicted for a site through its compliance model and the end-use demand actually metered on site. We calculated meter adjustment factors that were the ratio of metered usage to model usage for each end use. Since the metering adjustment affects the modeled energy usage, it was applied to the gross savings estimate of savings.

Meter Adjustment Calculation

Figure 21 shows the metered cooling load plotted against the modeled load for the 21 multifamily sites with good AC data. There are two sites that were modeled to use very little load but still used a considerable amount, and two sites that were modeled to have very high loads that did not use nearly that much. The rest of the sites were modeled to use between 0 and 2,500,000 kBtu apiece; only one of which was estimated to have used more than 500,000 kBtu. Overall, the multifamily sites appear to be using considerably less cooling load than predicted by the compliance models.

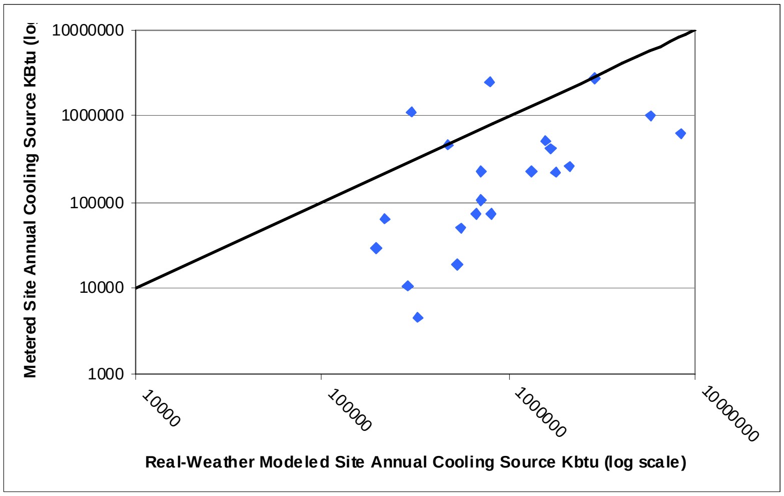


Figure 21: Multifamily Metered vs. Modeled Annual kBtu Cooling

This trend is also reflected in the heating data. Figure 22 shows that both modeled and metered heating usages fall within a narrower range than the cooling data. With the exception of two sites, however, all of the sites used significantly less energy than the models predicted.

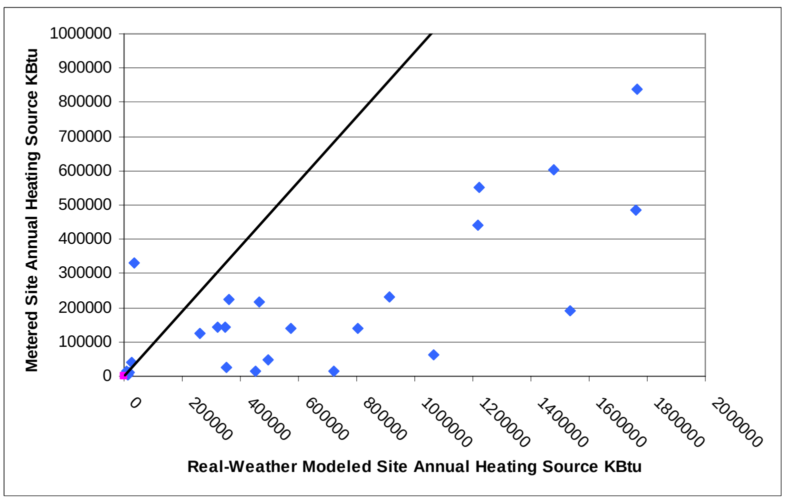


Figure 22: Multifamily Metered vs. Modeled Annual kBtu Heating

The water heating data further reflects the model overestimation seen in the other two end uses. In Figure 23, again, only two sites saw metered usage above that predicted by the compliance models.

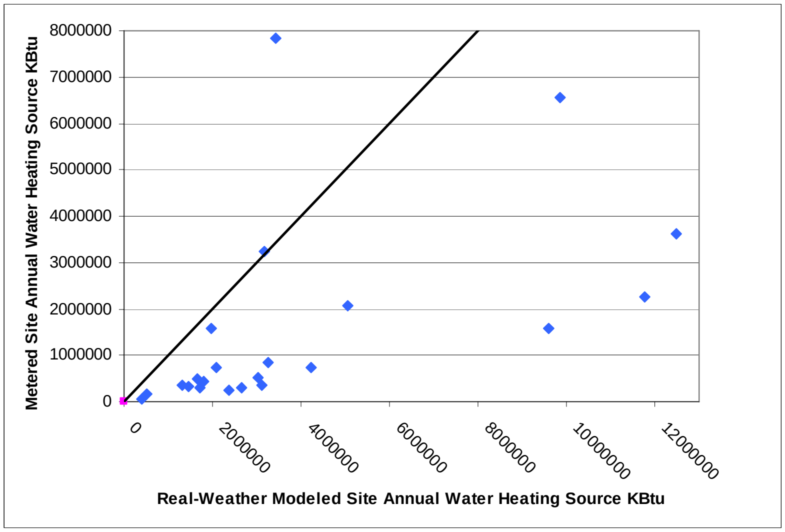


Figure 23: Multifamily Metered vs. Modeled Annual Water Heating

Meter Adjustment Factor Ratio Analysis

The multifamily sample had only one site in CEC climate zone 15, and so the "desert" climate zone was not broken out from "inland" for the calculation of the MF meter adjustment factor. As with the single family analysis, we used stratified ratio estimation to weight our sample up to the 2004-2005 ENERGY STAR® Homes multifamily participant population and calculate the ratio of metered usage to real-weather modeled usage. However, the sample of 24 sites was too small to adequately represent 16 climate zones. The next largest driver of variability in MF units after climate zone was thought to be Title 24 savings. Therefore, instead of stratifying by CEC climate zones, the sample was projected up to the total population by Title 24 savings using MBSS methodology. Strata were chosen such that the total variation of each was equal, and weights assigned so that the sample sites with data in each stratum were weighted to represent the population of sites in that stratum. Those weights were then used in stratified ratio estimation to produce the ratio estimates reported in Table 49.

End Use	Climate	Sample n	Ratio Meter Usage to Modeled Usage	Relative Precision
AC	Coastal	6	0.118	77.5% *
	Inland	15	0.397	45.8% *
Heat	Coastal	10	0.161	36.0% *
	Inland	12	0.212	68.8% *
Hot Water	NA	22	0.301	25.2% *

* Indicates statistically significantly different from ratio = 1

Table 49: Multifamily Meter Adjustment Factors by Climate Zone and End Use[44]

[44] All relative precisions were computed at the 90% level of confidence. The relative precisions indicate what percentage of the estimates the error bounds represent. If the estimate plus or minus that error bound does not include 1, then the estimate is determined to be statistically different from 1.

All of the multifamily meter adjustment factors were found to be statistically significantly different from 1. Metered cooling energy usage was 11.8% of modeled usage in coastal regions and 39.7% of modeled usage in inland regions. Heating ratios were equally low. Coastal dwellers used 16.1% of the model-projected heating energy. Multifamily sites in inland areas used 21.2% of modeled heating energy. These very low ratios for cooling and heating indicate that the assumptions made in the compliance software significantly overstate the space conditioning demands of multifamily residents.

These results are significantly different from the single family ratios. This difference can be explained, in part, by significant differences between how single and multi family structures are treated in the compliance software and how they are occupied in real life. The compliance software model all living spaces as having a constant temperature set point that the cooling or heating equipment maintains. This set-point is a large part of the discrepancy between modeled and metered results for both single and multi family units—homeowners generally do not keep a constant set point due to a combination of factors such as not being home 24/7, choosing alternative ventilation strategies, and having different comfort preferences. RLW thinks that a large part of the discrepancy between the multi and single family heating and cooling meter ratios can be explained by the fact that occupants of multi-family units tend to spend less time at home, on average, that occupiers of single-family units. Thus, in practice, multi family per-unit space conditioning loads are lower than modeled loads by a factor greater than their single-family counterparts.

Another factor that drives the multi family ratios lower is the economic differences between them and single-family homeowners. Sinec multi-family residents have lower incomes on average than single family residents, they are prone to have less disposable income to spend on space conditioning, and thus more economically pressured to engage in conservation methods such as having a higher cooling or lower heating thermostat set point.

Finally, multi-family units tend to have packaged-terminal ACs (PTACs) for cooling and either packaged-terminal heat pumps or hydronic heating (which tend to have only one or two blower coils) for heating. The upshot of this is that multifamily space conditioning tends to be much more space-targeted that single family homes. Instead of needing to heat or cool an entire 2000+ square-foot house in order to keep a single occupant comfortable, the inhabitant of a multi-family unit may only need to (and be able to) heat/cool a single room of living space. Thus, for any given level of personal comfort, the energy needs would be much lower.

Water heating is similarly overstated in the multifamily models. The metered sites indicate that true usage is 30.1% of that predicted by the compliance models for an average multifamily site. Like space conditioning, this is a much lower ratio than was estimated for single family homes. RLW thinks that this is partly due to the same occupancy patterns discussed above—being home less often, multi family occupants use less hot water per square foot than single family occupants.

Also, the size of the units may come into play here. The compliance software estimates more water heating energy usage for every square foot of floor space, but caps this increase at 2500 square feet. Few multi family units are this large, but roughly 40% of the single family units we metered were. Thus, the difference between multi and single family water heating meter ratios may be less a result of lower multi family metered usage than the result of more highly overstated multi family model usage on account of the cap on the model-based estimate of 40% of the single family homes.

Meter Adjustment Impacts on End-use Shares

Modeled multi family end-uses (right side of Figure 24) indicate that 80% of multifamily builder-affected energy usage is used for water heating. Most of the remainder, 15%, is used for heating and the rest for cooling (5%). According to our metered results, however, water heating still uses 78%, but cooling uses the larger share, 14%, compared to heating's 8% share. This is consistent with the single family results above that the meters indicate that the models give too large a share to heating and too small a share of energy use to cooling.

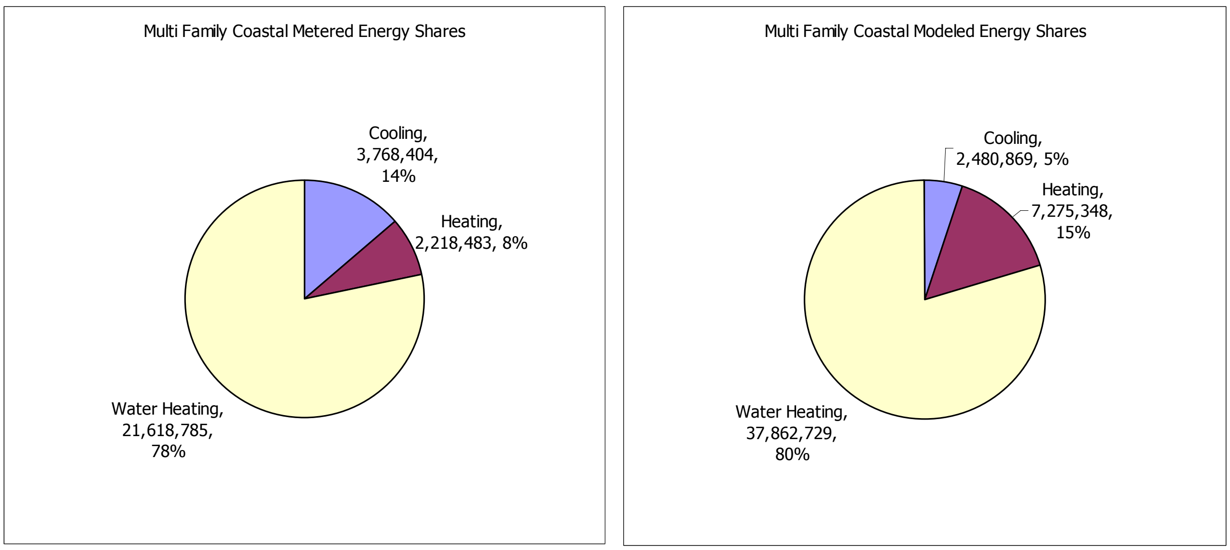
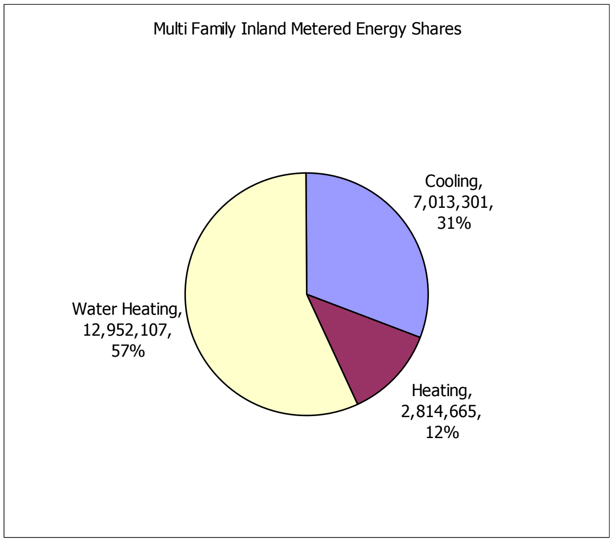


Figure 24: Multi Family Metered vs. Modeled Energy Usage Shares, Coastal

Finally, as shown in Figure 25, the meter results show very little shift in end-use proportionality for inland multi family sites. Cooling's metered share is slightly less than modeled, while both heating and water heating have marginally larger shares when metered vis-à-vis modeled.



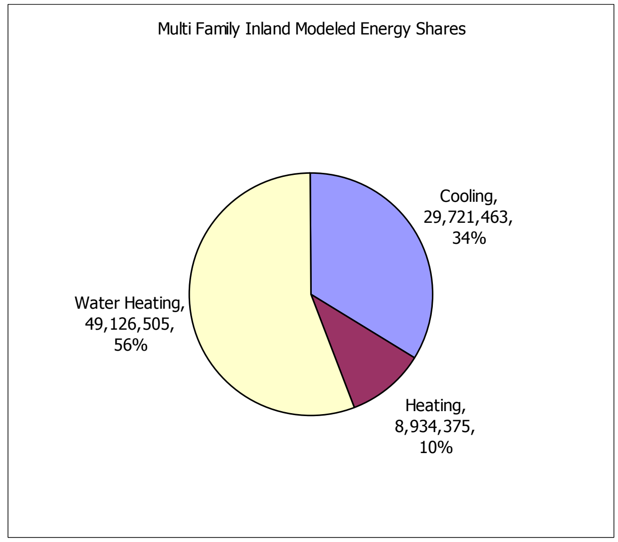


Figure 25: Multi Family Metered vs. Modeled Energy Usage Shares, Inland

Meter-Adjusted Savings

The gross savings calculated by applying the orientation adjustment to the tracking savings were broken down by utility and into coastal and inland climate zones so that the different ratios for the two climate zones could be applied. As an example, Table 50 shows how the ratios were applied for estimates of heating savings by utility. Since some sites were heated with gas systems (furnace and hydronic heating) and others with electricity (heat pumps and electric resistive heat), the heating results had to be subdivided into fuel types so that savings by fuel type could be calculated. The tables for the calculations for the other end uses are included in Appendix D.

Utility	Climate Zone	Heating Use - Therms				Heating Use - kWh			
		Adj. Gross	Meter Adjustment	Ex Post Gross Savings	Error Bound	Adj. Gross	Meter Adjustment	Ex Post Gross Savings	Error Bound
PGE	Coastal	23,250	0.161	3,734	1,346	(14,949)	0.161	(2,401)	865
	Inland	64,908	0.212	13,775	9,474	49,978	0.212	10,607	7,295
SCE	Coastal	2,632	0.161	423	152	2,133	0.161	342	123
	Inland	25,248	0.212	5,358	3,685	162,715	0.212	34,532	23,751
SoCalGas	Coastal	4,945	0.161	794	286	-		-	-
	Inland	95,572	0.212	20,282	13,950	140,001	0.212	29,711	20,435
SDGE	Coastal	127,504	0.161	20,475	7,380	47,801	0.161	7,676	2,767
	Inland	24,816	0.212	5,266	3,622	41,785	0.212	8,868	6,099

Table 50: Multifamily Meter-adjusted Savings with Error Bounds by Fuel Type Heating Only

The low multi family meter adjustment factors (15% - 30%) drove down program gross savings across the board. Table 51 shows the electricity savings generated by the program. For inland participants, there was an average per-dwelling-unit savings of 81 kWh per year for SDGE up to a 112 kWh per year savings for dwelling units in SCE's territory. Coastal savings were lower, ranging from PGE's 13.5 kWh/y/unit to SoCalGas's 21.3 kWh/y/unit.

Utility	Inland				Coastal			
	Dwelling Units	Ex Post Gross Savings	Error Bound	Gross Per Unit	Dwelling Units	Ex Post Gross Savings	Error Bound	Gross Per Unit
PGE	1773	159,857	68,719	90.2	985	13,347	12,238	13.5
SCE	1988	222,461	89,256	111.9	803	16,389	12,441	20.4
SoCalGas	5968	621,070	271,508	104.1	354	7,552	5,855	21.3
SDGE	1609	130,516	56,026	81.1	5,648	94,999	67,753	16.8
TOTAL	11,338	1,133,904	299,240	100	7,790	132,287	70,209	17

Table 51: Multifamily Gross Meter-adjusted Program Electricity Savings (kWh)

Gas gross savings were also lowered by the metered adjustment. All of the utilities' per unit savings for both inland and coastal climate zones fell in between SCE's coastal per-unit savings of 14.1 therms/year and PGE's coastal per-unit savings of 20.4 therms/year. Unlike electricity and the single family results, there was not a significant difference between per-unit gas savings between coastal units and inland units.

Utility	Inland				Coastal			
	Dwelling Units	Ex Post Gross Savings	Error Bound	Gross Per Unit	Dwelling Units	Ex Post Gross Savings	Error Bound	Gross Per Unit
PGE	1773	31,075	10,430	17.5	985	20,122	4,345	20.4
SCE	1988	33,942	8,093	17.1	803	11,330	2,754	14.1
SoCalGas	5968	88,890	22,220	14.9	354	5,096	1,122	14.4
SDGE	1609	30,579	7,337	19.0	5,648	90,563	19,147	16.0
TOTAL	11,338	184,487	26,867	16	7,790	127,111	19,857	16

Table 52: Multifamily Gross Meter-adjusted Program Gas Savings (Therms)

Net Savings

Net to Gross (using SERA NTG ratio, not including market effects)

Net ex-ante savings and net ex-post savings with realization rates (ex-post/ex-ante) are shown in the tables below by: kWh, therms, utility, and climate region. The net ex-ante savings were taken directly from the utility PIP filings. The net ex-post savings were determined from the meter-adjusted (ex post) gross savings multiplied by the multifamily NTG (0.50). To make this conversion, it was necessary to know the fuel type of each end use for each plan. We found that space cooling always used electricity, water heating always used natural gas, and space heating could use either (or both) natural gas and electricity. Based on the models in the registry, we determined a fuel type for space heating for each plan. In cases where both electric and gas heating equipment were specified, the energy usage was assumed to be half and half.

Electricity (kWh)							
Utility	Inland			Utility	Coastal		
	Net Ex Ante	Net Ex Post	Realization Rate		Net Ex Ante	Net Ex Post	Realization Rate
PGE	309,584	79,929	0.26	PGE	171,991	6,673	0.04
SCE	494,614	111,230	0.22	SCE	199,786	8,195	0.04
SoCalGas	1,752,205	310,535	0.18	SoCalGas	103,934	3,776	0.04
SDGE	472,402	65,258	0.14	SDGE	1,658,253	47,500	0.03
TOTAL	3,028,806	566,952	0.19	**TOTAL**	2,133,965	66,144	0.03

Gas (therms)							
Utility	Inland			Utility	Coastal		
	Net Ex Ante	Net Ex Post	Realization Rate		Net Ex Ante	Net Ex Post	Realization Rate
PGE	103,540	15,538	0.15	PGE	57,522	10,061	0.17
SCE	0	16,971	NA	SCE	0	5,665	NA
SoCalGas	176,653	44,445	0.25	SoCalGas	10,478	2,548	0.24
SDGE	47,626	15,289	0.32	SDGE	167,181	45,281	0.27
TOTAL	327,820	92,243	0.28	**TOTAL**	235,182	63,556	0.27

Table 53: Multi Family Program Realization Rates

Comparison of Multifamily End-Uses

Tracking database source energy figures are useful for comparison of end-uses across fuel types. Figure 26 shows net energy savings by end-use. The total height of each bar represents the standard design, or Title 24 Package D energy use. Since a single NTG ratio was applied to all gross savings, the net savings proportion is constant across end uses. Water heating is the dominant energy end-use, in contrast to single family findings where all end uses had similar energy shares.

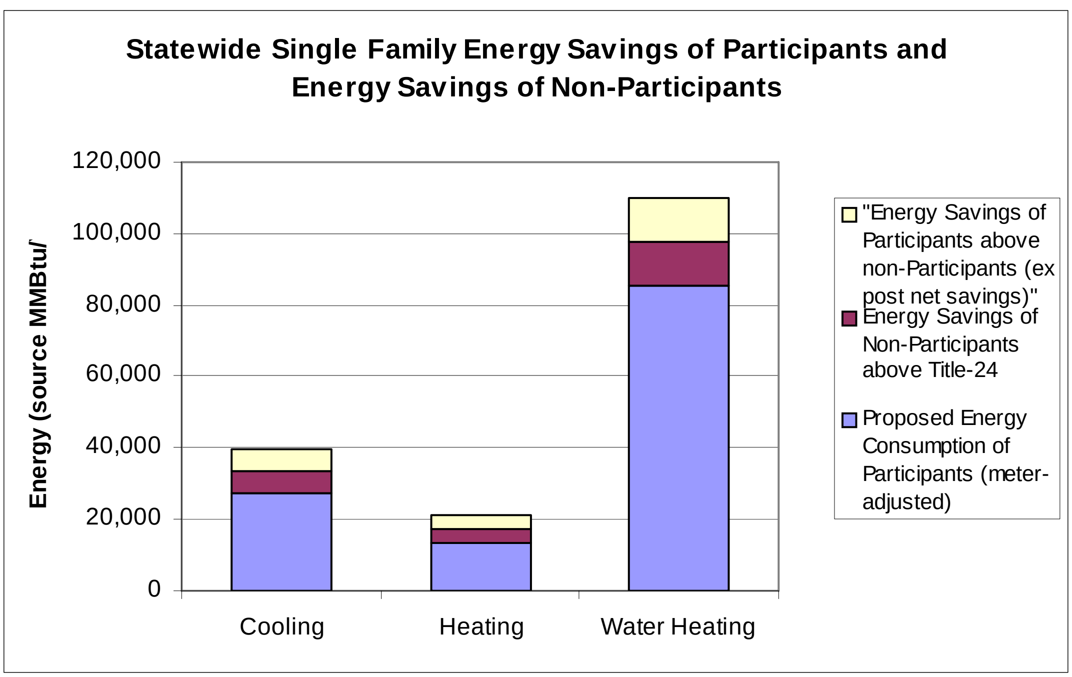
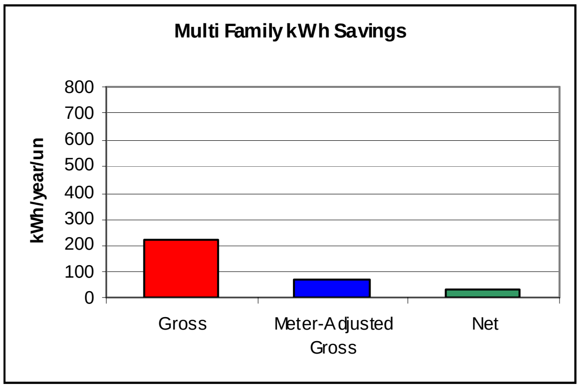


Figure 26: Statewide Multifamily Net Energy Savings

(Total height of each bar represents Standard design Title 24 Package D energy use)

Savings Compared to Gross and Non-Meter-Adjusted Net

Figure 27 shows how the net savings estimates compare to the gross and meter-adjusted gross savings results reported above. The meter adjustment factors, between 0.11 and 0.4 for multifamily end uses, drive the meter-adjusted estimate of gross savings and thus net savings very low relative to the pre-adjustment gross. This illustrates that savings estimates based on the compliance models for multifamily units significantly overstate the amount of savings because it overstates the energy that is actually used by residents of those units.



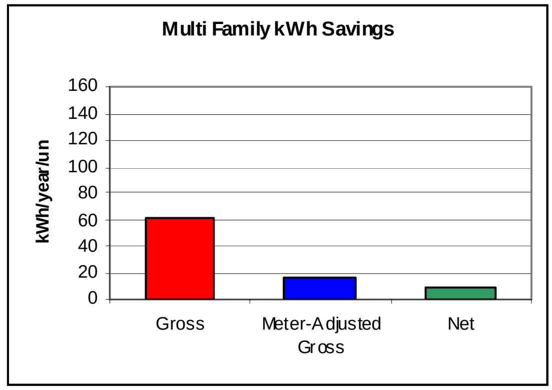


Figure 27: Multi Family Per-unit Overall Estimated Savings, by Analysis

Net to Gross (SERA)

There have been relatively few efforts to measure the net-to-gross impacts for these types of multifamily initiatives.[45] The NTG work is more difficult for this program than for many others because of two key factors:

- The key decision-makers are developers, and to some extent, builders, and owners. The decision-making may be more fragmented, so questions about the project and motivations for decisions may be difficult to answer.
- Asking about ENERGY STAR® Homes programs are difficult because it is not a single measure that is being rebated, but a set of design practices and measures that combined, lead to at least 15% savings beyond code. Gaining feedback on the savings and impacts compared to a similar project that didn't use these ENERGY STAR® elements necessarily requires an estimate compared to a hypothetical "similar" non-ENERGY STAR® project that doesn't exist.

In the detailed interviews that were conducted, attempts were made to talk with the most relevant decisionmaker(s). In addition, respondents were asked a variety of questions meant to understand behaviors and decisions relative to ENERGY STAR® elements. Also, as described below, corroborating information was asked in order to confirm responses and understand different nuances about the influences on decisions to incorporate ENERGY STAR® elements into the project. Finally, we talked to both participating and non-participating developers in order to get a better handle on baseline

[45] SERA conducted NTG analyses of 4 related programs (2 MF and 2 ENERGY STAR® efforts) in New York State, and previous work in California, for example.

practices in the absence of the program. These efforts have been designed to provide reasonable estimates of the NTG ratio for the program, and the direct and indirect effects from the ENERGY STAR® activities undertaken as part of the Statewide Program. These estimates are important to identify the range of the impact that the program has had on energy efficiency in multifamily buildings, above and beyond what would have occurred without the program.

2004-2005 Program Year Elements Leading to High Free Ridership

The results showed that for the 2004-2005 period, the participating multifamily projects have fairly high free-ridership rates (nearly half). This figure is similar to the results from the 2002-2003 report. The 2002-2003 and most of the 2004-2005 participants were in the program during a period when the program included a series of loopholes in Title 24 for multifamily structures. In fact, the on-site and interview work illustrated the fact that many builders were doing nothing different to meet ENERGY STAR® Homes requirement. The primary Title 24 loopholes associated with 2002-2003 multifamily housing were:

- The energy modeling programs included several baselines and assumptions that had the effect of allowing multifamily units to meet 15% for program purposes with few to no changes in standard practices.
    - Specifically, this included the use of a single-family baseline of 17% as a ratio for wall glazing area. However, multifamily unit layouts are usually limited to one or two walls for installing windows, so they could easily accomplish, for example, 8% glazing and therefore receive a credit toward exceeding Title 24 by 15%. In addition, the program used single-family occupancy levels for water heating (and multifamily units usually have lower occupancy levels). This was the source of another means by which multifamily units could gain credits toward 15% without making any design or equipment changes.

Given the tax benefits and the modeling issues, many of the builders did not need to (nor did they) make any changes beyond what they were going to do anyway in order to meet the qualifications for the ENERGY STAR® Homes Program. This means that the evaluation work will expect to find high high free-ridership, and this was one of the results from the project. The builders are building to 15% savings for reasons other than the program and its incentives.

The tax-related and modeling loopholes were closed with the October 2005 Title 24 code changes, and this will have a significant impact on the free-ridership estimates associated with later program years.

The sections below describe the steps and analyses used to estimate the net to gross ratio and its components.

NTG Data, Computations, and Results

The data were collected as part of the participant, and to some degree, the non-participant interviews conducted as part of the project.[46] The participant interviews provided direct data – self-reported – on free ridership, market effects, and baseline information. The non-participant surveys were used to provide information on non-participant market effects components and to provide context for standard practice.[47] The results for individual attribution questions are provided in the following paragraphs. The computations were conducted and the information summarized below provides feedback on the major trends and results related to net-to-gross (NTG) and its component factors.

Computing Free Ridership Factors: The questionnaire(s) included several variations of the core question to ascertain the share of the energy savings counted by the program that can be attributed to the effects of the program. Variations providing indications as to free ridership values are summarized below:

- If they had not participated in the program, the likelihood they would have installed <u>all</u> the same energy efficiency measures (Q-C2): 52.8%
- If they had not participated in the program, the likelihood they would have installed <u>some</u> of the same energy efficiency measures (Q-C2b): 66.2%
- Best estimate of the overall energy savings above Title 24 that were achieved due to the influence of the Program[48] : 47.0%[49]

These responses imply the free ridership, not accounting for influencing factors, is between 47% and 53%, and allowing for partial free ridership would imply a free ridership perhaps as high as 66%.

To provide more robust information from participants about their decision-making (a key factor in free ridership), we asked corroborating information as well. This corroborating information (or influencing factors) we included follows:

- Importance of program financial incentive in program participation (Q-B5): 57% said it was very important, and the average score (with 5=very important) was a 4.2.
- Value of the marketing assistance provided by program (Q-B20): 20% said much value from this assistance
- Program influenced their decision to increase energy efficiency beyond code very much (Q-C1a): 60-90%[50].
- Program's importance in decision to design and build the project to exceed T24 by 15% - very important (Q-C6): 19%.

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[46] The survey development and the interviews were conducted by Skumatz Economic Research Associates, Inc. (SERA).

[47] Both survey instruments are included in the Appendices.

[48] The first two free ridership questions, which asked verbal responses with clarifications about the percentage range implied (e.g., definitely or almost definitely, greater than 90% likely) returned responses from almost all interviewees. For these questions, we coded the midpoint of the corresponding range as the response. Open ended numbers garnered fewer answers. Too few responses from "minimum" and "maximum" for this value; "best estimate" response average is provided here.

[49] Responses from the 2002-2003 report for these three values were, respectively, 60.2%, 74.2%, and a range of 41.5%-51.9%.

[50] 90% of respondents said yes; 60% of non-responses are coded as don't know.

Free ridership was computed by using the responses to the direct free ridership question battery, adjusted to take into consideration the results from the "corroborating factors". If the corroborating factors indicated the following, the lower free ridership values were selected.

- For those respondents that stated the program was "very important", but provided a high free ridership factor, the information was considered inconsistent.
- For those that stated the program had a high influence, bur provided a high free ridership value, the information was considered inconsistent.

Using these methods, we were able to derive a more robust estimate of free ridership, using combined responses from several questions. The computations resulted in an estimate of 47% free ridership factor (0.47).[51] This result indicates that almost half of the savings from program records may not be strictly attributable to the program.

Computing Market Effects / Indirect Factors: Three types of indirect market effects are traditionally attributable to market transformation programs. These estimates are derived as follows.[52]

- **ME1 - Within Project Market Effects:** This includes additional energy efficiency measures and design practices installed at the (participating) site that are not covered by the program but are installed because of the influence of the program. However, the comprehensive nature of the ENERGY STAR® program makes it difficult to identify any measures "outside" the program. Therefore, no market effects are attributed to this type of indirect influence.

- **ME2 - Outside Project Market Effects**: The program has an effect in influencing participants to carry over ENERGY STAR® measures and practices to other non-participant projects.
    - A total of about 25% of the participating builders indicated that the program had influenced their practices at buildings that had not gone through the program. The influence was felt on about 46%-55%[53] additional buildings, beyond those asked about in the survey. The respondents stated that the average building size for these other buildings was about 52% of the project size, and about 70% of these resulting savings were attributable to the program influence. This implies that for the energy savings from the multifamily building (or unit) participants, the influence from the program carried over to other buildings to produce about 17%-20% additional savings in spillover of this type (outside project spillover).

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[51] If we substituted the average response for other respondents noting the same number of influencing factors is substituted, the estimated free ridership factor declines to 0.446. However, we prefer to use responses provided directly by the respondent.

[52] The topics were addressed in three pieces: 1) whether the factor exists, 2) the share of savings from this effect as a multiple of the direct program savings, and 3) the share of these savings that were influenced by / due to the program.

[53] 1.8-2.2 buildings on average times 25% of the participants reporting the presence of this effect

- **ME3 - Non-participant market effects**: The program can indirectly influence non-participant builders to upgrade their energy practices because of the influence of the program on the market.
  - This factor is one of the most difficult to estimate. Gathering information on the effects that the program has had on builders that have not directly participated in the program is difficult because the influence is indirect, and because attributing changes in practices specifically to the program is difficult to assign. To provide some level of feedback on this influence, we gathered data from both participants and non-participants. Generally, we would focus on non-participant feedback; however, we had a very small sample of non-participants, so we examined responses from both groups. Non-participants are generally replying about their own practices and influences; participants were asked about whether they believe non-participants have been influenced, or whether they spoke to them about modified practices. The derivation of estimates from participants and non-participants is summarized below.
    - Non-participant responses: About 50% of the non-participants interviewed experienced or believe this influence existed. The average number of buildings they reported that it may have influenced was about 0.67 each. However, we had minimal responses on size of buildings influenced or percent of savings in the buildings resulting from the influence. If we assume these buildings are equal in size to those participating in the program, our spillover estimate would be about 33%. However, if we use the estimate from the previous spillover calculation as a more conservative estimate of influence ratios (52% of size, 70% of savings), the non-participant spillover estimate from the non-participant effect is about 12%.
    - Participant responses: About 67% of participants reported they believed non-participants were influenced or reported they had talked to non-participant builders to encourage ENERGY STAR® practices. The average number of buildings they reported may have been influenced was about 0.71 buildings each. However, we had minimal responses on size of buildings influenced or percent of savings in the buildings resulting from the influence. If we assume these buildings are equal in size to those participating in the program, our spillover estimate would be about 46%. However, if we use the estimate from the previous spillover calculation as a more conservative estimate of influence ratios (52% of size, 70% of savings), the non-participant spillover estimate from the non-participant effect is about 17%.

- We might put more weight on the non-participant responses; however, that sample size was smaller. If we average the responses from the two groups, we compute a non-participant spillover value of 0.14. However, note that there were elements of the computations missing for many of the respondents – this factor is difficult for builders to estimate. Therefore, we use a range from about 0%-14% for this factor as a conservative estimate.

The results of these computations are provided in the table below.

Net to Gross Results: The estimated Net to Gross Ratio is developed in the following table.

		Indirect Market Effects			(1-Col A)	(1+Col B+C+D)	(E*F)
Source of Estimate	**A.** Free Rider	**B.** Inside	**C.** Outside	**D.** Non-Partic.	**E.** Net factor	**F.** Market Factor	**G.** NTG Ratio
Household - Participant, non-participant, and control groups	0.47-0.53	0.00	0.17-0.20	0 - 0.14	0.50	1.17- 1.34	0.55-0.71[54]

Table 54: Summary of NTG Elements and Computation of NTG Ratio

Comparison of Estimated NTG Values to Other Programs: The results can be compared to results from a review of net-to-gross results from programs at other utilities.[55] While not available as readily for multifamily buildings, the information gathered shows that ENERGY STAR® new homes and retrofit programs (in NY and elsewhere) tend to derive:

- Net Factor (1-Free ridership) of about 0.8 (free ridership of about 0.2), with values a little lower for new homes than retrofit;
- Market Effects of 0.4 to 0.5, with values a little lower for retrofit programs, and
- Net to gross ratios about 1.1-1.2.

The results from the ENERGY STAR® Multifamily program (2004-2005) indicate:

- Free ridership of 0.47-0.53, creating a *net factor* (1-FR) average value of 0.50, which is quite a bit lower than found for programs elsewhere;
- Market effects of 0.17-0.34, which is a little lower than the range provided elsewhere; and

[54] Note that the net-to-gross estimate from the 2002-2003 report was about 0.56-0.69.

[55] Skumatz, Lisa A. 2004. "Leveraging and Review of Indicators and NTG Results from US Programs", Skumatz Economic Research Associates, Inc. Report 2004-04, Superior, CO. and also summarized in Skumatz, Lisa A., Ph.D., John Gardner, and Charles Bicknell (SERA), "Techniques for Getting the Most from an Evaluation: Review of Methods and Results for Attributing Progress, Non-Energy Benefits, Net to Gross, And Cost-Benefit, Proceedings of the EEDAL conference, Turin Italy, May 2005

- NTG ratio of 0.55-0.71, about half the range found elsewhere.

The basis of the discrepancy of results rests with the low free ridership figure. We would expect the program influence factors or the NTG to be lower for this program, especially in this time period (2004-2005). Until "gaps" in the code and related modeling were addressed in the more recent standards, multifamily dwellings could readily meet the code with little to no change from baseline practices, so the influence of the program would be expected to be much lower than results for programs elsewhere. The code and modeling problems have been addressed in the 2005 code changes, and we expect to see significantly different program influence levels in the evaluations of later years of the program.

High Rise Multifamily Results

Multifamily high-rise buildings (four or more stories) are evaluated separately in this report and are analyzed using a wholly different methodology since they are subject to different requirements under California Title-24 building codes – high-rise buildings follow non-residential building codes. As a result, high-rise buildings have separate modeling and program requirements. Title-24 reports were reviewed for compliance margin requirements and for assignment of savings to gas or electricity. Ex-ante estimates were calculated using actual number of dwelling units completed and IOU multifamily per unit kWh and therm savings estimates (Utilities did not file separate planning estimates for high-rise buildings).

	GROSS COINCIDENT PEAK DEMAND REDUCTION PER UNIT (kW)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (kWh)	GROSS ANNUAL ENERGY SAVINGS PER UNIT (THERMS)
PGE MF	0.2237	218	73
SCE MF	0.3506	311	0
SDGE MF	0.5050	367	37
SoCalGas MF	0.5050	367	37

Table 55: Utility low-rise Multifamily per unit Savings Planning Estimates (applied to high-rise buildings)

Ex-post net energy savings estimates were calculated using Title-24 gross savings and the average multifamily NTG ratio of 0.5.[56] At best this is an approximation since the multifamily building code (and builders) is different for high-rise.

Summary of Results

There were twenty six high-rise buildings that qualified for inclusion in the '04-'05 ENERGY STAR® Homes program which represented over 2,100 dwelling units of new construction as shown in Table 56. This is a significant increase compared with the '02-'03 program cycle which only included three high-rise projects representing 170 dwelling units.

Utility	Buildings	Units
PG&E	5	269
SCE	4	528
SDG&E	15	733
SoCalGas	2	602

Table 56: High Rise Population

[56] Multifamily NTG was estimated by SERA, Inc.

One high-rise on-site inspection was conducted by RLW field staff. The on-site inspection focused on verifying installed equipment efficiencies because high-rise construction results in the majority of energy consumption in the central HVAC systems and domestic hot water and because of the difficulties in verifying envelope construction,. The inspection found that installed equipment was the same efficiency as specified in the Title-24 documentation.

Most high rise buildings took advantage of loopholes in Title-24 water heating requirements to achieve program compliance. These loopholes were closed with the October 2005 Title-24 update, but all high rise buildings completed in 04-05 (in this evaluation) entered the program under 2001 Title-24 while the loopholes were still open.

PG&E Results

PG&E had significant net negative electricity savings with a realization rate of -41%, and positive gas savings with a realization rate of 123%. These results are discussed further below.

Utility	PGE Projects	Dwelling Units	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/unit)
	PGE Ex Ante Net	269	46,970	175	15,709	58
	Ex Post Net Savings	269	-19,193	-71	19,320	72
	Realization Rate		-41%	-41%	123%	123%

Table 57: PG&E High-rise Energy Savings (Ex-Ante Net, Ex-Post Net, and Realization Rates)[57]

With only five total buildings it is difficult to assess high-rise energy savings trends or issues, however it is concerning to see that PG&E projects had negative electricity savings. In the 2002-2003 ENERGY STAR® Homes EM&V report there were two high-rise projects in PG&E territory, both with negative electricity savings. Program managers at PG&E and SCE added a new requirement in 2003 that projects needed to have positive electricity savings to qualify for the program. Since four out of five projects at PG&E yielded negative electricity savings it does not appear that this new requirement was followed.

The negative savings show up as negative realization rates. While this is concerning it is not particularly surprising given that most high-rise projects gain a significant amount of their compliance from water heating. This appears to be the case for PG&E's projects. Furthermore, at least one PG&E project was found to have dwelling units with electric resistance baseboard heating, the epitome of inefficient design. Details of PG&E's projects follow.

[57] IOU PIP unit savings were not filed separately for high-rise buildings, so the multifamily PIP estimates were used.

In previous years, it was discovered that negative electric savings were occurring since builders were gaining compliance through design specification that used efficient gas measures.

The 2003 program was changed to require positive electric savings. The projects in this evaluation with negative electric savings were committed in the 2002 program.

PGE Projects	CZ	Dwelling Units	CM	CFA	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/ unit)
Project ID's Suppressed	3	98	37%	64,317	-14,460	-148	11,391	116
	3	67	38%	57,060	-3,737	-56	11,498	172
	3	39	30%	20,369	-11,628	-298	6,809	175
	3	27	30%	31,695	10,968	406	4,212	156
	3	38	11%	46,784	-19,528	-514	4,730	124
Ex Post Gross Tracking Savings		269		220,225	-38,385	-143	38,640	144

Table 58: PG&E High-rise Ex-Post Gross (tracking) Savings[58]

SCE Results

Although SCE does not claim gas savings, positive gas savings were still realized, and the electricity realization rate was 73%.

SCE Projects	Dwelling Units	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/unit)
SCE Net Ex Ante Savings	504	125,395	249	NA	NA
Ex Post Net Savings	504	91,776	182	12,619	25
Realization Rate		73%	73%	NA	NA

Table 59: SCE High-rise Energy Savings (Ex-Ante Net, Ex-Post Net, and Realization Rates)

SCE's four projects were much more consistent in savings. All projects had positive, or zero, electricity and gas savings. Looking more closely at the four buildings it can be seen that two get the bulk of their savings in electricity while the other two have the majority in gas. Digging through the compliance documentation reveals that gas savings are coming from water heating, while electricity savings are derived from cooling via placing ducts in conditioned space.

[58] CZ=Climate zone, CM=compliance margin, CFA=conditioned floor area

SCE Projects	CZ	Dwelling Units	CM	CFA	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/unit)
Project ID's Suppressed	8	112	22%	108,078	75,116	671	2,561	23
	8	112	24%	116,871	81,456	727	3,015	27
	6	204	25%	66,160	-65	0	16,791	82
	6	76	25%	52,005	27,045	356	2,871	38
Ex Post Gross Tracking Savings		504		343,114	183,551	364	25,239	50

Table 60: SCE High-rise Ex-Post Gross (tracking) Savings

SDG&E Results

SDG&E had the most ENERGY STAR® high-rise dwelling units, the most net electricity savings, and was the only utility to have realization rates greater than 100% for both gas and electricity savings. The San Diego climate zone is characterized by near zero heating loads, so gas savings are coming from water heating, like all other utilities, while significant electricity savings were achieved through cooling.

SDGE Projects	Dwelling Units	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/unit)
SDGE Ex Ante Net	733	215,209	294	21,697	30
Ex Post Net Savings	733	246,763	337	19,649	27
Realization Rate		115%	115%	91%	91%

Table 61: SDG&E High-rise Energy Savings (Ex-ante Net, Ex-ante Post and Realization Rates)

Not all of the projects followed the same pattern as can be seen. One project below has electric per unit savings that are about five times larger than the average per unit electric savings.

SDGE Projects	CZ	Dwelling Units	CM	CFA	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/ unit)
Project ID's Suppressed	7	172	23%	91,604	45,399	264	6,834	40
	7	32	31%	36,433	18,127	566	2,612	82
	7	126	38%	133,961	96,379	765	10,302	82
	7	105	35%	104,863	42,130	401	8,588	82
	7	68	28%	74,106	15,719	231	6,269	92
	7	52	26%	61,438	9,729	187	4,804	92
	7	8	19%	5,720	5,692	712	69	9
	7	8	16%	5,720	4,227	528	98	12
	7	16	19%	11,640	10,263	641	180	11
	7	16	19%	11,640	10,058	629	219	14
	7	80	21%	120,134	209,501	2,619	-2,499	-31
	7	8	32%	4,120	4,430	554	291	36
	7	16	27%	8,240	5,888	368	583	36
	7	6	36%	3,090	5,358	893	218	36
	7	20	28%	10,636	10,626	531	729	36
Ex Post Gross Tracking Savings		733		683,345	493,527	673	39,299	54

Table 62: SDG&E High-rise Ex-Post Gross (tracking) Savings

SoCalGas Results

SoCalGas had two ESH program high-rise projects completed in 04-05. The results follow a similar pattern to PG&E with negative electricity savings and positive gas savings. Examination of the Title-24 reports reveals that all the savings are coming from water heating.

Again, SoCalGas participant customers achieved electricity savings even though these savings do not impact SoCalGas directly. SoCalGas did claim their ex ante electricity savings.

SCG Projects	Dwelling Units	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/unit)
SCG Ex Ante Net	602	176,747	294	17,819	30
Ex Post Net Savings	602	-23,779	-40	28,460	47
Realization Rate		-13%	-13%	160%	160%

Table 63: SoCalGas High-rise Energy Savings (Ex-ante Net, Ex-ante Post and Realization Rates)

SoCalGas Projects	CZ	Dwelling Units	CM	CFA	Annual Site Electricity Savings (KWh)	Annual Site Unit Electricity Savings (KWh/unit)	Annual Site Gas Savings (Therms)	Annual Site Unit Gas Savings (Therms/ unit)
Project ID's Suppressed	9	303	21%	272,343	-20,765	-69	29,059	96
	9	299	22%	266,111	-26,793	-90	27,862	93
Ex Post Gross Tracking Savings		602		538,454	-47,558	-79	56,921	95

Table 64: SoCalGas High-rise Ex-Post Gross (tracking) Savings

High Rise Verification Inspections

RLW scheduled two on-site inspections to verify high rise building characteristics. One building proved too difficult to access despite several scheduling attempts. The remaining site was inspected; all of the on-site findings are discussed here. Unlike the single family and low rise inspections, which had large enough samples to characterize the population, only one high rise project was visited. It is discussed in this section in a case study format.

The Title 24 documentation specified one 500,000 BTU boiler and no cooling. The on-site inspection revealed there were two identical boilers installed, but of the planned efficiency rating. This was found to be acceptable due to the system design, meaning the system installed "matched" the Title 24 plans. The systems were installed and controlled in a primary and back-up configuration; only one boiler is used at a time to provide hot water. The units were on a two week cycle, where every two weeks one boiler is switched on and the other is switched off, presumably intended to extend the life of the equipment and provide back-up in the event of unit failure.

The heating boiler similarly was installed with an identical back-up boiler. The configuration allowed one unit to provide the majority of the heating demand. The Title 24 model estimated the building load to be 439,000 BTU. It is common practice to install a boiler that is larger than the heating load to ensure the system meets demand. The installed boilers were 750,000 Btu units but since they have multi-staging they only reach their full input rate if the building reaches its peak heating demand. The second unit was in place such that if the primary boiler could not meet the load on the coldest days the second boiler would provide back-up. Statements from the facilities staff about their perceived run times for the units confirmed this control strategy was in place and operating as intended.

Previous low-rise multifamily on-site inspections found a high correlation between planned and as-built modeled energy usage. The inspection of this high rise building verified those findings. As a result of the similarity between plans and construction, the tracking savings estimates are believed to be accurate and no remodeling of the high rise projects was done and no adjustments to the savings estimates were deemed necessary.

High Rise Conclusions

Most high rise buildings took advantage of loopholes in Title-24 water heating requirements to achieve program compliance. These loopholes were closed with the October 2005 Title-24 update, but all high rise buildings completed in 04-05 (in this evaluation) entered the program under 2001 Title-24 while the loopholes were still open. One loophole provides a large water heating energy credit with the installation of a central water heating system, while another gives a large credit for any type of hot water distribution temperature or time controls. While the 0.5 multifamily NTG ratio reflects some of this free-ridership, probably very few of these high rise buildings would have qualified for the ENERGY STAR® program without this loophole.

Program managers at PGE and SCE added a new requirement in 2003 that projects needed to have positive electricity savings to qualify for the program. It does not appear that this new requirement was always followed.

In the future, if a significant number of high-rise buildings apply to the program, it may be appropriate to conduct additional on-site inspections and verification of the energy saving measures and building characteristics.

Process Methodology

This process evaluation is organized into four sections:

- *Process Evaluation Methodology* – A general overview of the methods used and the data collected for the process evaluation.
- *Market Actor Interview Findings* – A discussion of the findings from the interviews that includes a summary of the program goals, a program logic model approved by the program managers, and barriers to program participation.
- *Survey Results* – A review and discussion of the process evaluation survey results for participating and non-participating builders.
- *Recommendations* – A summation of the key issues that arose from the process evaluation, and recommendations for program process modifications.

The methodology is discussed here and the findings, results, and recommendations are all discussed the Process Results Chapter.

Methodology of the Process Evaluation

The process evaluation relied on a review of 2002-03 program assessments and program manager feedback to develop a logic model and researchable questions. These items were used to identify underlying programmatic issues. Those issues were then directed to the appropriate program participants (program mangers, market actors, ESH residents, etc.). These steps are detailed in this chapter.

Summary of Past Program Assessments

The program recommendations from the 2002 and 2003 report were based on observations and difficulties that arose while performing the impact evaluation. The previous recommendations covered a variety of aspects of the program, including the overall program methodology, project tracking, timeliness, compliance margins, and quality control. Recommendations from the previous impact analysis are listed below.

- Establish a common approach for estimating savings;
- Improve and standardize utility tracking systems;
- Implement a statewide program tracking system;
- Implement a common identifier between utility tracking and Registries;
- Develop a uniform definition of hard-to-reach and track participation;
- Improve timely project authorization to avoid timing and funding uncertainties;
- Raise the required margin of compliance for low-rise multifamily projects to no less than 20%;
- Perform continual review and QC of the Registries' data;
- Improve QC to ensure matching of Registry data and building characteristics;
- Enhancement of data quality and type input into Registries by raters;

- Address problems with parsed transfer files;
- Eliminate "transfer" file vulnerability;
- Consider whether the goal of the Program is less total energy use, or more efficient energy use;
- Certify Title-24 consultants; and
- Stricter enforcement of building codes and standards.

Changes between 2002-03 and 2004-05 Program Years

There were very few changes between the 02-03 and 04-05 program years. Two major changes that did occur were:

1. *The reduction of program incentive money at the 20% efficiency level.*
2. *Changes in compliance policy*. PG&E and SCE implemented a policy where positive electric savings had to be shown.

There was no difference in the incentive amounts between 2003 and 2004-05 programs. The major changes came between the 2002 and 2003 program years when the incentives for 20% or better performance were removed for all climates except single family inland areas. It was the intent of the utilities to maintain the 2003 incentive levels for the 2004-05 program because of the upcoming Title-24 code changes. The underlying belief in this lack of incentive change was that increasing code requirements while keeping the incentives the same would have, in effect, the same impact as keeping the code the same and reducing the incentives.

Another program change through these funding years was the change in strategy towards multifamily projects. The methodology used in the 2001 code did not address the unique situations that are in the multifamily structure, and as a result the energy savings in multifamily projects tended to be overstated.

The following table shows the incentive levels by program year and housing type.

	SINGLE FAMILY				MULTIFAMILY			
	Inland		Coastal		Inland		Coastal	
Program Year	15% better	20% better	15% better	20% better	15% better	20% better	15% better	20% better
2002	500	900	400	600	150	250	150	250
2003	500	700	400	-	150*	-	150*	-
2004-05	500	700	400	-	150*	-	150*	-
2006-08	500	-	400	-	200**	-	150**	-

* Plus assistance ($50 for inspection, $40 design assistance for SCE/PGE)
** No assistance for SCE/PGE (PGE said no one was utilizing design assistance)

Table 65: Incentive Levels through Program Years

As shown, the 20% tier was eliminated after the first program year for all but single family inland. By removing the majority of the 20% tier, the utilities were able to save incentive funding. In turn, the utilities were able to fund more participant builders.

Researchable Questions

The researchable questions that were outlined in the program evaluation plan were incorporated into interview guides that were administered to key market actors and participants. The researchable questions at the beginning of this section were developed during a meeting with all participating program managers. The session was conducted to ensure all the managers were able to input the questions about the program they wanted to see explored. Interview questions were composed to follow these researchable questions. Each type of program participant was interviewed using guides that were tailored to gather information that specific to his/her role in the program. Table 66 displays the researchable questions as outlined in the evaluation plan.

Questions/Researchable Issues	Utility Staff/ Mgrs	Contractors	Builders	Homebuyers	Source of Info
OVERALL PROGRAM GOALS & CONCEPTS					
What is the program concept?	X				Program Manager Interviews
What is the program rationale?	X				Program Manager Interviews
What are the program objectives/goals?	X				Program Manager Interviews
OVERALL PROGRAM DESIGN & IMPLEMENTATION					
What is the designed or intended program logic? Was it performed close to that design/intent? If not, why not?	X	X	X		Program Manager Interviews, Contractor & Builder Interviews
What are the major differences between the 2003 and 2004 programs (in terms of incentive amts, inspection credits, climate zone differences)?	X				Program Manager Interviews
How do the implementers track program participation? What improvements can be made? Were previous recommendations adopted?	X	X			Review of tracking system and other program materials
What kind of program QC is performed?	X	X			Staff and subcontractor interviews.
What do participants like/dislike about the program? Why do builders participate?			X		SERA Builder surveys. Strategy assessment interviews.
What issues/barriers, if any, hinder builders from participating in the program?			X		SERA Builder surveys. Strategy assessment interviews.; also informed by SERA NEB analysis
Do builders drop out of the program? Why? Do you track drop outs	X				Program Manager Interviews
How easy is it to design and build to certain thresholds? (free-ridership question)			X		SERA Builder surveys. Strategy assessment interviews.
How will the upcoming Title-24 code change affect builder participation?	X		X		SERA Builder surveys. Strategy assessment interviews.
How were incentive levels assessed? Are they inadequate or too generous?	X				Program manager interviews and PIP. Strategy assessment interviews.
Are certain implementation approaches better than others (SDGE Vs SCE Vs PGE)? What are the key differences?	X	X			Program Manager Interviews & Contractor Interviews (including Heschong Mahone Group, design assistance).
What are the NEBs of the program?	X	X	X	X	Key market actor interviews + Homeowner Surveys (SERA analysis)
What incremental value do home buyers place on ENERGY STAR Homes? Could that incremental value be increased?	X			X	SERA Homebuyer Surveys, including NEB analysis
To what extent does funding impact builder participation? How long does it take to fully commit the program? If funds were unlimited, how many homes do you think could be built?	X				Program Manager Interviews
MARKETING THE PROGRAM TO BUILDERS					
How was the marketing campaign implemented?	X	X			Staff and subcontractor interviews.
Were there specific goals to reach participant builders who would be considered Hard to Reach? Were, or will, these goals achieved?	X				PIP and interviews with PMs.
Are all market actors effectively being reached by the program? Is there any marketing directed to other actors such as Title-24, CHEERS raters, realtors, etc.?	X	X			Key market actor interviews, staff interviews, market assessment.
Was/is the marketing plan effective? Does it reach the right networks, the wrong networks? What marketing improvements can be made?	X	X			Program Manager Interviews
To what degree are ESH marketing materials reaching developers / builders?		X	X		SERA Builder / developer Surveys, Program Manager Interviews (see also Researchable question 28)
Are the builders fully utilizing the ESH marketing materials/tools currently available? Why or why not?	X		X		SERA Builder surveys
Do builders feel the ESH marketing materials/tools could be more effective?			X		SERA Builder surveys
APPLICATION PROCESSES					
How were sub-contractors found and selected? Are they qualified? What are the pre-requisite qualifications?	X	X	X		SERA builder survey and PM interviews
Are CHEERS and CalCerts adequately tracking participation and measures installed through the program? What improvements can be made? Were earlier recommendations addressed?	X	X			Interviews with program managers, CHEERS, CalCerts, RLW onsite inspections
What information does the C-HERS registry capture? Is this adequate? What improvements should the utilities recommend?	X	X			Interviews with program managers, CHEERS, CalCerts.

Table 66: Researchable Questions

Surveys Conducted

Interviews and surveys were conducted with a diverse group of program participants and market actors to gain a thorough understanding of the ESH program. RLW interviewed utility program managers, CalCERTS registry staff, managers of firms contracted to review building plans, and design assistance contractors.

As usual in process evaluation interviews, RLW recognizes that each interviewee likely has a vested interest in preserving the status quo on their behalf, or perhaps may characterize conditions in a way favorable to their viewpoint. We carefully weighed the merits of all responses from each interview, and looked for common threads and themes that arose from two or more interviewees.

SERA performed surveys of participant and non-participant single family builders, multifamily builders, and homeowners in order to gather data for the non-energy benefit (NEB) and net-to-gross (NTG) analyses. To capitalize on this efficiency they administered a number of process-related questions for RLW through their contact with program participants. The process-related responses from those surveys are examined in the Process Evaluation Chapter.

Process Results

This section presents a discussion of the market actor interview findings and program material review and is the basis for a large portion of the process evaluation findings. The researchable questions were used to guide the general topic area discussions. The section contains a synopsis of the program logic model, interview and survey findings, and a discussion of implemention challenges and recommendations.

Implementation of the ENERGY STAR® Homes Program

The ESH program is very complex in its implementation as a result of the many groups required to bring each project to completion. Design assistance teams, Title 24 consultants, plan check agencies, registries, and HERS raters all have roles in the ESH program, in addition to utility staff and program participants. Figure 28 demonstrates the major components a project goes through during the program. While each utility has their own methods for conducting individual program processes, the individual components are the same statewide.

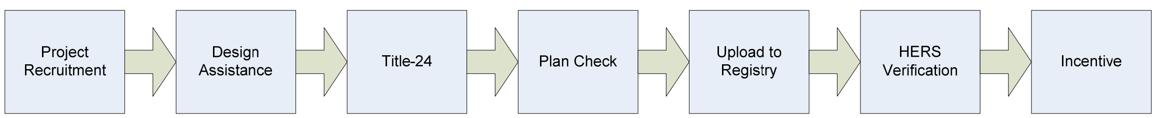


Figure 28: General Program Flow

Projects are recruited for the program, and some builders actively apply as they prepare new developments. Design assistance is available to design teams for multifamily projects for one utility. The design assistance helps the team explore options for raising the compliance of their project to the 15 or 20 percent levels. Once the design is complete a Title 24 consultant performs the energy compliance documentation using approved software. Title 24 requirements are California law, which include energy efficiency minimum requirements, and must be met by all builders, regardless of whether they intend to participate in the ENERGY STAR® Homes program or not. Builders must submit their building plans, Title 24 documentation, and a short application to the appropriate utility. At this stage, construction is usually in the planning and design, or early construction stage. If the utility approves the application, the ESH program reserves incentive funds for the builder based on the projected number of units approved. The plans and energy documents then go to the plan check agency who verifies the documentation is correct. Once the project passes plan check the building is uploaded to one of the HERS registries. The Registries store all of the construction details of a project in an online database used by the HERS raters. Once builders have actually constructed the homes, they must hire a HERS rater to verify HERS measures, if any, and to verify all other design specifications specified in the registry's Title 24 file including elements of the building envelope, fenestration and mechanical systems. Verifications are completed via on-site inspection(s) and/or test(s) of the constructed unit. If a builder constructs multiple units of the same design, not every unit is inspected, but instead a sample of units is inspected. Once the rater uploads the verification results to the registry the incentive is paid to the builder.

Figure 29 below depicts a program logic model that RLW constructed based on utility program manager interviews. This model was then sent to the program managers for review, and each concurred that this model was an accurate representation of the program logic.

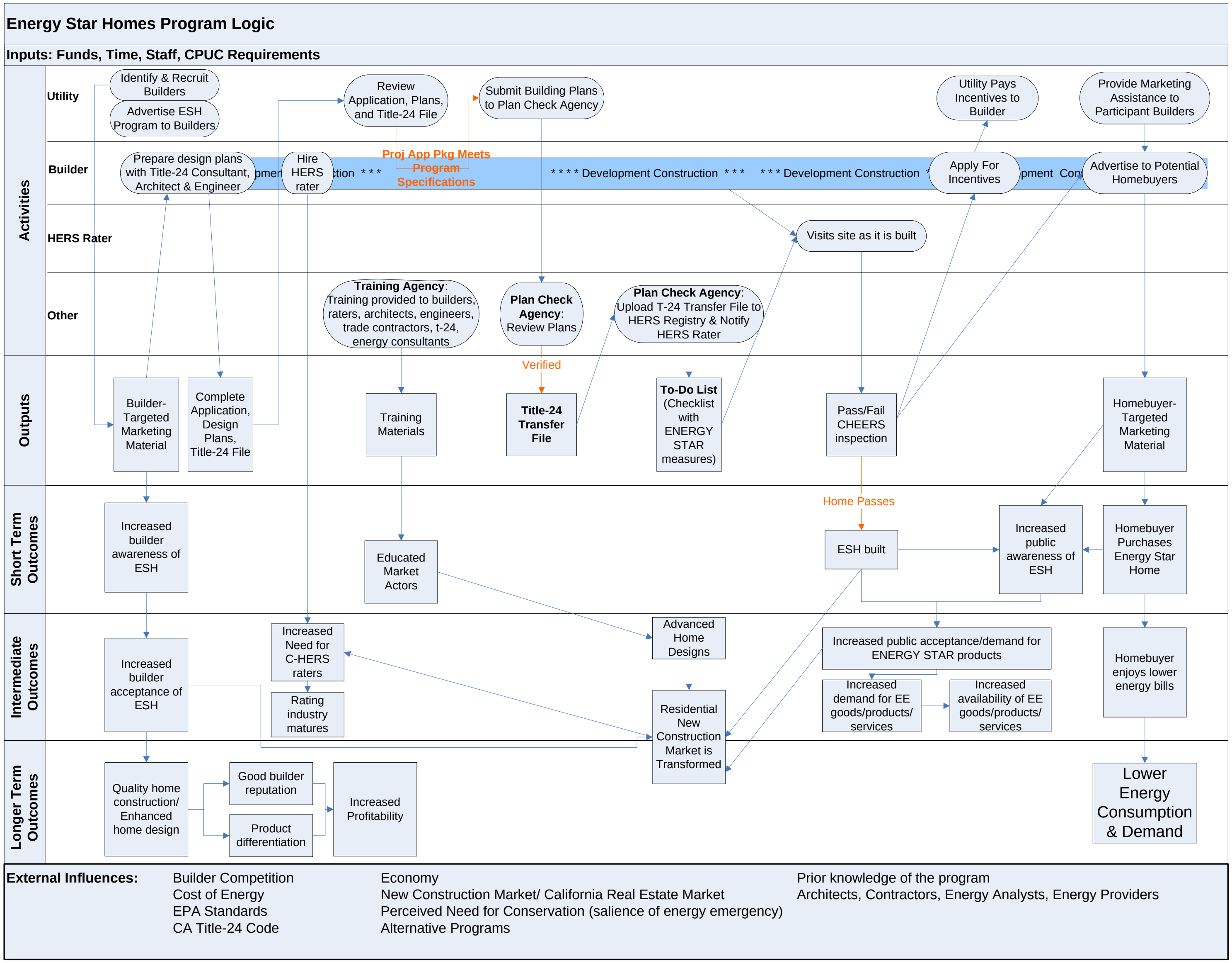


Figure 29: Program Logic Model

In this model, the activities and outputs are steps that integrate activities and resources from all the participants. As shown, the major elements are:

1. **Inputs**. These are the major, direct inputs to create and sustain the program: the initial requirements from the CPUC, the funding for incentives and program implementation, the staffing from the utilities for management;
2. **Activities**. These are the direct activities stemming from the initial inputs. Outputs (below) come directly from the activities, which in turn generate further activities. In this model, activities emanate from each of the three major participants – the utilities, the builders, and the HERS raters – as well as the third party agencies that conduct training and plan checks;
3. **Outputs**. These reflect the direct, tangible outputs from the activities performed. For the program, the outputs emanating from initial steps in the program in turn produce subsequent activities that generate further outputs; and
4. **Short, intermediate, and long term outcomes**. These are the expected and desired outcomes from the previous steps. As explained above, there are three general types of outcomes.

Short Term Outcomes

The short term outcomes show the immediate effect from the program outputs:

A. There is an increased awareness of ENERGY STAR® Homes by builders, related market actors, and ultimately consumers, and

B. The initial awareness leads to actions from and through the program, which then leads to the construction of ENERGY STAR® Homes.

Intermediate Outcomes

The intermediate outcomes show the intended ripple effect over the span of the program funding:

A. There becomes an established acceptance and continuation of design and building behavior by home developers;

B. A growing need for C-HERS raters appears, and the rating industry moves from a sideline function for some contracting firms into a primary business line;

C. Home designs become more energy efficient, and the market share for efficient homes increase; this in turn creates demand for energy efficient home products (appliances, lighting, air conditioning), and drives increased availability for these products by suppliers; and

D. The ultimate desired effect (reduced energy usage) is achieved by individual homeowners. This creates the individualized benefit of reduced costs for homeowners, and begins contributing towards the larger system benefit of reduced demand.

Long Term Outcomes

The long term outcomes show the wider ripple effect over the span of the program design and ultimately towards the exit of the program itself:

A. A wide market adoption is made for high quality energy efficient homes;

B. Builders who construct these types of homes create a distinctive, positive differentiation against other competitors, and are able to capture consistent profits from the margins they derive from their products; and

C. The utilities and the State of California reap the cost benefits of managing a flatter energy use and load profiles from the residential sector that otherwise would have continued to increase.

Program Design Issues

The managers identified several aspects of the program model that needed improvement; these issues were further informed through conversations with the market actors:

- The accuracy and quality of the models produced by the energy analysts, i.e. the Title 24 consultants;
- The accuracy, quality, and timeliness of the inspections performed by the HERS raters;
- Reducing the risk of error replication throughout a single large development, and building in more timely feedback, and
- Eliminating program funding uncertainties, and maintaining appropriate incentive levels.

Accuracy and Quality of Title 24 Documentation

The program managers noticed a problem with the accuracy and quality of the models produced by the energy analysts, i.e. the Title 24 consultants. Each consultant has a personal method for modeling buildings using the compliance software. This means that when different consultants are given the same set of plans, they are likely to produce slightly different results. The difference in modeler technique, combined with the existence of two different residential modeling software programs, could result in different energy savings for the same building. Several program managers expressed interest in "certifying" Title 24 consultants for the ENERGY STAR® Homes program in an effort to reduce differences in modeling. The basic concept is that utilities would conduct workshops to train Title 24 consultants on a standard, utility-approved method for completing documentation. The utilities would then provide this list of approved consultants for the builders to choose from. This would act to standardize the building energy models and would reduce some of the amount of administrative work the utilities have when dealing with errors in Title 24 transfer files. Items that might be "standardized" could include envelope measurements, equipment type and efficiency specifications, and construction assemblies.

It was also found in the interviews with program managers that plan check agencies take a lot of time to get the plans completed correctly. The length of time for plan check and approval is mostly affected by the quality of the Title 24 documents submitted by developers. Utility program managers expressed an interest to better monitor and control the quality of work from the Title 24 consultants. One interviewee from a plan check firm, for example, said that they can distinguish between those Title 24 firms which produce accurate documentation and others whose submissions regularly need correction. If the utilities pre-selected qualified Title 24 consultants that the builders could use, they could minimize the resources expended on plan check by only approving consultants that regularly produced accurate documentation. This would encourage firms that do not submit correct documentation to check their submissions more carefully to ensure that they are not disqualified from providing Title 24 documents for the ESH program.

Accuracy and Quality of HERS Rater Documentation

Several market actor interviewees also identified several weak points with the HERS rater procedures. Accuracy, quality, and timeliness of the inspections performed by the HERS raters all were challenges in the 2004-05 program. In 02-03 as well as throughout the 04-05 program, raters could simply pass or fail a measure without reporting the actual values recorded from the measure or detailing a specific reason for failure. Quality and accuracy could be improved if the raters captured information (i.e. enter specific values) as opposed to simply verifying items on a list. Only requiring "pass" or "fail" for measures provides no indicators in the database to ascertain if the rater closely examined each element.

Requiring a more detailed reporting format will ensure that a rater actually performs the rating and will help identify common reasons for post-construction exclusions from the program. This will help create better opportunities for utility staff to review and remedy problems by identifying measures that HERS raters should focus on when inspecting ENERGY STAR® Homes. Some interviewees expressed that raters could use more extensive training, especially in multifamily construction to ensure large savings possibilities are sufficiently captured. In addition, because raters are selected and paid by the builders, there may be an inherent conflict of interest where some raters may compromise the quality or accuracy of their reports in order to win continued work from the builder.

The quality of the work from HERS raters also arose from comments made by utility program managers and several other market actors. In an effort to push quality submissions by raters, both Registries have begun to set restrictive ranges on appropriate fields to ensure that out of range data do not get entered. Raters already go through a five day training to get HERS certified, but an ongoing refresher training course could provide further benefit.

Another interview comment was that the additional time required to complete a HERS inspection could be burdensome to builders, and may create a barrier in participating again in future programs. Staff from design assistance firms[59] mentioned that they have had to remind builders to select and schedule a rater early in the project to keep their project moving. These interviewees said that this step adds time to the completion of a project. They felt it was important in their role to keep an eye on projects and remind builders not to wait to arrange for a rater until the last minute.

[59] Design assistance firms focus on helping builders develop ESH compliant designs.

These observations were further supported by the on-site inspections of participant homes that RLW performed for the impact evaluation. RLW printed out the HERS checklist for a sample of homes and verified the existence of the measures and envelope characteristics and recorded installed efficiencies. RLW found that although the homes often did not match the original Title 24 plans, on average single family homes were constructed slightly more efficiently than originally planned. If raters are required to gather more details from the sites, it would inherently improve the quality of their work and the level of information stored in the database that could assist with both program implementation and evaluation.

Persisting Errors in Developments

The utility managers also noticed another problem that arises from the primary program coverage of large development projects. They found that it is easy for an error in one plan to be replicated throughout the development if the error is not identified during plan check. The result is that plan check agencies have to provide case-by-case education to Title 24 consultants. One plan check staff member expressed that the consultants eventually learn from these errors and avoid repeating them in subsequent submittals, but since typical construction timelines range over a number of years, this kind of feedback loop is a long and inadequate process spanning across a number of program funding cycles. Certification or continued learning workshops may speed up and codify this learning.

Adjustments to Incentive Levels

The incentive levels have changed slightly from the 2002-03 to the 2004-05 program. The incentive levels for the program are estimated to cover approximately half of the incremental cost to allow the average home to meet ESH requirements. There has been an adjustment to the original levels since the 2002 program year. At that point the 20% level incentives were dropped for all but the inland single family builders. The single family incentives have remained the same since inception.

As described later on in this section, survey results showed most builders rank the incentive as a primary motivator for participating in the program. Some program managers conjectured that funding uncertainties (i.e. funding running out by the end of the year) might prevent other builders from choosing to participate. This concern was also reiterated by one of the market actors, who said some developers have dismissed any possibility of participating because of the issue of program funding cycles. However, the survey results with builders revealed a majority of builders said that they had not been told that the program runs out of funding each year.

Some program managers felt the incentive levels were too generous given the rate at which the programs sold out each year. They expressed that this has been addressed in part by the Title 24 code change in 2005 that reduced the impact of the incentive dollars.

Design assistance incentives for builders are still provided for multifamily projects. The design incentives are primarily intended for the energy consultants that demonstrate focused attention towards energy efficient designs. Once a developer's design team has demonstrated proficiency in energy efficiency, no incentive is automatically proffered because the intent of the incentive is to subsidize initial learning and practice, but not act as a continual "reward" for repeated behavior.

Program Design – Summary

The overall program process design and logic is reasonably sound. There are ongoing issues in quality control for Title 24 consultants and HERS raters that can be partially attributable to the program structure. Altering the structure of the program design to require a more detailed reporting format may improve rater performance and program accuracy.

Errors introduced during the Title 24 documentation phase may lead to a development being disqualified after it has been constructed. Increasing education to Title 24 consultants may alleviate some of this problem.

And finally, incentive availability has been identified as an issue that may affect program participation. A future reduction of incentive levels may extend the period of time funding remains available.

Program Implementation

Differences in Utility Approaches

Each utility implements the ESH program differently. The main components of the ESH program implementation are participant recruitment, design assistance, and plan check.

Each utility has been operating their respective programs for several years with success. RLW held a roundtable discussion with all of the individual program managers from the four participating utilities. The following figure highlights the key steps in each utility's method, and links together what all of the managers consider the best method to operate the ESH program.

SDG&E / SoCalGas (SEMPRA) mostly maintain all services in-house and operate the program the same. PG&E and SCE outsource some key program functions to third party contractors. The figure below illustrates the main differences:

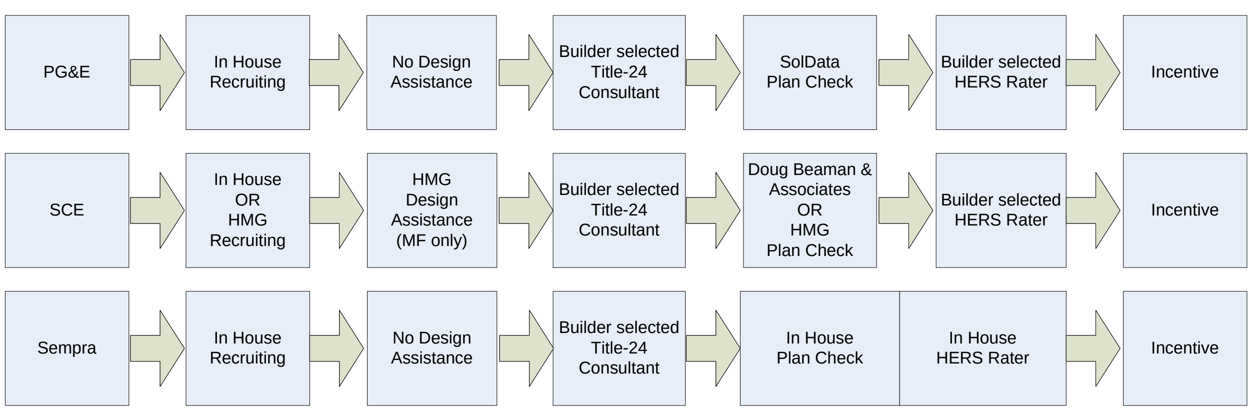


Figure 30: Implementation Differences between Utilities

PG&E Implementation

PG&E has contracted out several of the program functions. PG&E historically has found it challenging to recruit and maintain quality program staffing, and they determined in previous program years that outsourcing would be a more cost-effective and manageable approach. They maintain an in-house staff of approximately four people to implement the program and communicate with the contractors. PG&E uses several channels for program recruitment. They work with the Title-24 consultant and HERS rater communities to help spread awareness of the program. They also leverage PG&E's in-house developer representative team contacts with large developers and builders of residential projects. The developer representative team introduces the ESH program team developers at meetings where they explain the program and encourage participation. During the 2004-05 program PG&E did not offer design assistance. The plan check component of the program is out-sourced to SolData, who maintains a dedicated ESH plan check staff. Another firm is available to perform plan check for projects where SolData acts as the Title-24 consultant. PG&E also out sources the HERS inspections, allowing builders to select their own HERS raters.

SCE Implementation

Similar to PG&E, SCE has outsourced much of the program implementation. The Heschong Mahone Group (HMG) markets the multifamily program element. The design assistance was also dropped by SCE from earlier program years, with the exception of multifamily projects. HMG often aids multifamily builders with design assistance. Plan check is performed by Doug Beaman and Associates for single family or HMG for multifamily. Builders must select their HERS rater from the CHEERS or CalCERTS registry' websites.

Sempra (SDG&E/SoCalGas) Implementation

SEMPRA has developed and maintained in-house management and program staffing since program inception. Each utility account representative works with a number of builders to create awareness and to maintain on-going participation. SEMPRA uses in-house plan check staff trained on both the program and Title 24. They offer no design assistance to builders, but they do offer builders the convenience of in-house HERS rating staff. It could be valuable to compare builder perceptions of HERS rater timeliness across utilities in future evaluations.

Pros and Cons of Strategies

There are certain pros and cons to be found within the different utility program implementation strategies. One is the differences in marketing of the program either by utility account reps or implementation contractors. Using utility staff to market the program allows them to leverage their existing relationships within the builder community, which brings cost efficiency to the program, while implementation contractors may have to place more effort in developing relationships with builders. Account representatives, however, may be constrained by the amount of time and attention they can devote to marketing the program when they have other job responsibilities such as getting a customer's service activated. This is modulated, of course, by the fact that the utilities have an interest in meeting program participation goals. Implementation contractors have an inherent financial motivation to sell their services, subsidized by program incentives, to builders.

As previously discussed, a common complaint that came up during the interviews was the quality of the Title 24 documents submitted to the plan check agencies. Poor documentation results in extra work while the plan check agency and Title 24 consultant go back-and-forth fixing errors. As described, it is difficult to enforce quality control on the Title 24 consultants who produce the documentation. Ultimately, it is the responsibility of the building department to enforce the quality and accuracy of Title 24 documentation.

There are also differences in how utilities conduct plan checks. Some utilities keep the plan check portion of the program in-house with the belief that it provides tighter control over review of the plan check documents, though there is no evidence of this. Other utilities have had to contract out their plan check as a result of not being able to retain in-house staff. It seems more difficult to maintain the quality of workmanship, through occasional trainings and material review, with outside contractors than it would be with internal staff. Utilities that use outside contractors might benefit from an additional QC process to replicate the monitoring and feedback they would perform if the work was done in-house. Future evaluations may want to explore in-house vs. contracted plan check error rates. RLW is aware that NYSERDA uses their own program staff to conduct scheduled quality control process checks on implementation contractors to ensure consistency and quality is maintained during program delivery and suggests the possibility of exploring their reasoning in subsequent evaluations.

Sempra (SDG&E/SoCalGas) is the only utility that retains a staff of dedicated HERS raters to the builders for the ESH Program. While this adds to the program cost to train and maintain a staff of raters, it also offers several benefits to the builders and the program. Providing in-house raters guarantees their availability and ensures the timeliness of the project for the builder. Some builders in utility service areas where raters are contracted had expressed difficulty in securing a rater, both geographically and in an acceptable timeframe. Offering a pool of available and qualified raters to builders helps to ensure they are ready to test the home/unit as soon as it is completed. This eliminates the need for builders to spend time searching for qualified raters, which in turn helps encourage builder participation. These are all benefits to offering in-house raters but this does conflict with the program logic of developing a HERS rater industry. One interim solution may be to contract with one or more qualified firms for the ratings. This would still encourage external development of the industry but would allow the utility to work closely with the firm(s) to maintain rigorous standards and ensure timely inspections are occurring.

Like Sempra, PG&E staff develops and maintains one-on-one relationships with builders and performs outreach to the various building associations. Outside of the utility staff are Title 24 firms who work with builders as full service companies. These external firms use the program - and in particular, the incentives - as a marketing tool to sell their services to builders; in turn, the program incentives act as an offset to the builder costs that those firms charge for their services. In other words, the builder recoups most of the costs borne from hiring these services. In this way, the utility incentives act as a catalyst to keep two parts of the open marketplace functioning together.

Program Quality Control

There are two main steps in the process that are performed in order to ensure that the savings are being realized: 1) plan check and 2) HERS rater verification. There is also an additional CPUC mandated quality control measure on the HERS verification step that is not associated with savings verification.

Every project that participates in the program must go through plan check. Each unique structure plan must be submitted with a Title 24 compliance report, and it is the task of the plan checking entity to verify that the compliance report matches the blueprints, that the plan is meeting the program requirements, and that the structure was modeled correctly. As discussed earlier, Sempra does these plan checks in-house, while PG&E and SCE outsource this work.

Plan checks involve the review of development plans for Title 24 compliance, as well as a confirmation that the design is at least 15% more efficient than Title 24. As described by one contractor, this includes checking some of the blueprint take-offs against those in the Title 24 report. If an error is found, a memo is sent to the builder's Title 24 consultant and the utility staff specifying what corrections need to be made.

The plan check contractor for SCE incorporates an additional "equipment plan check" strategy for QC, where they track the house design according to the plans, and then document updates on a comparative column as "Actual". If measures shown on the plans are also what was actually constructed or installed, the developer checks it off; otherwise they write in what is different in the "Actual" versus "Plan". The plan check contractor then views the "Actual" entries to double-check if the plans still fit in within the program.

This strategy captures what the builder is doing, allows the plan check contractor to catch changes as they occur, and gives them sufficient time to get back to the builder to make changes before construction is completed. The checklist contains largely the same information the HERS raters take on-site; however, performing the check during the construction process instead of afterwards allows for changes that - if left undiscovered – would subsequently disqualify a project. In contrast, the PG&E and SEMPRA processes split the QC function from the plan check. In essence, once the plans are checked off, there is no further QC until the HERS rater performs the on-site. At that point it is too late to catch any construction changes that may disqualify a plan.

The additional quality control check incorporated into the program by the CPUC is a mandated review of 1% of the plans entered into the registry. This requires a second independent HERS rater to double check one out of every 100 plans. Management of quality workmanship becomes a problem for the registries, because any rating firm may create an unfair competitive advantage for themselves by acting less stringent on results, and thus gain favor from their builder clients over other more conscientious or thorough rating firms. The other condition uncovered during this evaluation is that the rater training currently has no ongoing QA oversight.

The current structure allows consultants and raters to operate without great concern of their work being verified and little repercussion for consistent errors. An increase in the sampling of QC sites and review of Title 24 and plan check documentation might encourage consultants and raters to ensure their work is done correctly. This could be especially effective if mistakes were tracked and repeat offenders incurred some penalty.

One issue discovered during this evaluation demonstrates the importance of quality Plan Check and HERS rater workmanship. Homes were examined in climate zone 3 where compliance margins reached 45% for water heating. There were 115 homes modeled in several different plans, but all were modeled by the same firm, for the same development, and apparently with the same conflicting information. The tank type is reported as instantaneous, but the tank size is reported as 40-50 gallons, a contradiction. Other water heating variables in the CHEERS database show contradictory information, indicating possible Title 24 modeling errors. While it is impossible to say what was actually installed without a field inspection, these models probably should not have passed plan check as they were submitted. Without further investigation it was not known what firm conducted plan check of these homes. A home with a 40%+ water heating compliance margin is almost automatically qualified for ENERGY STAR® status, so the impact of this one change could mean the difference between an average home an ENERGY STAR® home.

Since it was not possible to hand check every Title 24 model for potential errors or inconsistencies, the extent of errors can not be estimated, but suggests breakdowns in the programs system of checks and balances. EM&V contractors should identify problem sites and auditors should visit the homes, or the plan check agencies should be contacted, to better understand the plans with contradictory information.

Program Participation

Penetration of Market

RLW briefly examined how the level of participation compared to single family and multifamily housing starts by year. The table below shows housing starts leading up to and including the program years evaluated in this report.

Year	Single-Family	Multifamily (units)	State Total
2005	154,961	53,843	208,804
2004	151,417	61,543	212,960
2003	138,679	56,277	194,956
2002	123,865	43,896	167,761

Table 67: Yearly California Statewide Housing Starts[60]

The table below displays the total number of ESH that were completed (and rated) in each year. The early years of the program show lower participation rates since it can take 1-3 years to complete SF housing and 1-4 years for MF housing. As shown in the table below, the program penetration of single family homes has steadily increased over the four years, from less than 1% in 2002 to over 10% in 2005.

[60] Source: http://www.cbia.org/documents/member/statehousingstarts.pdf

Year	ESH Participation	SF Homes Constructed	Ratio
2005	16,609	154,961	10.7%
2004	14,504	151,417	9.6%
2003	5,807	138,679	4.2%
2002	1,043	123,865	0.8%

Table 68: Single Family Homes - Ratio between ESH Participation and New Construction Starts, Per Year

A similar summary of program penetration was also performed on multifamily units.

Year	ESH Participation	MF Units Construction[61]	Ratio
2005	9,206	53,843	17.1%
2004	9,922	61,543	16.1%
2003	6,541	56,277	11.6%
2002	740	43,896	1.7%

Table 69: Multifamily Homes - Ratio between ESH Participation and New Construction Starts, Per Year

Program Drop Outs

In the program manager interviews, it was mentioned that projects and builders occasionally drop out of the program. Although a project may drop out, the builder may nonetheless still participate with other projects.

The utilities do not currently track the specific reason for project drop outs, but most interviewees speculated that a major reason for drop outs is the timeline of construction projects. Many of the projects that do not make it through the program simply do not get their paperwork submitted in time. If a project takes longer to build than the program duration, they may technically be considered as "dropped out" because they were not completed by the time the program funding closes out.

Program managers said that some builders may also overestimate their capacity. If a builder over commits they may just drop participation on projects they were planning to finish. The utilities count these types of situations as "drop outs" because they earmark the funds early in the process, and then these funds must be reallocated.

Program managers also said there have been situations where a builder has dropped out of the program completely. They said that the typical reasons were expired applications or the builder expressed that their firm chose not to have the added cost of participating in the program.

[61] A unit is defined as an individual residence.

Building to Specific MF Thresholds

Compliance issues with multifamily sites had arisen in earlier program cycles. In PG&E's experience with the 2002/03 program, it was discovered that negative electric savings were occurring since some builders were gaining compliance through the design specifications that use efficient gas measures over anticipated similar electric equipment, such as water heaters. After the 2002/03 program year, the utility began disallowing multifamily projects with negative electric savings. SCE adopted the same requirement. PG&E and SCE required positive electric savings after the 2002/2003 program year.

The utility program managers interviewed for this evaluation felt that the methodology used in the 2001 code did not address the unique situations that tend to arise in the design and construction of multifamily structures, and as a result the energy savings in multifamily projects tended to be overstated. The 2005 code has addressed that and has corrected some of the elements so that multifamily projects are more correctly evaluated. Nonetheless, the managers felt that the compliance margin should have been raised from 15% to 25% for projects under the 2001 code.

The program has gained progress with affordable rate developers. Part of the motivation for the affordable rate builders is economic. They can maximize federal and state tax credits by meeting energy efficiency qualifications. The other motivation for many of these affordable rate builders lies in a more enlightened and informed attitude about achieving energy efficiency and the long term impacts on the tenants as evidenced by their responses to their motivation for participating.

Program Marketing

The utility program managers reported that no significant program marketing had been done for this 2004-05 program cycle. Program managers said that there was, in fact, little need to spend any more money on marketing when the single family program had usually been sold out by the first quarter of each year. No specific marketing tasks were done for multifamily projects, although outreach strategies have been pursued with both affordable and market rate developers.

The utility program managers said that they have no problem in recruiting builders. However, they felt that if program participation were to decline, marketing could become critical for program success. Currently the only joint marketing activity between utilities is advertising purchased for the Pacific Coast Builders Conference. Builder marketing and direct-to-homebuyer marketing was done by each utility independently. In the past (and with efforts extending beyond this particular program), PG&E has run TV and radio spots which generated large volumes of requests for homebuyer kits, but these spots were cut for this program cycle due to cost. The program managers did not feel that advertising and promotion in the past has had much impact in driving home buyers specifically to ENERGY STAR® because the overall demand for homes has been so strong.

The bulk of the outreach for the utilities is done through the existing relationships that their account executives have with builders. Some program managers reflected that language may be an initial barrier in outreach (i.e. builders of Asian or Hispanic descent), but overall, the utilities have no trouble recruiting potential builders. The account executives work with both the builders and their industry organizations to identify projects early, and then look to get the projects into the program process.

There are no specific metrics or goals for the account executives to specifically reach, but they are expected to have full subscription of the program by the time the program funding cycle is near completion.

The program managers said that there is a challenge in getting enough MF projects subscribed for the program and its related incentives. The interviews with other market actors revealed that there had been a need to strengthen utility knowledge in multifamily construction. The multifamily marketplace is a unique industry where programmatic processes, policies, and incentives for single family marketplaces do not apply cleanly to multifamily marketplaces. Future process evaluations could specifically address this by trying to characterize the multifamily building processes and program participation.

Program Implementation – Summary

The program operation for each utility is different, and is driven by the needs of internal management, available internal skill sets, and economics. Each utility has modified their program processes that fit their internal resources and hiring. As typical of business operational needs, the challenge is one of balancing operational quality and consistency versus cost and resource capacity. This challenge arises in several arenas - the recruitment and management of program participants internally versus outsourced; the availability and consistency of HERS raters; and the consistency and timeliness of the plan check process. There appears to be a need to build in a quality control function, particularly in the outsourced functions, that replicate the same level of checks and oversights of program delivery for those utilities with internalized program functions. If increased program participation is still desired, there may be a need to enhance recruitment and funding of additional raters (particularly in outsourced situations). This would serve the program in two ways: in volume to increase program capacity, and to be better available in outlying areas.

Quality control arises as a continued challenge. There are inconsistencies seen for Title 24 consultants and HERS raters. Increased sampling rates for quality control review might be sufficient to make consultants and contractors more diligent since errors would have a greater chance of being caught.

For this program cycle, there was sufficient program participation, and in fact utility program managers were careful that there was not an oversubscription and exhausted funding. For this program cycle, there has not been a perceived need by utility managers to conduct any mass marketing for the program.

Program marketing for the single family home marketplace took a smaller role in this funding cycle because goals in builder participation and incentives subscription, as well as the hard-to-reach marketplace, were sufficiently met.

Program Tracking and Databases

This section illustrates the findings from RLW's examination of the CalCERTS, CHEERS, and utility program data.

Description

The ESH program is tracked at two levels. Each utility has a tracking database and the registries each have independent tracking systems. As previously stated, this evaluation is based on tracking data from the registries and not the utilities' internal tracking databases. Using the registries is an acceptable substitute for utility tracking in this situation because they collect a sufficient amount of data. This is, however, a departure from standard evaluation procedure where utilities supply their internal databases. RLW recommends a review of each utility's databases in future evaluations.

Overarching tracking recommendations for the utilities and registries were made in previous reports. Program managers reported that the recommendations were adopted and have streamlined the current evaluation. Previous problems of linking utility tracking information to the CHEERS registry's project information have been eliminated now that the utilities and registries use the same tracking information for builders and projects.

RLW found that the main difficulties with the various tracking databases were missing data, differences found in fields, data accuracy, and data organization. RLW urges the utilities to organize a development session that would establish one database template that each utility can use. This consistency of program data tracking would allow evaluations to utilize one master database, which would make some evaluation tasks simpler and more cost effective.

Utility Tracking Databases

During Phase 1 of the 02-03 reporting, RLW recommended that the utilities track projects by the project ID number found in the registries. The utilities reportedly adopted this method and now use the ID number to track projects. Furthermore, it was reported by the program managers at the interview sessions that all of RLW's recommendations from the Phase I Report were adopted.

Additional 02-03 recommendations reportedly adopted into the utility tracking data were:

- Project Name
- Project Location (Address, City, Zip)
- Builder ID
- Builder Name and Location
- Plan ID (Application Number or ID for Model)
- Plan Name
- Proposed Number of Units for each Plan
- Actual Number of Units Built for each Plan and Plan Option
- Square Footage of Conditioned area of Each Unit
- Program Year
- Check Issue Date
- Project Completion Date
- Micropas or EnergyPro file name

RLW could not verify the actual adoption of these measures because the utilities individual tracking databases were not available for review. RLW recommends in future process evaluations that the data collected in each utility's database should be examined, and the valid features should be pooled from each to make a universal tracking database format.

Since the utilities' databases were not available RLW used the CHEERS and CalCERTS registries for program tracking. The registries contain much of the same information reported to be in the utility databases. In addition, the registry databases also contain specific HERS measure information which aided RLW in the verification of on-site findings.

Registry Description

The registries are independently owned and operated data warehouses. They are funded through the dues paid by HERS raters who "belong" to respective registries. There are currently two registries: the California Home Energy Efficiency Rating Service (CHEERS) and CalCERTS. A third registry, California Building Performance Contractors Association, should be available for future programs.

A registry first has contact with the program after a plan has been uploaded by a plan check agency. It is up to a builder to go to the registry and select a HERS rater. Once a rater has been selected they print out a measures sheet from the registry website. The check list tells the rater what measures were implemented in the new home and must therefore be verified. After rater verification, the project must be listed as either passing or failing the HERS inspection/test in the registry database.

Program Participation Tracking

The recent housing market in the state of California has been growing at such a rate that the ESH program was sold out each year. In that type of environment there was no need for specific builder retention efforts because the demand was so great. As a result, builder participation was not specifically tracked. Currently none of the utilities track detailed builder participation information (i.e. those visited, recruited, initially started, and those subsequently dropped out). As the new home construction marketplace slows, it may become more important to specifically track builder drop-outs and the reasons why. Each utility has its own project tracking, so it is conceivable that those databases could be leveraged to query which builders participate from year-to-year if it became necessary to encourage program participation. RLW has already developed a California Residential Builder (CARB) database which identifies many California builders, their volume, and their participation in the ESH program. This database could be further developed into a participant tracking system.

Program Tracking – Summary

The adoption of overarching tracking recommendations made in previous reports has streamlined the current evaluation. Problems of linking utility tracking information to the registry's project information have been eliminated, but differences in fields and data organization remain with the various tracking databases. RLW believes a development session with the program managers could be arranged that would ultimately produce one database template that each utility can subsequently use. Consistency in program data tracking would allow an evaluator to establish and use a single master database.

It would also greatly simplify the program evaluation if the databases housed detailed builder contact information for both corporate contacts and on-site contacts. RLW found that the databases often contained one or the other, but not both, which would be beneficial for evaluation purposes. The corporate contacts are necessary for conducting builder surveys, and the on-site contacts are helpful for gaining access to the sites for verification. Documentation of specific outreach tasks and outcomes, including subsequent dropouts or renewals of participation in new projects, increase opportunities to gain further insight and learning about the program processes.

For future evaluations, utility tracking databases should be made available for review, and the valid features should be pooled from each to make a universal tracking database format.

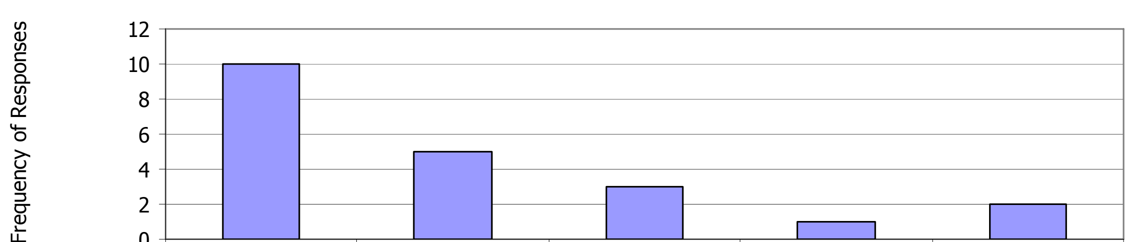
Survey Responses

This section illustrates the findings from the process-related questions that were included in the participating and non-participating single family builder, multifamily builder, and homeowner surveys. In order to ensure an accurate comparative analysis when possible, respondents were asked to rate many of their responses on a scale ranging from 1 to 5. Unless noted otherwise, in each scale a rank of 1 was the least and 5 was the greatest, i.e., 5 equals "very important", "greatest barrier", or "most difficult". Responses given, whether open ended or from a provided list, are presented here as they were gathered during the interview. In order to present findings accurately efforts were made not to form interpretations of the responses but instead to present the data as it was recorded.

Single-Family Builder Surveys

Process-related questions were asked of 33 single family builders that participated in the program and 21 that did not. Most of the questions were specific to their participant (P) or non-participant (NP) status but some questions did apply to both P and NP builders.

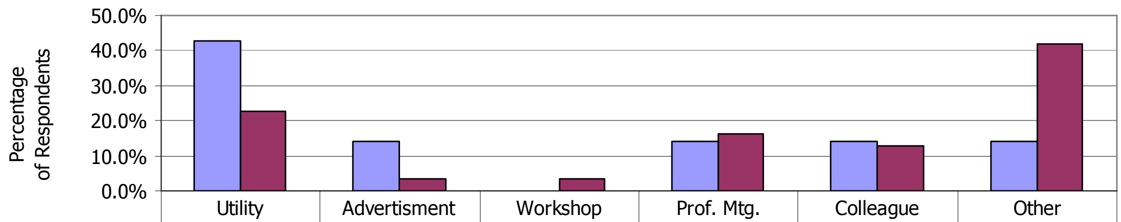
Non-participating builders were asked about their familiarity with the ESH program. Very few of the non-participating builders reported familiarity with the program. Nearly half stated they were not at all familiar with the program. If participant builder volume decreases as the California housing market cools, increased marketing may be needed to recruit more non-participating builders in order to maintain program goals.



	1 = Not at all	2	3	4	5 = Very familiar
Non-participants	10	5	3	1	2

Figure 31: Non-participant familiarity with the ESH Program

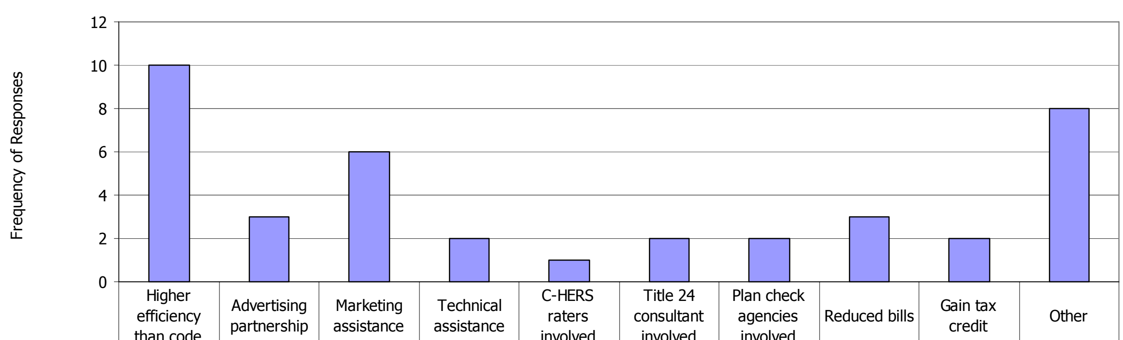
Both participants and non-participants were asked how they first became aware of the program. Of the 11 non-participant builders that responded they had some familiarity with the program only 7 responded to the question regarding where they first learned about the program. The majority learned about the program through the utilities (shown below). Advertisements, professional meetings, and colleagues were other sources that informed non-participants about the program. Only 23% of the participating builders reported learning of the program through the utilities. Most cited "Other" sources which included the internet, local city offices, and Title 24 firms. Since the program managers said that they have done most of their program outreach and recruitment through their account representatives, it appears that this outreach and awareness building has eventually filtered through to government and third party sources.



	Utility	Advertisment	Workshop	Prof. Mtg.	Colleague	Other
Non-Participant n = 7	42.9%	14.3%	0.0%	14.3%	14.3%	14.3%
Participant n = 32	22.6%	3.2%	3.2%	16.1%	12.9%	41.9%

Figure 32: Initial source of awareness about the program

The non-participants that had some level of familiarity with the Program were surveyed to identify their understanding of the program components. By far the most common perception of the program is that it requires higher efficiencies than code. Seven of the eight "Other" comments demonstrated understanding that the program offered incentive money. This implies that these non-participants have a basic understanding of the central goal of the program, although they do not recognize the other benefits of program participation.

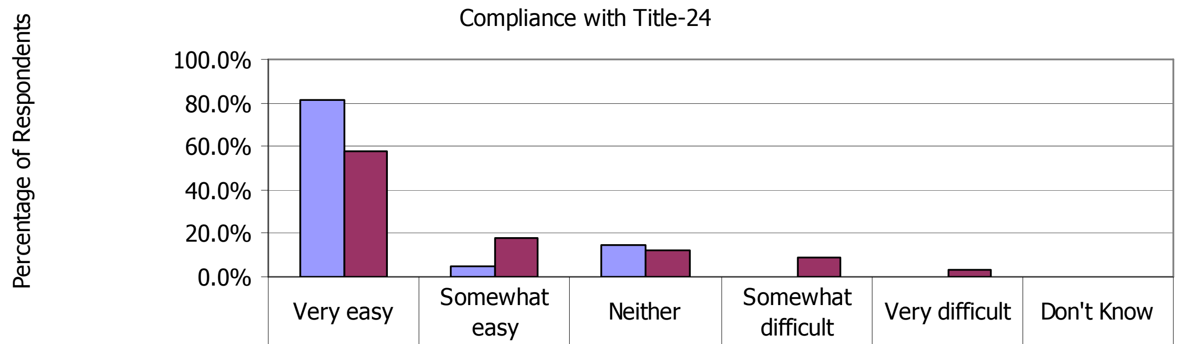


	Higher efficiency than code	Advertising partnership	Marketing assistance	Technical assistance	C-HERS raters involved	Title 24 consultant involved	Plan check agencies involved	Reduced bills	Gain tax credit	Other
Non-part n = 11	10	3	6	2	1	2	2	3	2	8

Figure 33: Non-participants - basic understanding of the program

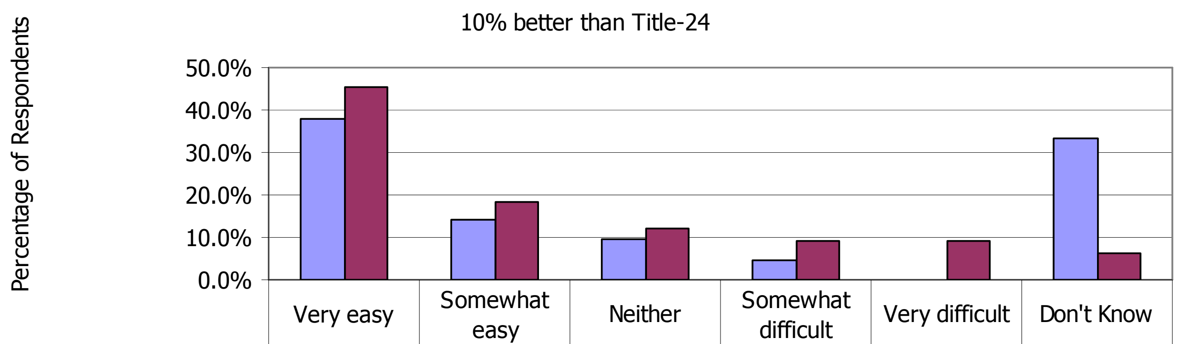
Since Title 24 building codes apply to all construction in California, both participating and non-participating builders were asked how difficult it was for them to build to different levels beyond code. The results of this question show in Figure 34a through Figure 34d show that, overall, builders find more difficulty in building to higher levels of efficiency. Interestingly, all of the non-participating builders reported no level of difficulty building to Title 24 while 12% of participating builders said they had difficulties just reaching Title 24. As the survey question moved to the 20% level of compliance, non-participants reported either increasing levels of difficulty or else not having any experience building to those levels.

The participating builders followed the same trend, and reported that compliance got more difficult as the levels increased toward 20%. However, percentages for participant builders lagged behind non-participant percentages, which at least imply that they felt they have had a slightly easier time gaining compliance.



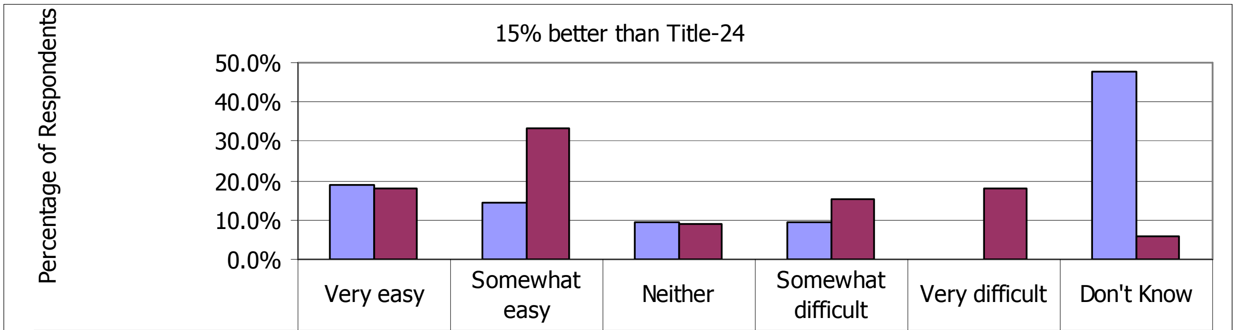
	Very easy	Somewhat easy	Neither	Somewhat difficult	Very difficult	Don't Know
Non-Participant n = 21	81.0%	4.8%	14.3%	0.0%	0.0%	0.0%
Participant n = 33	57.6%	18.2%	12.1%	9.1%	3.0%	0.0%

Figure 34a: Building to Title 24 level compliance



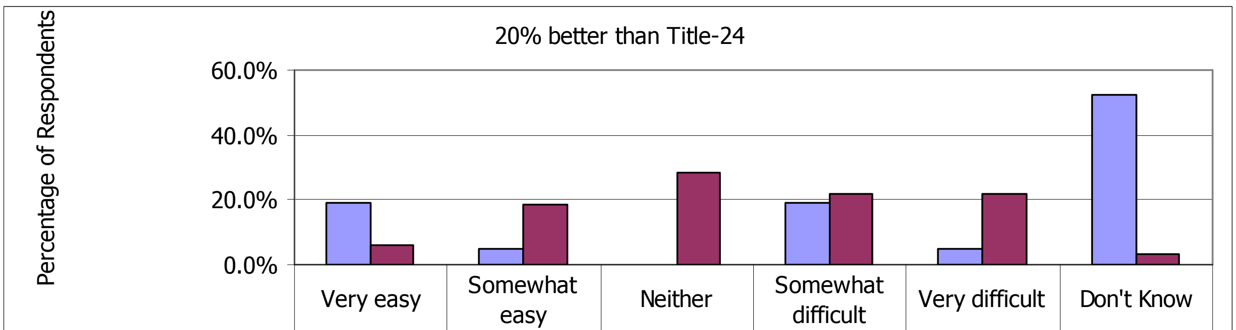
	Very easy	Somewhat easy	Neither	Somewhat difficult	Very difficult	Don't Know
Non-Participant n = 21	38.1%	14.3%	9.5%	4.8%	0.0%	33.3%
Participant n = 33	45.5%	18.2%	12.1%	9.1%	9.1%	6.1%

Figure 34b: Building to 10% higher than Title 24 level compliance



	Very easy	Somewhat easy	Neither	Somewhat difficult	Very difficult	Don't Know
Non-Participant n = 21	19.0%	14.3%	9.5%	9.5%	0.0%	47.6%
Participant n = 33	18.2%	33.3%	9.1%	15.2%	18.2%	6.1%

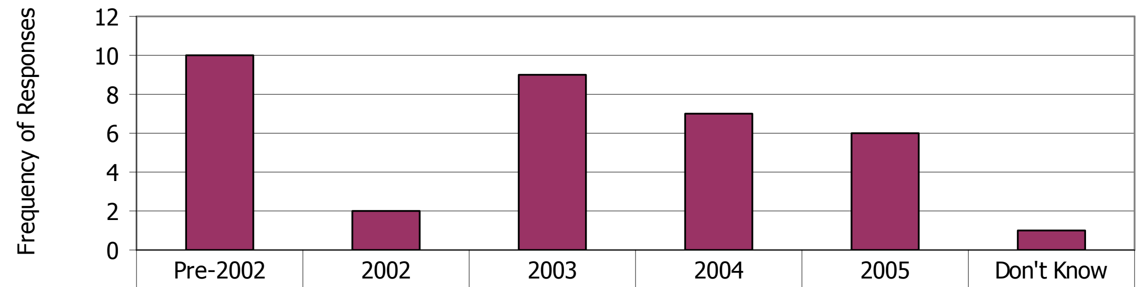
Figure 34c: Building to 15% higher than Title 24 level compliance



	Very easy	Somewhat easy	Neither	Somewhat difficult	Very difficult	Don't Know
Non-Participant n = 21	19.0%	4.8%	0.0%	19.0%	4.8%	52.4%
Participant n = 32	6.3%	18.8%	28.1%	21.9%	21.9%	3.1%

Figure 34d: Building to 20% higher than Title 24 level compliance

Participating builders were asked what year they learned of the ENERGY STAR® Homes program. The majority of respondents reported they were familiar with the program before 2002. Since the ESH program was not in place until 2002 it is possible that the pre-2002 responses were confusing the older Comfort Homes® program with the new ENERGY STAR® Homes program. Only two of the thirty-one respondents became familiar with the program in 2002. The survey responses also show a declining number of builders becoming newly familiar with the program each year. This suggests that there were likely more repeat participants than new entrants in subsequent years.



	Pre-2002	2002	2003	2004	2005	Don't Know
Participants	10	2	9	7	6	1

Figure 35: Approximate year respondent become familiar with the ESH program

When participating builders were asked what their most common reasons for participating in the program were, they cited "increasing the efficiency of the home", "obtaining incentive money", and "marketing". Typical open-ended comments were:

> *"Incentives and the ability to market homes as [efficient design]"*
>
> *"Our company wanted rebates & to make selling homes easier"*
>
> *"It's good to make houses [energy efficient]; we want the incentives"*

A few respondents commented they were either required by corporate direction to participate, or local building codes required homes to be built to a level 15% better than Title 24. This obviously points to a small level of free-ridership, although it is unknown how prevalent these municipal codes may be. We would recommend a future evaluation research step to investigate the prevalence of enhanced municipal residential building codes.

Builder motivations were next explored. Program participant builders were asked to rate the importance of the following five factors in regard to their decision to participate:

1. Financial incentives available to offset additional costs
2. Product differentiation
3. Advertising partnerships
4. Marketing assistance
5. Technical assistance

Responses trended toward being "Very Important" for each of these factors - except for technical assistance. The responses for "Technical Assistance" garnered fewer high rankings, which implies that this program feature has limited appeal to participants.

Importance	Incentives	Differentiation	Advertising Partnerships	Marketing	Technical Assistance
	n = 31	n = 31	n = 29	n = 28	n = 29
Not important = 1	9.7%	0.0%	13.8%	10.7%	17.2%
2	3.2%	6.5%	10.3%	7.1%	24.1%
3	25.8%	6.5%	17.2%	25.0%	20.7%
4	19.4%	19.4%	24.1%	21.4%	24.1%
Very important = 5	41.9%	67.7%	34.5%	35.7%	13.8%
Mean	3.8	4.5	3.6	3.6	2.9
Std. Dev.	1.3	0.9	1.4	1.3	1.3

Table 70: Importance of Factors in Decision to Participate

Program participant builders were next asked how they felt about a variety of challenges they may have experienced during their participation. They were asked to rate on a scale of 1 to 5 the following program aspects:

- Paperwork (i.e. "red tape")
- Uncertainty that program funding will be available
- Finding a qualified rater
- Scheduling a qualified rater
- The cost of a rater
- Requred margin of compliance above Title-24
- Increased time due to program requirements
- Added cost of the EE measures
- Added administrative cost associated with program participation

A majority of respondents felt that most of the items in the question were not difficulties – paperwork; finding, scheduling, and the cost of the certifier; compliance margins; increased project time; and administrative costs. Program funding uncertainties and the incremental costs of added measures created the most difficulty for the majority of respondents. This implies that both a longer funding cycle and continued incentives are both important to consider for future program offerings.

Difficulty	Paperwork	Prog. Fund Uncertainty	Finding Certifier	Scheduling Certifier
	n = 32	n = 25	n = 31	n = 31
Not difficult = 1	53.1%	44.0%	67.7%	67.7%
2	15.6%	8.0%	22.6%	16.1%
3	18.8%	20.0%	0.0%	9.7%
4	6.3%	20.0%	6.5%	3.2%
Very difficult = 5	6.3%	8.0%	3.2%	3.2%
Mean	2.0	2.4	1.5	1.6
Std. Dev.	1.3	1.4	1.0	1.0

Difficulty	Cost of Certifier	Margin of Compliance	Increased Project Time	Added Cost of Measures	Added Admin. Cost
	n = 29	n = 33	n = 32	n = 29	n = 21
Not difficult = 1	55.2%	69.7%	65.6%	27.6%	47.6%
2	31.0%	15.2%	9.4%	24.1%	28.6%
3	3.4%	6.1%	15.6%	20.7%	14.3%
4	10.3%	6.1%	6.3%	13.8%	4.8%
Very difficult = 5	0.0%	3.0%	3.1%	13.8%	4.8%
Mean	1.7	1.6	1.7	2.6	1.9
Std. Dev.	1.0	1.1	1.1	1.4	1.1

Table 71: Respondent Ratings on Perceived Difficulties

Program participant builders were next asked to rate their satisfaction with the overall program, the level of incentive, the margin of compliance required by the program, and the ease of program participation. The majority of respondents expressed some level of satisfaction with all of the program aspects. Over 80% of the program participants reported being satisfied with the overall program. Seventeen percent reported some level of dissatisfaction with the program's compliance margin. Fourteen percent reported some level of dissatisfaction with the ease of participation.

Program participant builders were asked the degree of positive or negative impact they perceived to determine the impact of the ESH program on the marketing of homes. Sixty-four percent of respondents felt the program had a positive impact on the marketability of the homes, with one quarter expressing that it was "very positive". This is useful to see in light of the fact that during this time period a very hot buyer's market might have circumvented any desire by developers to differentiate themselves as ESH builders.

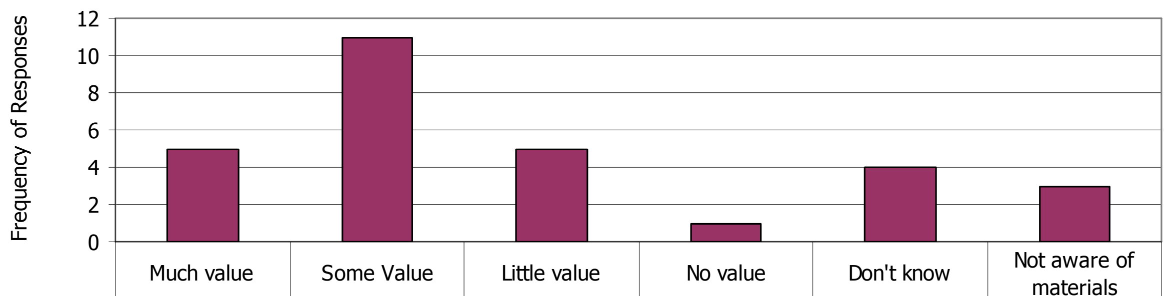
Impact	Marketability of Home	
	%	n = 28
Very negative	0.0%	0
Somewhat negative	0.0%	0
No impact	28.6%	8
Somewhat positive	39.3%	11
Very positive	25.0%	7
Don't know	7.1%	2

Table 72: Perceived Marketing Impact

Participants were asked about the features of the program they liked the best and the least. The majority of positive responses were related to the energy efficiency resulting from the program, the incentives, and the marketing benefits of ENERGY STAR® homes.

The most common complaints were related to compliance, incentive levels, and program expense. RLW cross examined the answers from the participants that said they did not like the compliance aspect of the program against an earlier question that rated the level of difficulty respondents had with compliance. Each respondent reported having no difficulty reaching the 15% levels. This suggests that although reaching compliance is the least liked aspect of the program, it nonetheless does not appear to be a significant barrier to participation.

Participating builders were questioned to determine the value of marketing assistance and promotional materials. Of those who responded, a majority (16 of 27) found "some" or "much" value in the marketing materials provided by the utility. This suggests that the materials held reasonable value in the eyes of most builders and at least supplemented any differentiator sales strategy they may have had.



	Much value	Some Value	Little value	No value	Don't know	Not aware of materials
Participants	5	11	5	1	4	3

Figure 36: How Valuable were the Marketing Assistance and Promotional Materials

Just as participants were asked why they participated, non-participants were questioned as to why they did not. They were asked to rate on a 1 – 5 scale the importance of the following five factors in their decision:

1. Insufficient financial incentives available to offset additional costs
2. No need for product differentiation
3. Insufficient benefit from advertising partnerships
4. Insufficient marketing assistance
5. Insufficient technical assistance

This question was only directed to the six respondents who ranked their familiarity with the program at 3 or higher on a scale of 1-5. Of those six, four reported the level of incentive played an important factor in their decision not to participate. The rankings for the remaining factors, product differentiation, advertising, marketing, and technical assistance all demonstrated these factors to be less important barriers to participation.

This suggests that the larger value proposition of supporting a differentiating strategy of providing energy efficient homes is either unknown or dismissed by those respondents, and that their main motivation, if they ever decide to participate, would be financial.

Non-participants were asked if they had heard of program monies being used up. This question was inserted in the survey because several program managers surmised that one participation barrier may be the perception by builders that the funding will run out before they complete a development project. Seven of nine respondents said they had not heard anything about project monies being used up. Only two responded that they had heard that monies run out. These results imply that this seems to be a minor issue and not necessarily prevalent as a perceived program condition.

Multifamily Builder Survey

Twenty multifamily builders that participated in the program and eight non-participants answered process related questions.

Non-participating builders were asked how familiar they felt they were with the ESH program. The responses in the graph below show that while non-participants have some familiarity with the program, improvements in non-participant awareness are still needed.

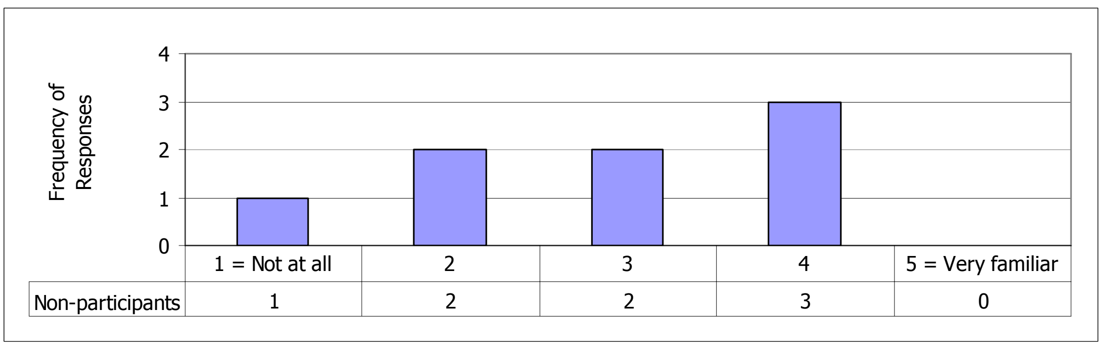
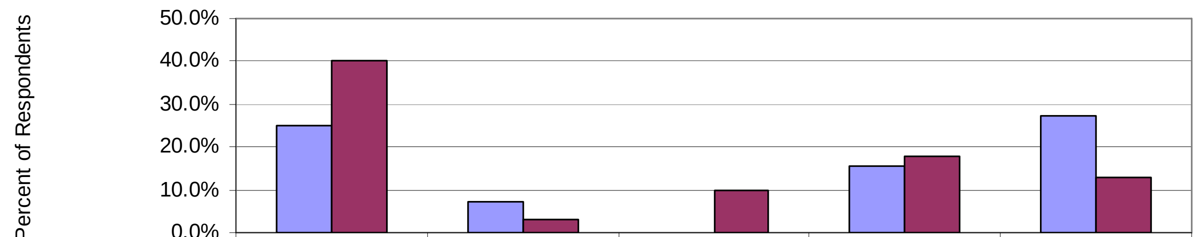


Figure 37: Familiarity with the ESH Program

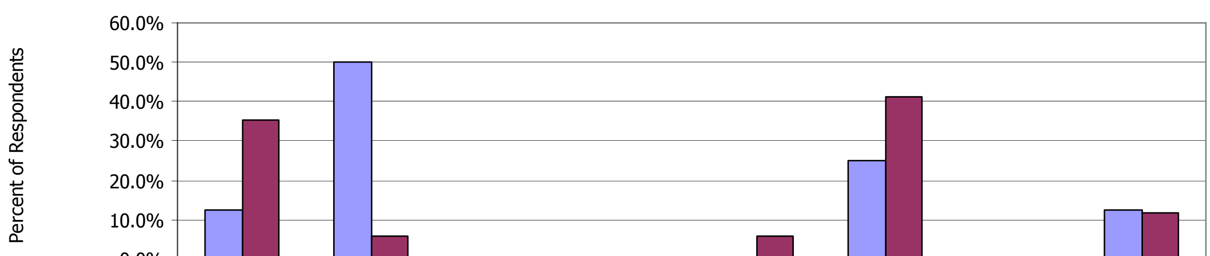
The majority of program participants reported learning of the program before 2002 while non-participant awareness has been increasing. Overall, most respondents claimed that they learned about the program either before 2002 or during the 2004-05 program cycle. This suggests that there may be more repeat participants than new ones over the span of several program funding years. It is unclear if the pre-2002 responses are connected to misunderstanding with other PG&E programs.



	Pre-2002	2002	2003	2004	2005
Non-participant n = 8	25.0%	7.1%	0.0%	15.4%	27.3%
Participant n= 20	40.0%	3.1%	9.7%	17.9%	13.0%

Figure 38: Year Respondents become Familiar with the Program

Both participant and non-participant multifamily builders were asked how they heard about the program. Forty-one percent of respondents learned of the program through a colleague, while a significant number (35%) found out through the utility. The majority of non-participants learned of the program through advertising. This result may demonstrate the usefulness of marketing in spreading awareness to non-participants. It should be noted, however, that the advertising did not result in participation. Personal contact by utility staff appears to still be the primary channel for gaining participation beyond initial awareness.

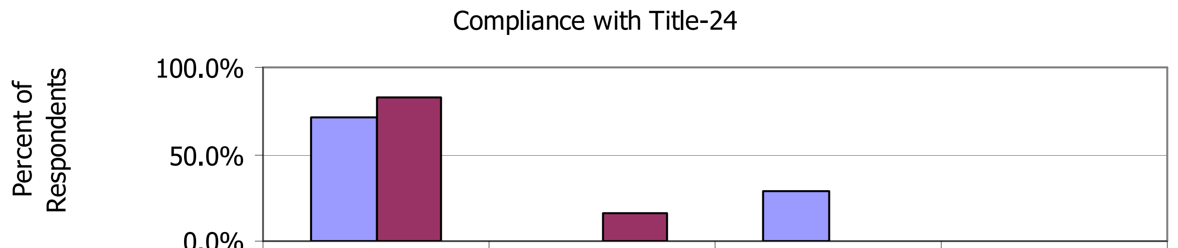


	Utility	Advertisement	List Serve	Workshop	Prof. Meeting	Colleague	Client	Other
Non-part n= 8	12.5%	50.0%	0.0%	0.0%	0.0%	25.0%	0.0%	12.5%
Participant n= 17	35.3%	5.9%	0.0%	0.0%	5.9%	41.2%	0.0%	11.8%

Figure 39: Where did you Hear about the Program?

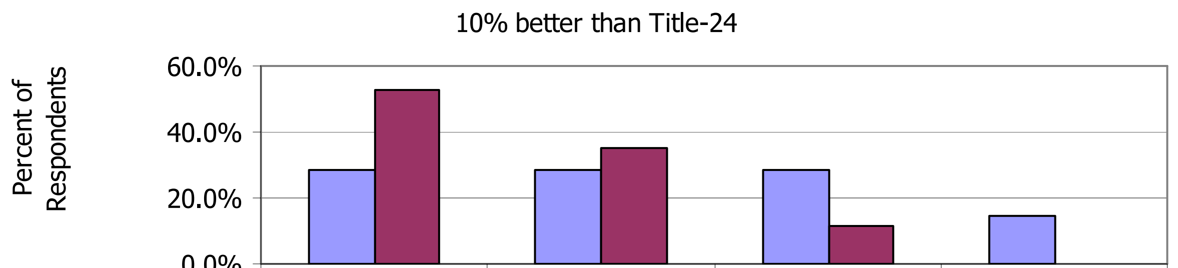
Respondents were asked to gauge the level of difficulty in meeting various efficiency tiers above Title-24. The results show, as might be expected, that as the compliance margin increases the highest percentage of responses shift from "Very easy" towards "Very difficult". These responses do show that participating builders are slightly more tolerant to higher margins of efficiency. However, two of the seven non-participants who reported it was "Very easy" to build to Title-24 levels maintained the same answer all the way up to a margin of 20% higher than Title-24.

The results at the 20% level appear to show that the participants find it more difficult than the non-participants; however, by sheer virtue of being a non-participant, these respondents may be oversimplifying their perceived ease of compliance.



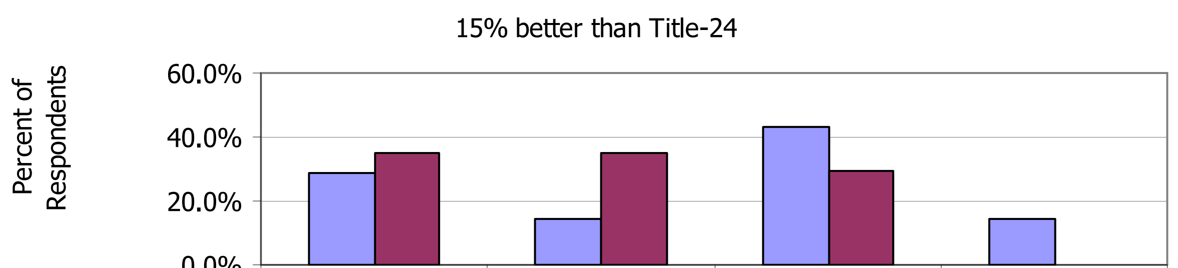
	Very easy	Somewhat easy	Somewhat difficult	Very difficult
Non-Part n = 7	71.4%	0.0%	28.6%	0.0%
Participant n = 18	83.3%	16.7%	0.0%	0.0%

Figure 40a: Building to Title-24 Level Compliance



	Very easy	Somewhat easy	Somewhat difficult	Very difficult
Non-Part n = 7	28.6%	28.6%	28.6%	14.3%
Participant n = 17	52.9%	35.3%	11.8%	0.0%

Figure 40b: Building to 10% better than Title-24 Level Compliance



	Very easy	Somewhat easy	Somewhat difficult	Very difficult
Non-Part n = 7	28.6%	14.3%	42.9%	14.3%
Participant n = 17	35.3%	35.3%	29.4%	0.0%

Figure 40c: Building to 15% better than Title-24 Level Compliance

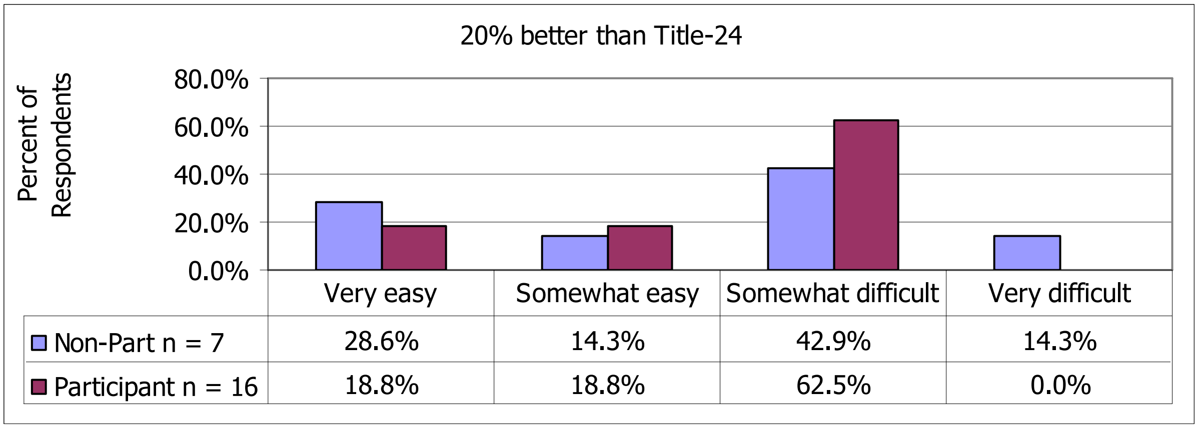


Figure 40d: Building to 20% better than Title-24 Level Compliance

When asked what their reasons were for participating, most MF builder respondents said their decision was related to money. Almost half (seven of the eighteen respondents) said they participated because of incentives, tax credits, or cost savings. Three respondents claimed they were required to participate. One of these respondents said that a city ordinance forced participation, but it is unclear if the other two answers reflected a governmental or corporate requirement.

Other reasons cited by respondents were:

> *"[It] has brand recognition and [we're] already building to that level."*
>
> *"[It] dove tails with LEED."*
>
> *"[For the] efficiency, to do our part, [and to a] small [amount, for the] money."*
>
> *"[We] did it because of affordability and to help energy consumption for tenants."*
>
> *"They [i.e. the customer] called [me] about it."*

The respondents were asked to rate, on a scale of 1 to 5, the importance of five factors in their decision to participate – "financial incentives", "product differentiation", "advertising partnerships", "marketing assistance", and "technical assistance". The respondents rated the financial incentives as important to their participation. The responses for the remaining four factors were very evenly distributed. However, product differentiation and marketing assistance were reported to be slightly more important to participation while advertising partnerships and technical assistance were slightly less.

Participants	Financial Incentives	Product Differentiation	Advertising Partnerships	Marketing Assistance	Technical Assistance
	n = 16	n = 15	n = 15	n = 15	n = 15
Not important = 1	12.5%	33.3%	40.0%	33.3%	33.3%
2	0.0%	0.0%	13.3%	6.7%	13.3%
3	12.5%	13.3%	13.3%	13.3%	13.3%
4	31.3%	33.3%	20.0%	26.7%	33.3%
Very important = 5	43.8%	20.0%	13.3%	20.0%	6.7%
Mean	4.0	2.6	2.1	2.4	2.3
Std. Dev.	1.5	1.5	1.7	1.8	1.7

Table 73: Factors in Decision to Participate

Participating respondents were asked about a variety of barriers to their participation in the program, such as red tape, funding uncertainties, finding, scheduling, or the cost of certifiers, compliance margins, increased project time, or added costs of the measures or administrative time. The results show that none of these were large barriers to the responding multifamily builders.

Barrier	Red tape	Funding	Finding certifier	Scheduling certifier	Cost of certifier
	n = 16	n = 16	n = 16	n = 16	n = 11
Not a barrier = 1	75.0%	75.0%	87.5%	87.5%	81.8%
2	18.8%	12.5%	12.5%	12.5%	18.2%
3	6.3%	6.3%	0.0%	0.0%	0.0%
4	0.0%	6.3%	0.0%	0.0%	0.0%
Barrier = 5	0.0%	0.0%	0.0%	0.0%	0.0%
Mean	1.3	1.4	1.1	1.1	1.2
Std. Dev.	0.6	0.9	0.3	0.3	0.4

Barrier	Compliance margin	Increased time	Added measure cost	Admin costs	Other
	n = 16	n = 16	n = 10	n = 11	n = 4
Not a barrier = 1	75.0%	87.5%	60.0%	63.6%	50.0%
2	12.5%	6.3%	20.0%	27.3%	0.0%
3	12.5%	0.0%	10.0%	0.0%	0.0%
4	0.0%	6.3%	10.0%	9.1%	0.0%
Barrier = 5	0.0%	0.0%	0.0%	0.0%	50.0%
Mean	1.4	1.3	1.7	1.5	3.0
Std. Dev.	0.7	0.8	1.1	0.9	2.3

Table 74: Barriers to Participation

Funding availability was not a major concern for multifamily builders. Only two of thirteen builders ranked their concern at a level of 4 or higher. Five respondents ranked their concern at a level 1, "Not at all concerned". The use of the financial incentive as an offset to additional building costs was very important, however, to most of the participants. Eleven of the thirteen responses stated this was either "Important" or "Very Important".

The responses (below) show there was very little problem with project acceptance from any entity. This may either reflect that those who participate are motivated and well trained to submit successful designs, a condition that the compliance standard may be too easy to meet, or possibly both.

	Utility	Plan Check	Rater
Yes	11	11	8
No	3	2	2
Total	14	13	10

Table 75: Immediate Project Acceptance by the Utility, Plan Check Firm or Rater

The next table shows the responses by participating multifamily developers on their levels of satisfaction. As shown, most were satisfied with all major facets of the program. For the overall scoring, only one respondent out of fifteen gave a score of "3" or lower. The same general ratio was true for the responses to the ease of participation. The rating responses to "Incentive" and "Compliance margin" had lower scores, but still scored averages higher than "3".

Satisfaction	Overall program	Incentive	Compliance margin	Ease of participation
	n = 15	n = 13	n = 15	n = 14
Dissatisfied = 1	0.0%	15.4%	0.0%	0.0%
2	0.0%	0.0%	6.7%	0.0%
3	6.7%	23.1%	13.3%	7.1%
4	33.3%	30.8%	26.7%	28.6%
Satisfied = 5	60.0%	30.8%	53.3%	64.3%
Mean	4.5	3.6	4.3	4.6
Std. Dev.	0.6	1.4	1.0	0.6

Table 76: Overall Satisfaction Rating with Aspects of the Program

Ten of the fifteen responses to the question "How large of an impact has the program had on the marketability of the MF buildings or units" said the program had "No Impact" on their units. The remaining five respondents all said there was a "Positive Impact". No one reported a negative impact on their project. This result appears to echo the comments from the interviews that a majority of MF developers who participate are those who build affordable rate units, or are those who are already informed and motivated about energy efficiency, and perhaps do not perceive any external marketing value derived from their participation.

Respondents were next asked how important energy efficient design was either to themselves or the building owner; or (for builders and developers) the importance to their customer. Energy efficient design was reported to be important to both cases. It was reported to be more important when the respondent was the building owner (12 out of 15) and less important (9 out of 15) when the respondent was building for a customer.

Participants were asked to discuss the program's strengths and weaknesses. This question allowed for open-ended responses, and a number of positive comments on program strengths revolve around the savings and value proposition. These comments came directly from the multifamily builders.

> *"Promoting energy efficiency, helping the state and homeowners save energy."*
>
> *"Recognition, people know the ENERGY STAR® label."*
>
> *"Encouraging efficiency."*
>
> *"Good PR for builders. Good advertising. It's worth it."*
>
> *"Building a better product for consumers."*
>
> *"Having all documentation in one place, steps are very clear, access to info."*
>
> *"Cost savings and affordability."*

The comments on the program's weaknesses tended to dwell on program process snags:

> *"Coordination. The check took a little time. And, it added 1 day to project."*
>
> *"In the past, homes were selling so well, it wasn't an important aspect."*
>
> *"The extra cost."*
>
> *"[The program is] constantly changing, it's a "moving target". Re-education, time and effort."*
>
> *"[The program doesn't] allow unique/creative approaches/adaptations."*
>
> *"Another step in development process (they have to bid every time)."*
>
> *"Difficult to understand incentives and time to get money back."*

Non-participants were asked about the importance of financial incentives, product differentiation, advertising partnerships, marketing assistance, and technical assistance in their decision not to participate in the program. Respondents reported that incentives and product differentiation were factors in their decision to not participate. Advertising, marketing, and technical assistance were reported to not be great factors in deciding not to participate.

Non-participants	Financial Incentives	Product Differentiation	Advertising Partnerships	Marketing Assistance	Technical Assistance	Other
	n = 4	n = 4	n = 2	n = 2	n = 2	n = 3
Not a factor = 1	50.0%	50.0%	50.0%	50.0%	50.0%	33.3%
2	0.0%	0.0%	0.0%	0.0%	50.0%	0.0%
3	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%
4	25.0%	25.0%	0.0%	0.0%	0.0%	0.0%
Factor = 5	25.0%	25.0%	0.0%	0.0%	0.0%	66.7%
Mean	2.8	2.8	2.0	2.0	1.5	3.7
Std. Dev.	2.1	2.1	1.4	1.4	0.7	2.3

Table 77: How Valuable was the Marketing Assistance and Promotional Materials

Four of the eight respondents provided answers to the question of the importance of barriers to their non-participation. Of these, each respondent only ranked those factors they were familiar with, leading to less than four responses for each factor. The number of responses are too few to characterize the program but the respondents did show that paperwork, funding uncertainties, the cost of raters, increased project time, and added cost were all barriers to participation.

Barrier	Paperwork	Prog. Fund Uncertainty	Finding Certifier	Scheduling Certifier	Cost of Certifier
	n = 3	n = 3	n = 3	n = 3	n = 2
Not a barrier = 1	33.3%	66.7%	66.7%	66.7%	50.0%
2	0.0%	0.0%	0.0%	0.0%	0.0%
3	0.0%	0.0%	0.0%	0.0%	0.0%
4	0.0%	0.0%	33.3%	33.3%	50.0%
Barrier = 5	66.7%	33.3%	0.0%	0.0%	0.0%
Mean	3.7	2.3	2.0	2.0	2.5
Std. Dev.	2.3	2.3	1.7	1.7	2.1

Barrier	Margin of Compliance	Increased Project Time	Added Cost of Measures	Added Admin. Cost	Other
	n = 3	n = 2	n = 1	n = 1	n = 3
Not a barrier = 1	66.7%	50.0%	0.0%	0.0%	0.0%
2	0.0%	0.0%	0.0%	0.0%	0.0%
3	0.0%	0.0%	0.0%	0.0%	0.0%
4	33.3%	50.0%	100.0%	100.0%	0.0%
Barrier = 5	0.0%	0.0%	0.0%	0.0%	100.0%
Mean	2.0	2.5	4.0	4.0	5.0
Std. Dev.	1.7	2.1	0.0	0.0	0.0

Table 78: Importance of Barriers to Program Participation

Just like single family builders, multifamily builders were asked if they had heard of monies being used up. Of the eight respondents, five had not heard about project monies being used up. Two had heard that monies were being used up and one respondent did not know. This reinforces the findings from the single family surveys that this preconception is not a great issue.

Resident Surveys

Surveys were administered to 44 ENERGY STAR® residents at the time of the on-site verification. One hundred and one non-participating residents were surveyed by phone. Respondent groups were asked the following questions:

- Are you aware this is an ENERGY STAR® home
- Did you know it was an ENERGY STAR® home when you purchased or rented it
- How did you first learn of the program
- If you put a one-time value on the EEMs in your home the amount would be
- Did you pay more for this house because of its energy features
- The respondents were also asked to rate the influence of several factors on their decision to purchase or rent an an ENERGY STAR® home

Twenty nine respondents currently knew their home was an ENERGY STAR® home, and fourteen did not. However, when asked if they knew their home was an ENERGY STAR® home before they purchased or rented it, only 24 said they knew their home was an ENERGY STAR® home while 19 said they did not know. This implies that, while builders may be using the program to market their homes, they may not make it a primary selling feature since almost half of residents didn't know the home was ENERGY STAR® when making their decision.

Respondents were next asked how they learned about the program. Thirty six respondents gave at least one source for learning about the program, and eight of those thirty six gave multiple responses. The most common source of learning about the program was from the builder or sales office. The second most common source was from contact with RLW Analytics. That means that 11 of the 44 homes we inspected during the evaluation learned their home was ENERGY STAR® by RLW telling them it was and asking to inspect it.

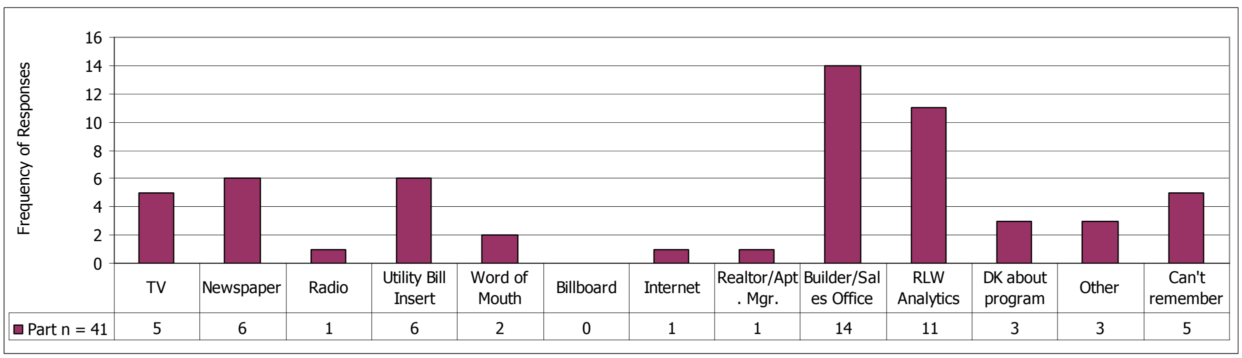


Figure 41: How did ESH Homeowners Learn about the ESH Program

Respondents were next asked to consider a list of energy efficiency features that were incorporated into their home, and to assign a dollar amount to those features. Almost all of the respondents associated a positive value to the energy efficiency features. However, more participants than non-participants felt they were experiencing a "negative value". Generally speaking, however, participants did value the EE features higher than non-participants.

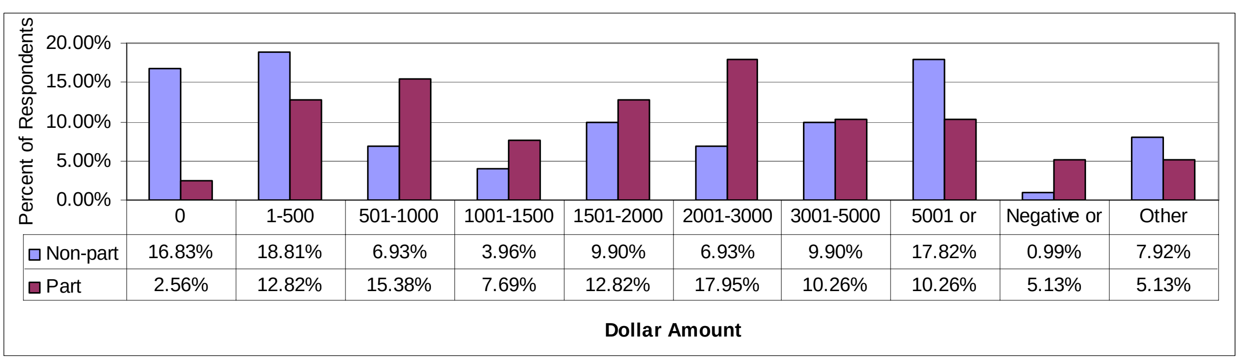


Figure 42: ESH homeowners: One-time Value on the EEMs in their Homes

Survey Response – Summary

Program participation appears to come in a significant level from those who have been aware of ESH or its predecessor for one or more years before this program cycle. Since program participation and incentive subscription has been met, program marketing has taken a secondary role, which may explain the lack of familiarity of the program by current non-participants. This is reinforced by the participating homeowner survey results that showed about half of those respondents said they didn't even know their home was ENERGY STAR® rated at the time of purchase.

Incentives and builder differentiation remain key motivating factors towards participation by single family builders. A majority found ENERGY STAR® homes a positive contribution to their developments' public marketability, and found reasonable value in the marketing assistance and materials. Funding uncertainty and added costs of measures are the largest difficulties perceived. Non-participants familiar with the program perceive that participation is largely an economic decision. Most builder participants are satisfied overall with the program, with the program compliance margin, and the ease of participation.

Multifamily builders from the survey are more driven by economics than other factors. None perceived any part of the program process, nor the compliance standard, as significant barriers.

Recommendations

Based on the outcomes of the interviews and survey results, RLW determined these key areas for further program recommendations.

Program Data

Registry Data

As reported in the previous section, the utilities adopted a number of recommendations for the registry data. This data was used as EM&V tracking for this evaluation. RLW recommends the following minor modifications for the registries themselves:

1. *There should be similar data fields across all the registries*. Currently the registries collect different data fields and in different formats. It would be less confusing to raters that participate in both CHEERS and CalCERTS if data were the same for all registries. Similar data in all registries will also greatly simplify future evaluations.
2. *Restrictors on fields should be inserted*. Restrictive ranges should be incorporated whenever possible into all registries in order to maintain data integrity. In any very large databases such as those used to track this program there are inherent data quality issues. However, even a cursory look through the registry data show errors that aren't even within acceptable bounds. Examples are; differing naming conventions for systems; efficiencies that are either missing or do not meet Federal mandatory minimum requirements; and differing orders of magnitude for input ratings.
3. *Descriptions of failures should be documented*. Currently the registries only allow for "pass" or "fail" as descriptions of a homes inspection. This prevents

any feedback loop to allow for any closer examination of what happened with failing homes, and to any subsequent program or process modifications. By requiring a more detailed description of failures, the opportunity will be created to explore failures and reduce the lost opportunities for savings.

Tracking Data

Currently, builder participation tracking is done on a utility level. Each utility tracks their participants in their own Microsoft Access Database. Based on the recommendation of the 2002-2003 EM&V report all utilities began using a "project ID" as the primary identifier of a project in their tracking database. In order to streamline any future evaluations of builder participation, RLW suggests that a builder participation database track, at a minimum, the following items:

1. Builder parent companies;
2. Project names;
3. Project type; and
4. Program year of project participation.

Additional useful information would be:

1. Full contact information for parents and subsidiaries;
2. Full contact information for project on-sites;
3. Project volume;
4. Project location; and
5. Project climate zone.

Of course this information would be most useful if each utility could gather identical fields of information and agree upon a program wide nomenclature for each field.

Additionally, each evaluation of the ESH program to date has utilized the third party registry databases for program tracking. While this has been acceptable in the past it will become problematic for future evaluations. RLW recommends switching from the use of the registries tracking to utility tracking databases. Each registry collects data in slightly different formats (i.e. field names, data ranges, and data formatting). Subsequent program years will see the addition of more third party registries as the industry continues to develop. These slightly disparate databases will begin to complicate evaluations. For that reason RLW strongly suggests that the next evaluation reviews each utility database and assists the utilities in developing one agreed upon tracking database format.

Quality Assurance and Quality Control

Key Issues

Several key issues had arisen from the interviews that pointed to prospective program improvements in quality assurance and quality control. There appears to be three different parts of the program process where modifications could occur to increase the accuracy and quality of the program process: 1) submissions by Title-24 consultants, 2) the inspection and reporting process with HERS raters, and 3) low QA sampling rates.

1. Title-24 consultants. There are several issues with the accuracy and quality of the model outputs produced by the Title-24 consultants. The larger story appears to be one of inconsistency. This issue shows up in the interview results about modeling approaches, submissions to plan check staff (whether in-house or outside agencies), and amounts of data omissions or errors. One solution is to establish a "pool" of consultants that attend utility sponsored trainings to maintain the current knowledge and develop similar modeling techniques.

2. *HERS raters*. A number of issues arose about the quality of HERS rater performance and outputs. There were concerns expressed about the program measures that only need a "pass" or "fail" with no explanations or specific measurements. RLW found through the impact side of this evaluation that ENERGY STAR® homes, on average, are slightly more efficient than originally planned. RLW believes that if raters are required to gather more details from the sites, it would inherently improve the quality of their work and the level of information on the database. Also, requiring a more detailed reporting format will ensure that a rater actually performs the rating and will help identify common reasons for post-construction exclusions from the program. This will help create better opportunities for utility staff to review and remedy problems by using the HERS raters' on-site findings to identify common problems that cause a project to be dropped from the program.

3. Low sampling rates. Because of the low sampling percentage for QA purposes – 1% - the program's quality assurance policies may not be equitable. This appears to set up conditions where any rating firm may create an unfair competitive advantage by acting less stringent on results, and thus gaining favor from builders. This low sampling percentage also allows for the greater possibility of rater quality inconsistencies to remain undetected.

<u>Recommendations</u>

In a public utility program, it is challenging to maintain consistent quality among many different market actors. In response, programs maintain quality delivery in these one or more ways below.

1. <u>Formalized and detailed program process guidelines, procedures, rules, etc</u>. The more traditional quality control approach utilizes a comprehensive code of procedures, behaviors, and rules that all parties are expected to follow. Certification and pre-qualified training is also established before participation is allowed. Standardization is established for all facets of program delivery, documentation, and performance.
2. <u>Ongoing QC checks and continual feedback</u>. This entails an established spot checking, documentation, and real time feedback to all parties within the process stream. RLW has observed, for example, how the New Hampshire utilities funded a third party QC contractor whose sole job was spot check and follow up on residential weatherization projects completed under their low income programs.
3. <u>Post program evaluation</u>. This is the process evaluation (as provided here) where the historical record is documented and assessed through the review of program databases, participant surveys, and market actor interviews.

For both Title 24 analysts and raters, there should be a focused emphasis on the quality instead of quantity of their work. Capturing the data correctly would also incrementally improve opportunities for evaluators to assess it as saturation data.

In an effort to increase the quality of the work from HERS raters, some Registries already have begun to set restrictive ranges on appropriate fields to make sure poor data does not get entered. Continuous training should be offered. Raters already go through a five day training to get certified but an ongoing "refresher" day of training would provide some benefit.

RLW's recommendations for quality control enhancements would be the following:

A. *Establish additional QC elements in the program procedures*. This would follow each of the items above. In particular, we recommend:

   a. Standardize the procedures for both Title 24 and HERS raters. We suggest a more formalized and standard set of procedures for both types of analysts. These procedures may largely be followed by several high quality firms who already perform this function, so the next logical step is to identify the best of those procedures and codify them for program-wide adoption.

   b. Establish training protocols for both Title 24 and HERS raters. Include a requirement for establishing and maintaining a set of minimum professional requirements. These requirements would require formal training and certification, as well as minimum requirements for updated training.

B. *Establish an independent third party quality control contractor.* We recommend that an independent quality assurance/quality control contractor provide uniform QA for all raters. This service would need to be equitably enforced across all registries, so it may serve best to have one for the northern and southern parts of the state. In this kind of arrangement, the QA/QC contractor would report directly to the utilities, and perform a sampling (possibly 10%) of all the work performed by HERS raters. The primary mission of this third party contractor would be education, not policing; that is, as deficiencies are discovered by the QA/QC contractor, he/she would then promptly follow up with that HERS rater or firm and provide specific education and guidance on correcting those deficiencies. Those raters or firms that continually perform short of minimum requirements would then be notified that they are in danger of having a penalty levied; perhaps having their registry dues raised, or even losing their opportunity to perform HERS rater work. This QA procedure could be coupled with any HERS inspections required by the CEC for Title-24 compliance.

C. *Examine feasibility of "certifying" Title-24 consultants for the ENERGY STAR® Homes program*. As identified earlier in the interview results, we recommend that the utilities could develop and provide a list of approved consultants for the builders to choose from. This would act to standardize how the buildings are modeled.

D. *Create and utilize a common tracking database across all utilities*. As identified earlier in the evaluation.

Multifamily Marketplace Participation

Although the single family home participation goals were met, the multifamily marketplace remained a challenge in this program funding cycle. The interview results, echoed in the participating survey results, revealed that the majority of multifamily developers who participate are those who build affordable rate units, or, are those who are already informed and motivated about energy efficiency.

We recommend that the next process evaluation for this program should have a focused assessment of the multifamily development marketplace. This research would specifically look closer at each of the market actors, and provide a market characterization of this industry. This characterization could also look at the baseline efficiencies of multifamily/multiunit construction, and identify what adjustments should be made for program eligibility, technical support, and incentive funding. A particular recommended goal of this characterization would be to examine the sub sector marketplace for high rise buildings. This would include an assessment of the baseline energy efficiency attributes of high rise construction and recommended high efficiency measures, as well as thresholds for program participation.

As shown in the survey results, non-participating multifamily builders were largely unfamiliar with the ESH program. We recommend that, if the single family marketplaces continue to gain participation, marketing dollars and resources are shifted to primarily address the multifamily marketplace. Personal contact by utility staff appears to still be the primary channel for gaining participation beyond initial awareness.

Secondary Recommendations

These secondary recommendations arose from the analysis of the process results.

A. *Consider increased funding for expanding the pool of qualified raters*. Several program managers said that some builders had expressed difficulty in securing a rater, both geographically and in an acceptable timeframe. This suggests that a focus on recruitment and additional funding could be useful for key areas of the state where there is no or constrained coverage. We recognize that this additional funding may not appear to be cost-effective; however, consideration should be made on the negative impact of lost opportunities to support justification of such funding.

B. *The utilities should keep close tabs on builder participation and homeowner sales, and be cognizant of the need to revise marketing efforts and funding.* The use of utility staff to market the program allows them to leverage their existing relationships within the builder community, which brings cost efficiency to the program. Some external mass marketing may be necessary to infuse new interest by builders who have yet to participate, as well as with new home buyers.

C. *The next process evaluation should examine the prevalence of enhanced municipal residential building codes*. One unexpected outcome in the surveys was the responses from single family and multifamily builders that they were required to build at levels higher than Title-24. This implies that some California communities are taking an active role in codifying advanced energy efficiency construction measures. Understanding this prevelance will give CEC and the utilities a closer understanding of how much impact these codes make on program participation, and if there may be growing issues of free ridership.

Conclusions and Recommendations

CPUC Reporting

Net Savings and Total Resource Cost

The final net impact estimates are presented in the following table. Total program net ex post electricity savings were 23,741,818 kWh and 25,504 kW and gas savings were 1,255,434 therms. These savings include all program participants: single family, multifamily low-rise and high-rise projects. Realization rates were calculated when ex ante estimates were available.[62] Ex ante values were calculated for "approved units" based on each utility's original per-dwelling-unit savings estimates. The IOU electricity savings realization rates for single family, multifamily, and high-rise[63] projects are:

Utility	kWh			Therms			kW		
	Net Ex Ante	Net Ex Post	Realization Rate	Net Ex Ante	Net Ex Post	Realization Rate	Net Ex Ante	Net Ex Post	Realization Rate
PGE	3,786,119	7,241,155	1.91	1,457,778	634,533	0.44	4,170	7,686	1.84
SCE	14,038,346	12,694,362	0.90	NA	371,772	NA	17,980	13,730	0.76
SoCalGas	2,874,807	2,050,545	0.71	234,344	97,608	0.42	4,194	2,202	0.53
SDGE	5,139,179	1,755,755	0.34	242,489	151,521	0.62	8,141	1,886	0.23
Total	25,838,451	23,741,818	0.92	1,934,611	1,255,434	0.65	34,485	25,504	0.74

Table 79: Combined (SF, MF, and high-rise) Electricity and Gas Savings Realization Rates

The kWh realization rate is less than 1.0 for all IOUs except for PG&E. This is a result of the other three IOUs expecting 2.5 to 4.5 times more ex-ante savings *per unit* than PG&E. Table 80 presents the IOU projected (i.e., the TRC at the beginning of the program) and recorded (i.e., the TRC at the end of the program) TRC ratios from the final 2004-05 EEGA workbooks.

The TRC benefit cost ratio in the Program Plans are based on the achievement of 100% of ex ante savings estimates. As explained previously, the evaluators were unable to compute an accurate TRC for the program given the life cycle of the 2004-05 CESNHP. The evaluation protocols for this segment look at projects completed in the evaluation year. Since some of the PY 2004-05 projects will not be completed until 2007 or 2008, RLW does not know what the total number of completed projects or the total energy savings will be. We suggest making this a requirement of the next program year evaluation, which should be able to look retrospectively at the evaluation results from previous years in order to calculate cost-effectiveness.

However, based upon the realization rate for the projects completed in 2004-05, we can obtain a general picture of where the program is likely to end up. Using PG&E as an example, the ex ante recorded TRC was forecasted to be 0.85, lower than the other TRC

[62] SCE did not claim any ex ante gas savings, although the participants that they funded through their program did generate gas savings. Similarly, SoCalGas's participant customers achieved electricity savings even though these savings do not impact SoCalGas directly. SoCalGas did claim their ex ante electricity savings.

[63] High Rise ex ante values were estimated by applying low-rise multifamily per unit savings estimates.

ratios estimated by the other IOUs. We have estimated the overall kWh realization rate for PG&E to be 1.9, which alone would push PG&E's program into the cost-effective range. However, PG&E's therm realization rate is less than 50%, which would bring down the TRC to the non cost-effective range.

For SCE, the TRC is recorded as 1.0. With a kWh realization rate of 90%, or achieved savings 10% less than SCE expected, the TRC would likely be slightly less than 1. For SoCalGas, the TRC is recorded as 1.87. With a kWh realization rate of 71% and a therm realization rate of 42%, the TRC would likely be less than 1. For SDGE, the TRC is recorded as 1.1. With a kWh kWh realization rate of 34% and a therm realization rate of 62%, the TRC would be less than 1 and the program is not going to be cost-effective.

Total Resource Cost Test from EEGA		
Utility	**Projected**	**Recorded**
PGE	0.70	0.85
SCE	0.88	1.03
SoCalGas	1.16	1.87
SDGE	0.67	1.11

Table 80: IOU Total Resource Cost Test Results (Final EEGA Workbook)

CPUC Lifecycle Tables

The following five tables present the net impact estimates for each IOU and overall, with the CPUC-Energy Division program identification number and the official program name for each year over which impacts are expected, over the effective useful life of the measures installed by the program.

In order to correctly complete the lifetime savings spreadsheet required by the CPUC, the first year savings must be forecast into the future based on an agreed upon effective useful life (EUL). The CPUC Policy Manual (August 2003) provides some EUL values to use for the 2004-05 program measures and footnotes the genesis of these values.[64] See also p. 26 of September 25, 2000 CALMAC report prepared pursuant to Ordering Paragraph 9 of D.00-07-017]. The Policy Manual does not provide the EUL for a residential whole house measure, although it is present in Table 3 of Appendix C2 of the 9/25/00 CALMAC report. The whole house energy use value in Appendix C2 is 19 years.

The residential new construction programs support integrated designs that reduce the whole house energy use. There are multiple energy efficient measures installed that synergistically interact to create the energy savings claimed by the program. We believe that to attempt to disaggregate the EUL and savings values based on the specific measures installed by each home may not be possible, and would not be appropriate.

This evaluation uses the 19 year EUL value that was determined previously with approval from the CPUC[65]. As such, the first year savings are forecast 18 years into the future equal to the total number of homes with first year savings.

[64] Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand Side Management (DSM) Programs (MA&E Protocols).

[65] The CPUC agreed to the use of the whole building EUL estimate of 19 years on December 1, 2006.

By Utility

Table 81: SCE - 1169-04(proc) and 1239-04 (SW)

SCE Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	1169-04(procurement) and 1239-04 (SW)								
Program Name:	CA ES New Homes								
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	17,548	12,694	22.47	13.79	NA	371,772
	2	2005	17,548	12,694	22.47	13.79	NA	371,772
	3	2006	17,548	12,694	22.47	13.79	NA	371,772
	4	2007	17,548	12,694	22.47	13.79	NA	371,772
	5	2008	17,548	12,694	22.47	13.79	NA	371,772
	6	2009	17,548	12,694	22.47	13.79	NA	371,772
	7	2010	17,548	12,694	22.47	13.79	NA	371,772
	8	2011	17,548	12,694	22.47	13.79	NA	371,772
	9	2012	17,548	12,694	22.47	13.79	NA	371,772
	10	2013	17,548	12,694	22.47	13.79	NA	371,772
	11	2014	17,548	12,694	22.47	13.79	NA	371,772
	12	2015	17,548	12,694	22.47	13.79	NA	371,772
	13	2016	17,548	12,694	22.47	13.79	NA	371,772
	14	2017	17,548	12,694	22.47	13.79	NA	371,772
	15	2018	17,548	12,694	22.47	13.79	NA	371,772
	16	2019	17,548	12,694	22.47	13.79	NA	371,772
	17	2020	17,548	12,694	22.47	13.79	NA	371,772
	18	2021	17,548	12,694	22.47	13.79	NA	371,772
	19	2022	17,548	12,694	22.47	13.79	NA	371,772
	20	2023						
	TOTAL	**2004-2023**	333,411	241,193			0	7,063,669

Table 82: PG&E Program ID-1128-04

PG&E Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	1128-04								
Program Name:	CA ES New Homes								
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	4,733	7,241	5.21	7.69	1,822,222	634,533
	2	2005	4,733	7,241	5.21	7.69	1,822,222	634,533
	3	2006	4,733	7,241	5.21	7.69	1,822,222	634,533
	4	2007	4,733	7,241	5.21	7.69	1,822,222	634,533
	5	2008	4,733	7,241	5.21	7.69	1,822,222	634,533
	6	2009	4,733	7,241	5.21	7.69	1,822,222	634,533
	7	2010	4,733	7,241	5.21	7.69	1,822,222	634,533
	8	2011	4,733	7,241	5.21	7.69	1,822,222	634,533
	9	2012	4,733	7,241	5.21	7.69	1,822,222	634,533
	10	2013	4,733	7,241	5.21	7.69	1,822,222	634,533
	11	2014	4,733	7,241	5.21	7.69	1,822,222	634,533
	12	2015	4,733	7,241	5.21	7.69	1,822,222	634,533
	13	2016	4,733	7,241	5.21	7.69	1,822,222	634,533
	14	2017	4,733	7,241	5.21	7.69	1,822,222	634,533
	15	2018	4,733	7,241	5.21	7.69	1,822,222	634,533
	16	2019	4,733	7,241	5.21	7.69	1,822,222	634,533
	17	2020	4,733	7,241	5.21	7.69	1,822,222	634,533
	18	2021	4,733	7,241	5.21	7.69	1,822,222	634,533
	19	2022	4,733	7,241	5.21	7.69	1,822,222	634,533
	20	2023						
	TOTAL	**2004-2023**	89,920	137,582			34,622,225	12,056,126

Table 83: SDG&E Program ID-1330-04

SDG&E Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	1330-04								
Program Name:	CA ES New Homes								
	Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
	1	2004	6,424	1,756	10.18	1.89	303,112	151,521
	2	2005	6,424	1,756	10.18	1.89	303,112	151,521
	3	2006	6,424	1,756	10.18	1.89	303,112	151,521
	4	2007	6,424	1,756	10.18	1.89	303,112	151,521
	5	2008	6,424	1,756	10.18	1.89	303,112	151,521
	6	2009	6,424	1,756	10.18	1.89	303,112	151,521
	7	2010	6,424	1,756	10.18	1.89	303,112	151,521
	8	2011	6,424	1,756	10.18	1.89	303,112	151,521
	9	2012	6,424	1,756	10.18	1.89	303,112	151,521
	10	2013	6,424	1,756	10.18	1.89	303,112	151,521
	11	2014	6,424	1,756	10.18	1.89	303,112	151,521
	12	2015	6,424	1,756	10.18	1.89	303,112	151,521
	13	2016	6,424	1,756	10.18	1.89	303,112	151,521
	14	2017	6,424	1,756	10.18	1.89	303,112	151,521
	15	2018	6,424	1,756	10.18	1.89	303,112	151,521
	16	2019	6,424	1,756	10.18	1.89	303,112	151,521
	17	2020	6,424	1,756	10.18	1.89	303,112	151,521
	18	2021	6,424	1,756	10.18	1.89	303,112	151,521
	19	2022	6,424	1,756	10.18	1.89	303,112	151,521
	20	2023						
	TOTAL	2004-2023	122,056	33,359			5,759,120	2,878,898

Table 84: SoCalGas Program ID-1244-04

SCG Program Energy Impact Reporting for 2004-2005 Programs

Program ID*:	1244-04							
Program Name:	CA ES New Homes							
	Year	**Calendar Year**	**Ex-ante Gross Program-Projected Program MWh Savings (1)**	**Ex-Post Net Evaluation Confirmed Program MWh Savings (2)**	**Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)**	**Ex-Post Evaluation Projected Peak MW Savings (2**)**	**Ex-Ante Gross Program-Projected Program Therm Savings (1)**	**Ex-Post Net Evaluation Confirmed Program Therm Savings (2)**
	1	2004	3,594	2,051	5.24	2.20	292,930	97,608
	2	2005	3,594	2,051	5.24	2.20	292,930	97,608
	3	2006	3,594	2,051	5.24	2.20	292,930	97,608
	4	2007	3,594	2,051	5.24	2.20	292,930	97,608
	5	2008	3,594	2,051	5.24	2.20	292,930	97,608
	6	2009	3,594	2,051	5.24	2.20	292,930	97,608
	7	2010	3,594	2,051	5.24	2.20	292,930	97,608
	8	2011	3,594	2,051	5.24	2.20	292,930	97,608
	9	2012	3,594	2,051	5.24	2.20	292,930	97,608
	10	2013	3,594	2,051	5.24	2.20	292,930	97,608
	11	2014	3,594	2,051	5.24	2.20	292,930	97,608
	12	2015	3,594	2,051	5.24	2.20	292,930	97,608
	13	2016	3,594	2,051	5.24	2.20	292,930	97,608
	14	2017	3,594	2,051	5.24	2.20	292,930	97,608
	15	2018	3,594	2,051	5.24	2.20	292,930	97,608
	16	2019	3,594	2,051	5.24	2.20	292,930	97,608
	17	2020	3,594	2,051	5.24	2.20	292,930	97,608
	18	2021	3,594	2,051	5.24	2.20	292,930	97,608
	19	2022	3,594	2,051	5.24	2.20	292,930	97,608
	20	2023						
	TOTAL	**2004-2023**	68,277	38,960			5,565,677	1,854,549

Statewide

Table 85: Sum (SCE+PG&E+SDG&E+SoCalGas)

Sum Of Energy Impacts for This 2004-2005 Program

2004-2005 form

Program IDs*: 1169-04, 1239-04, 1128-04, 1330-04, 1244-04

Program Name: CA ES New Homes

Year	Calendar Year	Ex-ante Gross Program-Projected Program MWh Savings (1)	Ex-Post Net Evaluation Confirmed Program MWh Savings (2)	Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)	Ex-Post Evaluation Projected Peak MW Savings (2**)	Ex-Ante Gross Program-Projected Program Therm Savings (1)	Ex-Post Net Evaluation Confirmed Program Therm Savings (2)
1	2004	32,298	23,742	43.11	25.50	2,418,264	1,255,434
2	2005	32,298	23,742	43.11	25.50	2,418,264	1,255,434
3	2006	32,298	23,742	43.11	25.50	2,418,264	1,255,434
4	2007	32,298	23,742	43.11	25.50	2,418,264	1,255,434
5	2008	32,298	23,742	43.11	25.50	2,418,264	1,255,434
6	2009	32,298	23,742	43.11	25.50	2,418,264	1,255,434
7	2010	32,298	23,742	43.11	25.50	2,418,264	1,255,434
8	2011	32,298	23,742	43.11	25.50	2,418,264	1,255,434
9	2012	32,298	23,742	43.11	25.50	2,418,264	1,255,434
10	2013	32,298	23,742	43.11	25.50	2,418,264	1,255,434
11	2014	32,298	23,742	43.11	25.50	2,418,264	1,255,434
12	2015	32,298	23,742	43.11	25.50	2,418,264	1,255,434
13	2016	32,298	23,742	43.11	25.50	2,418,264	1,255,434
14	2017	32,298	23,742	43.11	25.50	2,418,264	1,255,434
15	2018	32,298	23,742	43.11	25.50	2,418,264	1,255,434
16	2019	32,298	23,742	43.11	25.50	2,418,264	1,255,434
17	2020	32,298	23,742	43.11	25.50	2,418,264	1,255,434
18	2021	32,298	23,742	43.11	25.50	2,418,264	1,255,434
19	2022	32,298	23,742	43.11	25.50	2,418,264	1,255,434
20	2023						
TOTAL	**2004-2023**	613,663	451,095			45,947,022	23,853,243

Program Conclusions and Recommendations

What are builders actually doing to achieve ES compliance?

There is no common or distinct difference in building characteristics between ES homes and non-participant homes. The only consistent finding was that over 90% of ES homes take modeled energy credits for two HERS measures: tight ducts (<6%) and reduced air infiltration. A third measure often used is TXV valves (or proper refrigerant charge and airflow) for air conditioning, also requiring HERS inspection and/or testing.

However, these measures were not tested for in the baseline study. We do not know how many non-participant homes meet these standards, and accordingly cannot adjust the net savings to reflect it. It is entirely possible that some non-participant homes would have qualified for these energy credits, but did not take credit for them in their compliance model on account of testing costs. If that were the case, then *the estimates of baseline usage that come from the compliance software will be overestimated.* For instance, we do not know how many non-participant homes *would have* qualified for the infiltration credit in their Title 24 model but were not tested for it. If it turns out that standard practice results in 50% of homes built tightly enough to qualify,[66] and if the impact of taking that credit is a 2-3% increase in the compliance margin,[67] then the overall estimate of non-participants' compliance margin would understate their savings margin by 1 - 1.5 percentage points. Compared to the 15% compliance margin necessary for participant status, this would result in a 6% - 10% decrease in program energy savings.

Other findings that help account for increased modeled energy savings of ENERGY STAR® homes over non-participant homes include: a slight reduction in total window area, slightly higher equipment efficiencies, and more frequent use of radiant barrier, overhangs, and hot water re-circulating timers.

Additionally, Title-24 compliance authors often specify equipment in order to make the building minimally compliant with code in order to provide as much flexibility in equipment efficiency and insulation levels to the builder as possible. Identifying the efficiency improvements and standards achieved that are realized but not planned for in the documentation could significantly impact the non-participant baseline and therefore the amount of free-ridership in the program.

Orientation

The orientation of a home can significantly affect its space cooling and heating energy requirements, chiefly due to solar gain through windows. As part of the gross savings calculation, we computed the ratio of the average savings across all orientations to the savings from the orientation with the worst savings for each end use. The orientation results show that inland energy savings can be increased by 25% for space cooling, and 17% for space heating, simply by orienting a home from its worst energy orientation to its average energy orientation. For coastal cooling and heating, the respective

[66] A recent baseline study conducted by RLW in Texas indicates that many new homes actually would pass the infiltration testing necessary for the credit.

[67] A recent ad hoc sensitivity analysis indicated that there was a 2-3% increase in compliance margin for taking the blower door credit in the 2005 compliance software.

percentage increase in savings was 46% and 24%. We observed similar magnitudes in savings increases in MF. These percentage increases in savings are simply the change from worst to average. If the percentage were computed as the change from worst to best savings, then the percentage increase in savings would be even higher.

The program currently requires the compliance margin from each orientation to meet the program participation threshold, which is a good requirement. Even greater energy savings could be achieved by orienting homes to their best orientation. This is not a "new" discovery, as the advantages of passive solar design and home orientation have been known for centuries, but the orientation adjustment b-ratios, based on analysis of thousands of homes, provide a quantitative estimate of the energy "cost" to builders of ignoring orientation. Home orientation is a significant contributor to savings and should be given higher significance in program tracking to help improve savings estimates for each dwelling unit.

Compliance Software is an Ineffective Evaluation Tool by Itself

The Title-24 compliance software, whether intentionally or not, act as policy tools. Decisions are made to install or not install an efficiency measure based in large part on the credit given for that measure in the models. This makes the software valuable tools for influencing the decisions builder make as regard energy efficiency. However, as our metering analysis has confirmed, the models do not, by themselves, yield accurate estimates of energy usage and by extension energy savings. Therefore, despite the fact that their outputs are readily available for all members of the participant population, compliance software should not be used to estimate program savings. Normal sampling methodologies, such as the metering adjustment applied in this report, will be necessary to yield reliable estimates of program savings.

Ex-Ante Savings

SCE does not claim therm savings for the RNC program in their EEGA workbook filing. However, the SCE participant homes that were completed and inspected in 2004-05 realized 380,939 net therm savings relative to non-participants. PG&E's single family program has an extremely high realization rate. As mentioned previously, this is a result of the other three IOUs expecting significantly more ex-ante savings per unit than PG&E.

The utilities should work toward a common approach to estimating energy savings. The four utilities used varying approaches to estimate filed savings. Utilizing a common approach would benefit Program administration as well as Program evaluation. Moreover, a common approach may actually be more cost effective and accurate.

More Checks and Balances in Program Implementation

Currently the registries only allow for "pass" or "fail" as descriptions of a homes inspection. This prevents any feedback loop to allow for any closer examination of what happened with failing homes, and to any subsequent program or process modifications. By requiring a more detailed description of failures, the opportunity will be created to explore failures and reduce the lost opportunities for savings. Additionally, when inspectors identify characteristics that are better than planned, the inspectors should record the installed efficiencies and characteristics.

Some plan check agencies only get paid for projects that are admitted to the program, causing a potential conflict of interest for the agency to pass more projects. There is also a potential conflict of interest for HERS raters who are typically hired and paid by builders. HERS raters who "fail" plans often could have fear of not getting hired for additional work.

There is anecdotal evidence to suggest that some utilities may be under pressure to achieve program participation goals and this pressure may encourage bending of some program rules. For example, we have found plans that are less than 15% better than Title 24, we found plans with negative electricity savings in utility territories that don't permit it, and during interviews heard of at least one case where an applicant was rejected by one utility for non-compliance and the applicant applied to another utility and was accepted. A third party should double check that each plan complies with program requirements before the incentive is paid.

Coastal Impacts Might not be Worth the Cost

Coastal electricity per-unit impacts were less than half those of the inland projects. Gas savings were even lower in coastal versus inland programs across all the utilities. This raises the question of whether the savings realized in coastal areas are worth the same per-unit cost as inland savings, and whether the coastal zone incentives wouldn't be better spent on recruiting more inland participants, which could bring up a question about equity.

Occupant Behavior is as Important as Building Characteristics

Our billing analysis results, showing negative program savings in climate zones that the metering indicates positive savings, highlighted the fact that occupant behavior is one of the largest drivers of energy consumption. For this reason, future evaluations may want to explore ESH occupant behaviors. If people who choose to buy ENERGY STAR® homes are already conservation minded people and therefore purchase the homes to be eco-friendly or "green" than they may be conservative in their energy use already. This would reduce the energy usage, and therefore the energy savings of the home. Conversely a person who knows they already consume a lot of energy may purchase an ENERGY STAR® home because even with no change in their behavior, they will still have reduced bills; a person may even increase their comfort level, for example by lowering the temperature in their home during the summer, because they think their home is more efficient and they still may consume less energy.

Whether one or the other behavior is more prevalent would not only have a significant impact on estimated savings, but also has implications for how to best market a new construction residential energy efficiency program. The utilities could attempt to educate builders on how to best target their home sales to homeowners that would induce higher energy savings. However, this may be difficult because builders would have to be given an additional incentive to make this extra effort. Further studies should investigate the role these factors play in ENERGY STAR® home purchase decisions and their implications for overall household energy usage and savings.

Evaluation Recommendations

Baseline Study

A new baseline study should be performed for RNC that is well designed from a statistical perspective and is planned with net program evaluation in mind.

Baseline sampling needs to be done at the CEC climate zone level. There are 16 CEC climate zones in California for the very reason that any further aggregation results in comparing sites that have significantly different weather characteristics. The use of RMST zones, while more convenient for sample design and implementation, does not allow program analysis to be conducted climate zone by climate zone if necessary. The fact that only one non-participant was surveyed in CEC climate zone 9, despite it having almost 7% of the program population is a testament to this problem.

Baseline sampling should be random. The 2004 baseline study ended up drawing its sample heavily from a handful of housing developments, resulting in a study that potentially suffers from significant sampling bias. If clustered sampling is to be used to create logistical efficiencies, it should be done explicitly and statistically correctly.

The baseline study should seek to characterize all aspects of the home, not just confirm what is in the Title 24 compliance model. For the baseline study to act as a baseline for any program evaluation, the same data must be collected from the non-participant homes as will be collected from the participants. At a minimum, this would include demographic questions like those used in the billing analysis in this report and a complete site inspection so that when the Title 24 models for non-participant homes are used, they fully reflect the "as-built" characteristics of the home instead of the "as-planned" or "as-claimed."

In this study, we were limited to characterizing baseline energy usage as being equal to the outputs from the baseline sample's compliance software's estimates. RLW's experience with creating compliance models for builders indicates that builders usually try to model the structure with the greatest amount of flexibility during the building process. They will, for instance, ask that the minimally efficient AC or furnace be modeled, even if they plan on install more efficient units for the reason that they can always choose to put in a more efficient unit later. The baseline study would have caught many of these "as-built" changes when conducting their site surveys. What they would not have caught, however, are any optional credits (including infiltration testing, duct leakage testing, thermal mass, duct placement, duct surface area, and TXV) that the builder didn't claim but that the structure would have qualified for.

The addition of Quality Insulation Installation to the 2005 compliance code only increases the impact that not inspecting for these measures in the non-participant population will have on estimates of program savings.

Meter Data

The meter data analysis, while a costly endeavor, has highlighted much about this program and the evaluation methods that this report has been restricted to. The surprisingly low multifamily meter adjustment ratios indicate that the compliance software significantly overestimate the amount of energy consumed at a site, and hence overstate savings. That the single family ratios also imply adjustments of 25-35%

further point to the limitations of using compliance models as an evaluation tool. Due to a similar metering analysis not being conducted as part of the baseline study, RLW was forced to rely on the assumption that the metering ratios affecting participants would be the same as those affecting non-participants. If the billing analysis results are any indication, then this assumption is likely untrue, and even with meter adjustments, the model-based savings figures overstate program savings. Ideally, a similarly chosen sample of participant and non-participant homes should have their builder-affected end-uses metered if we are to create a more accurate estimate of the savings attributable to a residential new construction program. A metering analysis should likely be included in any future RNC baseline study.

Studies should be conducted on the metering data to learn more about residential usage patterns for builder-affected end-uses. As a result of this study, we have collected one of the most extensive sets of residential end-use meter data ever collected in the state of California. This study has made one use of those data—revising the end-use estimates of the compliance models—but we have the ability, among other things, to build complete annual hourly load curves for each end-use with this data, and it would be a waste to see those data go unexplored.

Net to Gross Ratio

Comparing it to the SERA Net to Gross (NTG) ratio, the meter-adjusted estimate of NTG from the DofD approach appears to have overstated the NTG ratio. This can, in part, be explained by the compliance credits that were not inspected in the baseline homes. SERA's NTG ratio is based on what the participant builders indicate they would have done in absence of the program and on non-participant responses about their construction practices. The net-savings NTG ratio was estimated based on what the *compliance models* say non-participant builders did in absence of the program. If non-participant builders were still building low-infiltration homes with low-leakage ductwork, then these baseline "savings" would not be reflected in the models. As such, the estimate of net savings based on the models would completely miss that these measures have a certain non-zero program-independent saturation. The SERA approach, on the other hand, may be better able identify this program-independent building quality as free ridership, and reduce the NTG ratio accordingly. Added surveys of non-participants builders could confirm the lower NTG ratio. Additionally, a new baseline study that at the outset was designated to serve as the baseline for RNC programs would enable the evaluators to better quantify NTG.

Need for Uniform Utility Tracking Data

The implementers need a statewide Program tracking system, other than the CHEERS and CalCERTS registries that ties a building plan to a payment amount and date. The registries are not an effective system for tracking Program information, especially as new C-HERS providers become active and begin working with participant builders. Each implementer not only has their own approach to tracking basic participation information, each tracks different data using different software (e.g. Excel, Access). These slightly disparate databases will complicate evaluations. A purpose of the statewide implementation of the ESH program was to increase uniformity in program delivery and program administration, including things such as tracking databases. A single statewide tracking system should be implemented. This database should also flag projects targeted to serve hard to reach customers, such as rural communities and moderate-income communities.

Verified Peak kW Estimates

In order to compute ex-post peak kW, a peak load factor was applied to the net ex-post kWh savings to obtain net ex-post kW savings. This method does not provide any independent verification of actual kW savings but instead applies a utility-derived "H-factor" to the evaluated kWh savings. RLW did not provide any verification of the "H-factor" under this contract. In future evaluations, we recommend that the evaluation contractor verify peak kW using metered data. Additionally, the definition of peak kW should be clarified and made uniform across evaluations as it suits the CPUC.

Addition of Demographic Variables to Billing Analysis

Though not all demographic variables proved statistically significant in the billing regression analyses, conducting the demographic survey allowed RLW to refine the billing analysis and allowed us to conclude that the non-significant variables were not the cause of the indicated savings. The impact of including demographic variables in the regressions ranged from a 5 therm decrease in participant savings up to a 38 therm decrease in participant savings. In some cases, the demographic variables were the difference in determining whether or not the participant variable, and thus the savings estimate, was statistically significant. Any future billing analysis that does not include sufficient demographic data is likely to less accurate than a billing analysis with demographic variables included. A billing analysis with larger sample sizes could be performed to confirm results obtained from a non-participant metering study.

Custom Weather Packing

The ability to rerun the compliance models using actual-year weather was essential to the success of this evaluation. The weather packer provided by EnerComp, while initially buggy, allowed RLW the most flexibility in choosing appropriate weather stations and comparing results. Had we entirely outsourced the weather file processing, all weather-related decisions would have been made without being able to see their impact and would have resulted in either a flurry of emails between the evaluator and the company providing the packing service, or a poorly executed weather-adjustment process. If compliance models are used to conduct future research, we recommend making sure that a custom weather packer for each is provided and tested with actual weather early on in the study.

Independent Quality Control

Additional on-site inspections or other means of verification may be prudent due to problems concerning program inspection, quality control and data in the HERS Registries identified by the evaluation. In various sections of this report, we discuss issues that could lead to projects not being built with the energy efficient characteristics reported by program implementers. For example, we discuss:

- Potential conflict of interest when the same agency is a.) The builder's agent for program participation requirements, b.) Responsible for authoring the Title 24 documentation, c.) Responsible for conducting the HERS inspections, and d.) Conducts the final plan check and uploads the transfer files.

Based on these findings, we suggest that utilities consider conducting on-site inspections by a third party to verify the building characteristics and measures being installed are in fact the same as what is shown in the HERS registry and/or transfer file. These activities may be most suitable for the EM&V contractor early on, and may only be needed until the aforementioned issues have been resolved.

Appendix A - Adjustments to Gross and Net Savings

Two adjustments were made to the tracking registries' energy savings to correct for missing or inaccurate data: orientation adjustments and inspection adjustments.

Orientation Adjustments

Orientation adjustments were only necessary for homes recorded in the CalCERTS registry. The orientation of a home can significantly affect its space cooling and heating energy requirements, chiefly due to solar gain through windows. However, when ENERGY STAR® homes are built and entered into the tracking registries (CHEERS and CalCERTS) their actual orientations are not recorded. Instead, production builders design homes which are built in all possible orientations, usually dependent upon the layout of the streets in a development. To accommodate this style of planning and to satisfy the ENERGY STAR® Homes program requirements, builders model their homes in north, east, south, and west orientations to show that energy consumption meets minimum program requirements in all four "cardinal" orientations. The CHEERS registry contains the modeled energy consumption for each orientation, and the average was used to calculate the gross energy savings for each home.

The CalCERTS registry only contains modeled energy for each plans' worst orientation, but clearly not all homes are actually built in the worst possible orientation. To adjust for this, the CHEERS data was used to estimate "average" orientation energy as a function of worst orientation energy. Unique orientation adjustment b-ratios were estimated for single family and multifamily housing.

Inspection Adjustments

All single family homes' energy savings were "inspection adjusted." The tracking savings were adjusted using findings from actual inspection data of 2002-03 ENERGY STAR® homes. This adjustment was necessary to correct for the differences between planned and inspected single family building characteristics. Adjustments were made at the end-use level and the inland/coastal region level. Multifamily homes did not require adjustment since on-site inspections found no significant differences from the plans.

Ratio Estimation and B-Ratios

Ratio estimation was used to adjust gross tracking energy savings through the use of b-ratios in six stratum: three end uses (heating, cooling, and water heating) in each of two climate regions (inland and coastal). The target variable of analysis, denoted y, is the energy use of the project (home). The primary stratification variable, the estimated energy savings of the project, is denoted x, and is obtained from the tracking database. A ratio model was formulated to describe the relationship between y and x for all projects in the population, such that $y = \beta x$. In statistical jargon, the ratio model is a (usually) heteroscedastic regression model with zero intercept. Beta (β) is referred to as a b-ratio. In the case of orientation adjustment, β is the sum of all homes' average orientation energy savings divided by the sum all homes' worst orientation energy savings within a stratum. A thorough description of ratio estimation can be found in the 2004 California Evaluation Framework. The orientation adjustments are based on a sample size of over 24,000 single family homes and 2,700 multifamily structures, while for inspection adjustments the sample sizes were much smaller, limited by the actual number of physical inspections conducted (a couple hundred).

Summary of Results

Orientation and inspection adjustment results are presented in Table 86.

Climate Region	End Use	Single Family		MultiFamily
		B-Ratios for Orientation Adjustments	B-Ratios for Inspection Adjustments	B-Ratios for Orientation Adjustments
Coastal	Cooling	1.46	0.95	1.35
	Heating	1.24	1.10	1.14
	Water Heating	1.00	0.93	1.00
Inland	Cooling	1.25	1.15	1.27
	Heating	1.17	1.04	1.07
	Water Heating	1.00	1.01	1.00

Table 86: B-ratios for Orientation and Inspection Adjustments

B-ratios less than one indicate less energy savings than computed from the tracking data, while b-ratios greater than one yield increased savings. For example, an inspection b-ratio of 0.95 for coastal cooling indicates that coastal ENERGY STAR® homes on average only achieved 95% of the claimed cooling savings, while the inland cooling b-ratio of 1.15 indicates ES homes on average achieved 115% of the claimed cooling savings.

Interpretation and Conclusions

These findings, although not the focus of this report, are very significant. For example, the orientation results show that inland energy savings can be increased by 25% for space cooling, and 17% for space heating, by orienting a home from its worst energy orientation to its average energy orientation.[68] Even greater energy savings could be achieved by orienting homes to their best orientation. This is not a "new" discovery, as the advantages of passive solar design and home orientation have been known for centuries, but the orientation adjustment b-ratios, based on analysis of thousands of homes, provide a quantitative estimate of the energy "cost" to builders of ignoring orientation. Conversely, water heating orientation b-ratios are 1.0, since the orientation of a home does not impact modeled energy water heating usage.

The inspection adjustments are also significant, but less surprising since many aspects of construction plans are not thoroughly identified at the time of energy modeling. Title-24 consultants often use minimum requirements necessary to gain compliance while providing the builder greatest flexibility at the time of construction and equipment selection. The inspection adjustment b-ratios estimate the energy difference between average plans and average as-built characteristics.

[68] Although coastal space cooling savings increases by a dramatic 46% with orientation adjustment, the actual energy savings due to this adjustment are small since the coastal region has much smaller cooling loads and many fewer new homes.

Single Family Adjusted Gross Energy Savings

Since orientation adjustments only applied to CalCERTS homes, these were calculated first, and then inspection adjustments were applied to all homes. B-ratios were multiplied by gross savings from CalCERTS tracking data to arrive at the Orientation Adjusted Gross Tracking Savings.

The second adjustment was applied to total gross savings (from CHEERS and adjusted CalCERTS data combined).

The overall impact of the two adjustments on gross tracking savings is presented in Table 87. The results in Column C are presented in the Single Family Findings chapter. As can be seen from Table 87, gross tracking savings from the raw data increases by 10.4% as a result of the two adjustments. We multiplied the CalCERTS portion of gross savings in (A) by the b-ratios for orientation adjustments to arrive at the orientation adjusted gross savings (B). This orientation adjusted gross savings (B) were then multiplied by the b-ratios for inspection adjustments in order to arrive at the final adjusted gross savings (C) that is both orientation and inspection adjusted.

Utility	Single Family Dwelling Units	Tracking Savings (kBtu/Year) (A)	Orientation Adjusted Savings (kBtu/Year) (B)	Orientation and Inspection Adjusted Savings (kBtu/Year) (C)	Percent Change from (A) to (C)
PGE	12,309	214,438,914	219,328,625	231,300,524	7.9%
SCE	13,297	251,528,119	263,453,798	284,916,379	13.3%
SCG	1,191	34,129,745	34,277,049	38,568,704	13.0%
SDGE	4,316	49,183,988	49,888,781	51,365,671	4.4%
Total	31,113	549,280,766	566,948,253	606,151,279	10.4%

Table 87: Single Family Tracking Savings, Orientation Adjusted Savings and Total Adjusted Savings

The breakdown of total adjusted savings by the three end uses can be seen in Table 88.

	Coastal Adjusted Savings - kBtu/Year	Inland Adjusted Savings - kBtu/Year	Total Adjusted Savings - kBtu/Year
Cooling	10,058,662	221,833,830	231,892,492
Heating	22,842,213	231,903,950	254,746,163
Water Heating	16,222,409	103,290,215	119,512,624
Total	49,123,284	557,027,995	606,151,279

Table 88: Breakdown of Total Adjusted Tracking Savings By End Use

Multifamily Adjusted Gross Energy Savings

There were only 36 multifamily projects recorded in CalCERTS for the 04-05 program years. Therefore orientation adjustments applied to these structures had little impact on total multifamily savings as shown in Table 89.

Utility	Multifamily Dwelling Units	Tracking Savings (kBtu/Year) (A)	Orientation Adjusted Savings (kBtu/Year) (B)	Percent Change from (A) to (B)
PGE	2,758	25,472,916	25,580,293	0.4%
SCE	2,791	23,513,763	23,947,620	1.8%
SCG	6,322	51,652,282	51,652,282	0.0%
SDGE	7,257	58,584,739	58,584,739	0.0%
Total	19,128	159,223,700	159,764,934	0.3%

Table 89: Multifamily Tracking Savings and Orientation Adjusted Savings

Inspection Adjustment B-Ratios from 02-03 On-site Inspections

Figure 43, Figure 44, Figure 45, Figure 46, Figure 47, and Figure 48 graphically show planned and inspected modeled energy consumption for the inspected homes. Note that planned and inspected energy savings are both modeled estimates of energy savings based on building characteristics. Potential bias in the modeling software could impact both planned and "inspected" energy savings.

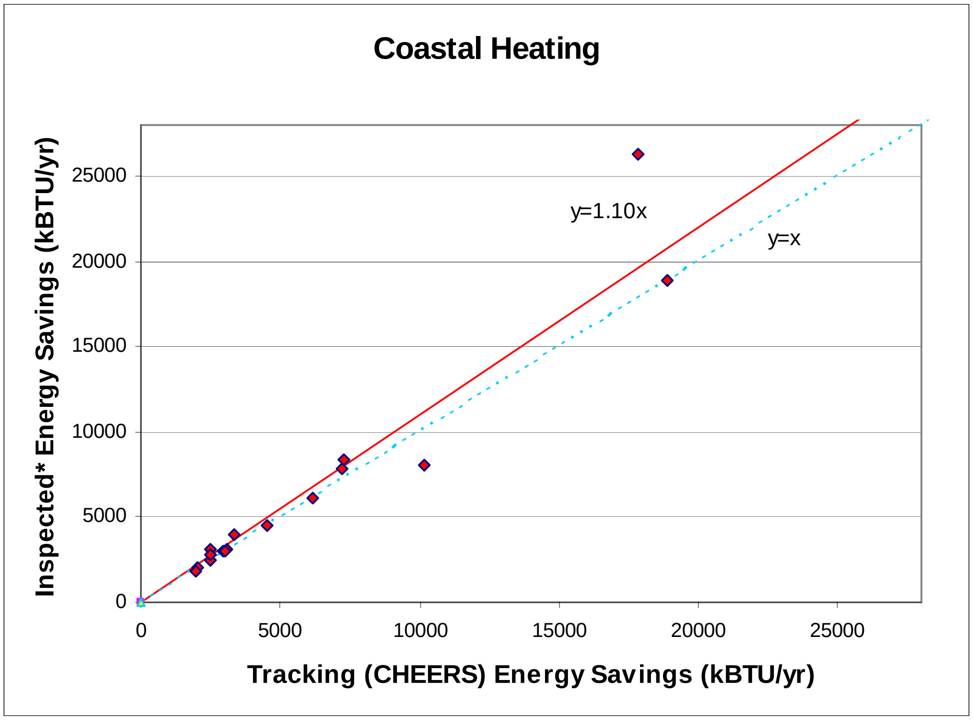


Figure 43: Single Family Coastal Heating - Tracking vs. Inspected Energy

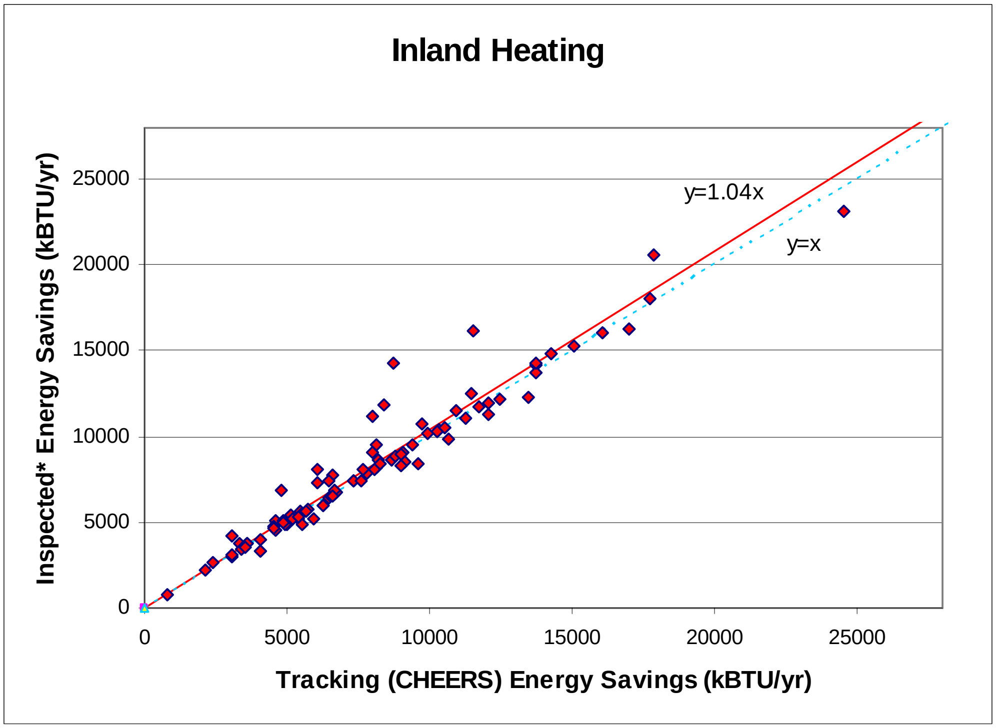


Figure 44: Single Family Inland Heating - Tracking vs. Inspected Energy

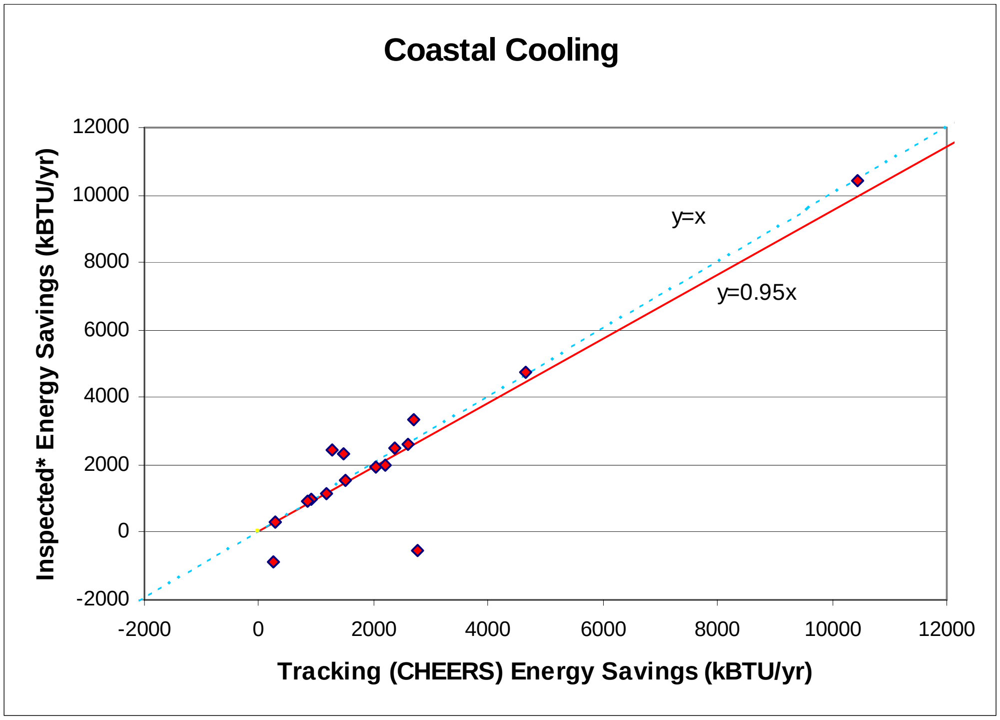


Figure 45: Single Family Coastal Cooling - Tracking vs. Inspected Energy

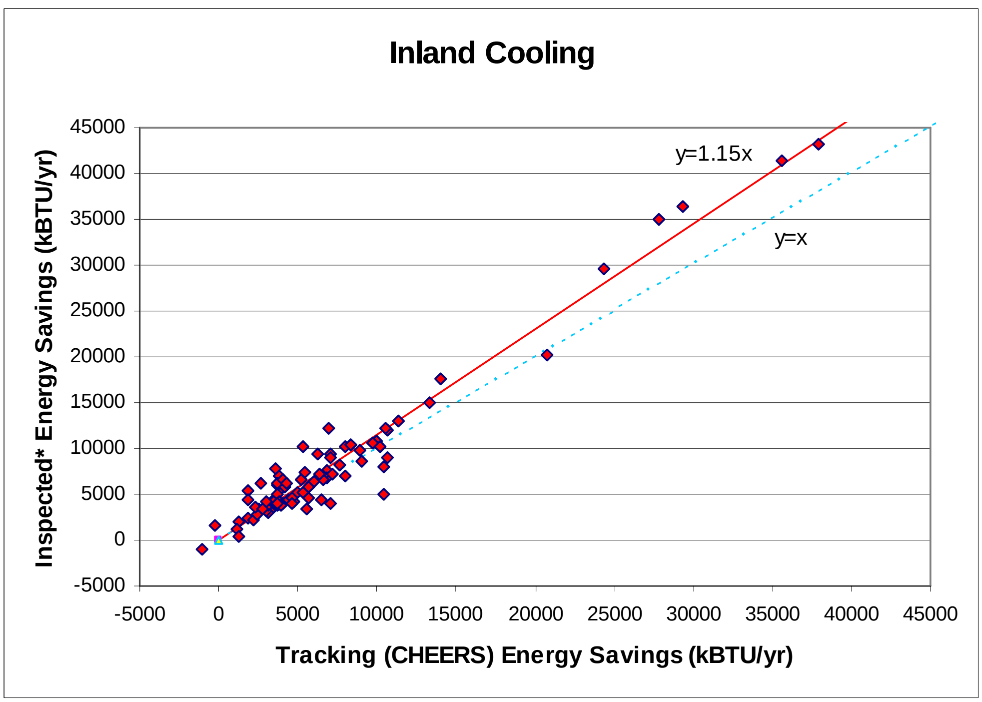


Figure 46: Single Family Inland Cooling - Tracking vs. Inspected Energy

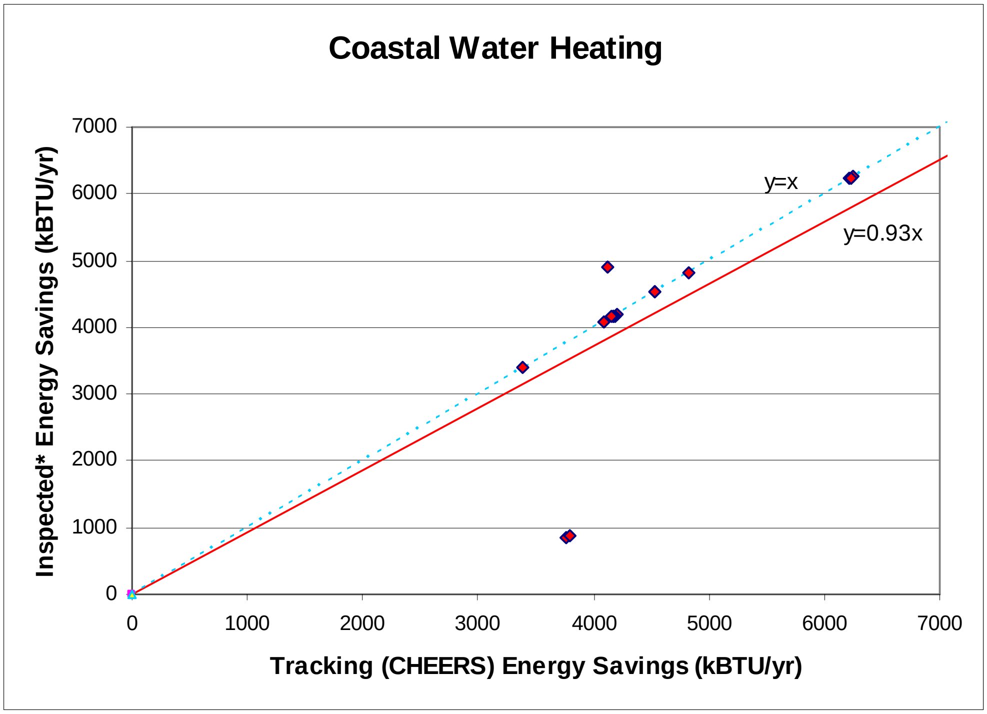


Figure 47: Single Family Coastal Water Heating - Tracking vs. Inspected Energy

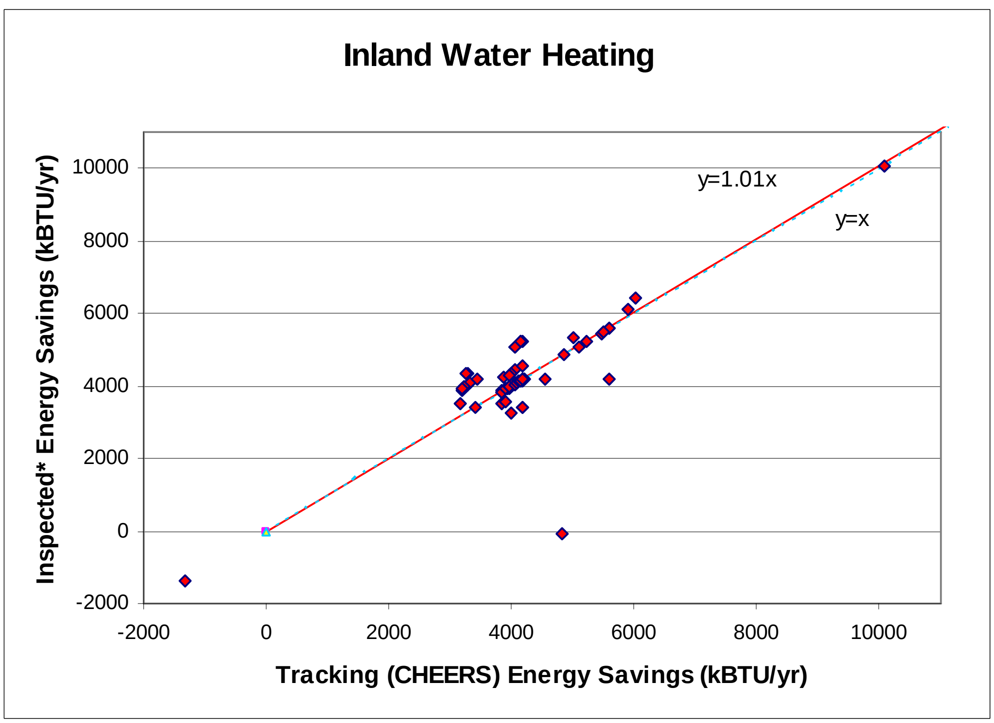


Figure 48: Single Family Inland Water Heating - Tracking vs. Inspected Energy

Appendix B - Net Savings: Difference-of-Differences Calculation Methodology and Comparison Groupings

Methodology and Equations for Computing Net Savings

The essence of the "difference-of-differences" analysis is to compare ENERGY STAR® Homes to non-participant homes' standard construction practices. While Gross savings is defined as the difference between Standard (package D) and Proposed modeled energy consumption, Net Savings is defined as the gross savings less naturally occurring savings (due to industry standard practice). If for one home,

S_p[69] = Participant CF-1R standard energy use (kBTU/sf-yr)

P_p = Participant CF-1R proposed energy use (kBTU/sf-yr)

S_{np} = Non-participant CF-1R standard energy use (kBTU/sf-yr)

P_{np} = Non-participant CF-1R proposed energy use (kBTU/sf-yr)

SF = Conditioned floor area of the home

Then, the

Net Savings = (Gross savings) – (Natural savings) = $(S_p-P_p)*SF - (S_{np}-P_{np})*SF$,

And the equation can be seen to motivate the name, as the Net savings is indeed a difference-of-differences.

$(S_{np}-P_{np})*SF$ represents "the naturally occurring non-participant energy savings due to current standard building practice." Unfortunately, S_{np} and P_{np} do not exist, since non-participant homes of the exact same size, location and other building characteristics were not constructed. To estimate them, a baseline study of residential new construction, conducted by Itron, was utilized.

The Net savings of the population of ENERGY STAR® homes was calculated as follows:

(1) Net savings = [savings of ENERGY STAR® Homes above standard] – [naturally occurring savings due to current practice]

(2) Savings of ENERGY STAR® Homes above standard = $[N_p * \overline{SF}_p * \overline{S}_p * \overline{CM}_p]$, and

(3) Estimated naturally occurring savings = $[N_p * \overline{SF}_p * \overline{S}_p * \overline{CM}_{np}]$

(4) So, Net Savings = $[N_p * \overline{SF}_p * \overline{S}_p * \overline{CM}_p] - [N_p * \overline{SF}_p * \overline{S}_p * \overline{CM}_{np}]$

(5) $= N_p * \overline{SF}_p * \overline{S}_p * [\overline{CM}_p - \overline{CM}_{np}]$

Where:

[69] The subscript p is used to denote Participants, and np is used for Non-Participants.

N_p = Number of ENERGY STAR® Homes participant homes

$\overline{SF}_p$ = Participant homes' average conditioned floor area = $\dfrac{\sum_{i=1}^{N_p} SF_{p_i}}{N_p}$

$\overline{S}_p$ = Participant homes' weighted average Standard energy consumption = $\dfrac{\sum_{i=1}^{N_p} S_{p_i} SF_{p_i}}{\sum_{i=1}^{N_p} SF_{p_i}}$

$\overline{CM}_p$ [70] = Participant homes' weighted average Compliance Margin =

$$\frac{\sum_{i=1}^{N_p}(S_{p_i} - P_{p_i})SF_{p_i}}{\sum_{i=1}^{N_p} S_{p_i} * SF_{p_i}}$$

$\overline{CM}_{np}$ [71] = Non-participant weighted average Compliance Margin =

$\dfrac{\sum_{i=1}^{N_{np}}(S_{np_i} - P_{np_i})SF_{np_i} * w_i}{\sum_{i=1}^{N_{np}} S_{np_i} * SF_{np_i} * w_i}$, where w_i s are the weights of the non-participant homes sampled in the baseline study. These non-participant case weights were used to extrapolate the true non-participant sample data to a population similar in composition to the population of ENERGY STAR® Homes Program participants.

What is the justification for equation (2)?

The Total Savings of the ENERGY STAR® Homes above standard must equal the sum of the savings of each individual home, or

Savings of the ENERGY STAR® Homes above standard = $\sum_{i=1}^{N_p}(S_{p_i} - P_{p_i})SF_{p_i}$

Is this equal to equation (2)? Is,

$$N_p * \overline{SF}_p * \overline{S}_p * \overline{CM}_p = \sum_{i=1}^{N_p}(S_{p_i} - P_{p_i})SF_{p_i} \ ?$$

By substitution into (2),

[70] Participant weighted average Compliance Margin is weighted by conditioned floor area of each home.

[71] The non-participant weighted average Compliance Margin is weighted by both the conditioned floor area of each home, and its associated sample weight from the baseline study.

Savings of ENERGY STAR® Homes above Standard =

$$N_p \frac{\sum_{i=1}^{N_p} SF_{p_i}}{N_p} * \frac{\sum_{i=1}^{N_p} S_{p_i} * SF_{p_i}}{\sum_{i=1}^{N_p} SF_{p_i}} * \frac{\sum_{i=1}^{N_p} (S_{p_i} - P_{p_i}) SF_{p_i}}{\sum_{i=1}^{N_p} S_{p_i} * SF_{p_i}} = \sum_{i=1}^{N_p} (S_{p_i} - P_{p_i}) SF_{p_i}$$

, so yes.

Similarly equation (3) is derived, and the difference between the two sums in (4) is justified as the Net Savings.

Single Family Participant and Non-Participant Comparison Grouping

This analysis was conducted at the individual CEC climate zone and end-use level. This is a fundamental necessary concept of the single family analysis since builders build homes differently in different climate zones. There were 575 non-participant homes from the Itron baseline study. This small non-participant sample, when distributed across the 16 CEC climate zones, led to very small sample sizes in some individual climate zones. Whenever sample sizes permitted, comparisons were done CEC-to-CEC climate zone. For example, participants from CEC climate zone 2 were compared to non-participants from CEC climate zones 2, 3, 4, and 5 as shown in Table 90.[72] On the other hand, participants from CEC climate zone 5 were strictly compared to all non-participants from CEC climate zone 5. Table 90 shows the frequency of participant and non-participant homes in each CEC climate zone and reference comparison groups.

CEC Climate Zone	Reference Climate Zone(s)	ESH Participants by CEC	Non-Participants by CEC	Non-Participants by Reference Climate Zone(s)
2	2, 3, 4, 5	192	10	40
3		359	7	
4		611	4	
5	5	30	19	19
6	6	279	81	81
7	7,8	2,933	8	107
8	8	1,645	99	99
9	8, 9	1,678	1	100
10	10	9,200	27	27
11	11	3,486	18	18
12	12	6,884	235	235
13	13	1,059	26	26
14	14	1,710	36	36
15	N/A	1,047	1	N/A
16	N/A	0	3	N/A
Total		31,113	575	N/A

Table 90: Participant and Non-participant Comparison Groups – Difference of Differences Analysis

[72] There were no participant homes in climate zone 1 or 16, No data (on participants or non-participants) was available for CEC climate zone 1.

CEC climate zones 2, 3, 4, 7, 9, and 15 had very few non-participant baseline sample homes, and therefore were grouped with other climate zones. Climate zone 15 was handled uniquely. Since climate zone 15 contained only one non-participant home, and its distinct weather is not reasonably approximated by adjacent CEC climate zones, it was determined there did not exist an appropriate non-participant reference group. Therefore, the gross savings from climate zone 15 were multiplied by a NTG ratio of 0.8 to arrive at the net savings.[73]

Table 91 below presents average floor area and compliance margins of the participants and the non-participants for each end-use and CEC climate zone. The difference in the compliance margins between the participant and the non-participant homes is the key factor driving estimated savings using the difference of differences methodology. As can be seen, this difference is positive for most comparison groups for heating, cooling and water heating, indicating positive savings in most climate zones.

				Heating			Cooling			Water Heating		
CEC Climate Zones	Reference Climate Zones	Participant Mean Floor Area	Non-Participant Mean Floor Area	Participants	Non-Participants	Difference	Participants	Non-Participants	Difference	Participants	Non-Participants	Difference
2		2,722		26%		0%	31%		23%	12%		-1%
3	2, 3, 4, 5	2,219	2,542	14%	25%	-11%	82%	8%	73%	22%	13%	9%
4		1,867		29%		4%	39%		31%	11%		-2%
5	5	1,881	2,573	20%	32%	-12%	56%	62%	-5%	12%	13%	-1%
6	6	3,123	2,872	5%	5%	1%	81%	64%	17%	10%	9%	1%
7	7,8	2,584	2,782	31%	29%	2%	32%	2%	29%	14%	8%	6%
8	8	2,905	2,752	31%	29%	1%	32%	2%	30%	17%	8%	9%
9	8, 9	2,539	2,742	36%	29%	6%	48%	2%	45%	11%	8%	3%
10	10	2,593	2,664	31%	21%	10%	37%	-9%	47%	14%	12%	1%
11	11	2,106	1,873	23%	16%	7%	28%	9%	19%	15%	13%	2%
12	12	2,531	2,566	24%	3%	21%	24%	-35%	59%	15%	11%	4%
13	13	2,173	1,564	22%	6%	16%	30%	-23%	53%	14%	17%	-2%
14	14	2,153	2,472	28%	-1%	28%	26%	-11%	37%	17%	12%	5%
15	N/A	2,200	1,810	26%	5%	22%	37%	-45%	82%	12%	13%	0%
16	N/A	2,722	2,435	N/A	3%	N/A	N/A	70%	N/A	N/A	11%	N/A

Table 91: Compliance Margins of Participants and Non-Participants By End Use and CEC Climate Zone

[73] California Standard Practice Manual, NTG Ratios, October, 2001

Appendix C - Sample Designs (Single family and Multifamily)

Single Family Sample Design

A sample of 50 single family participants were selected for verification inspections. Before conducting the sample design, RLW requested data on the population of ENERGY STAR® Homes from both CalCERTS and CHEERS. After the population[74] of ENERGY STAR® homes was defined, 50 single family homes were inspected from the CalCERTS registry for the 04-05 evaluation.

Only structures with "Passed" or "Passed but previously failed" status (which indicate ENERGY STAR® participants in the registries) were included. The climate zones reported in the CalCERTS data ranged from CZ2 to CZ15. As the CEC climate zones differ significantly from one another, they were used as different strata in the sample design.

There were several strategies that we considered when we decided on the sample design. As the single family homes were not expected to vary much in size, we decided to use proportional sampling for single family instead of model based statistical sampling. This means that we used a sampling framework where the fraction of the total population of participant homes in each CEC climate zone is the same as the fraction of homes sampled from that CEC climate zone.

CEC Climate Zone	Population - Number of Homes	Sample - Number of Homes
2	12	0
3	53	0
4	90	1
5	0	0
6	152	1
7	284	2
8	236	2
9	601	4
10	2,591	19
11	351	2
12	1,513	11
13	371	3
14	495	4
15	86	1
Total	6,835	50

Table 92: Single Family Population and Sample - CalCERTS

Our filtered population contained 6,835 single family structures. In the sample design task, we determined the appropriate number of units that should be included in the

[74] The impact methodology contains a description of the filters that were used to define the population of ENERGY STAR homes for Single Family.

participant sample in each stratum, and implemented the actual selection. Based on our budget, we determined that a sample size of 50 single family sites would be metered and inspected for this project. We proportionally allocated the 50 single family sample sites by CEC climate zone in order to determine the number of sample sites in each stratum. For each climate zone, we calculated the percentage of the total sites within the particular climate zone. We multiplied these percentages by 50, the desired sample size for the study, to yield the sample size for each stratum. After the sample design was approved, we requested customer contact data from the utilities. To insure that we would have enough lots as backups, 3 backups were pulled for every sample point.

Multifamily

The sample design for multifamily verification inspections had projects from both CalCERTS and CHEERS. After applying the participant filters, the CalCERTS database contained 36 multifamily lots. These 36 lots are from 5 multifamily projects. The CHEERS database on the other hand contained 153 unique projects. For the multifamily sample design, we decided to sample at the project level (complex). This is due to the fact that the multifamily structures were modeled differently for each project. Sometimes a single dwelling unit was assigned a unique structure or lot id. Other times, portions of a building consisting of multiple dwelling units, or the entire apartment complex with many dwelling units, was assigned a unique structure id.

Based on our budget, we determined that a sample size of 25 low-rise multifamily sites would be metered and inspected for this project. Our goal was to ensure that the participant sample provided statistically reliable results near the 20% level of precision at the 90% level of confidence. A sample size of 25 was determined to produce an overall relative precision of approximately 10%, an estimate that the California Public Utilities Commission was agreeable to. We decided to sample all 5 projects from the CalCERTS data and used MBSS to select 20 multifamily projects from the CHEERS data.

Our population of multifamily projects, after applying the same exclusion criteria described in the previous section on single family, contained 2,789 unique structures for CHEERS and 36 unique lots for CalCERTS. These structures were a part of 153 unique projects in CHEERS and 5 unique projects in CalCERTS. Information on square footage was available for every structure. We aggregated the square footage of all structures for each project and calculated the combined square footage for every project. We used two stratification variables – RMST climate zone and square feet for each project- to divide the population into several strata. Each climate zone was divided into one or two sub-strata for the purpose of selecting homes.

We used model based statistical sampling techniques to determine the square footage cut points for the multifamily sample design. Table 93 shows the cut points of each stratum, along with the population size, and the sample size in each stratum.

RMST Climate Zone	Project Square Feet		Population	Sample
	Minimum	Maximum		
1	0	1,642,946	18	1
2	0	1,245,151	41	4
2	1,245,152	9,021,462	8	4
3	0	1,306,035	43	4
3	1,306,036	5,185,868	17	4
4	0	1,021,205	10	1
4	1,021,206	2,469,239	6	1
5	0	1,535,394	10	1
Total			153	20

Table 93: Multifamily Stratification

The above table documents our multifamily sample design. It shows the total number of multifamily projects in the population and the sample in the eight strata.

Appendix D - Meter Data Analysis-Metering Methods and Model Comparisons

The primary purpose of the ENERGY STAR Homes (ESH) metering study was to measure actual end-use energy consumption for space heating, space cooling, and domestic hot water, and to compare those results with modeled consumption generated by approved California Title 24 energy code compliance software.

We installed temporary data logging equipment in a sample of ESH participant homes. The meter installation task was coupled with on-site inspections that were being conducted as part of the 2002-03 ESH impact evaluation. Data loggers were installed to obtain annual energy consumption for the three end-uses considered for Title 24 energy code compliance: space cooling, space heating and water heating. Data loggers collected data for one year in order to capture complete cooling and heating seasons. The data logging produced annual energy consumption and load shapes for each of these end-uses.

Metering Procedure

We pilot tested all metering equipment several homes prior to full rollout of the metering activities. Metering plans were tested on equipment that was similar to what was found in residential new construction. The pilot testing was critical because, in most cases, we deployed the meters in the spring of 2005 and did not return to retrieve the meters until summer of 2006. RLW did visit a small sub-sample of homes periodically during the metering period to validate that metering was collected data as intended. All special metering approaches that fell outside the typical plan such as boilers and wall HVAC units were revisited to ensure data integrity.

The major steps and timeline that were required to conduct the metering and prepare the data for analysis were,

1) **Inspect homes to be metered statewide, record all building characteristics, install meters, and perform spot power measurements for air conditioners (approx. 4 months)**
2) **Obtain raw metered data (approx. 1.2 years)**
3) **Retrieve Meters and Download Data (approx. 2 months)**
4) **Perform quality control (QC) and convert the raw data to energy usage**

End-use Metering

In order to provide a profile that is representative of a typical year, the monitoring period for the heating and cooling systems covered a minimum twelve month period. The monitoring periods covered each respective peak season along with shoulder months. This plan entailed equipment monitoring at the primary residence(s) for the following equipment comprising the three Title 24 end-uses:

1. Central and wall air conditioning units
2. Domestic hot water heaters and boilers
3. Central and wall heating systems

Additionally, one-time hand recorded field measurements were collected for the following:

- o Air conditioner condenser unit amps
- o Air conditioner power factor
- o Premise voltage

Single Family Metering

For each of the systems mentioned above, it was anticipated that the majority of the equipment would be of similar unit type and configuration as single family homes. Accordingly, the monitoring plan outlined an approach and necessary hardware based on the most probable equipment.

1. As expected, air con split air conditioning units with pad-mounted condensers with the evaporator coil coupled with the furnace in the attic of the residence. This configuration was present at all sites with air conditioning.
2. The domestic hot water heater was, in all cases, a standard residential, thirty to seventy-five gallon gas fired storage tank water heater.
3. The space heating systems were nearly all natural gas fired forced air unit of the standard or high-efficiency (90+) variety. Only one site out of the sample of 101 had heat pump.

Cycle and duration data from the monitoring of gas fired heating and water heating equipment, along with the equipment nameplate input capacity were used to estimate actual energy consumption of each unit. The monitoring was focused was on/off operation of the gas burners, as this was the most prevalent control approach. No modulating burners were encountered, though a few two-stage burners were encountered (Two stage burners required two data loggers to meter the control of each stage.)

Multi-family Metering

We expected to find less consistency in the types of multi-family cooling, space heating, and water heating systems. As a result, the initial step in the multi-family monitoring plan was for senior staff to conduct site surveys.. These surveys provided vital information regarding the particular characteristics of each system along and whether or not a system served multiple residences. Once the surveys were complete we developed the most appropriate monitoring plan.

1. The air conditioning systems were expected to be quite similar to single family dwellings, therefore the same monitoring plan was used as the majority of sites were split system air conditioners and heat pumps. Window/wall Package terminal air conditioners (PTACs) and package terminal heat pumps (PTHPs), or units presented access issues but the metering strategy was identical to that of split systems.

2. Multifamily water heaters were both storage tanks for individual dwelling units and central boilers serving multiple units. Most multifamily water heaters were standard storage type. These were metered in the same fashion as single family units. Some of the storage tanks had fan-powered flue vents, requiring a

different monitoring approach. When central boilers were encountered the make and model of were gathered and custom metering plans were developed for each boiler considering their unique characteristics.

3. Space heating systems for multifamily dwelling units were expected to have several configurations based on initial reviews of ESH plans. For the most part the various systems encountered utilized monitoring plans developed for other configurations and used innovative data analysis techniques. Hydronic heating using storage water heaters were the most typical system configuration and were metered identically to domestic hot water heaters that were not used for space heating. The data analysis developed a methodology to allocate usage to the space heating or domestic hot water end uses. Forced air furnaces were metered using the single-family protocol. Heat pumps were logged similar to AC units with an additional post processing step of allocating unit energy consumption to heating or cooling end-uses. Custom monitoring plans were developed for the small number of gravity wall furnaces and electric resistance baseboard heaters.

Data Summary

The actual number of each type of system and the status and quality of the data obtained are described in the following tables. As mentioned previously, single family homes used the same metering approach for the three end uses at every site. Table 94 below describes the number of installed loggers for each end use and the status of the data obtained. Compliance models were not available for two monitored single family homes and could not be included in the analysis.

Unit Type	Installed	Bad / Missing	Good Data	No MP Model	Used in Analysis
AC	97	3	**94**	2	**92**
DHW	101	12	**96**	2	**94**
Furnace	101	3	**89**	2	**87**

Table 94: Single Family Metering Summary

Multifamily cooling systems were predominantly split systems. Table 95 below shows success rate of the various cooling systems metered. There were several multifamily sites with no cooling systems in coastal climates.

Cooling	Installed	Bad/Missing	Good Data
Split AC	51	2	49
Split HP	20	0	20
PTHP	8	0	8
PTAC	4	0	4
no cooling	16	-	-

Table 95: Multifamily Cooling System Metering

Multifamily water heating was predominantly served by typical storage tank water heaters, Table 96. Some of the storage tanks had fan-powered flue vents (PVNT), requiring a different monitoring approach. Boilers served the sites that did not have either of the two storage water heater types. One site had a boiler with a dedicated gas meter. We assumed could use utility billing data to measure the usage of that unit and so did not install data loggers on it. Unfortunately, the billing data were not available for the study, and was excluded from the analysis.

DHW	Installed	Bad/Missing	Good Data
DHW Tank	75	15	60
DHW PVNT	8	0	8
Boiler (3 sites)	6	0	6
Boiler (dedicated gas meter)	1	1	0

Table 96: Multifamily Heating System Metering

Heating system types in multifamily homes varied widely, Table 97. A majority of systems were hydronic configurations that utilized typical storage hot water heaters to provide hot water to fan coils. Forced air furnaces were present at townhome/condominium type units and split heat pumps were present at several sites as well. Besides these central systems two sites had through wall heat pumps, one had gravity wall furnaces, and one had electric resistance heaters.

Heating	Installed	Bad/Missing	Good Data
Hydronic	40	4	36
Furnace	23	4	19
Split HP	20	0	20
PTHP	8	0	8
Wall Furnace	4	0	4
Electric Baseboard	4	0	4

Table 97: Multifamily Heating System Metering

Cooling End Use Energy

The air conditioner study period extended from spring 2005 through fall 2006 in all locations. This provided data throughout the cooling season. On each site visit, all premise air conditioner units underwent a spot power reading with a Fluke® power meter. Once each unit reached steady state operation the readings were recorded, along with the time of measurement. The ambient air temperature at that time from the site's associated weather station was incorporated into the end use analysis.

The amperage draw of each central air conditioning condenser unit was logged at the electrical disconnect. Through-wall units were metered inside the control panel. This amperage value was representative of all power consumed for wall units and the split-system outdoor components including compressor, condenser fan, and controls. For split systems, this amperage data in conjunction with the instantaneous readings of the unit's voltage and power factor along with nameplate fan power draw were used to calculate kilowatt and kilowatt hour energy use for cooling. In the event that multiple air conditioning units were found at a site, all units were tested and monitored, and ultimately summed together to produce the measure of total unit usage.

Cooling Systems

Split System Air Conditioner and Heat Pump

AC monitoring relied on data loggers recording average amperage every 20 minutes using current transducers. The current draw data were combined with an instantaneous power measurement (spot-watt) taken at the time of the meter installation. It was then possible to translate these current readings into estimates of annual energy consumption (kWh) of the air conditioner or heat pump. Fan kWh was estimated by estimating the fraction of each period that the AC was running and multiplying it by the kW input of the fan.

Single family air conditioner system types consisted entirely of split system air conditioners and split system heat pumps. The air conditioner monitoring approach was to record total condenser run-time utilizing the OWL 400 data logger with a 0-2.5 vdc output 50 amp split core current transducer (CT). This monitoring configuration operates by converting the analog signal of the 50 amp CT to a digital signal usable by the OWL 400. The amp to digital conversion approach was utilized because the OWL 400 is capable of recording 32,767 readings whereas most other data loggers in the class of the Owl 400 utilizing a CT with current output have significantly less memory. This was important because the configuration enabled us to capture the entire cooling season without having to retrieve data and re-launch the logger mid-project. This data logging configuration did not require an invasive (cutting or splicing) into the existing equipment or wiring.

The Owl 400 data loggers were configured to instantaneously sample the current draw every eight seconds, store the sampled data in temporary memory, and record the average of the eight second readings at twenty minute intervals. The twenty minute monitoring interval allowed us to gather 450 days of cooling run-time data—more than enough to capture a full year of data. The data loggers were configured to stop recording data when the memory reached capacity to avoid overwriting previously collected data.

To inform the run-time data with actual power demand, a one time spot power measurement of the condensing unit was taken using a Fluke 31 power meter. Power measurements were not taken until the air-conditioning unit had reached steady state operation. Note that blower fan current and run time data were not collected by the data logger. In homes with multiple air conditioners, multiple data loggers were installed.

Figure 1 shows the typical Owl 400 data logger installation implemented for this project.

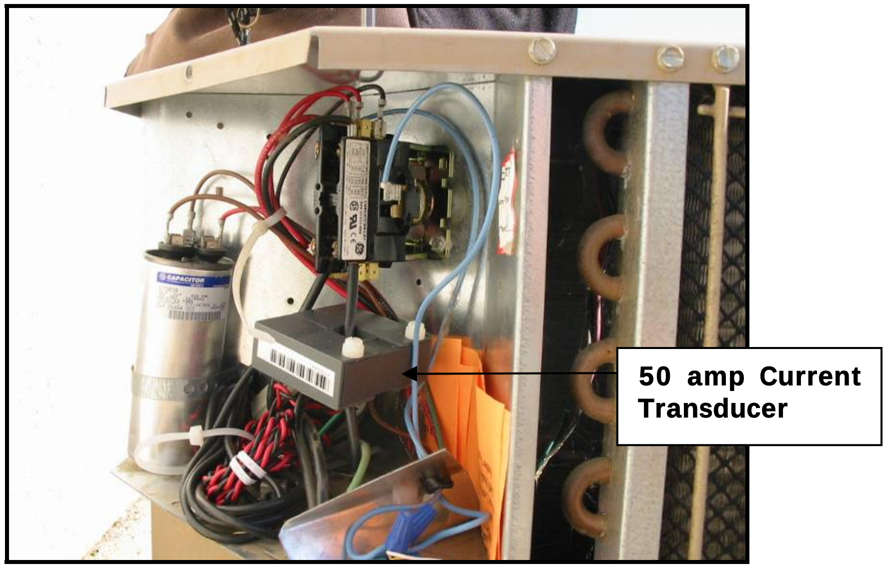


Figure 49: Air Conditioner Condenser Data Logger Installation

Package Terminal Air Conditioner (PTAC) and Heat Pumps (PTHP)

In multifamily dwellings we encountered through-wall air conditioners and heat pumps. Through-wall units, called package terminal air conditioners (PTAC) and heat pumps (PTHP), were logged in a similar fashion to split systems. The fan energy was included in the data. Units were not included in the study for occupants who said they used the fan-only option on the through wall unit.

Instead of logging at the electrical disconnect, the loggers were placed inside the control box where power enters the unit. This presented some access issues as shown in the figure below, but all units chosen were metered successfully.

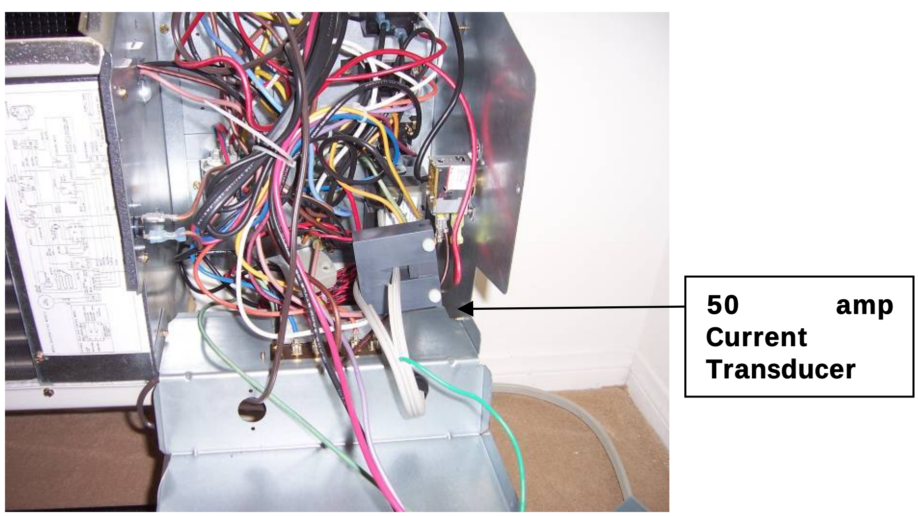


Figure 50: PTHP (Through wall unit) Meter Installation

Cooling Data Analysis

Cooling Fan Energy

Energy consumption of blower fans for central cooling systems was not metered explicitly. The cost was prohibitive to meter fan power draw at each site and the Title 24 compliance model energy use only includes fan energy associated with the system when it is in cooling mode and not when the fan is being used independently. Due to these factors the fan was assumed to draw constant power during any condenser run period. The runtime for air conditioning and heat pump systems was then multiplied by the by fan power draw to determine fan energy consumption. Cooling runtime for air conditioner and heat pump systems was calculated using the data and equipment performance curves. For PTHPs and PTACs, the fan energy was already included in the logged data.

Cooling Runtime

In order to quantify the fan energy used as part of cooling, we must first translate the measured amperage information into an estimate of runtime. The primary input data in the determination of runtime at one minute intervals is the logged amperage data and the cooling system performance curve used to determine the instantaneous power draw of the unit at a given outdoor temperature and indoor temperature and humidity. Ambient temperature used hourly weather data from the custom weather profile developed for each site. Evaporator inlet wet bulb temperature was assumed to be at the ARI standard condition of 67 F. The key data inputs are below.

AMP = Average Amp data, 20-minute interval (OWL Data)

odb = condenser inlet dry bulb temperature (°F) (Hourly Data)

ewb = evaporator inlet wet bulb temperature (°F) (Assumed constant at 67 F)

Combining these data with the nominal system efficiency and nominal cooling capacity allowed the use of the DOE-2 Bi-Quadratic performance curves for split systems. The EER for each system was determined from the ARI Database of system efficiencies based on the particular condenser and coil match. If no match could be found the average EER for that SEER level across all manufacturers was used. The EER is the amount of cooling delivered in kBtu/h divided by the power input in kW at the standard condition of 95 F odb, and 67 F ewb. The nameplate data and conversion calculations are as follows for system capacity and efficiency.

Tonnage = nominal system capacity in tons (Based on nameplate and matching)

Capacity = 12000•**Tonnage** (Btuh)

EER = System efficiency at standard conditions (Based on nameplate and matching)

EIRARI= 3.412• (1/**EER**)

The bi-quadratic performance curves for cooling delivered and energy input ratio as functions of condenser entering dry-bulb temperature (odb) and evaporator entering wet bulb temperature (ewb) are presented below.

SYSCOOL = Cooling Delivered = **CAPACITY•** [0.87403018 + -0.0011416•(**ewb**) + 0.0001711•(**ewb**)^2 + -0.00296•(**odb**) + 0.00001018•(**odb**)^2 + -0.00005917•(**ewb**)•(**odb**)]

SYSEIR = System Energy Input Ratio = **EIRARI•** [-1.063931 + 0.03065843•(**ewb**) + -0.0001269•(**ewb**)^2 + 0.015421•(**odb**) + 0.00004973•(**odb**)^2 + -0.0002096•(**ewb**)•(**odb**)]

The results are then translated into power draw by multiplying the energy input ratio by the amount of cooling delivered and converting the units back to Watts from Btu/h. The equation below incorporates the unit conversion in the determination power draw.

POWER=0.29308324•**SYSEIR•SYSCOOL** (Watts)

The power expected for a particular system with known efficiency and cooling capacity at any given hour for a particular location is now known. By combining the spot measurements taken at the time of meter installation, we calculated the expected amperage draw given the local weather conditions.

V = Volts from Spot Watt Data

PF = Power Factor from Spot Watt Data

AMPA=POWER / (V * PF)

If the unit was running for only a portion of the 20 minute interval the average amps divided by the expected amps yield the percentage of the interval the unit was running at full power. Multiplying the percentage by one-third of an hour (20 minutes) allowed for runtimes to be calculated in units of hours. The equation below was used for this analysis.

RUNTIME20 = (AMP/AMPA) * (1/3) (Hours)

The system's energy consumption was then calculated as the measure energy consumption plus the fan energy consumption. The fan kW draw was assumed constant and was taken from nameplate data. The equation below shows how energy was computed using measured time series amperage data and instantaneous power factor and voltage data along with using the computed runtime and nameplate fan power.

FANKW = Fan Power for the system from nameplate data

ENERGY = (1/3) * AMP * PF * V + RUNTIME20 * FANKW

Heat Pump Separation Methodology

In order to compare heat pump usage to the compliance model outputs, we had to separate the aggregated amperage data into its component end uses. To do this, we had to determine whether any recorded heat pump operation had been in heating or cooling mode. Because the sites were in varying climate zones and had different user preferences, there were no universal cutoffs for heating and cooling months. Therefore, it was necessary to look at each site's usage and determine whether each observation should be classified as heating load or cooling load.

The first step in our analysis was to import the data into Visualize-IT®, a Windows application developed by RLW Analytics. The software was designed to help summarize and analyze time series interval data. Visualize-IT® has two tools that make it ideal to analyze the heat pump data, time series graphing and energy prints.

Some sites had clearly defined winter and summer usage with distinct gaps between them. An example of this is shown by Figure 51, an energy print of a heat pump with clear usage patterns. The day of the year form the x-axis and the time of day, the y-axis in the energy print below. Lighter colors in the graphic indicate higher energy usage, while darker colors indicate period of low or non usage. Here, summer usage ran from May to October and winter usage ran from December to mid April. Summer usage was characterized by high concentration of use during the early afternoon and continued but lower use through the night. Winter use was characterized by a dual peak, one early in the morning when the user wakes up, and one in the evening when they return from work.

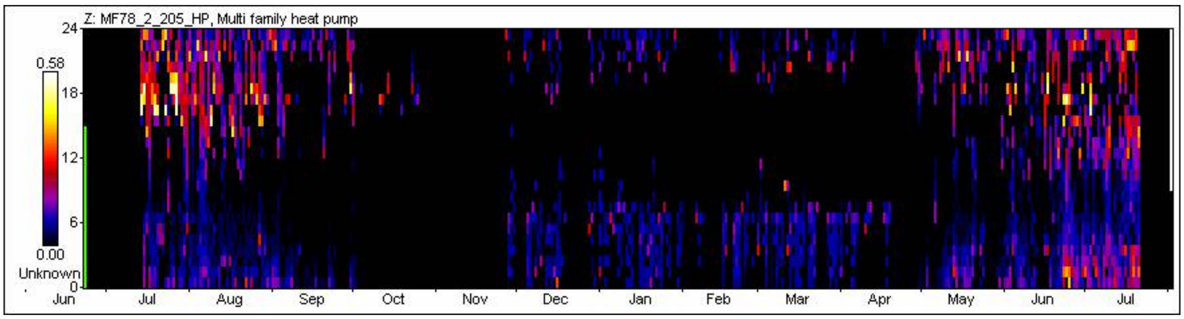


Figure 51: Heat Pump 78 Energy Print

Other sites required more analysis to determine whether the usage was heating or cooling. Figure 52 is an energy print of a site where simply looking at the energy print was inconclusive. Here, usage in May through September was definitely cooling and usage in December and January was heating. The other months' usage type cannot be determined simply by using the energy print. The next step for these months was to look at the usage during the months in question using time series graphing. Using these graphs we can determine what time the system was on and, based on normal characteristics of use, determine if it was heating or cooling. For example, in Figure 3, the pump was on intermittently from midnight to 10:22 am on March 12. This would appear to be heating data, but to be sure we cross checked the usage against the weather data for that site. The weather data for site 9 lists the temperature ranging from 43 to 54 degrees during this time span, confirming that the usage was heating.

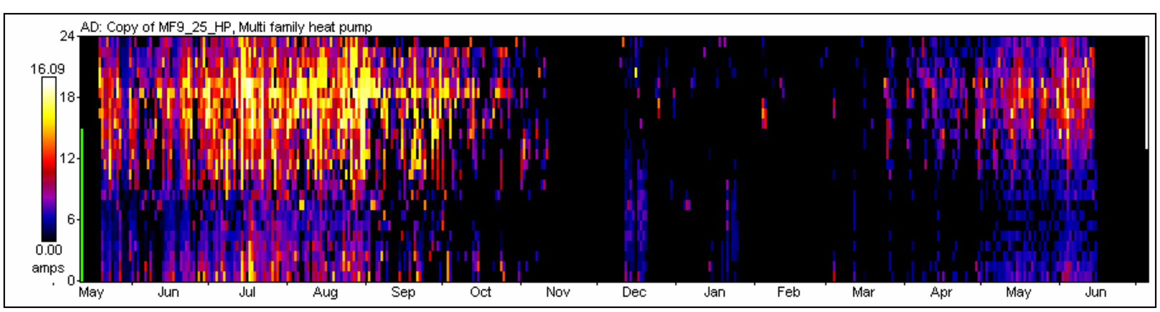


Figure 52: Heat Pump 9_25 Energy Print

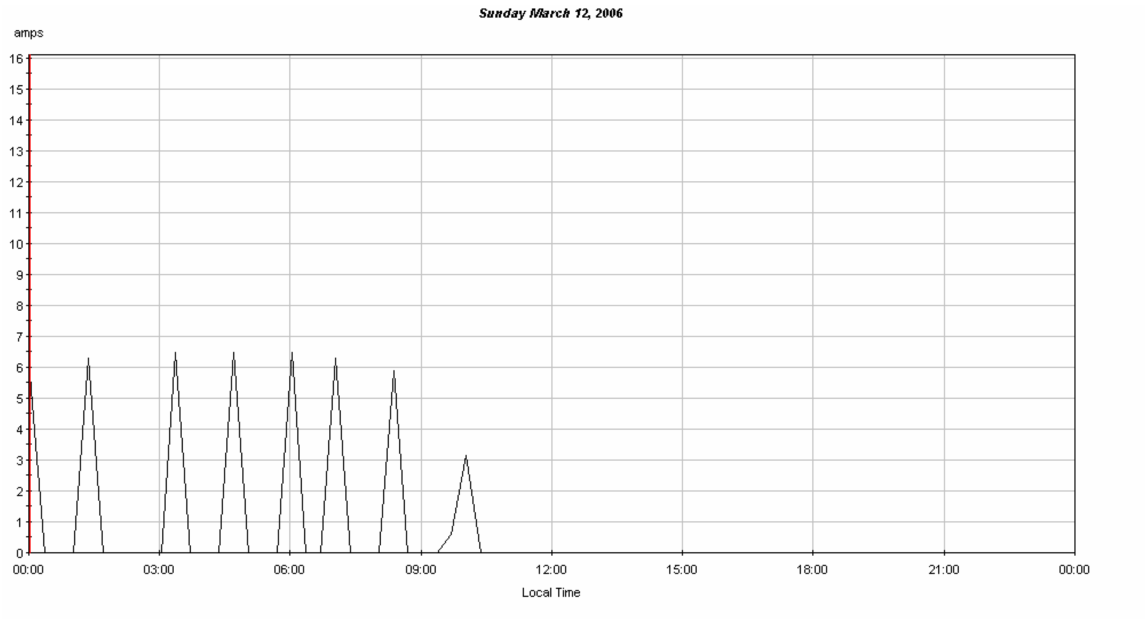


Figure 53: Heat Pump 9_25 Single Day Usage

Each of the 28 heat pumps in this study were looked at separately in Visualize-IT® using this methodology, and periods of heating and cooling use were assigned to each. The heating and cooling total kWh were then totaled for each day to yield the daily kWh cooling and daily kWh heating usage for the heat pump sites. The fan usages were then calculated for both end uses according to the methodologies described elsewhere in this report, and the heating fan kWh added to the heating usage total and the cooling fan kWh added to the cooling usage total. The 365 daily usages following the meter installation date were then totaled to yield the total annual cooling and total annual heating load for the meter adjustment factor analysis.

Domestic Hot Water (DHW) End Use Energy

There were indications from studies in other states, that domestic hot water usage can vary 20 – 35% seasonally. It was for this reason that we intended to continually monitor water heating for the entire one year study period. The most common residential water heater consisted of a storage tank, atmospheric burner, standing pilot, and a non-electric gas safety using a millivolt thermocouple. The venting was either side-wall or through the roof and we encountered only a few with power venting, and a few boilers at multifamily sites.

Pilot testing showed that a temperature sensor placed in the water heater flue would provide a reliable and consistent indicator of burner runtimes. It was a relatively elementary process to install the loggers in the flue. The nominal BTU rating when applied to actual unit runtimes provided cumulative fuel consumption for each appliance in the residence. The manifold (main burner) pressure was measured to verify proper delivery pressure for the first ten units in the study.

For power vented applications, the flue fan was metered by using a runtime logger. The fan ran just a few seconds longer than the burner in test situations, which allowed us to proceed with assuming the fan runtime to be equivalent to burner runtime. For boiler applications, all systems fed storage tanks. The loggers either logged runtime from the tank thermostat call for heat or runtime loggers were used to meter control signals that regulated the boiler firing stages. For one application, neither of these options were available and a custom enclosure and gas manometer were used with a runtime logger to determine firing rate and runtime directly.

Domestic Water Heating Systems

Storage Tank Domestic Hot Water (DHW) Heater

Since there were no electric controls found on the standard water heater, a unique challenge was posed when determining a strategy for logging the runtimes of each unit. It was readily apparent that gas metering, though quite precise, would prove to be far too costly and cumbersome. By itself, a standard model gas meter would only have provided total gas consumption and not runtime, duty-cycle, or other data. A meter would have needed to be specified with pulse output in order to obtain additional information. The physical size, piping location, and logistics also posed concerns.

Optical sensors were also considered, though they are likely impractical to install on modern water heaters where flame arresting features do not allow for an easy access line-of-sight to the burner. Water heaters required a more innovative solution, as the lack of access to the tank thermostat signal made a runtime logger impractical.

The method used was a thermocouple inserted into the exhaust flue to log the flue gas temperature. When the temperature goes above a certain threshold, the unit is determined to be in operation. By logging 90-second intervals, we were able to ascertain how long the unit burned gas. This was then multiplied by the manufacturer gas input rate to obtain the final energy usage. Unfortunately, different units were found to have different temperatures during periods of non-use and different temperature patterns during use, making a general model of usage difficult to create.

A Type J thermocouple was attached to HOBO Microstation with an Onset 12 bit, 0-5 V input adapter to translate the flue temperature to a voltage value readable by the HOBO Microstation. The resolution of the Onset voltage input adapter is 1.221 mV, which converts to approximately 41 degrees F. The usage model initially envisioned was developed through manufacturer specifications that a flue temp of at least 140 degrees F indicated the burner was firing. Therefore, a mV value of 4.167 or greater would indicate the burner was firing and the water heater burner was in operation for the model. In the data, however, there was unexpected inconsistency between flue gas temperatures of DHW systems that required us to interpret the data from each DHW meter separately. The details of this operation are described below in the section titled Voltage Cutoff Methodology.

After removing a screw from the flue, the end of the Type J thermocouple was inserted approximately six inches deep into the flue and covered with metal tape to secure the thermocouple for the duration of the study. The HOBO Microstation data loggers recorded an instantaneous flue temperature every ninety seconds. The ninety second sample rate easily allowed for a full year of monitored data for the domestic hot water systems. The loggers were configured to stop recording data when the memory reached capacity to avoid overwriting previously collected data.

To inform the run-time data with actual gas input, the water heater nominal input Btuh was obtained from the manufacturers' specifications. The manifold (main burner) pressure was measured on several units during the pilot sites to verify proper delivery pressure. Adequate gas pressure was found at all of the pilot sites.

Figure 54 shows the typical logger installation implemented for domestic waters with a convention flue. Homes with multiple water heaters were addressed with multiple data loggers.

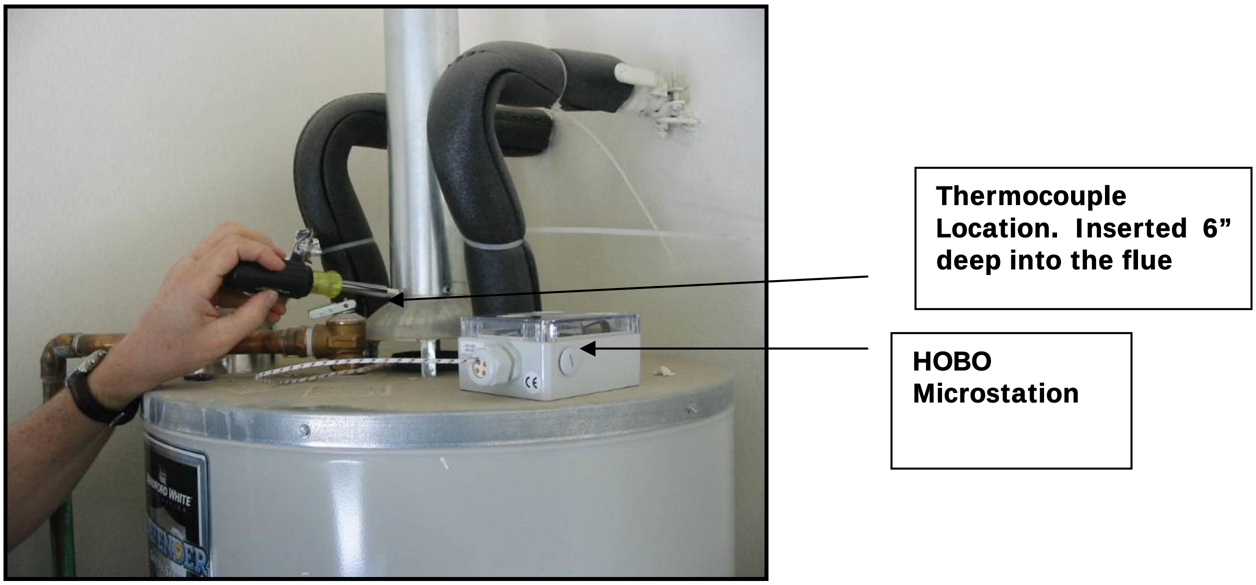


Figure 54: Domestic Hot Water Data Logger Installation

Storage Tank DHW Heater with Powered Flue Gas Venting

For power vented applications, the flue fan was metered by using a runtime logger. The fan ran only slightly longer than the burner in test situations, which allowed us to assuming the fan runtime to be equivalent to burner runtime. The gas input for the water heater was combined with the runtime of the venting fan to determine usage for power vent water heaters.

A power vent was provided to RLW by a tank manufacturer to help develop a monitoring plan for this application. The plan consisted of opening the fan controller which is illustrated in Figure 55. The fan was powered with a standard smaller gauge wire and ground wire. A small relay was spliced into the fan connections and the connections were secured and tugged to ensure the connections would hold for one year. An enclosure was used for the logger and relay such that only the wires being spliced into the fan connections would need to penetrate the fan control enclosure. Permission was granted to leave the relay and connections in place for all of these applications, allowing us to simply remove the data logger from the enclosure along with its connection cable to the relay.

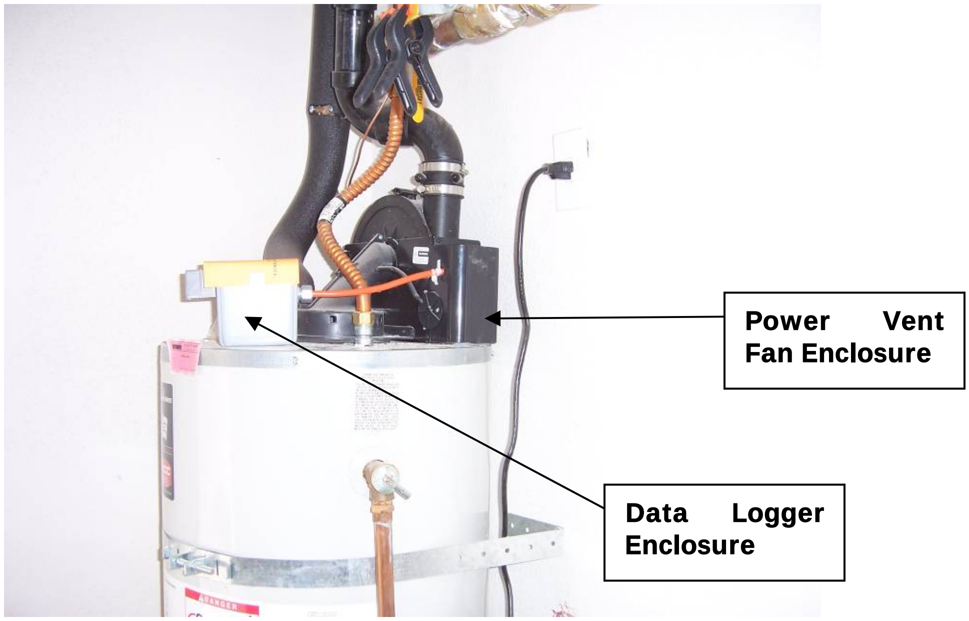


Figure 55: Power Vent Water Heater Logger Installation

Central Boiler

For boiler applications, all systems fed storage tanks. The loggers either logged runtime from the tank thermostat call for heat or runtime loggers were used to meter control signals that regulated the boiler firing stages. For one application neither option was available and a custom enclosure and gas manometer were used with a runtime logger to determine firing rate and runtime directly.

All the configurations in the study consisted of two multi-stage gas fired boilers feeding a common storage tank. These systems typically served a single building on site or in one case the entire site. The metering strategy was to log both boilers in this configuration to determine total gas consumption at the building level and allocate the usage to the rest of the building onsite based on the square footage of the buildings on site. The metering approach allowed us to determine runtime and the number of stages firing to determine the gas input during each run. The configuration and logger location are illustrated in Figure 56.

Figure 56: Boiler Logging application

Water Heating Data Analysis

Voltage Cutoff Methodology

A combination of low temperature resolution (the meters could only record the outputs from the thermocouples in 40˚F increments) and unexpected inconsistency between flue gas temperatures of standard water heater with conventional flues required us to interpret the data from each unit individually. The raw data, ranged from 0.006 V (30˚F - 70˚F) to 0.0153 V (518˚F - 559˚F). For each unit, a threshold voltage had to be selected in order to determine what flue gas temperatures to consider "on" times versus "off" times. There was no common threshold that could be used for all of the water heaters because each data set had different burn temperatures and baseline temperatures. Therefore, each water heater's cutoff was assessed individually to ensure accurate estimation of burn times.

The methodology began with importing the metered data for each water heater into Visualize-IT®, a Windows application developed by RLW Analytics. The software was designed to help summarize and analyze time series interval data. . Next, we found the typical burn temperature and baseline temperature by observing the data. Figure 51 shows the raw data of water heater 2786 as an example. It shows that during a typical burn the thermocouple measurement for this site was 0.0079 volts and the baseline measurement was 0.0018 volts.

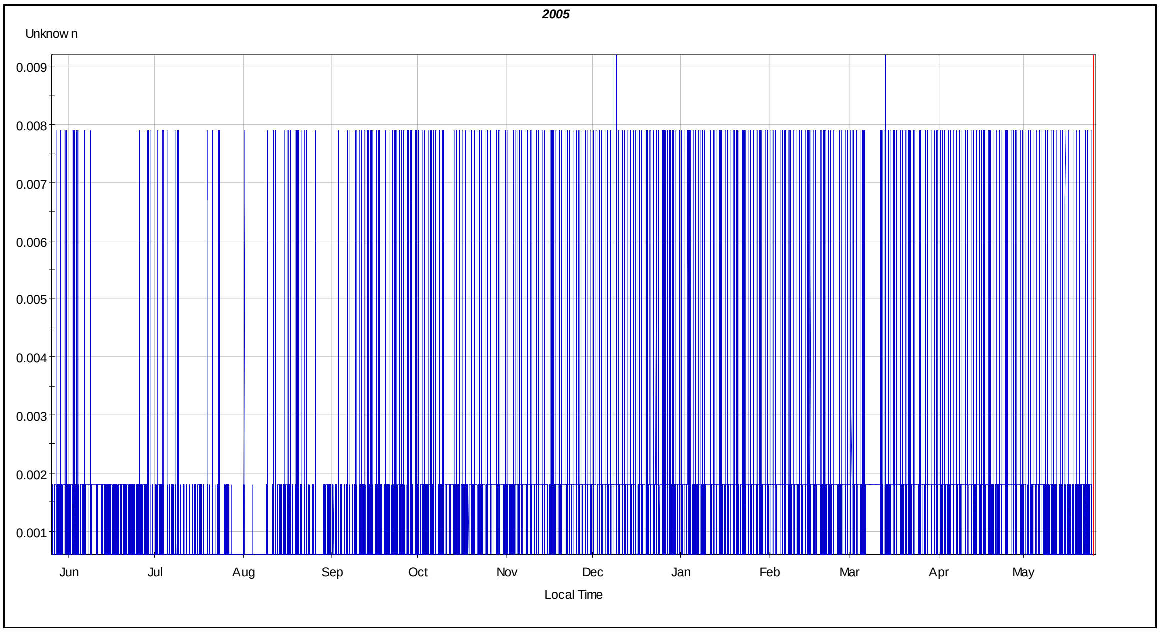


Figure 57: Water Heater 2786 Baseline and Burn Measurements

This was enough to characterize some of the units, but for most using the typical burn temperature as the threshold would not include the intermediate readings directly before a burn when the either the flue gas has not reached peak temperature yet. When the water heater burner has just cycled on, the measurements will be somewhere in between the average burn temperature and the baseline, but these intermediate voltages must be accounted for as burning time. However, there will also be intermediate measurements after the water heater has finished burning and the flue is cooling down that should not be included in burn time. Furthermore, this approach accounts that the measurements recorded are average readings over a 90-second period, and thus average some baseline readings in with burn readings at the beginning and end of a burn cycle. By counting the entire intermediate pre-burn period as burn time, and not counting the post-burns, the two should average out in the annual usage totals.

First, the regular threshold was typically chosen to be one measurement below the typical burn measurement. This helped account for minor fluctuations in measurements during a burn, as well as lower temperature burns. All observations equal to or greater than this threshold were labels as "burn" periods.

Next, in order to eliminate the intermediate post-burn temperatures and include the intermediate pre-burn temperatures measurements above the baseline temperature, but below the threshold were selected to be included in total burn time as well if they occurred directly before a period with above-threshold measurements. That is, observations above the baseline were labeled as burn periods if they occurred immediately before a definitive burn period.

To illustrate how this methodology worked under different scenarios, two water heaters are presented here as examples for analysis: water heater 2803 and 2786.

Figure 51 shows the Visualize-IT® results of water heater 2786 as an example. It is obvious that the average burn temperature measurement for this site is 0.0079 volts and the baseline temperature measurement is 0.0018 volts. Occasionally, the average burn temperatures were not so obvious, as illustrated in Figure 58 for water heater 2803. The average burn temperature could be 0.0116 volts or 0.0104 volts. For these cases, the lower burn temperature was selected as the threshold temperature. On the other hand, if the baseline had multiple values, then the highest baseline measurement was chosen. The baseline was 0.0031 volts for water heater 2803. It is not immediately apparent in Figure 58, but there are two potential baselines, 0.0018 and 0.0031. The higher of the two was selected.

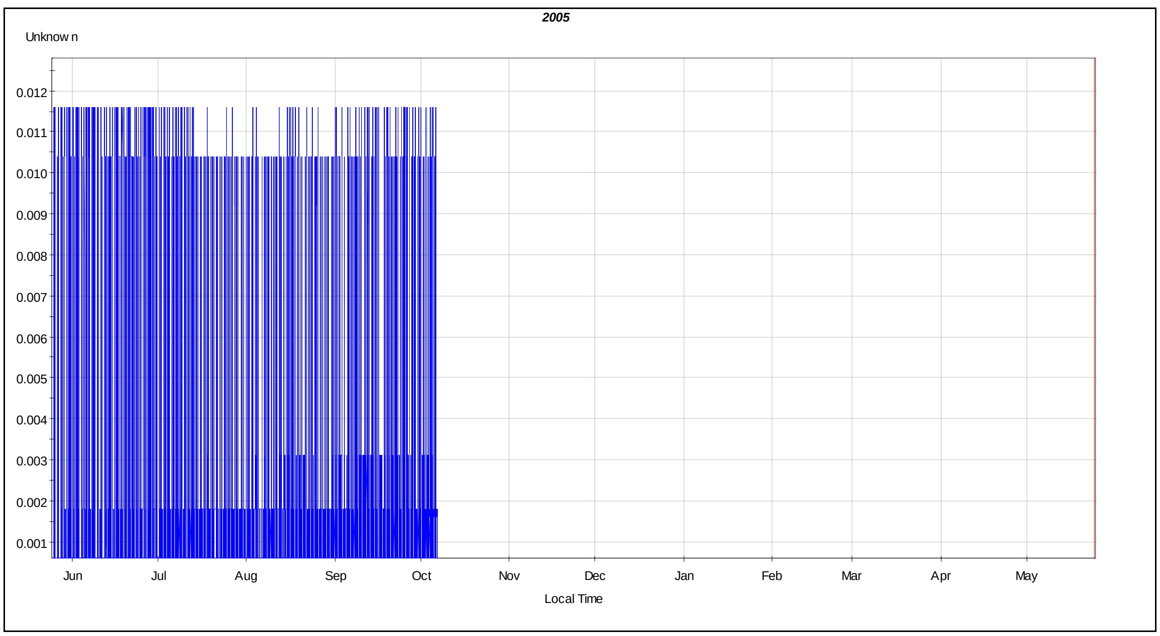


Figure 58: Water Heater 2803 Multiple Average Burn Measurements

Next, the threshold was selected for each unit. The burn threshold for unit 2786 would be selected one measurement below the typical burn measurement of 0.0079 volts, or 0.0067 volts. An example of a fluctuating burn temperature is shown in Figure 59. The cutoff was 0.0092 volts for water heater 2803, or one measurement below 0.0104 volts.

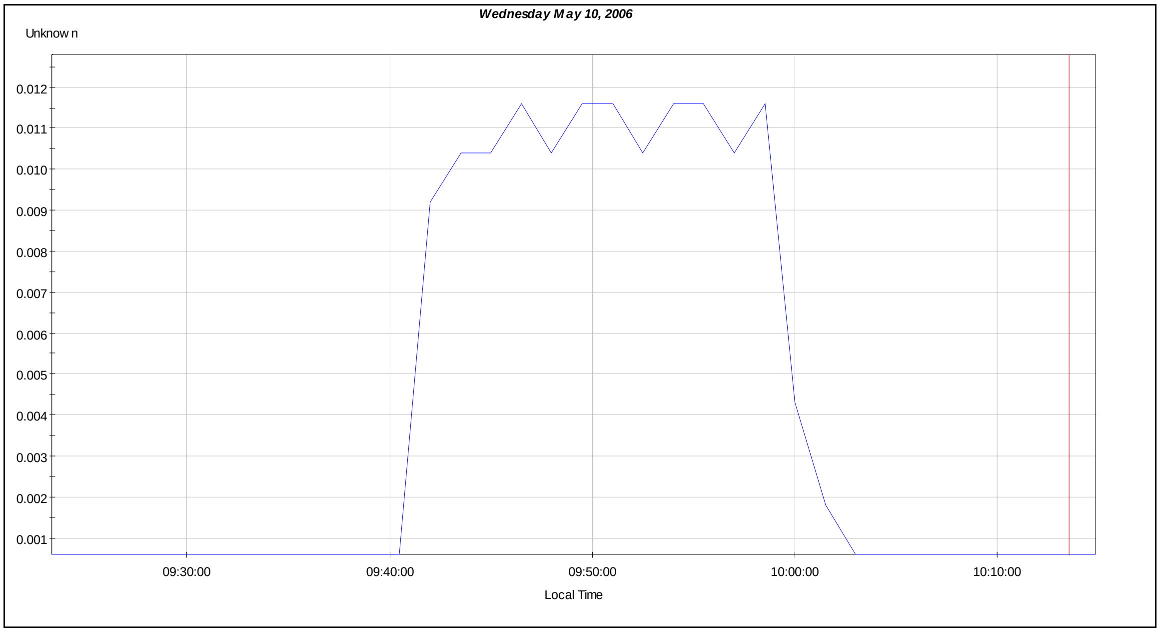


Figure 59: Burn Fluctuation Temperatures

Next, we determined any observations that should be included as pre-burns. The burn threshold for water heater 2786 was 0.0067 volts and the baseline 0.0031, as mentioned earlier. This means any measurement of 0.0043 or 0.0055 that occurred in the two measurements before a burn was included as burn time. Figure 60 shows intermediate measurements before and after the burn. There is a 0.0055 volt measurement as the water heater is turning on and a 0.0031 volt measurement after the water heater turns off. The 0.0055 measurement is included, and the 00031 measurement is not. Also note that if there was a 0.0055, followed by a 0.0018, followed by a 0.0067, the 0.0055 would not be included since it is not consecutive.

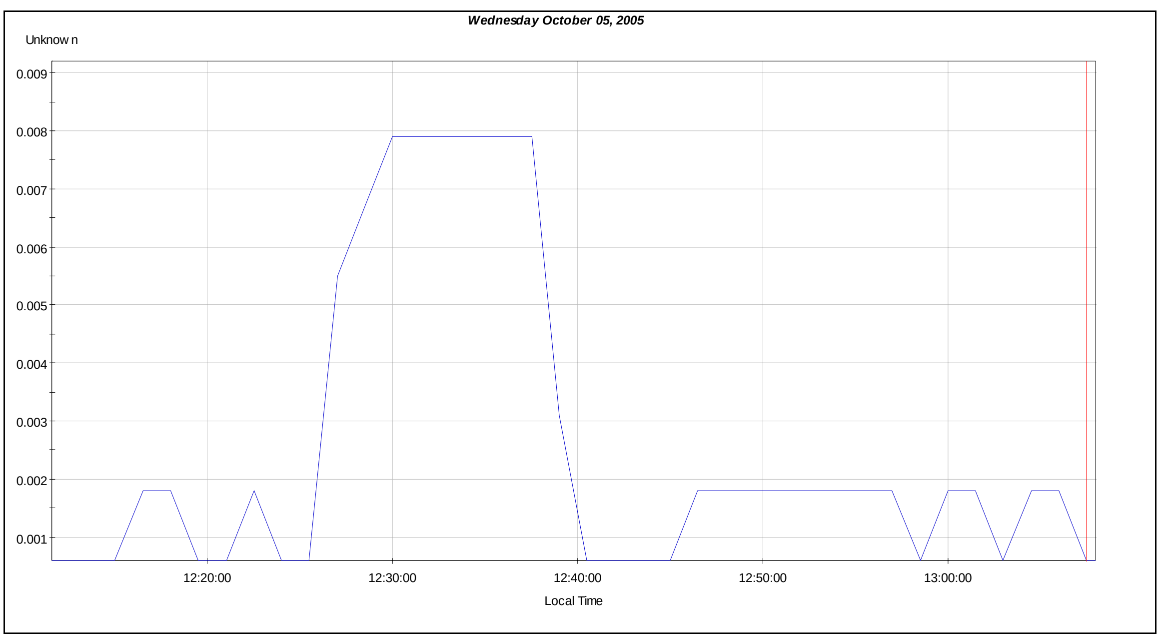


Figure 60: Water Heater 2786 Intermediate Measurements

Figure 61 shows a water heater where there is an intermediate temperature, 0.0031, not followed by a burn and is therefore not included.

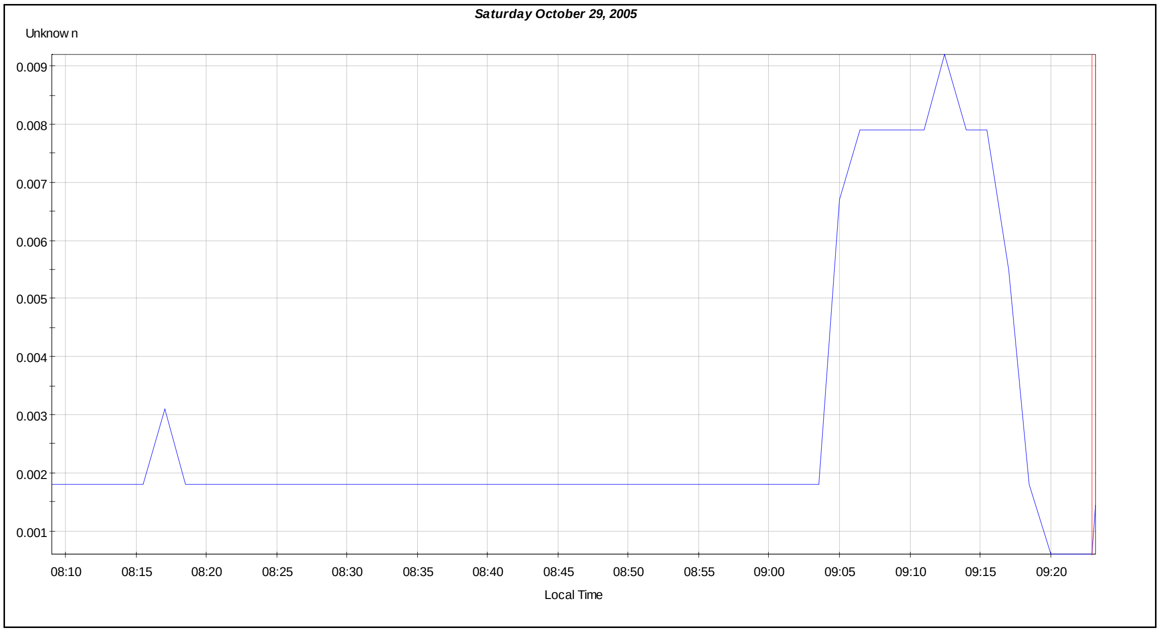


Figure 61: Intermediate Measurements Not Included in Burn

This methodology was applicable to approximately 96% of the water heaters. There were also a few water heaters that had the baseline or typical burn measurements change by season and those were accounted for in the analysis.

The remaining 4% of the water heater were examined more closely because either the baseline or typical burn measurements were not clear, or because there was too small of a measurement range. Water heater 16381 is shown in Figure 62 and there are only three measurements, 0.0006 volts, 0.0018 volts, and 0.0031 volts. The 0.0018 cannot be considered a burn because if we zoom in on a series of 0.0018 measurements, as in Figure 63, most of them bounce between the two measurements. The 0.0031 measurement could be considered a burn, but that would indicate the water heater only operated about ten minutes for the entire year, which is unreasonable. In this case, the water heater will not be included in the analysis set since there is no way to determine a reasonable threshold.

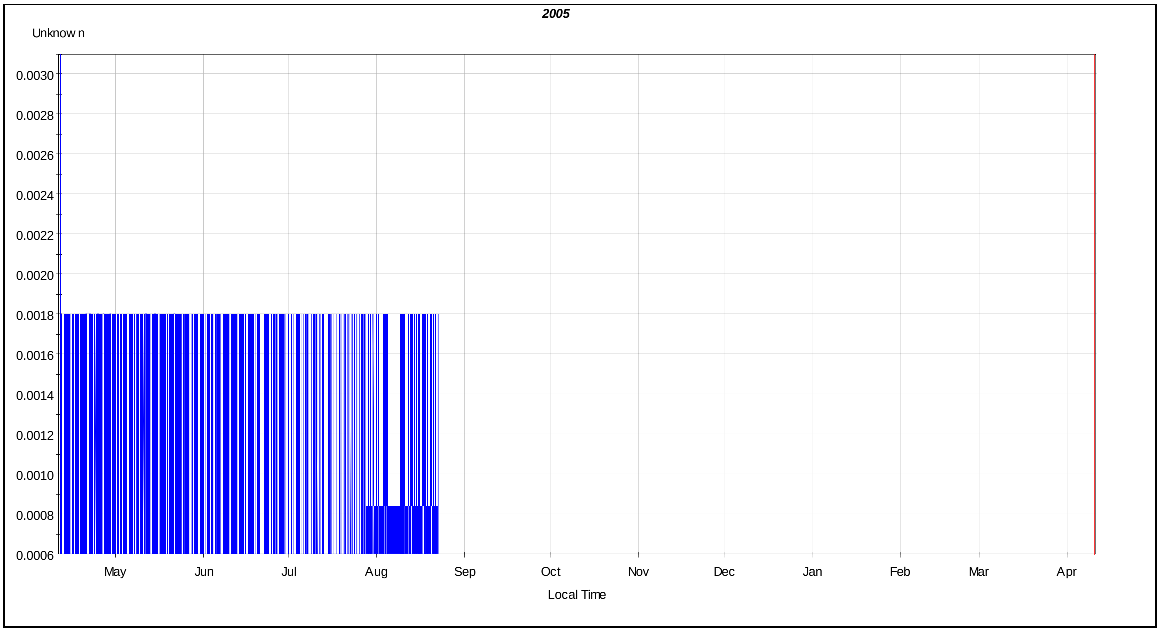


Figure 62: Water Heater 8562 Small Measurement Range

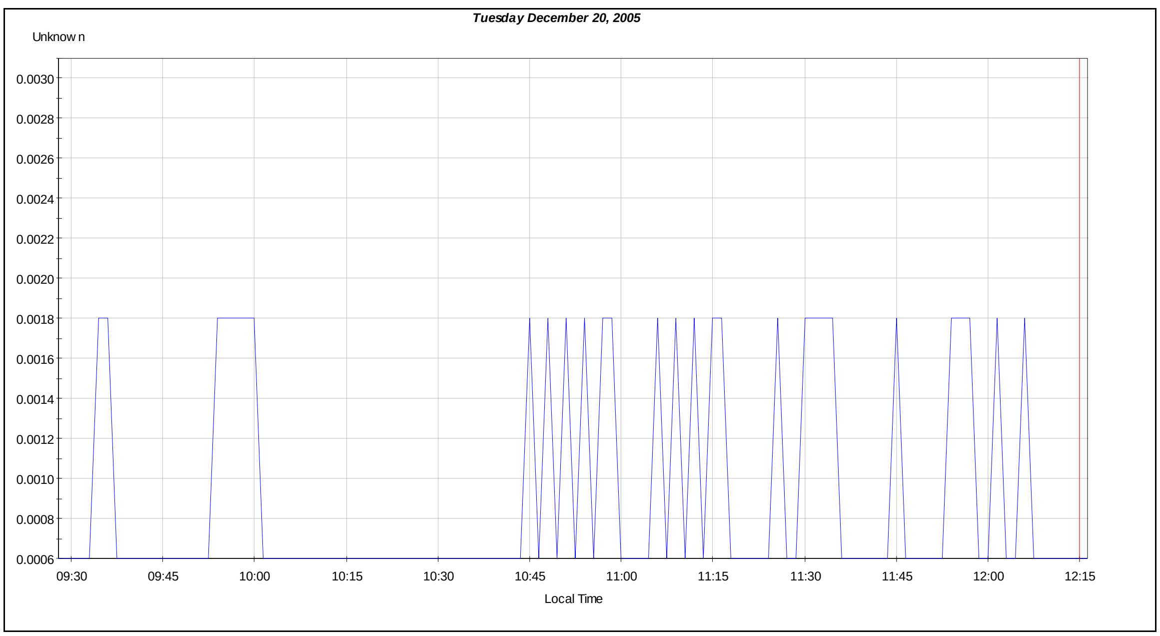


Figure 63: Water Heater 8562 Measurement Fluctuations

Based on the baseline and typical burn measurements, total usage time was calculated for each day of meter data; each "on" measurement counted as 90 seconds of water heater usage. This daily usage time was multiplied by the input rating of each site's water heater to yield the total kBtu used per day. For the adjustment factor analysis, these daily totals were summed for the 365 days following the meter installation date to yield an annual total usage for the study period.

Space Heating End Use Energy

The space heating study period extended from spring 2005 through fall 2006 for all locations. This provided data throughout the heating season. Gas furnaces, present at 100 single family sites and 23 multi-family sites, were monitored in a fairly straight-forward manner, using a runtime logger to record the percentage of each 20-minute period that the furnace was running. Using manufacturer input rates, we could compute the amount of gas burned in any given hour. A handful of sites had loggers set to a 15-minute logging period that only captured 11 months of data and had to be dealt with separately.

Space heating systems for multifamily dwelling units were expected to have several configurations based on initial reviews of ESH plans. Hydronic heating using storage water heaters were the most typical system configuration and were metered identically to domestic hot water heaters that were not used for space heating. Fan units for hydronic heating systems were inaccessible for any available runtime loggers or current transducers. The data analysis developed a methodology to determine if water heating energy was attributed to the space heating or domestic hot water end uses. Forced air furnaces were metered using the single-family protocol. Heat pumps were logged similar to AC and the data were analyzed to determine if the energy consumption was attributed to heating or cooling end-uses. Custom plans were developed for the small number of gravity wall furnaces and electric resistance baseboard heaters.

Heating Systems

Forced Air Furnace

The proposed monitoring plan was oriented towards single family residences that have forced air heating systems with low voltage (24 VAC) thermostats and a separate call for heating terminal in the heating control system. Inside the air handler section of each furnace there is a low voltage (24 VAC) control board with a terminal block consisting of separate relay contacts for heating, cooling, and fan operation. Upon receiving a call for heat signal from the thermostat, the heating relay contact undergoes a change of state resulting in the operation of the furnace.

The gas input and fan power draw was taken from nameplate data and applied to the unit runtime to determine energy consumption. By "slaving" a small relay off of the call for heating circuit we were able to precisely log the duration of a heating cycle. The relay contact change of state indicated runtimes. Owl 200 data loggers were used for central forced air furnaces. Considering the safety concerns and difficulty of measuring natural gas consumption, a unique approach was necessary to capture the forced air furnace run-time.

Figure 2 shows the typical logger installation implemented for forced air furnaces. For two stage heating units, we installed a second relay and OWL 200 to capture run-time for each stage. For multiple furnaces at a site we installed a logger for each furnace.

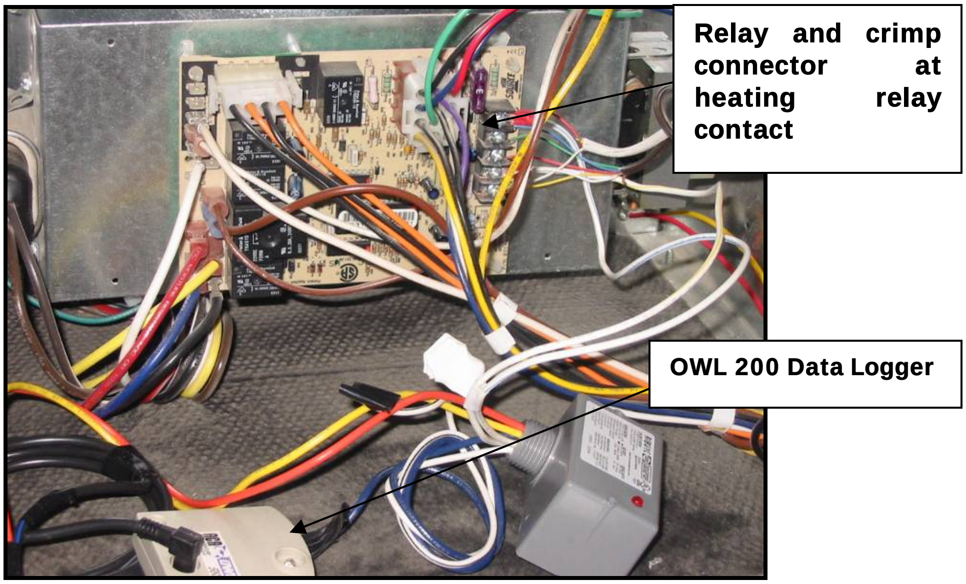


Figure 64: Forced Air Furnace Data Logger Installation

Initially, the main burner gas pressure was tested at each of the first ten units in the study to verify that the gas supply pressure was within the manufacturer's specifications. This was performed and consistently demonstrated that the gas supply pressure was sufficient. It was at that point that we confidently used the nameplate BTU/hour rating for the fuel consumption.

The Owl 200 data loggers were configured to instantaneously sample the heating circuit state every eight seconds, "on" or "off", store the sampled data in temporary memory, and record the average of the eight second readings at twenty minute intervals. So the final stored data was percent time "on" during each 20 minute interval. The 15 minute monitoring interval allowed us to gather more than a full year of heating run-time data. The loggers were configured to stop recording data when the memory reached capacity to avoid overwriting previously collected data.

The furnace nominal gas input rate (Btu/h) was obtained from the manufacturers' specifications and utilized to inform the run-time data with actual gas input. During the pilot sites the main burner gas pressure was tested at each furnace unit to verify that the gas supply pressure was within the manufacturer's specifications. By doing this, we demonstrated that the gas supply pressure is sufficient and RLW can confidently use the nameplate input Btuh rating for the fuel consumption calculations.

Heat Pump

The methodology for metering and analyzing split system and through-wall heat pumps is contained in the cooling end use section.

Hydronic Heating System

Hydronic heating using storage water heaters were the most typical multifamily heating system configuration and were metered identically to domestic hot water heaters that were not used for space heating. Fan units for hydronic heating systems were inaccessible for any available runtime loggers or current transducers as the power box cover was not removable, Figure 65. The data analysis developed a methodology to determine if hot water usage was attributed to the space heating or domestic hot water end uses. The analysis methodology of this separation is discussed below in the section Hydronic Separation Methodology.

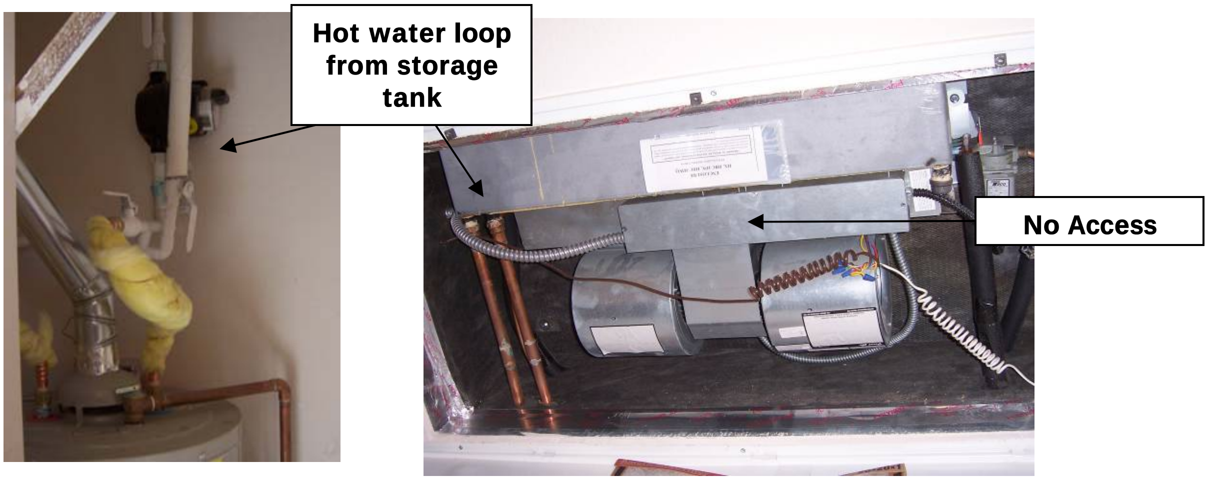


Figure 65: Hydronic Fan Coil Unit

Wall Furnace

A custom monitoring plan was developed for the one site with wall furnaces. A SmartReader 7 data logger was employed since it allows input at different voltage and amperage ranges. The system was initially tested with a digital multimeter to determine the low voltage signals to the gas control valve from a controller mounted on the wall next to the unit. The furnace had one firing rate so the loggers would be used to determine runtime directly my monitoring the opening and closing of the gas valve. The installation at the gas valve is shown in Figure 66. Runtime data were applied to nameplate gas input rates similar to forced air gas furnaces.

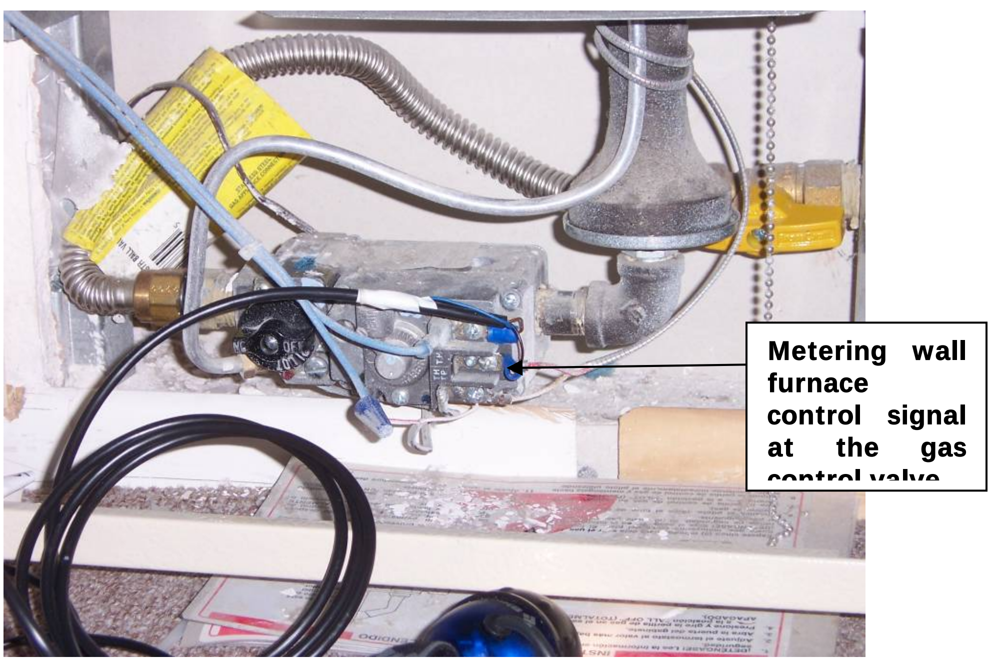


Figure 66: Wall Furnace Installation

Electrical Resistance Heater

A custom monitoring plan was developed for the one site with electric baseboard heaters. There was no access at the hard-wired heaters themselves. The monitoring plan employed a strategy to monitor the heaters at the dwelling unit's electrical panel. Since this heating system type was only present at one multifamily sample site (four metered units) Figure 67 shows the heaters and the lack of access at the unit and Figure 68 shows the electric panel and identification of the heater circuits that were logged in the study.

Since energy consumption of the unit was measured directly and any fan energy associated with the any of the units was included in the data no additional analysis techniques were required, similar to through-wall air conditioners.

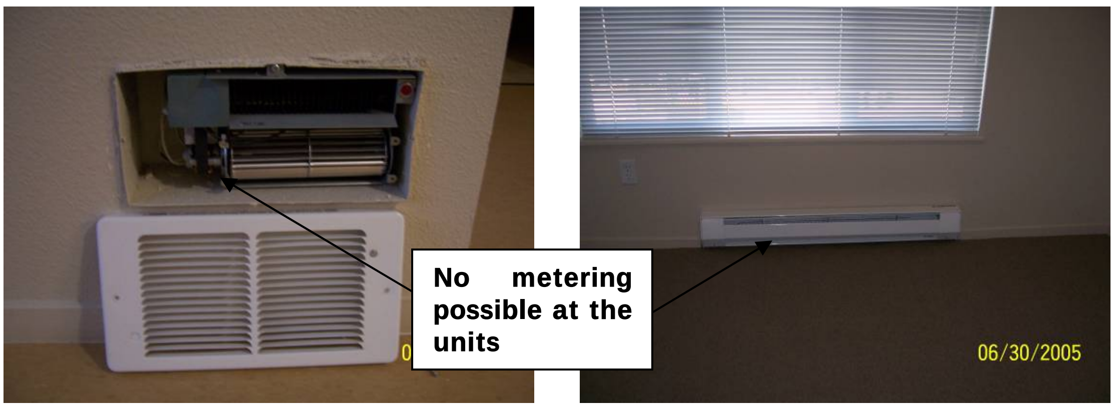


Figure 67: No Metering Possible

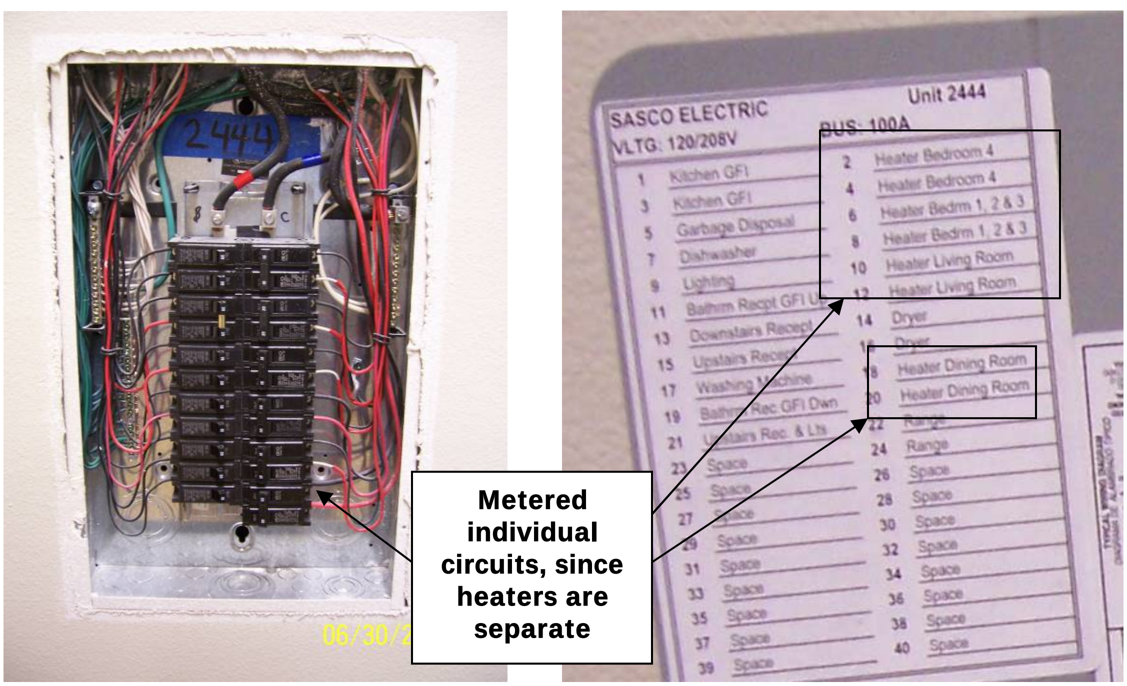


Figure 68: Metered Individual Circuits

Heating Data Analysis

Filling in values for missing dates: Meter Data on Furnaces

During the initial phase of the study, a miscalculation resulted in meters being installed with a 15-minute logging period instead of a 20-minute logging period. This resulted in a total of 27 sites having furnace meter data available for strictly less than a full year. In particular, data for these sites were not available for most of the 12th month of the metering period. For the sites with less than 12 months of data, an average of 22.67 days of data were missing.

We considered several econometric models to see which model predicted the missing data most accurately. A big percentage of usage data (slightly over 85%) had values equal to 0. The predictive capabilities of the models were tested first by including, and then by excluding all zero values. The following five models were considered:

Model 1: The initial model that we considered was:

$Total\ Load_{SITE,\ DAY\ OF\ THE\ WEEK,\ HOUR} = \beta_0 + \beta_1 * HDD.$

This model could not be run because there were not enough values for all 'day of the week' and 'hour' groups for all sites. More than 85% of the hourly usages were 0s, and there were often subgroups where all dependent values in the regression were 0.

We modified the model by replacing "Day of the week" by a "Weekday/Weekend" indicator. Even after this change with a much broader classification, enough number of values was not present for all categories. As this model (or its modification) could not be used for all groups and sites, it was not finally used.

Model 2: The second model considered was:

$$Daily\ Total\ Usage_{SITE} = \beta_0 + \beta_1 * Average\ Daily\ Temperature.$$

Model 3: We then considered a minor modification of the same model:

$$Daily\ Total\ Usage_{SITE} = \beta_0 + \beta_1 * Average\ Daily\ Temperature,$$

ignoring all records where daily total usage = 0.

Model 4: The fourth model that we considered was:

$$Daily\ Total\ Usage_{SITE} = \beta_0 + \beta_1 * Total\ Daily\ HDD,$$

using 55 degree Fahrenheit as the reference point, and including all records in the regression.

Model 5: The fifth model considered was:

$$Daily\ Total\ Usage_{SITE} = \beta_0 + \beta_1 * Total\ Daily\ HDD,$$

using 55 degree Fahrenheit as the reference point, and ignoring all records where daily total usage = 0.

We compared the actual values to the predicted values from the last four models applied to the 72 sites with a full year of data in order to determine which model would provide the best predicted values. Since data is missing for the month of April for most of the sites with missing time periods, we decided to use the model that provides the best predictions for April. For this purpose, we compared our April predictions from the last four models to the actual usages in April for the remaining sites for which data is available for 12 months, including the month of April.

Comparisons between actual and predicted daily total usages for two selected sites, for which April usage data are available, are shown in the following two visualize-IT diagrams. As can be seen from the diagrams, model 2 forecasts values that are closest to the actual values. We therefore used model 2 to predict values for all sites with missing values.

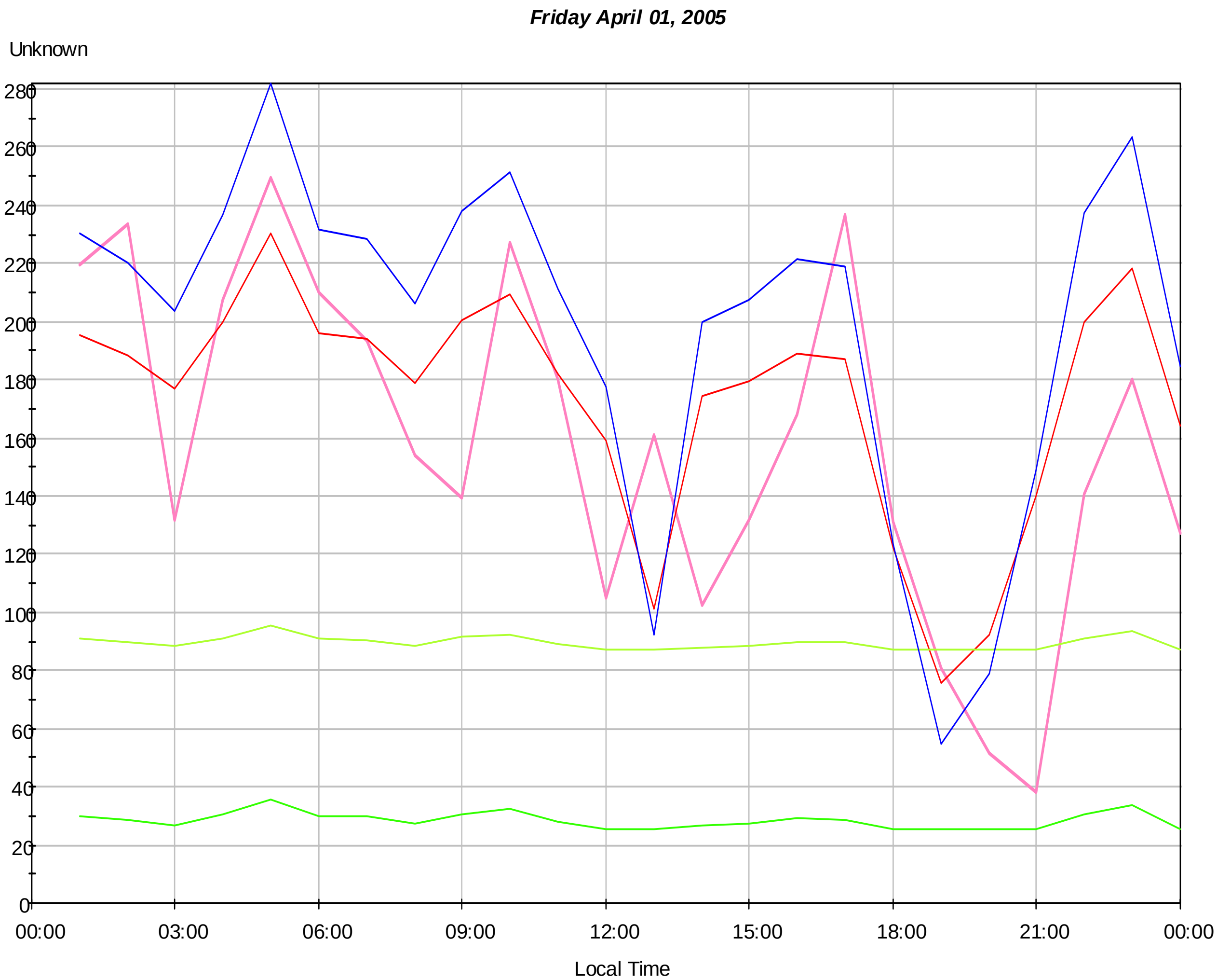


Figure 69: Site SF2722 (Pink -Actual, Red - Model 2, Blue – Model 3, Light Green – Model 4, Darker Green – Model 5)

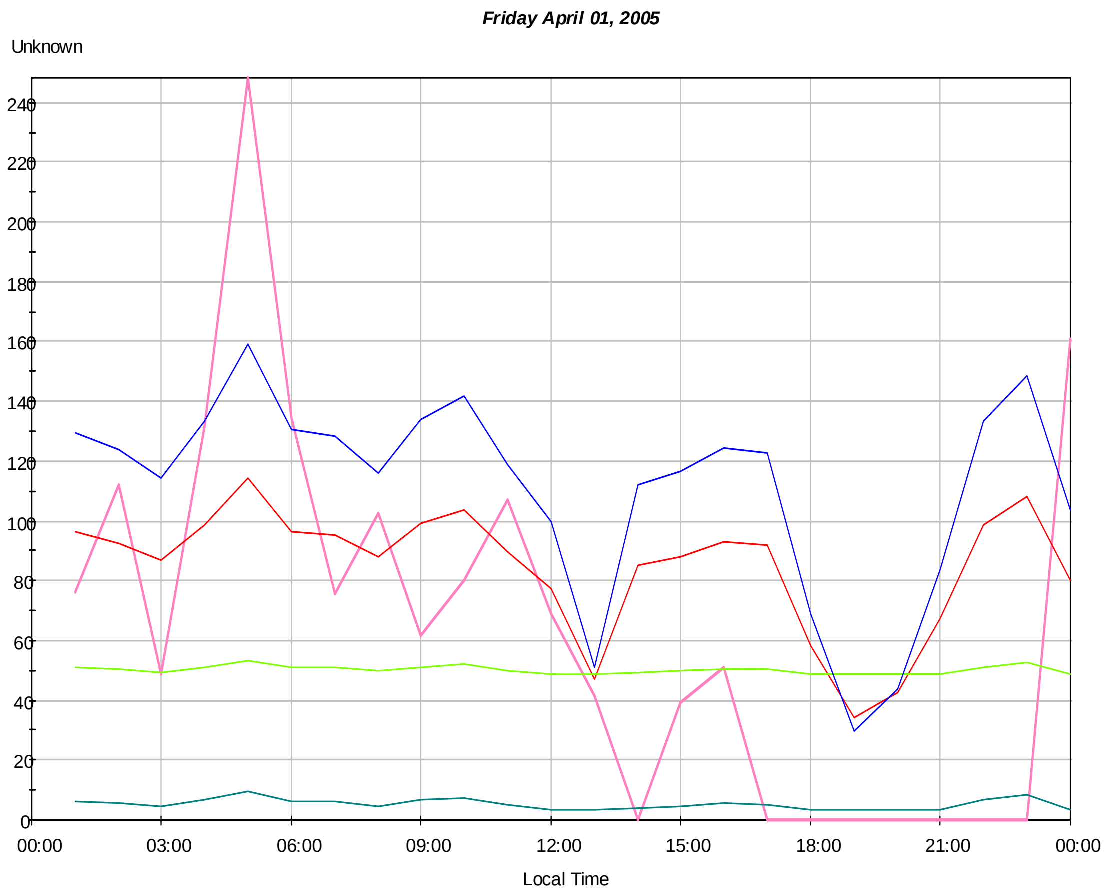


Figure 70: Site 2414 (Pink -Actual, Red - Model 2, Blue – Model 3, Light Green – Model 4, Darker Green – Model 5)

Table 98 shows the values of the coefficients from our regressions and the associated R-squares from the four models that we considered. As can be seen both from the diagrams and also from the results below, model 3 is generally inferior to model 2 (lower R*sq*), and model 4 in most cases can explain better than model 5. Although model 4 has higher R*sq* s (than model 2), the same model when ran for other sites (for which we already have data for 12 months) on average produced predictions slightly worse than model 2 for the month of April. Model 2 predicts the fluctuations in the daily total usages slightly better for the month of April, and was therefore chosen to predict the missing usage values for the 27 sites with less than a year's worth of data.

	Model 2			Model 3			Model 4			Model 5		
Site	Intercept	Coeff	R-sq	Intercept	Coeff	R-sq	Intercept	Coeff	R-sq	Intercept	Coeff	R-sq
1	571.56	-5.83	0.3400	563.98	-5.67	0.3303	164.79	0.76	0.4931	167.99	0.74	0.4935
2	474.52	-6.52	0.5578	556.64	-7.79	0.4030	27.55	0.74	0.6300	83.53	0.53	0.4831
3	89.71	-1.23	0.2768	202.86	-3.17	0.1439	-1.11	0.19	0.3839	22.69	0.15	0.1275
4	205.83	-2.79	0.5769	423.15	-6.93	0.6632	-0.76	0.43	0.7948	14.92	0.37	0.6055
5	211.56	-2.87	0.5105	430.33	-6.93	0.5859	-1.93	0.45	0.7305	16.22	0.40	0.5502
6	675.22	-8.73	0.6983	823.41	-11.37	0.5937	55.10	1.00	0.5315	123.21	0.68	0.3517
7	1023.71	-13.62	0.5457	1621.31	-24.23	0.4494	42.75	1.74	0.5125	208.98	1.17	0.2924
8	226.36	-3.09	0.5348	520.60	-8.66	0.6852	-3.33	0.49	0.7718	23.90	0.40	0.5576
9	376.44	-5.14	0.4176	806.37	-12.79	0.3448	-0.94	0.75	0.5226	88.91	0.53	0.2432
10	66.65	-0.93	0.0837	726.61	-12.87	0.5079	-4.50	0.17	0.1711	-30.78	0.63	0.3909
11	280.37	-3.75	0.3267	346.61	-4.51	0.0716	8.71	0.50	0.3323	86.68	0.22	0.0520
12	239.53	-3.25	0.4138	478.37	-7.32	0.3382	1.75	0.47	0.4999	64.52	0.30	0.2277
13	227.90	-3.11	0.4142	471.88	-7.50	0.3014	-2.16	0.48	0.5617	46.75	0.33	0.2316
14	246.41	-3.34	0.5365	487.85	-7.81	0.5732	1.67	0.48	0.6416	41.69	0.35	0.3957
15	236.04	-3.21	0.5321	512.51	-8.33	0.6906	-1.34	0.49	0.7031	41.03	0.36	0.5235
16	195.18	-2.66	0.3230	591.27	-9.88	0.4197	-1.53	0.41	0.4410	25.24	0.47	0.3737
17	260.36	-3.45	0.4133	463.62	-6.81	0.3167	11.97	0.44	0.3829	77.93	0.26	0.1602
18	478.95	-6.42	0.5896	746.52	-11.18	0.4242	13.85	0.86	0.6029	115.52	0.44	0.2430
19	448.83	-6.07	0.5808	913.99	-14.89	0.6354	4.44	0.88	0.6952	68.24	0.63	0.4195
20	181.18	-2.44	0.4398	285.55	-4.10	0.2142	3.57	0.34	0.4768	54.68	0.17	0.1457
21	226.42	-3.12	0.3359	604.91	-10.08	0.3346	-4.68	0.49	0.4763	38.38	0.43	0.2605
22	1485.50	-19.38	0.1307	37.78	19.05	0.0143	151.98	1.65	0.0553	1462.43	-2.94	0.0803
23	323.87	-4.37	0.5042	571.43	-8.81	0.3803	4.75	0.62	0.5784	70.10	0.38	0.2652
24	425.81	-5.82	0.4290	869.78	-13.64	0.3259	-4.42	0.89	0.5868	97.33	0.60	0.2604
25	784.34	-10.47	0.0850	1395.86	-3.04	0.0004	25.09	1.41	0.0875	1177.29	0.40	0.0024
26	477.22	-6.23	0.5883	683.57	-9.68	0.4719	12.40	0.88	0.7208	89.04	0.62	0.5150
27	572.64	-7.56	0.5557	929.12	-13.92	0.4956	2.63	1.14	0.7667	77.15	0.88	0.5365

Table 98: Intercepts and Coefficients from the Four Models

Once all sites had 365 days of actual or predicted data, average daily usage times were calculated for each. These times were then multiplied by the input rating of the furnace to yield daily kBtu usage. For the meter adjustment factor estimation, these daily usages were aggregated into annual kBtu heating usages for the 365 days following the meter installation date.

Hydronic Separation Methodology

In order to compare the meter data to the compliance model outputs, hydronic systems' usage had to be broken out into its component end uses. The systems' usages were first estimated using the same techniques as with normal domestic hot water systems. Figure 71 shows the total system energy use for a typical hydronic system. Summer usage, lasting for this unit from May – November, is fairly flat. During the heating season, there is a much larger range of daily usages, reflecting the variable demand for space heating over the winter months. To separate how much of this winter energy usage was for space heating, we had to develop a baseline hot water usage that could be applied over the heating-season months.

To develop this baseline, RLW took the three lowest monthly usages from the summer months with more than 10 days of usage. An average daily water heating usage was then calculated by summing the lowest three months and dividing by the total number of days in those months.

An examination of the single family domestic water meter data and the data from non-hydronic water systems in multifamily units found that there was a significant difference between average daily water heating energy demand in the six winter months (November – April) and the energy demand for water heating in summer months (May – October). A ratio analysis conducted on that data concluded that energy usage for water heating was 63.3% higher in winter months than in summer months, at a relative precision of 2.4% at the 90% level of significance. Therefore, the average daily hot-water usage baseline was scaled up 63% during the winter months to account for this difference.

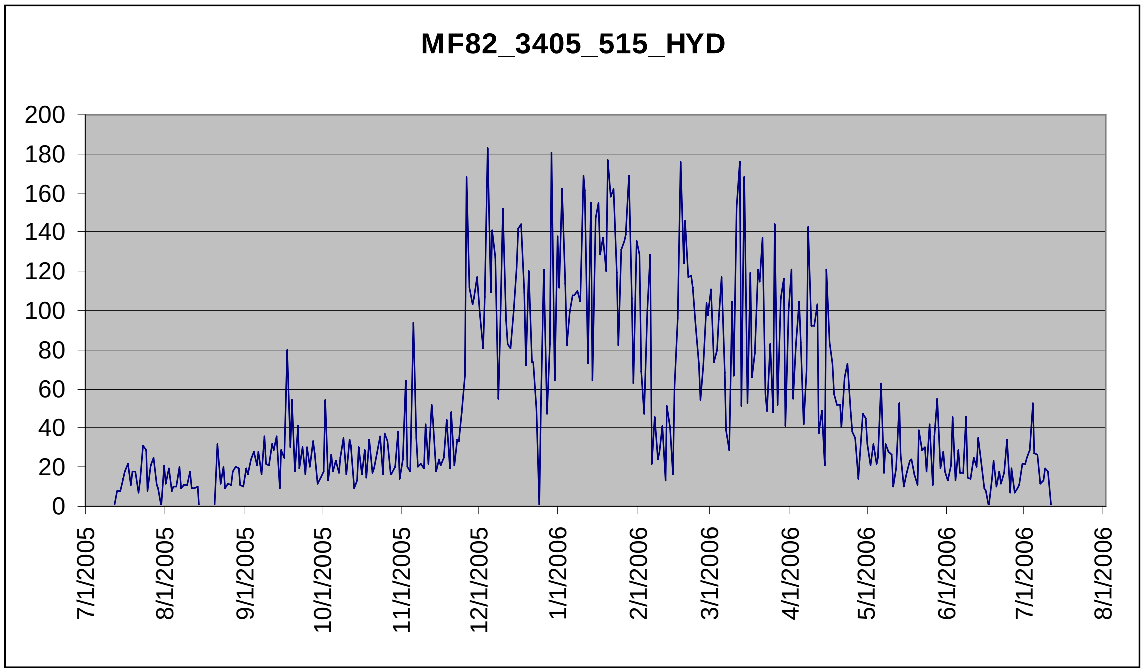


Figure 71: Total Hydronic Energy Usage

The raw data were then grouped into weekly usages. Weekly water heating was determined by comparing the total weekly energy usage to seven times the average daily baseline water heating usage, and taking the lesser of the two. During a mid-summer period defined as Jun 15 – Sep 15, we assumed no space heating occurred, and all usage was considered water-heating. The heating use was calculated by subtracting this weekly water usage from the weekly total usage. Figure 72 shows the weekly space heating and water heating usages estimated for the unit shown in Figure 71. The higher winter-time water heating usages reflect the 63% higher water-usage baseline used during these months.

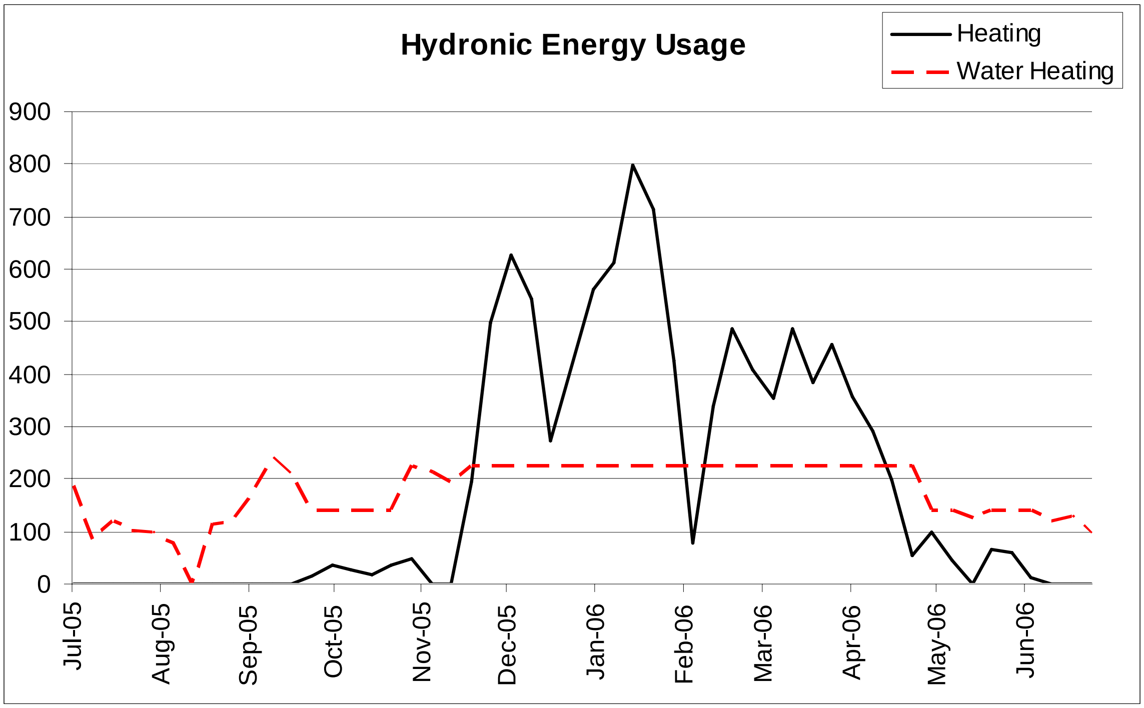


Figure 72: Average Weekly Heating vs. Water Heating Energy Usage

The two end uses were then totaled across one full year, starting the day after the site's meter was installed. The resultant annual heating and annual water heating usages were then included in the adjustment-factor ratio estimation.

Heating Fan Energy

Energy consumption of blower fans for central heating systems was not metered explicitly. The cost was prohibitive to meter fan power draw at each site and the Title 24 compliance model energy use only includes fan energy associated with the system when it is in heating mode and not when the fan is being used independently. Due to these factors the fan was assumed to draw constant power during the logging period. The runtime for heating and air conditioning systems was then multiplied by the fan power draw to determine fan energy consumption.

Furnace runtime was measured explicitly and PTHP and PTAC have fan energy included in the logged data. Heating runtime for heat pump systems was calculated using the data and equipment performance curves.

Heat Pump Heating Runtime

The primary input data in the determination of runtime at one minute intervals is the logged amperage data and the cooling system performance curve used to determine the instantaneous power draw of the unit at a given outdoor temperature and indoor temperature and humidity. Ambient temperature used hourly weather data at nearby weather stations. Evaporator inlet wet bulb temperature was assumed to be at the ARI standard condition of 67 F. The key data inputs are below.

AMP = Average Amp data, 20-minute interval (OWL Data)

odb = condenser inlet dry bulb temperature (°F) (Hourly Data)

Combining these data with the nominal system efficiency and nominal heating capacity allowed the use of the DOE-2 cubic performance curves for split system heat pumps. The HSPF for each system was determined from the ARI Database of system efficiencies based on the particular condenser and coil match. The HSPF is the seasonal amount of heating delivered in kBtu/h divided by the power input in kW at the standard condition of 47 F odb. The nameplate data and conversion calculations are as follows for system capacity and efficiency.

Tonnage = nominal system capacity in tons (Based on nameplate and matching)

Capacity = 12000•**Tonnage** (Btuh)

HSPF = System efficiency at standard conditions (Based on nameplate and matching)

EIR47=1/(0.4***HSPF**)

The cubic performance curves for heating delivered and energy input ratio as a function of condenser entering dry-bulb temperature (odb) are presented below.

SYSHEAT = **Capacity**•[0.253761 + 0.010435•(**odb**) + 0.000186•(**odb**)^2

-1.50E-06•(**odb**)3]

HEATEIR = EIR47•[1.563358 + 0.013069•(**odb**) + -0.001047•(**odb**)^2

+1.089E-05•(**odb**)3]

The results are then translated into power draw by multiplying the energy input ratio by the amount of cooling delivered and converting the units back to Watts from Btu/h. The equation below incorporates the unit conversion in the determination power draw.

POWER=0.29308324•**HEATEIR•SYSHEAT** (Watts)

The power expected for a particular system with known efficiency and heating capacity at any given hour for a particular location is now known. By combining the spot measurements taken at the time of meter installation, we calculated the expected amperage draw given the local weather conditions.

V = Volts from Spot Watt Data

PF = Power Factor from Spot Watt Data

AMPA=POWER/(V*PF)

If the unit was running for only a portion of the 20 minute interval the average amps divided by the expected amps yield the percentage of the interval the unit was running at full power. Multiplying the percentage by one-third of an hour (20 minutes) allowed for runtimes to be calculated in units of hours. The equation below was used for this analysis.

RUNTIME20 = (AMP/AMPA)*(1/3) (Hours)

The system's energy consumption was then calculated as the measure energy consumption plus the fan energy consumption. The fan kW draw was assumed constant and was taken from nameplate data. The equation below shows how energy was computed using measured time series amperage data and instantaneous power factor and voltage data along with using the computed runtime and nameplate fan power.

FANKW = Fan Power for the system from nameplate data

ENERGY = AMP*PF*V+RUNTIME20*FANKW

Meter to Model Raw Results

Figure 73, Figure 74, and Figure 75 are the raw single family meter adjustment results by climate zone and utility for each end use. Figure 76, Figure 77, and Figure 78 are the same results for multi family sites.

Utility	Climate Zone	Inspection-Adjusted Gross	Meter Adjustment Factor	Ex Post Gross Savings	Error Bound
PGE	Coastal	381,992	1.752	669,313	349,429
	Inland	4,985,343	0.797	3,974,754	591,336
SCE	Coastal	126,128	1.752	220,998	115,377
	Inland	12,553,439	0.797	10,008,704	1,489,024
	Desert	163,764	0.664	108,657	20,341
SoCalGas	Inland	213,069	0.797	169,878	25,273
	Desert	2,877,279	0.664	1,909,078	357,390
SDGE	Coastal	474,555	1.752	831,500	434,102
	Inland	683,697	0.797	545,103	81,097
	Desert	195,334	0.664	129,604	24,263

Figure 73: Single Family Meter Adjustment, Cooling

Utility	Climate Zone	Inspection-Adjusted Gross	Meter Adjustment Factor	Ex Post Gross Savings	Error Bound
PGE	Coastal	103,322	0.589	60,836	19,014
	Inland	1,165,547	0.614	716,025	223,792
SCE	Coastal	5,461	0.589	3,216	1,005
	Inland	1,047,093	0.614	643,255	201,048
	Desert	836	0.837	699	219
SoCalGas	Inland	12,755	0.614	7,836	2,449
	Desert	21,195	0.837	17,734	5,543
SDGE	Coastal	119,639	0.589	70,443	22,017
	Inland	70,897	0.614	43,554	13,613
	Desert	717	0.837	600	188

Figure 74: Single Family Meter Adjustments, Heating

Utility	Climate Zone	Inspection-Adjusted Gross	Meter Adjustment Factor	Ex Post Gross Savings	Error Bound
PGE	Coastal	45,837	0.813	37,282	5,363
	Inland	448,898	0.813	365,113	52,523
SCE	Coastal	5,461	0.813	4,442	639
	Inland	1,047,928	0.813	852,336	122,611
SoCalGas	Inland	33,950	0.813	27,614	3,972
SDGE	Coastal	119,639	0.813	97,308	13,998
	Inland	71,614	0.813	58,247	8,379

Figure 75: Single Family Meter Adjustments, Water Heating

Utility	Climate Zone	Orientation-Adjusted Gross	Meter Adjustment	Ex Post Gross Savings	Error Bound
PGE	Coastal	133,286	0.118	15,747	12,208
	Inland	376,333	0.397	149,251	68,331
SCE	Coastal	135,821	0.118	16,047	12,440
	Inland	473,859	0.397	187,929	86,038
SoCalGas	Coastal	63,922	0.118	7,552	5,855
	Inland	1,491,099	0.397	591,358	270,738
SDGE	Coastal	739,117	0.118	87,323	67,697
	Inland	306,734	0.397	121,648	55,693

Figure 76: Multi Family Meter Adjustment, Cooling

Utility	Climate Zone	Heating Use - Therms				Heating Use - kWh			
		Adj. Gross	Meter Adjustment	Ex Post Gross Savings	Error Bound	Adj. Gross	Meter Adjustment	Ex Post Gross Savings	Error Bound
PGE	Coastal	23,250	0.161	3,734	1,346	(14,949)	0.161	(2,401)	865
	Inland	64,908	0.212	13,775	9,474	49,978	0.212	10,607	7,295
SCE	Coastal	2,632	0.161	423	152	2,133	0.161	342	123
	Inland	25,248	0.212	5,358	3,685	162,715	0.212	34,532	23,751
SoCalGas	Coastal	4,945	0.161	794	286	-		-	-
	Inland	95,572	0.212	20,282	13,950	140,001	0.212	29,711	20,435
SDGE	Coastal	127,504	0.161	20,475	7,380	47,801	0.161	7,676	2,767
	Inland	24,816	0.212	5,266	3,622	41,785	0.212	8,868	6,099

Figure 77: Multi Family Meter Adjustment, Heating by Fuel Type

Utility	Climate Zone	Adj. Gross	Meter Adjustment	Ex Post Gross Savings	Error Bound
PGE	Coastal	54,508	0.301	16,388	4,131
	Inland	57,541	0.301	17,300	4,361
SCE	Coastal	36,280	0.301	10,908	2,750
	Inland	95,072	0.301	28,584	7,205
SoCalGas	Coastal	14,309	0.301	4,302	1,084
	Inland	228,194	0.301	68,608	17,295
SDGE	Coastal	233,114	0.301	70,087	17,667
	Inland	84,191	0.301	25,312	6,381

Figure 78: Multi Family Meter Adjustment, Water Heating

Appendix E - Billing Analysis Data, Methodology, and Weather Normalization

The goal of this billing analysis study is to use billing data from the utilities to compare the actual electricity and gas usage of participant ENERGY STAR® new homes to non-participant homes. To do this we had to control for other factors on energy use in order to isolate our key variable of interest, ENERGY STAR® homes program participation. During the 2002-03 ENERGY STAR® homes analysis, the lack of demographic information such as occupancy and income left us unable to resolve the question of negative program savings raised by the billing analysis. As a result, this year RLW conducted phone surveys of 212 participants and non-participants in climate zones 8 and 12 and conducted a variety of statistical tests to determine which of the multiple models specified would most accurately represent the data.

Statistical Methodology

There are three stepwise variable selection procedures that are often employed in linear regression: forward selection, stepwise selection, and backward elimination. The forward selection procedure starts with an equation that contains only the constant term and successively adds explanatory variables one-by-one, until the last variable added to the model is insignificant. Stepwise selection is essentially a forward stepwise procedure, with the exception that at each iteration, the possibility of deleting a variable is also considered.

The backwards elimination method first calls for fitting a model using all potential explanatory variables and calculating the t-statistic associated with each variable. The explanatory variables are then deleted from the model one-by-one, until all variables remaining in the model are associated with a significant t-statistic. During each iteration, the variable with the least explanatory power is identified and deleted from the model, until only statistically significant variables remain.

All of the analyses were pursued using multivariate regression models run in SAS using the backwards step-wise regression to eliminate the least significant variables. F-tests were performed on variables to insure that they could be dropped as a group as well as individually. The analysis used $p \leq 0.10$ as the threshold criteria for inclusion of explanatory variables in the models, meaning that for a variable to be considered significant in determining energy usage, there must be less than a 10% chance that the resulting coefficient could be different from zero based on purely random chance.

Data Sources

The data used by RLW to conduct this evaluation came from several sources. For the billing analysis, billing data was acquired from each of the investor owned utilities (IOU)s. Several thousand participant single family homes' bills were collected from August 2003 to December 2006 when available, using address matching on addresses obtained from the CHEERS registry. Billing data were also collected for the non-participant (baseline) homes for dates between September 2003 and December 2006, using the addresses provided by the authors of the 2004 baseline study.

The second data source was the California Home Energy Efficiency Rating System (CHEERS) Registry which provided participant information. Registry data includes detailed building characteristics information for participant structures. For a large number of the participant structures in the CHEERS Registry, RLW also obtained the original Micropas or EnergyPro Title 24 files. These files were provided by the implementers.

Another key data source for this study is the 2004 Residential New Construction Baseline Study (the baseline study). The baseline study's author provided RLW with raw data collected by building surveyors, as well as structure-specific Title 24 output generated in the process of conducting the study.

In order to perform the weather normalization, daily weather data was obtained from the Western Regional Climate Center. The climate center archives weather readings from hundreds of weather stations throughout California. Houses were linked by zip code to the nearest weather stations during the weather normalization calculations described in the weather-normalization section below.

Survey Information

With the following demographic questions we hoped to control for variables between ENERGY STAR® Homes and non-participant homes to isolate the program effects. The questions we asked were,

1. Number of full time residents there are in each house, categorized by adults 18 and over and children 17 and younger,
2. Number of temporary summer time adults and children,
3. Income range of the household in $25,000 increments, and
4. Number of residents at home on an average weekday during the day in the summer and winter.

Variable Definition

Eleven independent variables were ultimately defined and included in the preliminary analysis. In some cases, data were combined to create more meaningful sample sizes in the categories for analysis. For example, income data was originally collected in 5 groups of $25,000 increments. These were subsequently aggregated into three groupings of low, mid, and high, that had ranges of: less than $25,000, $25,000 to $75,000, and greater than $75,000.

Dependent Variable Creation – Weather Normalization Methodology

The CEC climate zones are very large, and houses may face different weather from houses located elsewhere in the same climate zone. Also, although we received over three years worth of billing data, not all of the homes were occupied for the full three years, and thus some may have data from 2003 while others may not. Because weather is different from year-to-year, this temporal variation in weather must also be controlled for in order to compare houses to one another. Therefore, before we could begin to model our data we needed to account for the variation in usage due to weather differences among houses within the same climate zone. In order to correct for both the spatial and temporal differences among houses within a climate zone, we used the Princeton Scorekeeping Model (PRISM) approach to normalize the energy usage figures in our data to the square-footage-weighted average weather in each home's CEC climate zone for the period 2003-2006.

Heating and Cooling Degree Days

Heating and cooling degree days are a measure of the respective cumulative degrees below or above a certain reference temperature. Heating degree days (HDD) are indicators of household energy consumption for space heating. Cooling degree days (CDD) are indicators of household energy consumption for space cooling.

For example, take a reference temperature of 70 degrees Fahrenheit. First, the high and low temperatures of the day are averaged. If the value is greater than the reference temperature, 70 degrees F, then there are (avgtemp – 70) cooling degree days. If the average temperature is less than 70 degrees, then there are (70 – avgtemp) heating degree days. This value is calculated for every day in a month and totaled to produce the CDD and HDD for each month. For our methodology, these values were computed for every reference temperature between 60 and 80 degrees F for CDDs and every reference temperature between 50 and 75 degrees F for HDD.

Temperature Normalization Methodology

Homes face different temperature-related energy demands depending on their location. The need for the temperature normalization arises from the fact that different homes are in different locations and thus face different weather. The normalized annual consumption of each home is an estimation of energy consumption that treats all homes within a climate zone as if they faced the same temperature conditions. This allows the comparison of the weather-normalized energy usage to reflect the impact of the actual building characteristics rather than any local differences in climate experienced.

The temperature normalization procedure finds its fundamental basis derived from the *Princeton Scorekeeping Model* (PRISM) algorithm. The PRISM algorithm develops a mathematical model that represents the temperature to energy consumption relationship.

This normalization analysis recognizes the fact that each home reacts differently to varying heating and cooling degree days, and each customer has unique space conditioning operating characteristics. Homes with more efficient heating or cooling appliances and equipments, radiant barrier insulation, magnetite windows and ceramic coating will consume less energy. A well designed house with good windows and better insulation will require much less heating or cooling.

This simplest model where the specification is such that energy consumption depends on either heating or cooling degree days only is shown in Equation 2.

$$U_i = \alpha + \beta * DD_i(\tau) + e_i$$

Where;

U_i = average daily consumption in interval i.
$DD_i(\tau)$ = average degree days in interval i, based on reference temperature
α,β = parameters to be estimated to minimize e.
e = a random error term.

Equation 2: The PRISM Heating Only Model

The PRISM model reflects that a customer's energy usage is equal to some base level α, and a linear function between a reference temperature τ, and the outside temperature. The constant proportionality, β, represents a customer's effective heat-loss or heat-gain rate.

As mentioned, PRISM recognizes that each customer has unique space conditioning operating characteristics. To capture these unique space conditioning characteristics, PRISM examines a range of heating and cooling reference temperatures. The model chosen to represent a customer's energy use is the model that best linearizes the relationship between usage and degree days. For each customer, an optimal model based on a unique temperature reference temperature (τ) is identified by the minimum MSE of the regression.

Once the optimal parameters have been established, normalized annual consumption is estimated using Equation 3.

$$NAC=365*\alpha+\beta*DD_o(\tau)$$

Where:

DD_o is the number of degree days expected in a typical year.

Equation 3: The Determination of Normalized Annual Consumption (NAC) [75]

When this model is applied to a home's heating characteristics, it is referred to as the *heating only model* (HOM). When this model is applied to a home's cooling characteristics, it is referred to as the *cooling only model* (COM).

We have three different end uses for the participant and non-participant new homes, heating, cooling, and water-heating. Heating and water-heating use only gas in our sample, and cooling always uses electric energy. The billing information contains separate

[75] For a more comprehensive technical discussion of PRISM, see Impact Evaluation Of Demand-Side Management Programs, Volume 1: A Guide to Current Practice, EPRI Report CU-7178,V1, page 5-6.

data from electric and gas usages. As electric energy is only used for cooling, it is expected that consumption of electric energy is mostly affected by cooling degree days, and unaffected by heating degree days. Similarly, since gas energy is used for heating, it is expected that consumption of gas energy is mostly affected by heating degree days and not cooling degree days.

We therefore ran the cooling only PRISM model for the temperature normalization procedure for electricity billing data. We similarly ran the heating only PRISM model with the gas data.

The standard PRISM approach uses usage and degree day data on a billing cycle basis. However, by doing that, the dependent variable has an inherent variability associated with the varying lengths of billing cycles. By bringing in the *average daily* usage as the dependent variable, the effects of the varying lengths of the billing cycle are mitigated for the estimation of the heating and cooling slopes (β). This is a result of the number of degree days being directly correlated to the number of days in the cycle. However, the estimate of base load (β_o) reflects the average base load per cycle and does not account for the days in the cycle. In effect, this estimate infers the base load will be β_o, regardless of the length of the cycle. Since base load usage is a function of time, this result may introduce a slight bias into the calculation. To eliminate this bias, the augmented PRISM approach uses usage per day per square foot of floor area as the dependent variable, and expresses the degree days on a per day basis.

From the COM the average daily weather-independent component α represents all non-cooling electricity usage and the average daily weather-dependent component ($\beta*DD_0(\tau)/365$) represents the cooling electricity usage. Since AC usage will be entirely contained within the weather-dependent portion of usage, the cooling analysis only looked at the weather-dependent component. From the HOM the average daily weather-independent component α represents all non-heating gas energy usage, and the average daily weather dependent component ($\beta*DD_0(\tau)/365$) represents the heating usage. Each gas end-use was regressed separately.

Thus, the three dependent variables for each climate zone for use in the regressions were,

- AC electricity usage *($\beta*DD_0(\tau)/365$* from the COM)
- Gas heating (α from the HOM), and
- Gas non-heating usage *($\beta*DD_0(\tau)/365$* from the HOM—mainly water heating, some cooking and clothes drying).

One complication with the PRISM approach should be mentioned here. Since cooling only uses electric energy, the PRISM model will associate increased electric energy usage on hot days with air conditioning, and similarly increased gas usage on cold days with heating usage. While it is accurate that people will use their air conditioners more on warmer days, it leaves out other factors that could play a part in increased consumption. For example, if a household has an additional summer time resident a portion of the increased usage should be attributed that visitor. The demographic survey questions were thus necessary in the regression models to refine the interpretation of the prism results.

Independent Variables

Independent variables were considered in two basic groups: housing characteristics and demographic information. Below we describe each independent variable and give the data source.

Housing Characteristics:

- Floor area: Measured floor area of house in square feet, per CHEERS registry
- # stories: Number of stories in a house, per CHEERS registry
- Participant: Dummy variable to track participant status, per CHEERS registry

Demographic Information:

- # fulltime adults residents: Number of permanent adult residents, per survey
- # fulltime children residents: Number of permanent children residents, per survey
- # temporary summer time adults: Number of adults residents that only stay during summer months, per survey
- # temporary summer time children: Number of children residents that only stay during summer months, per survey
- Income: Reported household income, per survey
    - o During regression analysis was broken down into 4 sub groups, termed low, mid, high, and non reported
- # home during summer day: Number of residents at home between the hours of 12pm and 6pm during the summer, per survey
- # home during winter day: Number of residents at home between the hours of 12 pm and 6pm during the winter months, per survey

Summary Statistics

The following tables show the results of the Demographic Phone Survey. The results are separated by ENERGY STAR® Homes participants and non-participants for each climate zone.

Table 99 shows the number of adult residents in each household for the two climate zones we collected survey information. In climate zone 12 there are more single adults for participants than their non-participant counterparts. This could possibly results in an increase in non-participant energy usage relative to participants as a result of a higher number of residents.

Number of Residents		1	2	3	4	5
8	Participant	0	22	1	1	0
	Non-Participant	5	16	5	3	1
12	Participant	13	59	8	1	2
	Non-Participant	1	60	8	5	1

Table 99: Number of Full Time Adult Residents

Table 100 lists the number of children residents per house for each climate zone. The highest percentage of households with no children were non-participants in climate zone 8 and participants in climate zone 12, which was consistent with the distribution of single adults from Table 99. Non-participant energy usage may be expected to be higher as a result of more children per household.

Number of Residents		0	1	2	3	4	5	6
8	Participant	10	7	6	1	0	0	0
	Non-Participant	14	3	10	1	0	0	0
12	Participant	52	11	14	5	0	0	1
	Non-Participant	27	11	23	12	1	0	1

Table 100: Number of Full Time Children Residents

Table 101 shows the number of temporary adult summer time residents. Results for this survey question were very similar across both climate zones, with participants having slightly fewer adult residents during the summer. We would expect to see non-participants showing slightly higher energy usage if any change at all, due to the marginal increase in adults during the summer.

Number of Residents		0	1	2	3	4	5	6
8	Participant	21	3	0	0	0	0	0
	Non-Participant	20	3	5	0	0	0	0
12	Participant	81	2	0	0	0	0	0
	Non-Participant	69	4	1	0	1	0	0

Table 101: Number of Temporary Adult Summer Residents

Table 102 lists the number of children that are temporary summer time residents. Again, the results are very similar between participants and non-participants, with non-participants having slightly higher number of summer time guests. This would be consistent with the results shown in Table 101 if some of the adults were parents bringing their children with them to visit during the summer.

Number of Residents		0	1	2	3	4	5
8	Participant	24	0	0	0	0	0
	Non-Participant	27	2	0	0	0	0
12	Participant	82	0	1	0	0	0
	Non-Participant	71	2	1	0	0	1

Table 102: Number of Temporary Children Summer Residents

Table 103 shows the reported household income, survey question 3, collapsed into the four groupings used in the regression analyses. It appeared that non-participants had higher reported income with over 50 percent of households having income greater than $75,000 for both climate zones, though we cannot say definitely due to the fact that approximately 50 percent of the participants chose not to report their income. We expected that the households with greater income would have increased energy usage due to owning more electronic devices. Also, houses with low income may be more conservative with AC and heating usage due to financial constraints. From the houses that reported their income, we expected non-participants to have increased income dependent energy usage.

		Low (<$25,000)	Mid ($25,000-$75,000)	High (>$75,000)	Non-Reported
8	Participants	0%	4%	39%	57%
	Non-Participants	0%	19%	62%	19%
12	Participants	6%	22%	25%	48%
	Non-Participants	3%	19%	53%	25%

Table 103: Demographic Income Results

Table 104 shows the number of residents that are home on weekdays between noon and 6 pm during the summer. Among both participants and non participants in Climate Zone 12, 86% of homes had residents home during the day. The non-participants, however, have a greater number of people at home on average: 2.0 as opposed to 1.8. In climate zone 8, 87% of participants had at least 1 resident at home during the day whereas non-participants in the same climate zone had 73%. We hypothesized that the presence of the initial daytime resident would have a much larger impact on electric energy usage than the incremental impact of each additional resident. As a result, we would expect slightly higher non-participant electric energy usage in Climate Zone 12 and higher participant electric energy usage in Climate Zone 8.

Number of Residents		**0**	**1**	**2**	**3**	**4**	**5**	**6**
8	Participant	3	3	13	4	1	0	0
	Non-Participant	8	7	5	8	0	2	0
12	Participant	11	21	31	15	5	0	0
	Non-Participant	10	21	16	18	8	1	1

Table 104: Number of Residents At Home during the Day (summer)

Table 105 shows the number of residents that are home weekdays between noon and 6 pm during the winter. In 87% of participant and 76% of non-participant homes within Climate Zone 8 there were residents home during the day. Climate zone 12 had residents home 84% of the time, and non-participants 85% of the time. Based on the hypothesis explained for daytime summer residents, we would expect that gas energy usage would be higher for participants than non-participants in Climate Zone 8 and comparable for Climate Zone 12. The similarity between the winter and summer daytime residents showed that daytime occupancy is not dependent on the season.

Number of Residents		**0**	**1**	**2**	**3**	**4**	**5**	**6**
8	Participant	3	5	12	3	1	0	0
	Non-Participant	7	10	4	7	1	1	0
12	Participant	13	27	33	7	3	0	0
	Non-Participant	11	32	13	10	7	1	1

Table 105: Number of Residents At Home during the Day (winter)

Modeling

Floor Area Models

The proper functional form that should be used to characterize the relationship between floor area and energy usage was not immediately clear. Whether it should be strictly linear, or some sort of function with a diminishing relationship is a matter of some debate. We decided to test a number of functional forms to find the one most appropriate for each climate zone and end use. We looked at three mathematical approaches: linear, log, and quadratic models of energy usage with respect to conditioned floor area. Looking at the distribution of usage with respect to floor area we could determine what line or curve would best represent that data.

A linear model of energy usage with respect to floor area would best represent the data if energy usage increased proportionately with floor area, something alone the lines 1 sq ft increase has the same impact on energy use.

Figure 79 shows the linear, log, and quadratic models applied to gas non-heating usage in an inland climate zone. Here the model of best fit is the solid line, which represents a linear model.

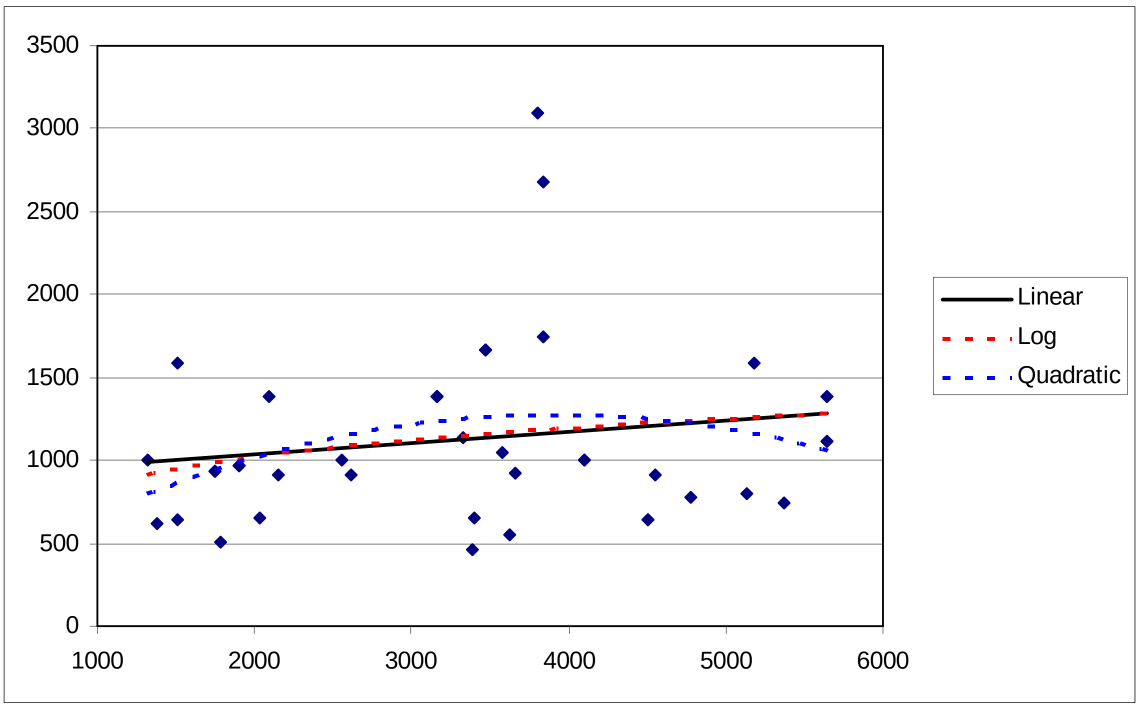


Figure 79: Example of a Best Fit Model Being Linear

Quadratic and logarithmic models of energy usage with respect to floor area capture diminishing increases in usage per square foot as the floor area gets larger. In a quadratic model returns don't diminish as quickly as a logarithmic model but still account for diminishing returns. Figure 80 shows the three models applied to heating usage in an inland climate zone. Here the quadratic model best captures the houses using more than 2500 kBtu between 3000 and 4000 square feet.

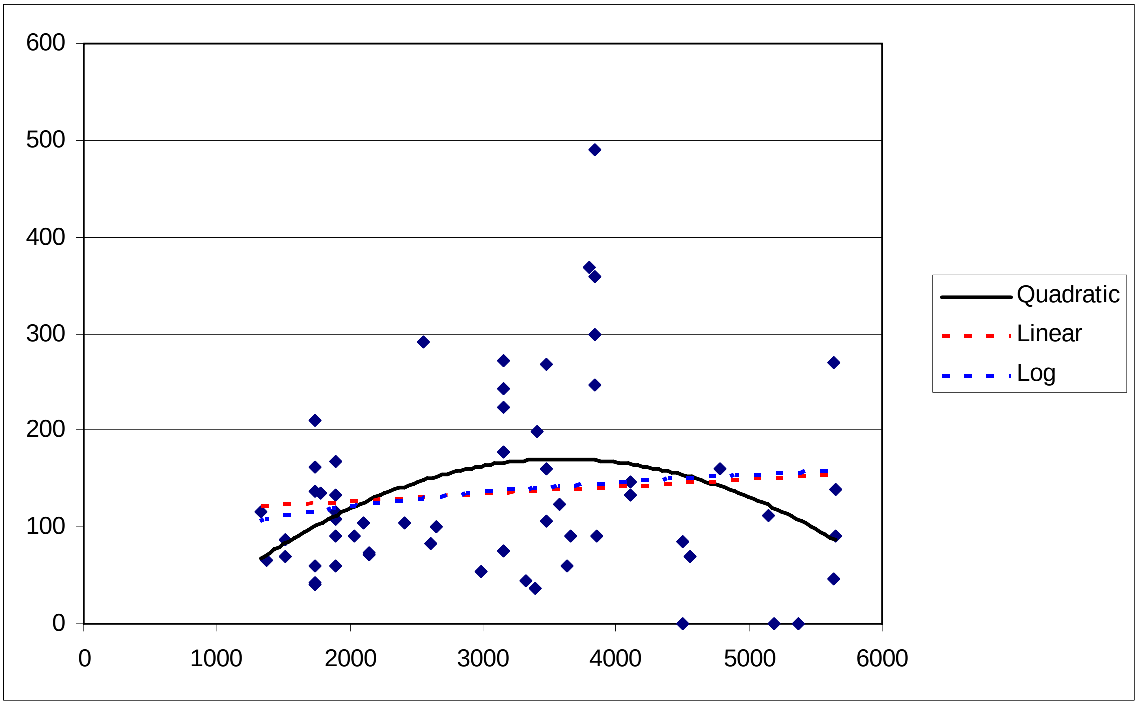


Figure 80: Example of a Best Fit Model Being Quadratic

Appendix F - Single Family Builder and Owner Responses on Program Savings and Influences (SERA)

Builder Responses On Program Savings And Influences

Program Savings and Influences

This section of the report uses data collected through interviews of both participant and non-participant single-family builders to provide feedback on the influence of the ENERGY STAR® program and the savings and free-ridership it is creating. Wherever possible, the results from both participant and non-participant builders will be presented side by side. As the surveys for the participants and non-participants were not identical, this is not always possible. The data that does coincide for the two groups is presented together first, followed by the participant single family data and finally the non-participant single family data is presented. The results displayed in this section will follow the same path as the original survey, presenting the data for each question in approximately the same order they were asked.

Energy Efficiency Compared to Title 24

Both the participant and non-participant builders were asked to compare the efficiency of their homes to the energy code (Title 24) standard in 2004-2005. If the level of efficiency was over 15% above code, the builders were asked how much over, and if it was under 15% over code, they were asked to relay how much under.

Participant Builders: Half of the participant builders responded that their homes exceeded the energy code by more than 15%, 46% said they exceeded code by 15%, and 4% answered that they exceeded code by less than 15%. Two builders exceeded code by 25%. In one case it was a builder who was working on a small number of extremely energy efficient demonstration homes who "did everything we could to make them highly energy efficient". Of the builders who exceeded code by over 15%, the average amount by which they exceeded code was 19%. Overall, participant builders exceeded code by 16.5% to 17%[76].

Non-Participant Builders: None of the non-participant builders exceeded code by more than 15%. About a quarter of them exceeded code by 15% and 26% exceeded code by less than 15%. For those that exceeded code by less than 15% the average amount over Title 24 was 9%. Most of the non-participant builders, 42% of them, built their homes just to code. The average amount by which non-participants exceeded code was 7%.

Comparison: Although 26% of the non-participants are achieving a level of efficiency high enough to be included in the program, none are surpassing the 15% efficiency mark. Compare this to the participant group where half of the builders are exceeding Title 24 by over 15%. Overall, 96% of the participant builders are achieving energy efficiency levels at or above 15% and 26% of the non-participants are doing so.

[76] This number varies depending on how missing data is addressed.

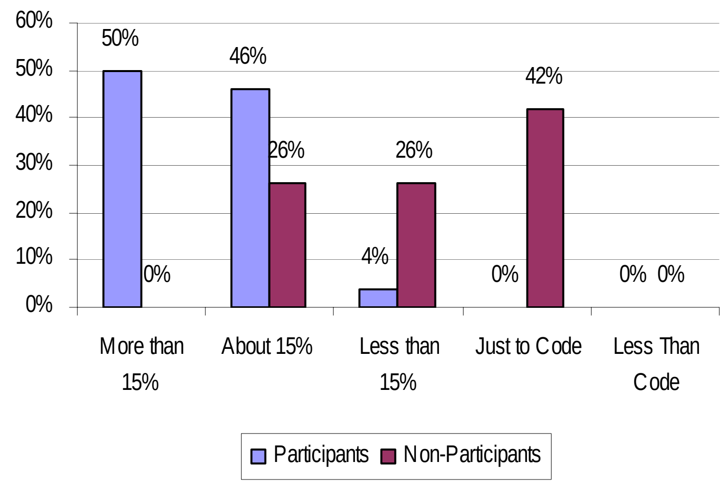


Figure 81: Home Energy Efficiency in Relation to Energy Code

(Participants N=29 Non-Participants N=19)

Characterization of 2004-2005 Homes Compared to Title 24

The participants were asked how efficient their homes would have been had they *not* participated, and non-participants were asked to characterize the efficiency of their homes compared to Title 24. Instead of responding with numbers as the previous question demanded, here respondents were asked to reply in words. They could reply that they are *much more efficie*nt down to *much less efficient* or somewhere in between.

Participants: Nearly 40% of the participants responded that had they not been involved in the ENERGY STAR® Program that their homes would have been *about the same* efficiency as Title 24. Only 4% responded that they would be *slightly less efficient* than Title 24. Over half (56%) of the participants said that they would have been from *slightly more efficient* to *much more efficient* than Title 24 had they not participated. Nearly all(96%) of participants are at or above 15% over code, while if they had not participated only 21% responded they would be *much more efficient* than Title 24 efficiency levels.

Participant Efficiency if They Had Not Participated

If the builders responded to C4 that they would have been *more efficient* even if they had not participated in the program, they were then asked what percent efficiency their homes would have achieved relative to Title 24. The maximum efficiency answered was 25% and the average was 14%.

Non-participants: None of the non-participants characterized their buildings as being below Title 24 efficiency. The majority of them, 47%, responded that there homes were *somewhat more efficient* than and 42% reported being the *same efficiency* as Title 24.

Comparison: For both groups, close to 40% responded that their homes would be, or were, right around the energy code efficiency levels for Title 24. While none of the non-participants said they were much more efficient than code, 27% of the participants said that they would build much more efficient than code even if they did not participate in the program. However, nearly half of the non-participants responded they are somewhat more efficient than code while only 27% of the participants said they would be somewhat more efficient than code. The results of both groups are compared in the following figure.

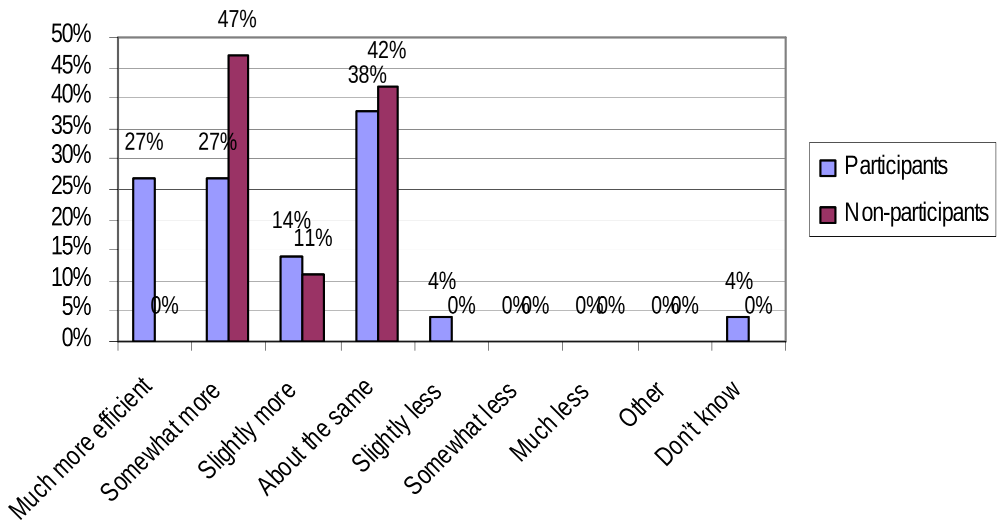


Figure 82: Comparison of Efficiency Characterization

(Participants N=29 Non-Participants N=19)

Reasons to Exceed Code

Both groups were asked if there were any reasons, other than the ENERGY STAR® program, for which they needed to exceed code by 15% or more.

Participants: The majority of participant builders did not have any other reason to exceed code; however, 35% of the builders did need to exceed Title 24 for other reasons. These included:

- Required by the city
- Agreement with the developer
- Competition
- Green Build initiative
- Other energy efficiency programs
- They always build homes to this level of efficiency

Non-Participants: Only 11% of the non-participants needed to exceed code for some other reason. These reasons were:

- To make a nicer house
- To make sure we hit code by aiming to go over it

The non-participants were also asked how often they were required to exceed Title 24 by 15% for tax credits or other funding reasons in 2004-2005. Of the 15% of the builders were required to do so, 10% replied that they were required to do so often, and 5% said they were always required to do so in 2004-2005. 58% said they never needed to exceed energy code by 15% for funding or tax reasons. These results are shown in the following Table and Figure.

	Did not have any other reason	Did have a reason	N Value
Participants	65%	35%	20
Non-participants	89%	11%	18

Table 106: Reasons to Exceed Code

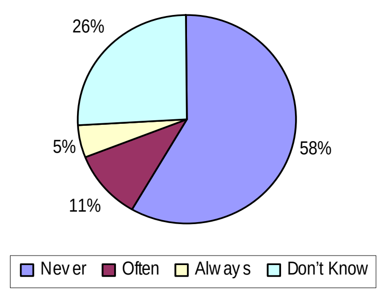


Figure 83: How Often Non-Participants Were Required to Exceed Energy Code for Tax Credits

1.2 Program Influence on Participant Builders

The following data relating to program effectiveness were gathered only from the participant builder group.

Program Influence

Approximately a third (38%) of the participant builders responded that their decision to install energy efficient measures beyond ones that they normally install in their housing projects was *somewhat* influenced by the ENERGY STAR® program. Equal amounts of builders, 24%, responded that they were either *very much* influenced by the program or *not at all influenced* by the program. Those that responded *not at all* were often participating because they already met the efficiency requirements of the program, and were participating to reap the benefits of the rebates, marketing and advertising. Some of these builders said:

- Our plans complied so we went for it
- The utility representative told us we already qualified without making any extra changes.
- We already had most of the features before we saw we were close to ENERGY STAR® requirements.
- We only submit homes that are above compliance already, we always build above code.

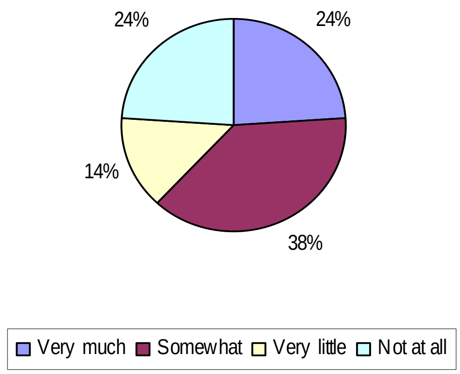


Figure 84: Program Influence to Install Energy Efficient Measures

(N=29)

Incorporating Energy Efficient Technologies

The participant builders were asked a series of questions regarding how many energy efficient technologies they would have installed in their housing projects had they not participated in the program. They were also asked why they would, or would not, have included these technologies. There were two levels they were asked to think about. The first is the likelihood that they would incorporate *all* of the same technologies; the second is if they would have incorporated *some of* the same technologies.

All of the Same Technologies

The most common answer when asked if they would incorporate *all* of the same technologies was *somewhat likely* with 32% of builders answering this. Slightly less (29%) builders responded that they *definitely would* have installed all of the same measures. Values between 0 and 100 were assigned to their answers where 100 means they definitely would have installed all of the same measures and 0 means they definitely would not have installed all of the same measures. The average response was 54; *slightly more often than not,* the builders would have installed all of the same energy efficiency measures. A quarter of the builders responded that the chances of installing the all of the same measures was *not very likely* or below. On the other hand, 40% answered that they were at least *very likely* to install all of the same energy saving measures.

Some of the Same Technologies

When asked how likely it was that they would install *some* of the same energy efficiency measures 47% responded that they *definitely* or *almost definitely* would have done so. When values were assigned to the answers, the average value was 70; it is more likely than not that they would have installed some of the same energy saving technologies. Only 10% of the builders said that they were *not at all likely* or less to install some of the measures and 71% said they were *very likely* or more to install some of the same measures. Almost half the builders responded that they would have installed *some* of the same technologies while less than a third of builders said they would have installed *all* of the same measures.

When asked why they would or would not have installed the measures without the program, the builders had a number of responses, including:

- We already do it, that's the way we build.
- We have been doing it this way for years and it's the way the house plans are made.
- Some stuff, like the HVAC system, are highly energy efficient even without the program.
- We want to build energy efficient homes and would do so with or without the program.
- Competition.
- We are required to participate by our company.
- It's a sellers market and the measures are too expensive.
- We would have done 100% of the same energy efficient measures without the program due to ordinance in the city.
- We would have done so no matter what.

The following Figure shows both the likelihood that builders would incorporate all of the same and some of the same energy-efficient technologies had the program not existed.

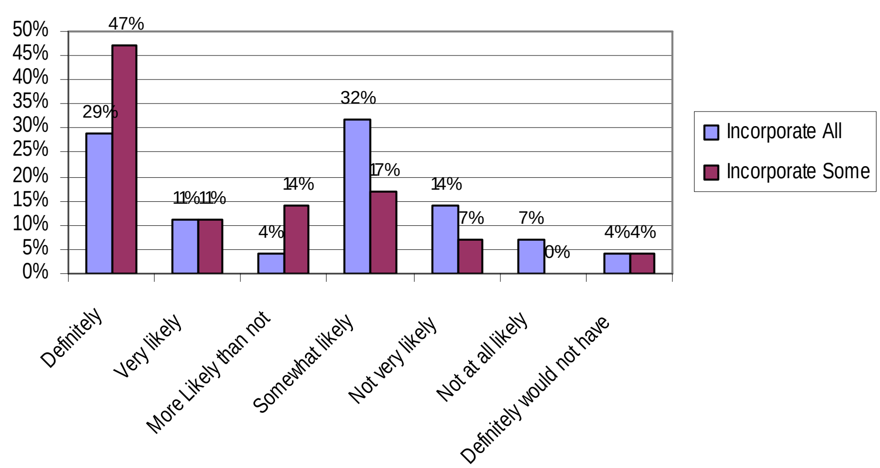


Figure 85: Incorporation of Energy Efficient Technologies

(Incorporate All N=28 Incorporate Some N=28)

Design Changes

About two thirds (63%) of the builders said that had they not participated in the program they would not have made any design changes that would have effected the energy efficiency of the home. One third (33%) of the builders replied that they would have made design changes in their buildings. The third of the builders that said they would make design changes were asked what these changes would have resulted in. Two of these builders replied that the design changes would have lowered the building efficiency. The others all replied that the changes would have resulting in savings ranging from a *little added savings* to a *great deal of added energy savings*. The builders who said their design changes would result in lower savings described the changes as:

- We would have done less insulation or different windows and it would have decreased the energy savings a little.
- We wouldn't have done the water heater and the HVAC the way we did.

Importance of Financial Assistance

Only 17% of the builders responded that the financial incentives of the program were *very important* to them in their decision to design energy efficient homes. A slightly higher percent (21%) of the builders said that the incentives were *not at all important*. The average score, on a scale of 1 to 5, where 1 is *not at all important* and 5 was *very important* was 3.1, showing a slight tilt toward *very important*.

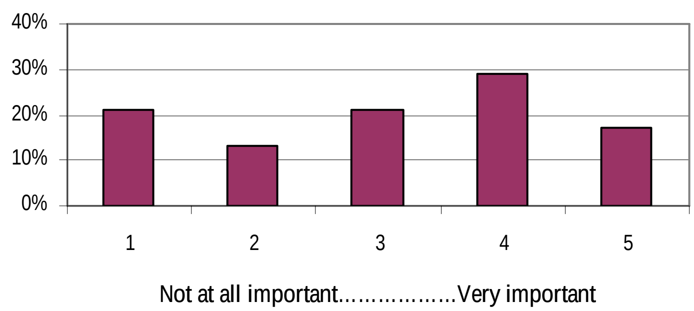


Figure 86: Importance of Financial Assistance

(N=24)

Best Estimate of Savings from Program

Three questions were asked of the participant builders to attempt to determine what share of the home's energy savings were due to the ENERGY STAR® program's influence. By asking the builders to first, estimate the minimum, and second, estimate the maximum, the builders were able to establish a range of savings that were due to the program. The third question asked the builders to look within this range and estimate what share of the home's energy efficient savings were due to the program. The average minimum share was 25% and the average maximum was 36%. The average savings the builders said was due to the program influence was 32%. A number of builders felt that either 0% of the savings were due to the program or 100%, and it was difficult to pin-point a number in-between. For example, when asked the minimum share of savings due to the program, 41% of the builders said 0% was due to the program and 14% said 100% due to the program, only 45% said a number somewhere in between.

Share of Savings Due to Program		**N Value**
Minimum Share	25%	22
Maximum Share	36%	22
Builder's estimate of Share	32%	24

Table 107: Estimates of Energy Savings

1.3 ENERGY STAR® Influence on Non-Participant Builders

Influence of ENERGY STAR®

The builders who had not participated in the ENERGY STAR® program were surveyed to determine whether the program is having an influence on their building practices. They were asked if they had heard of the program and what, if any effect the program had on the energy efficiency of their building projects. This was an open ended question and the responses to it were:

- Maybe some influence. I know that the standards are rising in the industry in general; there is growing awareness of green building.
- No, not really but PG&E has been helpful.
- Somewhat, if it's not too much money to get to 15% above Title 24 then we do it.
- No, I've never heard of it.
- Yes, I have heard of the program and am trying to bring it here, working on both windows and appliances.
- I buy ENERGY STAR® appliances for projects and suggest energy efficient measures when I can.
- No, I think people are getting more aware of energy efficiency issues but I don’t think the ENERGY STAR® Program is doing that, or if it is, it's probably a small impact.

Efficiency over Time

The builders were next asked to look at changes in their energy efficient design over time and respond as to which direction they are moving, towards more efficient design, less efficient, or staying the same. They were asked to compare their current project to a project from five years ago as well as to one from last year. If they had seen changes in efficiency, they were asked to describe what led to these changes.

Nearly half (53%) of the non-participant builders responded that they were building *much more efficient* homes now than five years ago. Only 5% said they have *stayed the same* over the past year in their energy efficiency, and none of them say they are becoming *less energy efficient*. When compared to last year's projects, 42% of builders say they have stayed the same and only 11% say they are much more efficient. Again, none of the builders are less efficient now than in the past. The following Figure shows the changes in efficiency over time for non-participant builders, both compared to projects five years ago and projects from last year.

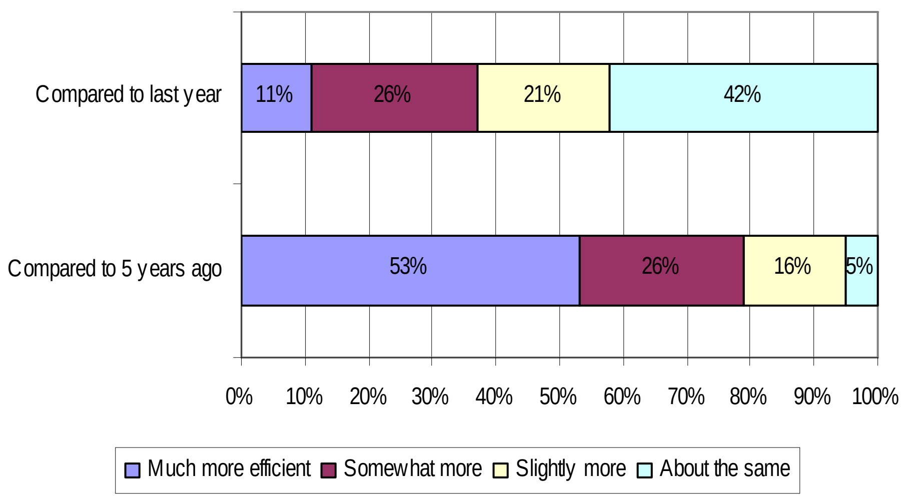


Figure 87: Efficiency Changes Over Time

(N=19)

The builders cited a number of different factors that have led to these changes. A third of the builders reporting said that the main influence on the change was Title 24. Some of the other factors were:

- There are two reasons; 1. Building design changes and 2. Technology advancements, especially with the thermal envelopes.
- Glazing is the main innovation/change.
- The industry standards are rising and we want to improve above the competition.
- We are learning more about energy efficiency and want to learn even more.
- The market is moving in this direction.
- We are very interested in green building and want to do good for the environment.
- People want energy efficient windows and renovations.

Costs and Rebates

The survey attempted to determine what the costs would be for builders to build to 15% over code, and what level of rebate would be a proper incentive to get the non-participants to build to this energy efficiency level. Unfortunately, the majority of the respondents were unable to give a value for what the costs or incentives would be. The surveyors attempted the gather data both in actual costs or percent of costs, but only a handful of respondents could come up with a number. Many of the builders were hesitant to give an answer, saying the costs can change greatly with every project.

For the builders who gave a percent of total costs to achieve 15% energy savings, the average cost was 5% of the total building cost. Of the builders who gave a dollar value, the average cost was $2,000 per home, but even with this number the builders said that it would vary depending on which project they are working on. Forty-three percent of the builders responded that they didn't know what the costs would be.

When it comes to the level of incentive, *don't know* was again the most common answer with 33% of the builders responding thus. Only 19% of the non-participants said that a rebate of 100% of the costs to achieve the 15% energy efficiency level would suffice. For the builders who could give a rebate in terms of percent of total cost, the average was 5.75% of the total costs, slightly above the 5% of total costs that builders felt it would take to achieve these savings. Two of the builders said that:

- There is no number that would work.
- Money is not the driver. The rebates are 'drinking money' compared to the overall cost of the home.

	% Total Cost	Dollar Value	N Value
Cost to Achieve 15% Savings	5%	$2,000	6
Level of Incentive Needed	5.75%	100% of the costs to achieve	4

Table 108: Level of Costs and Incentive

Average Savings

The final question in this section asked the non-participant builders to compare the energy efficiency of their average project in 2004-2005 to the energy code. None of the builders responded that their average projects were under code. Slightly over half of the builders (53%) responded that their average project was built with higher energy savings than the energy code and 47% said they built just to code in 2004-2005.

Related Effects On Builders

Increased Energy Efficiency

Both groups of builders were asked in which areas of their home projects they installed energy efficient equipment, or used building practices to increase the home's efficiency. For the non-participants, the question asked what technologies or practices they commonly use in their single family home projects. The participants were asked in which areas, if any, the ENERGY STAR® Program led them to increased efficiency of at least 15% over the Title 24 requirements. The responses for both groups are displayed together in the Figure below.

Participants: Only one of the participant builders responded that the ENERGY STAR® Program failed to cause him to increase efficiency in the home to 15% over Title 24 requirements. The remaining 98% of the builders responded that the program did lead to changes in at least one of the different areas. In two categories, *high performance windows* and *tighter ducts*, 86% of the builders responded that the program led them to increase efficiency. Besides the "other" category, where only one builder responded by saying the program effected his installation of insulation, the lowest category was *improved ventilation,* with less than half of the builders responding that the program led them to increase their efficiency in ventilation.

Non-Participants: The area of efficiency in which the non-participants most often increased efficiency over Title 24 requirements was in the installation of *high performance windows*. A large majority (79%) of the non-participants reported they normally install windows over energy code. In every category, over 50% of the builders reporting responded that they normally install technologies or use building practices to surpass the Title 24 requirements. This coincides with the results in the Table below, which shows that over half of the non-participant builders said that they build homes over the energy code efficiency levels.

The non-participants were again asked if they had heard of the ENERGY STAR® program, and if so, did the program have an influence on their decision to install these measures. Only one of the builders responded that it had had an influence on his installation of energy efficient measures. The categories that it led him to increase efficiency in were:

- Lighting
- Tighter Ducts
- Improved Ventilation
- Decreased Air Leakage

Nearly all (87%) of the builders who had heard of ENERGY STAR® said that it did not have an influence on their decision to install these technologies or measures. The builders who responded that the program did not have an influence on their decision to install higher efficiency measures were asked why they took the actions they did to install these measures. Their answers were:

- I believe in energy efficient design to make better homes.
- Customer demand.
- Those are my normal building practices, using the best available windows and HVAC and they are over Title 24.
- To make energy efficient homes, it is all about the cost-benefit of these measures on the home.
- To save residents money and to build energy efficient homes.

Comparison: In four of the categories of energy efficiency a higher percentage of participants reported that they install the energy efficient technologies than the non-participants, and in the other four categories the reverse is true. The categories are shown in the Table below. Remember however, that the participant builders are reaching a level of efficiency that is 15% over code as required by the ENERGY STAR® program, but when it comes to non-participants, most are not. It is known, from previous survey responses, that only 26% of the non-participants installing these measures are obtaining a level of efficiency that is 15% over the energy code while 98% of the participants are achieving energy efficient levels 15% over code.

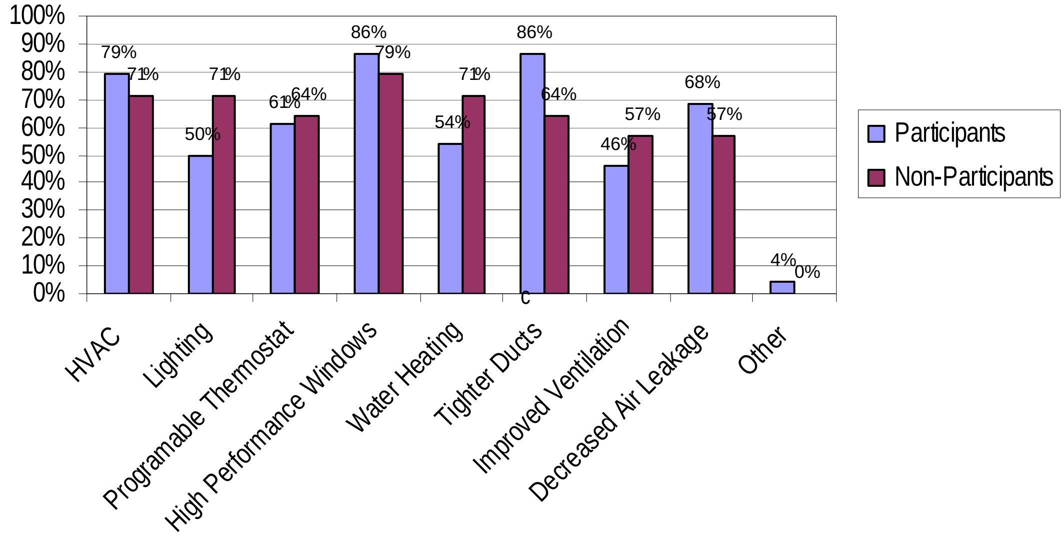


Figure 88: Installation / Penetration of Energy Efficiency Measures

(Participants N=28 Non-Participants N=14)

Measures Installed by a Higher Percent of Participant Builders	
• HVAC System • High Performance Windows	• Tighter Ducts • Decreased Air Leakage
Measures Installed by a Higher Percent of Non-Participant Builders	
• Lighting • Programmable Thermostat	• Water Heating • Improved Ventilation

Table 109: Comparison of Energy Efficient Measures

Anecdotal Evidence

Both groups of builders were asked if they had heard any anecdotal evidence from the home owners relating to energy use in the new homes. The majority of both groups responded that they had not, but a handful of the builders were able to provide some insight in this area. A higher percentage of non-participants had heard of evidence of decreased energy use than participant builders, but this could be due to the size of the firm they work for. More of the non-participants worked for smaller firms compared to participants and thus, they could have had more interaction with the home owners[77].

Participants: None of the builders had heard any evidence from the homeowners regarding increased energy use, but 20% of the builders responded that they have heard stories from the owners about decreased energy use. Some of the responses were:

- Yes, decreased bills for sure.
- Yes, seems to use less energy.
- Yes, it decreases energy use but ENERGY STAR® is only one piece of the pie.
- Yes, the HVAC system saves energy.

Non-participants: One of the non-participant builders responded that he had heard evidence of increased energy use due to the energy efficient measures he had installed. This was due to:

- The low flow toilets have to be flushed twice.[78]

Almost a third (29%) of the non-participants said that they have heard of anecdotal evidence of decreased energy use. The evidence they had heard relating to decreased energy use was:

- Some people say solar is saving a lot of money, maybe the tank-less water heater.
- Yes, bills seem to be lower.
- Yes, there is definitely lower energy use, I have done remodels where the new home is twice the size of the old and residents say they still have lower bills.
- Yes, lower bills from the windows.
- Yes, they are using less energy.

Spillover-related Responses from Builders

Participant and non-participant builders alike were surveyed to ascertain to what amount, if any, spillover is happening as a result of the ENERGY STAR® program and to find out why the builders believe it is occurring.

Participants: Almost half of the participant builders thought that builders that were not participating in the program were feeling the effects of the ENERGY STAR® program. Thirty-five percent of the builders felt that non-participants were not being affected by

[77] For more on firm sizes see Section 4, *The Builders*.

[78] Of course, not being heated water, this does not use more energy.

the ENERGY STAR® program. When asked why, the most common reply was that the non-participants were being affected due to *pressure within the market place* and from other builders to construct energy efficient projects. Many of the builders gave "other" reasons that they felt were affecting non-participants. The "other" factors effecting non-participants in the view of the participant builders were:

- All of the above, and the industry is moving that way.
- Increased energy costs.
- Government and municipal policies such as Title 24 requirements.
- They just want to build better homes.
- The prices for energy efficient technologies are coming down.
- Talk between builders and the sharing of knowledge.
- The technologies are becoming more main stream.

The participant builders were asked whether or not their participation in the ENERGY STAR® program had any spillover effect onto other projects they were working on. To determine this, the builders were asked if they had installed any energy efficient measures on any of their other projects that were not in the ENERGY STAR® program due to their participation in the program. Less than half (42%) of the builders reporting replied that they had not, but 20% of the builders responded that they had installed energy efficient measures on other projects that they normally would not have had it not been for the influence of the ENERGY STAR® program.

Non-Participants: Only 21% of the non-participants reporting said they were being influenced by the program while two thirds responded that they did not feel any influence of the program. Some of the comments regarding the program influence were:

- The ENERGY STAR® Program has influenced all five of the projects I've worked on this year.
- It influences all of my buildings.
- It has a very small influence.

When those who said they were influenced by the program were asked why, an equal amount said it was due to *pressure from consumers* and *market place pressure*. None of the non-participants said that they were being influenced due to *increased education* as a spillover from the program. When asked what "*other*" reasons were influencing them they said:

- Technological improvements.
- Availability of energy efficient equipment, it is easier to get now.

Comparisons: It is interesting to note the disparity in opinions relating to spillover. While 47% of participants felt that their counterparts were being influenced by the program only 21% of the non-participants actually said they were influenced by the ENERGY STAR® program. Also, only a third of builders participating felt that other builders were not being influenced while two third of the non-participants said they were not being influenced. Despite the differences in opinions about how many builders are being effected by spillover, it is apparent that there is a spillover effect occurring.

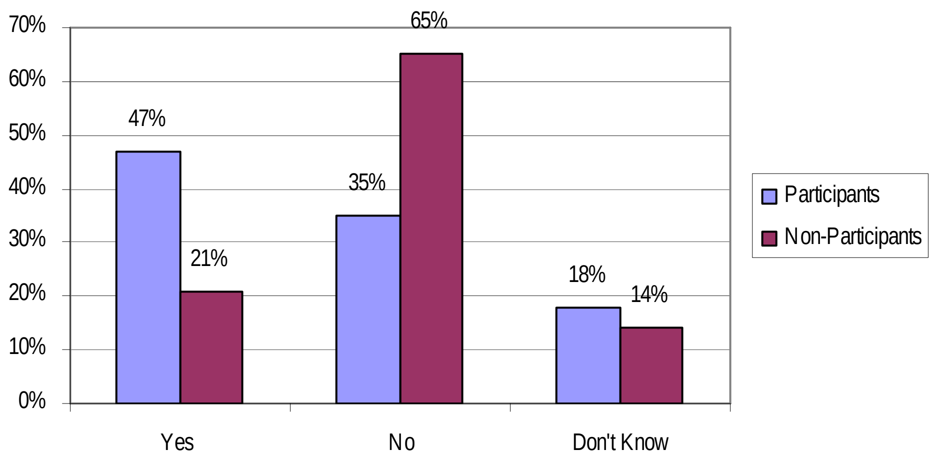


Figure 89: Are Builders Experiencing Spillover Effects?

(Participants N=29 Non-Participants N=17)

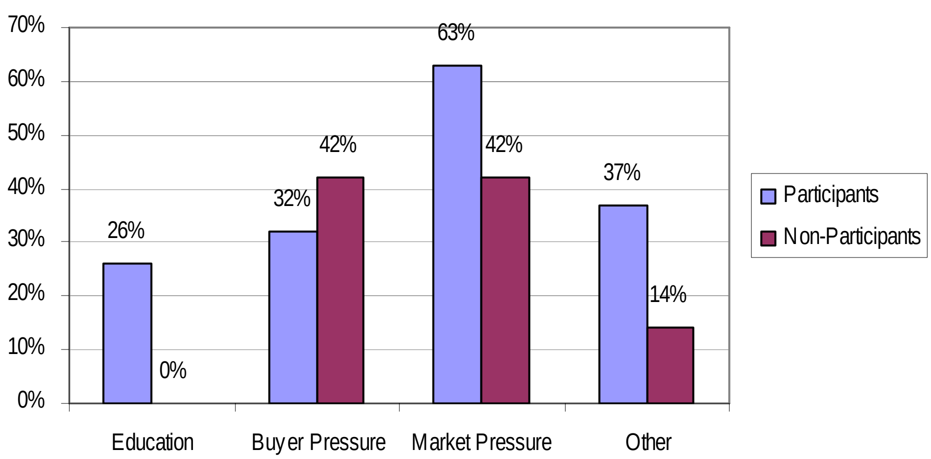


Figure 90: Reasons Builders are Influenced

(Participants N=17 Non-Participants N=7)

Owner Responses On Program Savings And Influences

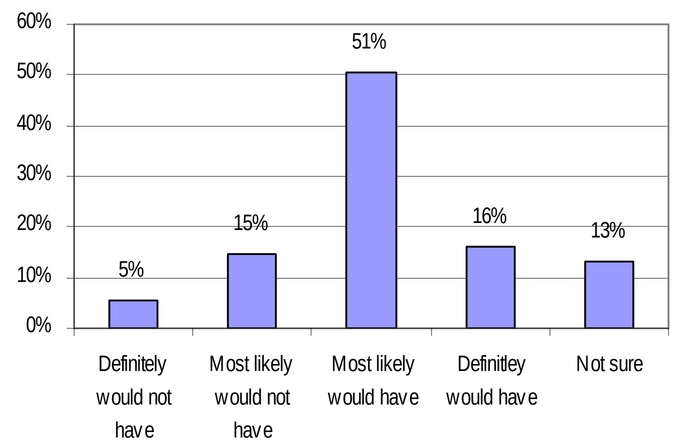
Program Savings and Influences

Owners were not the direct participants in the ENERGY STAR® Homes program, and were not the main actors regarding the measures to be installed in the homes. However, a few questions regarding the energy efficient measures and their impacts on homeowner decision-making were incorporated into the survey. On the other hand, however, the occupants are the major entities that live with any non-energy effects consequent to the energy efficiency measures, and as a result, the majority of the results from occupant surveys are included in the later chapter on non-energy effects. The following three questions sought to determine the resident's motivation to purchase the ENERGY STAR® home.

ENERGY STAR® Purchase Factor

The owner/occupants were surveyed to determine whether or not they would have rented the home if it was not an ENERGY STAR® rated home. One fifth of the residents responded that they either *definitely* or *most likely would not have* purchased or rented the home. Half of the residents reported that they *most likely would have* purchased the home even if it was not ENERGY STAR®, and 16% said they definitely *would have purchased* or rented the home regardless of the ENERGY STAR® rating. The distribution of these responses is shown in the Figure below.

(N=75)



Pay More for ENERGY STAR®

Figure 91: Likelihood of Purchasing/renting Home Without ENERGY STAR®

The participant households were next asked if they had paid more for the home because of it's ENERGY STAR® rating. The majority, close to 60%, of the residents responded that they *did not know* if they had paid more or less for the home because it was ENERGY STAR®. Almost a third of the participants reported that they paid the *same amount* for the home, and only 7% reported that they *paid more* for the home. These results are displayed in the Figure below.

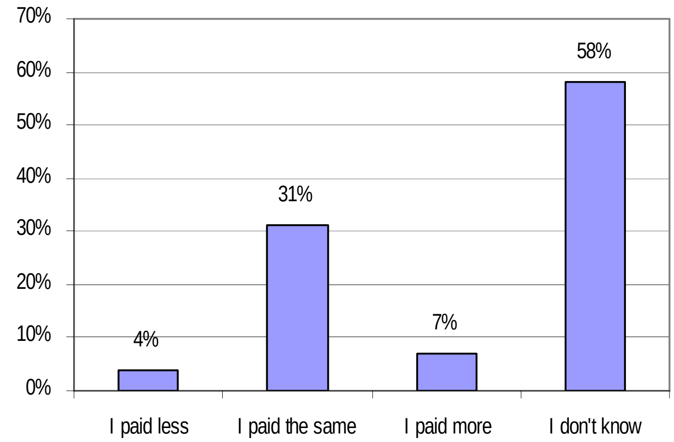


Figure 92: Pay More for ENERGY STAR®

(N=74)

Likelihood of Purchase

The owner/occupants were asked a hypothetical question regarding their likelihood of purchase. They were asked what the chance was that they would have selected the same home, with all the same design and energy features, if it had not been ENERGY STAR®. The responses were rather evenly distributed between *somewhat likely*, *more likely than not*, and *very likely*, with just over 20% reporting for each category. Only 3% reported that they *definitely would not have* selected the home, and 12% reported that the chance of them selecting the home without the ENERGY STAR® rating *was not very likely*. Almost 20% of the participants reported that they *definitely would have* selected the home. Each of the answers of likelihood was given a range of percents, and the midpoints of these ranges were used to determine the average likelihood that the residents would have selected the same home, with all the same features, if it was not ENERGY STAR®. The average likelihood of selection was 61%, *more likely than not* that the owner/occupants would have selected the home.

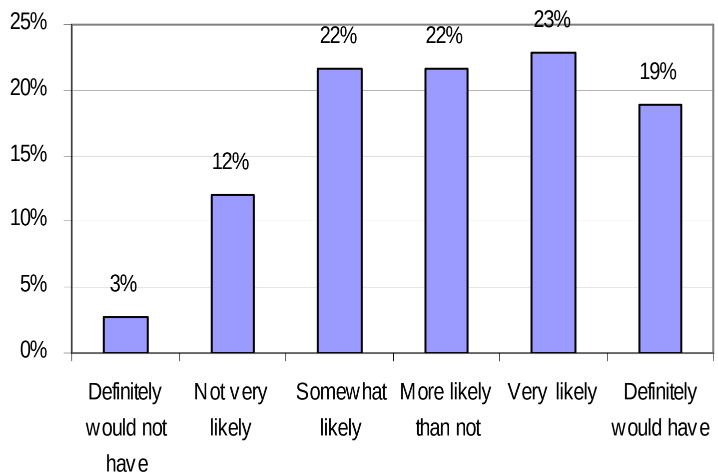


Figure 93: Likelihood of Selecting Home

(N=74)

Appendix G - Researchable Program Questions Informed by NTG and NEB Analyses (SERA)

The planning efforts for this evaluation included a review of the program theory and logic, and the researchable questions that could be supported by the research.[79] A summary of those researchable questions is presented in the following table. Those researchable questions that were expected to be informed by the NTG or NEB research are then listed in the second table, along with a summary of the relevant results addressing the issue.

The results from the NTG and NEB analyses provide feedback on a number of program and market progress indicators. The information is summarized in the following Table.

Program Indicator	Information from NTG and NEB Analysis
B - Educates market actors - Understanding of ESH benefits by builders and owners:	Results indicate significant NEBs recognized and associated with the program – equaling about half to two-thirds the value of energy savings.
C - Number of ESH homes built / savings attributable to the Program:	The NTG research indicates between 55%-71% of the participant energy savings associated with the program can be attributed to program effects. There were significant free riders (47%-53%) associated with the program because: 1) Builders indicated[80] that many projects need to exceed Title 24 by 15% for tax incentives / financing reasons (particularly for low income housing), and 2) The energy modeling programs included several baselines and assumptions that had the effect of allowing multifamily units to meet 15% for program purposes with few to no changes in standard practices.
N - Homebuyer enjoys lower energy bills:	Only about half to two-thirds of the Program's 15% energy savings can be attributed to the 2004-2005 program; most builders found they could participate in the program without changing the building measures because of the tax incentives program or energy modeling issues described above.
O - Builders promoting and advertising ESH:	Insufficient responses. .
P - More non-participating homes built to ESH standards:	The program attribution analysis showed that for the 2004-2005 program year non-participants may be upgrading the efficiency of their projects and incorporating ENERGY STAR® into non-participating buildings. These efforts are equal to about 7 (?)-14% of the energy savings associated with the program's direct

[79] Sebold, et.al., "A Framework for Planning and Assesssing Publicly Funded Energy Efficiency", Study ID PG&E-SW040, March, 2001, referred to as "California Framework Study.

[80] From the Strategy Assessment surveys conducted by RLW Analytics.

[81] In addition, about half the non-participants stated that they felt the influence of the program in the marketplace. This figure appears high for the early years of the program, and will be confirmed in the 2004-

Program Indicator	Information from NTG and NEB Analysis
	savings. [81]
Q – Direct and indirect program savings and environmental benefits provided:	Indirect benefits to participants are on the order of 95% of the direct associated program savings. After a NTG adjustment, these net NEBs are equal to about 53%-68% of the program's measured energy savings. One of the popular NEBs is the feeling of "doing good" for the environment by participating in the program.
S – Purchasers recognize benefits and spread word of ESH and value:	Participants recognized the energy savings associate significant NEBs with the program equal to about half to two-thirds of the value of the energy savings.
Y – Lower energy consumption and demand:	See Item N.

Table 110: Input to Researchable Questions for Multifamily Component of the California Statewide ENERGY STAR® Homes Program

2005 evaluation work.[This footnote doesn't make sense since we are reporting on 04/05 results. Please change or delete.]

Appendix H - MF Builder – Participant Questionnaire (SERA)

ENERGY STAR® MF RESIDENTIAL NEW CONSTRUCTION PROGRAM PARTICIPANT PROCESS/NTG/NEBS SURVEY: COMBINED BUILDER / DEVELOPER / OWNER SURVEY

Name______________________________________ Date _______________Start time: _____ End _____

Firm Name_________________________________ Phone __________________________

Project/Facility Address____

Project City / State / Zip ______________________________ Interviewer Initials __________

Gather these data from the database prior to the interview. If the information is not available from the database, ask the respondent.

A1. [IF not available from database]About how large is the multifamily building we are discussing, in square feet and units?

Square feet	Units
1. Up to 5,000 2. 5,001-10,000 3. 10,001-15,000 4. 15,001-25,000 5. 25,001-50,000 6. 50,001-100,000 7. 100,001-200,000 8. 200,001-500,000 9. Over 500,000 10. Don't know	Number: ______ __ Ranges: 1. 1-4 2. 5-10 3. 11-20 4. 21-50 5. 51-100 6. More than 100

A2. [IF Not in database] In what area of the state was the multifamily building constructed?

____

A. INTRODUCTION

Hello – My name is ____ and I work for SERA and I am calling on behalf of the State of California. We're researching a small sample of multifamily buildings that participated in the ENERGY STAR® Program.

The information we are gathering will be used to assess program accomplishments and improve the program.

We are calling about the building at ____________ address. Our records have you as the contact person. This interview will take approximately 15 minutes. Do you have a few minutes now?

➔ Are they the right person? If so, try to schedule. If not the right person, ask for contact information and start over with them. Contact info: ________________________ ____

[Note: when different wording needed for builders vs. owners, builders comes before slash; owners after slash.]

B. INTRO/BACKGROUND AND PROCESS EVALUATION ISSUES

B1. Which of the following roles did you / do you perform related to this building? (more than 1 response ok)

1. Developer
2. Builder
3. Owner

B2. What type of MF building / project was this? [read answer categories]

1. Market rate rental
2. Market rate for sale
3. Affordable housing
4. Senior / special needs
5. Other (specify):

B3. How many units are in this project? ______

B4. What type of building/buildings are in this project? (read / prompt responses)

1. Multistory apartment building with 5 or more units
2. Single story apartment building MF with 5 or more units
3. Apartment with 2-4 units
4. Single famly attached house (row house, town house)
5. Other (describe):

B5. What was the nature of this project in the ENERGY STAR® Multifamily Program at this building?

1. New construction
2. Addition to an existing building
3. Substantial renovation of an existing building(s)
4. Other (describe) ________________

B7. About what year did you become familiar with the ENERGY STAR® Multifamily program?

1. Before 2002
2. 2002
3. 2003
4. 2004
5. 2005

B8. On a 1-5 scale where 1=not at all familiar and 5=very familiar, how familiar would you say you are with the ENERGY STAR® Multifamily program?

1 2 3 4 5

B8a. Where did you hear about the program?

1. Utility 2. Advertisement (print or electronic) 3. List serve 4. Workshop	5. Professional meeting 6. Colleague 7. Client 8. Other (specify)

B8b. Was your experience with the program close to what you expected based on its description?

0. No ➔ how did it differ?
1. Yes
2. Don't know

B8c. What were your reasons for participating in the program?

B9. How important were the following factors in your decision to participate in the program? 1=not at all important, 5=very important. ➔ if 3 or less, ask "WHY?"

a. 1 2 3 4 5 Financial incentives

b. 1 2 3 4 5 To distinguish our buildings in the marketplace/ Product differentiation

c. 1 2 3 4 5 Advertising partnerships

d. 1 2 3 4 5 Marketing assistance

e. 1 2 3 4 5 Technical assistance provided by program

f. 1 2 3 4 5 Other (describe):

B10. Were there barriers to your participating in the program? How important were they? 1=not at all a barrier, 5=very much a barrier (check all that apply) → if 3 or more, ask "WHY?"

a. 1 2 3 4 5 Paperwork (Red Tape)

b. 1 2 3 4 5 Funding uncertainties

c. 1 2 3 4 5 Finding qualified certifier

d. 1 2 3 4 5 Scheduling certifier

e. 1 2 3 4 5 Cost of the certifier

f. 1 2 3 4 5 Required margin of compliance above Title 24

g. 1 2 3 4 5 Increased time and/or turnaround times

h. 1 2 3 4 5 Added cost of the energy efficient measures

i. 1 2 3 4 5 Added cost of participating in the program (staff time, resolving issues)

j. 1 2 3 4 5 Other (describe) ____

B10a. To what degree were you concerned with submitting your application(s) early before funding was all used up? 1=not at all concerned, 5=very concerned

B11. How difficult do you find it to design and build to meet the following threshold efficiency levels?

	Very easy	Somewhat easy	Somewhat difficult	Very difficult	Don't know	Building / designing to
a.						Title 24
b.						10% better than code
c.						15% better than code
d.						20% better than code

B11a. Did the UTILITY immediately accept or approve your building plans and application?

0. No (had to revise and resubmit plans to utility)
1. Yes
2. Don't know
3. Other (specify)

B11b. Did the PLAN CHECK AGENCY immediately approve your building plans/Title 24 file?

0. No (had to revise plans and Title-24 file)
1. Yes
2. Don't know
3. Other (specify)

B11c. Did the C-HERS RATER immediately approve your building?

0. No (had to modify building before it could pass inspection)
1. Yes
2. Don't know
3. Other (specify)

B12. How would you rate your satisfaction with the following aspects of the program on a 1-5 scale where 1= very dissatisfied, and 5=very satisfied. → if 2 or less, ask "WHY?"

a. 1 2 3 4 5 Overall program → if less than 3 ask "why" →

b. 1 2 3 4 5 Level of incentive → if less than 3 ask "why" →

c. 1 2 3 4 5 Required margin of compliance above Title 24 Code→ if less than 3 ask "why" →

d. 1 2 3 4 5 Ease and simplicity of program participation→ if less than 3 ask "why" →

B13. Did you rely on a Title 24 consultant or energy consultant to complete the documentation for Title 24 compliance?

1. Yes, fully. then, how were these sub contractors found and selected?
2. Yes, partly. then, how were these sub contractors found and selected?
3. No we did not
4. Don't know / refused

B14. How large an impact has the program had on the marketability of the MF building or units? [read]

1. No impact
2. Negative impact → somewhat negative or very negative (circle) SN VN
3. Positive impact → somewhat positive or very positive(circle)? SP VP

B15-B17. On a scale of 1 to 5 where 1=not at all important and 5=very important…How important is…→ if 3 or less, ask "WHY?" ________________________________

B15. 1 2 3 4 5	The financial incentive in helping offset additional costs for building to higher efficiency (for this building)
B16. 1 2 3 4 5	The importance of an energy efficient design to [you or your practice / you or the owner]?
B17. 1 2 3 4 5	[IF builder/developer]The importance of an energy efficient design to your customers?

B18. What is the program's biggest strength? Biggest weakness?

Strength:	Weakness:

B19. Did your participation in the program lead to any of fhe following benefits (check all that apply)?

1. Reduced bills for tenants
2. Marketing support
3. Gaining credits on tax exempt financing (especially for affordable housing participants)
4. Other (list):
5. Don't know / refused

B20. How valuable were the marketing assistance and promotional materials provided by the utility?

1. Don't Know
2. Not Aware of materials
3. Much Value→ Please explain:______________________________
4. Some Value → Please explain:______________________________
5. Little Value→ Please explain:______________________________
6. No Value→ Please explain:______________________________

B21. What types of marketing or advertising support would be <u>most valuable to you?</u>

C. SAVINGS, PROGRAM INFLUENCE, AND FREE RIDERSHIP

C1. To the best of your recollection, by what amount did this multifamily building/project exceed the energy code – was it more than 15%, about 15%, or less than 15%?

1. More than 15% ➔ About how much more -- what percent different from code? ______% (should be greater than 15%)
2. About 15%
3. Less than 15% ➔ About how much less -- what percent different from code? ______% (should be between 1 and 14%)
4. Don't know/refused

C1a. How much did your participation in the Program influence your decision to install additional energy efficiency measures and practices, beyond the ones you normally would have included in other multifamily buildings?

1. Very much
2. Somewhat
3. Very little
4. Not at all

C2. If you had not participated in the Program, or if the program did not exist, how likely is it that you would have incorporated ALL the same energy-efficiency technologies into this project at the same (or higher) level of efficencies?

1. __________(if they will give %, otherwise categories) 2. Definitely or almost definitely (greater than 90% likely) 3. Very likely (75% -90) 4. More likely than not (50-75%)	5. Somewhat likely (25-50%) 6. Not very likely (10-25%) 7. Not at all likely (less than 10%) 8. Definitely would not have 9. Other ____________________

C2a➔ WHY?____

C2b. If you had not participated in the Program, or if the program did not exist, how likely is it that you would have incorporated SOME OF the same energy-efficiency technologies into this project at the same (or higher) levels of efficiencies?

1. __________(if they will give %, otherwise categories) 2. Definitely or almost definitely (greater than 90% likely) 3. Very likely (75% -90) 4. More likely than not (50-75%)	5. Somewhat likely (25-50%) 6. Not very likely (10-25%) 7. Not at all likely (less than 10%) 8. Definitely would not have 9. Other ____________________

C2c. ➔WHY?____

C3. If you had not participated in the Program, or if the program did not exist, would you have made any design changes that would affect the energy efficiency of the building? If yes, what would you likely have changed?

0. No

1. Yes ➔ what changes (list/describe below)?

2,. Don't know/refused

C3A. IF YES, WHAT CHANGES -- DESCRIBE:

C4. Overall, if you had not participated in the Program, or if the program did not exist, how efficient do you believe this building would have been relative to Title 24?

1. Much more efficient 2. Somewhat more efficient 3. Slightly more efficient 4. About the same efficiency as Title 24	5. Slightly less efficient than Title 24 6. Somewhat less efficient than Title 24 7. Much less efficient than Title 24 8. Other (describe) ____________________ 9. Don't know / refused

C4a. If you had not participated in the Program, or if the Program did not exist, by what percent do you believe this building would have exceeded energy code? ________

C4b. Did you already have a need to exceed code by 15% for reasons other than the ENERGY STAR® Home Program?

0. No

1. Yes ➔ what were those reasons?

2,. Don't know/refused

C6. On a scale from 1 to 5, where 1="not at all important" and 5 is "very important", please indicate how important the Program or its financial assistance were in your decision to design and build the project to exceed Title 24 by 15% or more? ➔ 1 2 3 4 5

[For these next questions, ask relative to what they would have done/ requested without the program –"done" for developers/builders, "requested" for owners/managers.]

You noted above that this building achieved savings about ____% better than the energy code / Title 24 (from C1).

C8a. Thinking about this project, what would you estimate is the minimum or lowest share of the overall energy savings above Title 24 that you would estimate were definitely achieved due to the influence of the Program?

(this should be a number up to 100% of the savings)

[Record reponse in table below]

C8b. What would you estimate is the maximum or highest share of the overall energy savings above Title 24 that you would estimate might possibly have been achieved due to the influence of the Program? (this should be a number up to 100%)

[Record reponse in table below]

C8c. Thinking about this range, what would be your "best estimate" or best guess of the overall energy savings achieved at this building above Title 24 that you would say were achieved due to the influence of the Program? (number up to 100%)

[Record reponse in table below]

C9. Consider you average MF building built using your normal practices. How does the energy savings from this "normal" MF building relate to the energy code standards? (should relate to C4)

1. Less than code ➔ about what percent less than code
2. Just to code
3. Above code ➔ about what percent above code?

[IF a difference between C9% and C1%, then proceed; other wise skip to D2]

Then think about this difference between your standard practice of __<C9%>__and the efficiency level at which this building was constructed _<C1%>___...

C9a. Thinking about this project, what would you estimate is the minimum or lowest share of the overall energy savings above your standard practices that you would estimate were definitely achieved due to the influence of the Program? (this should be a number up to 100% of the savings)

[Record reponse in table below]

C9b. What would you estimate is the maximum or highest share of the overall energy savings above your standard practice that you would estimate might possibly have been achieved due to the influence of the Program? (this should be a number up to 100%)

[Record reponse in table below]

C9c. Thinking about this range, what would be your "best estimate" or best guess of the overall energy savings achieved at this building above your standard practice that you would say were achieved due to the influence of the Program? (number up to 100%)

[Record reponse in table below]

	Share of savings beyond Title 24 that are due to the program	**Compared to what you would have done without program**
Percent Savings	Beyond Title 24 (from C1)	C9. Compared to their standard practice: ____% more efficient
Minimum share of these saving due to program (0-100%)	8a..	9a.
Maximum share of these savings due to program (0-100%)	8b.	9b.
Best guess share of these savings due to the program (0-100% and within range of min/ max)	8c.	9c.

D. RELATED EFFECTS

D2. Did the program lead you to increase the efficiency level of the equipment that was installed? In which end-uses?

0. No
1. Yes ➔ Which ones?
   a. HVAC ___________
   b. Lighting __________
   c. Controls __________
   d. Envelope __________
   e. Water _____________
   f. Planning/coord ______
   g. Other ______________
2. None installed
3. Don't know

D3. Do you believe / have you heard evidence of changes in energy-related behavior by tenants or owners due to the installation of higher efficiency equipment compared to standard efficiency equipment? (e.g. turning up or down heat / turning up or down air conditioners, doing wash or dishes more or less often, etc.) Please describe.

	Actions / description	**Notes/ causes / evidence /**

		frequency
a. Increase energy use		
b. Decrease energy use		
b.Peak load changes		

E. SPILLOVER

E1. [IF C1 >15% and C4a<C1] You mentioned this building was _<C1>__% more efficient than Title 24 and that your original plans called for the building to be built to about __<C4a>__% greater than Title 24 code. About what percent of this increase would you say was due to the influence of the program?

_____% (enter a number from 0-100%)

E2. Did your experience with the Program cause you to install any additional energy efficiency measures or technologies *at other multifamily jobs or facilities* you are involved in beyond what you would have done otherwise?

0. No ➔ Go to Question E3
1. Yes ➔ About how many other facilities were influenced that were NOT in the program? _________
➔ about what multi-family square footage construction in the last year (or annually) does this represent? _________square feet
2. Don't know ➔ Go to question E3

E2a. (IF E2=yes) On average, would you estimate the average energy savings per building from these extra measures to be more than, similar to, or less than the savings from the energy efficiency measures from the program project we are discussing (e.g. the savings might be higher if other buildings are larger than the program building we've been discussing on average, or include more measures, or both)?

1. Less than current project ➔ About what percentage of the savings from the current project? (Enter a number less than 100%) ____%
2. About the same size
3. Larger than current project ➔ About what percentage of savings from the current project? (Enter a number greater than 100%) ____%

E2b. (IF E2=yes) About what share of these savings from the additional energy efficiency measures were influenced by the Program? (Enter a number equal to or less than 100%) _____%

E2c. (IF E2=yes) Can you explain how you were influenced? (do not read)

1. Learned about new technology
2. Recognized cost/benefit of measure
3. List: ________________________________

E3. Do you believe that builders / owners / buildings that have not participated in the ENERGY STAR® Program have been influenced to install higher efficiency measures or building practices in multifamily buildings because of the influence of the Program? For example, have you recommended measures to other buildings?

0. No 1. Yes 2. Don't know

E3d. (If E3=yes) About how many buildings have you talked with about this – about how many do you believe have installed additional energy efficiency equipment but have not participated in the program due to the program or your discussions? __________

E3e. About what square footage of multifamily buildings constructed annually would you say this represents? _______ square feet

E3f. About how many MF units does this represent? ________

E4. On average, what percent extra building energy savings would you estimate is achieved due to the program's influence? ____%

E5. Why is this happening / to what would you attribute this influence?

1. Education about improved practices
2. Pressure from buyers to get more efficient buildings
3. Marketplace pressure to keep up with participating builders / developers?
4. Other _________

N. NEBS

Now we'd like to ask a few questions about effects other than energy savings that may be realized by building owners or occupants due to the energy efficiency measures or practices from the Program.

N1. Do you believe [the owner / you] or the tenants experience any positive effects, above and beyond energy savings, that you would attribute to the measures installed due to the program – compared to the standard efficiency measures? Any negative effects?

Positive effects:

Negative effects:

N2. I'd like to read you a list of possible positive and negative effects. Do you believe [the owner / you] or tenants experience any positive or negative effects – or no effect – of this type from the energy efficiency measures included in this project compared to standard efficiency measures?(read in turn, record in table).

N2a. If positive, Would you say the annual benefits to the owner or tenants are more valuable or less valuable than the energy savings? (record in table)

N2b. If negative: would you say the impacts are more or less costly than the value of the energy savings? (record in table)

N2c. Which are the top three – in order (1=most valuable)

N2c. RANK TOP 3 IN ORDER	N2. Any effects, beyond energy savings specifically from the measures that were installed under the Energy Star program compared to if standard measures / practices had been used?	N 2. Positive, zero or negative effect (+1/0/-1)	N2a. Value Compared to Energy Savings [1]	DNK
	A. Operating Cost (other than energy)	-1 0 1	ML SL S SM MM	-9
	B. Equipment Maintenance –	-1 0 1	ML SL S SM MM	-9
	C. Equipment Performance –	-1 0 1	ML SL S SM MM	-9
	D. Equipment lifetime --	-1 0 1	ML SL S SM MM	-9
	E. Occupant Satisfaction	-1 0 1	ML SL S SM MM	-9
	F. Occupant Comfort	-1 0 1	ML SL S SM MM	-9
	G. Aesthetics /Appearance	-1 0 1	ML SL S SM MM	-9
	H. Lighting / Quality of Light	-1 0 1	ML SL S SM MM	-9
	I. Noise	-1 0 1	ML SL S SM MM	-9
	J. Building Safety	-1 0 1	ML SL S SM MM	-9
	K. Ease of Selling/leasing –	-1 0 1	ML SL S SM MM	-9
	L. Doing good for environment	-1 0 1	ML SL S SM MM	-9
	M. Power quality / reliability	-1 0 1	ML SL S SM MM	-9
	N. Other ____________ ____	-1 0 1	ML SL S SM MM	-9
	O. Other ____________ ____	-1 0 1	ML SL S SM MM	-9
	N2c. Now, thinking about the overall benefits and negative effects, from all the effects and topics we mentioned above – other than energy savings. Would you say that the total of all these "net" benefits is positive, negative, or there is no effect compared to standard efficiency measures /	-1 0 1	ML SL S SM MM [1] Stands for much less valuable, somewhat less valuable, same value, somewhat more valuable, and much more valuable.	-9

Now, we'd like you to think again about all the overall benefits and negative effects, from all the topics we mentioned above – other than energy savings.

N4. (NOTE: IF N2c is +1) Can you estimate about how valuable these benefits are, as compared with the energy savings – in percentage terms?

____% (NOTE: Work with them to make sure it expresses what they mean -- 100% means same value; 50% means half as valuable, 200% means twice as valuable, etc.)

dnk. Don't know/refused

N4b. (NOTE: IF N2c is -1) Can you estimate about how costly these negative impacts are, as compared with the energy savings – in percentage terms?

-____% (NOTE: Work with them to make sure it expresses what they mean -- 100% means the cost just balances the savings; 50% means half as costly, 200% means twice as costly, etc.)

dnk. Don't know/refused

N5. If we took away all these extra effects, can you estimate what you think [the owner/you] might be willing to pay to gain back these benefits, as an annual dollar amount?

$__________

dnk Don't know/refused

N5a. If we wanted to take away all these NEBs (positive and negative) that we discussed, how much would we need to pay [the owner /you], as an annual dollar amount?

$__________

dnk Don't know/refused

N6. Did [you / the developers / buiders] use non- energy benefits to help convince the building to install energy efficiency measures as part of this project?

0. No
1. Yes ➔

How important would you estimate these NEBs were in influencing your decision on the measures? (1=not important, 5=very important) 1 2 3 4 5 dnk

2. Don't know

N7. [IF Owner] Do you consider the measures you installed to be a hedge against future energy price increases and / or higher energy bills in the future?

0. No
1. Yes
2. Don't know

N8. [IF Owner] If yes, would you consider that an important benefit? (answer on a scale of 1=not at all important to 5-very important).

1 2 3 4 5 dnk

N9. If N8>1… How valuable is this risk effect relative to the estimated annual energy savings?

MMV SMV SV SLV MLV DNK

G. FIRMOGRAPHICS AND ATTITUDES

G1. Overall, how much has the ENERGY STAR® Program aided in increasing your knowledge about energy efficient technologies in buildings?

1. Very much
2. Somewhat
3. Very little
4. Not at all / stayed the same
5. Decreased
6. Don't know

G2. Do you believe energy prices will be rising or falling in the next 3-5 years?

1. Increasing a great deal
2. Increasing somewhat
3. Stay about the same
4. Decrease a little
5. Decrease a lot
6. Don't know

G3. Have you participated in other energy efficiency programs? If yes, was this a positive experience?

0. No

1. Yes ➔ on a 1 to 5 scale where 1 means very negative experience, and 5 means very positive experience and 3 is neutral (neither positive nor negative) how would you rank this previous experience? 1 2 3 4 5 dnk

2. Don't know

[IF OWNER / MANAGER, SKIP TO G9.]

G4. [IF developer/builder] Approximately how many full time employees does you firm have in California? Nationwide? Internationally?

CA:

US:

Total World:

G7. [IF developer/builder] About what percent of your business…

____% What percent of your multifamily construction / development work is outside of California?

____% About what percent of your Company's business is in the multifamily sector?

G9. Approximately how many buildings and units do you [build / own or manage] in the State of California? Nationwide?

	Number of buildings	Number of units
CA		
Nationwide		

G6. About what percentage of your multifamily buildings you [build / own or manage] in California is in the following areas of the state?

____% PG&E territory – northern and central CA

____% SCE territory –

____% SDG&E territory –

G8. Do you have any comments about the program that you would like to provide?

Thank you very much for your time! We really appreciate your help. If it turns out we need to clarify any issues, may I call you later? Thanks.

Appendix I - MF Builder – Non-Participant Questionnaire (SERA)

ENERGY STAR® MF RESIDENTIAL NEW CONSTRUCTION PROGRAM NON-PARTICIPANT PROCESS/NTG/NEBS SURVEY: COMBINED BUILDER / DEVELOPER / OWNER SURVEY

Name____ **Date** _____________Start time: _____ End _____

Firm Name___________________________________ **Phone** ____________________________

Project/Facility Address____

Project City / State / Zip ____________________________ **Interviewer Initials** _______ **Non-P Type**_______

A. INTRODUCTION

Hello – My name is ____ and I work for SERA and I am calling on behalf of the State of California Utilities. We're researching a small sample of multifamily buildings that did not participate in the ENERGY STAR® Program. The information we are gathering will be used to assess program accomplishments and improve the program.

This interview will take approximately 15 minutes. Do you have a few minutes now?

➔ *Are they the right person? If so, try to schedule. If not the right person, ask for contact information and start over with them. Contact info:* ____

[Note: when different wording needed for builders vs. owners, builders comes before slash; owners after slash.]

C. INTRO/BACKGROUND AND PROCESS EVALUATION ISSUES

We'd like you to think about a typical Multifamily building that you built / had built / developed between 2004-2005– one that did NOT go through the MF ENERGY STAR® Program. We're going to ask you some questions about multifamily projects you've been involved in "overall" and other questions will focus on this building.

A1. What is the name of the example complex we'll be discussing?________________________________

A1a. [IF not available from database]About how large is the multifamily building we are discussing, in square feet and units?

Square feet	**Units**
11. Up to 5,000 12. 5,001-10,000 13. 10,001-15,000 14. 15,001-25,000 15. 25,001-50,000 16. 50,001-100,000 17. 100,001-200,000 18. 200,001-500,000 19. Over 500,000 20. Don't know	Number: ______ __ Ranges: 7. 1-4 8. 5-10 9. 11-20 10. 21-50 11. 51-100 12. More than 100

A2. In what area of the state was the multifamily building constructed / specifically, what City?

____

B1. Which of the following roles did you / do you perform related to this building? (more than 1 response ok)

1. Developer
2. Builder
3. Owner

B2. What type of MF building / project was this? [read answer categories]

6. Market rate rental
7. Market rate for sale
8. Affordable housing
9. Senior / special needs
10. Other (specify):

B3. How many units are in this project? ______

B4. What type of building/buildings are in this project? (read / prompt responses)

4. Multistory apartment building with 5 or more units
5. Single story apartment building MF with 5

4. Single family attached house (row house, town house)

or more units
6. Apartment with 2-4 units

5. Other (describe):

B5. What was the nature of this project? Was it…

1. New construction
2. Addition to an existing building
3. Substantial renovation of an existing building(s)
4. Other (describe) ________________

B7. Before this call, had you heard of the ENERGY STAR® Multifamily program in California?

0. No
1. Yes
2. Don't know

B7a. [IF B7=1; AWARE] About what year did you become aware of the program?

6. Before 2002
7. 2002
8. 2003
9. 2004
10. 2005

B8. [IF B7=1; AWARE] On a 1-5 scale where 1=not at all familiar and 5=very familiar, how familiar would you say you are with the ENERGY STAR® Multifamily program?

1 2 3 4 5

B8a. [IF B7=1; AWARE] Where did you hear about the program?

5. Utility 6. Advertisement (print or electronic) 7. List serve 8. Workshop	5. Professional meeting 6. Colleague 7. Client 8. Other (specify)

B8b. What is your basic understanding of the program? (do not read, check all that apply)?

6. Higher efficiency than code
7. Advertising partnerships
8. Marketing assistance
9. Technical assistance
10. CHERS raters involved
11. Title 24 consultants involved
12. Plan check agencies involved

13. Reduced bills for tenants
14. Marketing support
15. Gaining credits on tax exempt financing (especially for affordable housing participants)
16. Other (list):
17. Don't know / refused

B8c. Did you or did this project participate in the program?

0. No
1. Yes → may want to terminate
2. Don't know

B8d. What were your reasons for NOT participating in the program?

B9. How important were the following factors in your decision NOT to participate in the program in 2004-2005? 1=not at all important, 5=very important. → if 3 or less, ask "WHY?"

a. 1 2 3 4 5 Insufficient level of financial incentives

b. 1 2 3 4 5 Don't need to distinguish our buildings in the marketplace/ Product differentiation

c. 1 2 3 4 5 Insufficient benefit from advertising partnerships

d. 1 2 3 4 5 Insufficient / unattractive marketing assistance

e. 1 2 3 4 5 Insufficient / unattractive Technical assistance provided by program

f. 1 2 3 4 5 Other (describe):____

B10. Were there barriers to your participating in the program? How important were they? 1=not at all a barrier, 5=very much a barrier (check all that apply) → if 3 or more, ask "WHY?"

a. 1 2 3 4 5 Paperwork (Red Tape)

b. 1 2 3 4 5 Funding uncertainties

c. 1 2 3 4 5 Finding qualified certifier

d. 1 2 3 4 5 Scheduling certifier

e. 1 2 3 4 5 Cost of the certifier

f. 1 2 3 4 5 Required margin of compliance above Title 24

g. 1 2 3 4 5 Increased time and/or turnaround times

h. 1 2 3 4 5 Added cost of the energy efficient measures

i. 1 2 3 4 5 Added cost of participating in the program (staff time, resolving issues)

j. 1 2 3 4 5 Other (describe) ____

B10a. Had you heard anything about project monies being "used up"?

0. No
1. Yes
2. Don't know

B10b. If yes, what had you heard? ____
____
____

B11. How difficult do you find it to design and build to meet the following threshold efficiency levels?

	Very easy	Somewhat easy	Somewhat difficult	Very difficult	Don't know	Building / designing to
a.						Title 24
b.						10% better than code
c.						15% better than code
d.						20% better than code

B13. Did you rely on a Title 24 consultant or energy consultant to complete the documentation for Title 24 compliance 2004-2005?

5. Yes, fully. Then, how were these sub contractors found and selected? Are they qualified?
6. Yes, partly. Then, how were these sub contractors found and selected? Are they qualified?
7. No we did not
8. Don't know / refused

B21. What types of marketing or advertising support would be most valuable to you?

C. SAVINGS, PROGRAM INFLUENCE, AND FREE RIDERSHIP

C1. To the best of your recollection, did this multifamily building/project exceed the energy code in 2004-2005, by what amount – was it more than 15%, about 15%, or less than 15%?

5. More than 15% ➔ About how much more -- what percent different from code? ______% (should be greater than 15%)
6. About 15%

7. Less than 15% ➔ About how much less -- what percent different from code? ______% (should be between 1 and 14%)
8. Just to code
9. Don't know/refused

C1a. How often did your multifamily projects in 2004-2005 require exceeding Title 24 by 15% for tax credits or other funding reasons?

4. Always
3. Often
2. Sometimes
1. Rarely
0. Never
-9. Don't know

C1b. [IF HEARD OF PROGRAM-B7] Did the ENERGY STAR® Homes program have any influence on the energy performance of your project? Describe.

C1c. How about on more recent projects? Describe.

C2. What are some of the energy efficiency technologies you commonly included in your multifamily projects on a normal basis in 2004-2005?

a. HVAC ___________
b. Lighting __________
c. Controls __________
d. Envelope __________
e. Water _____________
f. Planning/coord ______
g. Other ______________

C3. How would you characterize the efficiency of your 2004-2005 buildings compared to Title 24?

5. Much more efficient than Title 24 6. Somewhat more efficient 7. Slightly more efficient	5. Slightly less efficient than Title 24 6. Somewhat less efficient than Title

8. About the same efficiency	24 7. Much less efficient than Title 24 8. Other (describe) ____________________ 9. Don't know / refused

C4. Has the efficiency of your MF projects increased or decreased over time? __________How do current buildings compare with those built 2 to 3 years ago? How about compared to last year?

2-3 Years ago-

1. Much more efficient than 2 years ago 2. Somewhat more efficient 3. Slightly more efficient 4. About the same efficiency	5. Slightly less efficient 6. Somewhat less efficient 7. Much less efficient 8. Other (describe) ____________________ 9. Don't know / refused

Last Year-

1. Much more efficient than 2 years ago 2. Somewhat more efficient 3. Slightly more efficient 4. About the same efficiency	5. Slightly less efficient 6. Somewhat less efficient 7. Much less efficient 8. Other (describe) ____________________ 9. Don't know / refused

C4b. Did you already have a need to exceed code by 15% for any reason in 2004-2005?

0. No

1. Yes ➔ what were those reasons?____

2. Don't know/refused

C6. Approximately what is / would be the difference in total cost for you to construct or develop a MF project to a level that is greater than 15% better than Title 24 in 2004-2005?➔

______% of project costs

C6a. What level of an incentive might have made it attractive for you to increase the efficiency of your MF projects to a level that was greater than 15% better than Title 24 in 2004-2005? ➔

______% of project costs

C9. Consider your average MF building built in 2004-2005 using your standard practices. How does the energy savings from this "normal" MF building relate to the energy code standards? (should relate to C4)

4. Less than code ➔ about what percent less than code
5. Just to code
6. Above code ➔ about what percent above code?

D. RELATED EFFECTS

D2. [IF HEARD OF PROGRAM] Did the program lead you to increase the efficiency level of the equipment that was installed in 2004-2005? In which end-uses?

0. No   1. Yes ➔ Which ones?   2. None installed   3. Don't know

a. HVAC ___________
b. Lighting __________
c. Controls __________
d. Envelope __________
e. Water _____________
f. Planning/coord ______
g. Other _______________

D3. Do you believe / have you heard evidence of changes in energy-related behavior by tenants or owners due to the installation of higher efficiency equipment compared to standard efficiency equipment? (e.g. turning up or down heat / turning up or down air conditioners, doing wash or dishes more or less often, etc.) Please describe.

	Actions / description	**Notes/ causes / evidence / frequency**
a. Increase energy use		
b. Decrease energy use		

b. Peak load changes		

E. SPILLOVER

E3. [IF AWARE OF PROGRAM] Do you believe that builders / owners / developers like you that have not participated in the ENERGY STAR® Program have been influenced to install higher efficiency measures or building practices in multifamily buildings because of the influence of the Program in 2004-2005?

0. No 1. Yes 2. Don't know

E3d. (If E3=yes) Can you estimate about how many buildings you might have been involved with that have been influenced by the program? __________

E3e. (If E3=yes) About what square footage of multifamily buildings constructed annually would you say this represents? _______ square feet

E3f. (If E3=yes) About how many MF units does this represent? ________

E4. (If E3=yes) On average, what percent extra building energy savings would you estimate is achieved due to the program's influence? ____%

E5. (If E3=yes) Why is this happening / to what would you attribute this influence? [DO NOT READ]

5. Education about improved practices
6. Pressure from buyers to get more efficient buildings
7. Marketplace pressure to keep up with participating builders / developers?
8. Other _______________

N. NEBS

Now we'd like to ask a few questions about effects other than energy savings that may be realized by building owners or occupants due to the installation of energy efficiency measures or practices in MF buildings.

N1. Do you believe [the owner / you] or the tenants experience any positive effects, above and beyond energy savings, that you would attribute to energy efficiency measures and practices installed in MF buildings – compared to the standard efficiency measures? Any negative effects?

Positive effects:

Negative effects:

N2. I'd like to read you a list of possible positive and negative effects. Do you believe [the owner / you] or tenants experience any positive or negative effects – or no effect – of this type from the installation of energy efficiency measures compared to standard efficiency measures?(read in turn, record in table).

N2a. If positive, Would you say the annual benefits to the owner or tenants are more valuable or less valuable than the energy savings? (record in table)

N2b. If negative: would you say the impacts are more or less costly than the value of the energy savings? (record in table)

N2c. Which are the top three – in order (1=most valuable)

N2c. RANK TOP 3 IN ORDER	N2. Any effects, beyond energy savings specifically from installing EE measures and practices compared to if standard measures / practices had been used?	N 2. Positive, zero or negative effect (-1/ 0/ +1)	N2a. Value Compared to Energy Savings	DNK
	A. Operating Cost (other than energy)	-1 0 1	ML SL S SM MM	-9
	B. Equipment Maintenance –	-1 0 1	ML SL S SM MM	-9
	C. Equipment Performance –	-1 0 1	ML SL S SM MM	-9
	D. Equipment lifetime --	-1 0 1	ML SL S SM MM	-9
	E. Occupant Satisfaction	-1 0 1	ML SL S SM MM	-9
	F. Occupant Comfort	-1 0 1	ML SL S SM MM	-9
	G. Aesthetics /Appearance	-1 0 1	ML SL S SM MM	-9
	H. Lighting / Quality of Light	-1 0 1	ML SL S SM MM	-9
	I. Noise	-1 0 1	ML SL S SM MM	-9
	J. Building Safety	-1 0 1	ML SL S SM MM	-9
	K. Ease of Selling/leasing –	-1 0 1	ML SL S SM MM	-9
	L. Doing good for environment	-1 0 1	ML SL S SM MM	-9
	M. Power quality / reliability	-1 0 1	ML SL S SM MM	-9
	N. Other _____________ ____	-1 0 1	ML SL S SM MM	-9
	O. Other _____________ ____	-1 0 1	ML SL S SM MM	-9
	N2c. Now, thinking about the overall benefits and negative effects, from all the effects and topics we mentioned above – other than energy savings. Would you say that the total of all these "net" benefits is positive, negative, or there is no effect compared to standard efficiency measures / practices?	-1 0 1	ML SL S SM MM	-9

Now, we'd like you to think again about all the overall benefits and negative effects, from all the topics we mentioned above – other than energy savings.

N4. (NOTE: IF N2c is +1) Can you estimate about how valuable these benefits are, as compared with the energy savings – in percentage terms?

____% (NOTE: Work with them to make sure it expresses what they mean -- 100% means same value; 50% means half as valuable, 200% means twice as valuable, etc.)

dnk. Don't know/refused

N4b. (NOTE: IF N2c is -1) Can you estimate about how costly these negative impacts are, as compared with the energy savings – in percentage terms?

-____% (NOTE: Work with them to make sure it expresses what they mean -- 100% means the cost just balances the savings; 50% means half as costly, 200% means twice as costly, etc.)

dnk. Don't know/refused

N5. If we took away all these extra effects, can you estimate what you think [the owner/you] might be willing to pay to gain back these benefits, as an annual dollar amount?

$__________

dnk Don't know/refused

N5a. If we wanted to take away all these NEBs (positive and negative) that we discussed, how much would we need to pay [the owner /you], as an annual dollar amount?

$__________

dnk Don't know/refused

N6. Did [you / the developers / buiders] use non- energy benefits to help convince the building to install energy efficiency measures as part of this project?

0. No
1. Yes ➔
How important would you estimate these NEBs were in influencing your decision on the measures? (1=not important, 5=very important) 1 2 3 4 5 dnk
2. Don't know

N7. [IF Owner] Do you consider the measures you installed to be a hedge against future energy price increases and / or higher energy bills in the future?

0. No
1. Yes
2. Don't know

N8. [IF Owner] If yes, would you consider that an important benefit? (answer on a scale of 1=not at all important to 5-very important).

1 2 3 4 5 dnk

N9. If N8>1… How valuable is this risk effect relative to the estimated annual energy savings?

MMV SMV SV SLV MLV DNK

G. FIRMOGRAPHICS AND ATTITUDES

G1. How would you characterize your knowledge of advanced energy efficient technologies and practices – especially as they apply to MF buildings? Please use a scale of 1=not at all knowledgeable and 5=very knowledgeable.

1 2 3 4 5

G2. Do you believe energy prices will be rising or falling in the next 3-5 years?

4. Increasing a great deal
5. Increasing somewhat
6. Stay about the same

4. Decrease a little
5. Decrease a lot
6. Don't know

G3. Have you participated in energy efficiency programs? If yes, was this a positive experience?

0. No

1. Yes ➔ on a 1 to 5 scale where 1 means very negative experience, and 5 means very positive experience and 3 is neutral (neither positive nor negative) how would you rank this previous experience? 1 2 3 4 5 dnk

2. Don't know

[IF OWNER / MANAGER, SKIP TO G9.]

G4. [IF developer/builder] Approximately how many full time employees does you firm have in California? Nationwide? Internationally?

CA:

US:

Total World:

G7. [IF developer/builder] About what percent of your business…

____% What percent of your multifamily construction / development work is outside of California?

____% About what percent of your Company's business is in the multifamily sector?

G9. Approximately how many buildings and units do you [build / own or manage] in the State of California? Nationwide?

	G9a. Number of buildings	G9b. Number of units
1. CA		
2. Nationwide		

G6. About what percentage of the multifamily buildings you [build / own or manage] in California is in the following areas of the state?

____% PG&E territory – northern and central CA

____% SCE territory –

____% SDG&E territory –

G8. Do you have any comments about the program that you would like to provide?

Thank you very much for your time! We really appreciate your help. If it turns out we need to clarify any issues, may I call you later? Thanks.

Appendix J - SF Builder – NP Questionnaire (SERA)

ENERGY STAR® SF RESIDENTIAL NEW CONSTRUCTION PROGRAM <u>NON</u>-PARTICIPANT PROCESS/NTG/NEBS SURVEY: COMBINED BUILDER / DEVELOPER SURVEY

Name_______________________________________ Date _____________Start time: _____ End _____

Firm Name__________________________________ Phone ___________________________

Project/Facility Address____

Project City / State / Zip ___________________________ Interviewer Initials _______ Non-P Type_______

A. INTRODUCTION

Hello – My name is ____ and I work for SERA and I am calling on behalf of the State of California Utilities. We're researching a small sample of single family homes that did not participate in the ENERGY STAR® Program. The information we are gathering will be used to assess program accomplishments and improve the program. Your responses will remain confidential.

This interview will take approximately 15 minutes. Do you have a few minutes now?

➔ *Are they the right person? If so, try to schedule. If not the right person, ask for contact information and start over with them. Contact info: ________________________ ____________________________________*

[Note: when different wording needed for builders vs. developers, builders comes before slash; developers after slash.]

D. INTRO/BACKGROUND AND PROCESS EVALUATION ISSUES

We'd like you to think about a typical single family project that you built / developed between 2004-2005– one that did NOT go through the ENERGY STAR® Homes Program. We're going to ask you some questions about single family homes projects you've been involved in "overall" and other questions will focus on this home.

A1. What is the name of the development or general address of the example development we'll be discussing?______________________________________

A1a. [IF not available from database]About how large are these homes we are discussing, in square feet ? _______

A2. In what area of the state was the home constructed / specifically, what City and County?

____

B1. Which of the following roles did you / do you perform related to this home? (more than 1 response ok)

1. Developer
2. Builder
3. Other ____________

B2. What type of home was this? [read answer categories]

11. Market rate for sale
12. Affordable housing
13. Senior / special needs
14. Other (specify):

B3. How many homes were in this same development? ______

B4. I assume these were newly constructed homes. Is that true? (if so, circle 1. If not, continue) Was it (read 2-4)…

1. New construction
2. Addition to an existing home
3. Substantial renovation of existing home(s)
4. Other (describe) _______________

B5. On a 1-5 scale where 1=not at all familiar and 5=very familiar, how familiar would you say you are with the ENERGY STAR® Homes program?

Not at all familiar 1 2 3 4 5 [IF response is 1, 2 or Not Familiar SKIP to B8]

B5a. Where did you first learn about the program?

9. Utility 10. Advertisement (print or electronic) 11. List serve 12. Workshop	5. Professional meeting 6. Colleague 7. Client

	8. Other (specify)

B5b. What is your basic understanding of the program? (do not read, check all that apply)?

18. Higher efficiency than code
19. Advertising partnerships
20. Marketing assistance
21. Technical assistance
22. CHERS raters involved
23. Title 24 consultants involved
24. Plan check agencies involved
25. Reduced bills for tenants
26. Marketing support
27. Gaining credits on tax exempt financing (especially for affordable housing participants)
28. Other (list):
29. Don't know / refused

B5c. Did you participate in the program?

0. No
1. Yes ➔ for this home ➔revise home they talk about or terminate
2. Yes ➔ for another project
3. Yes – in past years (which years)
4. Don't know

B5d. What were your reasons for NOT participating in the program? (If the respondent answers they are "unaware" of the program, fill in with unaware and then skip to B8)

B6. I am going to read a list of factors that may have played a part in your decision NOT to participate in the program in 2004-2005? Please rate them on a scale of 1=not at all important, 5=very important. (➔ if 3 or less, ask "WHY?")

a. 1 2 3 4 5 Insufficient level of financial incentives available to help offset additional costs for building to higher efficiency standard

b. 1 2 3 4 5 Don't need to distinguish our buildings in the marketplace/ Product differentiation

c. 1 2 3 4 5 Insufficient benefit from advertising partnerships

d. 1 2 3 4 5 Insufficient / unattractive marketing assistance

e. 1 2 3 4 5 Insufficient / unattractive Technical assistance provided by program

f. 1 2 3 4 5 Other (describe):____

B7. I am going to read a list of possible challenges that you may have had considering your decision about participation in the program. I am interested in how important they were to you in this decision. Please rate each one on a scale of 1=not at all a barrier or concern, 5=very much a barrier or concern (check all that apply) (→ if 3 or more, ask "WHY?")

a. 1 2 3 4 5 Paperwork (Red Tape)

b. 1 2 3 4 5 Uncertainty that the program funding will be available

c. 1 2 3 4 5 Finding qualified certifier

d. 1 2 3 4 5 Scheduling certifier

e. 1 2 3 4 5 Cost of the certifier

f. 1 2 3 4 5 Required margin of compliance above Title 24

g. 1 2 3 4 5 Increased time and/or turnaround times

h. 1 2 3 4 5 Added cost of the energy efficient measures

i. 1 2 3 4 5 Added cost of participating in the program (staff time, resolving issues)

j. 1 2 3 4 5 Other (describe) ____

B7a. Had you heard anything about project monies being "used up"?

0. No
1. Yes
2. Don't know

B7b. If yes, what had you heard? ____
____

B8. How difficult do you find it to meet compliance for the following threshold efficiency levels?

	Building / designing to:	Very difficult (1)	Somewhat difficult (2)	Neither easy nor difficult (3)	Somewhat Easy (4)	Easy (5)	Don't know (99)
a.	Title 24						
b.	10% better than code						
c.	15% better than						

	code						
d.	20% better than code						

B9. If you were to participate in a program that offered marketing or advertising support. what types of marketing or advertising support would be most valuable to you?

C. SAVINGS, PROGRAM INFLUENCE, AND FREE RIDERSHIP

C1. To the best of your recollection, did these homes exceed the energy code in 2004-2005? If yes, by what amount – was it more than 15%, about 15%, or less than 15%?

10. More than 15% ➔ About how much more -- what percent different from code? ______% (should be greater than 15%)
11. About 15%
12. Less than 15% ➔ About how much less -- what percent different from code? ______% (should be between 1 and 14%)
13. Just to code
14. Less than code
15. Other ________________________________
16. Don't know/refused

C1a. How often did homes you built in 2004-2005 require exceeding Title 24 by 15% for tax credits or other funding reasons?

4. Always

3. Often

2. Sometimes

1. Rarely

0. Never

-9. Don't know

C1b. [IF HEARD OF PROGRAM-B7] Did the ENERGY STAR® Homes program have any influence on the energy performance of your project? Describe.

C1c. How about on more recent projects? Describe.

C3. How would you characterize the efficiency of your 2004-2005 homes compared to Title 24?

9. Much more efficient than Title 24 10. Somewhat more efficient	5. Slightly less efficient than Title 24

11. Slightly more efficient 12. About the same efficiency	6. Somewhat less efficient than Title 24 7. Much less efficient than Title 24 8. Other (describe) ____________________ 9. Don't know / refused

IF answer to C3 is >=4, then skip to C4.

C2. What are some of the technologies or practices you commonly included in your single family projects on a normal basis in 2004-2005 that are above Title 24?

a. Heating and Air Conditioning __________

b. Lighting _________

c. Programmable Thermostat _________

d. High Performance Windows _________

e. Water Heating____________

f. Tighter ducts

g. Improved ventilation

h. Decreased air leakage

C4. Has the efficiency of your SF projects increased or decreased over time? __________How do current homes compare with those built in the past? Specifically, compared to…

5 Years ago

5. Much more efficient now than 5 years ago 6. Somewhat more efficient 7. Slightly more efficient 8. About the same efficiency	5. Slightly less efficient 6. Somewhat less efficient 7. Much less efficient 8. Other (describe) ____________________ 9. Don't know / refused

C4a. 2004/2005

9. Much more efficient than 2004/5 10. Somewhat more efficient 11. Slightly more efficient 12. About the same efficiency	5. Slightly less efficient 6. Somewhat less efficient 7. Much less efficient 8. Other (describe) ____________________ 9. Don't know / refused

C4b. (IF changes) What led to these changes?

.

C4c. Did you already have a need to exceed code by 15% for any reason in 2004-2005?

0. No

1. Yes ➔ what were those reasons?____

2. Don't know/refused

C6. Approximately what is / would be the difference in total cost for you to construct or develop a SF home to a level that is greater than 15% above Title 24 in 2004-2005?➔

_______% of project costs

C6a. What level of an incentive might have made it attractive for you to increase the efficiency of your SF homes to a level that was greater than 15% above Title 24 in 2004-2005? ➔

_______% of project costs

C9. Consider your average SF home built in 2004-2005 using your standard practices. How does the energy savings from this "normal" SF home relate to the energy code standards? (should relate to C4)

7. Less than code ➔ about what percent less than code
8. Just to code
9. Above code ➔ about what percent above code?

D. RELATED EFFECTS

ASK only if C3<=4.

D2. [IF HEARD OF PROGRAM – B5>=3] You characterized your 2004/2005 buildings as more efficient than T24. Did the ENERGY STAR® program lead you to increase the efficiency level of the equipment that was installed or built to obtain the percentage over Title 24 in 2004-2005? For which technologies?

0. No	1. Yes ➔ Which ones?	2. None installed	3. Don't know
Why did you take the actions you did to be greater than Title 24?	a. Heating and Air Conditioning ___________ b. Lighting __________ c. Programmable Thermostat __________		

d. High Performance Windows __________

e. Water Heating_____________

f. Tighter ducts

g. Improved ventilation

h. Decreased air leakage

D3. Do you believe / have you heard anecdotal evidence of changes in energy-related behavior by residents / homeowners due to the installation of higher efficiency equipment compared to standard efficiency equipment? (e.g. turning up or down heat / turning up or down air conditioners, doing wash or dishes more or less often, etc.) Please describe.

	Actions / description	Notes/ causes / evidence / frequency
a. Increase energy use		
b. Decrease energy use		
c. Peak load changes		

E. SPILLOVER

If B5>=3, GO TO E3, else make this statement before reading E3: The ENERGY STAR® Program is a statewide program run by the investor owned utilities that provides incentives to builders who build residential structures that are at least 15% beyond Title 24 compliance values.

E3. Do you believe that builders / developers like you that have not participated in the ENERGY STAR® Program have been influenced to install higher efficiency measures or building practices in single family homes because of the influence of the Program in 2004-2005?

0. No   1. Yes   2. Don't know

E5. (If E3=yes) Why is this happening / to what would you attribute this influence? [DO NOT READ]

9. Education about improved practices
10. Pressure from buyers to get more efficient homes
11. Marketplace pressure to keep up with participating builders / developers?
12. Other _______________

N. NEBS

Now we'd like to ask a few questions about effects other than energy savings that may be realized by home owners or occupants due to the installation of energy efficiency measures or practices in SF homes.

N1. Do you believe the residents experience any positive effects, above and beyond energy savings, that you would attribute to higher energy efficiency measures and practices installed in SF homes – compared to the standard efficiency measures? Any negative effects?

Positive effects:

Negative effects:

Some builders and homeowners have noted a variety of positive and negative effects -- beyond energy savings -- that come from energy efficient measures and design in their new homes. These include effects like changes in equipment maintenance and performance, comfort, appearance, noise, ability to sell the home, doing good for the environment and other effects. Thinking about these kinds of effects – called non-energy benefits -- in association with these new homes…

N5c. (If this home is higher than standard efficiency) Thinking about the overall benefits and negative effects, can you estimate how valuable you think the total of all these effect would be to homeowners, compared to the energy savings from the extra efficient measures?

1. Zero effect
2. Positive but less valuable than energy savings ➔ ___ somewhat less ___ much less
3. Positive and more valuable than energy savings ➔ ___ somewhat more ___ much more
4. Negative but less costly than the energy savings (if needed… energy savings doesn't cover the negative effects) ➔ __somewhat less ___ much less
5. Negative and more costly than the energy savings ➔ __ somewhat more ___ much more
6. Don't know.

N6. (IF this home is higher than standard efficiency) Did you or the realtors use non- energy benefits to help convince the buyer to purchase this home??

0. No
1. Yes, we did ➔ Which non-energy effects did you discuss?

   How important would you estimate these NEBs were in influencing the home purchase decision? (1=not important, 5=very important) 1 2 3 4 5 dnk
2. Yes, realtor did ➔ Which non-energy effects did the realtor discussed?

   How important would you estimate these NEBs were in influencing the home purchase decision? (1=not important, 5=very important) 1 2 3 4 5 dnk
3. Don't know

N6a. (IF this home is NOT higher than standard efficiency) Did you believe that non- energy benefits would help convince buyers to purchase more energy efficient homes?

0. No
1. Yes ➔ which non-energy effects did you discuss?

How important would you estimate these NEBs would be in influencing the home purchase decision? (1=not important, 5=very important) 1 2 3 4 5 dnk

2. Don't know

N7. Do you consider energy efficiency measures in homes to be a hedge against future energy price increases and / or higher energy bills in the future?

0. No
1. Yes
2. Don't know

N8. (If N7=1 / yes) Would you consider that an important benefit? (answer on a scale of 1=not at all important to 5-very important).

1 2 3 4 5 dnk

N9. (If N8>1)… How valuable is this risk effect relative to the estimated annual energy savings?

MMV SMV SV SLV MLV DNK

G. FIRMOGRAPHICS AND ATTITUDES

G1. How would you characterize your knowledge of advanced energy efficient technologies and practices – especially as they apply to SF homes? Please use a scale of 1=not at all knowledgeable and 5=very knowledgeable.

1 2 3 4 5

G2. Do you believe energy prices will be rising or falling in the next 3-5 years?

7. Increasing a great deal
8. Increasing somewhat
9. Stay about the same

4. Decrease a little
5. Decrease a lot
6. Don't know

G3. Have you participated in energy efficiency programs? If yes, was this a positive experience?

0. No
1. Yes ➔ on a 1 to 5 scale where 1 means very negative experience, and 5 means very positive experience and 3 is neutral (neither positive nor negative) how would you rank this previous experience? 1 2 3 4 5 dnk
2. Don't know

G4. Approximately how many full time employees does you firm have in California? Nationwide? Internationally?

CA:

US:

Total World:

G7. About what percent of your business…

____% What percent of your single family construction / development work is outside of California?

____% About what percent of your Company's business is in the single family sector?

G9. Approximately how many homes do you [build / develop in the State of California on an annual basis? Nationwide?

	G9a. Number of homes
1. CA	
2. Nationwide	

G6. About what percentage of the single family homes you build / develop in California are in the following areas of the state?

____% PG&E territory – northern and central CA

____% SCE territory –

____% SDG&E territory –

____% Other: ________________

G8. Do you have any comments about the program that you would like to provide?

Appendix K - SF Owner –-Participant Questionnaire (SERA)

Participant Owner/Occupant Survey

2004-05 ENERGY STAR® New Homes Program Post Metering Survey

Participant Information	
RLW ID	
Name	
Street Address	
City	
Zip Code	
Phone Number	

Dear Participant,

Thank you again for participating in this study. While the surveyor is verifying the efficiencies and installation of items in your home, we are asking you to complete this questionnaire. Your responses will be kept completely confidential, and at no time will your name be associated with any of the responses. The information we collect will be used to make improvements to the ENERGY STAR® Homes Program in California.

All directions are in bold-face type. Your input will be used for future program development, so please respond to each section honestly and completely. ***Please circle one answer for each question unless otherwise directed***.

Thank you!

Demographics

1. How many people in the home are full time residents?

01 Adults 18 and older →____________

01a How many of the adults stay home during the day?_______

02 Children 17 and younger → ___________

2. How many people in the home are temporary summer time residents?

01 Adults 18 and older → ____________

01a Description of temporary stay:

____

02 Children 17 and younger → ___________

02a Description of temporary stay:

____

---

3. What is the total annual income range for the household?

01 < $25,000
02 $25,001-$50,000
03 $50,001-$75,000
04 $75,001-$100,000
05 >$100,000
06 Don't Know
07 Refused

General Information

---

4. What type of house is this home?

01 Single Family Detached – One Story
02 Single Family Detached – Two Story
03 Single Family Detached – Three or More Stories
04 Single Family Attached – One Story
05 Single Family Attached – Two Story
06 Single Family Attached – Three or More Stories

5. What is the conditioned square footage of the house?

a. Total: ______
b. First Floor:_______
c. Second Floor: _______
d. Third Floor:______

6. Which of the following gas loads are on the property?

01	Clothes Dryer	YES	NO
02	Stove/Range Top	YES	NO
03	Pool Heater	YES	NO
04	Spa Heater	YES	NO

05	Fireplace		YES	NO
06	Fixed Gas BBQ	YES	NO	

Section 1. ENERGY STAR® Home Awareness

- Are you aware that this is an ENERGYSTAR home?

  a) Yes
  b) No
  c) Did not know

- Did you know your home was an ENERGY STAR® home when you purchased or rented it?

  a) Yes
  b) No

- How did you learn about the ENERGY STAR® Homes program? Circle all that apply.

  a) TV
  b) Newspaper
  c) Radio
  d) Utility Bill Insert
  e) Word of Mouth (Family or Friend)
  f) Billboard Sign
  g) Website/ Internet
  h) From my Realtor or Apartment Manager
  i) Builder
  j) Contact with RLW Analytics
  k) Don't know about ENERGY STAR® Program
  l) Other:____________________
  m) Don't Know/Can't Remember

Section 2. Thermostat Use

- With regard to your household cooling practices, please circle all that apply.
  a) I never use the air conditioner
  b) I only use the air conditioner on the hottest days (Less than 10 days a year)
  c) The air conditioner is only on if I am at home
  d) The house is kept cool at all times in the summer
  e) I set the cooling thermostat up and down manually as needed
  f) I set the cooling thermostat program and leave it alone
  g) I set the cooling thermostat program and adjust *the temperature* as needed

- With regard to your household heating practices, please circle all that apply.
  a) I never use the furnace
  b) I only use the furnace on the coldest days (Less than 10 days a year)
  c) The furnace is only on if I am at home
  d) The house is kept warm at all times in the cool months
  e) I set the heating thermostat up and down manually as needed
  f) I set the heating thermostat program and leave it alone
  g) I set the heating thermostat program and adjust the temperature as needed

- On an average weekday, how many people are home during the day (12PM 6PM)?
  a) Summer: None 1 2 3 4 or more Don't Know
  b) Winter: None 1 2 3 4 or more Don't Know

Section 3. The Value of an ENERGY STAR®® Home

- Please rate the influence each of the following factors had in your decision to purchase or rent this home, where a 1 means the factor had no influence at all and a 7 means the factor had a large influence.

Factor	NO INFLUENCE ………..LARGE INFLUENCE							
a) ENERGY STAR® Rating	1	2	3	4	5	6	7	NA
b) ENERGY STAR® Mortgage Program	1	2	3	4	5	6	7	NA
c) Newly Built Home	1	2	3	4	5	6	7	NA
d) Size of Home	1	2	3	4	5	6	7	NA
e) Investment Opportunity	1	2	3	4	5	6	7	NA
f) Location	1	2	3	4	5	6	7	NA
g) School District	1	2	3	4	5	6	7	NA
h) Lot Size	1	2	3	4	5	6	7	NA
i) Price of Home/Rent	1	2	3	4	5	6	7	NA
j) Small Selection of Homes/Rentals Available	1	2	3	4	5	6	7	NA
k) Reputation of Builder	1	2	3	4	5	6	7	NA
l) Other ____________________________	1	2	3	4	5	6	7	NA
____								
____								

NA = does not apply to me

Please read the following statement, and then follow the directions below.

ENERGY STAR®® qualified homes are at least 15% more efficient than California state energy code. These savings are based on heating, cooling, and hot water energy use. The savings are typically achieved through a combination of:

- Building Construction Upgrades
- High Performance Windows
- Reduced Air Infiltration
- Improved Ventilation
- Upgraded Heating and Air Conditioning Systems
- Tight Duct Systems
- And Upgraded Water-Heating Equipment

After reading the information in the previous box, complete the following phrase by selecting a response from the options provided.

- "If I had to put a one time dollar-value on the efficient features in my home, I would price them at ____________"

(Choose Only One)

a) $0
b) $1 - $500
c) $501 - $1000
d) $1001 - $1500
e) $1501 - $2000
f) $2001 - $3000
g) $3001 - $5000
h) $5001 or more
i) Negative (cost) / I have been dissatisfied ➔ reduces value by about $_____
j) Other _______________

- Think about the effects that derive specifically from the fact that your home is ENERGY STAR®. How much do you think the following "non-energy" effects associated with the ENERGY STAR® equipment and features change the value of your home TO YOU AND YOUR FAMILY? (check one box per row)

	DECREASE IN VALUE					INCREASE IN VALUE			
Feature or effect (change in…)	Very strong decrease in value	Strong Decrease	Moderate decrease	Weak decrease	No Change	Weak increase	Moderate increase	Strong increase	Very strong increase in value
a) Quality construction	❑	❑	❑	❑	❑	❑	❑	❑	❑
b) High performance windows	❑	❑	❑	❑	❑	❑	❑	❑	❑
c) High efficiency furnace / AC system	❑	❑	❑	❑	❑	❑	❑	❑	❑
d) Higher efficiency water heater	❑	❑	❑	❑	❑	❑	❑	❑	❑
e) Comfort of home	❑	❑	❑	❑	❑	❑	❑	❑	❑
f) Amount of noise in the home	❑	❑	❑	❑	❑	❑	❑	❑	❑
g) "Doing good" for the environment	❑	❑	❑	❑	❑	❑	❑	❑	❑
h) Appear-ance of the equip-ment & home from new energy features	❑	❑	❑	❑	❑	❑	❑	❑	❑
i) Equipment maintenance and lifetime	❑	❑	❑	❑	❑	❑	❑	❑	❑
j) Family's illnesses, doctor visits, and lost days at job/school	❑	❑	❑	❑	❑	❑	❑	❑	❑
k) Reduced concerns about the bill (e.g. predict-ability, control, etc. separate from the level of the bill)	❑	❑	❑	❑	❑	❑	❑	❑	❑
l) Ease of selling the home in the future	❑	❑	❑	❑	❑	❑	❑	❑	❑
m) Other (specify) ________	❑	❑	❑	❑	❑	❑	❑	❑	❑

- If any of these categories of "non-energy" effects overlap for you – that is, you can't separate out their effects – please list them here by letter: ______________________

- Would you say the total of all the non-energy effects in the shaded / colored area (letters e-m) provide a positive value to you and your family or are they negative (a cost)?
  a) Negative / cost➔ ___ slightly negative ___moderately negative ___ very negative

  b) No value

  c) Positive / value ➔ ___ slightly positive ___ moderately positive ___ very positive

  d) Other ______________________

  e) Don't know

- Please take this opportunity to tell us about other energy efficient products or features you wanted, but were not offered or available.

(Skip if leasing or renting)

____

____

____

____

Section 4. Motivation to Buy ENERGY STAR®®

- Would you have purchased or rented this home if it was not an ENERGY STAR® home? (Circle One)
  a) Definitely would not have
  b) Most likely would not have
  c) Most likely would have
  d) Definitely would have
  e) Not sure

- Did you pay more for this house or pay more in rent because it is an ENERGY STAR® home? (Circle One)
  a) I paid less
     ➔ Approximately how much less? $__________ or Don't Know (for renters, put monthly rent difference)
  b) I paid the same
  c) I paid more
     ➔ Approximately how much more? $__________ or Don't Know (for renters, put monthly rent difference)
     ➔ Do you feel it was worth it? Yes No Not Don't Know
  d) I Don't Know

- How likely would you have been to select this same home with these same energy equipment and design features if it had not been ENERGY STAR®?

a) Definitely would not have selected (less than 10%)
b) Not very likely (10-25%)
c) Somewhat likely (25%-50%)
d) More likely than not (50%-75%)
e) Very likely (75%-90%)
f) Definitely or almost definitely would have selected (more than 90%)

- If you had known about the non-energy effects (items e-m listed in shaded area of table above) that may have resulted from the ENERGY STAR® equipment and features, would that have affected your likelihood of selecting this home?

a) Would have made me less likely to select
b) No difference
c) Would have made me more likely to select

Section 5. ENERGY STAR®® Home Compared to Prior Home

Please describe the Last Home that you lived in. Specifically, indicate the TYPE, AGE, and LOCATION:

- Do you own or rent/lease this home?
  a) Own
  b) Rent/lease (see following directions)

- My last home was: (Circle One)
  a) An apartment, condo or duplex
  b) A single family residence
  c) Other, please describe: ______________________

- Was it an ENERGY STAR® Rated Home? (Circle One)
  a) Yes
  b) No
  c) Don't Know

Note: ENERGY STAR® homes were not available in CA before 2000.

- Approximately, what year was that home built? (Enter Year Built or Circle "Don't Know")
  a) 2000 or 2005
  b) 1990 to 1999

c) 1980 to 1989
d) Before 1980
e) Don't Know

- Approximately, what square footage was your last home? 2000 or 2005
  a) Less than 1000 square feet
  b) 1000-1500 square feet
  c) 1500-2000 square feet
  d) 2500-3000 square feet
  e) Greater than 3000 square feet
  f) Don't Know
- My last home…..
  a) Had central air-conditioning
  b) Did not have central air-conditioning

- My last home…..
  a) Had gas heating
  b) Had electric heating

- My last home was located in:
  a) City: ___________________________________
  b) State: _______________

We are interested if you noticed any of the following effects in your new home, compared to your old home.

- Compared to my last home……….

#	Factor	Strongly Disagree	Disagree	No Change	Agree	Strongly Agree	
a.)	We leave the lights on longer	1	2	3	4	5	DK
b.)	We use the air-conditioner less	1	2	3	4	5	DK
c.)	We use the heater more	1	2	3	4	5	DK
d.)	We take longer showers	1	2	3	4	5	DK
e.)	We take fewer showers	1	2	3	4	5	DK
f.)	We do more laundry	1	2	3	4	5	DK
g.)	We use more electricity	1	2	3	4	5	DK
h.)	We use more natural gas	1	2	3	4	5	DK

- How would you compare the CONSTRUCTION QUALITY of this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- How would you compare the level of COMFORT in this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- How would you compare the WARMTH in the winter of this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- How would you compare the COOLNESS in the summer of this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- How would you compare the level of NOISE in this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- IF you noticed an impact on NOISE compared to your old home, which of the following differences or changes do you notice? (please circle one for each row, 1=strongly disagree; 7=strongly agree)

	Disagree Agree
a) Energy using equipment is noisier in new home	**1 2 3 4 5 6 7 don't know**
b) Energy using equipment is quieter in new home	1 2 3 4 5 6 7 don't know
c) Noise from outside NEW home is more noticeable / louder	1 2 3 4 5 6 7 don't know
d) Noise from outside NEW home is less noticeable / quieter	1 2 3 4 5 6 7 don't know
e) Other ________________	1 2 3 4 5 6 7 don't know
f) No impact noticed	1 2 3 4 5 6 7 don't know

- How would you compare NOISE in your current home to a SIMILAR but NOT ENERGY STAR® home?

  a) Our home is much worse
  b) Somewhat worse
  c) About the same
  d) Somewhat better
  e) Much better
  f) Don't know

- Some residents are interested in ENERGY STAR® because they associate reduced energy use with helping the environment… How would you compare the IMPACT ON THE ENVIRONMENT from this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- How would you compare the APPEARANCE OR "LOOK" OF THE EQUIPMENT AND ENERGY STAR® FEATURES of this home to your old home?
  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- Some households notice differences in the PERFORMANCE of the equipment (other than energy use or comfort levels). This may include differences in ability to control the equipment, differences in maintenance or lifetimes, or other performance-related differences… How would you compare the PERFORMANCE OF THE EQUIPMENT (heat, a/c, hot water, appliances) in this home to your old home?

  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- IF you noticed an impact on EQUIPMENT PERFORMANCE, which of the following differences or changes do you notice? (please circle one for each row, 1=strongly disagree; 7=strongly agree)

	Disagree Agree
a) More features / better control in new home	**1 2 3 4 5 6 7 don't know**
b) Fewer features / worse ability to control	1 2 3 4 5 6 7 don't know
c) Less maintenance	1 2 3 4 5 6 7 don't know
d) More maintenance	1 2 3 4 5 6 7 don't know

e) Longer lifetime	1 2 3 4 5 6 7 don't know
f) shorter lifetime	1 2 3 4 5 6 7 don't know
e) Other ________________	1 2 3 4 5 6 7 don't know
f) No impact noticed	1 2 3 4 5 6 7 don't know

- Some residents notice changes in the number or duration of illnesses of adults or children in the household, and this may have an effect on doctor visits, medicines, or lost days from work or school… Did you notice any changes in YOUR FAMILY'S ILLNESSES, DOCTOR VISITS, OR LOST TIME FROM WORK OR SCHOOL compared to when you lived in your old home?

  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home / no difference noticed
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- IF YOU HAD changes (better or worse)… Would you attribute these health changes to the ENERGY STAR® features of the home?
  a) No
  b) Yes, partly ➔ please explain:
  ____
  ____
  ____
  c) Yes ➔ please explain
  ____
  ____
  ____
  d) Don't know

- Some residents suggest that more energy efficient homes help reduce their concerns about paying energy bills for reasons beyond the bills being potentially lower. They become less worried about their ability to pay bills the bills may be more stable, consistent, and predictable… Did you notice any changes in YOUR CONCERNS ABOUT PAYING ENERGY BILLS (excluding the level of the bill) compared to your old home?

  a) Worse than our old home ➔ ___ much worse ___ somewhat worse
  b) Same as our old home
  c) Better than our old home ➔ ___ much better ___ somewhat better
  d) Don't know

- Do you feel there will be a difference in the ABILITY TO SELL OR RENT this home due to the energy efficiency equipment and design features?
  a) Worse than old home ➔ ___ Much harder to sell or rent
  ➔ ___ Somewhat harder to sell or rent
  b) Same as our old home
  c) Easier than old home ➔ ___ Much easier to sell or rent
  ➔ ___ Somewhat easier to sell or rent

d) Don't know

- If you have recognized "other" non-energy effects, please list them:

____

- Did you notice any changes in these OTHER effects compared to your old home?

a) Worse than our old home ➔ ___ much worse ___ somewhat worse
b) Same as our old home
c) Better than our old home ➔ ___ much better ___ somewhat better
d) Don't know

- Would you say your energy costs in the new home increased or decreased in the new home compared to the OLD HOME due to the new energy equipment and features?

a) Energy costs are much less in the new home ➔ please estimate about how much you save per month on average $_______
b) Energy costs are somewhat less in the new home ➔ please estimate about how much you save per month on average $_______
c) Energy costs are about the same in the new home
d) Energy costs are somewhat higher in the new home ➔ please estimate about how much extra you pay per month on average $______
e) Energy costs are much higher in the new home ➔ please estimate about how much extra you pay per month on average $______
f) Don't know

- About how much do you pay for your energy bill on a per-month basis in your new home?

$____________ for energy bill per month

- Do you recall the realtor or builder promoting this home based on any of the following "non-energy effects"? Please mark the ones they emphasized, and the ones that were most important to you.

Please mark the non-energy effects the realtor or builder emphasized to you.	**Please mark the effects that were most important to you in your decision to select the home**
❑ Construction Quality ❑ Comfort ❑ Noise ❑ Doing good for environment ❑ Appearance of equipment ❑ Performance (excluding comfort) (e.g. lifetimes, maintenance, etc.) ❑ Family's illnesses, doctor visits, lost time from work or school ❑ Energy bill payment concerns (predictability, etc.) ❑ Ability to sell home in future ❑ Other _____________ ❑ None	❑ Construction Quality ❑ Comfort ❑ Noise ❑ Doing good for environment ❑ Appearance of equipment ❑ Performance (excluding comfort) (e.g. lifetimes, maintenance, etc.) ❑ Family's illnesses, doctor visits, lost time from work or school ❑ Energy bill payment concerns (predictability, etc.) ❑ Ability to sell home in future ❑ Other ________________ ❑ None

Section 6. Comparisons – *the On-site Auditor may be able to help you with these questions*

- Would you say the following effects you received from this home compared to your old home have HIGHER VALUE or LOWER VALUE than the difference in energy bills compared to your old home?

	Effect is Less valuable than difference in bill			Effect is more valuable than difference in bill			Effect has negative value / dislike it	
	Much less valuable	Somewhat less valuable	Same Value as savings	Somewhat more valuable	Much more valuable	No value at all	Outweighs energy bill change	Less than energy bill change
a) Construction quality	❑	❑	❑	❑	❑	❑	❑	❑
b) Comfort	❑	❑	❑	❑	❑	❑	❑	❑
c) Noise	❑	❑	❑	❑	❑	❑	❑	❑
d) Doing good for environment	❑	❑	❑	❑	❑	❑	❑	❑
e) Appearance of equipment	❑	❑	❑	❑	❑	❑	❑	❑
f) Performance (excl comfort) (e.g. lifetime, maintenance, etc.)	❑	❑	❑	❑	❑	❑	❑	❑
g) Family illnesses / lost time from work/ school	❑	❑	❑	❑	❑	❑	❑	❑
h) Energy bill payment concerns	❑	❑	❑	❑	❑	❑	❑	❑
i) Ability to sell home in future	❑	❑	❑	❑	❑	❑	❑	❑
j) Other (specify) _________	❑	❑	❑	❑	❑	❑	❑	❑

	Effect is Less valuable than difference in bill			Effect is more valuable than difference in bill			Effect has negative value / dislike it	
	Much less valuable	Somewhat less valuable	Same Value as savings	Somewhat more valuable	Much more valuable	No value at all	Outweighs energy bill change	Less than energy bill change
k) TOTAL of all these effects	❑	❑	❑	❑	❑	❑	❑	❑

- Thinking about this list (letters a-j) from the table above, please complete the following statement.

"If I had to put a dollar-value on the total of all these non-energy effects in my home (one-time, not annual), I would value them at…..

(Choose One)

a) $0
b) $1 - $500
c) $501 - $1000
d) $1001 - $1500
e) $1501 - $2000
f) $2001 - $3000
g) $3001 - $5000
h) $5001 or more
i) Negative value (cost) / I have been dissatisfied ➔ reduces value by about $_____
j) Other _______________

- Please rank the following in order from most preferred (1) to least preferred (5). (circle rank)

  1 2 3 4 5 Full value of the non-energy effects (a-j in table above)

  1 2 3 4 5 Half value of the non-energy effects (a-j in table above)

  1 2 3 4 5 $500 in one-time gift and zero non-energy effects (a-j)

  1 2 3 4 5 $5000 in one-time gift and zero non-energy effects (a-j)

  1 2 3 4 5 $1000 in one-time gift and zero non-energy effects (a-j)

Section 7. Final Remarks

- What would you tell others about ENERGY STAR® Homes?

____

____

____

____

____

____

- Do you have any recommendations for the builder of your ENERGY STAR® home?

____

____

____

____

____

Thank you for completing this survey.

Appendix L - SF Owner –-Non-Participant Questionnaire (SERA)

ENERGY STAR® SF RESIDENTIAL NEW CONSTRUCTION PROGRAM NON-PARTICIPANT PROCESS/NTG/NEBS SURVEY

INTRODUCTION / GREETING

Hello – My name is ____ and I work for Skumatz Economic Research Associates (SERA) and I am calling on behalf of the State of California Utilities. We're researching a small sample of households that purchased new homes in the last couple of years to evaluate a program run by the utilities. We are aware that your household participated in a previous study related to new home construction and we appreciate the information and time you have already provided. At this time we are hoping to gather some additional supporting information. The information we are gathering will be used to assess how new home owners operate and perceive their new homes relative to their old house. All information you provide will be kept strictly confidential.

I1. S1 Are you 18 or older and the person who often deals with energy in the home? IF NOT) Is there a better time of day to reach that person?

S2 Do you have a few minutes now (IF YES, continue with Q1)? (if they ask, say it will take about 15 minutes)

(IF NO ➔) S3 Is there a better time or day? (schedule) ___________________________-

(IF NO / Refusal) S4 May I ask you just a couple of questions? (1=YES, 2=NO)IF Yes, go toR1)

R1. Would you say your new home is more energy efficient or less energy efficient than your old home?

1) Less energy efficient ➔ R1A___1 somewhat less ____2 much less

2) About the same

3) More energy efficient ➔ R1B___1 somewhat more ___ 2 much more

4) Don't know

R2. (If they say "more efficient"). Some households notice positive or negative changes in comfort, noise, appearance, maintenance, equipment lifetimes, illness, environmental, and other effects from more efficient homes. Thinking about the combination of these non-energy effects that you may have experienced…

Based on your experience in your home, would you say these effects ADD TO or DETRACT FROM the value of your home for you and your family ?

1) Detract ➔ R2A___ 1 detract very much from value ___ 2 detract somewhat from value ___ 3 detract slightly from value

2) 2 No change

3) 3 Add to ➔ R2B___ 1 Add very much to value ___ 2 add somewhat to value ___ 3 add slightly to value

4) don't know

R2. One last question… We are also interested in household changes in behavior. Compared to your last home would you say you agree or disagree with the following statements (Ask strongly disagree, disagree, no change, agree, strongly agree).

R3A We leave the lights on longer (1)SD (2)D (3)NC (4)A (5)SA

R3B We use the air conditioner less (1)SD (2)D (3)NC (4)A (5)SA

R3C We use the heater more (1)SD (2)D (3)NC (4)A (5)SA

Section 1. Thermostat Use

Q16 Do you own or rent/lease your CURRENT home?

a) 1 Own
b) 2 Rent / Lease

- With regard to your household <u>cooling</u> practices, I'm going to read a list of different ways people operate their air conditioner, after I read each item, please tell us whether you agree or disagree. (1=AGREE, 2=DISAGREE)

h) Q1A We never use the air conditioner A / D

i) Q1B We only use the air conditioner on the hottest days (Less than 10 days a year) A / D
j) Q1C The air conditioner is only on if we are at home A / D
k) Q1D The house is kept cool at all times in the summer A / D
l) Q1E I set the cooling thermostat up and down manually as needed A / D
m) Q1F I set the cooling thermostat program and leave it alone A / D
n) Q1G I set the cooling thermostat program and adjust *the temperature* as needed A / D

- With regard to your household heating practices, I'm going to read a list of different ways people operate their furnace, after I read each item, please tell us whether you agree or disagree. (1=AGREE, 2=DISAGREE)

h) Q2A We never use the furnace A / D
i) Q2B We only use the furnace on the coldest days (Less than 10 days a year) A / D
j) Q2C The furnace is only on if we are at home A / D
k) Q2D The house is kept warm at all times in the cool months A / D
l) Q2E I set the heating thermostat up and down manually as needed A / D
m) Q2F I set the heating thermostat program and leave it alone A / D
n) Q2G I set the heating thermostat program and adjust the temperature as needed A / D

- On an average weekday, how many people are home during the day (12PM 6PM)?

	(0)	(1)	(2)	(3)	(4)	(5)
c) Q3A Summer:	None	1	2	3	4 or more	Don't Know
d) Q3A Winter:	None	1	2	3	4 or more	Don't Know

Section 3. The Value of a New Home

- Please rate the influence each of the following factors had in your decision to purchase or rent this home, where a 1 means the factor had no influence at all and a 7 means the factor had a large influence (9=NA/Does not apply to me/No other factors)

Q4A Newly Built Home

Q4B Size of Home

Q4C Investment Opportunity

Q4D Location

Q4E School District

Q4F Lot Size

Q4G Price of Home/Rent

Q4H Small Selection of Homes/Rentals Available

Q4I Reputation of Builder

Q4J Energy Efficiency of Home

Q4K Other ___Q4OTH___

Factor	NO INFLUENCE …………LARGE INFLUENCE							
a) Newly Built Home	1	2	3	4	5	6	7	NA
b) Size of Home	1	2	3	4	5	6	7	NA
c) Investment Opportunity	1	2	3	4	5	6	7	NA
d) Location	1	2	3	4	5	6	7	NA
e) School District	1	2	3	4	5	6	7	NA
f) Lot Size	1	2	3	4	5	6	7	NA
g) Price of Home/Rent	1	2	3	4	5	6	7	NA
h) Small Selection of Homes/Rentals Available	1	2	3	4	5	6	7	NA
i) Reputation of Builder	1	2	3	4	5	6	7	NA
j) Energy Efficiency of Home	1	2	3	4	5	6	7	NA
k) Other ___________________________	1	2	3	4	5	6	7	NA
______________________________________								
______________________________________								

NA = does not apply to me

- Q5 Please think about the differences in energy equipment and measures in your new home. If you had to put a one time dollar-value on the energy –related features (i.e., the HVAC system, the water heating system, the lighting, the appliances) in your home compared to your old home, what would you price them at?

(Choose Only One)

01) $0

02) $1 - $500

03) $501 - $1000

04) $1001 - $1500

05) $1501 - $2000

06) $2001 - $3000

07) $3001 - $5000

08) $5001 or more

09) Negative (cost) / I have been dissatisfied ➔ reduces value by about $_Q5A____

10) Other __Q5OTH____________

- Q6 Would you say your new home is more energy efficient or less energy efficient than your old home?

1) Less energy efficient ➔ Q6A ___1 somewhat less ____2 much less

2) About the same

3) More energy efficient ➔ Q6B ___ 1 somewhat more ___2 much more

4) Don't know

- Q7 *(Skip this question if q6=Don't know)* Why?________________

Many households associate a number of effects with changes in the energy equipment in their homes. These effects can include changes in comfort, noise, appearance, environmental impacts, equipment maintenance or lifetime, family illnesses, bill concerns, ease of selling the home and other positive and negative non-energy effects.

- Q8 Would you say the total of all the non-energy effects we just discussed provide a positive value to you and your family or are they negative (a cost)?

1) Negative / cost➔ Q8A___ 1 slightly negative ___2 moderately negative ___3 very negative

2) No value

3) Positive / value ➔Q8B ___1 slightly positive ___ 2 moderately positive ___ 3 very positive

4) Other ___Q8OTH__________________

5) Don't know

Q9 Based on your experience in your home, would you say these effects ADD TO or DETRACT FROM the value of your home ***to you and your family*** ?

1) Detract ➔ Q9A___ 1 detract very much from value ___2 detract somewhat from value ___ 3 detract slightly from value

2) No change

3) Add to ➔ Q9B ___ 1 Add very much to value ___ 2 add somewhat to value ___ 3 add slightly to value

4) don't know

Q10 Do you believe these effects will be reflected in the resale value of your home?

1) No effect

2) Increase resale value ➔ Q10A___ 1somewhat ___ 2 great deal

3) Decrease resale value ➔ Q10A___1 somewhat ____2 great deal

4) Don't know

Q11 Please take this opportunity to tell us about energy efficient products or features you wanted, but were not offered or available, or that were interesting and offered but involved an extra cost?.

(Skip if leasing or renting)

Section 4. Motivation to Buy New Home

Q12 Did you pay more for this house or pay more in rent than your old home because of its energy features? (Circle One)

1) I paid less
   - ➔ Approximately how much less? $__Q12A________ or Don't Know (for renters, put monthly rent difference)
2) I paid the same
3) I paid more
   - ➔ Approximately how much more? $__Q12B________ or Don't Know (for renters, put monthly rent difference)
   - ➔ Do you feel it was worth it? Q12C 1= Yes 2= No 3=Don't Know
4) I Don't Know

(Q13 moved to later in the questionnaire)

Q14 If you had known about the non-energy effects that may have resulted from the energy equipment and features in your new home, would that have affected your likelihood of selecting this home?

1) Would have made me less likely to select
2) No difference
3) Would have made me more likely to select
4) It might have made a difference

5) I don't know

Section 5. New Home Compared to Prior Home

Now I'm going to ask you a few questions about your previous home.

Q15 Did you own or rent/lease your PREVIOUS home?

c) Own
d) Rent/lease

Q13 *[IF previous renter & current renter]* How much difference is there in rent comparing this home to your last home? __$______________

Q13A Is that [$ from q13] MORE or LESS than in rent compared to your last home? (1=More, 2=Less)

Q17 Was your last home

1) An apartment, condo or duplex
2) A single family residence
3) Other, please describe: _____Q17OTH________________

Q18 Approximately, what year was that home built? (Enter Year Built or Circle "Don't Know")

1) 2000 or 2005
2) 1990 to 1999
3) 1980 to 1989
4) Before 1980
5) Don't Know

Q19 Approximately, what square footage was your LAST home? 2000 or 2005

1) Less than 1000 square feet
2) 1000-1500 square feet
3) 1500-2000 square feet
4) 2500-3000 square feet
5) Greater than 3000 square feet
6) Don't Know ➔ How many bedrooms was your last home? _Q19A___

Q20 Approximately, what square footage was your CURRENT home? 2000 or 2005

1) Less than 1000 square feet
2) 1000-1500 square feet
3) 1500-2000 square feet
4) 2500-3000 square feet
5) Greater than 3000 square feet
6) Don't Know ➔ How many bedrooms was your last home? _Q20A___

Q21 *(If q20=q19 OR q19=Don't know OR q20=Don't know)* Is your new home larger or smaller than your old home? (1=Larger, 2=Same size, 3=Smaller)

Q22 Did your last home have central air-conditioning?

1) Yes
2) No

Q23 Did your last home have gas or electric heating

1) gas heating
2) electric heating

Q24. What city, county and state was your last home located?

c) City: ___Q24A___________________________________
d) County: _Q24B__________________
e) State: __Q24C______________

Q25 How long have you lived at your new home? _____ years

Q26 Has the number of persons living in your home full time changed between your old home and now at your new home?

1) Same

2) Smaller now ➔ how many fewer people now?: _Q26A___

3) Larger now ➔ how many additional people now? _Q26B__

4) Don't know

We are interested if you noticed any of the following effects in your new home, compared to your old home.

- I am going to read you a couple statements and I would like you to tell me if you agree or disagree with each statement. Compared to my last home……… (1=Strongly disagree, 2=Disagree, 3=No change, 4= Agree, 5= Strongly Agree, 9=Don't know)

Q27A We leave the lights on longer

Q27B We use the air-conditioner less

Q27C We use the heater more

Q27D We take longer showers

Q27E We take fewer showers

Q27F We do more laundry

Q27G We use more electricity

Q27H We use more natural gas

#	Factor	Strongly Disagree	Disagree	No Change	Agree	Strongly Agree	
a.)	We leave the lights on longer	1	2	3	4	5	DK
b.)	We use the air-conditioner less	1	2	3	4	5	DK
c.)	We use the heater more	1	2	3	4	5	DK
d.)	We take longer showers	1	2	3	4	5	DK
e.)	We take fewer showers	1	2	3	4	5	DK
f.)	We do more laundry	1	2	3	4	5	DK
g.)	We use more electricity	1	2	3	4	5	DK
h.)	We use more natural gas	1	2	3	4	5	DK

Q28 How would you compare the CONSTRUCTION QUALITY of this home to your old home? Is it better, worse or about the same?

1) Worse than our old home ➔ Q28A___ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q28B___ 1 much better ___2 somewhat better

9) Don't know

Q29 How would you compare the level of COMFORT in this home to your old home? Better, worse or about the same?

1) Worse than our old home ➔ Q29A___ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q29B___ 1 much better ___2 somewhat better

9) Don't know

Q30 How would you compare the WARMTH in the winter of this home to your old home? Better, worse or about the same?

1) Worse than our old home ➔ Q30A___ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q30B___ 1 much better ___2 somewhat better

9) Don't know

Q31 How would you compare the COOLNESS in the summer of this home to your old home?

1) Worse than our old home ➔ Q31A___ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q31B___ 1 much better ___2 somewhat better

9) Don't know

Q32 How would you compare the level of NOISE in this home to your old home?

1) Worse than our old home ➔ Q32A___ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q32B___ 1 much better ___2 somewhat better

9) Don't know

33. (If they answered previous question with a or c) Again, I have a few statements that I will read and I ask you rate your agreement with the statement. 1 means you strongly disagree and 7 means you strongly agree.

	Disagree Agree
Q33A Energy using equipment is noisier in new home	**1 2 3 4 5 6 7 don't know(9)**
Q33B Energy using equipment is quieter in new home	1 2 3 4 5 6 7 don't know(9)
Q33C Noise from outside NEW home is more noticeable / louder	1 2 3 4 5 6 7 don't know(9)
Q33D Noise from outside NEW home is less noticeable / quieter	1 2 3 4 5 6 7 don't know(9)
Q33E No impact noticed	1 2 3 4 5 6 7 don't know(9)

Q34 New energy equipment can sometimes be more efficient than old energy equipment. Some residents are interested in new energy equipment because they associate reduced energy use with helping the environment… Is the IMPACT ON THE ENVIRONMENT from this home compared to your old home better, worse or about the same?

1) Worse than our old home ➔ Q34A__ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q34B___ 1 much better ___2 somewhat better

9) Don't know

Q35 How would you compare the APPEARANCE OR "LOOK" OF THE EQUIPMENT AND FEATURES of this home to your old home?

1) Worse than our old home ➔ Q35A__ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q35B___ 1 much better ___2 somewhat better

9) Don't know

Q36 Some households notice differences in the PERFORMANCE of the equipment (other than energy use or comfort levels). This may include differences in ability to control the equipment, differences in maintenance or lifetimes, or other performance-related differences… How would you compare the PERFORMANCE OF THE ENERGY EQUIPMENT (heat, a/c, hot water, appliances) in this home to your old home?

1) Worse than our old home ➔ Q36A__ 1 much worse ___2 somewhat worse
2) Same as our old home
3) Better than our old home ➔ Q36B___ 1 much better ___2 somewhat better
9) Don't know

37. (If they answered previous question with a or c) I'd like you to rate your agreement with the following possible changes in features or performance of your energy equipment that may apply to your home. As before, 1 means you strongly disagree and 7 means you strongly agree.

...(insert "in new home"... at end of each item)	Disagree Agree
a) Q37A More features / better control in new home	**1 2 3 4 5 6 7 don't know(9)**
b) Q37B Fewer features / worse ability to control	1 2 3 4 5 6 7 don't know(9)
c) Q37C Less maintenance	1 2 3 4 5 6 7 don't know(9)
d) Q37D More maintenance	1 2 3 4 5 6 7 don't know(9)
e) Q37E Longer lifetime	1 2 3 4 5 6 7 don't know(9)
f) Q37F shorter lifetime	1 2 3 4 5 6 7 don't know(9)
g) Q37G No impact noticed	1 2 3 4 5 6 7 don't know(9)

Q38 Some residents notice changes in the number or duration of illnesses of adults or children in the household, and this may have an effect on doctor visits, medicines, or lost days from work or school… Were YOUR FAMILY'S ILLNESSES, DOCTOR VISITS, OR LOST TIME FROM WORK OR SCHOOL better, worse or about the same compared to when you lived in your old home?

1) Worse than our old home ➔ Q38A__ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q38B___ 1 much better ___2 somewhat better

9) Don't know

Q39 Skip if Q34 = b or d. IF YOU HAD changes (better or worse)… Would you attribute these health changes to the energy equipment or features of the home?

1) No

2) Yes, partly ➔ ask q39a

3) Yes ➔ ask q39a

4) Don't know

Q39A Please explain: ____
____
____

Q40 Some residents suggest that more energy efficient homes help reduce their concerns about paying energy bills for reasons beyond the bills being potentially lower. They become less worried about their ability to pay bills the bills may be more stable, consistent, and predictable… Are YOUR CONCERNS ABOUT <u>PAYING</u> ENERGY BILLS better, worse or about the same compared to your old home?

1) Worse than our old home ➔ Q40A__ 1 much worse ___2 somewhat worse

2) Same as our old home

3) Better than our old home ➔ Q40B___ 1 much better ___2 somewhat better

9) Don't know

Q41 Do you feel it will be easier, worse, or about the same TO SELL OR RENT this home due to the energy efficiency equipment and design features?

1) Worse than old home ➔Q41A ___ 1 Much harder to sell or rent
___ 2 Somewhat harder to sell or rent

2) Same as our old home

3) Easier than old home ➔Q41B ___1 Much easier to sell or rent
___ 2 Somewhat easier to sell or rent

9) Don't know

Q42 Are there any other positive or negative effects you have noticed? Please describe. ______________________

Q43. Now I would like to ask about your energy costs. Would you say your energy costs in the new home are lower, greater or about the same compared to the OLD HOME?

g) Energy costs are lower in the new home ➔ __ somewhat __ much ➔ Can you estimate about how much you save per month on average $_______

h) Energy costs are more in the new home ➔ ___ somewhat ___ much. ➔ please estimate about how much you save per month on average $_______
i) Energy costs are about the same in the new home
j) Don't know

Q44 Now I would like to ask about your energy costs. Would you say your energy costs in the new home are lower, greater or about the same compared to the OLD HOME <u>due to the new energy equipment and features</u>?

a) Energy costs are much less in the new home ➔ please estimate about how much you save per month on average $_______
b) Energy costs are somewhat less in the new home ➔ please estimate about how much you save per month on average $_______
c) Energy costs are about the same in the new home
d) Energy costs are somewhat higher in the new home ➔ please estimate about how much extra you pay per month on average $______

e) Energy costs are much higher in the new home ➔ please estimate about how much extra you pay per month on average $______
f) Don't know

Q45 About how much do you pay for your energy bill on a per-month basis in your new home? Can you recall what you paid at your old home?

$____________ for energy bill per month New Home

Typical bill at old home $_________ (or amount difference in $ or % terms (specify $ or % and if an increase of decrease) ________

Q46 Do you recall the realtor or builder promoting this home based on any of the following "non-energy effects"? … Which was most important to you?

(Read and mark the non-energy effects the realtor or builder emphasized to respondent).	**(Ask which of the ones marked was most important in respondent's decision to select the home)**
❑ Construction Quality ❑ Comfort ❑ Noise ❑ Doing good for environment ❑ Appearance of equipment ❑ Performance (excluding comfort) (e.g. lifetimes, maintenance, etc.) ❑ Family's illnesses, doctor visits, lost time from work or school ❑ Energy bill payment concerns (predictability, etc.) ❑ Ability to sell home in future ❑ Other ______________ ❑ None	❑ Construction Quality ❑ Comfort ❑ Noise ❑ Doing good for environment ❑ Appearance of equipment ❑ Performance (excluding comfort) (e.g. lifetimes, maintenance, etc.) ❑ Family's illnesses, doctor visits, lost time from work or school ❑ Energy bill payment concerns (predictability, etc.) ❑ Ability to sell home in future ❑ Other _________________ ❑ None

Section 6. Comparisons –

Q47 Now I'd like to ask you to compare your new home versus your old home in several categories. Some of these relate to the home itself, and others relate to how the home affects your lifestyle. For each question, please say whether your new home is better, worse, or the same as your old home.

	1= Positive Effect 2= No Effect 3= Negative Effect
a. Construction Quality	
b. Comfort, in terms of temperature, light, and other environmental conditions	
c. The home's ability to dampen noise from outside.	
d. The environmental friendliness and reduced energy consumption of the home	
e. The appearance of energy-related features and equipment in the home	

f. The overall performance and lifetime of energy-related equipment in the home	
g. Your ability to sell the home in the future	
h. Do you have more (-1), fewer (+1), or the same number of family illnesses and lost time from work or school?	
i. Do you have more (-1), fewer (+1), or the same amount of concern about paying your energy bills?	
j. Quantity and quality of light	
k. Is there anything else where your new home is notably better or worse than your old home?	
l. When you add up the impacts of everything we discussed, and only those things, is your new home better, worse, or about the same as your old home?	

Q48 [For Q47 a through l each, ask corresponding question below]

Q48a [Energy bills went up and effect above is positive (+1)] Your energy bills have gone up, but your [effect] is higher. Would you say that the benefit of having higher [effect] is much greater, a little greater, about the same, a little less, or a lot less than the drawback of the higher energy bills?

a) Much greater
b) Little greater
c) About the same
d) Little less
e) Lot less
f) Don't Know

Q48b [Energy bills went up and effect above is negative (-1)] Your energy bills have gone up, and your comfort is lower. Would you say that the drawback of [effect] is much greater, a little greater, about the same, a little less, or a lot less than the drawback of the higher energy bills?

a) Much greater
b) Little greater
c) About the same
d) Little less
e) Lot less
f) Don't Know

Q48c [Energy bills went down and effect above is positive (+1)] Your energy bills have gone down and the [effect] is better in your new home. Would you say that the benefit of having [effect] is much greater, a little greater, about the same, a little less, or a lot less than the benefit of the lower energy bills?

a) Much greater
b) Little greater
c) About the same
d) Little less
e) Lot less
f) Don't Know

Q48d [Energy bills went down and effect above is negative (-1)] Your energy bills have gone down, and [effect] has increased. Would you say that the drawback of having [effect] is much greater, a little greater, about the same, a little less, or a lot less than the benefit of the lower energy bills?

a) Much greater
b) Little greater
c) About the same
d) Little less
e) Lot less
f) Don't Know

Q48e [Energy bills Stayed the Same (or don't know) and effect above is positive (+1)] You mentioned a positive change in [effect]. Is this a large benefit, a small benefit, or does it make no difference to you?

a) Large benefit
b) Small benefit
c) Makes no difference
d) Don't Know

Q48f [Energy bills Stayed the Same (or don't know) and effect above is negative (-1)] You mentioned a negative change in [effect]. Is this a large drawback, a small drawback, or does it make no difference to you?

a) Large drawback
b) Small drawback
c) Makes no difference
d) Don't Know

Q49 Thinking about this list of non-energy effects, please complete the following statement.

"If I had to put a dollar-value on the total of all these non-energy effects in my home (one-time, not annual), I would value them at…..

(Choose One)

k) $0
l) $1 - $500
m) $501 - $1000
n) $1001 - $1500
o) $1501 - $2000
p) $2001 - $3000
q) $3001 - $5000
r) $5001 or more
s) Negative value (cost) / I have been dissatisfied ➔ reduces value by about $_____
t) Other _______________

Q50 Please rank the following in order from most preferred (1) to least preferred (5). (circle rank)

1 2 3 4 5 6 Full value of the non-energy effects (a-j in table above)

1 2 3 4 5 6 Half value of the non-energy effects (a-j in table above)

1 2 3 4 5 6 $500 in one-time gift and zero non-energy effects (a-j)

1 2 3 4 5 6 $5000 in one-time gift and zero non-energy effects (a-j)

1 2 3 4 5 6 $1000 in one-time gift and zero non-energy effects (a-j)

1 2 3 4 5 6 $100 in one-time gift and zero non-energy effects (a-j)

ENERGY STAR® is a joint program of the US Environmental Protection Agency and the US Department of Energy that works to save money and protect the environment through energy efficient products and practice. Introduced in 1992, ENERGY STAR® is a voluntary labeling program designed to identify and promote energy efficient products. These products deliver the same or better performance as comparable models while using less energy. Originally found on computer monitors, the ENERGY STAR® label can now be found on over 40 product categories, including appliances, lighting, office equipment and home electronics.

N5b. Randomly pick starting point of high) vs. low starting point

The exact price of the Non Energy Benefits (NEBs) that result from the ENERGY STAR® program is unknown, but is thought to be within a certain range. Suppose you could purchase just the benefits of this program that are not associated with energy use. Would you have been willing to pay:

$5,000 / home➔ NO – ask if they'd pay the lower amount, then stop. YES ➔ stop

$500 / home? ➔ NO – stop YES ➔ Ask if they'd pay the higher amount, then stop.

N5c. Now we'd like to try asking you a similar question a different way. Assume you have all the Non Energy Benefits (NEBs) that we talked about before. Do you believe you would be willing to accept <name in sequence> to give up these benefits – to give them to me? [once answered, may move on to next question]

$100/home – 1 time amount	y	n
$500/home	y	n
$1,000/home	y	n
$5,000/home	y	n

Section 7. Final Remarks

- Any other comments?

- Do you have any recommendations for the builder about your home?

Thank you for completing this survey

Appendix M - Overview of Stratified Ratio Estimation

Stratified ratio estimation combines a stratified sample design with a ratio estimator.[82] Both stratification and ratio estimation take advantage of supporting information available for each project in the population. As an example, suppose that an impact evaluation study is being undertaken to assess the annual energy savings of the projects undertaken in a given program. Suppose that the program tracking system provides an estimate of the annual energy savings of each project in the population. Suppose, furthermore, that a substantial fraction of the projects have comparatively small tracking savings but a relatively small number of projects have very large tracking savings. In this case, the coefficient of variation of the tracking savings will often be quite large, e.g., three or larger, and it can be expected that the population coefficient of variation of the actual savings is also large. In this case, the simple random sampling methods described in the preceding section would not be practical.

This problem can be partly mitigated by using the tracking estimate of savings as a stratification variable. Stratifying by the tracking savings generally reduces the coefficient of variation of actual savings in each stratum thereby improving the statistical precision.[83] Moreover, the sampling fraction can be varied from stratum to stratum to further improve the statistical precision. In particular, a relatively small sample can be selected from the projects with small tracking savings, but the sample can be forced to include a higher proportion of the projects with larger tracking savings. In particular, the largest projects can, if desirable, be included in the sample with certainty.

The tracking estimates of savings can also be used in ratio estimation. In impact evaluation, one ratio of interest is the realization rate, i.e., the ratio between the total gross annual savings of all projects in the population and the total tracking savings.[84] To understand the potential advantage of ratio estimation, suppose hypothetically that the actual savings of each project in the population is directly proportional to the savings recorded in the tracking system as illustrated in Figure 94.

In the extreme example illustrated in Figure 94, the actual savings of each project is 0.8 times the tracking estimate of savings. In other words, the tracking system systematically

---

[82] Statisticians have developed many other approaches to sample design and estimation, including sequential sampling, cluster sampling, multi-stage sampling, stratified sampling with mean per unit estimation, stratified sampling with regression estimation, etc. See, for example, *Sampling Techniques* (* Cochran 1977). Any of these methods may be appropriate in a particular application. The authors have found that stratified ratio estimation is generally effective in both impact and process evaluation studies, especially when (a) there is substantial variation in the size of projects in the Program, and (b) the tracking system provides fairly accurate estimates of the savings of each project. These conditions are frequently true for energy conservation Programs.

[83] In this case, however, the coefficient of variation of tracking savings within each stratum usually does not provide a meaningful estimate of the coefficient of variation of actual savings within each stratum. Therefore added information is needed to estimate the expected statistical precision and to choose the sample size, e.g., from a prior sample or from a model characterizing the relationship between tracking and actual savings.

[84] The net to gross ratio is another ratio of interest. Our experience has been that ratio estimation can be used to estimate essentially all parameters of interest in evaluation.

overstates the saving of each project by 20%. The realization rate, 0.8, is the slope of the line relating the actual savings to the tracking for every project. If the realization rate is known, then the true savings of all projects can be accurately estimated by multiplying the total tracking savings by the realization rate. Moreover, in this extreme case, the realization rate can be assessed perfectly by measuring the actual savings of any one project in the population.

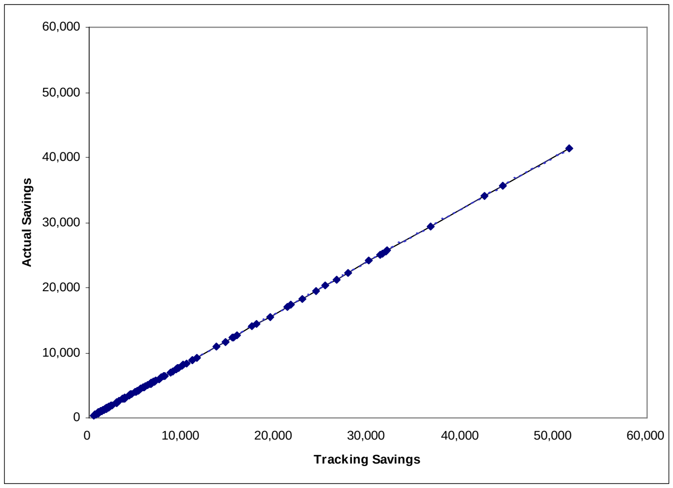


Figure 94: Ideal Case for Ratio Estimation

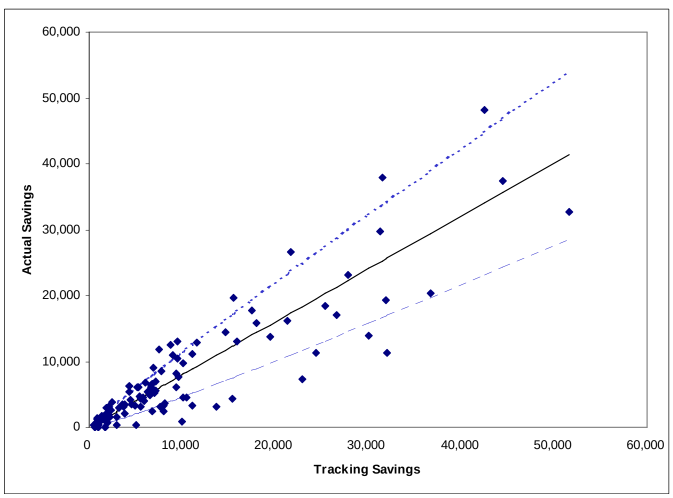


Figure 95: More Typical Relationship between the Actual and Tracking Savings

In practice, of course, there is always some random error in the association between the actual and tracking savings. Figure 95 illustrates a more typical situation. In this case the tracking estimate of savings is a good but not perfect predictor of the actual savings of each project. Nevertheless, the statistical precision can be greatly improved by using stratified ratio estimation to estimate the realization rate rather than by using simple random sampling to assess the average actual savings as discussed in the prior section.

Goals of the Section and Basic Definitions

This section will provide the tools needed to use stratified ratio estimation effectively in evaluation. The goal is to explain the underlying concepts in enough detail for users to be comfortable with the methodology. Specifically, this section will explain:

- How to estimate the population parameters of interest and to calculate the associated confidence intervals,
- How to characterize the population variation when efficiently stratified ratio estimation is to be used,
- How the expected statistical precision is related to the population variation and to the planned sample size assuming that efficient stratification is used,
- How to estimate the required sample size to achieve a desired relative precision,
- How to construct an efficiently stratified sample design, and
- How to estimate the relevant population variation from the sample for use in planning future studies.

Much of the notation needed to discuss the methodology of stratified ratio estimation is retained from the earlier discussion of simple random sampling. Let N denote the number of projects in the population and assume that the projects are labeled $i = 1, \ldots, N$. Let y denote any measurable variable of interest, such as gross or net savings and let y_i denote the value of y for project i. Y denotes the true total of y for all N projects in the population, i.e., $Y = \sum_{i=1}^{N} y_i$, and μ_y denotes the population mean of y, $\mu_y = \frac{Y}{N} = \frac{1}{N}\sum_{i=1}^{N} y_i$.

Stratified ratio estimation focuses on the relationship between y and a second variable, denoted x. The value of x is assumed to be known for each project in the population,[85] and to avoid minor notational inconveniences, x is assumed to be greater than zero for each project in the population. In the impact evaluation context, x is usually the tracking estimate of the savings of each project. X denotes the total of x for all N projects in the population, i.e., $X = \sum_{i=1}^{N} x_i$ and μ_x denotes the population mean of x, $\mu_x = \frac{X}{N} = \frac{1}{N}\sum_{i=1}^{N} x_i$.

The key population parameter of interest is the ratio between the population total of y and the population total of x, which is denoted B and defined by the following equation:

[85] Stratified ratio estimation can also be used when the denominator of the ratio is unknown. For example this methodology can be used to estimate the net to gross ratio. In this case, a different variable, usually the measure of size in the tracking system, is used for stratification.

$$B = \frac{Y}{X} = \frac{\sum_{i=1}^{N} y_i}{\sum_{i=1}^{N} x_i}.$$

Of course, B is also equal to the ratio between μ_y and μ_x, i.e., $B = \frac{\mu_y}{\mu_x}$.

Stratified sample design uses knowledge about the population to add efficiency to the sample design. A stratum is any subset of the projects in the population that is based on known information. A stratification of the population is a classification of all units in the population into mutually exclusive strata that span the population. Under a stratified sample design, simple random sampling is used to select a chosen number of projects from each of the pre-established strata.

Added notation is needed to discuss stratified sampling. Let L denote the number of strata and assume that the strata are labeled $h = 1, \ldots, L$. Let N_h be the total number of population projects in stratum h. Let n_h be the number of projects to be randomly selected from stratum h. Assume that n_h is greater than zero for each stratum h. Then $\sum_{h=1}^{L} N_h = N$, the total population size, and $\sum_{h=1}^{L} n_h = n$, the total sample size.

Using this notation, the stratified ratio estimator can be defined. For each project i in the sample, the case weight is defined according to the equation $w_i = N_h / n_h$ where h denotes the particular stratum that contains project i. Using the case weights, define the stratified ratio estimator of B, denoted b, as follows: [86]

$$b = \frac{\sum_{i=1}^{n} w_i \; y_i}{\sum_{i=1}^{n} w_i \; x_i} \quad .$$

The statistical precision of b can be assessed by calculating the standard error using the following equation:

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86 An equivalent equation is $b = \frac{\hat{Y}}{\hat{X}} = \frac{\sum_{h=1}^{L} N_h \; \bar{y}_h}{\sum_{h=1}^{L} N_h \; \bar{x}_h}$. Technically, the stratified ratio estimator is a biased estimator of the true population ratio. However, Cochran shows that the bias is small if the relative precision of $\sum_{h=1}^{L} N_h \; \bar{x}_h$ is small, pp. 160-167 (* Cochran 1977). In impact evaluation, the bias should be negligible if the population has been appropriately stratified by size as discussed later in this chapter.

$$se(b) = \frac{1}{\hat{X}} \sqrt{\sum_{i=1}^{n} w_i \, (w_i - 1)\, e_i^2} \quad .$$

Here $\hat{X} = \sum_{i=1}^{n} w_i \; x_i$ and $e_i = y_i - b \; x_i$. Then, as usual, the error bound can be calculated as $eb(b) = 1.645 \; se(b)$ and the relative precision can be calculated as $rp = eb(b)/b$.

Stratified ratio estimation can also be used to estimate the population mean or population total of y from the known population mean or population total of x. The estimator of the mean is $\hat{\mu}_y = b \; \mu_x$ and the corresponding standard error is $se(\hat{\mu}) = \mu_x \; se(b)$. The estimator of the total is $\hat{Y} = b \; X$ and the corresponding standard error is $se(\hat{Y}) = X \; se(b)$.

The Ratio Model

To develop a suitable sample design, it is necessary to characterize the relation between x and y in the population. This is done by assuming a statistical model called the ratio model. The primary equation of the ratio model is $y_i = \beta \; x_i + \varepsilon_i$. Here x_i and y_i denote the value of x and y for each project i in the population, β is an unknown but fixed parameter of the model that is similar to a regression coefficient, and ε_i is similar to the random error in a regression model. As in a regression model, the expected value of ε_i is assumed to be zero for each project i in the population. It is also assumed that $\varepsilon_1, \ldots, \varepsilon_N$ are mutually independent. Then μ_i is defined to be the expected value of y_i given x_i. Under the ratio model $\mu_i = \beta \; x_i$.

Instead of assuming that the standard deviation of ε_i is constant, the standard deviation of ε_i is allowed to vary from project to project. For any project i in the population, the standard deviation of ε_i is denoted as σ_i. This is called the residual standard deviation of project i. The population error ratio of x and y, denoted er, is defined to be

$$er = \frac{\sum_{i=1}^{N} \sigma_i}{\sum_{i=1}^{N} \mu_i} \, .$$

The error ratio is the key measure of the population variability in the relationship between x and y for stratified ratio estimation. The role of the error ratio in stratified ratio estimation is virtually the same as the role of the coefficient of variation in simple random sampling. Figure 96 shows several examples of error ratios ranging from 0.4 (a relatively strong relationship) to 1.0 (a weak relationship).

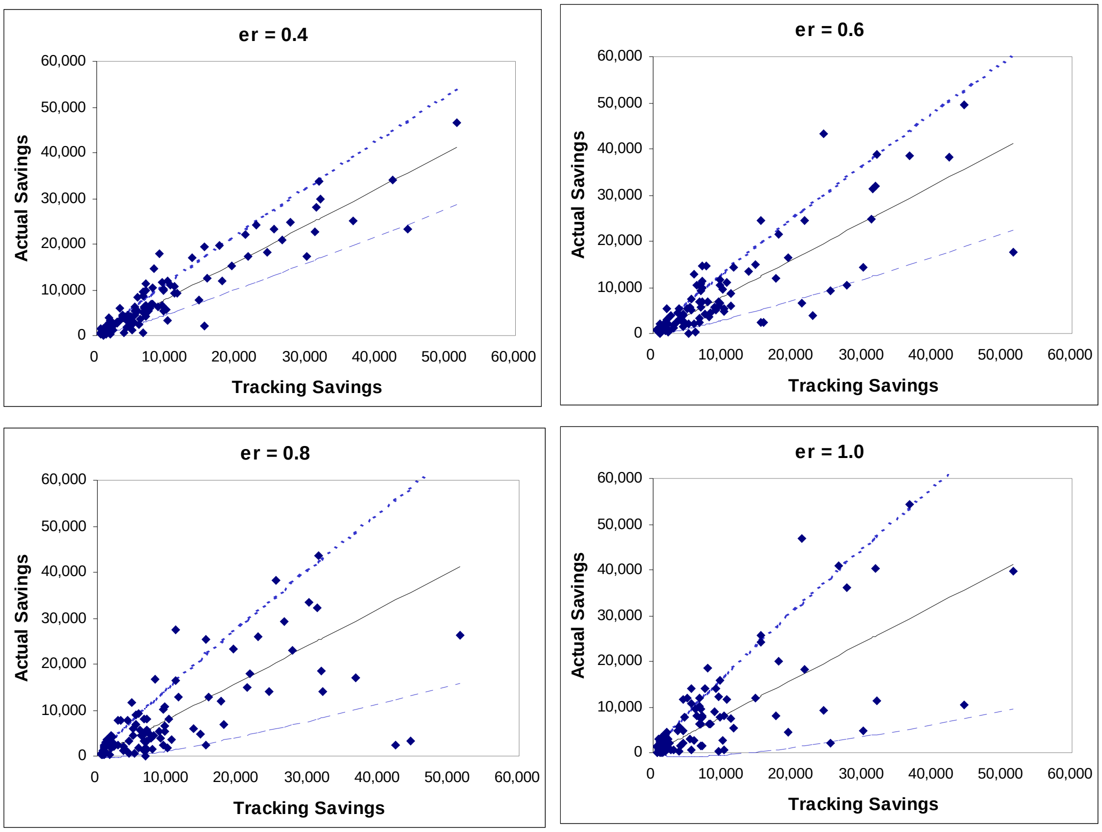

Figure 96: Examples of Different Error Ratios

The following specific functional form for σ_i is often assumed: $\sigma_i = \sigma_0 \, x_i^{\gamma}$. This is called the secondary equation of the model.[87] The secondary equation specifies that the residual standard deviation of each project i in the population is proportional to the value of x_i raised to the power γ, pronounced gamma. A common assumption is that $\gamma = 0.8$. This specification is used in constructing efficiently stratified sample designs and to assist in the estimation of the error ratio from a prior sample.

The secondary equation includes a parameter denoted σ_0. This parameter is determined by the error ratio as follows:

$$\sigma_0 = er \; \frac{\sum_{i=1}^{N} \mu_i}{\sum_{i=1}^{N} x_i^{\gamma}}.$$

87 Sarndal writes the secondary equation as $\sigma_i^2 = c \; x_i^{\gamma}$ (Sarndal et al. 1992), pp. 449.

Sampling Distributions

The simple random sampling section discussed the concept of repeatedly selecting a random sample of a fixed size from a fixed population, observing the value of a particular variable y for each sample project, and calculating appropriate statistics. This concept was used to define the sampling distribution of a statistic such as the sample mean. This same concept of repeated sampling is used in the present discussion with one extension. Instead of regarding y_i as fixed for each project i, y_i is assumed to vary randomly from sample to sample, generated by independent realizations of the ratio model. In other words, the sample is regarded to be randomly determined following the prescribed sample design, and the true values of y_i are considered to be randomly determined for all N units in the population following the ratio model. A more in-depth discussion of this concept can be found in Sarndal.[88]

Expected Statistical Precision and Choice of Sample Size

A key result for stratified ratio estimation is the following: Assuming that the ratio model is accurate, that the sample design is efficiently stratified for the model as described later in this section, that the population size N is large and that the 90% level of confidence is used, then the expected relative precision of the stratified ratio estimator is approximately equal to

$$rp = 1.645 \frac{er}{\sqrt{n}} .$$

This result can be used to guide the choice of the sample size. Suppose that the desired relative precision is denoted D. Under the preceding assumptions, the sample size needed to provide an expected relative precision of D at the 90% level of confidence is approximately

$$n = \left(\frac{1.645\, er}{D} \right)^2 .$$

These are the same equations given in the discussion of simple random sampling, but with the coefficient of variation replaced by the error ratio. If N is moderate or small, the finite population correction factor can be used as a first approximation as in simple random sampling. A somewhat more complex but more accurate way of adjusting the large population results for the size of the population will be presented later in this chapter.

For example, if $D = 0.10$ and $er = 0.5$, then the preceding equation gives

$$n = \left(\frac{1.645 \times 0.5}{0.10} \right)^2 = 68 .$$

Table 111 shows the results of this type of calculation for various values of er and D. Table 11.3 is similar to Table 13.1 except that in Table 13.3 the error ratio is used since

[88] (Sarndal et al. 1992), pages 448-471.

efficiently stratified ratio estimation is being discussed. The sample sizes shown in Table 13.3 are generally much smaller than in 1 because the error ratio is generally much smaller than the coefficient of variation for a given population.

		Error Ratio er						
		0.4	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**
Desired Relative Precision D	**0.25**	7	11	16	21	28	35	43
	0.20	11	17	24	33	43	55	68
	0.15	19	30	43	59	77	97	120
	0.10	43	68	97	133	173	219	271

Table 111: Required Sample Size Assuming a Large Population

Assessing the Error Ratio without a Prior Sample

Table 111, above, illustrated four examples of relationships between x and y. These are typical examples of the type of association expected under the ratio model, assuming various error ratios. In each graph, the solid line represents the expected value of y given x, $\mu_i = \beta\, x_i$, and the broken lines represent the one standard deviation intervals around the mean: $y_i = \beta\, x_i \pm \sigma_i$. In preparing these graphs, the secondary equation $\sigma_i = \sigma_0\, x_i^{\gamma}$ has been assumed with $\gamma = 0.8$.

In most impact evaluation studies, the error ratio can be expected to be in the range 0.4 to 1.0, as illustrated in Table 13.3. If the tracking system is expected to provide quite accurate estimates of the actual savings of most sample projects in the evaluation study, then the error ratio is likely to be relatively small, e.g., near 0.4. This might be the case, for example, if the program provides energy efficiency retrofits to large commercial buildings, and the tracking estimates of savings are based on a fairly detailed analysis of each project that is undertaken in the program. If the tracking system is expected to provide rather poor estimates of the actual savings of most sample projects in the evaluation study, then the error ratio is likely to be larger, e.g., near 1.0. This might be the case, for example, if the program is an express-style program that requires only a simple application and does not provide any site-specific analysis as part of the program delivery.

Estimating the Error Ratio from a Sample

When stratified ratio estimation is being used to analyze a sample, the sample can also be used to estimate the underlying error ratio for use in future sample designs. Assuming the secondary equation $\sigma_i = \sigma_0\, x_i^{\gamma}$ with $\gamma = 0.8$, then the error ratio can be estimated as

$$\hat{er} = \frac{\sqrt{\left(\sum_{i=1}^{n} w_i\, e_i^2 / x_i^{\gamma}\right)\left(\sum_{i=1}^{n} w_i\, x_i^{\gamma}\right)}}{\sum_{i=1}^{n} w_i\, y_i}\ .$$

Here, as usual, $e_i = y_i - b\, x_i$.[89]

Model-Based Stratification

The preceding results assume that stratified ratio estimation is used with an efficiently stratified sampling plan. This section will describe how to construct an efficiently stratified sampling plan. The goal is to group the projects into several strata based on the value of x, usually the tracking estimate of savings, and then specify the number of sample projects to be selected from each stratum. The following method is called model-based stratification by size.[90]

The following steps are required:

1. Create a spreadsheet or database listing each project in the population and providing the value of x_i for each project, $i = 1, \ldots, N$.
2. Use the assumed secondary equation of the ratio model to calculate σ_i for each project, $i = 1, \ldots, N$. Typically, $\sigma_i = \sigma_0\, x_i^{\gamma}$ where γ is a set value, often 0.8. The value of σ_0 can be calculated from the assumed value of the error ratio using the equation given previously. Sort the list by increasing σ_i. For each $i = 1, \ldots, N$ calculate the cumulative sum of the σ_i, $c_i = \sum_{j=1}^{i} \sigma_i$.
3. Choose the desired number of strata L, (usually three to five) and divide the projects in the sorted list so that the sum of the σ_i is approximately equal in each of the L strata. This can be done by calculating $h_i = INT(L \frac{c_i}{c_N} + 0.99999999)$.

   Here the *INT* function rounds the value down to the nearest integer and 0.99999999 has been added to the equation to keep the last project from being assigned to a new stratum.

Once the strata have been constructed as just described, the sample should be allocated equally to each stratum. If the sample size in a particular stratum exceeds the population size in that stratum, the projects in that stratum should be selected with certainty. If desired, the sample may be increased in the remaining strata so that the sample size is closer to the planned value.

In some applications, it may be desirable to stratify the population by a categorical characteristic of the projects as well as by size. For example, the projects might be stratified by building type, technology, contractor, or region. The underlying principle is that the sample size allocated to each categorical stratum should be proportional to the sum of the σ_i within each stratum. Given the definition of the error ratio, a convenient

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[89] If it is also necessary to estimate gamma from the sample, a method is available. See "Estimating regression models with multiplicative heteroscedasticity" (Harvey 1976).

[90] Another method of constructing strata is called Dalenius-Hodges stratification by size. The authors have chosen to emphasize model-based stratification because it is known to provide nearly optimal sample designs for stratified ratio estimation. See *Model Assisted Survey Sampling*, (Sarndal et al. 1992).

way to determine the sum of the σ_i within each stratum is to multiply the expected actual savings in each stratum by the error ratio assumed in the stratum. This gives the rule: the sample size allocated to each categorical stratum should be proportional to the product of the expected actual savings in each stratum and the error ratio assumed in the stratum.[91]

Once the sample size has been determined within each categorical stratum, the projects within each stratum should be further stratified by size as described above.

The Expected Statistical Precision for Any Sample Design

This section discusses how to assess the expected statistical precision of the stratified ratio estimator when stratified ratio estimation is used with an arbitrary sample design. These results assume that the ratio model is accurate and that the sample design is truly followed without non-response or other similar problems.

To develop the result of interest, a new concept is needed. For any given sample design, define the inclusion probability π_i to be the probability that project i is included in the sample, for all $i = 1, \ldots, N$ in the population. Assume that the inclusion probability is greater than zero for every project in the population, and that sample size n is fixed. There are two useful facts about inclusion probabilities. First, the population sum of the inclusion probabilities is equal to n. Second, for any stratified sample design, the inclusion probability is equal to the sampling fraction in each stratum.

Now the result: Let b be the stratified ratio estimator. Under the ratio model, the expected value of the standard deviation of b in repeated sampling is approximately

$$sd(b) = \frac{1}{X}\sqrt{\sum_{i=1}^{N}\left(\pi_i^{-1} - c\right)\sigma_i^2} \quad .$$

Here c is 1 if the finite population correction is desired, or 0 if not.[92] Under the ratio model, the expected relative precision can be defined to be $rp = sd(b)/\beta$.

The preceding equation can be used to assess the expected relative precision for any stratified sample design under the ratio model. This methodology can be used, for example, to explore the effect of increasing the number of strata. This type of analysis indicates that three to five model-based strata are adequate in most impact evaluation applications. This equation has also been used to explore the effect of using model-based stratification with a set value of gamma that is smaller than the value assumed in the ratio model. In several evaluation applications, it has been shown that there is very little loss in expected statistical precision if the strata are constructed using a gamma of 0.5 when the value in the secondary equation is 0.8. This tends to decrease the sampling fractions

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91 This result can be used to allocate evaluation resources among a portfolio of Programs, especially if the marginal evaluation cost per sample project is approximately the same for all projects in the portfolio. See the chapter on Uncertainty.

92 For example, the finite population correction might not be suitable if random measurement error is a large contributor to the residual standard deviation of each project.

in the strata containing larger projects. This can sometimes facilitate recruiting and data collection.

Using the preceding equation, a sample design is said to be optimal under the assumed ratio model if the inclusion probabilities minimize $sd(b)$ for a given sample size n. It can be shown that a sample design is optimal if and only if $\pi_i = n\,\sigma_i \Big/ \sum_{i=1}^{N} \sigma_i$ provided this is not greater than 1. If $n\,\sigma_i \Big/ \sum_{i=1}^{N} \sigma_i > 1$, then project i should be selected with certainty.[93]

Applicability to Impact Evaluation

Stratified ratio estimate also relies on the assumptions that the sample design is followed and that the true savings are measured for the sample projects with little or no bias, as discussed in the section on simple random sampling. Since the sample can generally be smaller with stratified ratio estimation than with simple random sampling, it should be possible to give even more attention to minimizing bias from self-selection, non-response, deliberate substitution of sample projects, or systematic measurement error.

Stratified ratio estimation is generally especially effective when simple random sampling is inappropriate. Whenever the coefficient of variation of savings is greater than one, stratified ratio estimation should be considered. Stratified ratio estimation will almost always be more effective than simple random sampling if the program provides good tracking estimates of savings.

Stratified ratio estimation often focuses on the relationship between the tracking estimates of savings and the actual savings. The two key parameters are the realization rate and error ratio. The realization rate is the slope of the trend line. It is the ratio between the average or total value of the actual savings and the average or total value of the tracking estimates. Thus, the realization rate reflects the amount of systematic bias in the tracking estimates of savings.

The error ratio, on the other hand, describes the strength of the association between the tracking estimates of savings and the actual savings, i.e., the variation of actual savings around the trend line associated with the realization rate. The error ratio measures whether the tracking savings are accurate from project to project across the population of projects.

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93 Under the ratio model, $\sum_{i=1}^{N} \mu_i = \beta\, X$. This result can be used to show that if $\pi_i = n\,\sigma_i \Big/ \sum_{i=1}^{N} \sigma_i$ for all projects in the population and $c = 0$, then $rp = 1.645\,\frac{sd(b)}{\beta} = 1.645\,\frac{er}{\sqrt{n}}$. This justifies our use of the error ratio to calculate the estimated relative precision assuming that a ratio estimator is used with an efficiently stratified sample design and a large population.

The error ratio is a useful indicator of the quality of the program delivery system. Well-designed and managed programs will tend to have smaller error ratios than programs with poorer control and less attention to detail. Indeed, if the error ratio is found to be higher than expected, it generally indicates that there is a problem with program delivery. Conversely, stratified ratio estimation tends to reward strong programs, i.e., those with relatively small error ratios, by making it possible to carry out an effective impact evaluation using a relatively small sample.

With stratified ratio estimation, the ratio model has been used to assist in the development of a suitable sample design. It is important to understand, however, that the model is only used to develop the sample design. The model is not used to support the statistical analysis of the sample data, except the estimation of the error ratio. If the model is accurate, the achieved statistical precision will be close to the expected statistical precision predicted by the model. If the model is inaccurate, the expected statistical precision may be inaccurate also. But even if the model is inaccurate, the stratified ratio estimator is still free of any material bias and the standard error is still a good guide to the achieved statistical precision.[94]

[94] Sarndal has referred to these methods as model-assisted since, although the analysis does not depend on the accuracy of the model, the model does guide the analysis. (Sarndal et al. 1992), pp. 227 and 239. Sarndal provides a much more general model called the generalized regression model which may, in some circumstances, suggest other estimators such as the difference or regression estimators, but the authors have found that the ratio estimator generally is suitable in evaluation.

Appendix N – Non-Energy Benefits (SERA)

Single Family Non-Energy Benefits (SERA)

Feedback on Non-Energy Effects from Builders

Non-Energy Benefits Responses

Although California's Statewide ENERGY STAR® Single family program is designed to save energy, the reality is that participation in energy efficiency (EE) programs or adoption of energy efficiency measures occurs for a host of reasons in addition to the specific goals of any program. When asked, participants routinely cite non-energy impacts and considerations either as a component of decision-making or as benefits they recognized after installing energy efficient equipment. In studies of commercial programs, participants routinely mention non-energy benefits (NEBs) as reasons for their satisfaction with various Programs.

We asked participants and non-participants an array of questions about these effects. This chapter discusses perceptions, directions, frequencies, and presence of NEBs based on feedback from participating and non-participating builders. The following chapter assesses similar information from the owner / occupants. The following chapter provides an analysis of the valuation – in dollar or energy savings equivalent terms – associated with the NEBs described in this and the next chapter.

The builders were asked a series of questions about effects other than actual energy savings that the occupants of the houses were realizing due to the installation of energy efficient measures or practices in the homes. As over half of the non-participant builders did install some type of energy efficient measures, these questions were appropriate for both groups.

Effects Experienced by Residents

The first question in this section asked builders if there were any positive or negative effects above and beyond the energy savings that they would attribute to the energy efficient measures they had installed. It was an open ended question where the builders could list anything they felt that the residents were experiencing.

Participants: Forty-six percent of the participant builders responded that they believed the residents were receiving some sort of positive effects above and beyond the energy savings of the home. None of the builders responded that the non-energy effects were affecting the residents negatively. When asked what were the positive non-energy benefits that the residents were receiving the builders had a variety of answers including:

- They enjoy a better built home.
- Conservation and the environment.
- These homes have lower maintenance and a higher resale value.
- Maybe the windows.
- The noise is lower in these homes.
- The home is quieter, get hot water quicker, there is sound reduction.
- The roof tiles, they look good, the aesthetic value.

Non-participants: Although only 52% of the non-participant builders said they were installing energy efficient measures over those required by Title 24, 57% felt that the non-energy benefits that owners derive from these energy efficient measures are adding a positive value to the residents. A very small percent (5%) of the builders thought that the energy efficient measures were adding a negative value to the home. The non-energy benefits that the builders felt homeowners were experiencing were:

- It is 100% positive, windows, comfort, all of the rooms being the same temperature, and being "green".
- Easier to use features, nicer looking.
- It all works together, it is hard to separate out the energy savings from the other benefits.
- Quality of construction, better performance of appliances and helping to improve the environment.
- Self satisfaction, there is a positive effect on the environment.
- They don’t care about the benefits, It's just vacation homes.
- Comfort of the home and doing good for the environment.
- Less noise pollution.

Comparison: Both groups of builders believe that not only are there non-energy benefits associated with the energy efficient measures, but that these benefits are adding a positive value to the homeowners for a variety of reasons. For both groups, approximately half of the builders reporting believed homeowners were receiving positive effects from the home's non-energy effects.

Comparison of Values

The builders were asked to compare the value of the non-energy benefits to the value of the energy savings to the resident. They were given a range of values from *positive to but much less valuable* than the energy saving to *much more valuable* than energy savings. They could also respond that the non-energy benefits were *costly* to the residents. This question was located toward the end of the survey for both groups and in many cases, the interviewee was running out of time and refused to answer this question. Seventy percent of the participant builders answered this question and 57% of the non-participants did so.

Participants: Half of the participant builders reporting believed that the value of the non-energy benefits is positive, but *less valuable* than the energy savings, 43% said the savings are only *somewhat less* valuable than the energy savings and 7% said they are *much less* valuable. Almost 20% of the builders said that the non-energy benefits are *more valuable* than the energy savings and 20% said the non-energy benefits have *zero* value for the homeowners. Once again, none of the participant builders said the non-energy benefits supplied a negative cost to the residents. The Figure below shows the distribution of the answers for both groups and the Table shows only the percents saying the non-energy benefits are *more valuable* or *less valuable* than the energy savings.

Non-participants: One third of the non-participant builders believe that the non-energy benefits supply *zero value* for the residents, 42% of the builders said the benefits were positive but *less valuable* than the energy savings and only 8% responded that the value of the non-energy benefits was *higher* than the energy savings.

Comparison: Neither group responded that the value of the non-energy benefits was costly, actually supplying the resident with a negative cost. A higher percent of the non-participants felt that the non-energy benefits added *zero value* to the resident and 18% of participants versus only 8% on non-participants responded that the value of the non-energy benefits was higher than the value of the energy savings. However, for both groups, the majority of builders believed that the non-energy benefits do add value to the homeowner – it is just a matter of how much.

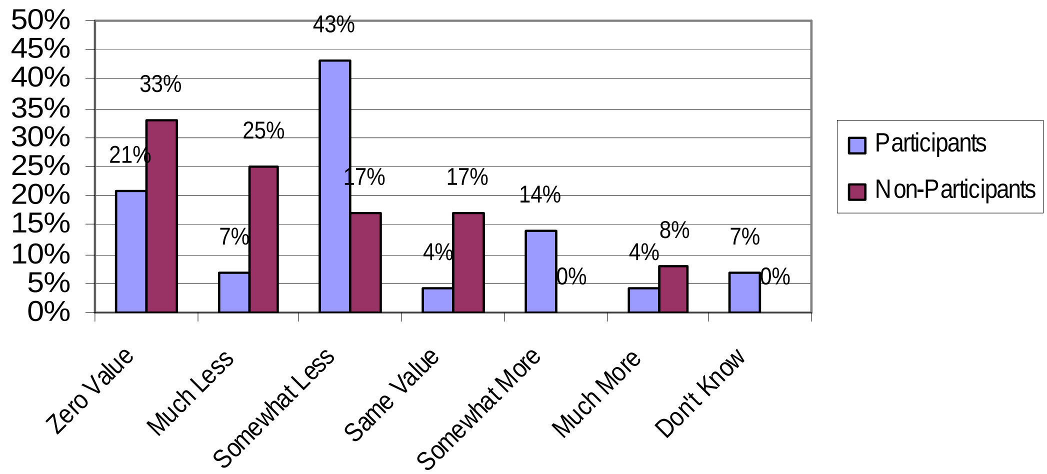

Figure 97: Comparative Value of Non-Energy Benefits

(Participants N=28 Non-Participants N=12)

	Less Valuable Than Energy Savings	More Valuable Than Energy Savings
Participants	50%	18%
Non-Participants	42%	8%

Table 112: Comparative Value of the Non-Energy Benefits

Non-Energy Benefits and the Sale of the Home

The survey next sought to determine whether the builders or realtors had used the non-energy benefits previously discussed to assist in the sale of the home. For the participant builders this question was asked to all of the interviewees while for the non-participants a caveat was applied, the question was only asked of builders who had previously responded that their projects were higher than standard efficiency. If the non-participants projects were not higher than standard efficiency the non-participants were asked if they believed that non-energy benefits would help convince buyers to purchase the higher energy homes.

Participants: Of the builders responding, 55% said that they had used the possible non-energy benefits of the home to help convince the homeowner to purchase the home. A smaller percentage (41%) of the builders responded that the realtors had used the possible non-energy benefits to sell the home. On a scale of 1 to 5 where 1 is not important and 5 is very important, the average importance of the non-energy benefits in selling the home for the builders was 3.2; this is shown in the Figure below. The benefits the builders discussed were:

- Mainly the environmental impact,
- Solar tubes.

Of the 41% who said realtors used the non-energy benefits to help sell the home the average score rating the importance of these benefits in selling the home was 2.9, slightly less than the score for the importance to the builders in selling the homes. The distribution of these scores is also shown in the following Figure. The benefit that the builders stated the realtors used was the reduced environmental impact of the home.

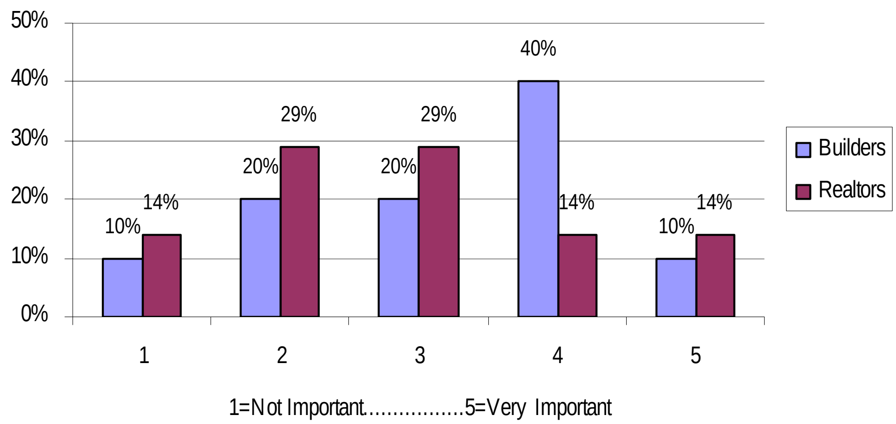

Figure 98: Importance of Non-Energy Benefits in Selling Home

(Builder perception of use by Builders and Realtors. Total completes for this question N=10)

Non-Participants: Of the non-participants reporting half said that they did use the non-energy benefits to help convince buyers to purchase their homes. Only 25% of the builders responded that the realtors used these benefits to sell the homes. The non-energy benefits that were promoted by the builders were:

- All of them, the high performance windows, the environment, and so on.
- Comfort of the home.
- The windows and the environment.

The average rating of the non-energy benefit's importance to selling the home was 2 on the same 1 to 5 scale that was used for the participant builders.

If the non-participant builders had responded that their projects were not more efficient than energy code, they were asked if they thought that the non-energy benefits discussed could have helped to sell the home. Forty-five percent of the non-participants did feel that even though their homes were not highly efficient, that using non-energy benefits as a selling point would help convince potential buyers to purchase home. These builders were asked what non-energy benefits could potentially help sell homes and responded that:

- The environmental benefits, long term efficiency.
- The overall package.

Comparison: The Table below shows the results of this question for both groups of builders and the non-participants whose projects were not over the energy code efficiency standards. The percent of participants and non-participants who used non-energy benefits to help sell the home was very similar, with around half of the builders in both groups using them. The difference lies in the importance the builders placed on these benefits in convincing the homeowners to purchase. For participants the average value of importance was 3.2 but for the non-participants the average value of the non-energy benefits in their importance to sell the home was only 2.

	Did Builder Use NEBs?		Did Realtor Use NEBs?	Average Importance
	Yes	No	Yes	Scale of 1 to 5
Participants	55%	36%	41%	3.2
Non-Participants Above Title-24	50%	25%	25%	2
Non-Participants not above Title-24	46%	36%	NA	2.8

Table 113: Non-Energy Benefits and Selling the Home [95]

Energy Efficiency as a Hedge

Both groups of builders were asked if they felt that energy efficiency measures installed in the homes serve as a hedge against future price increases.

Participants: The majority of builders said that the energy efficient measures do act as a hedge against energy price hikes, 75% said that they do consider them to be a hedge and only 18% said they do not. When asked if homeowners also considered the increased energy efficiency to be a hedge, 63% of the participants said they believed did while only 15% said they did not. The builders were also asked to place a value on this benefit to the homeowners on a scale from 1 to 5 with 1 being *not important* and 5 being *very important*. The average score was 3.7.

[95] Totals do not necessarily equal 100% as more than one answer could be given don't know response could be given as well.

When the builders were asked what the value of the increased energy efficiency of the home as a hedge was when compared to the actual energy savings of the home, 40% reported that the value was the *same as the energy savings* and 10% reported that the value *positive but less valuable* than the energy savings. None of the builders reported that the value as a hedge was *greater than the actual energy savings*.

Non-Participants: Close to 90% of the non-participants replied that they did consider energy efficient measures installed in the home to be a hedge against future price increases and only 12% said they did not. As with the participants, these builders were also asked to place a value on the importance of this benefit. The average value to the homeowners was 4.1.

When the value of the home as a hedge against energy price increases was compared to the value of the actual energy savings, 40% of the non-participants responded that it was the *same value*, 10% said it was a *higher value*, and 40% said it is *positive but less valuable* that the energy savings.

Comparison: The participants and non-participants alike felt that the energy efficient measures were a hedge against future energy price increases. Interestingly, although less of the non-participants installed energy efficient measures and as a group, when they did, in the majority of cases the measures they installed provided only a slight increase in efficiency, they still placed a higher value on energy efficiency as a hedge than the participants. Also, a higher percentage of non-participants believe the energy efficient measures act as a hedge. When it came to the value of the energy efficient measures in the home acting as a hedge, compared to the actual energy saving, the non-participants again placed a higher value on this benefit than the participant builders. Both groups had 40% of the respondents saying it was the same value but for the non-participants 10% said it was more valuable than the actual energy savings while none of the participant builders felt this was true.

	Hedge	**Not a Hedge**
Participants	75%	18%
Non-Participants	88%	12%

Table 114: Energy Efficient Measures acting as a Hedge Against Energy Price Increases

(N for Participants=28, N for non-participants=17)

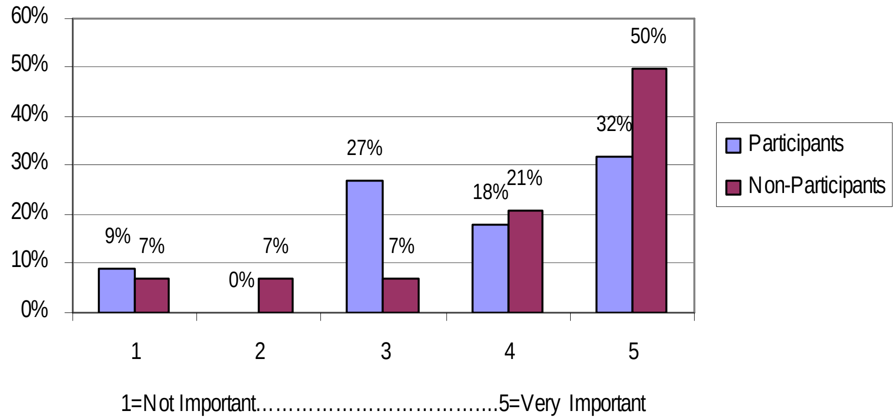

Figure 99: Value of the Home as a Hedge

Firmographics

Data were also gathered regarding the respondents and their businesses. Both the participants and non-participants were asked a similar set of questions for this section.

Knowledge of Energy Efficiency Technologies

Participants: The participants were asked to rate, on a scale of 1 to 5, where 1 is *very much*, 4 is *stayed the same*, and 5 is *decreased*, how much the ENERGY STAR® program has aided in increasing their knowledge of energy efficient design. None of the builders responded that the program *decreased* their knowledge and 93% responded that it had at least increased their knowledge *a little*. Seven percent of the builders said their level of knowledge had stayed the same and 42% reported that it had increased their knowledge *very much*.

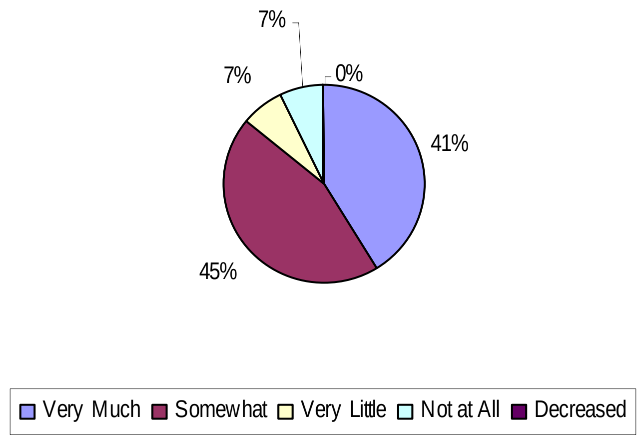

Figure 100: ENERGY STAR® Program's Effect on Participant Builder Knowledge

(N=29)

Non-Participants: The non-participants were asked to characterize their knowledge of advanced energy efficient technologies and practices on a scale of 1 to 5 where 1 is *not at all knowledgeable* and 5 is *very knowledgeable*. The average rating of builder knowledge was 3.5, showing that most of the builders consider themselves to be knowledgeable in energy efficient building practices. Thirty-two percent of the builders considered themselves to be *very knowledgeable* while conversely only 5% replied that they were *not at all knowledgeable*, the distributions of the responses are shown in the Figure below.

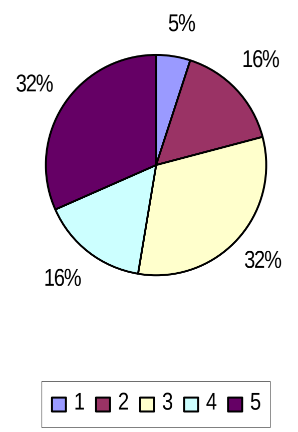

Figure 101: Characterization of Nonparticipant Builder Knowledge

(N=17)

Energy Price Predictions

The builders in both groups were asked to predict what they believe energy prices will be doing in the next 3-5 years. The choices provided ranged from *decrease a lot* to *increasing a great deal*.

Participants: Only 3% of the participant builders believed that the prices would *decrease a little* in the future. The vast majority believed that prices would be increasing, with 55% reporting they would *increase somewhat* and 41% reporting that they would be *increasing a great deal*.

Non-Participants: For the non-participants, 5% reported that they believe that prices will be *decreasing a little* in the future. Ninety percent of the non-participants believe that prices will be *increasing*, with 30% reporting they would *increase somewhat* and 60% reported they would *increase a great deal*.

Comparisons: Both groups of builders hold a similar view when it comes to predicting energy prices trends in the future. For both groups of builders, at least 90% reported that they felt that energy prices would be increasing in the future. A small percentage of each group also responded that they would be decreasing a little, but for both groups, it was a small minority.

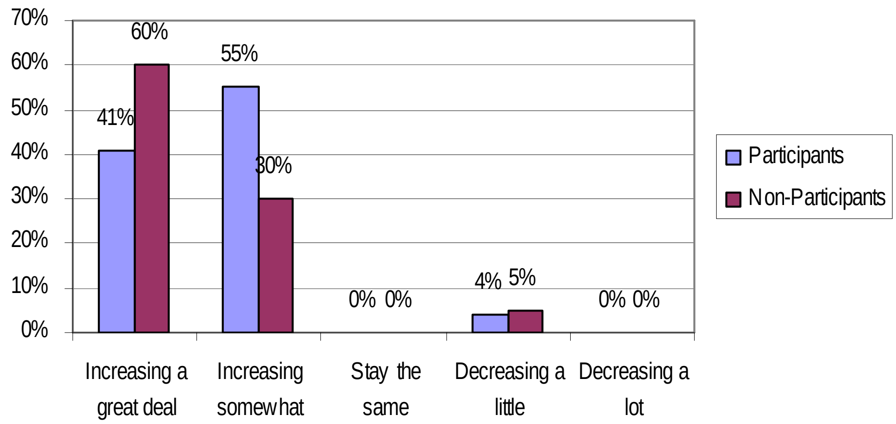

Figure 102: Direction of Energy Prices in the Future

(Participants N=29 Non-Participants N=20)

Participation in Energy Efficiency Programs

Participants: The majority of participant builders, 66%, had not previously participated in any energy efficiency programs, however 34% of them had. Of those that had previously participated, 50% of them said that they had a *very positive experience*, the average rating of their experience in other programs was 4.3 on a 5 point scale, where 5 means *very positive* and 1 is *very negative*. Some of the other programs builders had participated in were:

- Comfort Wise
- Efficiency for Living
- Greenbuild

Non-Participants: Just over half (53%) of the non-participant builders had previously participated in an energy efficiency program and 42% had not. Of those participating, 60% reported that they had a very *positive experience*, the average rating on the same 1 to 5 scale used for the participants, was 4.7. The programs they had participated in were:

- California Greenbuild
- Building America
- LEEDS
- ENERGY STAR®
- Build it Green
- Green Homes

Comparison: Interestingly, a higher percent of non-participants had previously participated in energy efficiency programs, also, of those that did participate ranked their experience as very positive, indicating that they would most likely be willing to participate energy efficiency programs again. Only 34% of the builders participating in the ENERGY STAR® program had been in other programs and 53% of those not in the ENERGY STAR® Program had been in other energy programs.

	Previously participated in Energy Program	Experience in Program (1=very negative; 5-very positive)
Participants	34%	4.3
Non-Participants	53%	4.7

Table 115: Builders Participation in Energy Efficiency Programs

(Participant N=29; non-participant N=19)

The Builders

The last part of the survey asked the builders a few questions regarding the size of their firm, where they build, and how much they build.

Participants: The average number of employees working in the participant firms in the state of California was 363 employees with a wide range, the minimum number of employees was 0, and the maximum was 5,000. When asked what the average number of employees the firms had working for them world wide the average was 2,251 employees. For the participant builders, on average, 89% of their work is in the single family sector. The average number of homes the builders construct, per year, in California is 1,034 homes, the minimum number of projects was 1 and the maximum was 7,000. The majority of the builders build in Pacific Gas and Electric territory, and the remaining 36% build in either Southern California Edison or San Diego Gas and Electric.

Non-Participants: The average number of employees working in the non-participant firms was 67, with the maximum size being a 500 person firm and the minimum size being 0 employees. Ninety-two percent of the non-participant builders work is in the single family sector. The average number of homes built by the non-participants last year in California was 39, with a minimum of one home a year and a maximum of 250 homes constructed last year. Just over half of the non-participants are building homes in Pacific Gas and Electric territory, 23% are building in Southern California Edison territory and 27% are in "other" territories, mostly local utilities.

Comparisons: The participant builders, as a group, worked for or owned, much larger companies than the non-participants, and thus, in most cases, built many more homes. Forty-seven percent of the non-participants worked in firms with 10 or less employees while 28% of the participant builders worked in firms that size. Only 16% of the non-participant firms had 100 or more employees but 36% of the participant builders had that many employees. The participants built, on average, 1034 homes last year and the non-participants built only 39 homes last year. Twelve percent of the non-participant firms built 100 or more homes last year and 65% of the non-participant firms built 100 or more homes in California last year.

	Avg. # of Employees	Avg. % in Single Family Sector	Avg. # of Homes
Participants	362	89%	1034
Non-participants	67	93%	39

Table 116: The Builders

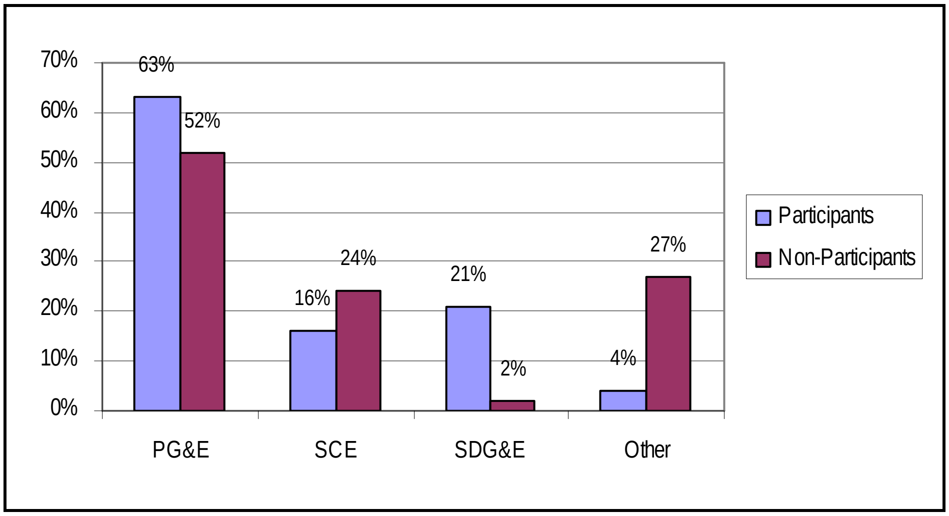

Figure 103: Distribution by Areas of State

	10 or less employees	100 or more employees	100 or more homes
Participants	47%	16%	12%
Non-participants	28%	36%	65%

Table 117: Comparisons

Feedback on Non-Energy Effects from Owners/Occupants

Non-Energy Benefits Responses from Participating Owners

The following pages present the results of the survey for both the non-participant and participant owner-occupants. Survey questions covered a variety of topics related to both the old home and the new home. The results from the participant owner/occupants are presented first, followed by the non-participant owner/occupant survey results.

The Value of an ENERGY STAR® Home

Influence of Factors in the Decision to Purchase or Rent

Respondents were given a list of 11 separate factors that might have had an influence on their decision to inhabit the ENERGY STAR® Home. They were also given a 12th category where they could list any other factor that played in their decision to buy or rent. A response of 1 signifies *no influence* and on the other end of the spectrum a 7 denotes a *large influence*. The respondents could also answer *not applicable* if the factor did not apply to them. The most important factor for purchase or rental was *newly built home* with a 6.1 rating, trailing close behind was *size of home* with a rating of 6. The least important factor was *small selection of homes/rentals available*. "*Other*" factors given included:

- Safe neighborhood for the kids.
- To be closer to family.
- Solar panels on the roof, other "green" features.

The Table below shows the average rating. The second Table shows the distribution of the responses.

Average Influence Rankings	
Newly Built Home	6.1
Size of Home	6.0
Location	5.7
Price of Home/Rent	5.5
Investment Opportunity	4.8
Other	4.6
Reputation of Builder	4.4
Lot Size	4.3
ENERGY STAR® Mortgage Program	3.9
School District	3.8
ENERGY STAR® Rating	3.6
Small Selection of Homes/Rentals Available	3.3

Table 118: Summary of Purchasing (Rental) Factors-Average

(N=70 for each question)

	1=No Influence ....7=Large Influence							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**NA**
ENERGY STAR® Rating	32%	4%	6%	21%	13%	1%	15%	4%

ENERGY STAR® Mortgage	59%	6%	3%	5%	5%	2%	6%	14%
Newly Built Home	6%	1%	3%	1%	9%	19%	61%	0%
Size of Home	6%	1%	0%	3%	13%	29%	47%	1%
Investment Opportunity	18%	3%	5%	12%	14%	18%	29%	2%
Location	6%	3%	1%	11%	10%	23%	44%	1%
School District	44%	3%	4%	4%	7%	6%	21%	10%
Lot Size	21%	6%	10%	14%	11%	14%	20%	3%
Price of Home/Rent	10%	0%	13%	0%	15%	24%	28%	0%
Small Selection of Homes	42%	9%	5%	14%	3%	12%	6%	9%
Reputation of Builder	16%	6%	7%	24%	13%	7%	24%	1%
Other	26%	0%	5%	16%	5%	11%	26%	11%

Table 119: Summary of Purchasing (Rental) Factors-Distribution

(N=70)

One Time Dollar Amount on Energy Related Features

Residents were asked to place a one time, not annual, dollar amount on the energy efficient features in their home. Before answering the questions, respondents were directed to read a statement about ENERGY STAR® homes describing the energy efficient measures installed in their home due to the program. The average dollar amount residents felt energy efficient measures were worth was $2,953[96]. The ranges of $1,501-$2,000 and $2,000-$3,000 were the most common responses, with both ranges being reported 26% of the time. Overall, 52% of the responses fell within the $1,501 to $3,000 range. Only one resident felt that there was a negative value associated with the energy efficient measures and 5% said the energy efficient measures were valued at $0.

The average value attributed to the energy efficient measures in the home was $2,953.

[96] To compute this average the midpoint of the ranges was used. One respondent answered that there was a negative dollar value associated with the energy efficient measures but did not give a dollar value. This response was not used in the calculation. 11 respondents said the value was $5,001 or more, a value of $5,500 was used for these calculations.

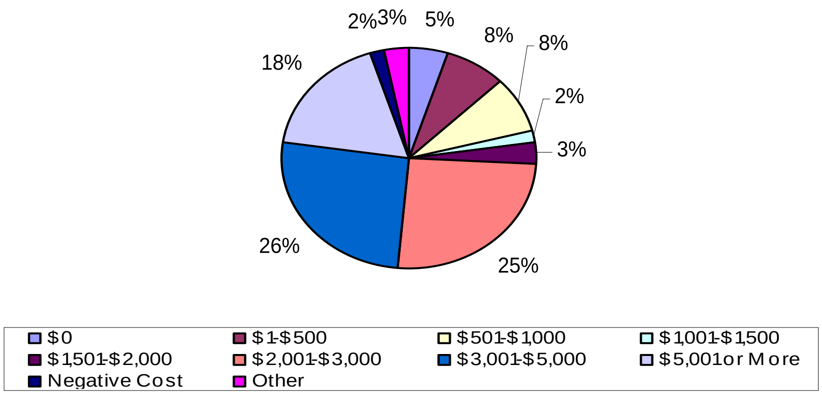

Figure 104: Summary of Value of Energy Efficient Measures

(N=62)

"Non-Energy" Effects Associated with ENERGY STAR® Equipment and Features

This question listed categories of possible effects and asked residents to respond by stating whether these factors resulted in a decrease or increase in value to the resident or his/her family. Values were given from -4, which correlated to a *very strong decrease* in value to 4 for a *very strong* increase in value. A score of zero represents *no change* from the factor. The next question asked respondents to determine the total effect of all the non-energy benefits. Values for the question ranged from -3 to 3, where -3 is *very negative* and 3 is *very positive*.

An overwhelming majority of residents responded that the effects on themselves and their families were positive. The only response with double digits in the negative column was for *amount of noise* in the home with 10% of respondents reporting a negative value. The highest percent of positive responses (92%) and the highest value (2.6) was for the category; *comfort of home*. Overall, 98% of the response reported that the total of the non-energy benefits added a positive value and the average value was 2.1, or moderately positive. None of the residents report the total of the non-energy effects had a negative value.

Feature or Effect	% Negative	% Positive	Average Value
Quality Construction	6%	85%	2.2
High Performance Windows	2%	91%	2.5
HVAC System	5%	89%	2.4
Higher Eff. Water Heater	6%	85%	2.3
Comfort of Home	4%	92%	2.6
Amount of Noise	10%	81%	1.9
"Doing Good" for Environment	4%	85%	2.1
Appearance of Equipment and Home	6%	68%	1.7
Equipment Maintenance/Lifetime	4%	78%	1.8
Family Illnesses	5%	47%	1.1
Reduced Concerns About Bills	0%	67%	1.6
Ease of Selling	2%	83%	2.2
Other	0%	50%	1.4
Total Effect of "Non Energy" Effects	0%	98%	2.1
-4=very strong decrease in value…………………+4=very strong increase in value			

Table 120: Non-Energy Effects and Average Values Associated with ENERGY STAR® Equipment and Features

(N for each question 70)

What Other Energy Efficient Products or Features do Residents Desire

The residents were given the opportunity to list or describe other energy efficient measures that they wanted installed but were either not offered or not available. The most often requested feature was solar panels, 38% of the residents asked for solar panels. Some of the responses were:

- Solar Panels (7 responses)
- Appliances, including clothes washers, dish washers, and kitchen appliances (5 responses)
- Low Flush Toilets
- Insulation in the attic

Influence of Non-Energy Benefits in Purchasing Home

This question asked residents if had they known about the non-energy benefits, would it have effected their decision to purchase/rent the home.

- 50% replied it would have made no difference.
- 35% of residents said it would have made them *more* likely to select the home.
- 15% responded that it would have made them *less* likely to select the home.

Comparison of ENERGY STAR® Home to Prior Home

This section of the survey used a battery of questions to ascertain the differences residents perceived between their current house and their previous residence, both in energy and non-energy factors. Some of the questions also asked residents to compare their current living situation to a similar but not ENERGY STAR® rated home. In addition to these data, information was collected and used to compare energy bills and the non-energy benefits that the realtor used when selling the home.

Comparison of Effects in New Home Versus Previous Home:

This set of questions listed 8 separate statements and asked the respondent to agree or disagree with the statement. The answers range from -2, *strongly disagree* to 2, *strongly agree*, where 0 is *no change* noticed. The data is presented in two forms. The stacked bar chart displays the distribution of the replies and the table shows the average value for a response. In the Table below, statements that are italicized and in bold are those which would be considered "good" from a conservation standpoint. For example, the statement "we use the air-conditioning less" is italicized because in a more energy efficient environment one would hope to see residents agree with this statement, a positive response. Nearly half of residents reporting agreed with this statement while only 25% disagreed. The average rating was 0.27.

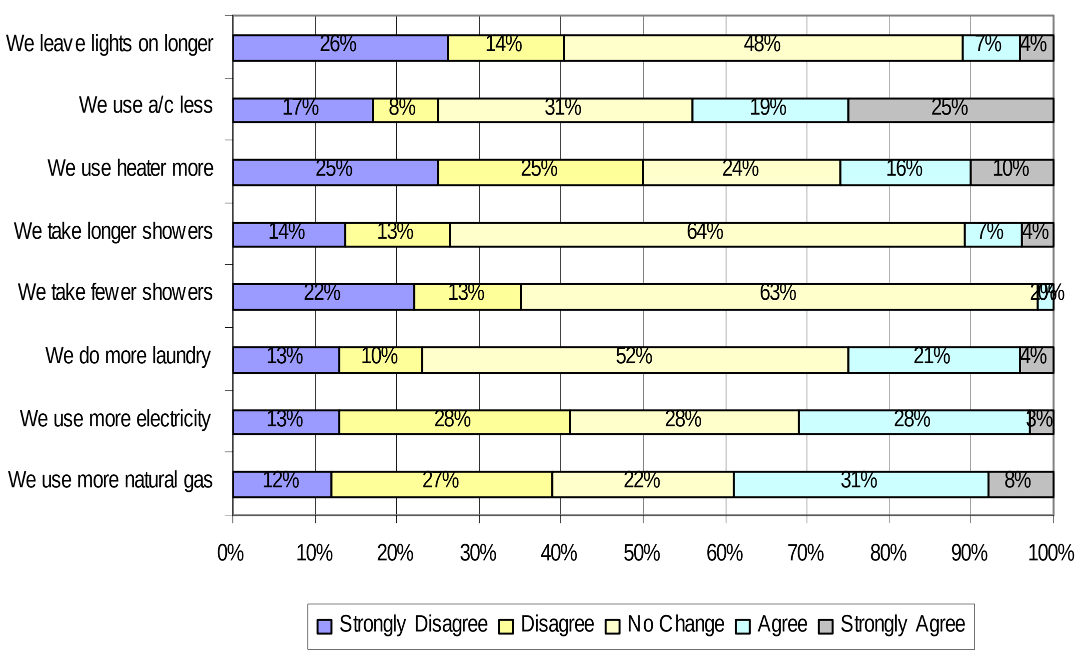

Figure 105: Energy-Related Behaviors in New Home vs. Previous Home

Statement	Average Response
We leave lights on longer	-0.51
We use heater more	-0.41
We take longer showers	-0.28
We do more laundry	-0.06
We use more electricity	-0.20
We use more natural gas	-0.04
We use A/C less	0.27
We take fewer showers	-0.54
-2 Strongly Disagree…………2 Strongly Agree	

Table 121: Average Score for Energy Behaviors in New Home vs. Prior Home

(N=72)

The next twelve questions in the survey also provided data comparing the current ENERGY STAR® rated home to the owner/occupant's previous residence. There were twelve individual questions directly comparing changes and effects of the new home with the last one. The respondents had choices ranging from *much worse* in comparison to *much better*. Values were assigned to these answers ranging from -3 to 3 respectively, with 0 once again signifying *no change* noticed.

For three of the twelve categories, all of the respondents reported that the effect in the new home was either negligible, or improved. These categories, with their corresponding percent positive replies were:

- Impact on the environment (89%)
- Ability to sell or rent the new home in the future (87%)
- "Other" effect (74%)
- Family illnesses or doctor visits (34%)

The low percent noted for positive scores relating to illnesses is due to a high number of *no change* responses, however, no residents felt that their new home increased illness or doctor visits[97]. The highest percent of negative effects noticed was regarding the *warmth in the winter* in the new home with 10% of responses indicating a negative change in this direction. However, at least one of these responses was also due in part due to the resident moving from a warm desert environment to a more mountainous region. The Table below shows the percent of positive and negative responses for each category as well as the average score for each.

[97] The issue of family illness and doctors visits is addressed in more detail later in this section.

Feature	Negative	Positive	Average Value
Construction Quality	9%	82%	1.8
Comfort	3%	87%	2.1
Warmth in Winter	10%	71%	1.6
Coolness in Summer	9%	66%	1.9
Noise	9%	75%	1.7
Impact on the Environment	0%	89%	2.1
Appearance of ENERGY STAR® Features	2%	69%	1.8
Performance of the Equipment	2%	83%	2.0
Family Illnesses or Doctor Visits	0%	34%	0.8
Concerns of Bill Payment	7%	66%	1.5
Ability to Sell or Rent	0%	87%	2.0
"Other" Effects	0%	74%	1.7
-3=Much worse..........................3=Much Better			

Table 122: Comparison of New Home Versus Old Home for Twelve Categories

(N=72)

Impact of Noise Compared to Old Home

Residents were asked a set of questions specifically focusing on differences in the noise of their current and past residence. The questions gathered data regarding both the noise generated specifically from the ENERGY STAR® appliances such as dishwashers or laundry machines, as well as the difference in the noise being transmitted from outside of the house to the inside. Once again, the rating goes from -3 to 3, correlating to *disagree strongly* to *agree strongly*. As with the effects previously addressed in this section the factors are delineated by "good" and "bad". "Good" answers are those that one would agree with if the energy efficient measures are acting the way they were intended. For example; one would expect the equipment in the new house to perform more quietly than in the old, hence, this would be a "good" answer. The opposite is true for the "bad" answers. An example for this set of questions of a "bad" effect is: *noise from outside is louder in the new house*. With the "good" effects a positive response is desirable and with "bad" effects a negative response is desired. The "good" effects are bold and italicized in the Table below.

In relation to noise in the house and from ENERGY STAR® equipment the results agreed with the desired effect. Positive responses were obtained for both the statement *energy equipment is quieter* and *noise from outside is quieter*. The Figure below shows the distribution of the responses to the different statements. The statement respondents most strongly agreed with was *noise from outside is quieter,* and the statements most strongly disagreed with were "*Other" impacts were noticed* and *noise from outside is louder*.

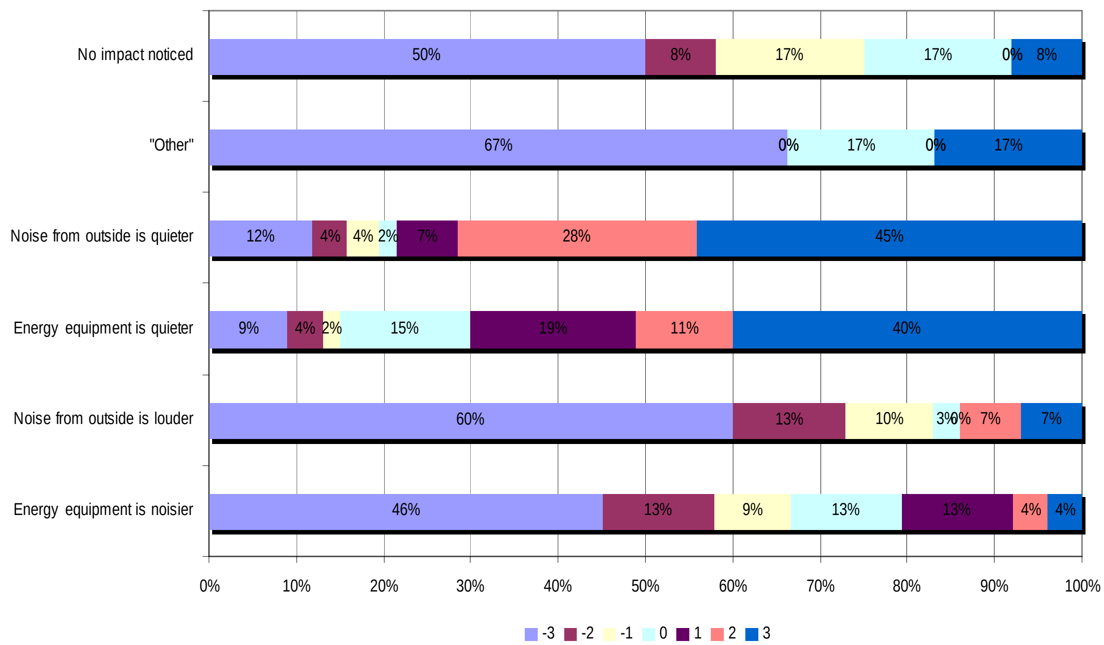

Figure 106: Effects of ENERGY STAR® Equipment and Features on Noise

Impact	Average
Energy equipment is noisier	-1.4
Noise from outside is louder	-1.8
Energy equipment is quieter	1.2
Noise from outside is quieter	1.5
"Other"	-1.5
No impact noticed	-1.6

Table 123: Reported Effects of Noise in New ENERGY STAR® Home Compared to Prior Home

(N=62)

The results of the last question relating to noise are summarized in the following Figure. Respondents were asked to compare their current home to a *similar* but not ENERGY STAR® rated home. The most common response was *don't know,* followed by *much better*, with 30% of the residents answering this way. No residents said that their home was *much worse,* and only 4% felt that it was *somewhat worse*. These results indicate that the ENERGY STAR® homes reduce noise for residents compared to their previous residence. This is due both to the equipment running quieter and a reduced amount of infiltration of noise from outside the ENERGY STAR® home.

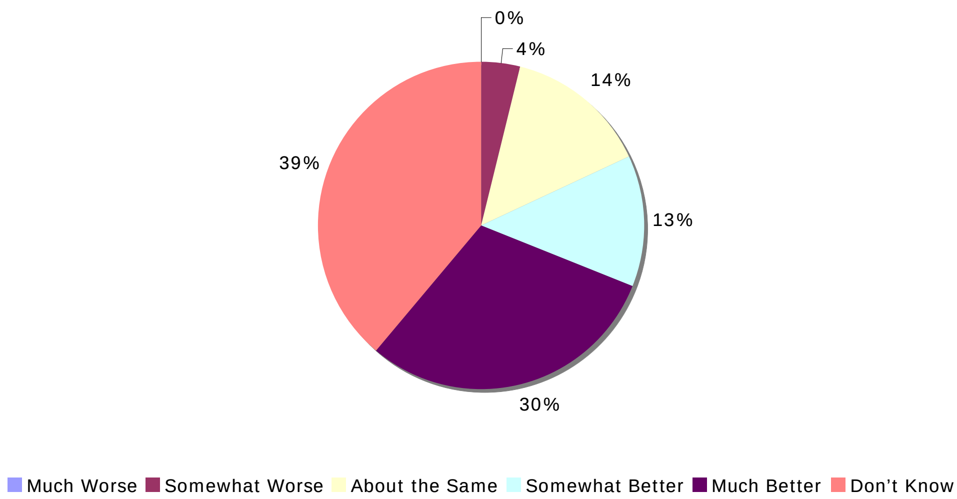

Figure 107: Comparison of Noise in Current Home to Similar Home

(N=70)

Changes in New Energy Efficient Equipment Performance

The set of questions pertaining to the performance of the ENERGY STAR® equipment was designed very much like those relating to noise. There were various statements regarding the energy equipment and respondents were asked to say whether they disagreed or agreed with them. The answers were again given values ranging from -3 to 3. The stacked bar Figure below displays the distribution of the responses. Also, as with the noise section, the Table separates statements into "good" and "bad" effects and shows the average rating for each. In this case, the "good" effects are statements such as:

- More features/better control in new home
- Longer lifetime
- Less maintenance

The statements categorized as "bad" are:

- Fewer features/worse ability to control
- More maintenance
- Shorter lifetime

The statement that residents most strongly agreed with were *more features/better control* in new home with 35% strongly agreeing and overall 83% of residents agreeing with the statement. Respondents most strongly disagreed with the statement that the new home's equipment had *fewer features/ worse ability to control* with 51% of the owner/occupants strongly disagreeing and 82% disagreeing at least somewhat. The overall average rating for all of the "good" effects was positive and for all of the "bad" effects was negative. These results show that the ENERGY STAR® equipment, in the opinion of the residents, performs better overall then the equipment in their old home, not only because of added features but also due to less maintenance and added lifetime.

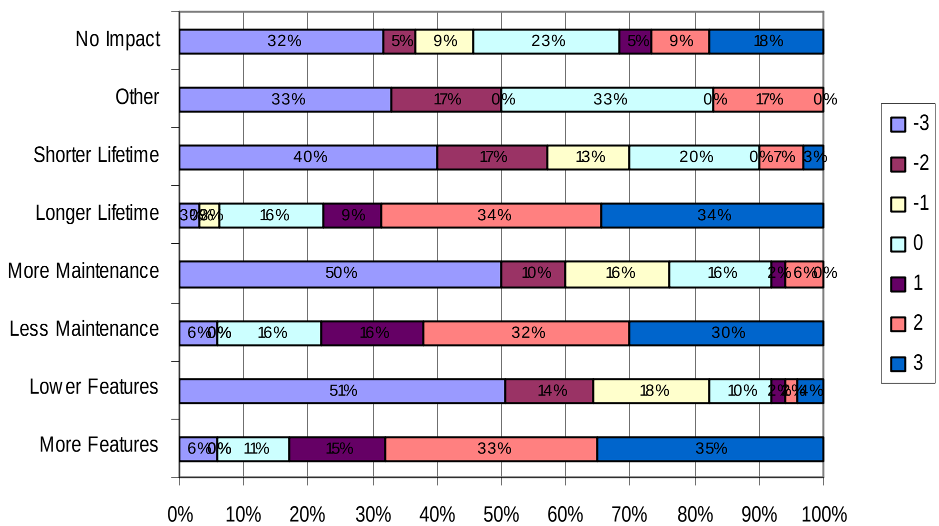

Figure 108: Summary of Changes in New Energy Efficient Equipment Performance

	Average
Fewer Features	-1.8
More Maintenance	-1.7
Shorter Lifetime	-1.4
More Features	1.7
Less Maintenance	1.5
Longer Lifetime	1.7
"Other"	-1
No Impact	-0.3
-3=Strongly Disagree…..3=Strongly Agree	

Table 124: "Good" and "Bad" Changes in New Energy Equipment Performance

(N=55)

Health-Related Changes from the ENERGY STAR® Home

This question was addressed in the summary of effects listed above. It was also followed up later in the survey to determine if the resident would attribute these health changes to the ENERGY STAR® features of the home. As mentioned earlier in this section (Table 6-5), none of the respondents felt that the new ENERGY STAR® home caused their health to be worse than their old home. The majority, 66%, responded that they *did not notice* a change between the old home and the new, while 34% felt that their health was at least *slightly better* in the new home.

The following Figure examines if the residents would attribute their health changes to the ENERGY STAR® and why they would do so. The reasons that occupants gave for these positive health changes were:

- Better air quality, less stress, better rest.
- It is not as cold in this house.
- Fewer allergens.
- Less yard work.
- No mold in the new house.

The reason that occupants gave that could negatively affect their health were:

- Tracy, (the new community) is an agricultural area and lots of dust finds its way into the house, more than in the old home.
- We live in a new area, there are more allergens.

When asked if they would attribute these health changes to ENERGY STAR® 46% said no and 39% said they didn't know. Only 16% responded that they would attribute the changes to ENERGY STAR® either fully or partly. The results are displayed in the following Figure.

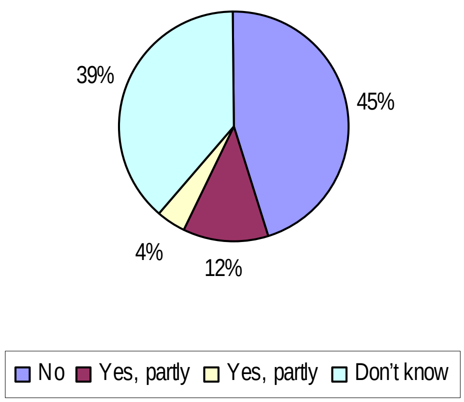

Figure 109: Health Changes Attributed to ENERGY STAR® Equipment

(N=57)

Comparison of Energy Costs in New and Old Home

Overall, 45% of residents responded that the energy costs in the new home were either *much lower* or *slightly lower* in the new home compared to the old. Only 10% of the respondents felt that the energy costs in the new home were *somewhat* or *much higher* in the new home compared to the old, 26% said they did not know. These results are displayed in the Figure below. The Table provides information on the average, minimum and maximum amounts that residents paid more or less for energy bills as well as the average monthly bill in the new home. There were only 4 responses that the new energy costs were higher and 25 that they were lower.

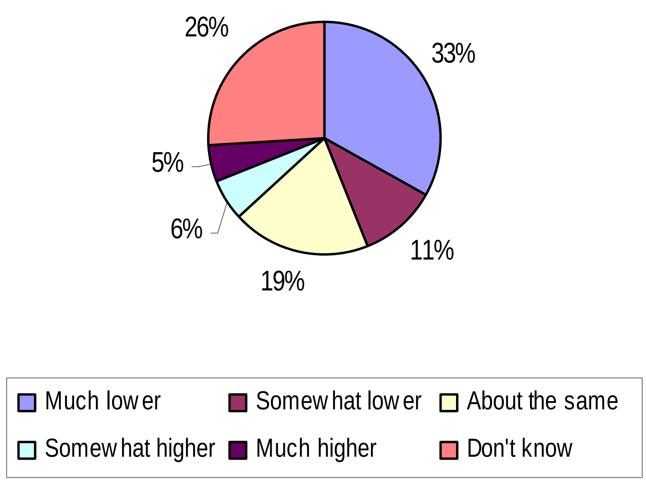

Figure 110: Summary of Energy Costs

(N=65)

	Average	Minimum	Maximum
How much more	$96	$30	$200
How much less	$97	$20	$250
Average monthly bill in new home	$141	$35	$500

Table 125: Average Energy Costs Per Month

(N=55)

Range of Energy Costs

Responses regarding increased or decreased energy costs were divided into 6 ranges of energy savings. For those residents who saw decreased energy costs the most common range of savings was $51-$100 per month with 45% falling within this range. For residents who saw increased energy costs, the most common response was that they *didn't know*, with 43% of the respondents responding this way. Some of the occupants found this question difficult to answer due to size differences in the new home versus the old home. The following response from a homeowner sums up this dilemma:

> *It is hard to compare the heating and cooling of the old home versus the new home because the new home is almost double the size; we are heating and*

cooling a much larger home. However, the new home seems pretty efficient in comparison to its size.

Amount Saved Per Month			Additional Amount Per Month	
$0-$50	14%		$0-$50	21%
$51-$100	29%		$51-$100	45%
$101-$150	0%		$101-$150	10%
$151-$200	14%		$151-$200	7%
$201-$250	0%		$201-$250	3%
More than $250	0%		More than $250	0%
Don't Know	43%		Don't Know	14%

Table 126: Responses regarding Energy Costs and Savings

Non-Energy Effects Used in Promotion of ENERGY STAR® Homes

Owner/occupants were asked to recall which non-energy benefits the builder or realtor utilized to promote the sale or rental of the property. They were then asked to note which of the non-energy benefits associated with the home were most important to *them*. The results of these questions are displayed side by side in the Figure below.

This set of questions revealed a striking result. Within 9 of the 11 categories there was little discrepancy noted between what effects the realtor or builder promoted and what effects were important to the residents. However, for two of the categories the differences were noticeable. For the effect, *ability to sell the home in the future*, only a third of residents reported that the realtor or builder promoted this benefit while nearly half of the residents said this was an important benefit to them. The largest disparity was observed for the benefit *doing good for the environment*. Only 23% of residents recalled the realtor or builder promoting this effect while nearly 70% said this is an important benefit to them. It was, in fact, the most important non-energy benefit to the residents.

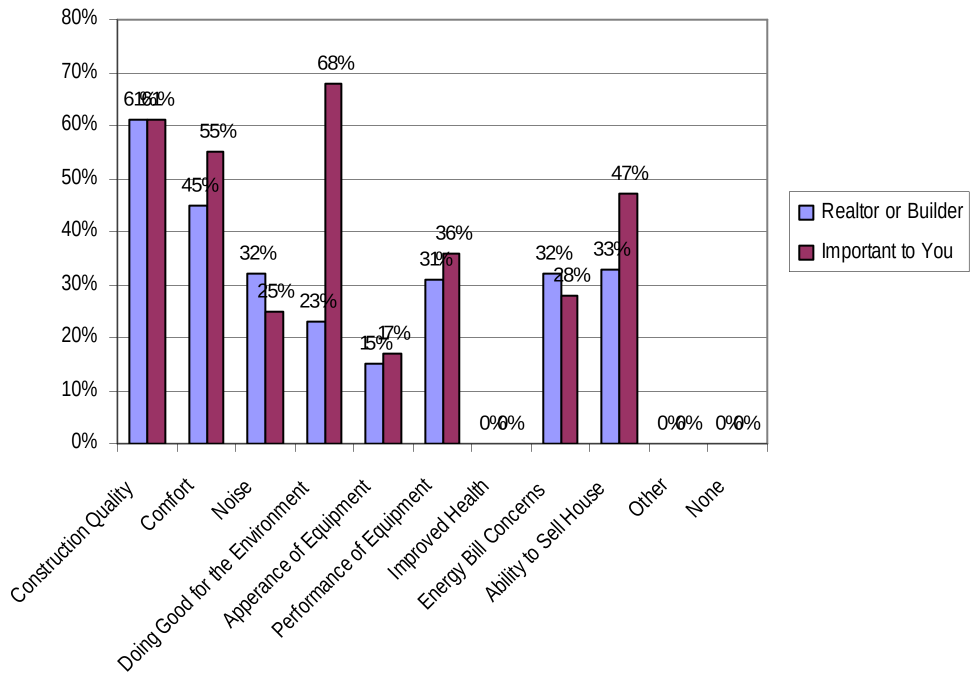

Figure 111: Summary of Promoted Non-Energy Benefits

(N=46)

Non-Participant Owner Occupant Responses

Value of a New Home

This section of the survey sought to determine the value of a new home to the non-participant owner/occupants of the home. The questions ranged from the factors influencing the purchase or rental of the property to the value of non-energy benefits (NEBs).

Home Purchase or Rental Factors

Survey respondents were asked to rate (on a scale of 1 to 7) the influence a number of factors had on their decision to purchase or lease their current home (the higher the rating, the larger the influence). Responses are presented both in terms of average and in terms of distributions of ratings.

In total, the highest rated influence factors were location (6.1 rating) and newly built home (6.0 rating). The lowest rated influence factors were small selection of available homes (3.0) and school district (3.4). The energy efficiency factor had an importance rating of 4.7, which was the sixth highest rating factor (out of 11 possible factors). Some of the "other" factors for purchase or rental noted by the residents were:

- My wife wanted a single story house.
- The design of the home. It had two stories

- The sprinkler system in the house were a factor
- My daughter lives near here.
- We need a place large enough for my mother-in-law to move in with us.

Average Influence Rankings	
Location	6.1
Newly Built Home	6.0
Other	5.9
Price of Home/Rent	5.8
Size of Home	5.7
Lot Size	4.9
Energy Efficiency of Home	4.7
Reputation of Builder	4.4
Investment Opportunity	4.3
School District	3.4
Small Selection Available	3.0
1=No influence……………..7=Large Influence	

Table 127: Summary of Purchasing (Rental) Factors –Average

(N=100)

	1	2	3	4	5	6	7	N/A
Newly Built Home	7%	1%	4%	2%	11%	8%	67%	1%
Size of Home	9%	2%	1%	3%	20%	17%	47%	2%
Investment Opportunity	24%	7%	10%	4%	14%	5%	34%	2%
Location	3%	1%	4%	5%	12%	16%	59%	1%
School District	48%	5%	3%	5%	9%	5%	25%	1%
Lot Size	10%	4%	11%	10%	22%	11%	32%	1%
Price of Home/Rent	3%	3%	4%	7%	17%	23%	43%	1%
Small Selection Available	50%	7%	3%	10%	9%	7%	14%	0%
Reputation of Builder	20%	7%	6%	13%	14%	9%	30%	1%
Energy Efficiency of Home	15%	3%	6%	10%	30%	11%	25%	0%
Other	0%	0%	1%	1%	3%	1%	6%	88%

Table 128: Summary of Purchasing (Rental) Factors -Distribution

(N=100)

One time dollar-value on energy-related features:

Residents were asked to place a one time, not annual, dollar value on the energy efficient measures in their home. In total, one-third of all survey respondents (34 percent) put a one-time dollar value of $500 or less on the energy-related features in their new home, when compared to their old home. An additional 16 percent of all survey respondents felt the energy-related features in their new home had a one-time dollar value of more than $5,000. Only 2 percent of respondents said the dollar value of their new home energy-related features was a negative cost (i.e., provided negative value) compared to their old home. Mid point values were assigned to the range responses to determine the average dollar amount the residents would place on the energy related features. For responses *greater than $5000* a value of $5,500 was assigned. The average value of the energy related features in the home for the non-participant owner/occupants is $2,054.

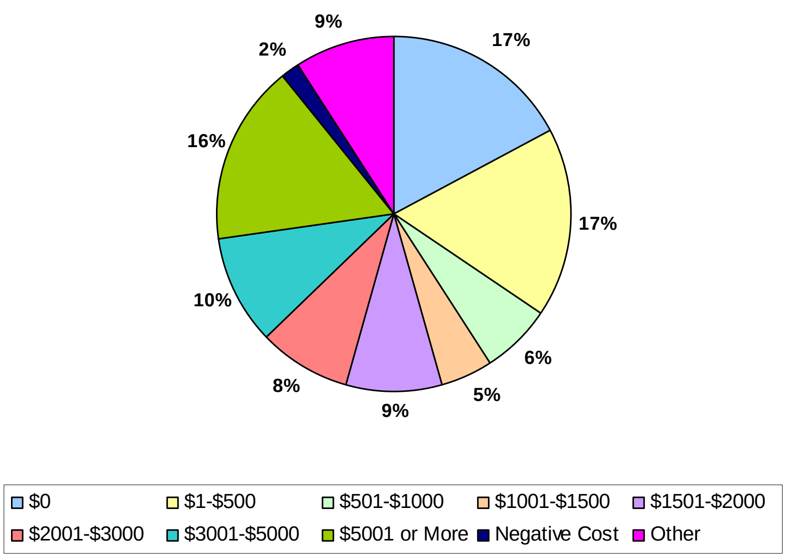

Figure 112: Summary of Energy-Related Features in New Home

(N=100)

Average Value of the Energy Related Features: $2,054

New Home vs. Old Home Energy Efficiency:

Overall, a significant majority of respondents (68 percent) felt their new home was either somewhat more or much more energy efficient than their previous home. An additional 20 percent felt their new and old homes had about the same energy efficiency. Only 10 percent of respondents indicated that their new home was either somewhat less or much less energy efficient than their old home. For those that responded that the new home was *more/less* energy efficient they were subsequently asked "why". Some of the reasons that the residents gave are displayed in the following table.

Reasons why less efficient	Reasons why more efficient
• Because it's a lot bigger (10 responses) • I think a lot of it has to so with the size of the home. I know the double pane windows cost us more, but I don't think they are any better at keeping out drafts. • There are two climate zones here versus one in the old home. • The old home had a swamp cooler • Because of the position of this house. I get an enormous amount of sun in the house and there are no tress or anything to keep the sun off the house. So even though the appliances are energy efficient , I use the electricity a lot more.	• Insulation (31 responses) • Windows (16 responses) • Energy efficient appliances (14 responses) • The water flow restriction helps us conserve water. • It does not face the sun. • We have really good energy efficient windows, and we have two heating systems that we can heat up one part of the house. We have a fireplace that is very efficient. • We have solar heating as well as two wood burning stoves and fans in every room. • My bills are much lower, the house is bigger but my bills are lower.

Table 129: Reasons Why Home is "More" or "Less" Efficient

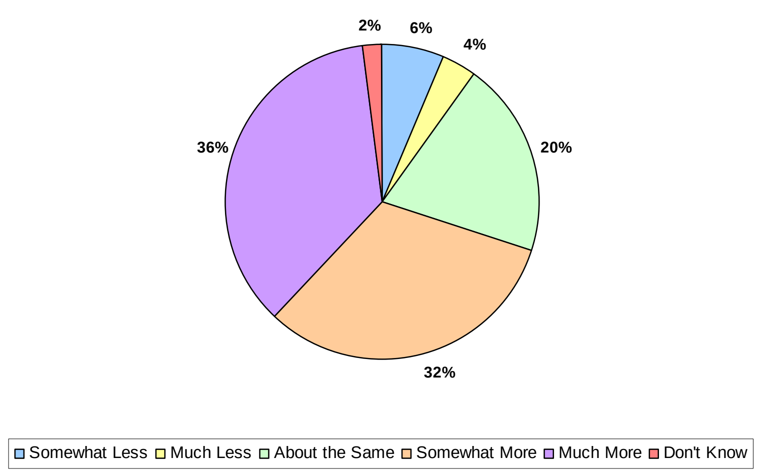

Figure 113: Summary of Energy Efficiency Between New and Old Homes

(N=100)

Value associated with non-energy effects:

An overwhelming majority of respondents felt non-energy effects provide a positive value. In total, 89 percent of survey respondents said non-energy effects were slightly, moderately, or very positive for their household. Only 5 percent of all survey respondents felt non-energy effects were of negative value (slightly negative – very negative) while 44% of the respondents said the value associated with the non-energy benefits is very positive.

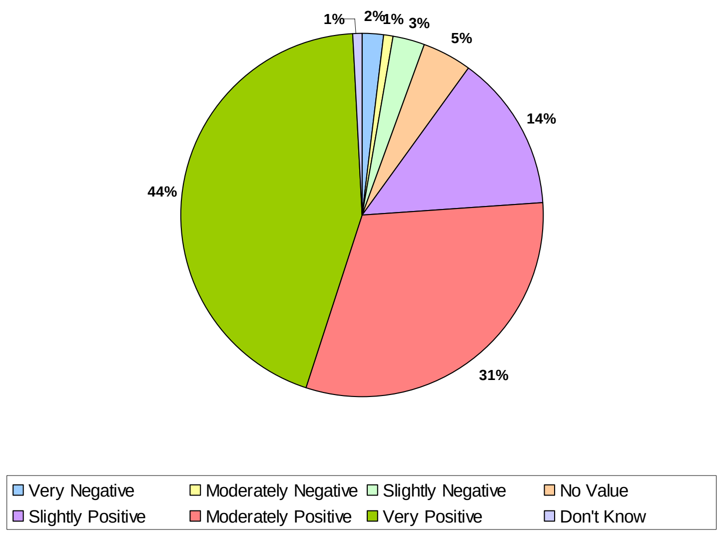

Figure 114: Summary of Non-Energy Effects

(N=100)

Non-energy effects on household value:

An overwhelming majority of respondents felt non-energy effects added to the value of their home for themselves and their families. In total, 88 percent of survey respondents said non-energy effects at least slightly added value to their household. Less than 5 percent of all survey respondents felt non-energy effects detracted from the value of their home. (Note that no respondents offered the category "detract slightly from value".)

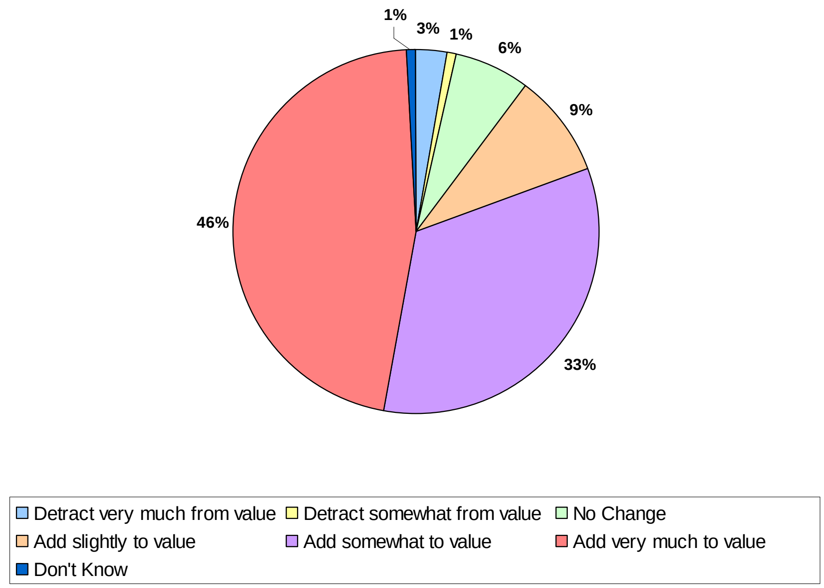

Figure 115: Summary of Non-Energy Effects on Household Value

(N=100)

Non-energy effects on resale value:

A majority of survey respondents felt that the non-energy effects would increase the resale value of their home. In total, 42 percent of respondents said the effects would somewhat increase the resale value and an additional 20 percent felt the effects would greatly increase the resale value. Almost one-third of respondents felt the non-energy effects would have no effect on the resale value. Only 3 percent felt that these effects would decrease the resale value of their homes.

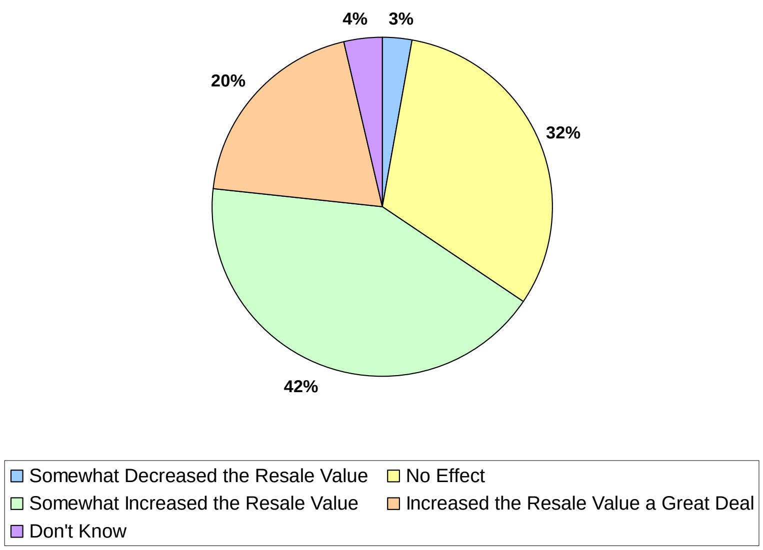

Figure 116: Summary of Non-Energy Effects on Resale Value

(N=100)

	% Positive	% Negative
Total Value of NEBs	89%	6%
Effect of NEBs on Household	88%	4%
Effect of NEBs on Resale Value	66%	3%

Table 130: Value of Total Non-Energy Benefits

(N=100)

Survey Respondents' description of desired energy efficient products:

Respondents were asked to describe any energy efficient products or features they desired, but were not offered or available, or that were interesting and offered but involved an extra cost. Some of the most common responses were:

- Solar panels(22 responses)
- Some type of change in the HVAC system, including more controls, more/less vents/ better furnace(10 responses)
- Insulation(3 responses)

Many of the respondents reported that they had received all of the energy efficient measures that they desired. A few of the other responses were:

- I can only think of a mechanism that pumps water through the floors and saves on heating
- When my refrigerator goes out I plan on getting the energy efficient ones, the same with my washer and dryer.
- The first thing that we were not offered was a tankless water heater, but that was not available. The other things not offered were the optional windows with the built in blinds in the windows which I really believe are a big energy saver.
- I was interested in atomic heating equipment. I do not have access to it or there was no availability of it, I just wanted to know more about it.

Motivation to Buy New Home

Payment for current home energy features:

Half of all survey respondents paid more for their current home because of its energy features, as opposed to their previous home. An additional 35 percent of respondents said they paid the same amount as their previous home for energy features. Only 5 percent indicated that they paid less for the energy features on their current home than on their previous home.

Of the 5% who reported that they had paid less for their home due to the energy efficient measures the amount paid ranged from $100 to $1,000 less. For the 50% of residents that paid more for their homes, 27 percent of respondents paid estimated that cost to be between $0 and $100 more. An additional 21 percent estimated the cost to be $101 - $500 for the added energy features. The average amount owners paid *less* for their homes due to the energy features was $345 and the average amount owners paid *more* for their homes was $701.25.

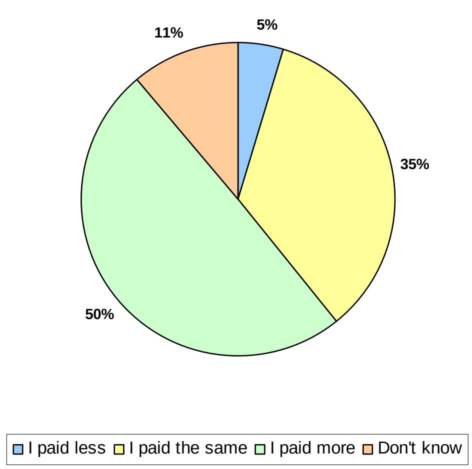

Figure 117: Summary of Energy Feature Costs

(N=100)

Amount Paid More for Home Due to Energy Features	
$0-$100	27%
$101-$500	21%
$501-$1000	12%
More than $1000	12%
Don't Know	29%

Table 131: Summary of Amount Paid for Energy Features (For Current Homes)

Feelings towards paying more for energy features:

Of the respondents who paid more for the energy features in their new home, an overwhelming majority (91 percent) felt it was worth paying more for these features. Only 8 percent felt it was not worth paying more for these energy features.

Whether it was "Worth It"	Percent
Yes	91%
No	8%
Don't Know	2%

Table 132: Summary of Perceptions Towards Paying More for Energy Features

Influence of Energy Equipment/Features on Home Selection

Over half of all respondents (55 percent) said that even if they had known about the non-energy effects that may result from the energy equipment/features in their new home, it would have made no difference in selecting their current home. Another 26 percent felt knowing about these non-energy effects would have made them more likely to select the home.

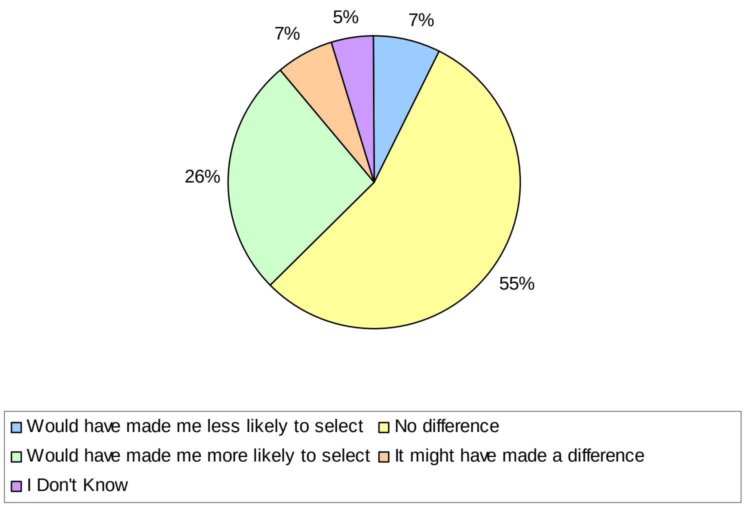

Figure 118: Influence of Energy Equipment/Features on Home Selection

(N=100)

Comparison of effects in new home vs. previous home

Nearly half (45 percent) of survey respondents either agreed or strongly agreed that they used more electricity in their new home (compared to their old home),and 38 percent believed that they used more natural gas. In both cases, more people cited greater use than less use, since about one-quarter of respondents noticed no change.

Also, when asked about a number of typical energy usage behaviors (e.g., laundry, showers, use of heater and air conditioner), no more than 27 percent or respondents agreed or strongly agreed that their use had gone up. Most reported the same usage or disagreed that usage had increased. (Due to the question wording, some who disagreed with the statement could actually be reporting no change.)

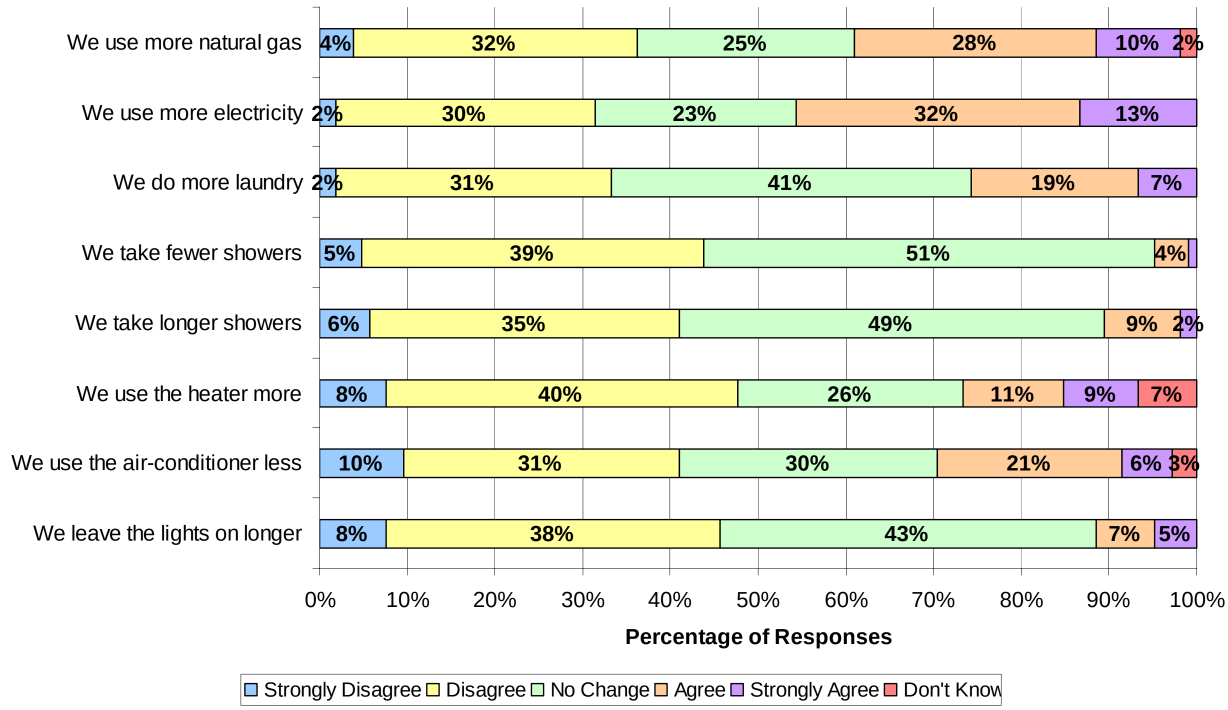

Figure 119: Summary of New Home vs. Previous Home Comparisons

(N=100)

Non-Energy Benefits

The next twelve questions in the survey asked the owner/occupants of the homes to compare the value of their current home to their previous one in a variety of non-energy categories. The range of answers for the questions was from *much worse* to *much better* or stayed the same. The following table displays the percent of respondents who reported either a positive or a negative change from the old residence to the new. If the resident reported either *somewhat better* or *much better* the answer is categorized as positive and vice versa.

The categories in which at least half of the owner/occupants reported their new home was better than the old home were:

- Comfort
- Construction quality
- Appearance of equipment
- Noise
- Performance of equipment
- Coolness in the summer

The category with the largest percent of residents reporting a positive change from the old home to the new was *comfort* with 72%. However, in four of the categories over 10% of the residents reported that the effect in the new home was worse than in the old. When it came to *concerns of paying bills*, a quarter of the residents said that the new home was *worse* than the old while only 19% of the residents reported that the new home was *better* than the old. The categories that had over 10% of the residents report that the new home was worse than the old were:

- Concerns of paying bills
- Coolness in the summer
- Construction quality
- Noise

The results of these questions are displayed in the Table below.

Feature	Negative	Positive
Construction Quality	11%	61%
Comfort	4%	72%
Warmth in Winter	7%	48%
Coolness in Summer	17%	55%
Noise	11%	57%
Impact on the Environment	7%	43%
Appearance of Equipment	1%	60%
Performance of Equipment	4%	55%
Family Illness or Doctor Visits	5%	19%
Concerns of Bill Payments	25%	19%
Ability to Sell or Rent	4%	43%

Table 133: Comparison of Non-Energy Effects

(N=100)

Impact of Noise Compared to Old Home

Residents were asked a set of questions specifically focusing on differences in the noise of their current and past residence. The questions gathered data regarding both the noise generated specifically from the energy related appliances such as dishwashers or laundry machines, as well as the difference in the noise being transmitted from outside of the house to the inside. The rating goes from -3 to 3, correlating to *disagree strongly* to *agree strongly*. In the analysis the factors are delineated as "good" and "bad". "Good" answers are those that one would agree with if the energy efficient measures are acting the way they were intended. For example; one would expect the equipment in the new house to perform more quietly than in the old, hence, this would be a "good" answer. The opposite is true for the "bad" answers. An example for this set of questions of a "bad" effect is: *noise from outside is louder in the new house*. With the "good" effects a positive response is desirable and with "bad" effects a negative response is desired. The "good" effects are bold and italicized in the following Table.

The Figure below shows the distribution of the responses to the different statements. The statement respondents most strongly agreed with was *noise from outside is quieter,* and the statement most strongly disagreed with was *energy equipment is noisier*.

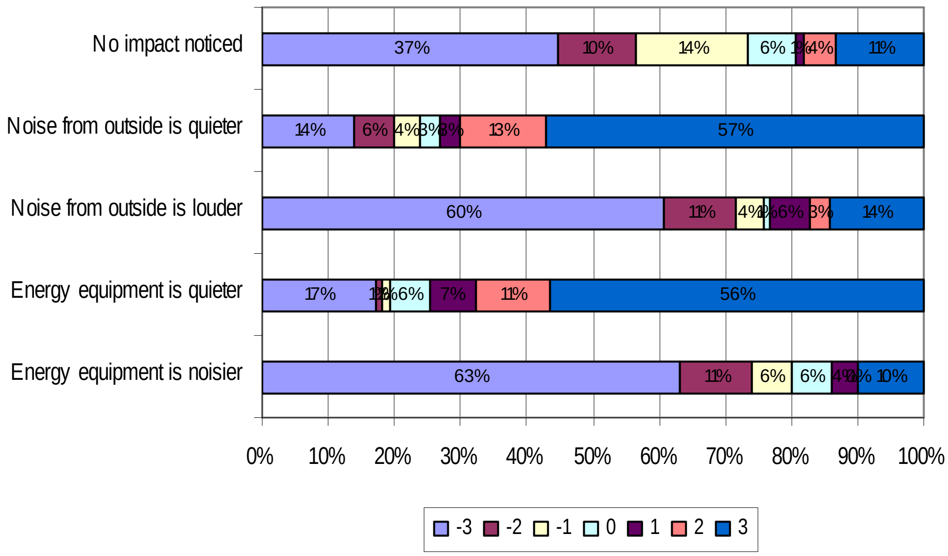

Figure 120: Comparison of Noise Related to Energy Efficient Equipment

(N=100)

Impact	Average
Energy equipment is noisier	-1.9
Noise from outside is louder	-1.6
Energy equipment is quieter	1.4
Noise from outside is quieter	1.5
No impact noticed	-1.2

Table 134: Effects of Noise, both "Good" and "Bad"

Changes in New Energy Efficient Equipment Performance

The set of questions pertaining to the performance of the energy related equipment was designed very much like those in the previous section dealing with noise. There were various statements regarding the energy equipment and respondents were asked to say whether they disagreed or agreed with them. The answers were again given values ranging from -3 to 3. The Figure below displays the distribution of the responses. Also, as with the noise section, the Table separates statements into "good" and "bad" effects and shows the average rating for each. In this case, the "good" effects are statements such as:

- More features/better control in new home
- Longer lifetime
- Less maintenance

The statements categorized as "bad" are:

- Fewer features/worse ability to control
- More maintenance
- Shorter lifetime

The statement that the residents most strongly agreed with was *more features/better controls* in the new home with 66% strongly agreeing with the statement and only 5% disagreeing. The statement most strongly disagreed with was *shorter lifetime* where 66% strongly disagreed with the statement and only 7% agreed. The overall average rating for all of the "good" effects was positive and for all of the "bad" effects the average ratings were negative.

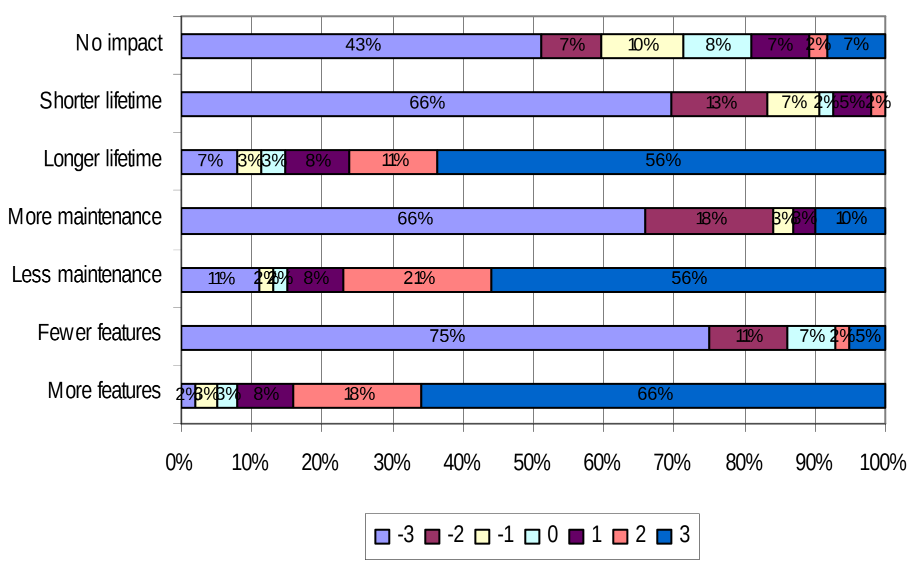

Figure 121: Comparison of Changes in Energy Equipment Performance

(N=100)

	Average Rating
Fewer Features	-2.3
More Maintenance	-2.0

Shorter Lifetime	-2.4
More Features	2.3
Less Maintenance	1.8
Longer Lifetime	2.0
No Impact	-1.5
-3=Strongly Disagree	+3-Strongly Agree

Table 135: Comparison of "Good" and "Bad" Changes in Energy Equipment

Health changes attributed to energy equipment/features

Over half of the survey respondents who experienced health changes in their current home did not attribute those changes to the energy equipment/features in their current home. Another 40 percent of respondents felt the energy equipment in their new home did help (either fully or partially) with their health changes. Respondents' explanations for why they attributed their health changes to energy equipment in their new home can be found in the appendices to this report.

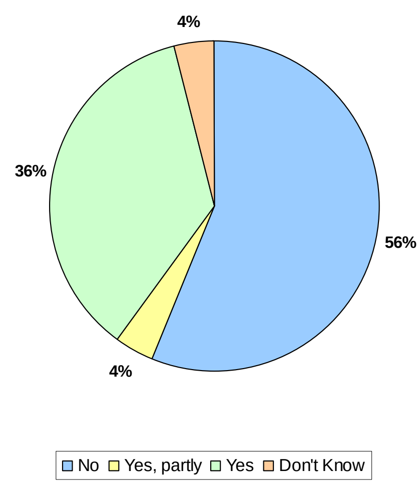

Figure 122: Summary of Energy Equipment's Role in Health Changes

(N=100)

Comparison of energy costs in new and old home

A total 43 percent of all respondents said their energy costs were either somewhat more or much more than they were in their previous home. Another 25 percent indicated their current energy costs were about the same as they were in their previous house. Thirty percent of respondents had either somewhat or much lower energy costs. Note that the new houses also tended to be larger than the previous houses, though, as reported earlier in the survey.

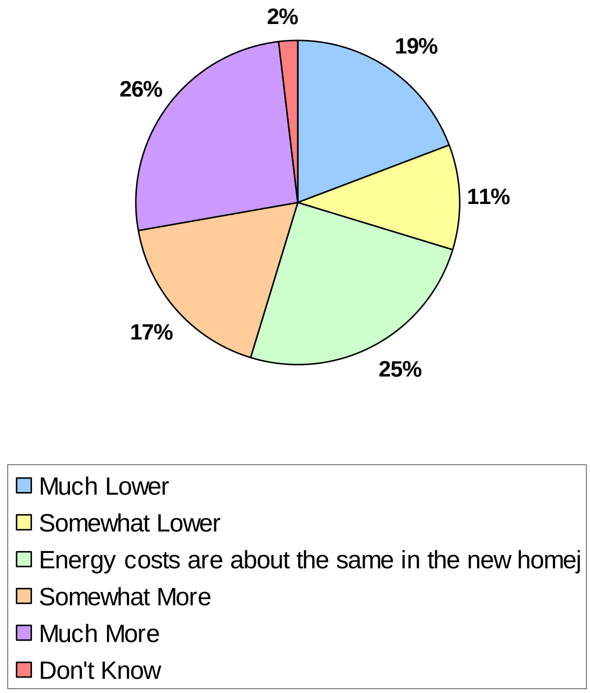

Figure 123: Comparison of Energy Costs for New Home Compared to Prior Home

(N=100)

Range of energy costs and savings

Among those with lower energy costs, 52 percent said they saved between $0 - $99 per month in their new home. In contrast, 53 percent of respondents who had higher energy costs in their new home said they spent an additional $100 - $200 in their new home. The average amount of money residents reported saving per month was $92 and the average amount more residents reported spending was $144.

	Amount Saved per Month	Additional Amount Spent per Month
$0-$99	52%	27%
$100-$200	35%	53%
More than $200	6%	11%
Don't Know	6%	9%
Average	**$92.00**	**$144.00**

Amount		

Table 136: Summary of Energy Costs and Savings

Comparison of energy costs in new and old home due to energy equipment

Respondents were split fairly evenly in the comparison of energy costs between their current and previous homes. Over one-third of all survey respondents felt that, due to new energy equipment and features, energy costs were the same in their new home as they were in the previous home. Also, 29 percent felt energy costs were either somewhat or much higher in their new home, while 30 percent felt costs were either somewhat or much lower in their new home. Estimated energy savings and expenses due to current energy equipment and features can be seen in the Table below. The average amount residents felt they were saving due to the energy equipment in the new home was $80.36 and the average cost of the energy equipment in the new home was $157.14.

	Extra Cost Saved per Month	**Added Cost Paid per Month**
$0-$99	56%	27%
$100-$200	25%	50%
More than $200	6%	17%
Don't Know	13%	7%
Average Amount	**$80.36**	**$157.14**

Table 137: Energy Costs Changes due to Energy Equipment

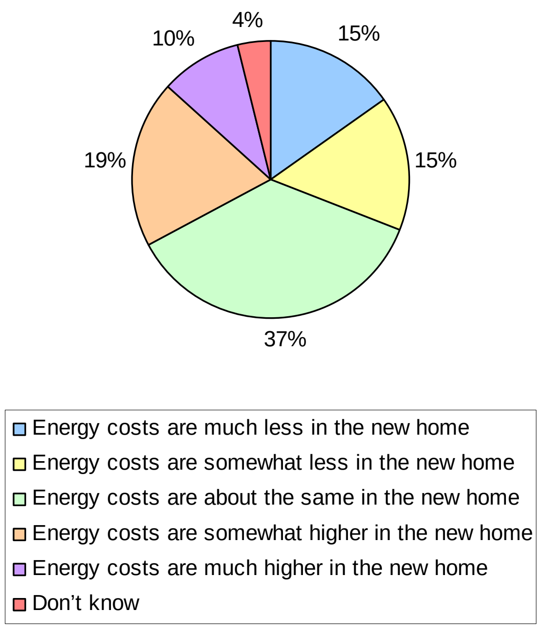

Figure 124: Summary of Energy Costs

(N=100)

Energy payments for current and previous home

Overall, respondents tend to pay more for their current energy bill than they did for their previous energy bill. In total, 28 percent of all respondents currently pay over $200 for their energy bill. In contrast, only 16 percent of respondents paid over $200 for their energy bill at their previous home. However, a slightly larger proportion also pay $50 or less in their new home compared to their previous home (9 percent versus 7 percent). The average energy payment in the new home is $190.42 and the average energy bill in the respondent's previous residence was $164.27.

Amount Paid Previous Home		Amount Paid New Home	
$0-$50	7%	$0-$50	9%
$51-$100	23%	$51-$100	17%
$101-$150	18%	$101-$150	17%
$151-$200	16%	$151-$200	12%
$201-$250	5%	$201-$250	11%

More than $250	11%
Don't Know	10%
Blank	10%

More than $250	17%
Don't Know	6%
Blank	10%

Table 138: Summary of New Home vs. Old Home Energy Payments

Promoted Non-Energy Effects

Owner/occupants were asked to recall which non-energy benefits the builder or realtor utilized to promote the sale or rental of the property. They were then asked to note which of the non-energy benefits associated with the home were most important to *them*. The results of these questions are displayed side by side in the Figure below.

The non-energy effect that was most important to the homeowners and the non-energy effect that was most promoted by the builders or realtors was the same, *construction quality*. Close to half of the owners remembered the realtor/builder promoting the *construction quality* of the home and 24% of the owners reported that that effect was important to them. None of the homeowners reported that *doing good for the environment* was important to them and only 1% reported that *energy bill payment concerns* were important to them when buying the house. The results of these questions are displayed in the Figure.

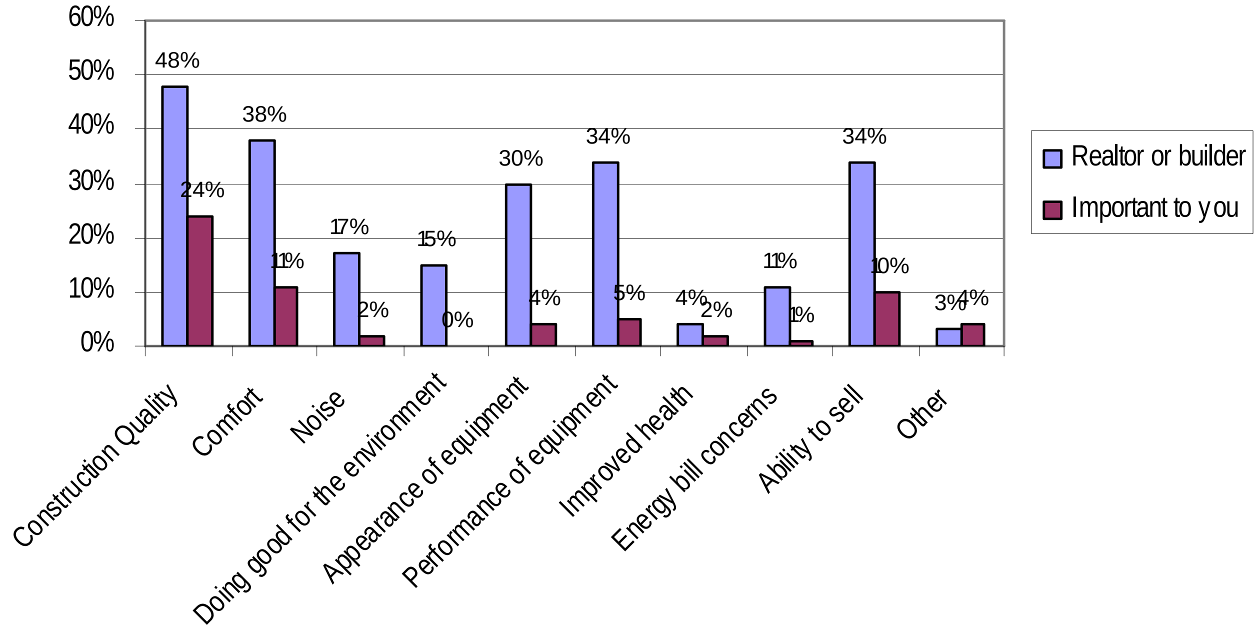

Figure 125: Summary of Promoted and Important Non-Energy Benefits

(N=100)

Computation of the Value of Non-Energy Effects from Builders and Occupants

Introduction

This chapter focuses on the computation of the values of the NEBs – in both dollar terms and terms relative to the energy savings provided by the program.

Importance of Indirect / Market Effects for Market Transformation Programs

The Single family component of the California Statewide ENERGY STAR® Homes Program incorporated a wide variety direct and indirect goals and outcomes. As a market-transformation-type program, indirect effects and hard-to-measure outcomes on the market and market actors are very important components of identifying "success" for the Program. In addition to success factors due to the number of ENERGY STAR® Homes and equipment, there were also a number that were related to non-energy benefits. These factors are described in the following sections.

Background on Non-Energy Benefits

While the focus of traditional program evaluations – energy savings, awareness, market share and other metrics – provide direct indicators of program effects, a significant body of work has developed around recognizing and measuring net non-energy benefits

(NEBs). NEBs include a variety of program impacts — positive and negative — that result from the program.[98] Strictly speaking, NEBs are "omitted program effects" – impacts attributable to the program, but often ignored in program evaluation work. After nearly a decade of research, more and more utilities and regulators are considering these effects.

In order to assess the NEBs associated with the California Statewide ENERGY STAR® Multi Family program, Skumatz Economic Research Associates (SERA) developed a questionnaire directed at identifying NEBs accruing to Program participants and perceptions about NEBs from non-participants. The sampling source was discussed earlier. The respondents included 16 participating builders and six non-participating builders for a total of 22 respondents. The small sample size affects the confidence to be placed in the results, but indicative information can be derived.

While the primary purpose of most energy efficiency programs is to save energy or reduce peak demand, these programs, by their nature, lead to a host of effects beyond these outcomes. These other effects are commonly called Non-Energy Benefits (NEBs) – even though not all the effects are positive.[99] There are three main types of net non-energy benefits based on who is the beneficiary:[100]

- **Utility/agency benefits.** These are positive or negative impacts that affect ratepayers and utilities and reduce revenue requirements – for example lower bad debt because of lower arrearages, lower line losses, power quality issues, and reduced labor cost from fewer bill-collection-related calls. These effects are generally valued at utility (marginal) costs.

- **Participant (or "user") benefits.** These consist of non-energy factors that benefit or affect the participant users of the energy efficient equipment beyond energy savings – for example, comfort, improved ability to pay bills, and a wide variety of factors included in the tables below. These effects are valued in terms relevant to the participant.

- **Societal benefits.** Non-energy impacts that (positively or negatively) affect the greater society or that can't be attributed directly to utility/ratepayers or participants. These include emissions/environmental benefits/health benefits, direct and indirect economic Multipliers, water system benefits (if they need fewer treatment plants, etc.), or similar items. These effects are valued as appropriate to the benefit category.

[98] Note that the literature has used the designation "non-energy benefits" although we examine both positive and negative impacts from energy efficiency measures. Although the conventional term NEB is used in this project, the name refers to "net" non-energy benefits.

[99] We most commonly call them "net non-energy benefits" to account for the negative benefits as well. We have also called them non-energy impacts, non-energy effects, non-utility benefits, and others, but the commonly accepted term in the literature is NEBs, so we use that convention.

[100] The literature has adopted the convention of categorizing NEBs into three groups based on beneficiary; this is developed from Skumatz, Lisa A., "Recognizing All Program Benefits: Estimating the Non-Energy Benefits of PG&E's Venture Partners Pilot Program (VPP)", 1997 Energy Evaluation Conference, Chicago, IEPEC, August 1997.

Typical categories of benefits based on a decade of past work follow in the Table below. This list is not comprehensive, and obviously some benefits can cross categories.[101] Whether specific benefits are included or excluded from the analysis tends to depend on which measures are included in the program, and the use intended for the NEB analysis. The list of benefits to be included in the program attribution analysis is usually refined in collaboration with the program staff.

NEB Categories	
Utility Benefits	
• Reduced carrying cost on arrearages (interest) • Bad debt written off • Shutoffs • Reconnects • Notices • Customer calls / bill or emergency-related • Other bill collection costs	• Emergency gas service calls (for gas flex connector and other programs) • Insurance savings • Transmission and distribution savings (usually distribution only) • Fewer substations, etc. • Power quality / reliability • Reduced subsidy payments (low income) • Other
Societal Benefits	
• Economic benefits – direct and indirect Multipliers • Emissions / environmental (trading values and/or health / hazard benefits) • Health and safety equipment • Water and waste water treatment or supply plants • Other	
Single family Participant Benefits[102]	
• Water / wastewater bill savings • Operating costs (non-energy)[103] • Equipment maintenance • Equipment performance (push air better, etc.) • Equipment lifetime • Tenant satisfaction / fewer tenant complaints • Comfort • Aesthetics / appearance • Lighting / quality of light • Noise • Safety, insurance	• Health issues • Ease of selling / leasing • Labor requirements (separate from equipment O&M) • Indoor air quality • Doing good for environment • Reliability of service / power quality • Savings in other fuels or services (as relevant) • Feeling of greater control over bill / understanding of energy use (residents if relevant) • NEGATIVES (usually incorporated into above) some may have worse maintenance, parts may be harder to get, greater training needs for maintenance staff, etc.

Table 139: Net Non-Energy Benefits (NEBs) Categories included in "NEB-It"© Model[104]

[101] We tend not to include tertiary type benefits like tax –related impacts, as we prefer to be more conservative.

[102] Positive and negative impacts, estimated using participant surveys for many of the NEBs.

[103] Sometimes omit if likely to double count with the next two categories

104 Skumatz, Lisa A., Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Single family Programs: Enhanced Techniques", EEDAL Conference Proceedings, London, England, 2006.

Note that several benefits arise in multiple categories. For example, having fewer bill-related calls to the utility benefits both the utility / ratepayers AND the households making or receiving those calls. This is not double-counting benefits – rather, it recognizes that some effects have multiple beneficiaries and each is valued at the appropriate tailored valuation method. For example, this saved time from calls may be valued at the marginal labor cost for customer service staff for the utility's benefit, and at the minimum wage rate for low income households. Benefits are recognized and realized by both groups; whether they are included in specific computations depends on their appropriateness to the application.

Estimation of the various categories of NEBs can be conducted using several key steps:

- Attribution of utility and societal NEBs can be measured using a combination of primary and secondary data. There is an extensive literature measuring the arrearage impacts of programs (particularly low income programs), as well as many others of these impacts. Detailed examination of the program impacts – or the literature– may be needed to estimate the impacts on reconnections and other factors that may be affected by the program.[105]

- Societal impacts also have a significant literature and indeed, the two key components, environmental and economic impacts – have a very high degree of volatility depending on the data sources and valuation methods used. Impacts on greenhouse gases (GHG) are increasing in importance and have been estimated in the literature.[106] There also exists a growing literature estimating the *net* economic impacts from energy efficiency programs, assuming a transfer of expenditures from electricity generation to economic sectors affected by the weatherization or other program.[107]
- Estimation of participant benefits rely mostly on responses to surveys, combined with a limited amount of programmatic and secondary data.

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105 See for example, Hall, Skumatz, and Megdal, "Low Income Public Purpose Test: Non-Energy Benefits for Low Income Weatherization Programs", prepared for PG&E, 2000 for an extensive discussion of these estimation methods.

106 These impacts are a "slippery slope" – they can be estimated in a simplistic way, or if health impacts are to be measured in detail, then issues related to specific microclimates and time of day and zones are important. For some programs, average generation mix should be used to assess emissions; for others (e.g. a peak load reduction program, residential air conditioning programs, etc.) emissions from marginal peak load plants should be used to estimate changes in emissions from the energy savings. Valuations are the source of considerable debate in the literature as wellFor some clients, there are values that have been agreed upon by the regulators. For others, we used specific values included in the literature, or averages of valuations from many sources. Which valuations are most appropriate depends on not only the location, but also the use to which the work will be applied.

107 Some of the literature is flawed in that they estimate the job creation and economic Multipliers of a gross expenditure toward conservation on the economy when instead they should be measuring the net impact of a transfer of funds. For an extensive discussion of the environmental and economic impacts, see Gardner and Skumatz, "Do Economic NEB Multipliers Vary with Program Design and State?", forthcoming, proceedings for the ACEEE Summer Study, Asilomar, CA, 2006, and Imbierowicz and Skumatz, " The Most Volatile Non-Energy Benefits (NEBs) – New Research Results "Homing In" On Environmental And Economic Impacts", American Council for an Energy Efficient Economy Summer Study, held in Asilomar, CA, ACEEE, Washington, DC, August 2004.

Estimating Participant NEBs

The most challenging portion of non-energy benefits work is assessing the participant portion of the benefits. SERA has spent considerable time on this issue, and has pioneered, tested, and compared several credible methods of estimating these "hard to measure" (HTM) impacts based on the results of NEB analyses for several thousand program participants over 10 years. The research includes an evaluation of measurement options with respect to: ease of response by respondent / comprehension of the question by respondents; reliability of the results / volatility; conservative / consistent results; and computation clarity, among other criteria. Some common measurement approaches that have been applied to NEBs include: [108]

- **Contingent valuation (CV) including Willingness to pay (WTP) / willingness to accept (WTA):** The contingent valuation approach to measuring NEBs involves some manner of asking program participants to place a dollar value on the benefits that they experienced. Contingent valuation is one of the standard methods of measuring the value of environmental damage in litigation and has long been debated in the environmental economics literature. There are two basic variations of the contingent valuation method. The first, Willingness to Pay (WTP), asks participants to estimate how much (usually in dollars annually) they would be willing to pay for the NEBs that they claim to have experienced. As the name implies, Willingness to Accept (WTA) asks them to estimate how much they would accept in compensation if they were divested of those same benefits. Empirically, WTP and WTA values tend to fall near one another, although there is considerable theory and evidence that WTA values average higher than their counterparts.[109] All types of contingent valuation approaches to measuring NEBs are subject to some degree of bias. Economists believe that WTP and WTA questions may either (a) lead respondents to believe that they have entered a bargaining situation in which they have an incentive to misrepresent the true value of the good in question or (b) appear so hypothetical that respondents do not seriously consider the true value to them of the benefit that is under consideration, leading to highly variable replies.

- **Direct computations of value to owner:** Direct computations of value have the advantage of accuracy; however, they are rarely computed (especially in the case of residential programs). Therefore, two significant problems arise from this approach: missing data and bias. Few participants perform direct computations of benefits, leading to significant missing data. Also, those computing the effects are unlikely to represent a random sample of beneficiaries, but would more likely

[108] The descriptions in this section are derived from Skumatz and Gardner, "Differences in the Valuation of Non-Energy Benefits According to Measurement Methodology: Causes and Consequences", Proceedings of the AESP Conference, San Diego, 2006, and Skumatz, Lisa A., "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value", Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings held in Asilomar, CA, ACEEE, Washington, DC, August 2004. Other revealed and stated preference, statistical methods, and other approaches have also been used.

[109] Horowitz, John and K.E. McConnell. 2004. "Willingness to Accept, Willingness to Pay and the Income Effect." October, 2004.

include those with high benefits; hence, generating a biased set of data. Direct estimation of benefits using statistical approaches can also be computed. However, data are likely available for only a subset of benefits[110] categories or from a small sample of participants.

- **Discrete choices or ordered logit**: Discrete choice or ordered logit approaches have proven to be robust methods for estimating NEBs.[111] Unfortunately, they are relatively difficult to administer via telephone and are a better fit for mail, web, email or similar applications.[112] Discrete choice and ordered approaches can also be more difficult for residential participants to answer.

- **Comparative, scaling, or relative valuations:** Scaling techniques for measuring NEBs are straightforward and involve asking program participants to express the value of the NEBs that they experience relative to a numeraire with which they are familiar. Our approach uses energy savings as the comparison. Direct scaling asks participants to express the benefits that they experience as a percentage of their energy savings. This approach is advantageous in that it easily produces participant-level energy savings Multipliers that should, at least in theory, more accurately reflect the value of the NEBs that each participant received. It also produces answers to a higher degree of standardization. Although energy savings may differ among participants, there can be no disagreement regarding what is meant when a respondent reports that they experienced non-energy benefits on the order of ten percent of their energy savings. Direct scaling does, however, present some drawbacks. Though having benefits expressed as a percentage of energy savings is desirable for many reasons, survey respondents may find it difficult to estimate that percentage at all, let alone with any reassuring degree of accuracy. Very often respondents (especially residential respondents) are not terribly comfortable with percentages. The issue of accuracy may be dealt with statistically by assuming a normal distribution error in respondent replies.[113] The issue of missing data, however, can seriously disrupt program analysis – it is extremely important to present participants with survey questions that they can actually answer.

  Relative scaling attempts to resolve that problem. Relative scaling questions once again ask respondents to value the non-energy benefits that they experience relative to their energy savings. Rather than asking about percentages, they ask

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[110] For example, see Lisa Heschong's (Heschong Mahone Group) work on daylighting in a retail chain and in schools in Proceedings of the ACEEE Summer Study on Buildings, Asilomar, CA, 2004 and 2004.

[111] See Gardner and Skumatz, "NEBs in the Commercial and Industrial Sector", forthcoming, Proceedings from the ACEEE Summer Study on Buildings, Asilomar, CA 2006.

[112] Web approaches have been demonstrated starting in 2004 in work in New Zealand. See write-up in Stoecklein and Skumatz, "Using NEBs to Market Zero and Low Energy Homes in New Zealand", Proceedings of the ACEEE Summer Study, Asilomar, CA, 2004.

[113] Monte Carlo simulations or statistically-appropriate hot deck imputations can help address this issue of missing data. See, for example, Holt, Barnes, Skumatz, "Non-Response in Energy Surveys: Systematic Patterns and Implications for End-Use Models", The Energy Journal, 1988.

them to express the benefits qualitatively relative to their energy savings using verbal options (much more valuable, etc.). This approach presents an easier-to-answer question (and thus, generally includes less missing data), but is less directly translated into a dollar value. Regardless of the specific type of scaling question used, the technique is very successful in producing meaningful and interpretable responses. Empirical research indicates scaled NEBs values are, in general, much more stable than those obtained through the techniques primary competitor: contingent valuation.[114]

Selected Measurement Approach

These measurement methods can be complex to implement, and a great deal of work has been conducted to refine the techniques. Based on research over 10 years on more than 50 programs, we have found that generally, comparative or relative valuations[115] perform substantially better than other methods. Willingness to pay (WTP) can often provide very volatile numbers and respondents have an extremely difficult time understanding the concept of stating a dollar amount they would be willing to pay for these benefits. We have incorporated Multiple measurement methods into the same studies, and have found that on average, WTP is volatile (and less conservative), and that scaling, discrete choice, and other measurement methods we have adapted perform more reliably; our research incorporates these approaches.[116]

The key estimation approaches employed in this study were the relative and direct scaling approaches. WTP / WTA questions were also asked but almost no responses were obtained.

Valuing the NEBs

A key objective of the NEB portion of the evaluation was to "value" previously unvalued or undervalued benefits to participation in the program. Extensive field experience and a wide body of literature suggest that, for programs such as the California Statewide ENERGY STAR® Single family program, the value of the NEBs experienced by participants can be as much as, or more than, the energy savings that occur due to program effects.[117]

[114] For additional corroboration, see Skumatz, 2004, *op. cit.*

[115] Methods pioneered and adapted by the authors, based on the academic literature; see descriptions in Skumatz, Lisa A., "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value", Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings held in Asilomar, CA, ACEEE, Washington, DC, August 2004.

[116] For an analysis of comparative, willingness to pay, and labeled magnitude scaling methods, see Skumatz, Lisa A., Ph.D., "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value", Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, held in Asilomar, CA, American Council for an Energy Efficient Economy, Washington, DC, August 2004.

[117] Bicknell and Skumatz, "Non-Energy Benefits (NEBs) in the Commercial Sector: Results from Hundreds of Buildings", Proceedings from the ACEEE Summer Study, Asilomar, CA, 2004 and sources mentioned therein.

NEBs Valuation Methodology

To estimate the value to participants of the home energy-efficiency improvements implemented through the program, we employed the relative comparison value method of NEBs valuation.

We asked participant and non-participant builders and owners about NEBs in terms of their relative value on a verbal scale. These responses were translated into numeric values. Respondents were asked about the value of the benefits relative to energy savings using a five-point scale (much less valuable, somewhat less valuable, same value, somewhat more valuable, and much more valuable). The relative values were then scaled to percentage-of-energy-savings values obtained from other empirical research, SERA research, and academic scaling literature. Because these questions are more quickly answered than percentage responses - and because time on the surveys was limited - this was the approach used for valuing individual NEB categories as well as the overall totals.

One potential problem associated with each approach is the issue of "adding up." Generally, when asked the value of individual benefits, the total is greater than the figure that respondents provide when answering a question about the total of all the benefits. That is, the sum of the parts is greater than their estimated totals. The issue is addressed by normalizing the individual benefits - reducing their values proportionally to add to the estimated total benefits as valued by the respondents. Both individual and total benefits were asked in association with estimating the NEBs for the Program to allow for this normalization.

A final methodological issue relates to the issue of "net" non-energy benefits.[118] The appropriate approach for attributing NEBs to the program is to provide estimates that are "net" in three ways.[119]

- **Net Positive and Negative**: First, despite the historical name for these impacts (non-energy benefits), both positive and negative impacts must be incorporated.[120] Both positive and negative impacts are explicitly requested - for each individual NEB and for the total of all NEBs - there is no presumption of a positive effect. The results are the combination of positive and negative valuations.

- **Net above New Standard Equipment**: Second, to attribute the impact due to the program, the respondents need to be asked about the NEBs for the new efficient equipment relative to the base non-efficient equipment that would otherwise have been purchased. The appropriate comparison is generally not the new efficient equipment but the standard efficiency equipment that would otherwise have been installed.[121] The respondents are asked to specify the net

[118] These nuances are important components of the proper evaluation approach and have been incorporated into this NEB research.

[119] Skumatz, Lisa A., "Methods and Results for Measuring Non-Energy Benefits in the Commercial and Industrial Sectors", Proceedings of the ACEEE Industrial Conference, West Point, NY, July 2005.

[120] The term we use is "net non-energy benefits" (NNEBs) but we will refer to them as "NEBs" in this paper. Over a 10 year period, we have developed effective (proprietary) methods of asking these questions and valuing the responses. In addition, a model "NEB-It"© is used to compute values.

[121] However, some caveats are needed, depending on how the work is to be used. It may be that in the case

non-energy benefits from the energy efficient equipment installed through the program - above and beyond the effects they would have realized from installation of a standard efficiency model. While it is true that this may be somewhat difficult for respondents to answer, it is the appropriate comparison for the program to make. It is important to note, however, that it is also a conservative approach.

- **Net of Free Ridership / NTG Considerations**: A third adjustment is also appropriate. If there are free riders that would have purchased the same equipment without the program, then the NEBs associated with that equipment should not be attributed to the program. Only those benefits from installations that would not have happened without the program's influence should be attributed to the program, so the NEBs associated with free riders should be omitted, and net to gross ratios could appropriately be applied.

To account for this last effect, we use the free ridership and net to gross factors computed earlier in this report in order to provide a fully attributable estimate of the program's net NEB effects.

In this study, care was taken to assure that the non-energy benefits that were attributed to the program were not intentionally overstated or biased.

Overview of NEBs Impacts

Three elements of valuation of the NEBs are explored, including:

- Percent reporting positive vs. negative effects in NEBs, by category,
- Share of the value represented by each NEB category, and
- Total value of the NEBs.

Results from each analysis are discussed below, as well as implications of the results. We combine the results from the builders (participants and non-participants) and the owner/occupants (participants and non-participants) in the tables because it provides an opportunity to examine whether there appear to be differences in perceptions between actor types and between participants and non-participants and actor types.

Percent Reporting Positive and Negative NEBs

All respondents were asked whether they associated negative, positive, or no non-energy impacts with the ENERGY STAR® equipment and measures. The directions (negative, no or positive impact) of the non-energy effects reported by program participants and non-participants and actor types are presented in the Table below. Participants were asked whether they experienced any differential effects from using high-efficiency equipment instead of standard equipment; responses from non-participants were based on their

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of residents that would not have purchased new equipment at all without the program, a case may be made that for participant NNEBs, they recognize all the change from old equipment to the new efficient equipment. Also, if the measures would not have been installed for a period of time, the full NNEBs may be appropriately credited (as should the savings) during the interim. However, these are fine points on the principles discussed above.

perceptions of differences between ENERGY STAR® energy efficient compared to standard new equipment.

	Builder Participant			Builder Non-Participant			Occupant Participant			Occupant Non-Participant		
Category	**Neg**	**None**	**Pos**	**Neg**	**None**	**Pos**	**Neg**	**None**	**Pos**	**Neg**	**None**	**Pos**
Non-energy Operating cost	8%	25%	67%	40%	0%	60%	n/a	n/a	n/a	n/a	n/a	n/a
Construction quality	n/a	n/a	n/a	n/a	n/a	n/a	0%	2%	98%	7%	29%	64%
Equip maintenance	0%	64%	36%	20%	60%	20%	note[122]	n/a	n/a	note[123]	n/a	n/a
Equip Performance	0%	55%	45%	0%	100%	0%	0%	2%	98%	2%	40%	58%
Equip Lifetime	0%	55%	45%	0%	100%	0%	Note	n/a	n/a	Note	n/a	n/a
Occupant satisfaction	0%	27%	73%	0%	40%	60%	n/a	n/a	n/a	n/a	n/a	n/a
Occupant Comfort	0%	27%	73%	0%	40%	60%	0%	0%	100%	2%	25%	73%
Illnesses	n/a	n/a	n/a	n/a	n/a	n/a	0%	14%	86%	3%	21%	76%
Aesthetics / Appearance	9%	82%	9%	0%	20%	80%	0%	13%	87%	1%	44%	55%
Lighting / Quality of Light	30%	40%	30%	0%	60%	40%	n/a	n/a	n/a	4%	35%	61%
Noise	0%	27%	73%	0%	100%	0%	0%	2%	98%	3%	35%	62%
Energy bill payment concern	n/a	n/a	n/a	n/a	n/a	n/a	0%	4%	96%	0%	27%	74%
Building Safety	0%	100%	0%	0%	100%	0%	n/a	n/a	n/a	n/a	n/a	n/a
Ease of leasing/selling	0%	57%	43%	0%	40%	60%	0%	4%	96%	5%	32%	63%
Doing good for	0%	30%	70%	0%	25%	75%	0%	6%	94%	9%	39%	53

[122] For owners, equipment lifetime and maintenance were included in equipment performance to shorten the list for a mail / clipboard survey.

[123] For owners, equipment lifetime and maintenance were included in equipment performance to shorten the list for a mail / clipboard survey.

Category	Builder Participant			Builder Non-Participant			Occupant Participant			Occupant Non-Participant		
	Neg	None	Pos	Neg	None	Pos	Neg	None	Pos	Neg	None	Pos
environment												%
Power quality / reliability	0%	78%	22%	0%	100%	0%	n/a	n/a	n/a	n/a	n/a	n/a
Other[124]	n/a	n/a	n/a	n/a	n/a	n/a	0%	0%	100%	n/a	n/a	n/a

Table 140: Direction of NEBs Impacts

Positive and Negative Effects:

The most commonly positive NEBs for participating builders included improvements in: comfort, noise, satisfaction, and "doing good for the environment". For non-participant builders, the most commonly positive responses were for aesthetics / appearance, and "doing good for the environment", comfort, satisfaction, ease of selling/leasing, as well as non-energy operating costs.

Owners were most positive about improvements in construction quality, performance of the equipment, comfort, noise, bill payment concerns, ease of selling / leasing, and "doing good for the environment". Non-participants had the most positive perceptions about comfort, illnesses, construction quality, and the ease of selling or leasing the property. Few reported experiencing any effects, positive or negative, in building safety, aesthetics or power quality.

Builders had two main areas of negative concern – lighting and quality of light (for participants) and maintenance (for non-participants). Participants did not note maintenance as a major concern, indicating that possibly program education, the models supported by ENERGY STAR®, or experience have led them to omit maintenance as an ongoing concern with the measures in the program.

Owners and occupants noted few significant negative NEBs. There were none for participants; non-participants had skepticism about "doing good for the environment" and the construction quality. For each of these categories, however, a greater percentage of respondents reported experiencing positive effects than did negative effects.

Relative Values of the NEBs by Category

The table below shows the proportion of the total NEBs reported by program participants attributable to the various NEB effects categories. After the respondents were asked – category by category – whether they associated negative, positive, or no non-energy effects with the energy efficient ENERGY STAR® equipment, those reporting non-zero impacts were asked a follow-up question. If their response was positive, they were asked

[124] Respondents noted cleaner air / less dusty home, among other items.

whether the NEB was more or less valuable than the incremental energy savings associated with the ENERGY STAR® equipment, and how much more or less valuable, using a relative scale (much more, much less valuable, etc.). If their response was negative, they were followed up with requests for information about whether the NEBs were more (or less) costly than the energy savings, and how much more or less costly. The relative answers are then translated into average percentages or ratios using SERA's empirical research on more than 50 programs, and the results are incorporated into SERA's "***NEB-It***"© model. The percentage of total value associated with each NEB category is presented in the Table.

The results show that the total NEBs value is distributed fairly evenly across categories, with no one category garnering an especially high or low share. Operating costs and owner satisfaction were somewhat more highly rated or valued by participating builders; owners found greatest value from improvements in comfort, with all categories well-received. The least valuable categories were building safety and power quality, each of which accounted for relatively low shares of the total NEBs.

Category	Builders Participants	Builders Non-Participants	Occupants Participants[125]
Operating Cost	13%	7%	n/a
Energy bill payment concerns	n/a	n/a	10%
Construction quality	n/a	n/a	10%
Maintenance	7%	7%	Incl in perf.
Equipment Performance	9%	8%	10%
Equipment Lifetime	9%	8%	Incl in perf.
Occupant Satisfaction	11%	8%	n/a
Occupant Comfort	4%	8%	11%
Illnesses	n/a	n/a	9%
Aesthetics	4%	8%	9%
Light Quality	9%	8%	n/a
Noise	7%	8%	10%
Building Safety	1%	8%	n/a
Ease of Selling/Leasing	5%	7%	10%
Helping the Environment	11%	7%	10%

[125] Note that, given that they have no energy savings to respond to, shares using a similar definition were not available for the non-participating owners. Non-participating builders were considered knowledgeable enough to judge NEBs relative to potential savings.

Category	Builders Participants	Builders Non-Participants	Occupants Participants[125]
Power Quality/Reliability	4%	8%	n/a
Other	1%	0%	11%
Total	100%	100%	100%

Table 141: NEBs Shares

Overall NEBs Value Estimates

The data were used to estimate the value of the total NEBs perceived by participants. Responses to several questions were used:

- Verbal scaling responses to whether the total NEBs are more or less valuable than the energy savings; and
- Estimates of the one-time value of the non-energy benefits in dollar terms.

For the percentage responses, the average percent (including both positive and negative responses) was computed to derive the overall NEB energy savings multiplier. The verbal responses were analyzed as described above. The results provide the value of total NEBs as a multiple of energy savings attributable to the program.[126]

The table below presents a summary of the estimates of the total value of the program-attributable NEBs in terms of the energy savings due to the program. Using the comparison technique described in the methodology section, respondents were asked to describe the NEBs that they experienced in terms of the energy savings arising due to the energy efficiency improvements implemented in their housing project.

- Percentages: The total value of the NEBs reported by participating builders was 96% of energy savings. The value experienced by participants was 125% of the energy savings that occurred as a result of building energy efficiency improvements, based on the verbal scaling results. The value reported by non-participant builders was about 46%[127] of the energy savings.[128]
- Dollars: Note that participating owners were asked for their approximate energy savings. They stated savings of approximately $47 per month, or $712 per year. If we assume a 5 year[129] undiscounted value of the NEBs at approximately $3,560. If the energy savings value of $1,500 lifetime is used[130], five year, we find estimates for lifetime $1,875 from participating owners, $900 from participating

[126] In addition, responses to willingness to pay questions were examined as well as requests for percent of NEB value relative to energy savings. In each case, there were too few responses to report.

[127] Using data from only about 10 respondents; small sample.

[128] Non-participant owners did not provide information in these energy-savings-based terms.

[129] National statistics estimate households move about once every five years.

[130] Estimated / provided by RLW, February 2007.

builders, and less than $700 from non-participant builders. Participating and non-participating owners were asked to put a dollar value on the total of NEBs in a home, and their estimated value was value of $3,148[131] for participants and about $2,900[132] for non-participants.

Adjustments for Net Attributable Effects: Earlier in this report the net-to-gross (NTG) ratio was computed. The results showed that free ridership was 46%-58% (about 42-54% of the savings associated with the program would likely have occurred without the program). In addition, the results showed induced market effects of about 38%-66% from the program. The resulting NTG ratio is 58%-88%, a ratio that represents the share of program monitored energy savings that could be attributed to the impacts of the program.

Combining the NEBs estimates and the NTG results, an adjusted figure for NEBs is computed and is presented in the Table.

Category	Value – Builders (participants)	Owners (participants)
A. Computed value of NEBs (participants)	96% of program energy savings	125% of program energy savings; savings approximately $1,900-$3,000
B. Free ridership (from Table 3.1)	46-58% of total energy efficiency improvements	46-58% of total energy efficiency improvements
C. Market Effects (from Table 3.1)	38-66% market effects	38-66% market effects
D. NTG (from Table 3.1; B*C)	58%-88%	58%-88%
E. Attributable Total NEBs value Multiplier (A*D)	56%-84% of program energy savings	72%110% of program energy savings

Table 142: NEBs Value Estimates

Summary and Implications

These results imply that the program's benefits go beyond providing efficiency and energy savings to homeowners. On a per-household basis, the program's measures and practices lead to benefits that are worth another 96%-125% of the value of the energy savings. Additional computations can estimate the NEBs that are "attributable" to the program – taking account of free ridership and potentially indirect market effects impacts. These computations derive an estimate of an additional 56% to 110% in added value from the program's array of non-energy impacts that accrue to residents. The NEBs add to the

[131] Computed using mid-ranges of question requesting estimate of one-time values of NEBs. Used value of $5,500 for "$5001 or more. No negative responses were given.

[132] Computed using mid-ranges of question requesting one-time values. Used value of $5,500 for "$5001 or more", and estimates were insensitive to the value assumed for the negative value within a range of -$100 to -$1,000. (No values were provided for the 3% reporting negative values.)

benefits side of benefit-cost analyses, suggesting that participants recognize significant additional benefits from the program beyond simply energy savings.

The NEB results indicate that the most valuable of the non-energy impacts in homes include improvements in comfort, noise, construction quality, and other performance features, as well as "doing good for the environment". These impacts – particularly the comfort benefits – may be important to include in program materials to help encourage participation.

The tables of results in this section suggest several points about the NEBs arising from the ENERGY STAR ® Program:

- **In general, satisfaction with the non-energy effects of the program is high**. Negative effects were reported for very few of the categories discussed, and in each instance of a negative report, a much greater percentage of those answering the question reported a positive effect for the same category.

- **Equipment effects are important to participants**. A substantial proportion of the participants (builders and/or households) surveyed reported positive effects relating to the operating costs and equipment performance-related categories for the equipment that was installed under the program. Cumulatively, these equipment effects comprised almost 40% of the total NEBs associated with the program (from the builder perspective).

- **The environmental effects of the program are also important to participants**. More than 90% of respondents claimed positive effects from "doing good for the environment" as a result of participating in the program. Furthermore, the same environmental benefit category accounted for 10% of the total household-valued program-attributable NEBs.

- **There are differences in NEB perceptions between participants and non-participants:** The results show that there are several areas in which participants and non-participants have different perceptions about energy efficient equipment.
    - For builders, non-participants are considerably less positive about non-energy operating costs changes and maintenance than participants; however, the non-participant sample is very small, so differences are only indicative. Lighting considerations were a concern for participating builders.
    - Participant households are more positive about most of the benefit categories than non-participants; however, most of the leading categories are important to both participating and non-participating households.
    - Participants and non-participants had fairly similar perceptions about the effect of energy efficient ENERGY STAR® equipment on maintenance, performance, lifetime, light quality, and ease of selling / leasing the buildings/homes, all of which showed strong value.

These results imply that concerns about the equipment and its features (including maintenance and lighting) may represent "barriers" to adoption of energy efficient equipment for participants or potential participants. If energy efficient ENERGY STAR® equipment does not, in fact, perform worse in these areas, then education or outreach may be needed to change these perceptions among non-participants. If, however, there are performance issues associated with energy efficient ENERGY STAR® equipment, then the program information (and potentially incentives) may be needed to address the barriers.

These results can be used in several ways.

- Benefit-cost analysis (and associated payback) shows a significantly higher return to program participants than an analysis of energy savings alone. In gross terms, benefits are nearly doubled (or more from the household perspective).
- Program marketing materials should emphasize the strong NEBs including improvements in non-energy operating costs, comfort, doing good for the environment, performance, reduced noise, and other benefits.
- Program outreach or design should incorporate methods to address perceived barriers reported by non-participants (maintenance, and non-energy operating costs and lighting). The issues may be addressed by education; however, if the barriers represent real problems, program incentives may be needed.
- A majority of respondents indicated that NEBs were important in influencing their decisions to invest in the ENERGY STAR® measures under the program.

Multifamily Non-Energy Benefits (SERA)

Feedback on Non-Energy Effects

Non-Energy Benefits Responses

Although California's Statewide ENERGY STAR® Multifamily program is designed to save energy, the reality is that participation in energy efficiency (EE) programs or adoption of energy efficiency measures occurs for a host of reasons in addition to the specific goals of any program. When asked, participants routinely cite non-energy impacts and considerations either as a component of decision-making or as benefits they recognized after installing energy efficient equipment. In studies of commercial programs, participants routinely mention non-energy benefits (NEBs) as reasons for their satisfaction with various Programs.

We asked participant and non-participant builders an array of questions about these effects. This chapter discusses perceptions, directions, frequencies, and presence of NEBs. The following chapter provides an analysis of the valuation – in dollar or energy savings equivalent terms – associated with the NEBs described in this chapter.

The multi family builders were asked a series of questions about effects other than actual energy savings that the occupants of the MF buildings may have been realizing due to the installation of energy efficient measures or practices in the MF units.

Effects Experienced by Residents

The first question in this section asked builders if there were any positive or negative effects above and beyond the energy savings that they would attribute to the energy efficient measures they had installed. It was an open ended question where the builders could list anything they felt that the residents were experiencing.

Participants: Close to a third of the builders responded that there were indeed positive effects above and beyond energy savings that they would attribute to the installation of the energy efficient measures. There was however, 13% of the builders that reported that the energy efficient measures had a negative effect on the homeowners. The only negative effect mentioned was that the air leakage requirements were too strict, causing a lack of ventilation or air movement within the complex. This effect was noted by two different participant builders. The positive effects range from deceased use of energy to increased national security due to a lowered reliance on foreign energy sources. Both the positive and negative effects the builders attributed to the energy efficient measures are listed below in the following table.

	Positive Value	**Negative Value**
%of builders who would attribute value to the energy measures	31%	13%
The effects the tenants experience	• Cut energy use • Great insulation/less energy use • Higher consciousness • Increase the quality of the final product • Positive effect on the environment/ national security	• Buildings are too tight, ventilation • Too tight, not enough ventilation

Table 143: Positive and Negative Non-Energy Benefits

Non-participants: None of the multi-family non-participants would attribute any negative effects to the added energy efficient measures and 50% of them reported that there were positive effects derived from the energy efficient technologies above and beyond the monetary savings. The added non-energy benefits that the non-participant builders noticed were:

- The effects on the environment
- They reduce CO2 in the atmosphere and the demand for energy
- The savings are passed on to the customer

Comparison: Both the non-participant and the participant builders would attribute positive non-energy effects that go above and beyond the actual energy savings to the energy efficient measures that they installed in the multi-family projects. None of the non-participants reported any negative effects but 13% of the participants did. The only negative effects noted however, were due to the high levels of sealing in the units to combat air leakage to obtain the 15% energy efficient standards, which the majority of non-participants did not do.

Non-energy Effects Compared to Energy Savings

A battery of questions were posed to both groups of builders asking them to state the value of a number of possible non-energy effects specifically derived from the installation of energy efficient measures. The builders were asked to respond whether they believed the non-energy effect had a *positive*, a *negative*, or *no effect* on the owner/occupant. For example, the builders were asked what the effect was of the *equipment lifetime* of the energy efficient technology installed in the multi-family home. If the builders believed that the energy efficient equipment lifetime was shorter than non-energy efficient equipment than they would respond that it is a *negative* effect, if it lasts as long as the energy efficient technology it would be *zero*, and if they believed that the energy efficient equipment lasts longer than the standard equipment they would answer it has a *positive* non-energy effect.

Participants: Overwhelmingly, the participant builders reported that the non-energy effects of the energy efficient equipment and technologies installed in the projects is believed to be positive. In only three of the twelve categories the builders reported a negative effect. Additionally, in only one of these three categories was the percentage of builders reporting a negative effect in the double digits. The three categories in which builders noted negative effect were:

- Lighting
- Aesthetics
- Operating Costs

The categories with more than 70% of the builders noting a positive effect were:

- Occupant satisfaction
- Occupant comfort
- Noise (both of the equipment and from outside of the home)
- Impact on the environment

The data collected for this section are displayed in the Table and Figure below. The table displays the percentage of the builders reporting values for each category, and the figure displays the distribution of these responses graphically.

	Positive	None	Negative	N Value
Operating Costs	67%	25%	8%	12
Equipment Maintenance	36%	64%	0%	11
Equipment Performance	45%	55%	0%	11
Equipment Lifetime	45%	55%	0%	11
Occupant Satisfaction	73%	27%	0%	11
Occupant Comfort	73%	27%	0%	11
Aesthetics	9%	82%	9%	11
Lighting	30%	40%	30%	10
Noise	73%	27%	0%	11
Ease of Selling	43%	57%	0%	7
Impact on Environment	70%	30%	0%	10
Power	22%	78%	0%	9

Table 144: Value of Non-Energy Benefits to Participant Builders

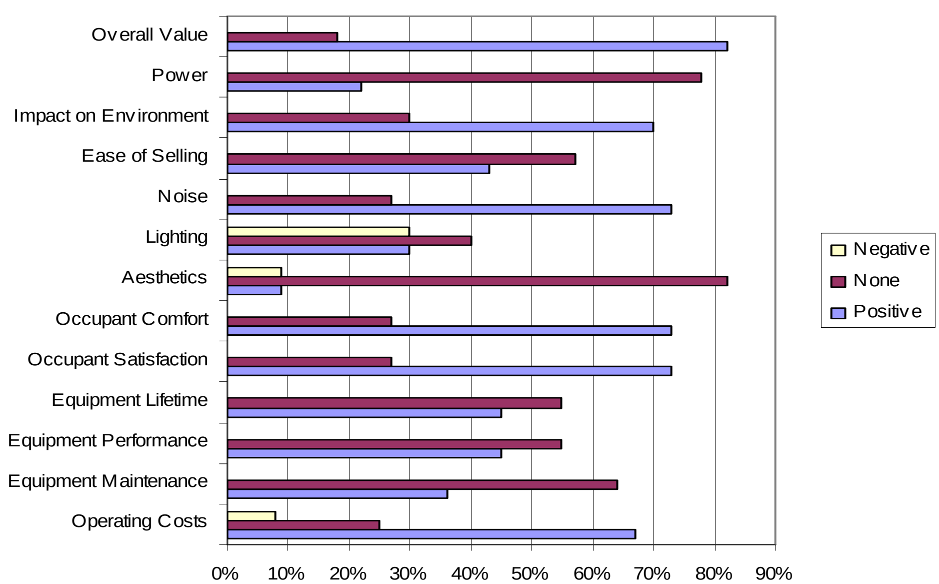

Figure 126: Value of Non-Energy Benefits to Participant Builders

Overall Value

Participants: The final question relating to non-energy benefit value comparison asked the builders to look back at all the effects they were previously asked about and give an *overall value* for the non-energy effects. The *overall value* had the highest percent of builders reporting that it is a positive value, with 82%. Only 18% of the builders reported that the non-energy benefits have no added value compared to standard practices, and none of the builders reported an overall negative value. This shows how the cumulative effect of all of the non-energy benefits outweighs the effect of any one single non-energy benefit.

	Positive	None	Negative	N Value
Overall Value	82%	18%	0%	11

Table 145: Overall Value of the Non-Energy Benefits to Participant Builders

Non-Participants: The non-participants often attributed *no effect* to the energy efficient measures they installed. In four of the twelve categories, 100% of the builders responded that there is no effect attributed to the energy efficient equipment or measure. When it came to equipment maintenance, 60% of the non-participants reported that the energy efficient equipment had a negative effect. The non-energy effect with the highest percentage of builders reporting a positive value was the effect on the environment. In five of the twelve categories, a higher percentage of builders attributed a positive effect to the value compared to negative or zero, in six of the categories the majority of builders attributed zero value to the effect, and in one category the majority of non-participants reported a negative value. The results are displayed in the following two Tables.

	Positive	None	Negative	N value
Operating Costs	60%	40%	0%	5
Equipment Maintenance	20%	20%	60%	5
Equipment Performance	0%	100%	0%	3
Equipment Lifetime	0%	100%	0%	3
Occupant Satisfaction	60%	40%	0%	5
Occupant Comfort	60%	40%	0%	5
Aesthetics	0%	80%	20%	5
Lighting	40%	60%	0%	5
Noise	0%	100%	0%	4
Ease of Selling	60%	40%	0%	5
Impact on Environment	75%	25%	0%	4
Building Safety	0%	100%	0%	5
Power	0%	100%	0%	4

Table 146: Value of Non-Energy Benefits to Non-Participant Builders

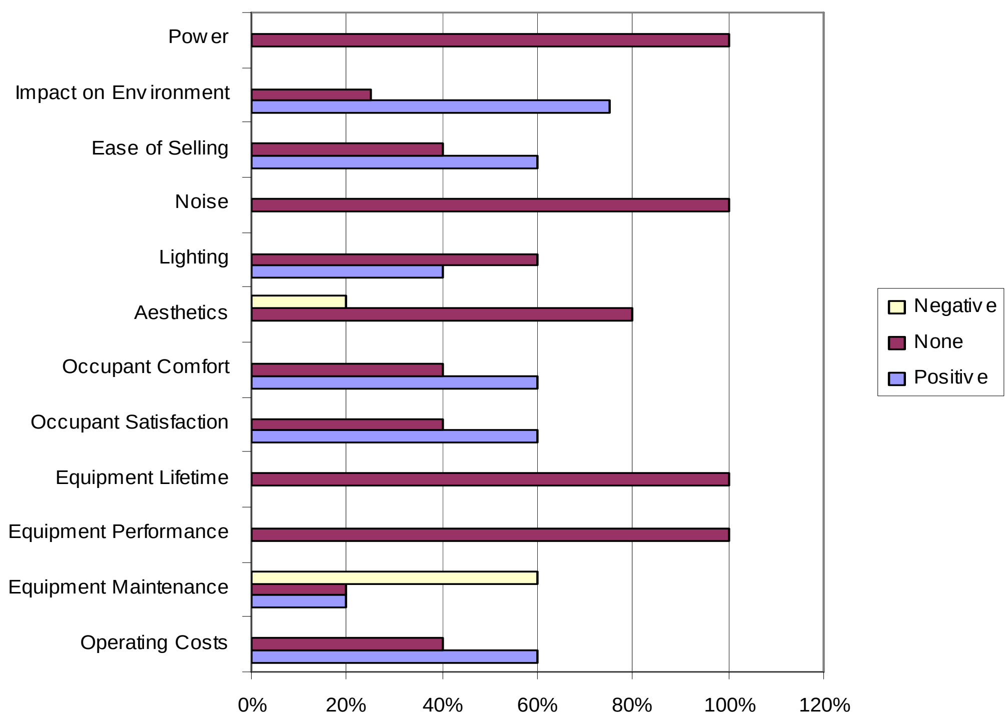

Figure 127: Value of Non-Energy Benefits to Non-Participant Builders

Overall Value

When the non-participants were asked to think back on all of the non-energy effects and place an overall value on them, only 20% of the builders reported a *negative* effect and likewise, only 20% reported *no effect*. The majority, 60%, reported a *positive* value to the non-energy effects. Like the participant builders, the non-participants believe the cumulative effect of the non-energy benefits to be greater than the singular effects.

	Positive	**None**	**Negative**
Overall Value	60%	20%	20%

Table 147: Overall Value of the Non-Energy Benefits to Non-Participant Builders

Comparison: As a group, a larger percentage of participant builders place a positive value on the non-energy effects attributed to the energy efficient measures and equipment installed in the projects. Overall, none of the participants believe there is a *negative* value to the effects, while 20% of the non-participants do. Conversely, 82% of the participants place a *positive* value on the effects while only 60% of the non-participants do so. However, the majority of both groups of builders believe that the value of the non-energy benefits is *positive*. In none of the categories of effects did 100% of the participants report that the effect had *no value,* but in 4 of the categories, 100% of the non-participants assigned zero value to the effect. This could be due to a lack of familiarity with some of the energy efficient technologies as more of the participants install and use the energy efficient technologies and equipment that the non-participants. In both groups at least 70% of the builders reported a *positive* value to the effect on the environment. Also, a small portion of both groups reported a *negative* value associated with the aesthetics of the energy efficient equipment or measures. The figure below displays only the percentage of builders in both groups that believe there is a positive value associated with the effect.

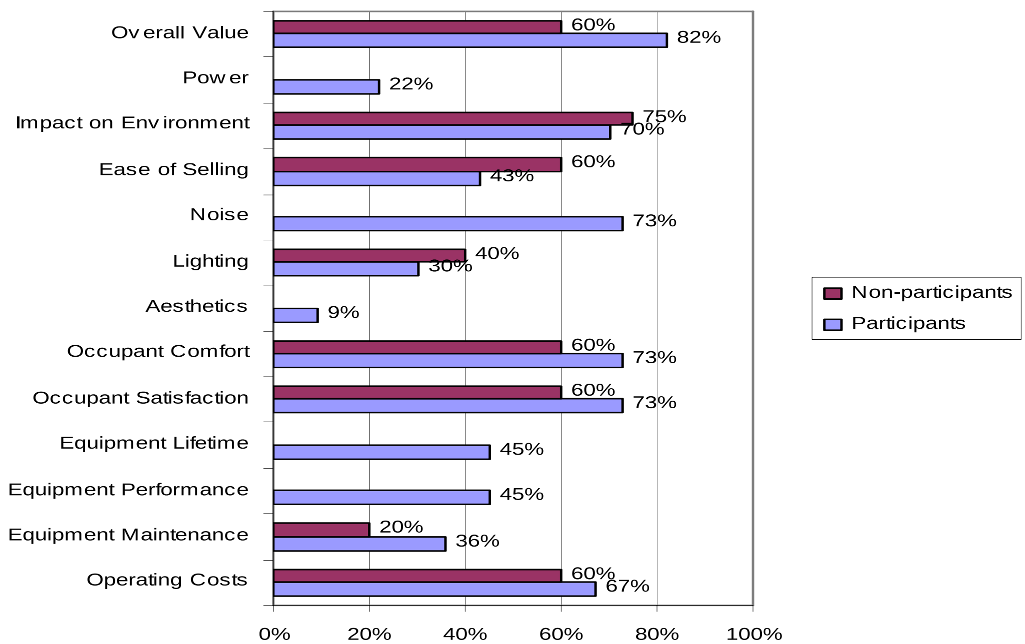

Figure 128: Positive Non-Energy Effects

Non-Energy Benefits and the Installation of Energy Efficient Measures

Both groups of builders were asked if they had used the non-energy benefits associated with the energy efficient measures as a way to help convince the building owner to install the energy efficiency measures as part of this project.

Participants: The overwhelming majority of participant builders did not use the non-energy benefits as a means of convincing the owner to install energy efficient measures. Only one builder reported that he did. When asked how important he felt the non-energy benefits were in influencing the decision on the measure, he reported that they were *not very important*.

Non-participants: The majority of non-participants did not use the non-energy benefits to "sell" the energy efficient measures but 40% of them did. Of the builders that did use the non-energy benefits one of them was willing to answer how important they were for him in influencing the decision to install and he reported that they were *somewhat important*.

Energy Efficiency as a Hedge

Both groups of builders were asked if they felt that energy efficiency measures installed in the homes serve as a hedge against future price increases.

Participants: Almost all of the participant builders reporting (90%) believe that the energy efficient measures installed in the multi-family projects do act as a hedge against future energy price increases. Only 10% of the builders reported that they did not believe so. The builders who responded that they did feel the energy efficient measures act as a hedge, were then asked to relate how important that benefit was. They did so on a scale of 1 to 5, where 1 is *not at all important* and 5 is *very important*. One third of the builders said that it is a *very important* benefit and 78% of them reported that it was at least a 3 or more on the scale. None of the builders responded that it was *not at all important* as a benefit. The average rating on the 1 to 5 scale was 4.1.

The builders were also asked to rate the value of the energy efficient measures acting as a hedge when compared to the annual energy savings associated with the energy efficient measures. A quarter of the builders reported that they believed the value of the energy efficient measures as a hedge was *much more valuable* than the energy savings, and overall, 38% reported that the value of a hedge was at least *somewhat more valuable* than the energy savings. Conversely, 13% of the builders reported that the value as a hedge was *much less* than the annual energy savings.

Non-participants: The non-participant builders were also asked whether or not they believe that the energy efficient measures act as a hedge and a slight majority, 60%, reported that they did believe so. The remaining 40% reported that they did not feel the energy efficient measures function as a hedge. When asked what the value of the energy efficient measures acting as a hedge were on the same 1 to 5 scale, 33% responded that they were either *very important* with a score of five, and 33% each rated the value with either a score of 3 or 4. None of the builders reported that it was *not at all important*. The average rating was 4.

When asked to compare the value of the energy efficient measures as a hedge to the annual energy savings, all of the non-participant builders reporting responded that the value as a hedge is *somewhat less valuable* than the energy savings.

Comparison: For both the participant and non-participant groups, the majority of the builders reported that they believe the energy efficient measures they installed do act as a hedge against future price increases. They also both felt that it was an important benefit. None of the builders in either group reported that the value of the measures as a hedge was *not at all important*. When the builders compared the value of the measures as a hedge to the annual energy savings, 38% of the participants reported that it was at least *somewhat more valuable* than the energy savings while none of the non-participants did so.

	Hedge	Not a Hedge	N Value
Participants	90%	10%	10
Non-Participants	60%	40%	5

Table 148: Energy Efficient Measures acting as a Hedge Against Energy Price Increases

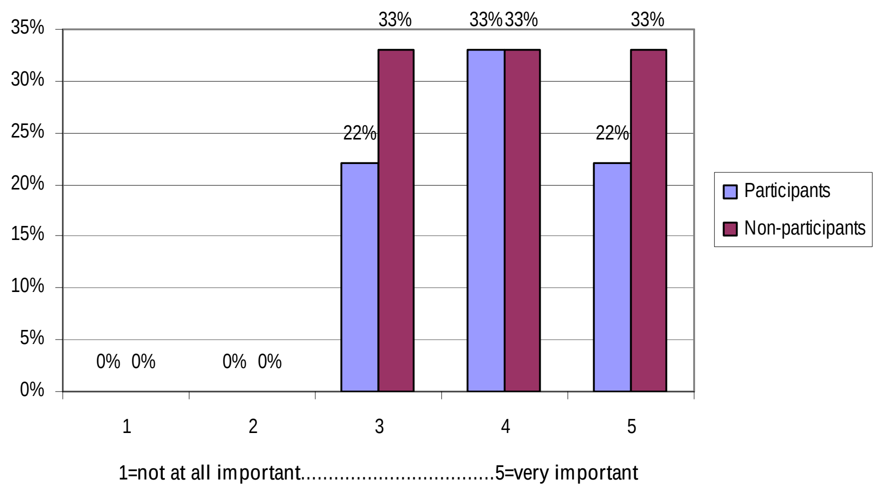

Figure 129: Value of the Home as a Hedge

(Participants N=10 Non-Participants N=5)

Computation of Non-Energy Effects

This section focuses on the computation of values of the non-energy benefits – in both dollar terms and terms relative to the energy savings provided by the program.

Importance of Indirect / Market Effects for Market Transformation Programs

The Multifamily component of the California Statewide ENERGY STAR® Homes Program incorporated a wide variety direct and indirect goals and outcomes. As a market-transformation-type program, indirect effects and hard-to-measure outcomes on the market and market actors are very important components of identifying "success" for the Program. In addition to success factors due to the number of ENERGY STAR® Homes and equipment, there were also a number that were related to non-energy benefits. These factors are described in the following sections.

Background on Non-Energy Benefits

While the focus of traditional program evaluations – energy savings, awareness, market share and other metrics – provide direct indicators of program effects, a significant body of work has developed around recognizing and measuring net non-energy benefits (NEBs). NEBs include a variety of program impacts — positive and negative — that result from the program.[133] Strictly speaking, NEBs are "omitted program effects" – impacts attributable to the program, but often ignored in program evaluation work. After nearly a decade of research, more and more utilities and regulators are considering these effects.

In order to assess the NEBs associated with the California Statewide ENERGY STAR® Multifamily program, Skumatz Economic Research Associates (SERA) developed a questionnaire directed at identifying NEBs accruing to Program participants and perceptions about NEBs from non-participants. The sampling source was discussed earlier. The respondents included 16 participants and six non-participants for a total of 22 respondents. The small sample size affects the confidence to be placed in the results, but indicative information can be derived.

While the primary purpose of most energy efficiency programs is to save energy or reduce peak demand, these programs, by their nature, lead to a host of effects beyond these outcomes. These other effects are commonly called Non-Energy Benefits (NEBs) – even though not all the effects are positive.[134] There are three main types of net non-energy benefits based on who is the beneficiary:[135]

- **Utility/agency benefits.** These are positive or negative impacts that affect ratepayers and utilities and reduce revenue requirements – for example lower bad debt because of lower arrearages, lower line losses, power quality issues, and reduced labor cost from fewer bill-collection-related calls. These effects are generally valued at utility (marginal) costs.

- **Participant (or "user") benefits.** These consist of non-energy factors that benefit or affect the participant users of the energy efficient equipment beyond energy savings – for example, comfort, improved ability to pay bills, and a wide variety of factors included in the tables below. These effects are valued in terms relevant to the participant.

- **Societal benefits.** Non-energy impacts that (positively or negatively) affect the greater society or that can't be attributed directly to utility/ratepayers or participants. These include emissions/environmental benefits/health benefits, direct and indirect economic multipliers, water system benefits (if they need fewer treatment plants, etc.), or similar items. These effects are valued as appropriate to the benefit category.

[133] Note that the literature has used the designation "non-energy benefits" although we examine both positive and negative impacts from energy efficiency measures. Although the conventional term NEB is used in this project, the name refers to "net" non-energy benefits.

[134] We most commonly call them "net non-energy benefits" to account for the negative benefits as well. We have also called them non-energy impacts, non-energy effects, non-utility benefits, and others, but the commonly accepted term in the literature is NEBs, so we use that convention.

[135] The literature has adopted the convention of categorizing NEBs into three groups based on beneficiary; this is developed from Skumatz, Lisa A., "Recognizing All Program Benefits: Estimating the Non-Energy Benefits of PG&E's Venture Partners Pilot Program (VPP)", 1997 Energy Evaluation Conference, Chicago, IEPEC, August 1997.

Typical categories of benefits based on a decade of past work follow in the Table below. This list is not comprehensive, and obviously some benefits can cross categories.[136] Whether specific benefits are included or excluded from the analysis tends to depend on which measures are included in the program, and the use intended for the NEB analysis. The list of benefits to be included in the program attribution analysis is usually refined in collaboration with the program staff.

NEB Categories	
Utility Benefits (not estimated in this analysis)	
• Reduced carrying cost on arrearages (interest) • Bad debt written off • Shutoffs • Reconnects • Notices • Customer calls / bill or emergency-related • Other bill collection costs	• Emergency gas service calls (for gas flex connector and other programs) • Insurance savings • Transmission and distribution savings (usually distribution only) • Fewer substations, etc. • Power quality / reliability • Reduced subsidy payments (low income) • Other
Societal Benefits (not estimated in this analysis)	
• Economic benefits – direct and indirect multipliers • Emissions / environmental (trading values and/or health / hazard benefits) • Health and safety equipment • Water and waste water treatment or supply plants • Other	
Multifamily Participant Benefits[137]	
• Water / wastewater bill savings • Operating costs (non-energy)[138] • Equipment maintenance • Equipment performance (push air better, etc.) • Equipment lifetime • Tenant satisfaction / fewer tenant complaints • Comfort • Aesthetics / appearance • Lighting / quality of light • Noise • Safety, insurance	• Health issues • Ease of selling / leasing • Labor requirements (separate from equipment O&M) • Indoor air quality • Doing good for environment • Reliability of service / power quality • Savings in other fuels or services (as relevant) • Feeling of greater control over bill / understanding of energy use (residents if relevant) • NEGATIVES (usually incorporated into above) some may have worse maintenance, parts may be harder to get, greater training needs for maintenance staff, etc.

Table 149: Net Non-Energy Benefits (NEBs) Categories included in "NEB-It"© Model[139]

[136] We tend not to include tertiary type benefits like tax –related impacts, as we prefer to be more conservative.

[137] Positive and negative impacts, estimated using participant surveys for many of the NEBs.

[138] Sometimes omit if likely to double count with the next two categories

[139] Skumatz, Lisa A., Evaluating Attribution, Causality, NEBs, and Cost Effectiveness in Multifamily Programs: Enhanced Techniques", EEDAL Conference Proceedings, London, England, 2006.

Note that several benefits arise in multiple categories. For example, having fewer bill-related calls to the utility benefits both the utility / ratepayers AND the households making or receiving those calls. This is not double-counting benefits – rather, it recognizes that some effects have multiple beneficiaries and each is valued at the appropriate tailored valuation method. For example, this saved time from calls may be valued at the marginal labor cost for customer service staff for the utility's benefit, and at the minimum wage rate for low income households. Benefits are recognized and realized by both groups; whether they are included in specific computations depends on their appropriateness to the application.

Estimation of the various categories of NEBs can be conducted using several key steps:

- Attribution of utility and societal NEBs can be measured using a combination of primary and secondary data. There is an extensive literature measuring the arrearage impacts of programs (particularly low income programs), as well as many others of these impacts. Detailed examination of the program impacts – or the literature– may be needed to estimate the impacts on reconnections and other factors that may be affected by the program.[140]
- Societal impacts also have a significant literature and indeed, the two key components, environmental and economic impacts – have a very high degree of volatility depending on the data sources and valuation methods used. Impacts on greenhouse gases (GHG) are increasing in importance and have been estimated in the literature.[141] There also exists a growing literature estimating the *net* economic impacts from energy efficiency programs, assuming a transfer of expenditures from electricity generation to economic sectors affected by the weatherization or other program.[142]
- Estimation of participant benefits rely mostly on responses to surveys, combined with a limited amount of programmatic and secondary data.

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[140] See for example, Hall, Skumatz, and Megdal, "Low Income Public Purpose Test: Non-Energy Benefits for Low Income Weatherization Programs", prepared for PG&E, 2000 for an extensive discussion of these estimation methods.

[141] These impacts are a "slippery slope" – they can be estimated in a simplistic way, or if health impacts are to be measured in detail, then issues related to specific microclimates and time of day and zones are important. For some programs, average generation mix should be used to assess emissions; for others (e.g. a peak load reduction program, residential air conditioning programs, etc.) emissions from marginal peak load plants should be used to estimate changes in emissions from the energy savings. Valuations are the source of considerable debate in the literature as wellFor some clients, there are values that have been agreed upon by the regulators. For others, we used specific values included in the literature, or averages of valuations from many sources. Which valuations are most appropriate depends on not only the location, but also the use to which the work will be applied.

[142] Some of the literature is flawed in that they estimate the job creation and economic multipliers of a *gross* expenditure toward conservation on the economy when instead they should be measuring the *net* impact of a transfer of funds. For an extensive discussion of the environmental and economic impacts, see Gardner and Skumatz, "Do Economic NEB Multipliers Vary with Program Design and State?", forthcoming, proceedings for the ACEEE Summer Study, Asilomar, CA, 2006, and Imbierowicz and Skumatz, " The Most Volatile Non-Energy Benefits (NEBs) – New Research Results "Homing In" On Environmental And Economic Impacts", American Council for an Energy Efficient Economy Summer Study, held in Asilomar, CA, ACEEE, Washington, DC, August 2004.

Given that the 2004-2005 Program Year included only 25 participants, estimate of the societal and utility benefits are not included in this report.[143] This report on the 2004-2005 program year focuses benefits that accrue to program participants.

Estimating Participant NEBs

Possible Measurement Approaches

The most challenging portion of non-energy benefits work is assessing the participant portion of the benefits. SERA has spent considerable time on this issue, and has pioneered, tested, and compared several credible methods of estimating these "hard to measure" (HTM) impacts based on the results of NEB analyses for several thousand program participants over 10 years. The research includes an evaluation of measurement options with respect to: ease of response by respondent / comprehension of the question by respondents; reliability of the results / volatility; conservative / consistent results; and computation clarity, among other criteria. Some common measurement approaches that have been applied to NEBs include: [144]

- **Contingent valuation (CV) including Willingness to pay (WTP) / willingness to accept (WTA):** The contingent valuation approach to measuring NEBs involves some manner of asking program participants to place a dollar value on the benefits that they experienced. Contingent valuation is one of the standard methods of measuring the value of environmental damage in litigation and has long been debated in the environmental economics literature. There are two basic variations of the contingent valuation method. The first, Willingness to Pay (WTP), asks participants to estimate how much (usually in dollars annually) they would be willing to pay for the NEBs that they claim to have experienced. As the name implies, Willingness to Accept (WTA) asks them to estimate how much they would accept in compensation if they were divested of those same benefits. Empirically, WTP and WTA values tend to fall near one another, although there is considerable theory and evidence that WTA values average higher than their counterparts.[145] All types of contingent valuation approaches to measuring NEBs are subject to some degree of bias. Economists believe that WTP and WTA questions may either (a) lead respondents to believe that they have entered a bargaining situation in which they have an incentive to misrepresent the true value of the good in question or (b) appear so hypothetical that respondents do not seriously consider the true value to them of the benefit that is under consideration, leading to highly variable replies.

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[143] Given the small number of participants, the total value of the societal and utility NEBs would be fairly small.

[144] The descriptions in this section are derived from Skumatz and Gardner, "Differences in the Valuation of Non-Energy Benefits According to Measurement Methodology: Causes and Consequences", Proceedings of the AESP Conference, San Diego, 2006, and Skumatz, Lisa A., "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value", Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings held in Asilomar, CA, ACEEE, Washington, DC, August 2004. Other revealed and stated preference, statistical methods, and other approaches have also been used.

[145] Horowitz, John and K.E. McConnell. 2004. "Willingness to Accept, Willingness to Pay and the Income Effect." October, 2004.

- **Direct computations of value to owner:** Direct computations of value have the advantage of accuracy; however, they are rarely computed (especially in the case of residential programs). Therefore, two significant problems arise from this approach: missing data and bias. Few participants perform direct computations of benefits, leading to significant missing data. Also, those computing the effects are unlikely to represent a random sample of beneficiaries, but would more likely include those with high benefits; hence, generating a biased set of data. Direct estimation of benefits using statistical approaches can also be computed. However, data are likely available for only a subset of benefits[146] categories or from a small sample of participants.

- **Discrete choices or ordered logit**: Discrete choice or ordered logit approaches have proven to be robust methods for estimating NEBs.[147] Unfortunately, they are relatively difficult to administer via telephone and are a better fit for mail, web, email or similar applications.[148] Discrete choice and ordered approaches can also be more difficult for residential participants to answer.

- **Comparative, scaling, or relative valuations:** Scaling techniques for measuring NEBs are straightforward and involve asking program participants to express the value of the NEBs that they experience relative to a numeraire with which they are familiar. Our approach uses energy savings as the comparison. Direct scaling asks participants to express the benefits that they experience as a percentage of their energy savings. This approach is advantageous in that it easily produces participant-level energy savings multipliers that should, at least in theory, more accurately reflect the value of the NEBs that each participant received. It also produces answers to a higher degree of standardization. Although energy savings may differ among participants, there can be no disagreement regarding what is meant when a respondent reports that they experienced non-energy benefits on the order of ten percent of their energy savings. Direct scaling does, however, present some drawbacks. Though having benefits expressed as a percentage of energy savings is desirable for many reasons, survey respondents may find it difficult to estimate that percentage at all, let alone with any reassuring degree of accuracy. Very often respondents (especially residential respondents) are not terribly comfortable with percentages. The issue of accuracy may be dealt with statistically by assuming a normal distribution error in respondent replies.[149] The issue of missing data, however, can seriously disrupt program analysis – it is

[146] For example, see Lisa Heschong's (Heschong Mahone Group) work on daylighting in a retail chain and in schools in Proceedings of the ACEEE Summer Study on Buildings, Asilomar, CA, 2004 and 2004.

[147] See Gardner and Skumatz, "NEBs in the Commercial and Industrial Sector", forthcoming, Proceedings from the ACEEE Summer Study on Buildings, Asilomar, CA 2006.

[148] Web approaches have been demonstrated starting in 2004 in work in New Zealand. See write-up in Stoecklein and Skumatz, "Using NEBs to Market Zero and Low Energy Homes in New Zealand", Proceedings of the ACEEE Summer Study, Asilomar, CA, 2004.

[149] Monte Carlo simulations or statistically-appropriate hot deck imputations can help address this issue of missing data. See, for example, Holt, Barnes, Skumatz, "Non-Response in Energy Surveys: Systematic Patterns and Implications for End-Use Models", The Energy Journal, 1988.

extremely important to present participants with survey questions that they can actually answer.

Relative scaling attempts to resolve that problem. Relative scaling questions once again ask respondents to value the non-energy benefits that they experience relative to their energy savings. Rather than asking about percentages, they ask them to express the benefits qualitatively relative to their energy savings using verbal options (much more valuable, etc.). This approach presents an easier-to-answer question (and thus, generally includes less missing data), but is less directly translated into a dollar value. Regardless of the specific type of scaling question used, the technique is very successful in producing meaningful and interpretable responses. Empirical research indicates scaled NEBs values are, in general, much more stable than those obtained through the techniques primary competitor: contingent valuation.[150]

Selected Measurement Approach

These measurement methods can be complex to implement, and a great deal of work has been conducted to refine the techniques. Based on research over 10 years on more than 50 programs, we have found that generally, comparative or relative valuations[151] perform substantially better than other methods. Willingness to pay (WTP) can often provide very volatile numbers and respondents have an extremely difficult time understanding the concept of stating a dollar amount they would be willing to pay for these benefits. We have incorporated multiple measurement methods into the same studies, and have found that on average, WTP is volatile (and less conservative), and that scaling, discrete choice, and other measurement methods we have adapted perform more reliably; our research incorporates these approaches.[152]

The key estimation approaches employed in this study were the relative and direct scaling approaches. WTP / WTA questions were also asked but almost no responses were obtained.

Valuing the NEBs

A key objective of the NEB portion of the evaluation was to "value" previously unvalued or undervalued benefits to participation in the program. Extensive field experience and a wide body of literature suggest that, for programs such as the California Statewide ENERGY STAR® Multifamily program, the value of the NEBs experienced by participants

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[150] For additional corroboration, see Skumatz, 2004, *op. cit.*

[151] Methods pioneered and adapted by the authors, based on the academic literature; see descriptions in Skumatz, Lisa A., "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value", Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings held in Asilomar, CA, ACEEE, Washington, DC, August 2004.

[152] For an analysis of comparative, willingness to pay, and labeled magnitude scaling methods, see Skumatz, Lisa A., Ph.D., "Comparing Participant Valuation Results Using Three Advanced Survey Measurement Techniques: New Non-Energy Benefits (NEB) Computations of Participant Value", Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings, held in Asilomar, CA, American Council for an Energy Efficient Economy, Washington, DC, August 2004.

can be as much as, or more than, the energy savings that occur due to program effects.[153]

NEBs Valuation Methodology

To estimate the value to participants of the home energy-efficiency improvements implemented through the program, we employed the relative comparison value method of NEBs valuation.

We asked the MF builders about NEBs in terms of their relative value on a verbal scale. These responses were translated into numeric values. Respondents were asked about the value of the benefits relative to energy savings using a five-point scale (much less valuable, somewhat less valuable, same value, somewhat more valuable, and much more valuable). The relative values were then scaled to percentage-of-energy-savings values obtained from other empirical research, SERA research, and academic scaling literature. Because these questions are more quickly answered than percentage responses - and because time on the surveys was limited - this was the approach used for valuing individual NEB categories as well as the overall totals.

One potential problem associated with each approach is the issue of "adding up." Generally, when asked the value of individual benefits, the total is greater than the figure that respondents provide when answering a question about the total of all the benefits. That is, the sum of the parts is greater than their estimated totals. The issue is addressed by normalizing the individual benefits - reducing their values proportionally to add to the estimated total benefits as valued by the respondents. Both individual and total benefits were asked in association with estimating the NEBs for the Program to allow for this normalization.

A final methodological issue relates to the issue of "net" non-energy benefits.[154] The appropriate approach for attributing NEBs to the program is to provide estimates that are "net" in three ways.[155]

- **Net Positive and Negative**: First, despite the historical name for these impacts (non-energy benefits), both positive and negative impacts must be incorporated.[156] Both positive and negative impacts are explicitly requested - for each individual NEB and for the total of all NEBs - there is no presumption of a positive effect. The results are the combination of positive and negative valuations.

- **Net above New Standard Equipment**: Second, to attribute the impact due to the program, the respondents need to be asked about the NEBs for the new efficient equipment relative to the base non-efficient equipment that would

[153] Bicknell and Skumatz, “Non-Energy Benefits (NEBs) in the Commercial Sector: Results from Hundreds of Buildings”, Proceedings from the ACEEE Summer Study, Asilomar, CA, 2004 and sources mentioned therein.

[154] These nuances are important components of the proper evaluation approach and have been incorporated into this NEB research.

[155] Skumatz, Lisa A., “Methods and Results for Measuring Non-Energy Benefits in the Commercial and Industrial Sectors”, Proceedings of the ACEEE Industrial Conference, West Point, NY, July 2005.

[156] The term we use is ”net non-energy benefits” (NNEBs) but we will refer to them as ”NEBs” in this paper. Over a 10 year period, we have developed effective (proprietary) methods of asking these questions and valuing the responses. In addition, a model “NEB-It”© is used to compute values.

otherwise have been purchased. The appropriate comparison is generally not the new efficient equipment but standard equipment that might have been installed.[157] The respondents are asked to specify the net non-energy benefits from the energy efficient equipment installed through the program - above and beyond the effects they would have realized from installation of a standard efficiency model. While it is true that this may be somewhat difficult for respondents to answer, it is the appropriate comparison for the program to make. It is important to note, however, that it is also a conservative approach.

- **Net of Free Ridership / NTG Considerations**: A third adjustment is also appropriate. If there are free riders that would have purchased the same equipment without the program, then the NEBs associated with that equipment should not be attributed to the program. Only those benefits from installations that would not have happened without the program's influence should be attributed to the program, so the NEBs associated with free riders should be omitted, and net to gross ratios could appropriately be applied.

To account for this last effect, we used the free ridership and net to gross figures computed earlier in order to provide a fully attributable estimate of the program's NEB effects.

In this study, care was taken to assure that the non-energy benefits that were attributed to the program were not intentionally overstated or biased.

Overview of NEBs Impacts

Three elements of valuation of the NEBs are explored, including:

- Percent reporting positive vs. negative effects in NEBs, by category,
- Share of the value represented by each NEB category, and
- Total value of the NEBs.

Results from each analysis are discussed below, as well as implications of the results.

Percent Reporting Positive and Negative NEBs

Both participants and non-participants were asked whether they associated negative, positive, or no non-energy impacts with the ENERGY STAR® equipment and measures. The directions (negative, no or positive impact) of the non-energy effects reported by program participants and non-participants are presented in the Table below. Participants were asked whether they experienced any differential effects from using high-efficiency equipment instead of standard equipment; responses from non-participants were based on their perceptions of differences between ENERGY STAR® energy efficient compared to standard new equipment.

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[157] However, some caveats are needed, depending on how the work is to be used. It may be that in the case of residents that would not have purchased new equipment at all without the program, a case may be made that for participant NNEBs, they recognize all the change from old equipment to the new efficient equipment. Also, if the measures would not have been installed for a period of time, the full NNEBs may be appropriately credited (as should the savings) during the interim. However, these are fine points on the principles discussed above.

	Participants			Non-Participants		
Category	**Negative**	**No Effect**	**Positive**	**Negative**	**No Effect**	**Positive**
Operating cost (other than energy)	8%	25%	67%	0%	40%	60%
Equip maintenance	0%	64%	36%	60%	20%	20%
Equip Performance	0%	55%	45%	0%	100%	0%
Equip Lifetime	0%	55%	45%	0%	100%	0%
Occupant satisfaction	0%	27%	73%	0%	40%	60%
Occupant Comfort	0%	27%	73%	0%	40%	60%
Aesthetics / Appearance	9%	82%	9%	0%	80%	20%
Lighting / Quality of Light	30%	40%	30%	0%	60%	40%
Noise	0%	27%	73%	0%	100%	0%
Building Safety	0%	100%	0%	0%	100%	0%
Ease of leasing/selling	0%	57%	43%	0%	40%	60%
Doing good for environment	0%	30%	70%	0%	25%	75%
Power quality / reliability	0%	78%	22%	0%	100%	0%

Table 150: Direction of NEBs

Participants: Participants noted environmental benefits, operating cost, comfort, occupant satisfaction and noise reduction as among the most commonly positive categories associated with the program. In each of these categories, more than half of those surveyed reported a positive effect. Comfort-related effects and the effect of "doing good for the environment" were each rated as positive by more than 70% of respondents, punctuating the idea that some of the most important consequences of the program are distinct from the goals of increased energy efficiency and cost savings, at least in the eyes of program participants.

Few reported experiencing any effects, positive or negative, in building safety, aesthetics or power quality. For every other category, nearly half of those surveyed reported experiencing some effect. The only categories for which negative effects were reported were light quality (30%), non-energy operating costs, and appearance (8-9%). For each of these categories, however, a greater percentage of respondents reported experiencing positive effects than did negative effects.

Non-Participants: Non-participants were most likely to associate positive benefits in the form of improved appearance and doing good for the environment, as well as lower non-energy operating costs, occupant satisfaction, comfort, and ease of selling / leasing the dwelling. For each of these categories, half or more thought the energy efficient ENERGY STAR® equipment delivered positive NEBs compared to standard efficiency equipment. Few thought there were positive effects from performance, lifetime, noise, safety, or power reliability effects.

Almost half were concerned about non-energy operating costs, and one-fifth of the non-participants feared the energy efficient equipment would have more troublesome maintenance than standard equipment. Recall, however, that there were relatively few non-participant respondents.

Relative Values of the NEBs by Category

The table below shows the proportion of the total NEBs reported by program participants attributable to the various NEB effects categories. After the respondents were asked – category by category – whether they associated negative, positive, or no non-energy effects with the energy efficient ENERGY STAR® equipment, those reporting non-zero impacts were asked a follow-up question. If their response was positive, they were asked whether the NEB was more or less valuable than the incremental energy savings associated with the ENERGY STAR® equipment, and how much more or less valuable, using a relative scale (much more, much less valuable, etc.). If their response was negative, they were followed up with requests for information about whether the NEBs were more (or less) costly than the energy savings, and how much more or less costly. The relative answers are then translated into average percentages or ratios using SERA's empirical research on more than 50 programs, and the results are incorporated into SERA's "***NEB-It***"© model. The percentage of total value associated with each NEB category is presented in the Table.

The results show that the total NEBs value is distributed fairly evenly across categories, with no one category garnering an especially high or low share. Operating costs, equipment maintenance, equipment lifetime, occupant satisfaction, quality and quantity of light, and environmental benefits were the most valuable categories, each taking close to at least 10% of the total NEBs value associated with the program. The least valuable categories were building safety and power quality, each of which accounted for only 1% of total NEBs.

Category	Participants	Non-Participants
Operating Cost	13%	7%
Maintenance	7%	7%
Equipment Performance	9%	8%
Equipment Lifetime	9%	8%
Occupant Satisfaction	11%	8%
Occupant Comfort	4%	8%
Aesthetics	4%	8%
Light Quality	9%	8%
Noise	7%	8%
Building Safety	1%	8%
Ease of Selling/Leasing	5%	7%
Helping the Environment	11%	7%

Category	Participants	Non-Participants
Power Quality/Reliability	4%	8%
Other	1%	0%
Total	100%	100%

Table 151: NEBs Shares

Overall NEBs Value Estimates

The data were used to estimate the value of the total NEBs perceived by participants. Responses to several questions were used:

- Verbal scaling responses to whether the total NEBs are more or less valuable than the energy savings; and
- Percentage responses to whether the total NEBs are more or less valuable than the energy savings.

For the percentage responses, the average percent (including both positive and negative responses) was computed to derive the overall NEB energy savings multiplier. The verbal responses were analyzed as described above. The results provide the value of total NEBs as a multiple of energy savings attributable to the program.[158]

The table below presents a summary of the estimates of the total value of the program-attributable NEBs in terms of the perceived energy savings due to the program. Using the comparison technique described in the methodology section, respondents were asked to describe the NEBs that they experienced in terms of the energy savings arising due to the energy efficiency improvements implemented in their housing project.

- The total value of the NEBs experienced by participants was 96% of the energy savings that occurred as a result of building energy efficiency improvements, based on the verbal scaling results.
- The value reported by non-participants was 92% of the energy savings.
- Using the percentage responses from participants, the estimated value of the NEBs was 72% of the value of the energy savings. The computed value from non-participant responses was 55%.[159]

Adjustments for Net Attributable Effects: Earlier in this report the net-to-gross (NTG) ratio was computed. The results showed that free ridership was 47%-53% (half the savings associated with the program would likely have occurred without the program). In addition, the results showed induced market effects of about 17-34% from the program. The resulting NTG ratio is 55%-71%, a ratio that represents the share of program monitored energy savings that could be attributed to the impacts of the program.

Combining the NEBs estimates and the NTG results, an adjusted figure for NEBs is computed and is presented in the Table.

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[158] In addition, responses to willingness to pay questions were examined. There were too few responses to report.

[159] In most previous work, the results from the percentage and verbal scaling methods are more similar. The results in this report likely suffer from small sample size issues.

Category	Value
A. Computed value of NEBs (participants)	96% of program energy savings
B. Free ridership (from Table 6.8)	47%-53% of total energy efficiency improvements
C. Market Effects (from Table 6.8)	17%-34% market effects
D. NTG (from Table 6.8; B*C)	55%-71%
E. Attributable Total NEBs value multiplier (A*D)	53% to 68% of program energy savings
F. Percentage-based value	72% gross; 40%-51%

Table 152: NEBs Value Estimates

Summary and Implications

These results imply that the program's benefits go beyond providing efficiency and energy savings to homeowners. On a per-household basis, the program's measures and practices lead to benefits that are worth another 96% of the value of the energy savings. Additional computations can estimate the NEBs that are "attributable" to the program – taking account of free ridership and potentially indirect market effects impacts. These computations derive an estimate of an additional 53% to 68% in added value from the program's array of non-energy impacts that accrue to residents. The NEBs add to the benefits side of benefit-cost analyses, suggesting that participants recognize significant additional benefits from the program beyond simply energy savings.

The NEB results indicate that the builders perceive the most valuable of the non-energy impacts in homes include lower operating costs, positive benefits from "doing good" for the environment, improvements in equipment (lower maintenance, longer equipment lifetimes, and better performance), and improved satisfaction with the dwelling. These impacts – particularly the comfort benefits – may be important to include in program materials to help encourage participation.

The tables of results in this section suggest several points about the NEBs arising from the ENERGY STAR® Program:

- **In general, satisfaction with the non-energy effects of the program is high.** Negative effects were reported for only two of the categories discussed, and in each instance of a negative report, a much greater percentage of those answering the question reported a positive effect for the same category.

- **Equipment effects are important to participants.** A substantial proportion of the participants surveyed reported positive effects relating to the operating costs, maintenance, performance and lifetime of the equipment that was installed under the program. Cumulatively, these equipment effects comprised almost 40% of the total NEBs associated with the program.

- **The environmental effects of the program are also important to participants.** About 70% of respondents claimed positive effects from "doing good for the environment" as a result of participating in the program. Furthermore, the same environmental benefit category accounted for 11% of the total program-attributable NEBs.

- **There are differences in NEB perceptions between participants and non-participants:** The results show that there are several areas in which participants and non-participants have different perceptions about energy efficient equipment.
    - Non-participants are considerably less positive about non-energy operating costs changes, occupant satisfaction, and environmental effects than participants; however, the non-participant sample is very small, so differences are only indicative.
    - Participants are less positive about aesthetics and comfort (as well as power quality and safety) issues than non-participants;
    - Participants and non-participants had fairly similar perceptions about the effect of energy efficient ENERGY STAR® equipment on maintenance, performance, lifetime, light quality, and ease of selling / leasing the buildings/units.

These results imply that concerns about the equipment and its features (including operating costs, aesthetics, and lighting) may represent "barriers" to adoption of energy efficient equipment for participants. Non-participants perceive operating costs and maintenance as barriers. If energy efficient ENERGY STAR® equipment does not, in fact, perform worse in these areas, then education or outreach may be needed to change these perceptions among non-participants. If, however, there are performance issues associated with energy efficient ENERGY STAR® equipment, then the program information (and potentially incentives) may be needed to address the barriers.

These results can be used in several ways.

- Benefit-cost analysis (and associated payback) shows a significantly higher return to program participants than an analysis of energy savings alone. In gross terms, benefits are nearly doubled; in net terms the benefits are increased by half to two-thirds.
- Program marketing materials should emphasize the strong NEBs including: operating costs, satisfaction, doing good for the environment, performance, and equipment lifetimes.
- Program outreach or design should incorporate methods to address perceived barriers reported by non-participants (maintenance, and non-energy costs). The issues may be addressed by education; however, if the barriers represent real problems, program incentives may be needed.