PG&E Residential New Construction Program Impact Evaluation

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Pacific Gas & Electric's 1992 Residential New Construction (RNC) Program was a comprehensive program that delivered significant summer energy savings and peak reduction. The Program encouraged builders to exceed Title-24 cooling efficiency standards by at least 10% by installing measures such as high-efficiency air conditioning with increased insulation levels. Incentives for premium-quality high-performance windows were also available once the 10% minimum improvement had been achieved. In 1992, nearly 10,000 participants had completed construction and been paid a rebate.

A comprehensive impact evaluation was performed for the 1992 Program, based on collection of extensive data from participants and nonparticipants. These data included billing, site audit, tracking system, survey and end-use and whole-premise load data. Unlike many other new construction program evaluations, these data allowed development of baseline *and* enhanced engineering simulation models from participant and nonparticipant characteristics and energy usage. Because end-use metering data were collected, *both* baseline and enhanced (including installed Energy Efficiency Measures [EEMS]) MICROPAS3 models were calibrated. Using these models, customer-specific engineering adjustment factors were developed by running minimum and maximum parameter values for key selected parameters (e.g., percent glass, window shading). Combining the participant data with the adjustment factors allowed site-specific and measure-specific impacts to be calculated. Net-to-gross issues were also addressed. The statistically-adjusted engineering (SAE) analyses have produced realization rates by customer segment and climate zone.

Introduction

Pacific Gas & Electric Co.'s (PG&E's) RNC Program consisted of two components through December 1992, the PG&E California Comfort Home (CCH) and High Performance Window (HPW) Programs. The RNC Program was designed to deliver significant summer energy savings and peak reduction. It offered incentives to builders for installing energy efficient features that exceeded Title-24 standards by at least 10% of the cooling budget.

The RNC evaluation was conducted for PG&E by Quantum Consulting Inc. and employed integrated evaluation techniques which used engineering estimates, load data, and billing analysis to produce a robust overall estimate for program savings. This paper describes the development of a method to extrapolate the survey-based engineering model, using the program participant information, to supply participant-specific engineering estimates for use in the billing analysis. This approach maximizes the use of available data for improving the impact estimate. This paper also summarizes the results of the impact evaluation of the program through the end of 1992.

Evaluation Approach

This paper covers the CCH and HPW program components from their introduction in the spring of 1991 through December 1992. Figure 1 illustrates the contribution of each intermediate analysis step to the integrated impact analysis.

Engineering Analysis estimates the energy and demand impacts in the absence of participants' behavioral responses to the program measures (such as snapback and free-ridership effects). The engineering analysis hourly simulation model estimates prototypical homes with energy-usage patterns that are subject only to day-to-day variation in weather. The effects of individual household occupancy patterns are not modeled. That is, the engineering analysis accounts only for the physical change—not behavioral change—in energy usage attributable to program measures.

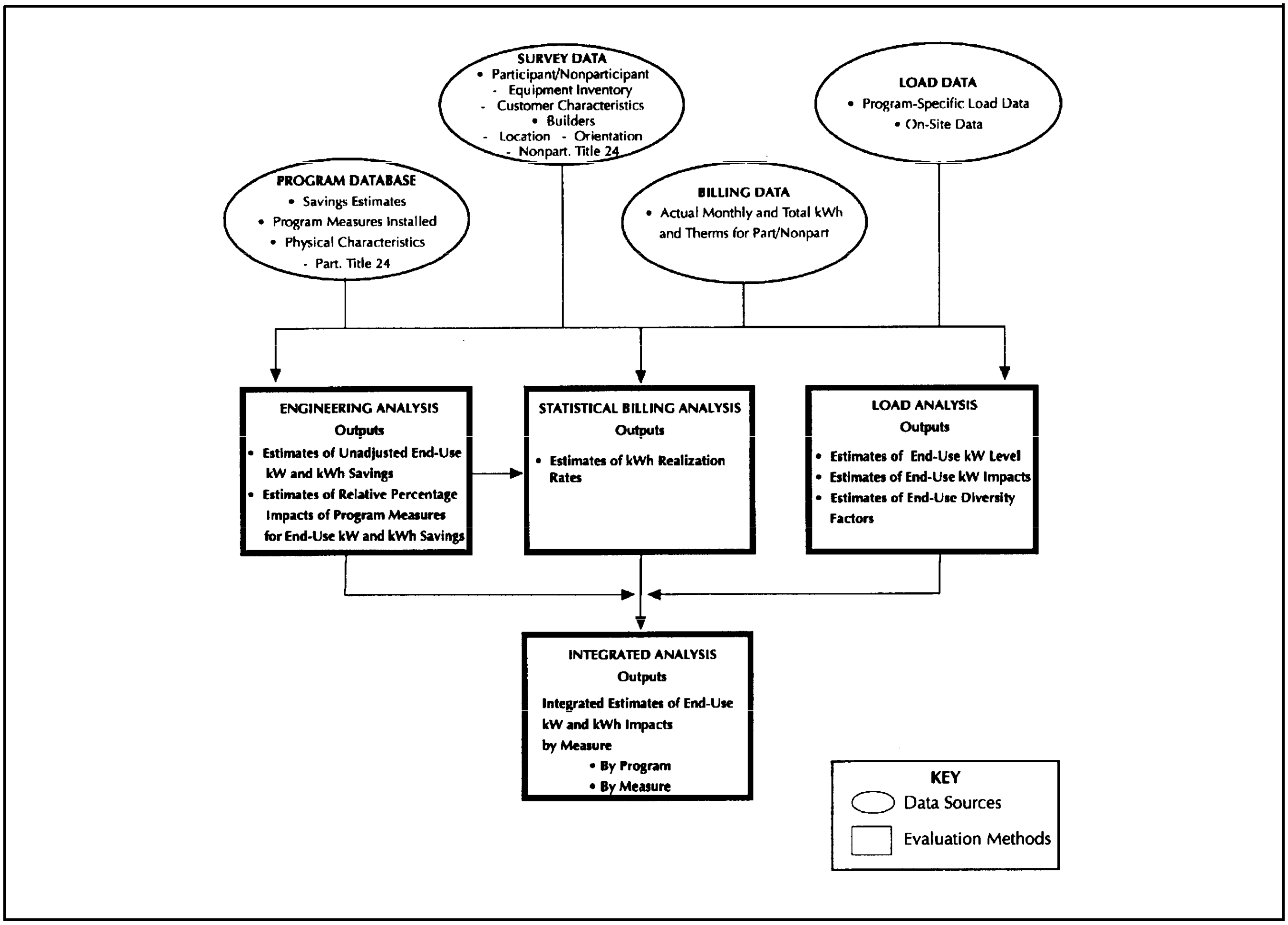

Figure 1. Integrated Impact Evaluation Approach

Statistical Billing Analysis produces estimates of kWh realization rates and accounts for participants' occupancy patterns and behavioral responses to program measures; and changes in baseline energy usage through the use of a comparison group of nonparticipants.

Load Analysis produces end-use specific estimates of demand (kW) impacts and diversity factors. These estimates were used to calibrate the engineering models to better simulate actual usage patterns and estimate coincident system peak demand impacts.

Integrated Analysis combines the outputs of the intermediate analyses to produce a comprehensive, systematic estimate of the energy and load impacts by measure for all participants in the program.

Data Sources

Five key data sources were used in the evaluation to perform the intermediate analysis steps which led to the integrated impact results. Table 1 illustrates the data sources used in the RNC evaluation.

Table 1. Integrated Impact Evaluation Data Sources

Data Source	Participant	Nonparticipant
Tracking System	9,534	N/A
Customer Survey	616	653
Builder Survey	66	50
Billing Data	616	653
Load Data - Summer 1993	114	124

The PG&E Tracking System (Program database) contained technical information on participant unit shell and appliance characteristics: (1) Title-24 plan-check estimates of baseline (initial design without program measures installed) and enhanced (approved program design with program measures installed) cooling kWh and heating therms; (2) program measures installed-insulation levels, AC SEER rating, window U-value; (3) other characteristics of homes such as climate zone, single/multi-family, production/custom, and square footage; and (4) Calculation of kW savings.

Survey Data were collected from participant and nonparticipant occupied units and directly from builders: participant and nonparticipant data, including appliance holdings, household characteristics, occupancy patterns, and attitudes; and participant and nonparticipant builder surveys contributed information on location and orientation of metered participant and nonparticipant homes, Title-24 information on nonparticipant homes, and the builders baseline building practices.

PG&E billing data contributed monthly energy usage for participant and nonparticipant occupied units included in the metered and survey samples and the participant database.

Load data were collected for the key participant segments, representing the largest share of units in the program, to calculate air conditioner (AC) operating factors. On-site surveys were conducted for all metered sites in order to further document site characteristics. In 1993, the metered sites included 114 participant and 124 nonparticipant units; 90 sites included AC end-use metering. Air conditioner load data were produced from the remaining sites by using QC'S HELP™ disaggregation algorithm. Figure 2 shows participant and nonparticipant AC load profiles for a weekday in June 1993. As illustrated, the nonparticipants' load exceeded the participants' load by a substantial margin during the period between 16:00 and 18:00.

Participant Segmentation

Participants were segmented by climate, building type, and program component. The sample allocation targeted California Energy Commission (CEC) Climate Zones 11, 12, and 13, representing 81% of the total participation. These climate zones represent the majority of the central valley of California and the hottest climates in the PG&E service territory. Climate Zone 12 had the coolest summer temperatures. Production homes were the primary target market and were expected to represent the majority of the participation, accounting for 80% of paid program participation, with production homes comprising the majority of these units. The whole-premise and end-use meter allocation was limited to single-family production homes, since these units would introduce less variability into the sample while representing a larger population of participants.

Engineering Analysis Approach

The engineering analysis was performed to provide the basis for estimating customer-specific electric and gas energy consumption and summer peak demand. The overall impact evaluation then utilized customer-specific estimates of savings for use in the statistical billing analysis. The engineering analysis followed the approach illustrated in Figure 3, with the five steps summarized as follows.

1. Develop a MICROPAS3 nonparticipant model based on the characteristics of the metered sample of buildings, the actual weather with one prototype developed for Climate Zone 12. The nonparticipant model was calibrated using load data collected for Climate Zone 12.

2. Adapt the calibrated nonparticipant model to *create* the participant baseline, by adjusting the non-programmatic building characteristics-such as square feet and number of stories–and of the calibrated nonparticipant model to those of the participant metered buildings. This model then represents the *baseline* for the participant population.

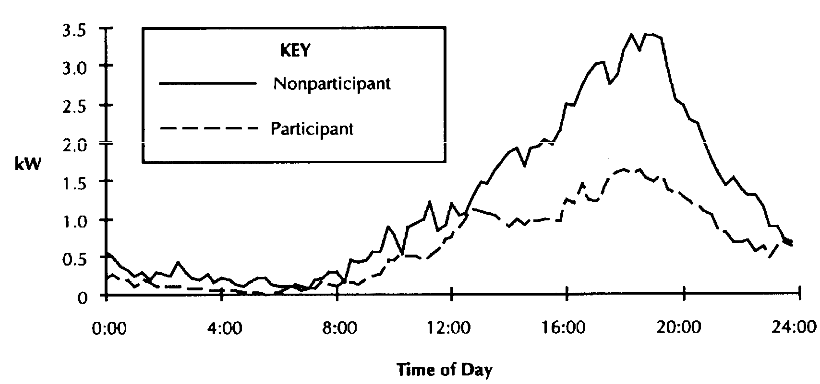

Figure 2. PG&E California Comfort Home Program Air Conditioner Load Profiles

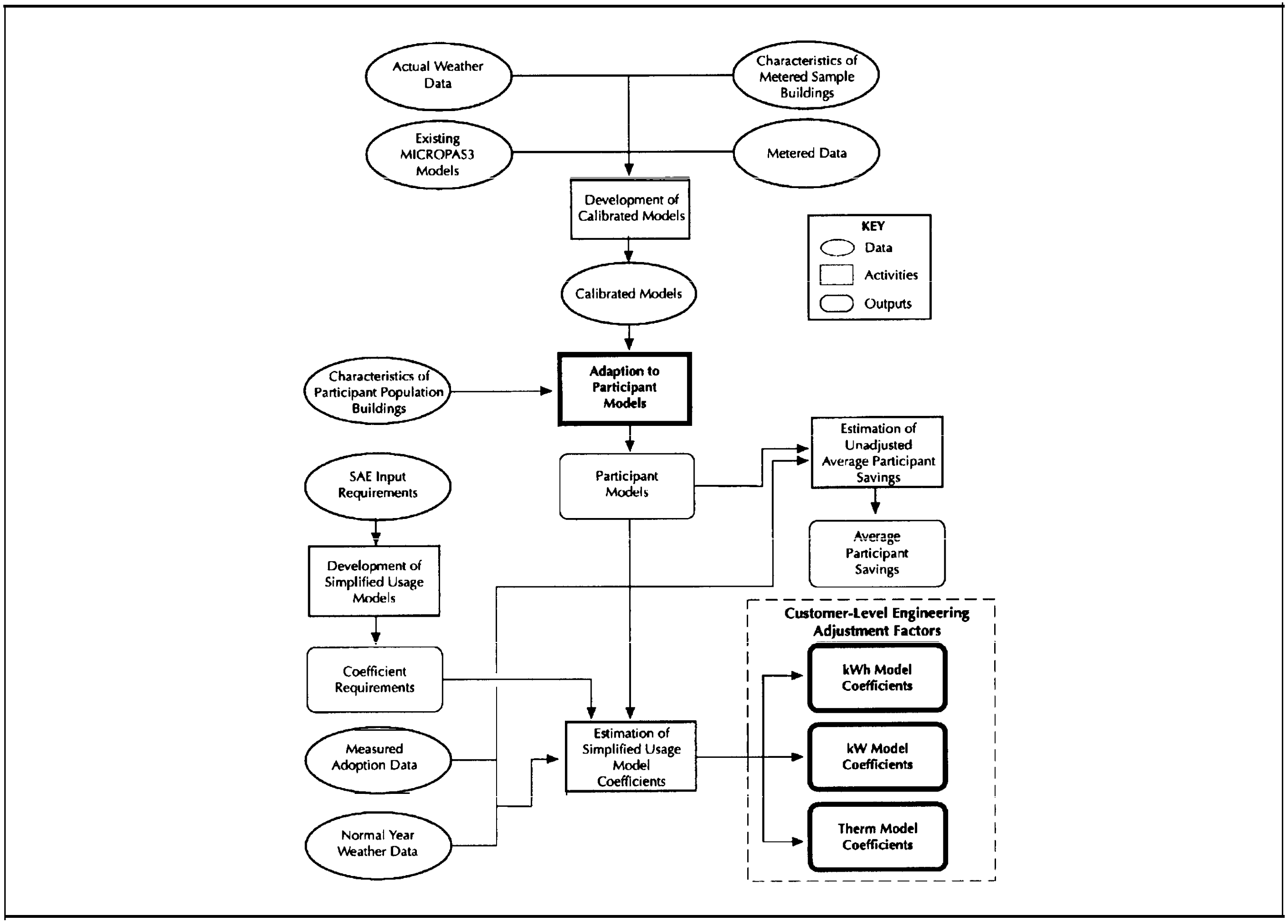

Figure 3. Overview of Engineering Analysis Approach

measures—such as air conditioner SEER and R-Values of insulation.

4. Utilize the participant and baseline engineering models to estimate the unadjusted impacts by segment.

5. Develop customer-level engineering adjustment factors estimated through simulations of prototypical homes that vary the key model inputs. These factors are then used to calculate energy-use estimates for each unit used in the analysis.

The customer-level engineering adjustment factors were used to simulate every building in the paid-participant population. This approach was employed because the large number of participants in the program made participant-specific full MICROPAS3 simulations impractical. The adjustment factors were developed as follows. The PG&E database was analyzed to identify key building parameters that were available for most participants in the program. Five key parameters were selected and minimum, maximum, and average values were computed. These parameters were: percent glass, wall U-value, roof U-value, window U-value and window shading coefficient. While holding four of the parameters at the average values, MICROPAS3 simulations were conducted at the minimum and maximum values for each parameter. This allowed for the development of customer-level engineering adjustment factors for each parameter. The customer-level engineering adjustment factors were then used to compute an adjusted engineering estimate for each participant in the program. Average values were used for participants that were missing data for the key factors.

Cooling Energy Savings by Measure and Climate Zone

The SEER improvement from the CCH Program was the dominant effect in the RNC Program. The engineering estimates of cooling energy savings, by measure and climate zone, are illustrated in Figure 4. SEER improvement made the most substantial contribution to cooling energy savings, ranging between 67% and 71%, depending on climate zone. The HPW Program was the second most significant measure in Climate Zones 11 and 12. HPW Program participation in Climate Zone 13 was

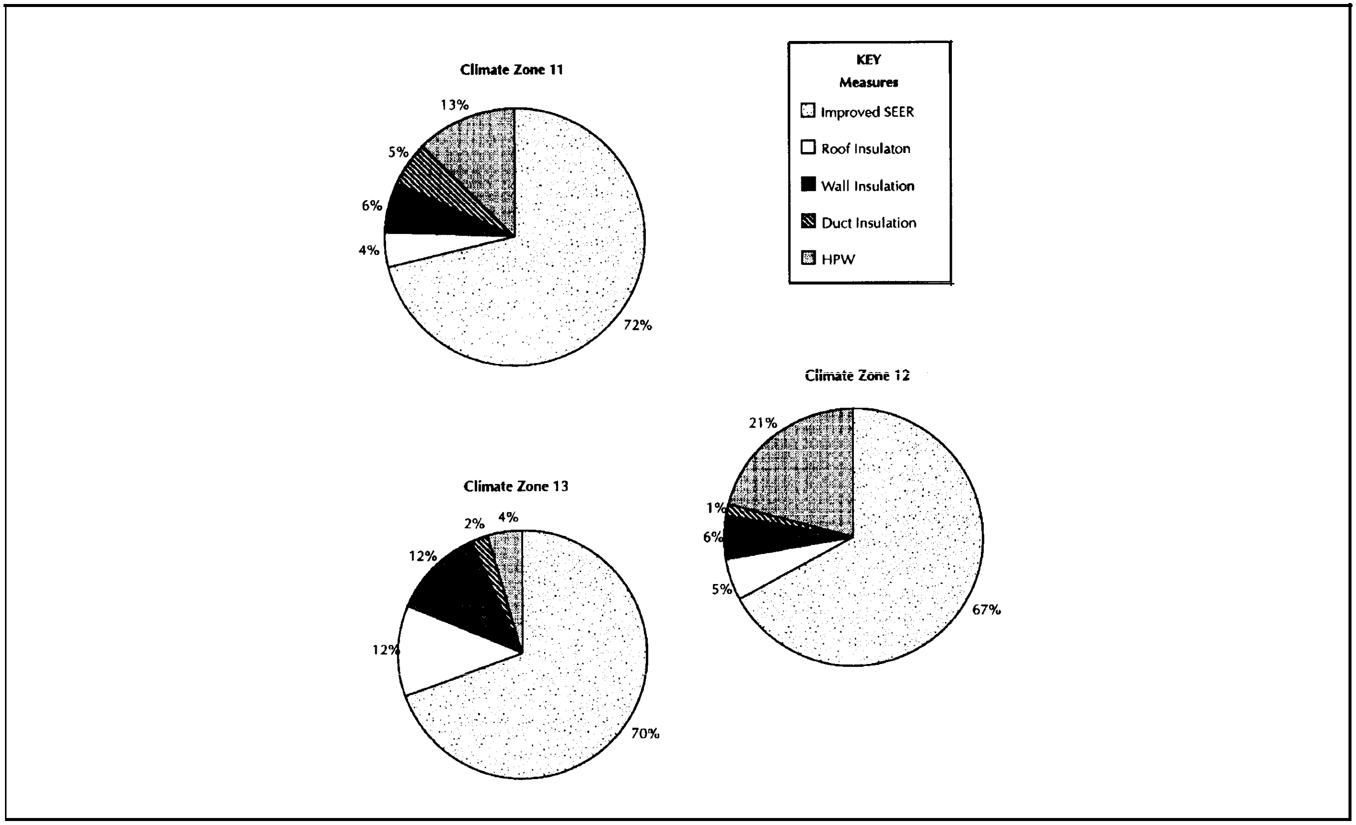

Figure 4. Engineering Estimates of Cooling Energy Savings by Maeasure and Climate Zone

substantially less than that in Climate Zones 11 and 12. Roof and wall insulation both had a larger (and equal) share of the percentage savings, as a result of the low participation in the HPW Program.

Heating Energy Savings by Measure and Climate Zone

The primary program component that contributed to heating energy savings was the HPW Program. Heating energy savings were driven by the HPW Program in all areas, with contributions ranging from 44% to 84%, as shown in Figure 5. The difference in participation levels for the HPW Program was most evident in the differences across climate zones. For Climate Zone 13, which had the lowest HPW Program participation, the other insulation features made a more significant contribution to the heating savings. Wall insulation was the second most significant contributor to heating savings.

Peak Demand Savings by Measure and Climate Zone

The large contribution of the SEER impacts to load reduction was shown in the peak demand reduction contribution in all climate zones. The engineering estimates of peak demand savings, by measure and climate zone, are illustrated in Figure 6. The relative contribution of the individual measures to the overall kW demand savings were similar to the contribution to cooling energy savings. The contribution of SEER improvement was greater for peak demand than for energy savings. The demand savings presented here were calculated as the average impact from 17:00 to 18:00.

Preliminary Integrated Results

By December 1992, when the original program had finished, the preliminary total estimated energy and load savings of the 9,534 Paid Units are shown in Table 2.

Table 2 shows that the ex ante energy estimates overstated the ex post electric results by over one-third, and understated the thermal results by one-third. The ex ante peak load estimate is comparable to the ex post impact, due principally to the limited amount of load data available for the 1992 evaluation. The ex post load impacts shown should not be interpreted as statistically-adjusted estimates in the same sense as the energy impacts. The Summer 1993 load data analysis will support specification of a more robust SAE model so reliability of the impacts can be better assessed.

The most prominent finding for the 1992 RNC Program was the dominant effect that air conditioner SEER

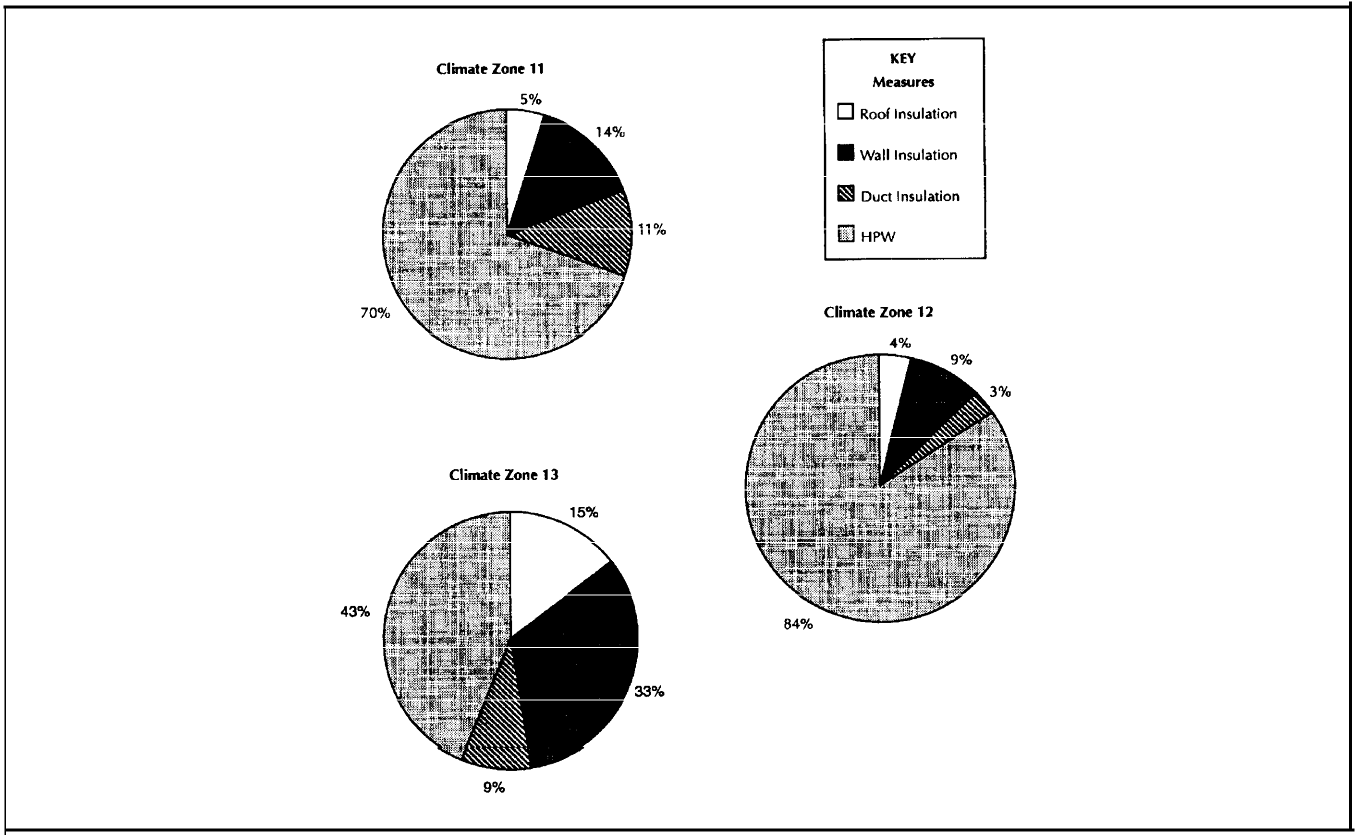

Figure 5. Engineering Estimates of Heating Energy Savings by Measure and Climate Zone

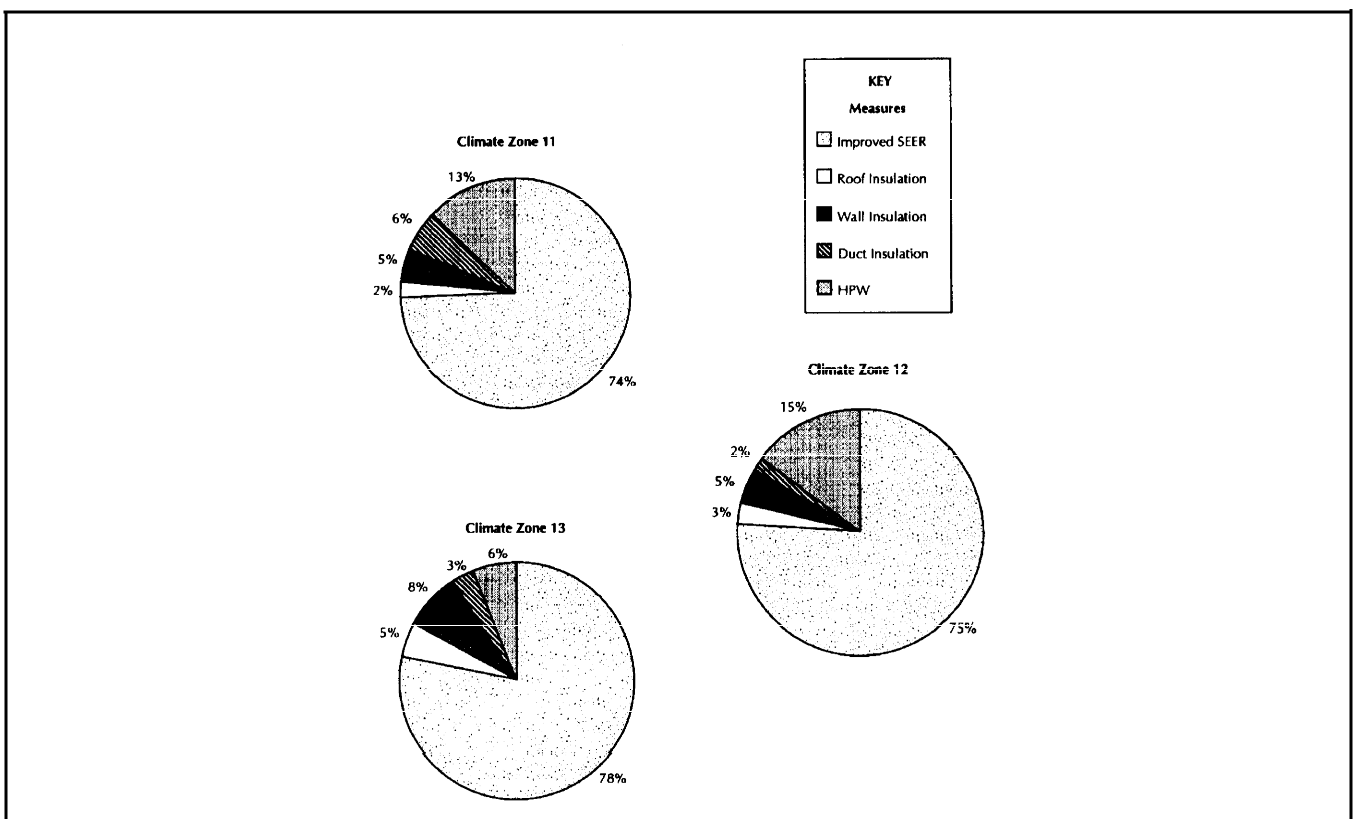

Figure 6. Engineering Estimates of Peak Demand Savings by Measure and Climate Zone

Table 2. Integrated Results for 1992 Program

Impact Type	Units	Ex Ante Estimates from PG&E Database	Ex Post Results Lower 90% Confid. Limit	Mean	Upper 90% Confid. Limit
Electric Energy	GWh	8.9	5.1	6.4	7.7
Thermal Energy	kTherms	350	454	552	650
Peak Load	MW	5.69	NA	5.74	NA

improvement had on the electric energy and demand program impacts. Improvements in the SEER value accounted for 67% to 72% of the cooling kWh energy savings, and 74% to 78% of the kW demand savings. The HPW Program accounted for 43% to 84% of the heating (gas) savings for Climate Zones 11, 12, and 13. The large variation in the HPW Program heating savings was due to low participation in the HPW Program in Climate Zone 13.

In addition, the differences in impacts between Climate Zones illustrate the variety of new home construction practices that are used by builders. This is shown by the different contribution of the HPW Program across Climate Zones. For all three types of impacts, the HPW contribution in Climate Zone 13 is much less than in the other zones.

Finally, the 1992 RNC Program's net-to-gross ratio provides an indication of how the program changed builders' actual compliance with Title-24 efficiency standards. If the ratio were 1.0, then the program has had a very significant effect on all participating units. The net-to-gross ratio for production builders, representing the program's target market, was over 0.95, based on builders' responses to survey questions regarding their historical building practices. The overall RNC Program net-to-gross ratio was 0.97 after responses of custom and production builders were pooled and after adjustment for the Title-24 baseline. Thus, the 1992 PG&E RNC Program appears to have significantly influenced builders to construct more energy-efficient homes than they had built historically.