Whole House Retrofit Impact Evaluation

Evaluation of Energy Upgrade California Programs

Work Order 46

California Public Utility Commission, Energy Division

Prepared by DNV GL - Energy

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# Executive Summary

DNV GL, on behalf of the California Public Utilities Commission (CPUC), conducted an impact evaluation of the 2010-2012 Whole House Retrofit Program (also known as, Energy Upgrade California - EUC) implemented by the California Investor Owned Utilities (IOUs). The scope of the evaluation included conducting billing analysis to determine gross savings and realization rates and surveys to support estimating program free ridership. The key outcomes from this study will meet the CPUC’s requirement for ex post verification of EUC program performance in terms of energy savings and provide IOUs with feedback on areas for possible improvement as they continue with design enhancements.

##### Program Description

There are two main Whole House Retrofit program elements sponsored by the four California IOUs: (1) the Prescriptive Whole House Retrofit Program (PWHRP) or Basic Path, and (2) the Whole House Performance Program (WHPP) or Advanced Path. The overall structure of the programs is similar across the four IOUs, aiming to provide wide-ranging energy efficiency measures to existing California residential dwellings. The main objectives of the program are:

* Promote completion of retrofits based on preferred building science loading order
* Funnel participation to core Energy Efficiency (EE), Demand Response (DR), distributed generation (e.g., California Solar Initiative) portfolios,
* Increase awareness of energy savings retrofits through statewide coordinated marketing campaigns
* Coordinate with communities, local governments, and allied third-parties for outreach on local retrofit and available contractor training opportunities

##### Evaluation Approach

The evaluation approach included two components. The first component was a g*ross savings analysis* that followed a billing analysis approach that addressed the challenges of evaluating a program during the early stage of implementation. Some of the challenges included: (1) no prior cycle program activity, (2) program starting during the middle of the 2010-2012 CPUC program cycle, and (3) program overlap with similar American Recovery and Reinvestment Act (ARRA) funded efforts until late 2012. The billing analysis methods used followed the California Evaluation Protocols and the Evaluation Framework.

The second evaluation component was a *self-reported free ridership analysis* used to adjust the gross savings estimates to net savings estimates. The approach used participant and stakeholder surveys, following best practices for self-report according to the *Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approach*[[1]](#footnote-2). The self-report analysis focused on determining savings attributable to IOU-funded projects and did not fully address the possible overlap with ARRA funding.

##### Key Findings

Below are key findings regarding how the program implementation in terms of the tools used and the current design/incentives are possibly influencing energy savings:

* The program used an energy simulation tool to estimate site specific savings. The tool’s overestimation of energy consumption has been well documented in the ex ante review and IOU process evaluations. The evaluation team found that gross savings were less than expected despite the adjustments that the IOUs made to the ex ante savings. The actual energy consumption, especially electric consumption, is not normally distributed around the average. Therefore, the assumptions the tool made were based on an incorrect average and did not capture the true extremes of high and low usage. This means that for a given home the estimate of savings could be higher than the estimated usage. This idea is further described in the full report.
* The majority of survey respondents scored as partial free riders. Survey responses support that many were planning to do a single measure regardless of incentive, and that the program was responsible for inducing additional measures. Estimated free ridership would be lower if the program claimed only the savings for the additional measures the participants were not already considering prior to the retrofit.
* An analysis of the survey and demographic from the PG&E’s Energy Upgrade California Process evaluation along with results from this study provided additional insight and context to the analysis of the program impacts. We found that when the ARRA funding ended, participation seemed to migrate toward the Pacific coast, toward areas that have higher home values and incomes, but less potential electric savings. These homes tend to have lower savings and little need for financing to help fund projects.

**Program Impacts**

The evaluation results are presented in Table 1. We present results derived from estimating savings using a billing analysis with comparison group approach. We estimated total net savings by applying the gross realization rate and the net-to-gross ratio (NTGR) to the program’s ex ante savings claims. The gross realization rates were different for 2010-11 and 2012 and thus were applied separately in the full report, while this summary provides the totals for the program cycle.

Key findings from the analysis indicated that realizations are very low. The possible reasons for such discrepancies in GRR are that the Advanced path simulation tool overestimates usage and savings even more than that reflected in the ex ante adjustments. The Basic path which did not have ex ante adjustments had a higher realization rate, but the net savings of Basic was not evaluated as this study focused on Advanced path. Overall SCE had the highest realization rates for both paths. One possibility is different QC and QA processes, but the programmatic differences by IOU were not studied. One overall factor for realization rates is participation was more towards the coast than inland so the simulation tool may do a worse job at estimating savings on the coast compared to inland. A hypothesis is that the model does a poor job accounting for operable window ventilation which would explain part of the issue that shows realization rates are worst for PG&E which had participation in areas with good opportunities for night cooling with air conditioning.

We also note that gas realization rates are higher than electric. The incentives are based on relative savings of total site energy so the gas portion would be weighted more heavily than electric savings which may lead to more gas savings. The issues with the overestimation of consumption remain and gas realization rates are still relatively low. This cannot be explained by ventilation, but may have more to do with thermostat setpoints and homes being kept at lower temperatures than model assumptions.

Even though the IOUs may have different approaches for implementing the programs, the Net-to-Gross ratios do not vary that much across IOUs. Partial freeridership appears to be prevalent, but for the Advanced path the freerider measures vary by site.

Table 1: Estimated Savings for the Whole House Retrofit Programs 1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fuel (Unit)** | **Program Participants** | **Total Ex Ante Savings per Year (Adjusted for Advanced)** | **Gross Realization Rate (Relative to Claimed Savings)** | **Net to Gross Ratio (Ex Ante for Basic)** | **Total Gross Savings Per Year** | **Total Net Savings Per Year** |
| Advanced | | | | | | | |
| PG&E | Electricity (kWh) | 2,650 | 4,219,142 | 12.8% | 0.58 | 538,429 | 312,289 |
| Gas (Therms) | 3,618 | 749,510 | 35.6% | 0.58 | 266,637 | 154,649 |
| SDG&E | Electricity (kWh) | 318 | 329,668 | 14.0% | 0.64 | 46,173 | 29,551 |
| Gas (Therms) | 311 | 53,712 | 36.5% | 0.64 | 19,585 | 12,534 |
| SCE | Electricity (kWh) | 692 | 677,269 | 50.3% | 0.68 | 340,397 | 231,470 |
| SCG | Gas (Therms) | 639 | 139,271 | 63.4% | 0.68 | 88,237 | 60,001 |
| Basic | | | | | | | |
| PG&E | Electricity (kWh) | 92 | 12,466 | Not Evaluated | 0.80 | 12,466 | 9,973 |
| Gas (Therms) | 92 | 2,254 | Not Evaluated | 0.80 | 2,254 | 1,803 |
| SDG&E | Electricity (kWh) | 402 | 346,529 | 30.8% | 0.80 | 106,878 | 85,503 |
| Gas (Therms) | 393 | 16,219 | 39.1% | 0.80 | 6,336 | 5,069 |
| SCE | Electricity (kWh) | 1539 | 637,860 | 88.0% | 0.80 | 561,149 | 448,919 |
| SCG | Gas (Therms) | 170 | 2,244 | Not Evaluated | 0.80 | 2,244 | 1,795 |

The evaluation team also made a direct comparison of ex post realization rates to compare to the ex ante disposition for Advanced path. The ex ante review final disposition provided adjustment factors for Advanced path claims which are applied to tracking data through ex ante realization rates. Table 2 compares the ex ante and ex post gross realization rates for Advanced path participants.

Table 2: Realization Rate Comparison for Advanced Path

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fuel (unit)** | **Fixed Effects Model** | | | | | |
| **2010-12** | | | | | |
| **Program Participants** | **Average Ex Ante** | **Savings Estimate** | **Gross Realization Rate** | **Applied Ex Ante Gross Realization Rate** | **Approved Ex Ante Gross Realization Rate** |
| Advanced Path | | | | | | | |
| PG&E | Electricity (kWh) | 2,650 | 2,654 | 203 | 7.7% | 60.0% | 40.0% |
| Gas (Therms) | 3,618 | 345 | 74 | 21.4% | 60.0% | 80.0% |
| SDG&E | Electricity (kWh) | 318 | 2,592 | 145 | 11.1% | 40.0% | 40.0% |
| Gas (Therms) | 311 | 216 | 63 | 34.0% | 80.0% | 80.0% |
| SCE | Electricity (kWh) | 692 | 2,447 | 492 | 34.4% | 40.0% | 40.0% |
| SCG | Gas (Therms) | 639 | 272 | 138 | 69.3% | 80.0% | 80.0% |

**Recommendations**

The below recommendations are based on findings from this impact evaluation and from the Process Evaluations regarding targeted marketing. The impact evaluation showed energy savings to be lower than expected, with the gas savings across program delivery types and IOUs closer to expectations than electric savings which varied. The evaluation also determined that partial free riders comprised a majority of program participants in the Advanced Path.

* The impact evaluation found that like the ex ante disposition and the first IOU process evaluation, the energy simulation software overestimates usage and savings. The evaluation team recommends support for statewide efforts via CALTEST to look at additional software options and program requirements that better predict consumption or that require using billing data to calibrate estimates. Some of the evaluation team members supported these efforts via technical working group. The recommendations suggested in this section require that future estimates are calibrated or are more accurate than current estimates.
* Change from incentives based on percent savings for site energy and provide incentives similar to the non-residential custom programs on a dollar per unit of energy basis ($/kWh and $/therm). Currently the relative savings approach provides the same dollar amount to homes with low and high usage and does not align with the value of electric savings that is part of cost effectiveness calculations. Savings per unit of energy would provide more money to save more energy on an absolute basis and may increase program uptake in hotter climates by properly valuing electric savings.
* Only provide incentives and claim savings for measures that the customer was not already considering. Only modeling the measures the customer would not have done in absence of the program will reduce free ridership. This documentation of which measures the customer would be doing can also support identifying early replacement measures and distinguishing them from replace on burnout. The incentives would also then support “deeper” retrofits as opposed to providing some funding for free rider measures and only partial funding for additional measures.
* Refocus the program toward inland areas with warmer temperatures (high use of cooling) and align financial support (additional incentives/financing) according to available household capital in order to achieve higher net savings.
* Homes with higher consumption near the coast have greater base load than cooling load. For these homes, the program should emphasize measures that focus on advanced lighting, appliances, and electronics to increase site specific savings.

**Conclusions**

Overall, the Whole House Retrofit program as currently implemented is not meeting its energy savings goals. This is caused by a combination of factors that include (a) overestimation of savings in the retrofit planning (building modeling) phase, (b) indications of substantial takeback, and (c) program deployment in mild weather areas where building shell measures are not likely to generate large energy savings.

The process evaluations and this impact evaluation provide recommendations to improve gross and net savings. Many of the recommendations require improved energy estimating tools or estimates calibrated to actual consumption. The programs could consider a scenario of improved savings after implementing tool calibration or improvement, targeted marketing to high users, targeted measures based on location (or more specifically the estimated weather-dependent load), and incentives per unit of energy saved. The normalized annual consumption from this evaluation can be used to review whether higher percent savings would then create substantial changes in program cost effectiveness.

# Introduction

This document presents the impact evaluation of the California investor-owned utilities (IOUs) Program Year 2010-2012 Whole House Retrofit Programs, also known by their marketing name Energy Upgrade California.

The primary objectives of the 2010-12 Whole House Retrofit impact evaluation are to:

1. Evaluate the gross and net savings resulting from the 2010-12 whole house measures and programs
2. Provide feedback to the IOUs on the performance of these programs and their measures to support future program design improvements and future program ex ante impact estimation
3. Support the California Energy Efficiency Strategic Plan Goals

Section 1 of this report (this introduction) includes evaluation and program overviews. Section 2 describes the methodology and results of the gross savings estimates. Section 3 presents the estimation of free ridership based on survey results, and the estimation of net savings. Section 4 summarizes conclusions and recommendations. Last, the Appendix contains materials that enable a deeper view of the evaluation’s methodology and results, such as interim gross impact results, further analysis of free ridership by different customer groups, and the survey instrument that was used to collect attribution data.

## Evaluation Overview

The evaluation included two primary components that were designed to estimate savings while informing future program design.

The first one is a g*ross savings analysis*, which followed a billing analysis approach tailored to this stage of the program. Specifically, the approach addressed the following difficulties: (1) there was no prior cycle program activity, (2) the program started during the middle of the 2010-2012 CPUC program cycle, and (3) there was overlap with similar American Recovery and Reinvestment Act (ARRA) funded efforts until late 2012. The billing analysis methods adhered to the California Evaluation Protocols and the Evaluation Framework.

The second one is a *self-reported free ridership analysis*, which was required to adjust the gross savings estimates to net savings estimates. The approach used best practices such as Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approach[[2]](#footnote-3). The self-reported analysis focused on attribution of savings to the investor-owned utility (IOU) funding and did not fully address the ARRA additional funding issues.

At the time this report was published, the evaluation team is conducting additional analysis of peak savings using interval (smart meter) data from program participants.

This program evaluation addresses the levels of gross and net energy savings achieved by these programs. It does not address other matters that the Energy Division will take into account as it shapes future portfolios, such as cost effectiveness and implementation issues.

## Program Descriptions and Participation

The IOU Whole House Retrofit programs offer a multi-tiered approach for single family homes and two unique approaches for multi-family buildings. They use the Energy Upgrade California (EUC) branding and financing program and the IOU incentive programs. In addition, they tie into California Assembly Bill 758 (AB758), which requires the California Energy Commission (CEC) to develop programs that provide and promote comprehensive retrofits for existing buildings.

The IOUs’ statewide Whole-House Retrofit and Multi-family Programs operated concurrently in 2011 and early 2012 with the CEC ARRA Program. The IOU programs share common goals with the CEC program and AB758, including implementing energy-saving retrofit measures, developing the retrofit workforce, refining and enforcing quality assurance, and creating a market value through building energy ratings and labels for a home’s energy performance.

The IOU and CEC ARRA programs offered packages of prescriptive measures (Basic Upgrade Package) as well as performance-based incentives (Advanced Upgrade Package). The market linkage points of the CEC and IOU programs are the Energy Upgrade California brand and website as well as contractors trained to market both programs to customers. Energy savings estimates, program quality assurance (QA), and program evaluation for IOU programs and ARRA programs were coordinated where practical by the CPUC Energy Division (CPUC-ED) and the CEC.

During the ARRA period which ended March 2012, the IOU programs offered matching rebates to the CEC programs. In some cases, IOU rebates are paired with ARRA Whole House Programs rebates directly. In other cases, the ARRA Whole House Programs funds did not provide direct rebates, but paid to obtain a performance rating that can lead customers to take advantage of IOU Basic and Advanced Upgrade Package rebates and Energy Upgrade California program financing.

CPUC Decision 09-09-047 required the IOUs to include a prescriptive whole-house retrofit program component in their statewide residential program, consistent with the Commission’s guidance.

Pacific Gas & Electric’s (PG&E’s) Whole House Performance Program aims to deliver a set of energy efficiency measures geared to meet the needs of individual households that occupy existing homes. The program has both marketing and an educational component. The program also provides training to contractors through the Energy Training Centers, where the contractors can perform whole-house diagnostics, propose comprehensive residential retrofits, and install energy improvement measures.

Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), and Southern California Gas (SCG) plan to achieve their goal of providing comprehensive energy efficiency improvements to a majority of existing homes in California by 2020.

##### Statewide Program Description

There are two main whole house retrofit paths that are being sponsored by the four California IOUs: (1) the Prescriptive Whole House Retrofit Program (PWHRP) or Basic Path, and (2) the Whole House Performance Program (WHPP) or Advanced Path.

The overall structure of the programs is similar across the four IOUs, aiming to provide wide-ranging energy efficiency measures to existing California residential dwellings to reduce energy consumption. The following descriptions were compiled and summarized from the available program implementation plans. The Basic Path plans to accomplish the following:

* Promote completion of retrofits based on preferred building science loading order
* Offer a holistic path towards home performance by aggregating key elements of a dwelling into its core elements: building envelope and fixed lighting, heating, cooling, hot water, and appliances
* Continuously engage customers over time as they progress toward a home performance approach
* Funnel participation from core Energy Efficiency (EE), Demand Response (DR), distributed generation (e.g., California Solar Initiative) portfolios, increase awareness through statewide coordinated marketing campaigns, and contribute to education and outreach activities with local government partners
* Coordinate with communities, local governments, and allied third-parties for outreach on local retrofit and available contractor training opportunities
* Coordinate with local financing opportunities, as appropriate
* Utilize no-cost (to the consumer) Home Energy Efficiency Surveys (HEES) as an entry point to identify opportunities for efficiency improvements[[3]](#footnote-4)
* Coordinate with the extensive network of heating ventilation and air conditioning (HVAC) contractors already participating in IOU programs
* Provide rigorous Quality Assurance and Quality Control, consistent with the Home Performance with ENERGY STAR® (HPwES) program for elements completed within the prescriptive work scope
* Define the project baseline for existing household energy usage, and
* Be compatible with Home Energy Rating System (HERS) requirements.[[4]](#footnote-5)

Some eligible measures that qualify for PWHRP or Basic Path are:

* Air sealing
* Attic insulation
* Duct sealing
* Insulation of domestic hot water pipes, and
* Combustion safety (no savings)

The Advanced Path builds off the Basic Path and, because it is more customized than the Basic Path, it also accomplishes the following:

* Requires higher levels of contractor training and qualifications
* Requires a commercially available and approved building simulation software and methodology to model site-specific performance and estimate energy savings for the project
* Establishes a project baseline by a “test-in” and “test-out” method compatible with the requirements of the CEC HERS assessments and the national Home Performance with ENERGY STAR® (HPwES) program
* Typically completed in a condensed timeframe
* Provides greater incentives than the Basic Path
* Includes additional measures such as:
* HVAC systems
* Wall insulation
* Floor insulation
* Permanent lighting fixtures and controls, and
* Appliances

As mentioned previously, the residential retrofit programs being offered by the four utilities very closely mirror one another. Both the Basic (“Prescriptive”) Path and the Advanced Path aim to deliver a set of energy efficiency measures geared to meet the needs of individual households in existing homes and reduce energy consumption.

##### Core Programs Budgets and Accomplishments

The Statewide Whole House Retrofit Program is being independently implemented by PG&E, SCE, SCG, and SDG&E under the overall program IDs PGE21008, SCE-SW-001H, SCG 3600 and 3618, and SDG&E 3156 and 3116, respectively. Table 2 below presents the program budget and expenditures for each IOU’s whole house retrofit offering.[[5]](#footnote-6)

Table 3: Program Budgets and Spending by IOU Program through December 2012

|  |  |  |  |
| --- | --- | --- | --- |
| Utility | Program | 2010-2012 Program Revised Budget | 2010-12 Program Expenditure |
| PG&E | PGE21008 | $28,562,757 | $25,310,500 |
| SCE | SCE-SW-001H | $26,125,000 | $7,015,300 |
| SCE-TP-003 | $10,205,994 | $10,664,321 |
| SCG | SCG3618 | $8,000,000 | $2,961,632 |
| SCG3600 | $5,656,350 | $3,375,428 |
| SDG&E | SDGE3156 | $13,000,000 | $5,753,260 |
| SDGE3116 | $2,011,633 | $1,166,401 |

## Final 2010-12 Tracking Savings and Ex Ante Savings Disposition

There were two levels of ex ante savings that the IOUs reported for this program: (a) the energy savings estimates obtained directly from EnergyPro, the software utilized for building energy use modeling, and (b) claimed savings: the EnergyPro results adjusted by the IOUs for the purposes of computing expected energy savings. The utilities applied the following factors to Advanced Path ex ante savings estimates from EnergyPro:

Table 4: Claimed Savings Factors (Gross Realization Rates)   
Applied to Advanced Path (Custom Measures) EnergyPro Estimates

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Approved[[6]](#footnote-7)** | | **Applied** | |
| **Utility** | **kWh** | **Therms** | **kWh** | **Therms** |
| PG&E | 0.40 | 0.80 | 0.60 | 0.60 |
| SCE | 0.40 | - | 0.40 | - |
| SDG&E | 0.40 | 0.80 | 0.40 | 0.80 |
| SCG | - | 0.80 | - | 0.80 |

Table 4 provides energy and demand savings targets and final accomplishments for each utility’s whole house program offerings.[[7]](#footnote-8) The table differentiates between the non-lighting measures, which were the focus of this evaluation, and the lighting measures assessed under the Residential Advanced and Upstream Lighting Impact Evaluation (Work Order 28).

Table 5: 2010-2012 Savings by IOU Program and Measure Group

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Number of Homes (estimate) | Envelope, HVAC, Water Heat Measures | | | Lighting Measures | | |
| Utility and Program | Program Name | Installed kWh Savings | Installed kW Savings | Installed Therm Savings | Installed kWh Savings | Installed kW Savings | Installed Therm Savings |
| PG&E  PGE21008 | Whole House Performance Program | 3,837 | 6,948,112 | 8,658 | 1,249,183 | 83,791 | 6 | - |
| SCE  SCE-SW-001H | Whole House Prescriptive Program | 1,556 | 498,689 | 140 | 2,780 | 139,171 | 15 | (2,131) |
| SCE  SCE-TP-003 | Comprehensive Home Performance | 693 | 677,269 | 1,309 | 54,520 | - | - | - |
| SoCalGas  SCG3618 | Prescriptive Whole House Retrofit | 23 | - | - | 1,480 | - | - | - |
| SoCalGas  SCG3600 | Local Whole Home Performance | 181 | - | - | 26,734 | - | - | - |
| SDG&E  SDGE3156 | Prescriptive Whole House Retrofit | 406 | 355,179 | 120 | 32,429 | 120,086 | 7 | (670) |
| SDG&E  SDGE3116 | Local Whole Home Performance | 314 | 411,665 | 392 | 44,089 | - | - | - |

## 2010-2012 Program Participants

This section describes Energy Upgrade California Whole House program participants in terms of their geographical distribution, timing of participation, and energy consumption. A brief description of the program’s ex ante savings is also included.

### Geographical Distribution

Figure 1 to Figure 3 show the geographical distribution of program participants by zip code in the IOU service territories. Shades of green represent one to 3 participants in a zip code, shades of yellow represent 4 to 20, orange represents 21 to 40, and red represents 41 or more participants in the same zip code. There are 1,300 zip codes with at least one program participant in California. The top six zip codes have 50 program participants or more.

Figure 1: Distribution of 2010-2012 Program Participants   
in the PG&E Service Territory

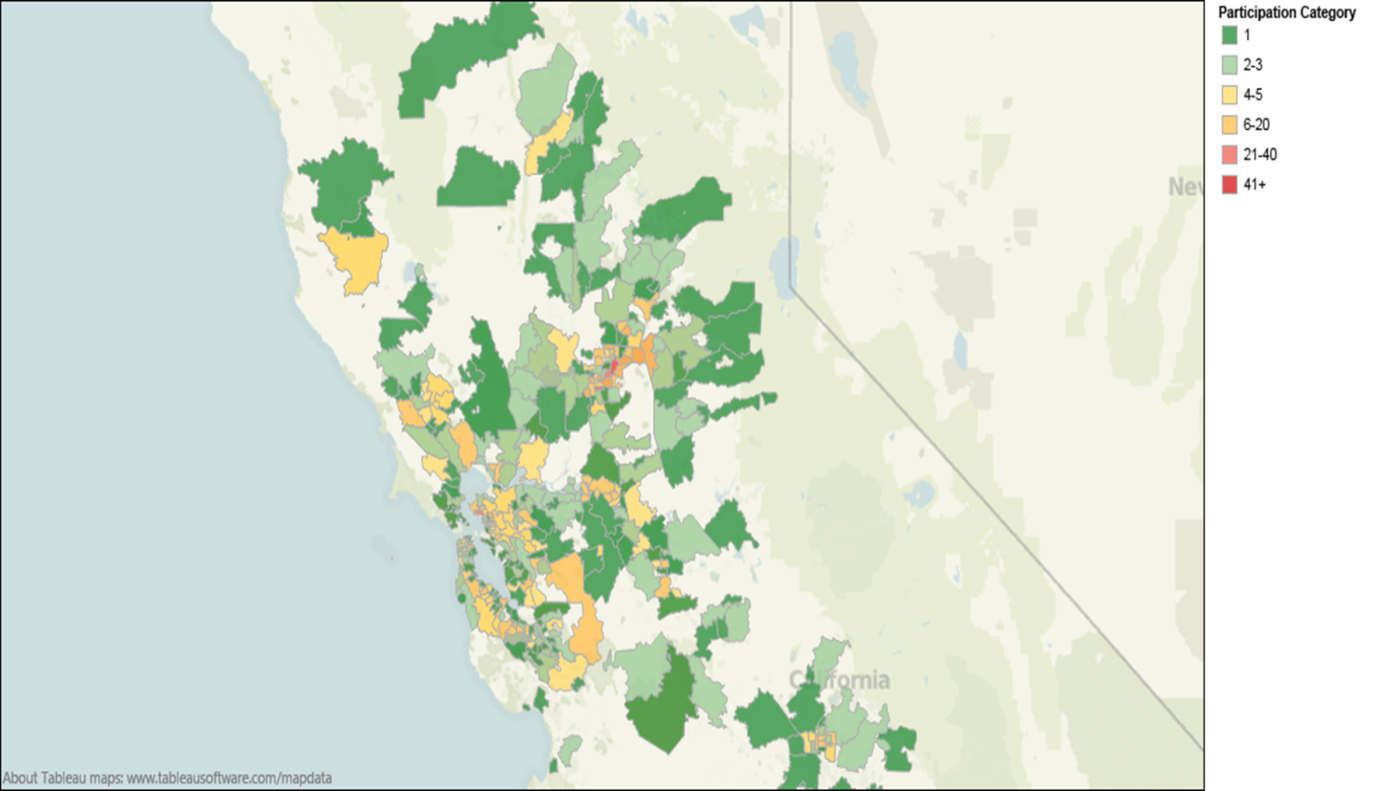
=

Figure 2: Distribution of 2010-2012 Program Participants   
in the SCE Service Territory

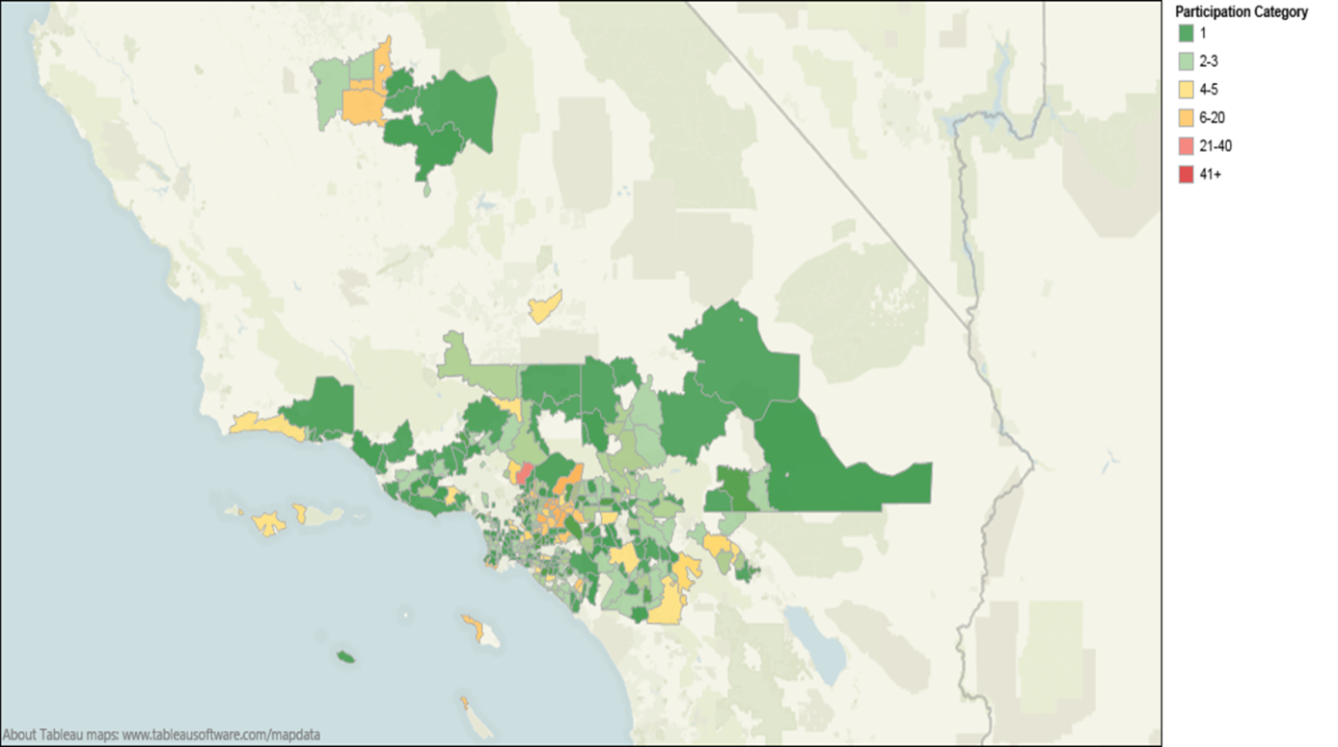
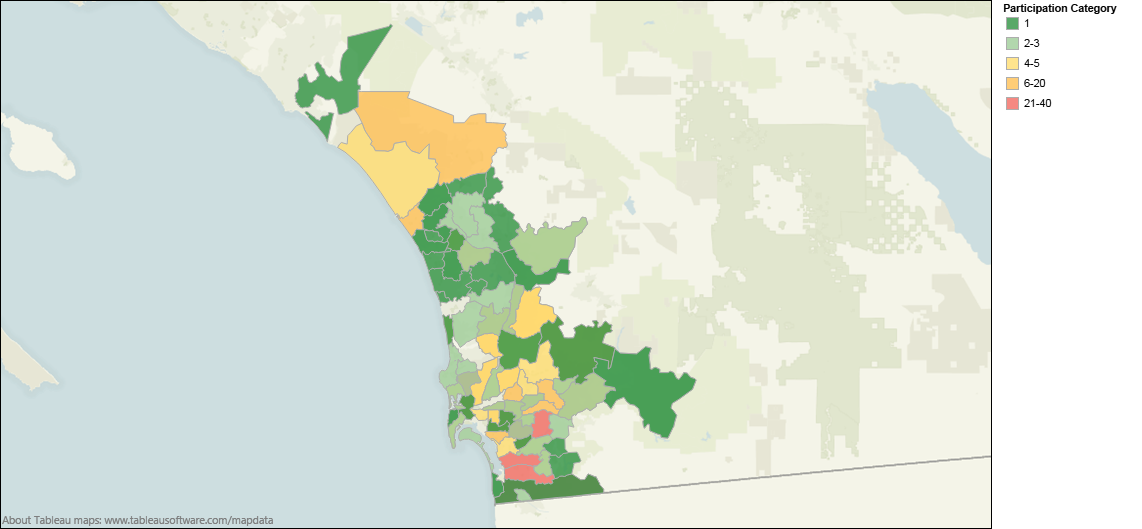
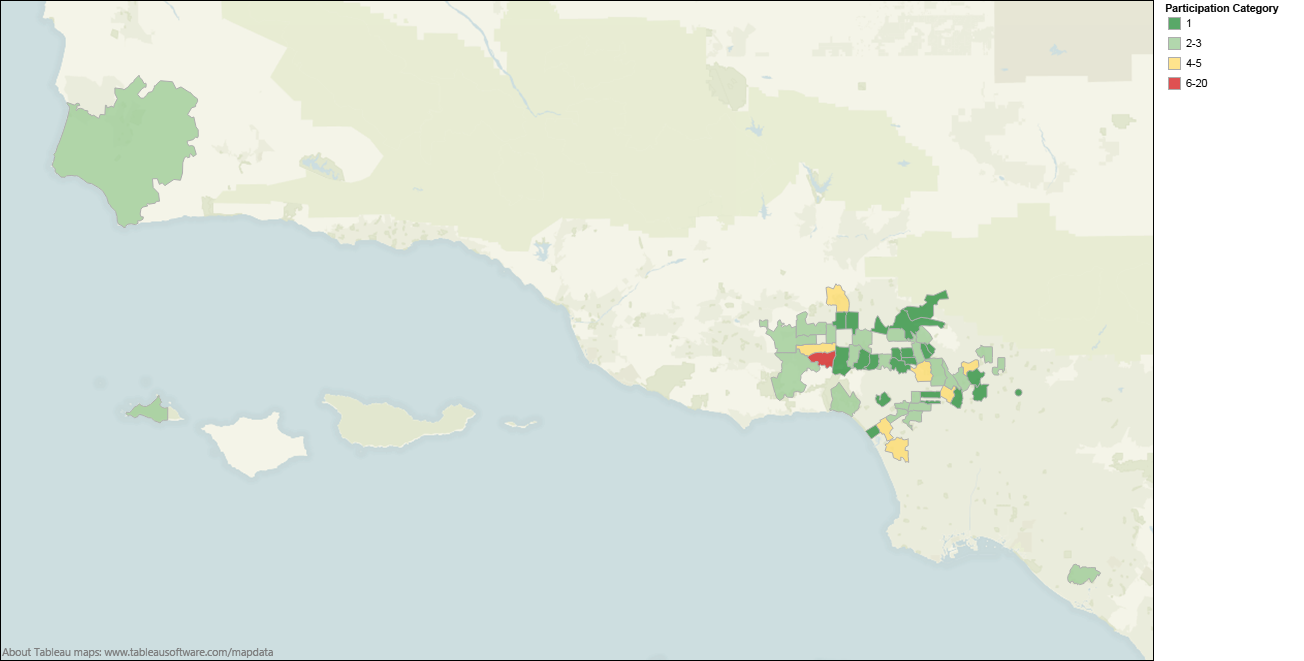


Figure 3: Distribution of 2010-2012 Program Participants  
in the SDG&E Service Territory



**Figure 4: Distribution of 2010-2012 Program Participants   
in the SCG Service Territory**



Program participation tends to be more concentrated in some specific climate zones. California Climate Zones are presented in Appendix ‎A. The climate zones with the most program participants as a percent of each utility’s participants are:

* 27% of PG&E’s program participants (1,049 customers) are in Climate Zone 3
* 46% of PG&E’s program participants (1,762) are in Climate Zone 12
* 16% of SCE’s program participants (368) are in Climate Zone 8
* 48% of SCE’s program participants (1,070) are in Climate Zone 9
* 7% of SCG program participants (58) are in Climate Zone 8
* 70% of SCG program participants (565) are in Climate Zone 9
* 36% of SDG&E’s program participants (256) are in Climate Zone 10
* 63% of SDG&E’s program participants (446) are in Climate Zone 7

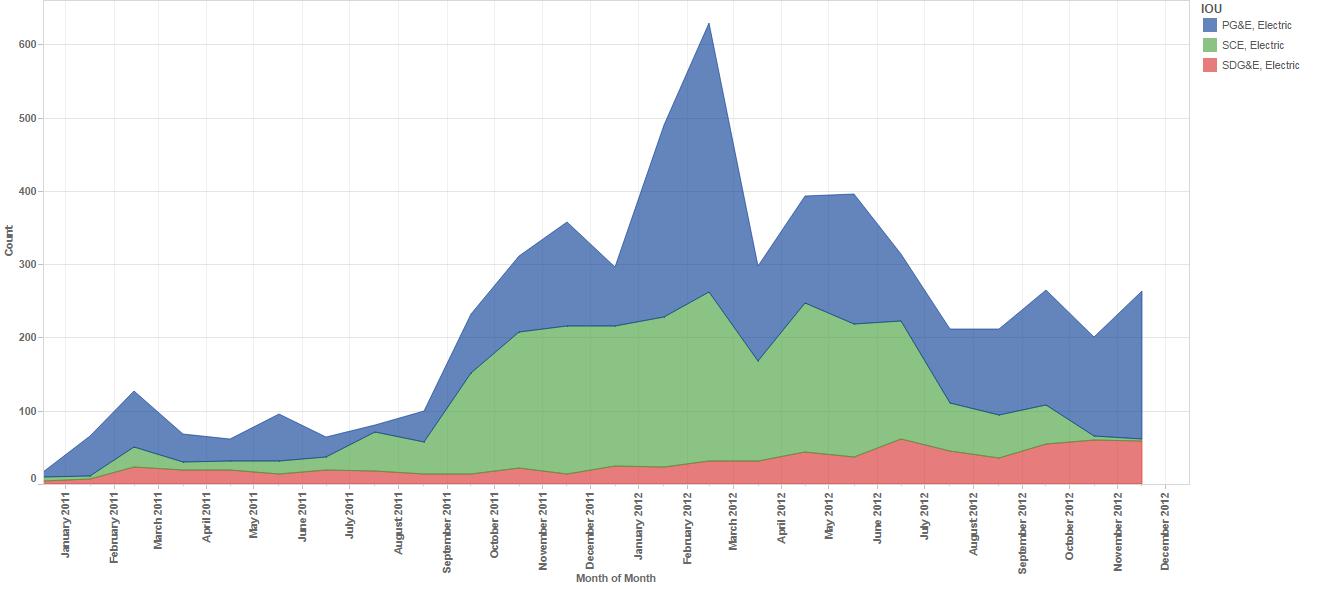
The distribution by climate zone shows that the program concentrated on areas that are in mild weather.

## Timing of Participation

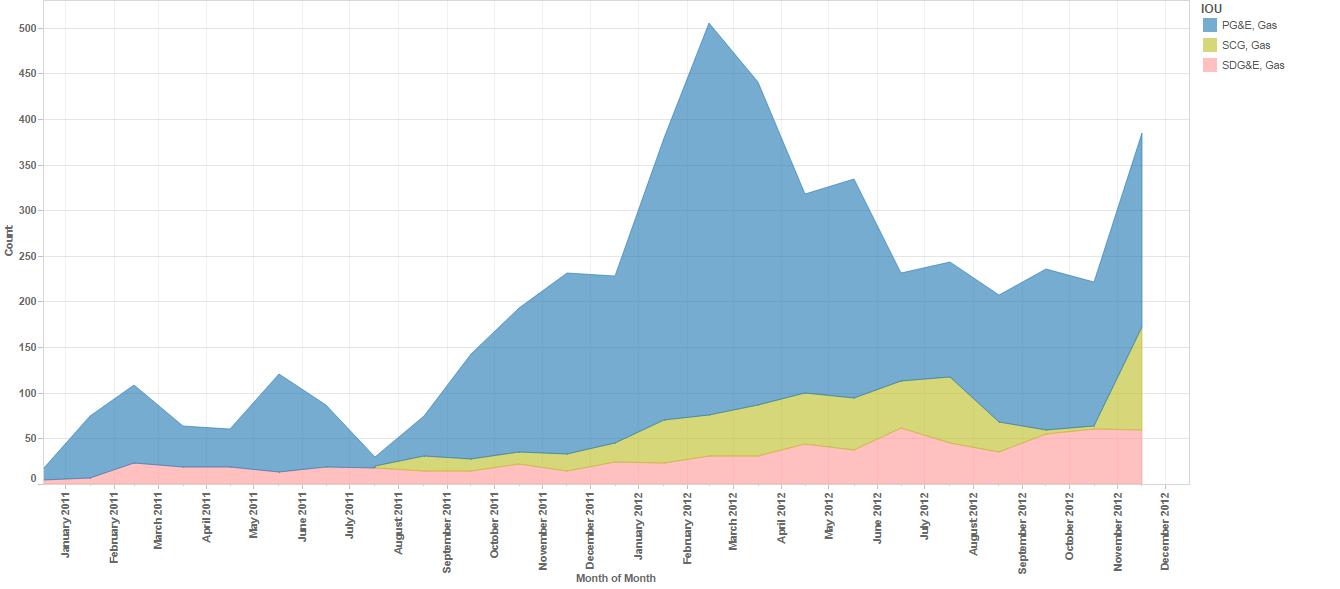
This section describes the number of participants per month and year across all IOUs. The influence of ARRA-funded program on the IOU programs is clear. The ARRA program ended in March 2012. It is visible that several joint ARRA-IOU projects were completed just before and at the deadline.

Figure 5: Number of Program Participants per Calendar Month

Electric Accounts



Gas Accounts



## Pre-Retrofit Equipment Conditions for Advanced Path

This report does not deal with classifying measures as “early retirement” versus “add-on retrofit” or “normal replacement”/”replace-on-burnout” as required by D.11-07-030/D.12-05-015. For the Advanced Path measures (those for which the savings were calculated with EnergyPro) the IOUs claimed the savings from the pre-existing to the post-install for the full life of the measure and using a measure life that is not well documented. For water heating replacements and AC and furnace replacements evidence of “early retirement” is required to claim the pre-existing baseline, and only for the remaining life of the pre-existing equipment (defined as 1/3 the life of the equipment by policy). This report provides information on the pre-existing efficiencies of the equipment replaced, but does not make adjustments to the savings estimates. Appendix F provide a comparison of the pre-retrofit equipment efficiency for Advanced path simulation models compared to the replace on burnout code baseline for piece of equipment.

To some extent the freeridership adjusts for measures that would have been replaced in the absence of the program. Meaning there are zero net savings for replace on burnout measures if they were indicated as freerider measures. This still means that the dual baseline is not fully addressed by the estimated gross savings.

# Gross Savings

This evaluation included three primary activities that estimate savings while also informing future program design: gross savings analysis, free-ridership analysis, and net savings estimation. The gross savings analysis followed a billing analysis approach tailored to the state of the program at the time of the evaluation: no prior cycle program activity, participation started during the middle of the 2010-2012 program cycle, and the program worked simultaneously with similar ARRA funded programs until March of 2012.

## Method Overview

Whole-building retrofits involve the installation of multiple measures. Because of this, the estimation of total savings requires a comprehensive method for capturing the combined effect of the installed measures. The general method recommended for this type of program is a billing analysis – the comparison of post-participation energy use to energy use that is unaffected by the program and a valid comparison.

The billing analysis method used in this evaluation (Pooled Fixed Effects regression model) is compliant with the International Performance Measurement and Verification Protocol (IPMVP) option Method C, Whole Facility, the California Evaluation Protocols[[8]](#footnote-9), and the California Evaluation Framework[[9]](#footnote-10), and wasrecently published in the Department of Energy’s Uniform Methods Project (UMP) Whole-Building Retrofit Evaluation Protocol[[10]](#footnote-11).

The Pooled method is appropriate to the Whole House Retrofit program due to the lack of a comparison group during the first stage of the program between 2010 and 2011. There are evaluation challenges inherent in a program where all participants are self-selected, and the characteristics that drive this self-selection are extremely difficult to measure and assess in both participants and non-participants. Some of these challenges can be addressed by utilizing the program’s pipeline (its future participants) as a comparison group. This evaluation also included a comparison group approach where subsequent program participants were used as a comparison group for prior program participants. To emphasize:

Gross savings for this study were estimated in two phases:

* Phase 1 (preliminary results) included IOU residential customers that participated in the program in 2010 and 2011. Given that these two years were the first in the Program and that participation in 2010 was minimal, this Phase does not include a comparison group analysis. Phase 1 estimates were used to provide a savings preview to the Energy Division and the IOUs. These estimates are presented in Appendix ‎D.
* Phase 2 (final results) included participants from 2010 through 2012. A Pooled Fixed Effects model without a comparison group was tested. The results of this test are included in Appendix ‎B. The methodology utilized for the gross savings estimates included in this section is a Pooled Fixed Effects with a comparison group.

Two billing analysis approaches were used to estimate program savings:

* The first approach analyzed participants’ pre- and post-consumption in a pooled fixed effects framework without a comparison group. This was the only method applied in Phase 1, since there was no comparison group data available when the Phase 1 analysis was conducted. This method was also tested in Phase 2.
* The second approach also employed a pooled fixed effects model, but evaluated program savings with the use of subsequent participants as comparison group. As described above, this approach was used only in Phase 2

Both approaches utilized a site-level model that was used to estimate cooling and heating set points for program participants that were used as inputs to the fixed effects models. This section discusses the site-level model and the Pooled Fixed Effects model with comparison group. The discussion on the Pooled Fixed Effects model without comparison group is presented in Appendix ‎B.

### Site-Level Modeling

DNV GL conducted site-level modeling[[11]](#footnote-12) to estimate: (a) individual outdoor temperatures that trigger cooling and heating for each program participant, and (b) a weather-adjusted consumption that reflects a typical weather year for each site.

The model specification used is the following:

Where:

|  |  |
| --- | --- |
|  | Average electric (or gas) consumption per day for participant *i* during billing month *m* |
|  | Base load usage (intercept) for participant *i*, |
| Him | Heating degree-days (HDD) at the heating base temperature H, |
| Cim(C) | Cooling degree-days (CDD) at the cooling base temperature (not included in gas model), |
|  | Heating coefficient, determined by the regression, |
|  | Cooling coefficient, determined by the regression (not included in gas model), |
| H | Heating base temperatures, determined by choice of the optimal regression, |
| C | Cooling base temperatures, determined by choice of the optimal regression, and |
| im | Regression residual. |

Rather than forcing the same degree-day base temperature on all of sites used in this study, we estimated consumption across a range of heating and cooling degree day bases. CDD bases covered 64oF to 84oF while HDD bases covered 50oF to 70oF. Electric consumption was estimated using the following models: ‘heating and cooling model’, ‘cooling only model’, ‘heating only model’ and ‘base load only model’. Gas consumption was estimated using the following models: ‘heating-only’ and ‘base load only’. For each model estimated, we used an F-test to determine which model specification is superior, and we chose the best heating degree base for each site based on the individual R-squared.

The distributions of cooling and heating base temperatures from the ‘best’ model were examined. The median of the degree-day bases (70oF for cooling and 60oF for heating) was selected, and the models were re-estimated.

**Normalized Annual Consumption:**

Where:

|  |  |
| --- | --- |
| *NACi* | Normalized annual consumption for customer i, |
| *H0* | Annual TMY[[12]](#footnote-13) HDD calculated at the optimal heating base temperature for participant i, |
| *C0* | Annual TMY CDD calculated at the optimal cooling base temperature for participant i (not included in gas model), and |
|  | Base load and heating parameter estimates from the site-level models. |

The median of the optimal base temperatures for heating and cooling were used as the set points for calculating degree-days in the fixed effects model.

### Pooled Fixed Effects Model with Comparison Group

The goal of billing analysis in energy efficiency program evaluation is to measure the change in consumption due to the program, while accounting for the effect of natural changes in consumption, such as due to milder or extreme weather, general economic conditions, disruptions in service and other effects that are external to the program. These externalities can be accounted for with the use of a comparison group.

This evaluation’s research plan called to construct comparison groups that are composed of customers who have opted into the same program as the participants. For Phase 2, we examined the use of participants in 2012 as comparison group for 2011 participants and participants in 2013 as comparison for 2012 participants. If the comparison group was found to be adequate, we would estimate a fixed effects model with the use of the comparison group. If not, we would default back to the fixed effects model without comparison group.

**Construction of the Comparison Group**

Because future participants will soon participate in the program, they are unlikely to install program measures on their own during their pre-participation period. The self-selection into the program makes participants unique and different from the rest of the population. Because of this, the use of future participants as a comparison group can address the issue of self-selection bias in ways that a comparison group constructed from the general population cannot do.

DNV GL constructed a two-year pre-installation period that mirrors the pre-and post-installation periods of the evaluated participants. These consecutive non-program periods were matched with the pre- and post-installation periods of the participants to control for non-program change in the estimates of savings. The first pre-installation year of the comparison group corresponded to participants’ pre-installation period while the second pre-installation year of the comparison group corresponded to the post-installation period of the participants.

Based on the installation dates reported in the tracking data, participants were assigned 12-month pre- and 12-month post-installation periods after considering a blackout period of approximately 60 days. Blackout periods were assigned to billing cycles prior and at the time installation took place. For households in the comparison groups, installation dates were shifted by 14 months prior participation to create a two-year pre-installation periods that reflects the pre and post period of the participants.

Table 6 shows an example for designating pre- and post-installation period for participants and comparison group. The blackout column refers to the period in which the installation of program measures is taking place. The data from the blackout period is excluded from the models.

Table 6: Example of Pre- and Post-Installation Designation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Program | Group | Install date | Pre-install | Blackout | Post-install |
| 2011 Evaluation | 2011 Participants | Jan2011 | Dec2009 – Nov2010 | Dec2010 – Jan2011 | Feb2011 - Jan2012 |
| Future installers (2012 Participants) | Mar2012 | Feb2011 - Jan2012 | Feb2012 – Mar2012 | Apr2012 - Mar2013 |
| Future installers for comparison (move installation date back by 14 months) | Jan2011 | Dec2009 – Nov2010 | Dec2010 – Jan2011 | Feb2011 - Jan2012 |
| 2012 Evaluation | 2012 Participants | Jan2012 | Dec2010 – Nov2011 | Dec2011 – Jan2012 | Feb2012 - Jan2013 |
| Future installers (2013 Participants) | Mar2013 | Feb2012 - Jan2013 | Feb2013 – Mar2013 | Apr2013 - Mar2014 |
| Future installers for comparison (move installation date back by 14 months) | Jan2012 | Dec2010 – Nov2011 | Dec2011 – Jan2012 | Feb2012 - Jan2013 |

Table 7 summarizes the effects captured by participant and comparison groups for each period. For households that participated in 2011, the pre- and post-difference provided a savings estimate that combined program-related effect and exogenous (non-program-related, natural trend) change. The comparison group, made up of households that became program participants a year later, captured only exogenous changes during the two-year pre-installation periods. Removing the comparison groups’ difference (exogenous, natural trend only) from the 2011 participant group’s difference (program + exogenous, natural trend) removed the changes due to natural trends and provided an estimate of savings that is due to the program.

Table 7 :Pre- and Post-Installation Differences of   
Participants and Comparison Groups

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Group | Pre-Installation | Post-Installation | Pre-/Post-Installation Difference Within Group | Pre-/Post-Installation Difference Between Groups |
| Participants | Natural trend | Natural trend + program effect | Program effect + effects from natural trend | Program savings |
| Future Participants\* (Comparison Group) | Natural trend | Natural trend | Effects from natural trend |

\*Installed more than a year after the households with which they are matched for comparison purposes

In the fixed effects model with comparison group, all monthly consumption data (both pre- and post-installation) of eligible participants and the two year-long pre-installation consumption data of the comparison group were included in a single model for each IOU, with the following specification:

Where:

|  |  |
| --- | --- |
|  | Average electric (or gas) consumption per day for participant *i* during billing period *m* |
|  | Fixed effect (or specific intercept) for participant *i* |
|  | Post-retrofit period indicator (1 for post-installation and 0 for pre-installation period) |
|  | Average daily cooling degree days (CDD) at 70⁰F for participant *i* during billing period *m (not included in gas model)* |
|  | Average daily healing degree days (HDD) at 60⁰F for participant *i* during billing period *m* |
|  | Interaction term between post indicator and CDD *(not included in gas model)* |
|  | Interaction term between post indicator and HDD |
|  | Interaction term between treatment indicator and CDD*(not included in gas model)* |
|  | Interaction term between treatment indicator and HDD |
|  | Interaction term between treatment indicator and post indicator |
|  | Interaction term between treatment indicator and post indicator and CDD |
|  | Interaction term between treatment indicator and post indicator and HDD |
|  | Monthly binary variables for each billing month |
|  | Change in energy consumption during post-installation period |
|  | Effect of cooling on energy consumption during pre-installation period |
|  | Effect of heating on energy consumption during pre-installation period |
|  | Change in the effect of cooling on energy consumption during post-installation period |
|  | Change in the effect of heating on energy consumption during post-installation period |
|  | Difference in HDD across the whole period between participant and comparison group |
|  | Difference in CDD across the whole period between participant and comparison group |
|  | The difference in the change in consumption during post-installation period between treatment and comparison group |
|  | The difference in the change in the effect of cooling on energy consumption during post-installation period between treatment and comparison group |
|  | The difference in the change in the effect of heating on energy consumption during post-installation period between treatment and comparison group |
|  | Error term for participant *i* in month *m* |

Weather-normalized savings were calculated as:

Where:

|  |  |
| --- | --- |
|  | Coefficients determined by the fixed effects model |
|  | Average daily CDD calculated using temperature data from TMY3 or CTZ2 of the participants *(not included when estimating gas savings)* |
|  | Average daily HDD calculated using temperature data from TMY3 or CTZ2 of the participants |

## Data Summary

This section describes the data used in the impact evaluation of the Whole House Upgrade program. DNV GL collected information from the CPUC’s program tracking database, IOU billing data, and weather data from NOAA[[13]](#footnote-14) and NREL[[14]](#footnote-15) and CTZ2.[[15]](#footnote-16) Prior to analysis, we examined all data for completeness and potential data issues such as duplicates, extreme values, missing observations and other inconsistencies.

Table 8 describes the tracking, billing, customer, and weather datasets used in this evaluation.

Table 8: Datasets Used in this Whole House Retrofit Impact Evaluation

| **Data** |  | **PG&E** | **SCE** | **SCG** | **SDG&E** |
| --- | --- | --- | --- | --- | --- |
| **Tracking Data** | Program name | Whole House Performance Program | Whole House Prescriptive Program/ | Prescriptive Whole House Retrofit/ | Prescriptive Whole House Retrofit/ |
| (Source: CPUC Tracking Data 2010-2012) | Comprehensive Home Performance | Local Whole Home Performance | Local Whole Home |
|  |  |  | Performance |
|  | Number of Program Participants [1] | 3,823 | 2,231 | 828 | 720 |
|  | Installation period | July 2010-December 2012 | December 2010- | March 2011- December 2012 | November 2010- December 2012 |
|  | Dec-12 |
|  | Total electric (kWh) savings - Basic and Advanced (unadjusted) | 7,044,372 | 2,331,032 | 8,658 | 1,170,699 |
|  | Advanced Path Total electric (kWh) savings - EnergyPro | 7,031,903 | 1,693,172 | 0 | 824,170 |
|  | Total electric (kWh) savings – claimed with adjustment | 4,231,610 | 1,315,129 | 8,658 | 676,197 |
|  | Total gas (therms) savings - Basic and Advanced (unadjusted) | 1,251,441 | -1,334 | 176,340 | 90,605 |
|  | Advanced Path Total gas (therms) savings - EnergyPro | 1,249,183 | 0 | 174,091 | 67,140 |
|  | Total gas (therms) savings - claimed with adjustment | 751,768 | -1,334 | 141,522 | 62,656 |

| **Data** |  | **PG&E** | **SCE** | **SCG** | **SDG&E** |
| --- | --- | --- | --- | --- | --- |
| **Billing Data** | Billing periods available | Monthly billing data from Jan. 2009-Dec. 2012 | Monthly billing data from Jan. 2009-Feb. 2013 | Monthly billing data from Jan. 2009-Dec. 2012 | Monthly billing data from Jan. 2009-Feb. 2013 |
| (Source: IOU) |
| **Customer Data** | Available | Yes | Yes | Included in billing data | Yes |
| (Source: IOU) |
| **Weather Data** | Available: | Yes | Yes | Yes | Yes |
| (Source: NOAA, NREL, and CTZ2) | Actual, TMY3, and California Climate Zone weather data |

[1] For the purposes of this table, a Program Participant is equivalent to a residential premise in the utilities’ customer information data. The number of participating accounts is slightly higher (3,837 for PG&E, 2,248 for SCE, 828 for SCG, and the same -720- for SDG&E).

Table 9 summarizes the program population by installation year and the final sample used in billing analysis for each IOU.

Table 9: Number of Program Participants   
and Number of Program Participants Used in Billing Analysis

| **Data Disposition** | **PG&E** | **SCE** | **SCG** | **SDG&E** |
| --- | --- | --- | --- | --- |
| **Number of program participants** | **3,823** | **2,231** | **828 (a)** | **720** |
| By Fuel |  |  |  |  |
| Both electric and gas | 2,445 |  |  | 686 |
| Electric only | 205 |  |  | 21 |
| Gas only | 1,173 |  |  | 13 |
| By program year |  |  |  |  |
| 2010 Participants | 6 | 8 |  | 2 |
| 2011 Participants | 992 | 723 | 98 | 188 |
| 2012 Participants | 2,825 | 1,500 | 711 | 515 |
|  |  |  |  |  |
| Total number of sites in Advanced Path | 3,731 | 692 | 639 | 318 |
| Total number of accounts linked to electric bills | 2,650 | 2,218 |  | 693 |
| Total number of accounts linked to gas bills | 3,618 |  | 613 | 684 |
| Total number of net metered sites | 442 | 138 |  | 63 |
| Sites with 6 to 12 months in the pre and post period | 2,292 (elec) | 1,959 | 561 | 631 (elec) |
| 3,137 (gas) | 584 (gas) |
| Sites with 9 to 12 months in the pre and post period | 2,177 (elec) | 1,888 | 543 | 610 (elec) |
| 2,984 (gas) | 561 (gas) |
| Sites with 12 months in the pre and post period | 2,091 (elec) | 1,828 | 536 | 595 (elec) |
| 2,864 (gas) | 548 (gas) |
| **Sites excluded from Billing Analysis** | | | | |
| Sites that installed lighting measures only | 0 | 0 | 0 | 7 |
| Sites with zero ex ante kWh and therms savings | 91 | 1 | 2 | 7 |
| Sites with estimated/adjusted meter readings during the analysis period | 76 (elec) | 159 | 3 | 25 (elec) |
| 47 (gas) | 22 (gas) |
| Sites with very low average annual consumption (less than 1,000 kWh/year and/or less than 40 therms/year) | 150 (elec) | 93 | 17 | 37 (elec) |
| 130 (gas) | 51 (gas) |
| **Final sample used in Billing Analysis** | | | | |
| **Total number of sites with electric** | **1,625** | **1,486** |  | **558** |
| 2011 Participants | 422 | 462 |  | 137 |
| 2012 Participants | 1,203 | 1,024 |  | 421 |
| **Total number of sites with gas** | **2,737** |  | **536** | **532** |
| 2011 Participants | 707 |  | 57 | 130 |
| 2012 Participants | 2,030 |  | 479 | 402 |

(a) SCE column totals exclude 19 accounts with missing IDs

## Gross Savings Estimates

This section presents the gross savings for program years 2010-2012 estimated during Phase 2 (final results) of this evaluation.

Phase 1 (preliminary results) included IOU residential customers that participated in the program in 2010 and 2011. Phase 1 estimates are presented in Appendix ‎D.

### Site-Level Model Results

DNV GL estimated weather-adjusted electric and gas consumption for each site using site-level models. The normalized annual consumption (NAC) from these models allowed for a pre- and post-installation comparison of energy consumption under a normal weather year. NAC was estimated for the pre- and post-installation period of the participants using the optimal degree-day base for each site. This individual degree day base is a representation of the outdoor temperature at which each house needs heating or cooling. Each house has a unique degree day base due to its level of envelope insulation, infiltration, internal/solar gains, and thermostat set point schedule (i.e., at home during the day, not at home during the day, preferred set points). This modeling approach allowed the underlying structure of the degree-day data to conform to the unique characteristics of each site instead of imposing a fixed degree-day basis on all sites.

The percentage change in NAC removes the effect of weather differences in the pre- and post-periods, but it is confounded by other factors. The next step in the analysis, the pooled fixed effects model, captures changes from effects such as program participation, and externalities such as consumption trends and other unobserved site-specific characteristics.

Figure 6 compares the average NAC level between the pre- and post-period of participants for electric and gas by IOU. The blue bars represent NAC during the pre-installation period while the horizontal line in each bar represents NAC for the post-installation period. The values in percent represent the overall change in NAC.

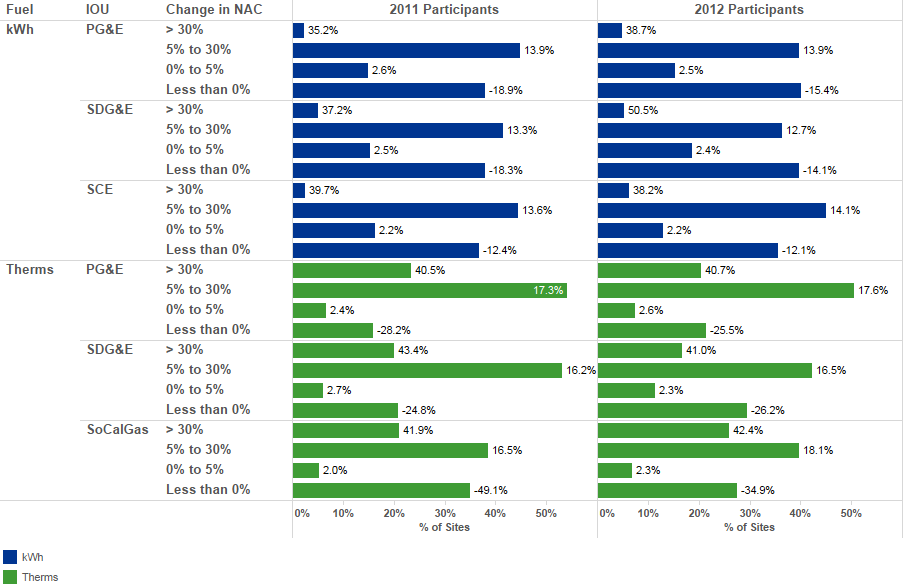
Figure 6: Change in Normalized Average Consumption



Results showed that, on average, 2011 participants reduced their electric normalized annual consumption between 3% and 5% while 2012 participants reduced their gas NAC by 6% to 8 %. In general, the average electric NAC in the pre- and post-installation period were relatively lower for 2012 participants. For gas, the percent reduction in NAC was relatively higher than electric. On average, 2011 participants reduced their gas normalized annual consumption between 10 and 18% while 2012 participants reduced their gas NAC by around 11% to 16%.

Figure 7 summarizes the distribution of participants by the level of change in NAC from the pre- to the post-retrofit period by IOU and program year. The values next to the bars represent the average savings for each bin. The horizontal axis represents the percent of customers in each bin. Results showed that the level of change in NAC varies among participants, but the overall savings distribution pattern was similar between 2011 and 2012 participants.

Figure 7: Distribution of Participants by the Change in Normalized Annual Consumption (NAC)



More than 40% of the participants had reductions in electric NAC from 5% to 30%, while less than 10% of the participants had electric NAC reductions of more than 30%. We also found that more than 30% of the participants showed an increase in electric NAC after participating in the program across all IOUs. Specifically we found the following patterns:

**Electric**

* PG&E: slight decrease in the percent of 2012 participants in the lower bins
* SDG&E: slight increase in the percent of 2012 participants in the lower bins
* SCE: slight increase in the percent of 2012 participants in the upper bins

**Gas**

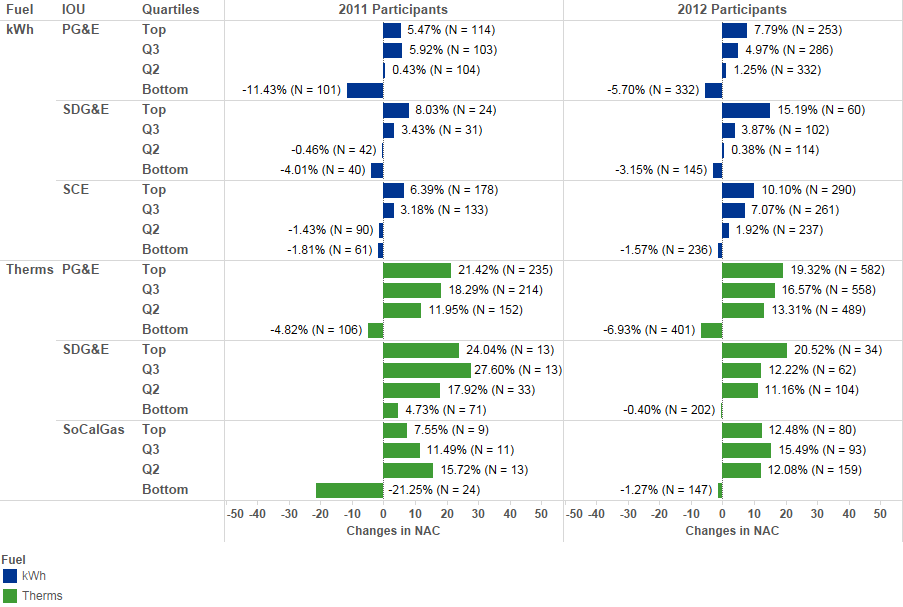
* PG&E: increase in the percent of 2012 participants in lowest bin
* SDG&E: increase in the percent of 2012 participants in lowest bin
* SoCalGas: decrease in the percent of 2012 participants in upper bin

DNV GL also examined the differences in the change of NAC across different quartiles to show differences in NAC reductions between high energy users and low energy users. The different quartiles are described below:

* The ‘Top’ quartile includes participants whose pre-installation consumption belong in the 75th percentile and above of the overall consumption distribution,
* ‘Q3’ represents participants whose pre-installation consumption belong in the 50-75th percentile of the overall consumption distribution
* ‘Q2’ represents participants whose pre-installation consumption belong to the 25-50th percentile of the overall consumption distribution
* The ‘Bottom’ quartile comprises of participants whose pre-installation consumption fall in the lowest 25th percentile of the overall consumption distribution

Figure 8 presents average change in NAC across different quartiles by IOU and program year. The values in percent next to the bars correspond to the average change in each quartile while the values in parenthesis show the number of sites that belong to each quartile.

Figure 8: Change in Normalized Annual Consumption by Quartile



Overall, we found that there is a correlation between greater household consumption before participating in the program and greater savings. Specifically we found that:

1. Households in the top quartile reduced electric consumption at an average rate of over 5% for all IOUs with SDG&E showing the highest NAC reduction in the top quartile; and
2. Households in the top quartile reduced gas consumption at an average rate of around 20% or more for all IOUs except SoCalGas. SDG&E showed the highest NAC reduction in the top quartile and showed the lowest increase in NAC in the bottom quartile across IOUs.
3. On average, households in the bottom quartile increased gas and electric consumption from the pre- to the post-installation periods, except for gas consumption of 2011 SDG&E participants. No systematic changes that would increase energy use in households were revealed in surveys. This finding shows the savings uncertainty of low users is high.
4. For electric, PG&E participants showed the highest increase in NAC after program participation while SCE had the lowest increase.
5. For gas, only SDG&E 2011 participants showed gas NAC reductions after program participation. SoCalGas participants in 2011 showed an increase in normalized annual consumption of over 20% in the post-period. However, it is important to note that the total number of SoCalGas participants in the 2011 program year is small.

Figure 6 and Figure 7 show the change in NAC between pre- and post-installation period across different groups. The percentage change in NAC only removes the effect of weather differences in the pre- and post-periods, but it is confounded by changes that are not weather related. To account for such factors, we estimated a pooled fixed effects model that accounts for consumption trends and other unobserved site-specific characteristics.

### Pooled Fixed Effects Model Results

DNV GL estimated gross program savings using a fixed effects model for each IOU and program year. This analysis was performed twice: with and without the use of a comparison group.

Results with a comparison group are included in this section. Results with no comparison group are included in Appendix ‎B.

The second analysis was done to include a comparison group in a pooled fixed effects framework. This was done in an attempt to capture changes in household characteristics that might have affected consumption during the analysis period and may not have been captured in the first analysis. DNV GL utilized future program participants as a comparison group. Specifically, we used 2012 program participants as the comparison group for 2011 program participants and used 2013 program participants as a comparison group for 2012 program participants. Details about comparison group specification are described in the methodology section.

Table 10 summarizes the number of sites in the participant and comparison groups for program years 2011 and 2012. We only conducted this second analysis for IOUs with reasonable number of sites in the participant and comparison group. Due to a very low number of comparison program participants, results from the second analysis SoCalGas 2011 and 2012 participants and SDG&E 2012 participants.

Table 10: Number of Sites Used in Analysis in the Participant and Comparison(a) Groups for Program Year 2011 and 2012

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fuel** | **Group** | **Basic** | | **Advanced** | |
| **2011** | **2012** | **2011** | **2012** |
| PG&E | Electric | Comparison | -- | -- | 854 | 704 |
| Participants | -- | -- | 422 | 1,203 |
| Gas | Comparison | -- | -- | 1,489 | 1,063 |
| Participants | -- | -- | 854 | 2,030 |
| SCE | Electric | Comparison | 712 | 340 | 712 | 340 |
|  | Participants | 313 | 721 | 149 | 303 |
| SCG | Gas | Comparison | -- | -- | 346 | 66 |
| Participants | -- | -- | 57 | 479 |
| SDG&E | Electric | Comparison | 302 | 32 | 302 | 32 |
| Participants | 19 | 303 | 113 | 109 |
| Gas | Comparison | 296 | 38 | 296 | 38 |
| Participants | 20 | 295 | 110 | 107 |

(a) When applicable, the comparison groups are the same for Basic and Advanced and for both years

For the remaining IOUs with enough number of sites in the comparison group, DNV GL examined the groups’ validity. A key requirement when using future participants as comparison group is that program and target population must be stable throughout multiple years. To verify uniformity in target population across program years, we examined the distribution of participants and future participants across different climate zones. In addition, we compared average monthly electric and gas consumption in the pre-period to ensure that consumption trends are similar between participants and comparison group.

Based on our analysis, PG&E and SDG&E 2011 and 2012 participants had a more or less similar distribution by climate zone and trends in consumption during the pre-retrofit period. On the other hand, we found that participation for SCE was not very stable between 2011 and 2012 program years where very big households from CZ 15 joined the program in the latter part of the 2011. This caused the average electric consumption during the last quarter of pre-period to shift above the consumption curve of the comparison group. For this reason, we will not be reporting results for the secondary analysis for SCE.

The secondary analysis for 2012 participants involved the use of 2013 participants as comparison group. Only PG&E and SCE had enough number of 2013 participants for use as comparison group. Because it is likely that 2013 Program participants are different from the 2010-2012 Program participants, creating a valid comparison group from 2013 participants to mirror 2012 participant characteristics is difficult. We identified the following differences: for PG&E, we found that the percentage of 2013 participants was higher in CZ 12 and 13 compared to 2012. Also, PG&E consumption trends between the two groups diverge. SCE had a higher percentage of 2013 participants from CZ8 compared to 2012. We also found that consumption trends of 2012 and 2013 participants during the pre-program period were not similar for SCE.

Table 11 summarizes the results from the pooled fixed effects approach with a comparison group. We found that the percent savings estimates were very similar from one year to the next for electric and gas savings estimates only increased by around 1%. Similar to the results from the primary analysis, the program generated higher gas savings than electric savings.

Table 11: Program Savings from Pooled Fixed Effects Model With Comparison Group

| **IOU** | | **Fuel** | | **Fixed Effects Model**  **2011 with Comparison Group** | | | | | | | | **Fixed Effects Model**  **2012 with Comparison Group** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **N** | | **Savings Estimate** | | **Std Error** | | **% Savings** | | **N** | | **Savings Estimate** | | **Std Error** | | **% Savings** | |
| Advanced Path | | | | | | | | | | | | | | | | | | | |
| PG&E | | Elec | | 1,276 | | 177.5 | | 88.9 | | 2.1% | | 1,907 | | 212.3 | | 73.6 | | 2.7% | |
|  | | Gas | | 2,196 | | 77.6 | | 6.9 | | 12.9% | | 3,093 | | 72.3 | | 6.3 | | 12.8% | |
| SCG | | Gas | | 403 | | 45.6 | | 19.03 | | 10.2% | | 545 | | 154.8 | | 21.7 | | 33.3% | |
| SDG&E | | Elec | | 415 | | 300.5 | | 168.7 | | 4.4% | | 141 | | -15.8 | | 313.1 | | -0.2% | |
| Gas | | 406 | | 67.0 | | 10.9 | | 16.9% | | 145 | | 58.9 | | 15.9 | | 14.6% | |
| SCE | | Elec | | 861 | | 691.4 | | 138.6 | | 8.2% | | 643 | | 393.8 | | 134.8 | | 4.7% | |
| Basic Path | | | | | | | | | | | | | | | | | | | |
| SDG&E | | Elec | | 321 | | 791.6 | | 373.3 | | 9.6% | | 335 | | 232.9 | | 205.0 | | 3.5% | |
| Gas | | 316 | | 67.9 | | 15.0 | | 18.5% | | 333 | | 12.6 | | 10.5 | | 3.5% | |
| SCE | | Elec | | 1,025 | | 742.9 | | 205.8 | | 6.8% | | 1,061 | | 200.4 | | 127.6 | | 2.3% | |

We limit our analysis to the use of future participants as comparison group because the number of prior participants (in 2010) is very low. The Whole House program started in 2010 and only few customers participated during the first year of the program. The analysis team did not consider creating a comparison group by matching participants to the general population because it is not possible to compensate for self-selection. Participants that self-select into the program are different from the rest of the population in ways that are not visible to evaluators. The program is likely to attract customers that belong to higher income groups, who possess relatively larger houses and have relatively older heating and cooling equipment in the house. Also, it is worth noting that program participants are likely to have some level of awareness on energy efficiency and desire to upgrade their home and/or save energy. To incorporate these factors in the creation of a non-participant comparison group would be difficult and very expensive.

The gross savings estimates produced with this approach do not address dual baselines. In the case of individual measures, the billing analysis methodology could compensate for savings measured and adjust for savings above the energy code for replace-on-burnout measures. Since whole house programs include a combination of insulation and air sealing measures with no code baseline and equipment measures with code baselines, this distinction could not be made explicitly.

### Gross Realization Rate

The evaluation team took the final billing analysis results and the original ex ante savings claims and developed a gross realization rate for the two phases of the analysis. The number of participants in Phase 2 is greater so the final gross realization rate is more heavily weighted towards later participants.

Table 12: Gross Realization Rates

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fuel (unit)** | **Fixed Effects Model** | | | | **Fixed Effects Model** | | | |
| **(2011 With Comparison Group)** | | | | **(2012 With Comparison Group)** | | | |
| **Program Participants** | **Average Ex Ante** | **Savings Estimate** | **Gross Realization Rate** | **Program Participants** | **Average Ex Ante** | **Savings Estimate** | **Gross Realization Rate** |
| Advanced Path | | | | | | | | | |
| PG&E | Electricity (kWh) | 692 | 2,337.9 | 177.5 | 7.6% | 1,958 | 2,765.1 | 212.3 | 7.7% |
| Gas (Therms) | 944 | 373.5 | 77.6 | 20.8% | 2,674 | 335.3 | 72.3 | 21.6% |
| SDG&E | Electricity (kWh) | 162 | 1,355.2 | 300.5 | 22.2% | 156 | 3,873.7 | -15.8 | -0.4% |
| Gas (Therms) | 158 | 141.3 | 67.0 | 47.4% | 153 | 292.8 | 58.9 | 20.1% |
| SCE | Electricity (kWh) | 228 | 870 | 691.4 | 79.5% | 464 | 3,222.3 | 393.8 | 12.2% |
| SCG | Gas (Therms) | 98 | 25.0 | 45.6 | 182.7% | 541 | 317.3 | 154.8 | 48.8% |
| Basic Path | | | | | | | | | |
| PG&E | Electricity (kWh) | 72 | 135.5 | PassThru | 100% | 20 | 135.5 | PassThru | 100% |
| Gas (Therms) | 72 | 24.5 | PassThru | 100% | 20 | 24.5 | PassThru | 100% |
| SDG&E | Electricity (kWh) | 24 | 1806.5 | 791.6 | 43.8% | 378 | 802.8 | 232.9 | 29.0% |
| Gas (Therms) | 25 | 33.88 | 67.9 | 200.4% | 368 | 41.7 | 12.6 | 30.2% |
| SCE | Electricity (kWh) | 466 | 267 | 742.9 | 278.2% | 1,073 | 478.5 | 200.4 | 41.9% |
| SCG | Gas (Therms) | 0 | 0 | 0 | 0% | 170 | 13.2 | PassThru | 100% |

# Free Ridership and Net Savings

## Method overview

The central objective of the WO46 Whole House Impact Evaluation survey was to capture program participants’ self-reported responses that provide information on free-ridership and allow estimation of net-to-gross ratios which are then used to adjust gross savings estimates. This self-reported approach involved asking Advanced Path participants a series of questions that were aimed at establishing if the measure(s) would have been installed in the absence of the program, and if so, the extent to which the level of measure installation might have differed in the absence of the program.

Total (full) free-riders were those who would have installed exactly the same measure with quantity, efficiency, and time (QET) being unchanged, even in the absence of the program. The questions were designed to capture both pure and partial free-ridership, where participants who are partial free-riders would have undertaken/installed the measure(s), but of lesser quantity, at and/or lesser efficiency, or at a different time.

Apart from the core free-ridership question modules, the survey also includes questions on the following:

* Information received by the respondent from their project contractor
* Project financing
* Prior implementation of energy efficiency measures (as excerpted from the standard segmentation questions provided by the IOUs)
* Attitude towards the environment, price sensitivity (as excerpted from the standard segmentation questions provided by the IOUs)
* Standard respondent demographics and household characteristics

### CPUC Guidelines

The WO46 Whole House Impact Evaluation survey was developed in adherence to the CPUC guidelines[[16]](#footnote-17) provided for residential net-to-gross (NTG) instruments. The survey development process followed by the evaluation team solicited IOU input, incorporated changes to the survey based on feedback, and finalized the survey subsequent to multiple rounds of this process.

The survey was conducted in January 2014 with residential decision-makers and Advanced Path participants in the 2010-2012 cycle of the Energy Upgrade California programs. The survey included a series of warm-up or setup questions that served to remind the respondents of the details of their participation in the program and that helped validate the internal consistency of responses. Table 13 below summarizes the specific details of the WO46 Whole House Impact Evaluation Survey that map to the guidelines set by the CPUC for residential NTG surveys.

Table 13: Demonstration of Compliance with CPUC-ED and MECT Guidelines   
for NTG Estimation

| CPUC/MECT Guidelines | WO46 Whole House Impact Evaluation Survey |
| --- | --- |
| Timing of the Interview | The survey was conducted in January 2014 and within a year of conclusion of the 2010-2012 program cycle. |
| Identifying the Correct Respondent | Respondents were screened and the survey was conducted with decision makers for the project. |
| Set-up Questions, Use of Multiple Questions, Validity and Reliability, Consistency Checks, and Ruling Out Rival Hypotheses | * Multiple questions were used at the start of the survey as a “warm-up,” such as audits conducted prior to project implementation, fees paid, and contractors used. * These questions helped the respondent “think back” to the time under consideration and prepare the context for subsequent program participation and measure-specific questions, thus contributing to more accurate recollections and hence responses. * The right flow of warm-up questions and follow-up questions improved recall, ensured that responses pertained to the program under consideration and helped rule out or minimize any rival effects. * Follow-up questions were asked based on responses to select questions and served as consistency checks. |
| Making the Questions Measure Specific | The survey was modular. The set of free ridership questions were asked for each measure the respondent reported that they installed. |
| Partial Free-ridership | The survey had Quantity, Efficency, and Timing (QET) questions (both overall and by measure) that included response options to capture both partial and pure free-ridership. |
| Deferred Free-ridership | Timing questions included response options that captured deferred free ridership, which is participants installing measures promoted by the program earlier than originally planned. |
| Pre-testing the Questionnaire | The survey was tested both internally by DNV GL/the evaluation team and with respondents using a soft-launch to refine and finalize instrument prior to a full rollout. |
| Qualified Interviewers | The CATI survey was conducted by Discovery Research Group, which is an experienced and approved subcontractor on projects for the CPUC. DNV GL monitored interviewing and cycled through all the interviewers active on the phone to provide feedback, if any, to the CATI subcontractor. |
| Handling Non-responses and “Don’t Know” | Non-response and “Don’t Know” responses were taken at face value when the survey was administered and the respondent was skipped to the next survey module, as applicable. Post-field data processing included examination of both variable level and respondent level non-response, and any variables or records with non-response over a certain threshold will be imputed or expunged. The survey data exhibits this to a minimal degree and thus does not necessitate the above processing step. |
| Weighting NTGR | Case weights have been applied to the sample estimates in order to develop a NTGR estimate that is representative of the population. |
| Precision of the NTGR | The total sample size for this study (n=527) was well over the minimum required to allow estimation of the NTGR at the level of precision specified by the guidelines, which is 90% level of confidence +/- 10%. |
| Scoring Algorithms | The questions used as input and the exact details of the scoring algorithm are outlined with examples later in this chapter. |

### Survey Version: Short-form vs. Long-form

The evaluation team recognized that the customer decision-making process for participation in the program and the selection of measures implemented differs by respondent. Early discussions with the project team and the IOUs also surfaced concerns regarding survey length. Both these factors combined led to development of a survey tailored to the respondents’ reported decision making process for program participation. This allowed for administering a tighter and shorter survey in select cases, as summarized in Table 14 below, thus reducing respondent fatigue where possible and resulting in economies of time and costs for the evaluation itself.

Respondents were asked about the specific measures installed and whether they considered the measures installed as a single package for which they made one purchasing decision versus considering each measure individually. Respondents that stated that they considered the installations as one single package were asked about the overall likelihood of installing the measures in the absence of the program, and if they would have installed these measures at the same levels of efficiency, in the same quantity, and at the same time, in the absence of the program.

Respondents who were unable to definitively answer the overall free-ridership questions related to quantity, efficiency, and timing and/or those who indicated that their response to these questions differed based on the measure being considered, were taken through a modular survey with free-ridership questions corresponding to each measure installed, hereafter referred to as the long-form of the survey. The remainder of the respondents were taken through the short-form of the survey, which skips them directly to the latter part of the survey with questions regarding information they received from their contractor, project finances, attitudes, adoption of energy efficient behaviors, project finances, household characteristics, and demographics.

Table 14: Survey Version: Short-Form vs. Long-Form Sample Composition

|  |  |
| --- | --- |
| Description | Number of Completes |
| Short-form survey (single package, overall project free-ridership) | 132 |
| Long-form survey (measures considered individually, free-ridership for each installed measure) | 395 |
| Total | 527 |

## Survey Sample Design

In consultation with the IOUs and staff consultants, the CPUC approved surveying of Advanced Path participants only. There were two main reasons for this decision: (a) the Basic Path has been discontinued, and thus it is more important to learn from Advanced Path participants, and (b) Advanced Path participants account for most of the EUC savings.

DNV GL analyzed the 4,807 Advanced Path participants and stratified them as follows:

* Utility
  + Pacific Gas & Electric
  + Southern California Edison/Southern California Gas
  + San Diego Gas & Electric
* Climate zone groups
  + Climate Zone Group “Mild” (M) – T24 Climate Zones: 1 through 7, and 16
  + Climate Zone Group “Inland” (I) – T24 Climate Zones: 8 through 14
  + Climate Zone Group “Desert” (D) – T24 Climate Zone: 15

This climate zone grouping is consistent with what was utilized in other Energy Division studies such as California Lighting and Appliance Saturation Study (“CLASS” – WO 21) and the Residential/Advanced/Upstream Lighting Impact Evaluation (WO 28).

* Level of Ex Ante Savings
* Top third, middle third, and bottom third for each commodity, plus zero savings.
* Zero savings are those where the utility does not serve that commodity and a corresponding account at other utility could not be identified.
* Minimum number of participants

The stratification by climate zone group and level of savings resulted in 30 strata, some with very few sample points. These strata were “collapsed” (combined with adjoining strata) until each of the final strata had at least 5% of the total number of Advanced Path Participants.

A sample size of 600 surveys was defined in the scope of work, based on budget and a priori assumptions. Response rates were very low. This prompted the following two actions: Further collapsing, so that no stratum weight is over 12, with the exception of Stratum 11; and open surveying, so that all eligible program participants were called several times. The original design included a primary group of randomly selected participants within each strata, that would be supplemented with other participants if there were not enough survey respondents within the primary group

The following table describes the original sample design and the final sample design for the purposes of weight estimation and survey analysis.

Table 15: Insert Table Title Here

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stratum Number** | **Utility** | **Climate Zone Group** | **Level of Electric Savings (1)** | **Level of Gas Savings (1)** | **Advanced Program Participants** | **Advanced Program Participants w/ Phone Numbers** | **Target Number of Surveys** | **Target Weight** | **Final Number of Surveys** | **Preliminary Weight** | **Final Level of Electric Savings (1)** | **Final Level of Gas Savings (1)** | **FINAL Weight** |
| 1 | PG&E | I | 0 | 1 | 414 | 402 | 46 | 9 | 28 | 14.79 | 0 | 1,2,3 | 11.21(2) |
| 2 | PG&E | I | 0 | 2,3 | 348 | 338 | 38 | 9 | 40 | 8.70 |
| 3 | PG&E | I | 1 | 1 | 556 | 532 | 61 | 9 | 63 | 8.83 | 1 | 1 | 8.83 |
| 4 | PG&E | I | 1 | 2,3 | 185 | 181 | 21 | 9 | 27 | 6.85 | 1 | 2,3 | 6.85 |
| 5 | PG&E | I | 2 | 1,2,3 | 306 | 298 | 34 | 9 | 39 | 7.85 | 2,3 | 1,2,3 | 8.90(2) |
| 6 | PG&E | I | 3 | 1,2,3 | 121 | 121 | 14 | 9 | 9 | 13.44 |
| 7 | PG&E | M | 1 | 1 | 739 | 708 | 81 | 9 | 92 | 8.03 | 1 | 1 | 8.03 |
| 8 | PG&E | M | 1 | 2,3 | 523 | 508 | 57 | 9 | 74 | 7.07 | 1 | 2,3 | 7.07 |
| 9 | PG&E | M | 2,3 | 1,2,3 | 273 | 261 | 30 | 9 | 28 | 9.75 | 2,3 | 1,2,3 | 9.75 |
| 10 | PG&E | I, M | 1,2,3 | 0 | 211 | 207 | 26 | 8 | 23 | 9.17 | 1,2,3 | 0 | 9.17 |
| 11 | SCE/SCG | I | 0 | 1,2,3 | 126 | 47 | 23 | 5 | 5 | 25.20 | 0 | 1,2,3 | 25.20 |
| 12 | SCE/SCG | I | 1 | 1,2,3 | 289 | 289 | 58 | 5 | 20 | 14.45 | 1,2,3 | 1,2,3 | 12.00(2) |
| 13 | SCE/SCG | I | 1,2,3 | 0 | 100 | 97 | 19 | 5 | 12 | 8.33 | 1,2,3 | 0 | 8.33 |
| 14 | SCE/SCG | I | 2,3 | 1,2,3 | 215 | 215 | 44 | 5 | 22 | 9.77 | 1,2,3 | 1,2,3 | 12.00(2) |
| 15 | SCE/SCG | M | 1,2,3 | 1,2,3 | 87 | 79 | 17 | 5 | 14 | 6.21 | 1,2,3 | 1,2,3 | 6.21 |
| 16 | SDG&E | I, M | 1,2,3 | 1,2,3 | 314 | 249 | 31 | 10 | 31 | 10.13 | 1,2,3 | 1,2,3 | 10.13 |
|  | TOTAL |  |  |  | 4,807 | 4,532 | 600 |  | 527.0 |  |  |  |  |

(1) 1 = Bottom third, 2 = Middle third, 3 = Highest third, 0 = Commodity not present

(2) Strata 1 and 2, 5 and 6, and 12 and 14 were collapsed due to an insufficient number of responses

## Scoring Examples

### Overall Free Ridership: Short-Form Survey Respondents

Respondents who indicated that they considered all the measures installed as a package for which they made a single purchase decision answer questions related to free ridership as shown in Table 16. The overall free-ridership score for a respondent who completes the short form of the survey is aggregated up from the free-ridership scores computed based on the quantity, efficiency, and timing (QET) questions. Table 16 below displays the questions used to address overall free-ridership, response options and associated scoring. A score of 1 indicates a total/pure free-rider, a score between 0 and 1 indicates partial free-ridership, and a score of zero indicates zero free ridership.

The shaded rows in the below are used as an example of a response sequence which would result in the respondent being assigned an overall free-ridership score of (1.0 + 1.0 + 0.5/3) = 0.83.

Table 16: Free-ridership Scoring for Short-Form Survey Respondents

|  |  |  |  |
| --- | --- | --- | --- |
| **OVERALL QUANTITY** | |  |  |
| QT1. In the absence of the program, would you have installed ... [READ LIST, SINGLE RESPONSE] …of the measures? | | | |
| **Response Code** | **Description** | **Free-ridership score** |  |
| 1 | ALL [go to overall efficiency EF1] | 1 |  |
| 2 | SOME [go to first applicable measure section] | 0.5 |  |
| 3 | NONE [go to overall efficiency EF1] | 0 |  |
| -97 | Don’t know [go to first applicable measure section] |  |  |
| -98 | Refused [go to first applicable measure section] |  |  |
|  |  |  |  |
| **OVERALL EFFICIENCY** | |  |  |
| EF1. In the absence of the program, would you have opted to install insulation and equipment with the same levels of efficiency? | | | |
| **Response Code** | **Description** | **Free-ridership score** |  |
| 1 | Yes | 1 |  |
| 2 | No | 0 |  |
| -97 | Don’t know [go to first applicable measure section] |  |  |
| -98 | Refused [go to first applicable measure section] |  |  |
|  |  |  |  |
| **OVERALL PROJECT TIMING** | |  |  |
| T1. In the absence of the program, would you have undertaken this project… [READ LIST, SINGLE RESPONSE]? | | | |
| **Response Code** | **Description** | **Free-ridership score** |  |
| 1 | At the same time [SKIP TO T3] | 1 |  |
| 2 | Earlier | 1 |  |
| 3 | Later | 0.5 |  |
| 4 | Never [SKIP to T2\_v] | 0 |  |
| -97 | Don’t know [go to first applicable measure section] |  |  |
| -98 | Refused [go to first applicable measure section] |  |  |

### Measure Level Free Ridership: Long-Form Survey Respondents

Respondents who took the long-form of the survey answer questions related to free ridership for each measure that they report installing. In some cases, the quantity, efficiency, and timing questions may not have been relevant for the specific measure under consideration. For example, those who stated that they had their ducts air sealed to reduce leakage were only asked whether the timing of undertaking the installation would be different in the absence of the program. Quantity and efficiency related free-ridership questions were not applicable to this measure. Table 17 below displays the free-ridership questions asked of respondents who indicate installing any one of attic/ceiling, wall, or floor insulation. Like in the overall free-ridership scoring example above, scores were aggregated up from responses to the QET questions to arrive at measure-level free-ridership scores. Responses as shown in the shaded rows below were scored as   
(0.5 + 1.0 + 0.5)/3 = 0.67.

Table 17: Free-ridership Scoring for Long-Form Survey Respondents

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **INSULATION - QUANTITY** | |  | |  | |
| **INS3\_#.** In the absence of the program, would you have installed **more or less** **<MEASURE>**? Would you have … ***[READ LIST, SINGLE RESPONSE]*** | | | | | |
| **Response Code** | **Description** | | **Free-ridership score** | |  |
| 1. | Covered LESS area/square feet | | 0.5 | |  |
| 2. | Covered the SAME area | | 1.0 | |  |
| 3. | Covered MORE or | | 1.0 | |  |
| 4. | Would NOT have installed <MEASURE> [ SKIP TO NEXT APPLICABLE MEASURE] | | 0.0 | |  |
| -97 | [Don’t know] | |  | |  |
| -98 | [Refused] | |  | |  |
|  |  | |  | |  |
| **INSULATION -EFFICIENCY** | | |  | |  |
| Insulation is rated as an “R-Value”, where the higher the R-value, the better the insulation's effectiveness ***[READ ONLY ONCE - FOR FIRST APPLICABLE MEASURE WITHIN INSULATION]*** | | | | | |
| **INS4\_#.** In the absence of the program, how different would your installed R-Value have been? For **<MEASURE>,** would you have installed…***[READ LIST, SINGLE RESPONSE]*** | | | | | |
| **Response Code** | **Description** | | **Free-ridership score** | |  |
| 1. | A lower R value | | 0.5 | |  |
| 2. | The same R value | | 1.0 | |  |
| 3. | A higher R value | | 1.0 | |  |
| 4. | Would not have installed any insulation [ SKIP TO NEXT APPLICABLE MEASURE] | | 0.0 | |  |
| -97 | [Don’t know] | |  | |  |
| -98 | [Refused] | |  | |  |
|  |  | |  | |  |
| **INSULATION -TIMING** | | |  | |  |
| **INS5\_#.** In the absence of the program, would you have installed <MEASURE>… ***[READ LIST,*** *SINGLE RESPONSE****]?*** | | | | | |
| **Response Code** | **Description** | | **Free-ridership score** | |  |
| 1. | At the same time | | 1.0 | |  |
| 2. | Earlier | | 1.0 | |  |
| 3. | Later | | 0.5 | |  |
| 4. | Never | | 0.0 | |  |
| -97 | [Don’t know] | |  | |  |
| -98 | [Refused] | |  | |  |

### Aggregated Overall Free Ridership: Long-Form Survey Respondents

For respondents who took the long form of the survey, measure level free-ridership scores, as computed above, are aggregated to obtain one overall respondent level free-ridership score. In the example shown in Table 18 below, the respondent has installed 5 measures. The overall free-ridership score for the respondent is simply the average of the free-ridership scores for each measure installed and is computed as (0 + 0 + 0.5+ 0.5 + 0.5)/5 = 0.3.

Table 18: Individual Respondent free-ridership scores – Illustrative Example

|  |  |
| --- | --- |
| Measure | Free-ridership Scores |
| Attic Insulation | 0.0 |
| Wall Insulation | 0.0 |
| Floor Insulation | No Measure |
| Air Sealing | 0.5 |
| HVAC Systems Upgrade - Heat Pump | No Measure |
| HVAC Systems Upgrade - Furnace | No Measure |
| HVAC Systems Upgrade - Air Conditioning | No Measure |
| HVAC Duct Leakage Reduction | 0.5 |
| HVAC Duct Insulation | 0.5 |
| EE Water Heater | No Measure |
| Hot Water Distribution | No Measure |
| Window replacement | No Measure |
| Respondent level free-ridership score (across all installed measures) | **0.3** |

## Net-to-Gross Results

The free-ridership analysis began with a review of the distribution of scores based on the number of measures installed and the results for each individual measure. Case-weights are applied to ensure that the sample is balanced to reflect true population proportions. The final case-weighted results by utility, geography, and other subgroups of interest such as short-form versus long-form survey respondents are then provided and will be applied to the gross savings results.

### Free-ridership Scores by Number and Type of Measures Installed

The cross tabulation in Table 19 below displays the distribution of free-ridership scores by the number of measures installed. The proportion of respondents that indicated zero free-ridership decreased as the number of measures installed increased. Partial free-ridership was lower amongst respondents who installed one to two measures at 62% versus more than 80% for those who installed three or more measures.

Table 19: Free-ridership Case-Weighted Scores by Number of Measures Installed

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Free-ridership Score Categories→ | Zero Free- ridership | Partial Free-ridership | | | | Pure free-ridershipPure free | Number of respondents |
| Number of measures installed↓ | 0 | > 0, <= .25 | > .25, <= .5 | > .5, <= .75 | >.75, <1 | 1 |  |
| 1 to 2 | 17% | 11% | 26% | 14% | 11% | 20% | 35 |
| 3 to 4 | 13% | 27% | 26% | 21% | 9% | 5% | 150 |
| 5 to 7 | 12% | 20% | 32% | 19% | 11% | 6% | 288 |
| 8 to 11 | 7% | 15% | 31% | 19% | 20% | 7% | 54 |
| Number of respondents | 63 | 110 | 158 | 100 | 61 | 35 | 527 |

Table 20 : Free-ridership Case-Weighted Scores by Number of Measures Installed

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Free-ridership Score Categories→ | Zero Free- ridership | Partial Free-ridership | | | | Pure free-ridership | Number of respondents |
| Number of measures installed↓ | 0 | > 0, <= .25 | > .25, <= .5 | > .5, <= .75 | >.75, <1 | 1 |  |
| 1 to 2 | 6 | 4 | 9 | 5 | 4 | 7 | 35 |
| 3 to 4 | 19 | 40 | 39 | 31 | 13 | 8 | 150 |
| 5 to 7 | 34 | 58 | 93 | 54 | 33 | 16 | 288 |
| 8 to 11 | 4 | 8 | 17 | 10 | 11 | 4 | 54 |
| Number of respondents | 63 | 110 | 158 | 100 | 61 | 35 | 527 |

Free-ridership scores by type of measures installed, as displayed in Table 21 below, indicate that there are significant differences in both the installation rate and the level of free-ridership for the installed measures. While energy efficient windows were reportedly installed by less than 20% of the sample, the level of pure free-ridership was highest for this measure at 7% compared with other measures for which pure free-ridership ranged from 1% to 3%. Wall insulation and domestic hot water distribution measures had the highest proportion of respondents, with zero free-ridership at 13% and 10% respectively compared with other measures for which this proportion ranges from 1% to 8%. Shell measures such as air sealing and insulation and HVAC measures such as duct leakage, duct insulation, and HVAC systems upgrades were reportedly the highest installed measures. Approximately 90% of respondents installing each of these measures could have been described as partial free-riders.

Table 21: Free-ridership Case-Weighted Scores by Type of Measure Installed

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Free-ridership Score Categories→ | Zero Free- ridership | Partial Free-ridership | | | | Pure Free-ridership |  | Average Free-ridership scores |
| Measures installed↓ | 0 | > 0, <= .25 | > .25, <= .5 | > .5, <= .75 | >.75, <1 | 1 | **Number installing measure↓** |  |
| Short Form | 25% | 27% | 15% | 3% | 13% | 17% | 132 | **42%** |
| Attic/Ceiling Insulation | 8% | 21% | 35% | 23% | 11% | 3% | 321 | **49%** |
| Wall Insulation | 13% | 21% | 39% | 16% | 10% | 1% | 129 | **34%** |
| Floor Insulation | 6% | 24% | 38% | 18% | 13% | 2% | 124 | **31%** |
| Air Sealing | 8% | 21% | 36% | 23% | 9% | 3% | 259 | **37%** |
| HVAC Systems Upgrade – Heat Pump | 5% | 14% | 37% | 28% | 16% | 1% | 192 | **54%** |
| HVAC Systems Upgrade – Furnace | 1% | 19% | 37% | 28% | 14% | 1% | 118 | **46%** |
| HVAC Systems Upgrade – Air-conditioner | 8% | 18% | 31% | 24% | 19% | 0% | 39 | **56%** |
| HVAC Duct Leakage Reduction | 8% | 18% | 37% | 24% | 10% | 3% | 325 | **41%** |
| HVAC Duct Insulation | 7% | 18% | 37% | 26% | 11% | 2% | 250 | **47%** |
| Energy-Efficient Water Heater | 5% | 17% | 41% | 25% | 10% | 2% | 135 | **55%** |
| Domestic Hot Water Distribution | 10% | 16% | 40% | 23% | 8% | 2% | 126 | **40%** |
| Windows | 4% | 19% | 27% | 26% | 17% | 7% | 100 | **66%** |

Table 22 : Free-ridership Case-Weighted Scores by Type of Measure Installed

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Free-ridership Score Categories→ | Zero Free- ridership | Partial Free-ridership | | | | Pure Free-ridership |  |
| Measures installed↓ | 0 | > 0, <= .25 | > .25, <= .5 | > .5, <= .75 | >.75, <1 | 1 | **Number installing measure↓** |
| Short Form | 32 | 35 | 21 | 4 | 17 | 23 | 132 |
| Attic/Ceiling Insulation | 25 | 68 | 108 | 75 | 37 | 8 | 321 |
| Wall Insulation | 15 | 28 | 47 | 23 | 14 | 2 | 129 |
| Floor Insulation | 7 | 31 | 45 | 21 | 18 | 2 | 124 |
| Air Sealing | 20 | 53 | 92 | 61 | 25 | 8 | 259 |
| HVAC Systems Upgrade – Heat Pump | 9 | 26 | 70 | 55 | 31 | 1 | 192 |
| HVAC Systems Upgrade – Furnace | 2 | 24 | 42 | 32 | 17 | 1 | 118 |
| HVAC Systems Upgrade – Air-conditioner | 3 | 8 | 12 | 8 | 8 | 0 | 39 |
| HVAC Duct Leakage Reduction | 25 | 59 | 116 | 80 | 36 | 9 | 325 |
| HVAC Duct Insulation | 17 | 44 | 90 | 67 | 28 | 4 | 250 |
| Energy-Efficient Water Heater | 7 | 24 | 54 | 34 | 14 | 2 | 135 |
| Domestic Hot Water Distribution | 11 | 21 | 51 | 29 | 11 | 3 | 126 |
| Windows | 4 | 18 | 27 | 27 | 18 | 6 | 100 |

### Distribution of free-ridership scores

Overall free-ridership scores were computed for short-form and long-form survey respondents, as detailed above. Table 23 below summarizes the distribution of free-ridership scores across the total sample. The majority of the respondents could have been described as partial free-riders at more than 80%, and significantly smaller segments of the sample could have been described as pure free-riders and zero free-riders at 7% and 12% respectively.

Table 23: Distribution of Case-Weighted Free-Ridership Scores

A further examination of average free-ridership scores by subgroups of interest, such as IOU service territory, number of measures implemented by respondents, short-form versus long-form, and geography, reveals that the level of free-ridership does not differ significantly by the subgroups as shown in Table 24 below.

Table 24: Distribution of Case-Weighted Free-Ridership Scores by Subgroups of Interest

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Group | N | Average Free-Ridership Score | Standard Error of Mean | 95% Confidence Interval for Mean | |
| Total | 527 | 44% | 0.01 | 42% | 47% |
| PG&E | 423 | 46% | 0.02 | 43% | 49% |
| SCE/SCG | 73 | 40% | 0.03 | 33% | 47% |
| SDG&E | 31 | 43% | 0.05 | 32% | 53% |
| Short form | 132 | 42% | 0.03 | 35% | 49% |
| Long Form | 395 | 45% | 0.01 | 42% | 48% |
| Inland | 288 | 44% | 0.02 | 41% | 48% |
| Coastal | 239 | 44% | 0.02 | 41% | 48% |
| One to Two Measures | 35 | 54% | 0.06 | 42% | 66% |
| Three to Four Measures | 150 | 41% | 0.02 | 37% | 46% |
| Five to Seven Measures | 288 | 44% | 0.02 | 40% | 47% |
| Eight to Eleven Measures | 54 | 49% | 0.04 | 40% | 58% |

## Measure Costs and Savings Weighted Free-Ridership Scores

The free-ridership scores presented thus far assigned equal weights for each of the measures implemented. Since the cost to implement and the potential savings varies by measure, the next step in the analysis involved an examination of free-ridership scores with measure level weights that reflected variable costs and savings. Table 25 summarizes the measure cost and the measure savings weights, developed by the evaluation team based on the total energy perspective, that were used in this analysis.

Table 25: Measure Cost and Measure Savings Weights

|  |  |  |
| --- | --- | --- |
| Measures Implemented | Measure Costs Weight | Measure Savings Weight |
| Attic Insulation | 5 | 20 |
| Wall Insulation | 10 | 15 |
| Floor Insulation | 5 | 10 |
| Air Sealing | 5 | 10 |
| HVAC Systems Upgrade | 25 | 10 |
| HVAC Duct Leakage Reduction | 5 | 15 |
| HVAC Duct Insulation | 5 | 3 |
| Energy Efficient Water Heater | 10 | 5 |
| Hot Water Distribution | 5 | 2 |
| Window Replacement | 25 | 10 |

The above weights were applied to measure level free-ridership scores and then aggregated to obtain overall respondent level measure costs and measure savings weighted free-ridership scores. Evaluators assigned weights based on the total energy perspective and these may be broken into electric and gas weights based on estimates other than the EnergyPro estimates which are acceptable to the CPUC. Case weights were then applied to measure weighted respondent level scores to obtain free-ridership scores at the total sample level and for subgroups of interest. Results from this analysis are summarized in Table 26 below. While the application of measure cost weights resulted in free-ridership scores in the same range as before, measure-savings weighted free-ridership scores were marginally lower. We would interpret this finding to mean that measures with higher savings weight had lower levels of free-ridership.

Table 26: Measure Cost and Savings Weighted Free-Ridership Scores

| Group | n | Case Weighted | Case Weighted and Measure Cost Weighted | Case Weighted and Measure Savings Weighted |
| --- | --- | --- | --- | --- |
| Total | 527 | 44% | 45% | 40% |
| PG&E | 423 | 46% | 46% | 42% |
| SCE/SCG | 73 | 40% | 41% | 32% |
| SDG&E | 31 | 43% | 44% | 36% |
| Short form | 132 | 42% | 42% | 42% |
| Long Form | 395 | 45% | 46% | 40% |
| Inland | 288 | 44% | 45% | 40% |
| Coastal | 239 | 44% | 45% | 41% |
| One to Two measures | 35 | 54% | 54% | 52% |
| Three to Four measures | 150 | 41% | 42% | 35% |
| Five to Seven measures | 288 | 44% | 45% | 40% |
| Eight to Eleven measures | 54 | 49% | 50% | 47% |

## Free Ridership by Potential Covariates and Participant Demographics

The evaluation team investigated several possible calculations for the free ridership estimate and ultimately the case-weighted and measure savings weighted results were the most defensible. With a free ridership estimate of 0.40 the NTGR is simply the compliment or 0.60. As discussed previously in this chapter, the distribution of free ridership estimates revealed that there were many partial free riders and those partial free riders ended up driving the overall estimate as they primarily fell within the range of 0.25 to 0.5 as shown in Table 26with a normal distribution around that bin. The evaluation team applied the IOU-specific final NTGRs to the gross realized savings to develop final net savings estimates.

The covariates examined in this analysis included several demographic variables and the demographic distribution of participants is of particular interest to understand program participation/adoption. We note that certain customer segments have disproportionately higher representation amongst program participants:

* Almost 60% of participants did not avail of project financing
* More than 70% of the participants are aged 45 years or older
* Almost 75% of the participants have a four-year college degree education or higher
* More than 50% of the participants who provided income information stated that they had annual household incomes of over $100,000

This indicates that the majority of the participants in the program were highly-educated, middle-aged, and established customers with a level of affluence that does not necessitate availing of project financing. This is an important finding for the program because in order to achieve its adoption goals, it will require targeted marketing and messaging to reach other key customer segments. Additionally, more than 67% of participants state that their home was built before 1970, which seems logical given that these buildings would be more in need of retrofits compared to those of a later vintage.

## Net-to-Gross Ratio

The evaluation team investigated cost and savings weights for the free ridership estimate and ultimately the measure savings and case-weighted results were the most defensible. With a free ridership estimate of 0.44 the NTGR is simply the compliment or 0.56. As discussed in this chapter, the distribution of free ridership estimates revealed that there were many partial free riders, which ended up driving the overall estimate as they primary fell within the range of 0.25 to 0.5 with a normal distribution around that bin (Table 23).

# Conclusions and Recommendations

The evaluation team estimated total net program savings by applying the gross realization rate and the NTGR to the program ex ante savings claims. After developing the final savings estimates, the team developed a set of conclusions based on the data and analysis. Finally, the team looked at the recommendations from the IOU process evaluation and determined whether the impact analysis further supports the recommendations of the process evaluation or allows the CPUC and the IOUs to prioritize the recommendations.

## Final Net Savings

The evaluation team estimated total net program savings by applying the gross realization rate and the NTGR to the program ex ante savings claims. The gross realization rates were different for 2010-11 and 2012 and thus are presented in separate tables. The total net savings by IOU and fuel across the 2010-12 program cycle follow.

Table 27: Final Savings for 2010-2011 Participants

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fuel (unit)** | **Fixed Effects Model** | | | | | | | | | |
| **(2011 With Comparison Group)** | | | | | | | | | |
| **Program Participants** | **Mean Ex Ante Savings per Year (Un-Adjusted)** | **Mean Ex Ante Savings per Year (Adjusted)** | **Mean Ex Post Savings per Year** | **Gross Realization Rate** | **Net to Gross Ratio** | **Mean Net Savings Per Year** | **Net Savings as Percent of (Ex Ante \* Applied GRR)** | **Total Gross Savings Per Year** | **Total Net Savings Per Year** |
| Advanced Path | | | | | | | | | | | |
| PG&E | Electricity (kWh) | 692 | 2,337.9 | 1,402.7 | 177.5 | 7.6% | 0.58 | 103.0 | 7.3% | 122,844 | 71,249 |
| Gas (Therms) | 944 | 373.5 | 224.1 | 77.6 | 20.8% | 0.58 | 45.0 | 20.1% | 73,226 | 42,471 |
| SDG&E | Electricity (kWh) | 162 | 1,355.2 | 542.1 | 300.5 | 22.2% | 0.64 | 192.3 | 35.5% | 48,640 | 31,130 |
| Gas (Therms) | 158 | 141.3 | 113.1 | 67.0 | 47.4% | 0.64 | 42.9 | 37.9% | 10,557 | 6,756 |
| SCE | Electricity (kWh) | 228 | 870 | 347.9 | 691.4 | 79.5% | 0.68 | 470.2 | 135.2% | 157,719 | 107,249 |
| SCG | Gas (Therms) | 98 | 25.0 | 20.0 | 45.6 | 182.7% | 0.68 | 31.0 | 155.3% | 4,469 | 3,039 |
| Basic Path | | | | | | | | | | | |
| PG&E | Electricity (kWh) | 72 | 135.5 | 135.5 | Not Evaluatted | 100% | 0.80 | 108.4 | 80% | 9,756 | 7,805 |
| Gas (Therms) | 72 | 24.5 | 24.5 | Not Evaluatted | 100% | 0.80 | 19.6 | 80% | 1,764 | 1,411 |
| SDG&E | Electricity (kWh) | 24 | 1806.5 | 1806.5 | 791.6 | 43.8% | 0.80 | 633.3 | 35% | 18,777 | 15,022 |
| Gas (Therms) | 25 | 33.88 | 33.88 | 67.9 | 200.4% | 0.80 | 54.3 | 160% | 1,695 | 1,356 |
| SCE | Electricity (kWh) | 466 | 267 | 267 | 742.9 | 278.2% | 0.80 | 594.3 | 223% | 346,093 | 276,874 |
| SCG | Gas (Therms) | 0 | 0 | 0 | 0 | 0% | 0.80 | 0.0 | NA | - | - |

Table 28: Final Savings for 2012 Participants

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fixed Effects Model** | | | | | | | | | | |
| **(2012 With Comparison Group)** | | | | | | | | | | |
| **Program Participants** | **Mean Ex Ante Savings per Year (Un-Adjusted)** | **Mean Ex Ante Savings per Year (Adjusted)** | **Mean Ex Post Savings per Year** | **Gross Realization Rate** | | **Net to Gross Ratio** | **Mean Net Savings Per Year** | **Net Savings as Percent of (Ex Ante \* Applied GRR)** | **Total Gross Savings Per Year** | **Total Net Savings Per Year** |
| Advanced Path | | | | | | | | | | | |
| PG&E | 1,958 | 2,765.1 | 1,659.1 | 212.3 | | 7.7% | 0.58 | 123.1 | 7.4% | 415,586 | 241,040 |
| 2,674 | 335.3 | 201.2 | 72.3 | | 21.6% | 0.58 | 42.0 | 20.9% | 193,410 | 112,178 |
| SDG&E | 156 | 3,873.7 | 1,549.5 | -15.8 | | -0.4% | 0.64 | -10.1 | -0.7% | (2,467) | (1,579) |
| 153 | 292.8 | 234.2 | 58.9 | | 20.1% | 0.64 | 37.7 | 16.1% | 9,028 | 5,778 |
| SCE | 464 | 3,222.3 | 1,288.9 | 393.8 | | 12.2% | 0.68 | 267.8 | 20.8% | 182,678 | 124,221 |
| SCG | 541 | 317.3 | 253.8 | 154.8 | | 48.8% | 0.68 | 105.3 | 41.5% | 83,768 | 56,963 |
| Basic Path | | | | | | | | | | | |
| PG&E | 20 | 135.5 | 135.5 | Not Evaluatted | | 100% | 0.80 | 108.4 | 80% | 2,710 | 2,168 |
| 20 | 24.5 | 24.5 | Not Evaluatted | | 100% | 0.80 | 19.6 | 80% | 490 | 392 |
| SDG&E | 378 | 802.8 | 802.8 | 232.9 | | 29.0% | 0.80 | 186.3 | 23% | 88,101 | 70,481 |
| 368 | 41.7 | 41.7 | 12.6 | | 30.2% | 0.80 | 10.1 | 24% | 4,640 | 3,712 |
| SCE | 1,073 | 478.5 | 478.5 | 200.4 | | 41.9% | 0.80 | 160.3 | 34% | 215,056 | 172,045 |
| SCG | 170 | 13.2 | 13.2 | Not Evaluatted | | 100% | 0.80 | 10.6 | NA | 2,244 | 1,795 |

## Conclusions

The evaluation concluded that resulting savings were less than planned. These lower savings result from a confluence of factors.

The program used an energy simulation tool to estimate site specific savings. The tool’s overestimation of energy consumption has been well documented in the ex ante review and IOU process evaluations. The evaluation team found that gross savings were less than expected despite the adjustments that the IOUs made to the ex ante savings. The actual energy consumption, especially electric consumption, is not normally distributed around the average. Therefore, the assumptions the tool made were based on an incorrect average and did not capture the true extremes of high and low usage. This means that for a given home the estimate of savings could be higher than the estimated usage. This idea is further described in the next section.

In addition to the gross savings, the majority of survey respondents scored as partial free riders. Survey responses support that many were planning to do a single measure regardless of incentive, and that the program was responsible for inducing additional measures. Estimated free ridership would be lower if the program claimed only the savings for the additional measures the participants were not already considering prior to the retrofit.

At the time of this report, the IOUs and other stakeholders published a new effort, CALTEST,to better calibrate, or at least compare, simulation estimates to billed energy consumption.

The figure below depicts the ratio of ex ante savings divided by consumption in the pre-installation period. On the horizontal axis, a value of 1 means that ex ante savings are equal to consumption. , a value of 2 means that the ex ante savings are twice the pre-installation energy use, and so on. Since these analyses exclude net metering sites, any value greater than one would be physically impossible.

Figure 9: Distribution of ExAnte Savings and Consumption Ratio



Last, the evaluation team recommends additional work to do targeting and focusing on the homes with consumption that is high enough to compensate for the fact that the program may inherently attract partial free riders. The following section includes additional support for these ideas that were raised in the non-impact IOU studies.

## Recommendations

The impact evaluation showed energy savings to be lower than expected, with the gas savings across program delivery types and IOUs closer to expectations than electric savings which varied. The evaluation also determined that partial free riders comprised a majority of program participants in the Advanced Path. The impact evaluation found that like the ex ante disposition and the first IOU process evaluation, the energy simulation software overestimates usage and savings. The evaluation team recommends support for statewide efforts via CALTEST to look at additional software options and program requirements that better predict consumption or that require using billing data to calibrate estimates. Some of the evaluation team members supported these efforts via technical working group. The recommendations suggested in this section require that future estimates are calibrated or are more accurate than current estimates.

The evaluation team developed key recommendations based on the evaluation findings that may inherently improve gross realization rates and net to gross.

* Change from incentives based on percent savings for site energy and provide incentives similar to the non-residential custom programs on a dollar per unit of energy basis ($/kWh and $/therm). Currently the relative savings approach provides the same dollar amount to homes with low and high usage and does not align with the value of electric savings that is part of cost effectiveness calculations. Savings per unit of energy would provide more money to save more energy on an absolute basis and may increase program uptake in hotter climates by properly valuing electric savings.
* Only provide incentives and claim savings for measures that the customer was not already considering. Only modeling the measures the customer would not have done in absence of the program will reduce free ridership. This documentation of which measures the customer would be doing can also support identifying early replacement measures and distinguishing them from replace on burnout. The incentives would also then support “deeper” retrofits as opposed to providing some funding for free rider measures and only partial funding for additional measures.

## Support for Program Recommendations in Process Evaluations

The evaluation team could not develop program recommendations based solely on the impact results, therefore the evaluation team reviewed the relevant process evaluations conducted over the past few years on the Energy Upgrade California programs. These studies include the following:

* 2010–2012 PG&E AND SCE WHOLE HOUSE RETROFIT PROGRAM PROCESS EVALUATION STUDY – SBW CONSULTING, INC.. December 12, 2012
* 2010–2012 PG&E WHOLE HOUSE RETROFIT PROGRAM PHASE II PROCESS EVALUATION STUDY –SBW CONSULTING, INC.. December 31, 2013
* PG&E WHOLE HOUSE PROGRAM: MARKETING AND TARGETING ANALYSIS - OPINION DYNAMICS CORPORATION April 2014

The recommendations across process evaluations regarding targeting for marketing may be the most important in terms of realizing savings. Refocusing the program toward inland areas with warmer temperatures and providing more support based on household available capital would be the mechanisms to achieve the higher savings. The evaluation team based this recommendation support on the lower than expected gross savings, geographic participation shift in SCE that led to lower savings from 2010 to 2012, and the survey demographics indicating that participants were relatively well paid, highly educated, and many did not take advantage of financing for a relatively expensive project. We do think that location and available capital may be intrinsically linked. When the ARRA funding ended, participation seemed to migrate toward the Pacific coast to ZIP codes that have higher home values and home incomes, but these are also locations with less potential electric savings. This implies that the program may have to provide additional incentives to attract the homes with the greater potential savings from retrofits. The homes with higher consumption near the coast have more base load than cooling load and other measures focused on advanced lighting, appliances, and electronics may have substantial site specific savings.

Overall the most recent study reviewed, the PG&E Marketing and Targeting analysis, may provide the best summary of recommendations, all of which seem to be supported by the impact evaluation. The evaluation thought it best to provide the four complete recommendations from the report’s executive summary. These should apply to all IOUs based on our impact analysis.

*Recommendation #1: Address Constraints in Messaging and Design: Financial constraints are the largest reason for not being able to take action. The program needs to address financial constraints by making customers aware that there is financial support available if they cannot afford the upfront cost of the retrofit.*

*Recommendation #2: Lead with Home Comfort Message But Add Environment: Home comfort is the dominant motivator for whole house upgrades. However, our research shows that environmental messaging, when combined with comfort messages, may be the most powerful of all messaging.*

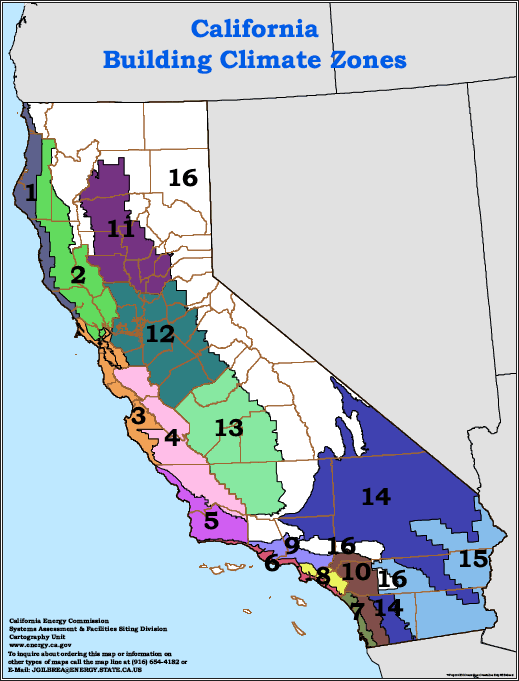
*Recommendation #3: Consider New Potential Measure Bundles: Based upon customers’ intent to install multiple measures in the near future, there are two potential bundles of measures that could be used for the basic path to help encourage participation.*

*Recommendation #4: Score and Micro-target Customers: The overall savings from this program are lower than expected. Targeting high savers would help to increase savings (and average savings per home) in the future. Based on our analysis of household-level savings, using a minimum of these 13 key variables, and the stage model that can predict who has intent to do whole house upgrades, PG&E can score its entire residential customer base to identify which customers are more likely to intend to take action along and which customers have the potential for high energy savings. This would help the program target the right customers with direct marketing and outreach.*

# Appendix

1. Climate Zone Map

Figure A1. California Building Climate Zones



1. Pooled Fixed Effects Model Without Comparison Group
   1. Method Overview of the Pooled Fixed Effects Model without Comparison Group

As a first step in the billing analysis for this evaluation, DNV GL prepared a Fixed Effects model with no comparison group. For each IOU, all monthly consumption data (both pre- and post-installation) of eligible participants were included in a single model with the following specification:

Where:

|  |  |
| --- | --- |
|  | Average actual electric (or gas) consumption per day for participant *i* during billing period *m* |
|  | Fixed effect (or specific intercept) for participant *i* |
|  | Post-retrofit period indicator (1 for post-installation and 0 for pre-installation period) |
|  | Average daily cooling degree days (CDD) at 70⁰F for participant *i* during billing period *m (not included in gas model)* |
|  | Average daily healing degree days (HDD) at 60⁰F for participant *i* during billing period *m* |
|  | Interaction term between post indicator and CDD70 *(not included in gas model)* |
|  | Interaction term between post indicator and HDD60 |
|  | Monthly binary variables for each billing month |
|  | Change in energy consumption during post-installation period |
|  | Effect of cooling on energy consumption during pre-installation period |
|  | Effect of heating on energy consumption during pre-installation period |
|  | Change in the effect of cooling on energy consumption during post-installation period |
|  | Change in the effect of heating on energy consumption during post-installation period |
|  | Error term for participant *i* in month *m* |

Weather-normalized savings were calculated as:

Where:

|  |  |
| --- | --- |
|  | Coefficients determined by the fixed effects model |
|  | Average daily CDD calculated using temperature data from TMY3 or CTZ2 of the participants *(not included when estimating gas savings)* |
|  | Average daily HDD calculated using temperature data from TMY3 or CTZ2 of the participants |

* 1. Results of the Pooled Fixed Effects Model without Comparison Group

The first set of savings estimates were produced using a pooled fixed effects approach without the use of comparison group. The pooled approach addressed exogenous change without the inclusion of a separate comparison group. In this model, participants who received a measure installation during a certain time interval served as a steady-state comparison for other participants in each other time interval. Table 28 summarizes program savings estimates from the pooled fixed effects approach.

Table 29: Program Savings from Pooled Fixed Effects Model without Comparison Group

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **Fuel** | **Fixed Effects Model**  **(2011 Participants)** | | | | **Fixed Effects Model**  **(2012 Participants)** | | | |
| **n (a)** | **Savings Estimate** | **Standard Error** | **% Savings** | **n (a)** | **Savings Estimate** | **Standard Error** | **% Savings** |
| PG&E | Electric | 422 | 159.1 | 151.3 | 1.9% | 1,203 | 199.7 | 87.4 | 2.5% |
| Gas | 707 | 70.5 | 17.2 | 11.8% | 2,030 | 31.7 | 9.7 | 5.6% |
| SDG&E | Electric | 137 | 370.0 | 227.3 | 5.2% | 421 | 90.1 | 152.5 | 1.3% |
| Gas | 130 | 63.0 | 30.8 | 16.1% | 402 | 24.0 | 16.6 | 6.4% |
| SCE | Electric | 462 | 270.0 | 234.5 | 2.7% | 1,024 | 442.5 | 133.3 | 5.2% |
| SCG | Gas | 57 | -0.2 | 34.9 | 0.0% | 479 | 45.5 | 17.3 | 9.5% |

(a) The difference between the total number of program participants and the final number of program participants used in this analysis is illustrated in Table 9.

Results from the pooled fixed effects model are summarized below:

**Electric**

* Overall average savings estimates for 2011 program year range from around 2% to 5%. However, savings were not statistically significant.
* PG&E and SCE savings estimates for 2012 participants were 2.5% and 5.2% and are statistically significant at 95% confidence level while SDG&E program participants in 2012 did not show evidence of program savings.

**Gas**

* PG&E and SDG&E produced statistically significant savings of more than 10% for the 2011 program year. The savings estimate for SoCalGas is not reported for the 2011 program year because the number of participants is very small.
* Gas savings of 2012 PG&E and SDG&E participants were statistically significant and less than half of the savings generated by 2011 participants. SoCalGas produced around 10% savings for 2012 program year.

1. Free Ridership by Demographic Variables

We examined free ridership scores by potential covariates to understand how free ridership varied as a function of specific customer segments. While there are marginal differences, these were not statistically significant for the majority of the covariates examined below. Free-ridership was significantly higher for the customers with an education level of high school or less (60%) compared with those with an advanced degree or post-graduate work (43%). Free ridership was significantly higher later in the program cycle, at 46% in program year (PY) 2012 versus 39% in PY2011.

The covariates examined included several demographic variables and the demographic distribution of participants is of particular interest to understand program participation/adoption. We note that certain customer segments have disproportionately higher representation amongst program participants:

* Almost 60% of the participants in did not avail of project financing
* More than 70% of the participants are aged 45 years or older
* Almost 75% of the participants have a four-year college degree education or higher
* More than 50% the participants who provided income information stated that they had annual household incomes of over $100,000

This indicates that the majority of the participants in the program were highly educated, middle-aged, established customers with a level of affluence that does not necessitate availing of project financing. This is an important finding for the program as in order to achieve its adoption goals, it will require targeted marketing and messaging to reach other key customer segments. .

Table 30: Free Ridership Scores by Household Characteristics

| **Group** | **N** | **Average Free Ridership Score** | | **Standard Error of Mean** | **95% Confidence Limit for Mean** | |
| --- | --- | --- | --- | --- | --- | --- |
| **Project Financing** | | | | | | |
| Availed of project financing | 215 | 43% | | 2% | 39% | 47% |
| Did not avail of project financing | 312 | 45% | | 2% | 41% | 49% |
| **No significant difference in free ridership by project financing.** | | | | | | |
|  | | | | | | |
| **Home Vintage** | | | | | | |
| Before 1970 | 347 | 43% | | 2% | 40% | 46% |
| In the 1970s | 90 | 46% | | 3% | 39% | 52% |
| In the 1980s | 56 | 51% | | 4% | 43% | 59% |
| In the 90s or after | 33 | 48% | | 5% | 37% | 58% |
| **No significant difference in free ridership by home vintage.** | | | | | | |
|  | | | | | | |
| **Number of bedrooms** | | | | | | |
| 1-2 | 80 | 38% | | 3% | 31% | 45% |
| 3-4 | 419 | 45% | | 2% | 42% | 48% |
| 5 or more | 28 | 54% | | 6% | 41% | 67% |
| **No significant difference in free ridership by number of bedrooms in the home.** | | | | | | |
|  | | | | | | |
| **Difference in household size - Post - Pre retrofit** | | | | | | |
| Increase | 63 | 42% | | 4% | 35% | 50% |
| Same | 396 | 44% | | 2% | 41% | 47% |
| Decrease | 68 | 49% | | 4% | 41% | 57% |
| **No significant difference in free ridership by change in size of household.** | | | | | | |
|  | | | | | | |
| **Post retrofit household size** | | | | | | |
| 1 | 70 | 38% | | 4% | 30% | 46% |
| 2 | 215 | 48% | | 2% | 44% | 53% |
| 3 | 80 | 45% | | 3% | 38% | 52% |
| 4 | 111 | 41% | | 3% | 35% | 46% |
| 5 or more | 21 | 48% | | 8% | 32% | 64% |
| **No significant difference in free ridership by size of household (post retrofit).** | | | | | | |
|  | | | | | | |
| **Age** | | | | | | |
| Under 34 | 48 | 47% | | 5% | 38% | 56% |
| 35 to 44 | 96 | 47% | | 3% | 40% | 54% |
| 45 to 54 | 114 | 41% | | 3% | 36% | 46% |
| 55 to 64 | 124 | 45% | | 3% | 40% | 51% |
| Over 65 | 132 | 43% | | 3% | 37% | 48% |
| **No significant difference in free ridership by age.** | | | | | | |
|  | | | | | | |
| **Education** | | | | | | |
| Less than high school or high school | 26 | 60% | | 7% | 46% | 73% |
| Some college, trade or technical school | 75 | 45% | | 4% | 38% | 52% |
| Business or technical school (2 year) | 21 | 44% | | 5% | 33% | 56% |
| College graduate (4 year) | 152 | 43% | | 3% | 37% | 48% |
| Post graduate work or advanced degree | 238 | 43% | | 2% | 39% | 46% |
| **Barely statistically significant difference in free ridership between those who have a high school or less than high school degree and those who have an advanced degree or post-graduate work  at 60% vs 43%.** | | | | | | |
|  | | | | | | |
| **Income** | | | | | | |
| Income less than $100k | 225 | 41% | | 2% | 37% | 45% |
| Income greater than $100k | 229 | 47% | | 2% | 43% | 51% |
| **No significant difference in free ridership by income.** | | | | | | |
|  | | | | | | |
| **Program Year** | | | | | | |
| PY2010 | 1 | 100% | N/A | | N/a | N/A |
| PY2011 | 132 | 39% | 3% | | 34% | 44% |
| PY2012 | 394 | 46% | 2% | | 43% | 49% |
| **Barely statistically significant higher free ridership later in the program cycle at 46% in PY2012 versus 39% in PY2011.** | | | | | | |

1. Survey Instrument
2. **WO46 Whole House Impact Evaluation Homeowner** **Computer-Aided Telephone Interview (CATI) Survey Instrument**
3. **Introduction**
4. *[TARGET: Trying to reach current owner or co-owner of home. If co-owners, respondent should have been involved in renovation decisions].*

**Lead-in:** Hello, my name is \_\_\_\_\_\_\_\_\_ and I am calling from Discovery Research Group. We are conducting a study to help <**IOU>** improve their energy efficiency programs for their customers. May I speak with <Mr/Ms NAME>?

If owner is unavailable, ask: “May I speak to whomever made the decision in your household to participate in Energy Upgrade California?”

* *If owner/decision maker is not home/unavailable: record best time to call back.*

CALL BACK DATE/TIME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* *If owner lives elsewhere and/or has diff. phone #: record name, phone#, best time to call.*

***[REPEAT LEAD-IN FOR RESPONDENT, IF NEEDED]***

We are conducting a study of households that participated in the **Energy Upgrade California** **program** **to install energy efficiency measures**. The California Public Utilities Commission will use this information to help plan programs to benefit homeowners and save energy.

I want to assure you that this **is NOT A SALES CALL** and your answers will be kept **strictly confidential** and reported only in the aggregate.

***[IF REQUIRED]:*** This study is sponsored by the California Public Utilities Commission.

***[IF REQUIRED]:*** We are calling on behalf of the California Public Utilities Commission. The CPUC is conducting a study to gauge the energy savings from **the Energy Upgrade California program**, in which your household participated.

***[IF REQUIRED]:*** This survey will take about 30 minutes.

***[IF REQUIRED]****:* You may confirm that this is a legitimate study by contacting Mona Dzvova, the California Public Utilities Commission study manager, at 415-703-1231 or Mona.Dzvova@cpuc.ca.gov

***[CONTINUE ON TO SCREENER]***

1. **Screener**
2. I’d like to confirm that you are the decision maker for the **energy efficiency project** undertaken at **<ADDRESS>**. Would you describe yourself as the …***[READ LIST, ACCEPT SINGLE RESPONSE ONLY***
3. Homeowner who is occupant @ **<ADDRESS>** and decision maker for the project**🡺*[Go to S2]***
4. Homeowner who is not occupant @ **<ADDRESS>** but is decision-maker for the project**🡺*[Go to S2]***
5. Renter @ **<ADDRESS>** and decision maker for the project 🡺***[Go to S2]***
6. **NOT** decision maker for the project 🡺[*Ask for owner’s name and best time to call. If contact has no connection to address, record disposition and Thank and Terminate]*

-97. Don’t know🡺 Thank and Terminate

-98. Refused 🡺 Thank and Terminate

1. When did you complete the project under the Energy Upgrade California program? ***[READ OPTIONS]***
2. Prior to 2010 🡺 Thank and Terminate
3. Between 2010 and 2012
4. After 2012🡺 Thank and Terminate

-97. Don’t know🡺 Thank and Terminate

-98. Refused 🡺 Thank and Terminate

1. **Project Details – Warm Up questions**
2. **Energy Audit**
3. Prior to undertaking this project, did you have an energy assessment/energy audit done of your home to identify measures that would save energy and reduce energy costs?

1. Yes 🡺 **Proceed to A2**

2. No 🡺 **Skip to M1**

-97. (Don’t know)🡺 **Skip to M1**

-98. (Refused)🡺 **Skip to M1**

1. Did the energy assessment/energy audit you received incorporate the following elements? [**READ LIST.** **CODE: 1 = YES, 2 = NO, -97 = DON’T KNOW, -98 = REFUSED**.]
2. In-person inspection of your home
3. Blower door test with large fan to measure air leakage
4. Tests to measure leaks in heating and air conditioning ducts, sometimes known as “Duct Blaster”
5. Testing of the combustion efficiency of your furnace or space heater/boiler
6. A report of results from the energy audit
7. In-person discussion of results and energy saving options with contractor
8. A projection of energy savings from possible retrofits
9. Did the contractor who performed the Energy Audit also carry out the improvements to your home? ***[DO NOT READ LIST]***
10. Yes – all of the improvements
11. Yes – some of the improvements
12. No – none of the improvements

-97 Don’t know

-98 Refused

1. Was there a fee for the Energy Audit?
2. Yes
3. No

-97 Don’t know

-98 Refused

1. Did the energy audit identify opportunities to save energy in your home that you had not been aware of before the audit?

1. Yes

2. No

-97. Don’t know

-98. Refused

1. **Measures Installed**

**M1.** As part of this project, which of the following home improvements did you have installed? Did you ***…***

***[READ LIST IN ORDER]***

| Order | Measure Type | Installed?  *1 = YES; 2 = NO; -97 = DON’T KNOW; -98 = REFUSED* | Direction for Measure specific questions |
| --- | --- | --- | --- |
| 1 | Add insulation to the attic or ceiling (*IF REQUIRED:* *typically attic, but may include flat rof home and vaulted ceilings)*. | M1\_1 | Ask about next Measure |
| 2 | Add insulation to the walls | M1\_2 | Ask about next Measure |
| 3 | Add insulation to the floor (crawlspace) | M1\_3 | If M1\_1 = Y or M1\_2 = Y or M1\_3 = Y go to Insulation |
| 4 | Seal the building envelope (sometimes referred to as weatherization/whole house leakage reduction) | M1\_4 | If Y go to Whole House Leak Reduction |
| 5 | Upgrade the HVAC system (new furnace/air conditioner) | M1\_5 | If Y go to HVAC System |
| 6 | Air seal HVAC ducts and reduce leakage | M1\_6 | Ask about HVAC Duct Insulation |
| 7 | Insulate HVAC ducts | M1\_7 | If M1\_6 =Y or M1\_7 =Y go to Duct Improvements |
| 8 | Install a new high efficiency water heater | M1\_8 | Water Heater |
| 9 | Insulate hot water pipes *e.g.* Domestic Hot Water Distributions | M1\_9 | Hot Water Distribution |
| 10 | Replace windows | M1\_10 | Window |
| 11 | Install Renewable ^ *e.g.* Solar/PV | M1\_11 | Renewables |
| 12 | Other *e.g.* pool pumps  Specify \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | M1\_77 |  |

1. **If DK/Ref or 97 or 98 to all measures then T&T.**
2. **If m1\_77=Other is the only measure they say they have and m1\_1—m1\_11=no/dk/ref then T&T**
3. **M1 should ASK ABOUT ALL MEASURES** and then move on
4. **M2.** Which of the following describes how you approached this project?
5. You thought of all the measures installed as a PACKAGE for which you made ONE purchasing decision *[go to QT1]*
6. You considered each measure individually *[go to first applicable measure section, per responses and table in M1]*
7. -97. Don’t know *[go to first applicable measure section, per responses and table in M1]*
8. -98. Refused *[go to first applicable measure section, per responses and table in M1]*

[Note: Discovery – for this and any subsequent instance where we skip to **the applicable measure section** please capture in a binary indicator called **MEASURE**=1.

If the respondent is never asked any of the measure by measure questions then **MEASURE** stays at its initialized value = 0.]

1. **OVERALL QUANTITY**

**QT1.** In the absence of the program, would you have installed ..***.[read each response option] …***of the measures?

1. ALL ***[go to overall efficiency EF1]***
2. SOME ***[go to first applicable measure section****]*
3. NONE ***[go to overall efficiency EF1]***

-97. Don’t know ***[go to first applicable measure section****]*

-98. Refused ***[go to first applicable measure section****]*

1. **OVERALL EFFICIENCY**

EF1. In the absence of the program, would you have opted to install insulation and equipment with the same levels of efficiency?

1. Yes
2. No

-97. [Don’t know] ***[go to first applicable measure section****]*

-98. [Refused] ***[go to first applicable measure section****]*

1. **OVERALL PROJECT TIMING**

**T1.** In the absence of the program, would you have undertaken this project… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time ***[SKIP TO T3]***

2. Earlier

3. Later

4. Never ***[SKIP to T2\_v]***

-97. [Don’t know]  ***[go to first applicable measure section****]*-98. [Refused]  ***[go to first applicable measure section****]*

**CONSISTENCY CHECK**

**T2.** How many months **earlier** *(if T1=2)/***later** *(if T1=3)* would you have undertaken this project?

***[***1 to 48, 97 = Don’t know, 98 = Refused]

***[RECORD RESPONSE]***

**T2\_v**. Why would you have **accelerated** *(if T1=2)***/delayed** *(if T1=3/***never undertaken** *(if T1=4)* this project? ***[OPEN END]***

***[RECORD VERBATIM]***

**T3.** *[If T1=1=At the same time]* How long had you been planning to undertake this project?

***[RECORD RESPONSE: Number (***1 to 96, -97 = Don’t know, -98 = Refused) ***and Unit (Weeks, Months, Years,*** -97 = Don’t know, -98 = Refused)***]***

**T3\_1.** *[If T1=1=At the same time]* Prior to learning about the program, had you already obtained bids to undertake this project?

1. Yes
2. No

-97. [Don’t know]

-98. [Refused]

***[For all respondents with M2=1 and MEASURE=0 ( those who have not been skipped to the measure sections thro EF\*, T\* question responses etc), go to C1 (Information received from contractor) and then proceed to PF1 and ask ALL PF\* questions, SEG\* questions and HH\* questions***

***For all respondents with M2=2, Go to first applicable measure section. CHANGE MEASURE to = 1***

***]\*\****

1. **QUANTITY AND EFFICIENCY QUESTIONS - BY MEASURE**
2. **INSULATION - (EXCEPT DUCTS)**
3. **Measure1 - Attic or Ceiling Insulation**
4. **Measure2 – Wall Insulation**
5. **Measure3 – Floor Insulation**

*(Complete the entire INS\* series of questions for the first applicable measure and then move on to the next measure and so on.)*

**INS1\_#.** In the absence of the program, would you say your likelihood of **hiring a contractor** to install **<MEASURE>** was… ***[READ LIST, SINGLE RESPONSE]***

1. Very likely
2. Somewhat likely
3. Somewhat unlikely
4. Very unlikely
5. -97. [Don’t know]
6. -98. [Refused]

**INS2\_#.** In the absence of the program, would you say your likelihood of installing **<MEASURE>** was…?

1. Very likely

2. Somewhat likely

3. Somewhat unlikely

4. Or very unlikely

-97. [Don’t know]

-98. [Refused]

1. ***INSULATION (EXCEPT DUCTS) - QUANTITY***

**INS3\_#.** In the absence of the program, would you have installed **more or less** **<MEASURE>**? Would you have … ***[READ LIST, SINGLE RESPONSE]***

1. Covered LESS area/square feet
2. Covered the SAME area
3. Covered MORE or
4. Would NOT have installed **<MEASURE>**? ***🡺[ SKIP TO NEXT APPLICABLE MEASURE]***

-97. [Don’t know]

-98. [Refused]

1. ***INSULATION (EXCEPT DUCTS) -EFFICIENCY***

Insulation is rated as an “R-Value”, where the higher the R-value, the better the insulation's effectiveness ***[READ ONLY ONCE - FOR FIRST APPLICABLE MEASURE WITHIN INSULATION]***

**INS4\_#.** In the absence of the program, how different would your installed R-Value have been? For **<MEASURE>,** would you have installed…***[READ LIST, SINGLE RESPONSE]***

***01***

1. A lower R value
2. The same R value
3. A higher R value
4. Would not have installed any insulation *🡺****[ SKIP TO NEXT APPLICABLE MEASURE]***

-97. [Don’t know]

-98. [Refused]

1. ***INSULATION (EXCEPT DUCTS) -TIMING***

**INS5\_#.** In the absence of the program, would you have installed <MEASURE>… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

***[GO TO NEXT APPLICABLE MEASURE]***

1. **WHOLE HOUSE LEAKAGE / AIR SEALING**

**AS1.** In the absence of the program, would you say the likelihood of air sealing your home was… ***[READ LIST,*** *SINGLE RESPONSE****]***

1. 1. Very likely
2. 2. Somewhat likely
3. 3. Somewhat unlikely
4. 4. Or very unlikely
5. -97. [Don’t know]
6. -98. [Refused]
7. ***AIR SEALING -TIMING***

**AS2.** In the absence of the program, would you have **air sealed your home**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

***[GO TO NEXT APPLICABLE MEASURE]***

1. **HVAC SYSTEM UPGRADE**

**HSU1**. You mentioned you undertook an HVAC systems upgrade.

1. Did you install a/an**….[READ LIST. Multiples accepted]**
2. ***[If HUS1a\_#=1=Yes]*** What is the efficiency rating**/<EFFICIENCY UNIT>** of your new **<EQUIPMENT>?**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **EQUIPMENT** | **HSU1a\_#**  **Installed?**  *1 = YES; 2 = NO; -97 = DON’T KNOW; -98 = REFUSED* | **EFFICIENCY UNIT** | **HSU1b\_#**  **Efficiency Rating**  *-97 = DON’T KNOW;  -98 = REFUSED* |
| 2 | Furnace |  | AFUE |  |
| 3 | Air conditioner |  | SEER |  |
| 1 | Heat pump |  | HSPF |  |

***[Questions below asked for HSU1a\_#=1=Yes***

***Cycle back to next equipment installed once section is complete, as required]***

**HSU2\_#.** Was the [**EQUIPMENT]** that you installed… **[READ LIST, SINGLE RESPONSE ONLY]**

1. A replacement due to a/an **[EQUIPMENT]** that had failed or was broken
2. A replacement due to the **[EQUIPMENT]** that was not performing well
3. A replacement to improve **[EQUIPMENT]** efficiency
4. A brand new installation where a/an **[EQUIPMENT]** did not exist previously
5. A/ An **[EQUIPMENT]** in addition to an existing one, or
6. Other \_\_\_ **[RECORD VERBATIM]**

-97. [Don’t know]

-98. [Refused]

**HSU3\_#.** Before getting this **[EQUIPMENT]** installed did you have a current service agreement with an HVAC contractor for this particular system?

1. Yes

2. No

-97. [Don’t know]

-98. [Refused]

**HSU4\_#.** In the absence of the program, would you say your likelihood of getting this **<EQUIPMENT>** installed was… ***[READ LIST,*** *SINGLE RESPONSE****]***

1. Very likely

2. Somewhat likely

3. Somewhat unlikely

4. Or very unlikely

-97. [Don’t know]

-98. [Refused]

1. ***HVAC SYSTEM UPGRADE (HSU) –EFFICIENCY***

**HSU5\_#.** In the absence of the program, would you have installed…? **…[READ LIST, SINGLE RESPONSE ONLY]**

1. the standard efficiency **<EQUIPMENT>**/to code requirements
2. the same efficiency
3. a lower efficiency than what you installed but higher than standard
4. higher efficiency than what you installed
5. Would not have installed a/an **<EQUIPMENT>** *🡺****[ SKIP TO NEXT APPLICABLE MEASURE]***

-97. [Don’t know]

-98. [Refused]

1. ***HVAC SYSTEM UPGRADE (HSU) –TIMING***

**HSU6\_#.** In the absence of the program, would you have installed **a/an <EQUIPMENT>**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

***[GO TO NEXT APPLICABLE MEASURE]***

1. ***HVAC DUCT LEAKAGE REDUCTION***
2. **WARM-UP**

**HDLR1.** Where is the majority of the duct system located in your home?

***[IF NECESSARY****:* A location could be the first story ceiling, a wall, attic, floor or crawlspace.]

***[RECORD VERBATIM. CODE THIS AS LOCATION\_REF1, LOCATION\_REF2, etc]***

1. **CONSISTENCY CHECK**

**HDLR2.** Before having your ducts air sealed, did you…***[READ LIST, SINGLE RESPONSE]***

1. **Consider doing it yourself*(IF REQUIRED****: - such as inspecting the condition, searching for disconnected ducts, searching for leaks or applying mastic tape on your ducts or registers)*
2. **Actually did some part of it yourself**
3. **Did neither**

-97 Don’t know

-98 Refused

1. **FREE\_RIDERSHIP**

**HDLR3.** In the absence of the program, would you say the likelihood of your **air sealing your ducts** was***… [READ LIST,*** *SINGLE RESPONSE****]***

1. 1. Very likely
2. 2. Somewhat likely
3. 3. Somewhat unlikely
4. 4. Or very unlikely
5. -97. [Don’t know]
6. -98. [Refused]
7. ***HDLR –TIMING***

**HDLR4.** In the absence of the program, would you have **air sealed your ducts**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

1. ***[GO TO NEXT APPLICABLE MEASURE]***
2. ***HVAC DUCT INSULATION***
3. **FREE\_RIDERSHIP**

**HDI1.** In the absence of the program, would you say the likelihood of your **insulating your ducts/replacing your ducts** was***… [READ LIST,*** *SINGLE RESPONSE****]***

1. 1. Very likely
2. 2. Somewhat likely
3. 3. Somewhat unlikely
4. 4. Or very unlikely
5. -97. [Don’t know]
6. -98. [Refused]
7. ***HDI –TIMING***

**HDI2.** In the absence of the program, would you have **insulated your ducts**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

1. ***[GO TO NEXT APPLICABLE MEASURE]***
2. **RENEWABLE ENERGY**

**RE1.** When did you get Solar PV? ***[READ LIST,*** *SINGLE RESPONSE****]***

1. At the same time as the other measures undertaken
2. Earlier
3. Later

-97. [Don’t know]

-98. [Refused]

**RE2.** Did you participate in the California Solar Initiative? [IF NECESSARY: “It is a program that provides rebates for customers who install solar panels to generate part of their own energy.”]

1. Yes
2. No

-97. [Don’t know]

-98. [Refused]

1. **WATER HEATER**

**WH1**. Please confirm that the water heater you upgraded to was a***…***

***[READ LIST, RANDOMIZE, SINGLE RESPONSE]***

1. New Tank
2. New Tankless
3. Solar Water Heater
4. Other (Specify)
5. -97. Don’t know ***🡺Skip to next applicable measure***
6. -98. Refused 🡺***Skip to next applicable measure***

**WH2.** In the absence of the program, would you say the likelihood of installing this water heater was***… [READ LIST,*** *SINGLE RESPONSE****]***

1. 1. Very likely
2. 2. Somewhat likely
3. 3. Somewhat unlikely
4. 4. Or very unlikely
5. -97. [Don’t know]
6. -98. [Refused]
7. **WATER HEATER – EFFICIENCY**

**WH3**. In the absence of the program, would you have installed a water heater with an Energy Factor/efficiency that was…

***[READ LIST,*** *SINGLE RESPONSE****]..?***

*[IF REQUIRED: THE WATER HEATER’S EFFICIENCY IS MEASURED AS AN ENERGY FACTOR (EF), WHICH IS USUALLY LISTED BESIDE THE* ***ENERGYGUIDE LABEL****. THE HIGHER THE NUMBER, THE MORE ENERGY EFFICIENT THE WATER HEATER.]*

1. Lower than installed
2. Same as installed
3. Higher than installed
4. Would not have installed ***[SKIP TO NEXT APPLICABLE MEASURE]***

-97. [Don’t know]

-98. [Refused]

*CONSISTENCY CHECK*

**WH4\_1**. What is the Energy Factor/EF of your water heater?

***[OPEN END. DON’T KNOW/REFUSED ACCEPTABLE]***

***[RECORD VERBATIM]***

1. ***WH–TIMING***

**WH5.** In the absence of the program, would you have installed **the water heater**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

***[GO TO NEXT APPLICABLE MEASURE]***

1. **HOT WATER DISTRIBUTION**

**HWD1**. Please confirm that the Hot Water Pipe Distribution system upgrade was… ***[READ LIST, ACCEPT MULTIPLES]***

1. Insulation on hot water pipes
2. New piping that included insulation
3. Demand-initiated recirculation systems
4. -97. Don’t know (Skip to next measure undertaken)
5. -98. Refused (Skip to next measure undertaken)

**HWD2.** In the absence of the program, would you say the likelihood of upgrading your Hot Water Pipe Distribution System was***… [READ LIST,*** *SINGLE RESPONSE****]***

1. 1. Very likely
2. 2. Somewhat likely
3. 3. Somewhat unlikely
4. 4. Or very unlikely
5. -97. [Don’t know]
6. -98. [Refused]
7. ***HWD –TIMING***

**HWD3.** In the absence of the program, would you have **installed a** **Hot Water Pipe Distribution System**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

1. ***[GO TO NEXT APPLICABLE MEASURE]***
2. **WINDOW REPLACEMENT**

**WIN1.** What kind of windows did you get?

1. Gas filled, Low-E
2. Vacuum filled, Low-E
3. Other [DESCRIBE] [RECORD VERBATIM]

-97. Don’t know

-98. Refused

**WIN2.** In the absence of the program, would you say the likelihood of your **replacing your windows** was***… [READ LIST,*** *SINGLE RESPONSE****]***

1. 1. Very likely
2. 2. Somewhat likely
3. 3. Somewhat unlikely
4. 4. Or very unlikely
5. -97. [Don’t know]
6. -98. [Refused]
7. ***WIN–TIMING***

**WIN3.** In the absence of the program, would you have **replaced your windows**… ***[READ LIST,*** *SINGLE RESPONSE****]?***

1. At the same time

2. Earlier

3. Later

4. Never

-97. [Don’t know]

-98. [Refused]

***[GO TO NEXT SECTION –INFORMATION RECEIVED FROM CONTRACTOR – C1]***

1. **INFORMATION RECEIVED FROM CONTRACTOR**
2. In discussing plans for your project, did your contractor bring up any of the following issues?  
   **[READ LIST. RANDOMIZE. ACCEPT MULTIPLES. OTHER IS ALWAYS LAST]**

|  |  |
| --- | --- |
| **Issue** | ***1 = YES; 2 = NO; -97 = DON’T KNOW; -98 = REFUSED*** |
| Energy savings on your monthly bill due to the project | C1\_1 |
| Rebates on equipment purchases and contractor services | C1\_2 |
| Effect of renovations on comfort, such as eliminating drafts and hot or cold spots in the home | C1\_3 |
| Effect of renovations on indoor air quality | C1\_4 |
| Effect of renovations on safety of heating and cooling equipment | C1\_5 |
| Effect of renovations on controlling mold | C1\_6 |
| Other (Specify) | C1\_7, C1\_other |

**PROJECT FINANCES (3 MIN)**

1. As you may recall, you received incentives from Energy Upgrade California to cover some of your improvement costs, but you also had to pay some of those costs. Please tell me if you used financing to pay for any portion of the improvements you made through the program? **[IF NEEDED: Financing could include a credit card, taking out a loan, getting financing through your contractor, refinancing your home mortgage, and other situations where you borrow the money and repay it over time.]**
2. Yes 🡺 **GO TO PF2, if MEASURE=0[[17]](#footnote-18),**

**skip to HH1, if MEASURE=1]**

1. No 🡺 **Skip to HH1**

-97. Don’t know 🡺 **Skip to HH1**

-98. Refused🡺 **Skip to HH1**

1. What type of financing did you use? ***[ACCEPT MULTIPLES. READ LIST IF NEEDED.]***
2. ***1 = YES; 2 = NO; -97 = DON’T KNOW; -98 = REFUSED*** 
   * + 1. Credit card
       2. Personal loan
       3. Energy Upgrade California affiliated loan or energy loan product **[EUC lenders include Matadors Credit Union, San Diego Metropolitan Credit Union, GreenStreet Lending (Umpqua Bank), SMUD, CHF Residential Energy Retrofit]**
       4. Home equity line of credit or second mortgage
       5. PowerSaver loan **[Sun West or W.J. Bradley]**
       6. Contractor sponsored or arranged financing
       7. New first mortgage **[Not a PowerSaver loan]**
       8. Refinanced mortgage
3. Other **[SPECIFY: \_\_\_\_\_\_\_\_\_]**
5. What were the most important reasons for using financing to pay for your Energy Upgrade project? ***[DO NOT READ. SELECT ALL THAT APPLY, OPEN-ENDED WITH PRE-CODED LIST]***
6. To spread cost over a longer period (monthly payment vs. large upfront payment)
7. Didn’t have the entire amount available in cash at the time of making improvements
8. To take advantage of an attractive interest rate offer
9. To make the improvement cash flow positive (monthly energy bill savings greater than monthly installment)
10. Made financial sense [Specify what this means:\_\_\_\_]
11. It was the easiest option
12. 7. Other [SPECIFY: \_\_\_\_\_\_\_\_\_]
13. -97. Don’t know
14. -98. Refused
15. How did you find out about your lender? ***[DO NOT READ, SELECT ALL THAT APPLY, OPEN-ENDED WITH PRE-CODED LIST]***
    * + 1. Existing relationship (have worked with them before / do personal banking there)
        2. Television
        3. Radio
        4. Print media (magazine, newspaper article or advertisement)
        5. Billboard/outdoor ad
        6. Direct mail/brochure/postcard
        7. Energy Upgrade California or Utility recommendation
        8. Energy Upgrade California website
        9. Contractor
        10. Realtor
        11. Home builder
        12. Family/friends/word-of-mouth
        13. Social Media
16. 14. Other **[SPECIFY: \_\_\_\_\_\_\_\_\_]*, CODE OPEN-ENDED RESPONSE INTO PF4\_7\_V)***
17. -97. Don’t know
18. -98. Refused
19. What was the interest rate you were charged? If your loan was variable rate or had an introductory rate, please say it is variable rate. ***[RECORD RESPONSE, acceptable range 0-100 or variable rate]***
20. PF5\_v “Is a variable rate”=1
21. -97. Don’t know
22. -98. Refused
23. How many months was the financing was for? ***[RECORD RESPONSE, IN MONTHS]***
24. *(If respondent states answer in* ***YEARS****, provide interviewer option to enter into an interim variable for* ***YEARS*** *which will then be converted to* ***MONTHS****. Final data for this question should be in* ***MONTHS*** *for all respondents.)*
25. How difficult was it for you to obtain your financing? Was it...?
    * + 1. Not at all difficult
        2. Not too difficult
        3. Somewhat difficult
        4. Very difficult
26. -97. Don’t know
27. -98. Refused
28. What about the process was **<PF7>?** ***[[DO NOT READ, SELECT ALL THAT APPLY, OPEN-ENDED WITH PRE-CODED LIST]***
29. Process was simple and straightforward
30. Easy to get approval
31. Could apply online
32. Difficult to get approval **[SPECIFY WHAT WAS DIFFICULT: \_\_\_\_\_\_\_\_\_]**
33. Difficult to get pre-approval **[SPECIFY WHAT WAS DIFFICULT: \_\_\_\_\_\_\_\_\_]**
34. Had to go to multiple banks to get approved
35. Unresponsive bank **[SPECIFY ANY ISSUES: \_\_\_\_\_\_\_\_\_]**
36. Paperwork **[SPECIFY WHAT ABOUT PAPERWORK WAS DIFFICULT: \_\_\_\_\_\_\_\_\_]**
37. Hard to make a decision due to too many financing options
38. Hard to make a decision due to a lack of information
39. Could not apply online
40. Had to go to bank to sign the paperwork
41. Had to take time off work
42. Process was complicated or not clear
43. Process took a long time
44. Other **[SPECIFY: \_\_\_\_\_\_\_\_\_]**
45. -97. Don’t know
46. -98. Refused
47. How satisfied are you with the financing? Would you say you are …
    * + 1. Very satisfied
        2. Somewhat satisfied
        3. Not too satisfied
        4. Not at all satisfied
48. -97. Don’t know
49. -98. Refused
50. What about the financing are you **<PF9>** with? ***[DO NOT READ, SELECT ALL THAT APPLY, OPEN-ENDED WITH PRE-CODED LIST]***
    * 1. Process was easy and straightforward
      2. Process was quick
      3. Good interest rates
      4. Good repayment options
      5. Can repay/check balance online
      6. Lender has good customer service
      7. Took too long to secure
      8. Too much paperwork and hassle
      9. No option to pay/check balance online
      10. Interest rate too high
      11. Interest rate increased
      12. Had to pay fees
      13. There was a mistake in my bill
      14. Lender has bad customer service
      15. Costs or other issues were not fully explained up front
      16. Other **[SPECIFY: \_\_\_\_\_\_\_\_\_]**
51. -97. Don’t know
52. -98. Refused
53. **SEGMEN**T**ATION ITEMS (3 MIN)**
54. Have you had the following installed in your household?

***1 = YES; 2 = NO; -97 = DON’T KNOW; -98 = REFUSED***

1. Programmable thermostats?
2. Motion detectors for your lights?
3. Vent in your attic area to keep the attic cooler?
4. Ceiling fans ***[ASK ONLY OF HOMEOWNERS, NOT RENTERS]***
5. Have you heard of a carbon footprint? ***(IF NECESSARY:*** A carbon footprint is a measure of the energy you use, either directly or indirectly. This includes but is not limited to the energy consumption from your home, your transportation, your diet, and your purchases).

***1 = YES; 2 = NO; -97 = DON’T KNOW; -98 = REFUSED***

1. On a scale of 1 to 7, where 1 is Strongly Disagree and 7 is Strongly Agree, please tell me how much you agree or disagree with the following statements:
2. I compare prices of at least a few brands 1 2 3 4 5 6 7 DK Ref
3. before I choose one.
4. I do **not** feel responsible for conserving 1 2 3 4 5 6 7 DK Ref
5. energy because my personal contribution is
6. very small.
7. I’m going to read you a list of 6 reasons why people might change their daily actions to save energy.Please tell me which **ONE** of these would motivate you the **MOST** to save energy? ***[READ CHOICES] [IF DK, PROBE*** “if you had to choose from the following reasons which one would motivate you the most”] [RANDOMIZE]
8. 1. Saving money
   2. Maintaining Health
   3. Protecting the environment
   4. For the benefit of future generations
   5. Reducing our dependence on foreign oil
   6. Helping California lead the way on saving energy
9. -97. Don’t know
10. -98. Refused
11. **RESPONDENT AND HOUSEHOLD CHARACTERISTICS**

My last questions are used for statistical purposes only. All individual information is kept **completely confidential.**

1. About, when was this home/building first built? [RECORD RESPONSE, READ LIST IF NEEDED]
2. Before the 1970s
3. 1970s
4. 1980s
5. 1990-1994
6. 1994-1999
7. 2000s
8. -97. Don’t know
9. -98. Refused
10. Roughly how large is the living area of your home in terms of square feet?

**ENTER NUMBER OF SQUARE FEET, Don’t know = -97, Refused = -98 \_\_\_\_\_\_\_\_**

**HH2\_TB**. Did you increase the living area/square footage of your home at the same time or after you undertook this whole house retrofit project?

**-97, Refused = -98 \_\_\_\_\_\_\_\_**

1. How many bedrooms does your home have?

*[IF NECESSARY: The energy use patterns of homes can be affected by the number of bedrooms.]*

Number of bedrooms: \_\_\_ **[1 through 25, Don’t know = -97, Refused=-98]**

1. How many bathrooms does it have?

*[IF NECESSARY: The energy use patterns of homes can be affected by the number of bathrooms.]*

Number of bathrooms: \_\_\_\_\_\_\_\_\_

**[1 thru 25, Don’t know = -97, Refused=-98]**

**[If half baths, enter decimal, e.g., 1 and ½ bath = 1.5]**

1. What is the main fuel used to heat your home? **[READ LIST]** 
   1. Oil
   2. Natural gas
   3. Propane
   4. Electricity
   5. Other [SPECIFY] \_\_\_\_\_\_\_\_

-97. Don’t know

-98. Refused

1. [**IF HSU0\_2 ≠ 1**] Does your home have central air-conditioning?
   1. Yes
   2. No

-97. (Don’t know)

-98. (Refused)

**HH6\_TB**. Did you have central air-conditioning prior to undertaking this project?

* 1. Yes
  2. No

-97. (Don’t know)

-98. (Refused)

1. Do you **[“also” if HH6=1]** have any window air-conditioning units?

1. Yes

2. No

-97. (Don’t know)

-98. (Refused)

**HH7\_1** **(If HH7=1=Yes) How many?**

Number of wall units: \_\_\_\_\_\_\_\_\_ **[1 through 25, Don’t know = -97, REF= -98]**

**HH7\_TB**. Did you have these window/wall air-conditioning units prior to undertaking this project?

1. Yes
2. No

-97. (Don’t know)

-98. (Refused)

1. Does your home have a pool and/or spa?
2. Pool only
3. Spa only
4. Both pool and a spa
5. Neither a pool nor a spa

-97. (Don’t know)

-98. (Refused)

**HH8\_TB.** Did you have this/these prior to undertaking this project?

1. How many people, including yourself, lived in this home **before** the retrofit?\_\_\_\_\_\_   
   [Don’t know= -97, Refused = -98]
2. How many people, including yourself, live in this home **after** the retrofit? \_\_\_\_\_\_   
   [Don’t know= -97, Refused = -98]
3. Which of the following categories includes your age? **[READ LIST]**
4. Under 25
5. 25 to 34
6. 35 to 44
7. 45 to 54
8. 55 to 64
9. 65 or over

-97. Don’t know

-98. Refused

1. I’m going to read several education categories. Please stop me when I come to the highest level of schooling you’ve completed. **[READ LIST]**

1. Less than high school

2. High school graduate

3. Some college, trade or technical school

4. Completed business or technical school (2 year)

5. College graduate (4 year)

6. Post graduate work or advanced degree

-97. Don’t know

-98. Refused

1. Which of the following ranges includes your total household income in 2012? Please stop me when I come to the appropriate range. **[READ LIST]**
2. Less than $50,000
3. between $50,000 and $75,000
4. between $75,000 and $100,000
5. between $100,000 and $150,000
6. $150,000 or more

-97. (Don’t know)

-98. (Refused )

1. *[ASK IF PF1=1 and MEASURE=1 and ASKHH14=1]* Would you be willing to participate in follow-up research that is focused on learning more about the financing you availed of for this project?
2. 1. Yes
3. 2. No
4. -97. (Don’t know)
5. -98. (Refused)
6. **[INTERVIEWER: RECORD GENDER]**
7. **Wrap-up – (Use this when respondent completes the survey)**

Those are all the questions I have for you today. Thank you very much for your time and cooperation. You are helping us improve energy conservation programs in California.

1. **T&T (Use this when respondent does NOT go through the entire survey and is screened out).**

Those are all the questions I have for you today. Thank you so much for your time ***[THANK AND TERMINATE]***

1. Phase 1 Gross Savings Estimates

Phase 1 was presented to the ED and other stakeholders prior to having post retrofit data for 2012 participants. The effort helped us test the methodology and get input while awaiting Phase 2 data. The following table illustrates gross consumption and savings by IOU for Phase 1:

Table 31. Energy Use and Program Savings Estimates by IOU for 2010-2011

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Consumption/Savings** | **Annual Electric (kWh)** | | | **Annual Gas (Therms)** | |
| **PG&E** | **SCE** | **SDG&E** | **PG&E** | **SDG&E** |
| No. of sites | 389 | 483 | 137 | 648 | 129 |
| Actual Consumption Per Site (not weather-normalized) |  |  |  |  |  |
| Avg Annual Usage Before Installation | 8,428 | 9,894 | 7,096 | 623 | 410 |
| Avg Annual Usage After Installation | 8,149 | 9,834 | 6,780 | 506 | 344 |
| Weather-Adjusted Consumption Per Site (Using TMY3) |  |  |  |  |  |
| Avg Annual Usage Before Installation | 8,498 | 10,076 | 6,990 | 604 | 391 |
| Avg Annual Usage After Installation | 8,143 | 9,588 | 6,645 | 492 | 321 |
| % Change in Energy Use | -4% | -5% | -5% | -19% | -18% |
| Weather-Adjusted Consumption Per Site (Using CTZ2) |  |  |  |  |  |
| Avg Annual Usage Before Installation | 8,361 | 9,788 | 6,922 | 602 | 341 |
| Avg Annual Usage After Installation | 8,065 | 9,419 | 6,579 | 490 | 280 |
| % Change in Energy Use | -4% | -4% | -5% | -19% | -18% |
| Estimated Program Savings |  |  |  |  |  |
| Normalized annual savings Using TMY3 |  |  |  |  |  |
| Annual Savings Estimate | 5.6 ns | 290.2 ns | 366.2\* | 68.0\*\* | 59.2\*\* |
| Standard Error | 184.9 | 224.7 | 212.1 | 18.5 | 29.3 |
| Percent Savings | 0.1% | 3% | 5% | 11% | 15% |
| Normalized Annual Savings Using CTZ2 |  |  |  |  |  |
| Annual Savings Estimate | -31.60 ns | 301.9 ns | 275.7ns | 62.3\*\* a | 62.3\*\* a |
| Standard Error | 181.5 | 225.2 | 196.6 | 18.4 | 28.4 |
| Percent Savings | -0.4% | 3% | 4% | 11% | 18.2% |
| Ex Ante EnergyPro Savings as Percent of Total Annual Usage | 35% | 11% | 27% | 60% | 40% |
| Ex Ante Claimed Savings as Percent of Total Annual Usage | 21% | 6% | 18% | 36% | 34% |

\* Statistically significant at 10% level (90% confidence interval)

\*\*Statistically significant at 5% level (95% confidence interval)

ns Not statistically significant

a Same gas savings estimate for PG&E and for SDG&E

When looking at the table, it is important to consider:

* Actual consumption (not weather normalized) is the energy use average of the 12 months before and 12 months after participation in the program. These two figures cannot be directly compared because weather, the most influential variable in energy use, varies from one year to the next.
* Weather-adjusted consumption is the weather-normalized energy use average of the 12 months before and 12 months after participation in the program, obtained from the PRISM estimates. These estimates may show an increase or decrease in use compared to the prior year, which is not adjusted for program effects, and thus cannot be used directly to estimate savings. For example, if program participants are already reducing their energy use prior to implementing the program measures for reasons that are independent of the program, post-retrofit weather-normal energy use may be lower, but such change cannot be attributed to the program.
* Estimated program savings are the changes in pre-/post- retrofit weather-normalized consumption that are attributed to the program. These savings estimates are calculated from the fixed effects model that controls for site-specific characteristics that do not change over time and for the overall consumption trend that is not program-related.

Overall, we found that:

1. The program generated statistically significant reductions in electricity consumption for SDG&E using TMY3 normal weather, but not using CTZ2 normal weather. Reductions were not significant for PG&E and SCE using either normal weather. For SDG&E, the average estimated savings were 366 kWh per year[[18]](#footnote-19), or about 5% of weather-normalized annual consumption.

For SDG&E, the average estimated savings are 366 kWh per year[[19]](#footnote-20), or about 5% of weather-normalized annual consumption.

1. The program generated statistically significant reductions in gas consumption for PG&E and SDG&E. For PG&E, the average estimated savings were 63.2 therms per year, or about 11% of weather-normalized annual consumption. For SDG&E, the same 63.2 therms per year amounted to 15% of weather-normalized annual consumption.
2. EnergyPro ex ante savings estimates were a very large percent of annual use. These are presented in the bottom row of Table 30. They rangde from 11% (SCE Electric) to 60% (PG&E Gas).
3. Pre-Retrofit Equipment Efficiencies for Advanced Path

For water heating replacements and AC and furnace replacements evidence of “early retirement” is required to claim the pre-existing baseline, and only for the remaining life of the pre-existing equipment (defined as 1/3 the life of the equipment by policy). This report provides information on the pre-existing efficiencies of the equipment replaced, but does not make adjustments to the savings estimates. This Appendix provides a comparison of the pre-retrofit equipment efficiency for Advanced path simulation models compared to the replace on burnout code baseline for piece of equipment. A short description is followed by the tables.

**Central Furnaces:** Existing average efficiencies higher than the baseline AFUE value of 0.79 were observed for climate zones 2, 6, 7, 9, 10, 12, and 16. This means that dual baseline is not necessarily an issue for this equipment other than Climate Zone three which is below Baseline and has a high proportion of the PG&E population.

**Heat Pump Heating Efficiency:** Existing average efficiencies higher than baseline efficiency at 7.7 were observed for climate zones 6, 7, and 9. On the other side, the HSPF values were on the lower end for climate zones 3, 12, 13 and 16. However, for the samples with observed HSPF higher than baseline value do not represent to the majority of the samples. Further, higher than baseline efficiencies were observed for large size houses.

**Heat Pump Cooling Efficiency:** Existing average efficiencies higher than the baseline heat pump cooling at 13.0 SEER were observed only for climate zone 9, and for all other observed zones the existing heat pump cooling efficiencies were less than the baseline efficiency. The climate zone 9 is evident to have higher cooling demand than the remaining climate zones put in the above table. As the majority of the sampled houses have AC units, the number of houses for this characterization was small in number.

**Domestic Hot Water Heater:** Existing average efficiencies higher than baseline AFUE efficiencies at 0.62 were observed for those samples with lower sizes, and they were for climate zones 5, 6, 8, 14 and 16 which were for locations both inland and at the southern CA. However, for the samples with bigger sample sizes reported Energy Factors lower than baseline efficiency.

**Air Conditioning Unit Efficiency:** Existing average efficiencies across all climate zones and sample sizes were observed to be less than the baseline SEER value at 13.0. Lower values for SEER Upper Bound were observed for climate zone 11 and 12, and to some extent in climate zone 13. They all correspond to significantly higher sample sizes. Higher SEER values were observed in climate zone 5 and 6.

Table 1: Central Furnace

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **T24 Climate Zone** | **Heating Efficiency Type** | **Count** | **Conditioned Floor Area\_Mean** | **Heating E fficiency \_Mean** | **Heating Efficiency \_StdErr** | **AFUE Upper Bound** | **Average Higher than Baseline** | **Heating Efficiency \_Min** | **Heating Efficiency \_Max** |
| PGE | 2 | AFUE | 310 | 1,879 | 0.83 | 0.02 | 0.85 | Yes | 0.50 | 4.20 |
| PGE | 3 | AFUE | 1663 | 1,740 | 0.78 | 0.00 | 0.78 |  | 0.00 | 2.20 |
| PGE | 4 | AFUE | 646 | 1,992 | 0.78 | 0.00 | 0.78 |  | 0.39 | 0.95 |
| PGE | 5 | AFUE | 16 | 1,901 | 0.76 | 0.02 | 0.79 |  | 0.64 | 0.95 |
| PGE | 11 | AFUE | 286 | 2,015 | 0.78 | 0.00 | 0.78 |  | 0.56 | 0.97 |
| PGE | 12 | AFUE | 2767 | 1,796 | 0.79 | 0.00 | 0.80 | Yes | 0.00 | 6.60 |
| PGE | 13 | AFUE | 261 | 1,920 | 0.77 | 0.00 | 0.77 |  | 0.50 | 0.96 |
| PGE | 16 | AFUE | 7 | 2,297 | 0.82 | 0.02 | 0.84 | Yes | 0.78 | 0.90 |
| SCE | 6 | AFUE | 71 | 1,885 | 0.78 | 0.01 | 0.79 | Yes | 0.60 | 0.96 |
| SCE | 8 | AFUE | 50 | 1,524 | 0.78 | 0.01 | 0.79 |  | 0.65 | 0.95 |
| SCE | 9 | AFUE | 514 | 1,671 | 0.81 | 0.01 | 0.82 | Yes | 0.60 | 4.20 |
| SCE | 14 | AFUE | 10 | 2,084 | 0.78 | 0.00 | 0.79 |  | 0.78 | 0.80 |
| SDGE | 7 | AFUE | 177 | 1,881 | 0.79 | 0.01 | 0.81 | Yes | 0.50 | 2.20 |
| SDGE | 10 | AFUE | 79 | 2,093 | 0.80 | 0.00 | 0.80 | Yes | 0.70 | 0.93 |

Table 2: Heat Pump Heating Efficiency

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **T24 Climate Zone** | **Heating Efficiency Type** | **Count** | **Conditioned Floor Area\_Mean** | **Heating Efficiency \_Mean** | **Heating Efficiency \_StdErr** | **HSPF Upper Bound** | **Average Higher than Baseline** | **Heating Efficiency \_Min** | **Heating Efficiency \_Max** |
| PGE | 3 | HSPF | 18 | 1,736 | 3.89 | 0.33 | 4.21 |  | 3.40 | 7.70 |
| PGE | 4 | HSPF | 6 | 2,775 | 6.73 | 0.44 | 7.17 |  | 5.60 | 8.00 |
| PGE | 11 | HSPF | 133 | 1,267 | 5.87 | 0.07 | 5.94 |  | 3.40 | 9.50 |
| PGE | 12 | HSPF | 141 | 1,922 | 6.16 | 0.07 | 6.23 |  | 3.40 | 9.20 |
| PGE | 13 | HSPF | 14 | 2,523 | 6.20 | 0.38 | 6.58 |  | 3.40 | 7.60 |
| PGE | 16 | HSPF | 4 | 1,358 | 4.51 | 0.63 | 5.14 |  | 3.41 | 5.60 |
| SCE | 9 | HSPF | 14 | 2,196 | 7.53 | 0.69 | 8.21 | Yes | 3.41 | 12.00 |
| SDGE | 7 | HSPF | 4 | 3,612 | 6.85 | 1.22 | 8.08 | Yes | 3.41 | 9.20 |

Table 3: Heat Pump Cooling Efficiency

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **T24 Climate Zone** | **Heating Efficiency Type** | **Count** | **Conditioned Floor Area\_Mean** | **Cooling Efficiency\_ Mean** | **Cooling Efficiency\_ StdErr** | **Cooling Eff Upper Bound** | **Average Higher than Baseline** | **Cooling Efficiency\_ Min** | **Cooling Efficiency\_ Max** |
| PGE | 4 | HSPF | 6 | 2,775 | 11.30 | 1.10 | 12.39 |  | 8.00 | 13.00 |
| PGE | 11 | HSPF | 133 | 1,267 | 8.60 | 0.10 | 8.77 |  | 8.00 | 16.00 |
| PGE | 12 | HSPF | 141 | 1,922 | 9.10 | 0.10 | 9.26 |  | 7.00 | 15.50 |
| PGE | 13 | HSPF | 14 | 2,523 | 10.60 | 0.60 | 11.23 |  | 8.00 | 14.00 |
| PGE | 16 | HSPF | 4 | 1,358 | 4.00 | 2.30 | 6.31 |  | - | 8.00 |
| SCE | 9 | HSPF | 14 | 2,196 | 13.90 | 1.10 | 15.05 | Yes | 8.00 | 26.00 |
| SDGE | 7 | HSPF | 4 | 3,612 | 11.00 | 1.10 | 12.17 |  | 9.10 | 13.00 |

Table 4: Domestic Hot Water

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **T24 Climate Zone** | **Heating Efficiency Type** | **Count** | **Conditioned Floor Area\_Mean** | **Energy Factor\_Mean** | **Energy Factor\_StdErr** | **EF Upper Bound** | **Average Higher than Baseline** | **Energy Factor\_Min** | **Energy Factor\_Max** |
| PGE | 2 | AFUE | 310 | 1,879 | 0.61 | 0.01 | 0.61 |  | 0.53 | 0.96 |
| PGE | 3 | AFUE | 1,663 | 1,740 | 0.58 | 0.00 | 0.59 |  | - | 0.98 |
| PGE | 4 | AFUE | 646 | 1,992 | 0.58 | 0.00 | 0.59 |  | - | 0.98 |
| PGE | 5 | AFUE | 16 | 1,901 | 0.65 | 0.03 | 0.68 | Yes | 0.53 | 0.84 |
| PGE | 11 | AFUE | 286 | 2,015 | 0.59 | 0.01 | 0.60 |  | 0.53 | 0.99 |
| PGE | 12 | AFUE | 2,767 | 1,796 | 0.58 | 0.00 | 0.58 |  | - | 0.98 |
| PGE | 13 | AFUE | 261 | 1,920 | 0.57 | 0.00 | 0.58 |  | - | 0.93 |
| PGE | 16 | AFUE | 7 | 2,297 | 0.65 | 0.04 | 0.69 | Yes | 0.53 | 0.80 |
| SCE | 6 | AFUE | 71 | 1,885 | 0.63 | 0.01 | 0.64 | Yes | 0.52 | 0.96 |
| SCE | 8 | AFUE | 50 | 1,524 | 0.62 | 0.01 | 0.63 | Yes | 0.52 | 0.84 |
| SCE | 9 | AFUE | 514 | 1,671 | 0.60 | 0.00 | 0.61 |  | 0.53 | 0.98 |
| SCE | 14 | AFUE | 10 | 2,084 | 0.60 | 0.03 | 0.62 | Yes | 0.53 | 0.80 |
| SDGE | 7 | AFUE | 177 | 1,881 | 0.59 | 0.00 | 0.60 |  | 0.45 | 0.84 |
| SDGE | 10 | AFUE | 79 | 2,093 | 0.61 | 0.01 | 0.62 |  | 0.53 | 0.95 |

Table 5: Air Conditioning

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **IOU** | **T24 Climate Zone** | **Heating Efficiency Type** | **Count** | **Conditioned Floor Area\_Mean** | **Cooling Efficiency\_ Mean** | **Cooling Efficiency\_ StdErr** | **SEER Upper Bound** | **Average Higher than Baseline** | **Cooling Efficiency\_ Min** | **Cooling Efficiency\_ Max** |
| PGE | 2 | AFUE | 310 | 1,879 | 10.86 | 0.19 | 11.05 |  | 0.50 | 18.00 |
| PGE | 3 | AFUE | 1,663 | 1,740 | 11.00 | 0.10 | 11.10 |  | - | 40.00 |
| PGE | 4 | AFUE | 646 | 1,992 | 11.62 | 0.11 | 11.72 |  | - | 24.50 |
| PGE | 5 | AFUE | 16 | 1,901 | 12.00 | 0.47 | 12.47 |  | 8.00 | 13.00 |
| PGE | 11 | AFUE | 286 | 2,015 | 9.86 | 0.10 | 9.96 |  | 6.60 | 16.00 |
| PGE | 12 | AFUE | 2,767 | 1,796 | 9.45 | 0.04 | 9.49 |  | - | 18.50 |
| PGE | 13 | AFUE | 261 | 1,920 | 10.16 | 0.15 | 10.30 |  | 6.00 | 16.50 |
| PGE | 16 | AFUE | 7 | 2,297 | 11.22 | 0.63 | 11.85 |  | 9.80 | 13.00 |
| SCE | 6 | AFUE | 71 | 1,885 | 11.02 | 0.51 | 11.53 |  | - | 17.00 |
| SCE | 8 | AFUE | 50 | 1,524 | 11.59 | 0.26 | 11.85 |  | 7.00 | 14.00 |
| SCE | 9 | AFUE | 514 | 1,671 | 10.83 | 0.09 | 10.92 |  | - | 16.80 |
| SCE | 10 | AFUE | 35 | 1,795 | 10.07 | 0.40 | 10.47 |  | 0.50 | 13.10 |
| SCE | 13 | AFUE | 29 | 1,916 | 10.05 | 0.55 | 10.61 |  | - | 15.00 |
| SCE | 14 | AFUE | 10 | 2,084 | 9.71 | 0.42 | 10.13 |  | 8.00 | 13.00 |
| SDGE | 6 | AFUE | 2 | 2,161 | 12.00 | - | 12.00 |  | 12.00 | 12.00 |
| SDGE | 7 | AFUE | 177 | 1,881 | 11.21 | 0.22 | 11.43 |  | 0.50 | 14.00 |
| SDGE | 8 | AFUE | 4 | 2,578 | 10.53 | 0.83 | 11.35 |  | 9.70 | 13.00 |
| SDGE | 10 | AFUE | 79 | 2,093 | 10.93 | 0.25 | 11.18 |  | 7.80 | 16.00 |

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1. [↑](#footnote-ref-2)
2. Ridge, Richard, Ken Keating, Lori Megdal, and Nick Hall (2007). Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches. Prepared for the California Public Utilities Commission. Ridge, Richard, Ken Keating, Lori Megdal, and Nick Hall (2007). Guidelines for Estimating Net-To-Gross Ratios Using the Self-Report Approaches. Prepared for the California Public Utilities Commission [↑](#footnote-ref-3)
3. The HEES program provides residential customers with entry-level energy surveys online, over the phone, or by mail. The surveys are not intended to serve as an audit but are meant to provide consistent messaging and an easy on-ramp to the Whole House Retrofit Program. The HEES surveys are also a link between the California Solar Initiative (CSI) and the Whole House Retrofit Program.

   The HEES program is not the same as the Universal Audit Tool (UAT), also known as the Progressive Energy Audit Tool (PEAT) program. [↑](#footnote-ref-4)
4. The Basic Path will not require a HERS rating or a performance-level audit upon completion of work. Participating contractors are encouraged to coordinate with HERS raters to provide customers with ratings upon completion of work as a method of educating the marketplace and leveraging an opportunity to draw customers to the Advanced Path. [↑](#footnote-ref-5)
5. Final Energy-Efficiency Groupware Application (EEGA) monthly report, December 2012. [↑](#footnote-ref-6)
6. Skala, Peter. California Public Utilities Commission, Energy Division.   
   2013-2014\_EnergyUpgradeCalifornia-AdvancedPath\_CoverLetter\_1March2013\_Final.doc [↑](#footnote-ref-7)
7. 2010-12 Quarterly Tracking Data Claims. The number of homes was estimated from unique tracking accounts. [↑](#footnote-ref-8)
8. http://www.cpuc.ca.gov/nr/rdonlyres/27629e7a-f01a-48ca-8b2c-b07ecee7dd5a/0/caenergyefficiencyevaluationprotocols.doc [↑](#footnote-ref-9)
9. http://www.calmac.org/events/California\_Evaluation\_Framework\_June\_2004.pdf [↑](#footnote-ref-10)
10. The Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. http://energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf

    The entire set of the Uniform Methods Project’s protocols is available at:

    http://energy.gov/eere/downloads/uniform-methods-project-methods-determining-energy-efficiency-savings-specific [↑](#footnote-ref-11)
11. The site-level modeling approach was originally developed for the Princeton Scorekeeping Method (PRISM™) software. [↑](#footnote-ref-12)
12. Typical Meteorological Year (TMY3)

    http://rredc.nrel.gov/solar/old\_data/nsrdb/1991-2005/tmy3/ [↑](#footnote-ref-13)
13. National Oceanic and Atmospheric Administration Hourly Weather Data [↑](#footnote-ref-14)
14. National Renewable Energy Laboratory (NREL), U.S.., U.S. Department of Energy Typical Meteorological Year weather data. [↑](#footnote-ref-15)
15. California Energy Commission’s California Thermal Zones Typical Weather Data. This data was not used in this evaluation. [↑](#footnote-ref-16)
16. <http://www.energydataweb.com/cpucFiles/26/DraftGenericResidentialNTGInstrument_2.pdf> [↑](#footnote-ref-17)
17. Ask remainder of Project Finance questions if **MEASURE=0** and PF1=1=used a loan or financing to pay for the project – i.e. we are asking the entire finance series only of those who did **NOT** go through the long form of the questionnaire where they were asked questions from each applicable measure section (rather than the overall quantity, efficiency, and timing questions).

    **NOTE:** Binary indicator MEASURE created per comment (alongside M2), “MEASURE” stays=0 if respondent did NOT go through ANY of the measure sections.] [↑](#footnote-ref-18)
18. Using TMY3 weather [↑](#footnote-ref-19)
19. Using TMY3 weather [↑](#footnote-ref-20)