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Evaluation of Pacific Gas and Electric Company's Home Energy Report Initiative for the 2010–2012 Program

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1 Executive Summary

This report documents FSC's evaluation of Pacific Gas and Electric Company's (PG&E's) Home Energy Reports (HERs) initiative; its primary purpose is to document the processes of: evaluation design; participant selection and control group selection; energy savings estimation; and field research and analysis to avoid double-counting of savings. PG&E contracted with Opower Inc. to produce the print-based HERs, which compare household energy use to that of similar neighbors. The HERs provide a number of energy savings tips. The main numerical output of this report is estimated net electric and gas savings attributable to the program through December 2012. The report also provides ancillary analyses that may be of interest to PG&E and others who seek to understand how HERs bring about savings and which customers are most likely to provide high savings.

Since August 2011, PG&E has sent monthly or quarterly HERs to a large number of residential customers. The HERs compare a customer's electric and/or gas usage (depending on which fuels PG&E supplies to a given household) to an average of similar homes' usage as well as to an average of the most efficient 20% of similar homes' usage. Several studies of HER experiments with utilities across the country have shown a typical program impact of 1-3% of annual energy savings in electricity and gas among residential customers.

The initiative was implemented in waves, starting with the Beta wave, which was launched in August 2011 and included about 58,000 PG&E customers in the treatment group. The Beta wave was followed by the Gamma wave, which was launched in November 2011 and included about 184,000 customers in the treatment group. Finally, Wave One was launched in February 2012 and included about 395,000 customers. Each wave included a randomly-drawn, representative control group for use in savings estimation.

The initiative includes single-fuel gas and electric customers as well as dual-fuel customers. The initiative also tested the "standard frequency" cadence of three initial monthly reports followed by bi-monthly reports and a "reduced frequency" cadence of three initial monthly reports followed by quarterly reports. Also, the program can be implemented using monthly HERs (standard frequency) or quarterly HERs (reduced frequency).

The savings estimates reported here include electric savings from August 2011 to December 2012. Total electricity savings estimates include savings from the following segments of the program:

- Beta wave, standard HER frequency, dual-fuel, highest usage quartile (launched August 2011);
- Gamma wave, standard HER frequency, dual-fuel, all usage quartiles (launched November 2011);
- Gamma wave, standard HER frequency, electric-only, all usage quartiles (launched November 2011);
- Gamma wave, reduced HER frequency, dual-fuel, all usage quartiles (launched November 2011); and
- Wave One, standard HER frequency, dual-fuel, highest 3 usage quartiles (launched February 2012).

Table 1-1 outlines the composition of each of the PG&E HER waves.

Table 1-1: PG&E HER Wave Composition

Wave	Total Treatment (Initial #)	Dual-fuel	Electric-only	Gas-only	Frequency (S=Standard, R=Reduced)	Energy Use Quartile(s)
Beta	60,000	Y	N	N	S	4
Gamma	~190,000*	Y	Y	Y*	S, R	1, 2, 3, 4
Wave One	400,000	Y	N	N	S	2, 3, 4

*Because of the removal of SMUD customers from the Gamma Gas-only Wave, the exact number of gas-only customers in Gamma is not known, but is much less than the 15,000 that were initially sampled.

This report also documents gas savings for the same period of time for the Beta, standard HER frequency dual-fuel; Gamma standard frequency and reduced frequency, dual-fuel; and Wave One standard frequency, dual-fuel waves.

Table 1-2 shows the aggregate savings estimates for each of these waves. The total estimated electric savings from the program through December 2012 is 49.9 Gigawatt hours (GWh). Of this total, more than half came from Wave One of the program, which was the largest wave in terms of the number of customers. Wave One is also the wave in this analysis that was most recently launched, so it is reasonable to assume that its overall savings rate is lower due to the ramp up period. Wave One also excluded customers in the lowest quartile of energy use, who tend to save less.

The total estimated gas savings from the program through December 2012 is 1,469 thousand Therms (thms), which came in substantial measure from all waves of the program.

Table 1-2: August 2011 Through December 2012 HER Savings

Aggregate Savings	Beta	Gamma				Wave One		Total	Reduct-ion for Up-stream	Reduct-ion for Down-stream	Adj. Total
		Dual		Electric-only	Gas-Only	Dual	Electric-only				
		Standard	Reduced								
Electric (in GWh)	12.7	5.8	4.8	4.4	NA	25.9	3.1	56.7	-6.6	-0.2	49.9
Standard Error	(0.9)	(0.6)	(0.6)	(0.5)	NA	(1.6)	(0.7)	(4.9)	–	–	(4.9)
Gas (in ,000 thms)	538	224	232	–	13	461	-	1,469	–	–	1,469
Standard Error	(68)	(42)	(42)	–	NA*	(125)	-	(278)	–	–	(278)

*Given its small sample size, the Gamma gas-only savings estimates have currently been estimated using a highly approximate method not amenable to accurate standard error estimates.

Savings estimates are calculated using a regression model appropriate for estimating impacts in the context of a randomized controlled trial (RCT). Standard errors are calculated using the same model, allowing for arbitrary correlation in errors for a given customer. For those more familiar with typical energy efficiency evaluations, the statistical methods employed here may be unfamiliar. The regression estimates based on the RCT design directly produce a net savings estimate for the treatment conditions. No gross estimates exist. The only adjustment to the net savings estimate is a subtraction for savings claimed by other programs.

An important aspect of the HER program is that, while the savings estimates themselves are highly accurate, it is not entirely clear through what actions customers in the treatment conditions achieve savings. Therefore, there is the possibility that some savings are achieved through participation in energy efficiency programs run by PG&E. The most important example in this context is the Upstream Lighting Program (ULP) through which PG&E provides lower priced compact fluorescent lamps (CFLs) to consumers. Since ULP rebates are provided to retailers and manufacturers rather than to retailer buyers, PG&E does not track retail CFL sales that occur through this program. There is no simple way to know how many HER customers saved energy through purchasing CFLs made cheaper through the ULP. A similar issue arises with energy efficient television sets rebated through the Business and Consumer Electronics (BCE) program. The BCE program provides retailer rebates for stocking highly efficient televisions and does not capture information on retail buyers. There are several programs through which PG&E directly provides customers monetary incentives to take up certain energy efficiency measures. For the remainder of the report, programs in which PG&E pays incentives to retailers or manufacturers are referred to as upstream measures while programs where PG&E pays incentives directly to retail customers are referred to as downstream measures. In all of these programs, there is the potential for HER savings to be double-counted by other PG&E programs unless a specific effort is undertaken to estimate the overlap between savings observed in the treatment groups and the proportion of these savings claimed elsewhere in PG&E's portfolio.

For downstream measures, PG&E has provided customer rebate records to determine how much savings from HERs will have already been claimed by other programs. For upstream measures, FSC performed a Home Inventory field survey in which CFLs and qualifying TVs were counted at the homes of treatment and control customers to determine the degree to which HERs have led customers to achieve savings through these programs. The result of these efforts is that the savings results shown in Table 1-2 exclude 6.6 GWh that would otherwise be double counted by upstream programs and 0.2 GWh that would otherwise be counted by downstream programs.

2 Introduction and Program Background

Opower is one of a growing number of companies whose primary aim is to lower energy usage through providing programs featuring energy usage feedback and behavioral suggestions. Opower works with utilities to provide periodic reports to residential customers called Home Energy Reports (HERs). Opower's HERs compare a customer's monthly electric and/or gas usage to an average of similar homes' usage as well as to an average of the most efficient 20% of similar homes' usage. These "neighbor comparisons" are based on a variety of customer characteristics, including location, home square-footage, presence of a pool, and type and number of air conditioning and/or heating units.

The neighbor comparison is used to give the customer one of three ratings:

- *Great* – the customer is more efficient than both average neighbors and efficient neighbors
- *Good* - the customer is more efficient than average neighbors but less efficient than their efficient neighbors
- *More than Average* - the customer is less efficient than both average neighbors and efficient neighbors

If a customer receives a rating of "Good" or "More than Average," the HER will include a dollar amount of savings that the customer could realize on their annual energy bills by matching their efficient neighbors' usage. HERs also provide a list of several simple energy savings tips and their potential annual dollar savings. For customers receiving reports on their electric usage, the reports include a graph of their load shape by hour for an average day from the last month of usage. Load shapes are not provided for natural gas usage because interval data is collected only once daily.

It is not currently well understood what actions customers take that lead to the savings due to HERs. The general hypothesis behind the HERs is that the neighbor comparisons provide a social motivation to customers to adjust their energy usage habits in multiple ways. Several studies of Opower HER programs with utilities across the country establish a typical effect size of 1-3% on annual energy usage among residential customers.[1] This effect is generally thought to be primarily due to changes in behavior (turning off lights, adjusting the thermostat a few degrees, etc.) rather than to significant investments in more energy efficient home equipment, with the primary supporting evidence being that it seems unlikely that such a mild treatment would lead to major investments.

The remainder of this report contains two main elements. First, there is documentation of the design, implementation and evaluation of the RCT underlying this program. This contains the overview of the program waves and their design in the rest of Section 2; followed by a set of evidence for the proper implementation of the RCT in Section 3, which takes the form of tables and figures demonstrating the close comparability of treatment and control groups prior to the onset of the program; and concluding with the regression methods and results in Section 4 that – but for a small adjustment – constitute the net energy savings due to the HER program and not due to any other PG&E program. Second is the documentation of the field work and related analysis done to ensure no double counting of savings for HER and other PG&E energy efficiency programs. Section 5 contains discussion of the analysis done

[1] For further information on this point including results from several different implementations, see "Social Norms and Energy Conservation." By Hunt Allcott. Journal of Public Economics, Vol. 95, No 9-10 (October), pages 1082-1095.

regarding this issue for PG&E's downstream measures; Section 6 contains similar discussion for upstream measures; and Appendix A documents the field work done to provide the data used in Section 6 as well as further data providing evidence of the concrete effects of HERs on recipients' actions.

2.1 HER Waves

The PG&E/Opower HER program began in 2011 with several pilot waves – the first of which was a test wave ("Alpha") to PG&E current and retired employees to test the customer response to HERs. The next pilot wave ("Beta") launched in August 2011 to 58,000 dual-fuel (i.e., receiving both their gas and electric service from PG&E) customers in the top quartile[2] of gas and electric usage in service areas in the San Francisco Bay Area.[3] The Beta wave also included the same number of randomly-chosen control customers to enable savings estimation. The published "Opower effect" findings from both Opower and an outside evaluator establish higher energy savings from high-usage customers both on a percentage and on a real basis, so customers in the top quartile of usage are ideal for initial program targeting efforts.

The next wave ("Gamma") launched in November 2011 to a residential sample stratified across energy usage quartiles and PG&E baseline territories to allow savings estimates on different quartiles of usage as well as different territories. The PG&E service territory is broken into 10 zones that correspond to baseline territories.[4] Customers from the dual-fuel, electric-only, and gas-only billing designations were sampled separately so that dual-fuel treatment customers have a specific dual-fuel control group (and so on for electric and gas-only). The composition of each of these groups at the time of sampling was 72,300 treatment and 72,300 control dual-fuel customers, 45,000 treatment and 45,000 control electric-only customers, and 15,000 treatment and 15,000 control gas-only customers. Gas-only customers who receive electricity service from Sacramento Municipal Utilities District (SMUD) were excluded after the sample was selected since SMUD has its own HER program in place, so the actual number of gas-only customers receiving reports is much lower than 15,000.

The Gamma wave was additionally designed to test the effects of customers receiving HERs at a lower frequency (once a quarter as opposed to the standard once every other month after a once-a-month initial frequency for both groups for the first three months), so an additional group of 72,300 dual-fuel customers were designated to receive HERs at this reduced frequency. This reduced frequency group was stratified in the same manner as the standard dual-fuel treatment group, allowing the established dual-fuel control group to act as a control for both the standard frequency and the reduced frequency treatment groups of dual-fuel customers. Table 2-1 shows the Gamma sample as it was initially drawn, including stratification. Energy use quartiles for dual-fuel customers were determined based

[2] The top (4th or highest) quartile refers to the 25% of energy users who use the most energy on average (using the most energy as compared to the rest of the population). Conversely, the lowest, bottom, or first quartile is the 25% of users who use the least amount of energy on average.

[3] In the case of each wave, the number of customers who received reports even in the first mailing was less than the number initially drawn due to customer accounts closing between the sample being drawn and the first report being mailed. For the Beta wave, 60,000 customers were initially chosen to receive reports, but only 58,000 were sent the first report.

[4] A detailed map of the 10 PG&E baseline territories is attached in Appendix D.

on an overall energy index that accounted for electric and gas use. Usage quartiles were calculated within each baseline territory.

Table 2-1: Gamma Treatment Customers by Baseline Territory, Usage Quartile, and Fuel Type Selected for Initial Sample

Baseline Territory	Dual-fuel Customers by Usage Quartile				
	1	2	3	4	TOTAL
P	0	0	0	0	0
R	3,750	3,750	3,750	3,750	15,000
S	3,750	3,750	3,750	3,750	15,000
T	3,075	3,075	3,075	3,075	12,300
W	3,750	3,750	3,750	3,750	15,000
X	3,750	3,750	3,381	4,119	15,000
Total	18,075	18,075	17,706	18,444	72,300
Baseline Territory	**Dual-fuel Reduced Frequency Customers by Usage Quartile**				
	1	2	3	4	TOTAL
P	0	0	0	0	0
R	3,750	3,750	3,750	3,750	15,000
S	3,750	3,750	3,750	3,750	15,000
T	3,075	3,075	3,075	3,075	12,300
W	3,750	3,750	3,750	3,750	15,000
X	3,750	3,750	3,381	4,119	15,000
Total	18,075	18,075	17,706	18,444	72,300
Baseline Territory	**Electric-only Customers by Usage Quartile**				
	1	2	3	4	TOTAL
P	1646	2,143	2,114	1,834	7,737
R	2,204	2,204	2,204	2,204	8,816
S	1,974	1,477	1,506	1,786	6,743
T	0	0	0	0	0
W	0	0	0	0	0
X	5,428	5,428	5,428	5,428	21,712
Total	11,252	11,252	11,252	11,252	45,008
Baseline Territory	**Gas-only Customers by Usage Quartile**				
	1	2	3	4	TOTAL
P	0	0	1	0	1
R	210	221	204	216	851
S	3,372	3,342	3,359	3,346	13,419
T	0	0	0	0	0
W	0	0	0	0	0
X	168	187	186	188	729
Total	3,750	3,750	3,750	3,750	15,000

The next wave of HERs (Wave One) was launched in February 2012 with the primary purpose of the wave being to produce energy savings for a large number of customers, rather than testing. Wave One did not include customers in the lowest usage quartile or gas-only customers. The wave was also much larger than Gamma with 400,000 HER recipients and 100,000 corresponding control customers. The customers in this wave were not stratified and represented a wider range of baseline territories than the previous waves. Table 2-2 shows Wave One by baseline territory and usage quartile. In this case, usage quartiles were calculated over the entire PG&E residential population, rather than within zones as was done for the Beta and Gamma waves, because the sample frame was not stratified.

Table 2-2: Wave One Treatment Customers by Baseline Territory, Usage Quartile, and Fuel Type

Baseline Territory	Dual-fuel Customers by Usage Quartile				
	1	2	3	4	TOTAL
P	0	981	1,006	726	2,713
Q	0	0	0	0	0
R	0	10,006	15,583	17,284	42,873
S	0	23,371	35,657	34,238	93,266
T	1	22,587	15,177	5,383	43,148
V	0	0	0	1	1
W	0	1,793	2,381	2,184	6,358
X	0	70,260	67,074	31,561	168,895
Y	0	4	13	5	22
Other	0	136	597	2,202	2,935
Total	1	129,138	137,488	93,584	360,211
Baseline Territory	**Electric-only Customers by Usage Quartile**				
	1	2	3	4	TOTAL
P	0	232	453	869	1,554
Q	0	9	41	104	154
R	0	374	555	857	1,786
S	0	356	424	937	1,717
T	0	3,309	1,481	401	5,191
V	0	0	0	0	0
W	0	3,522	6,036	7,860	17,418
X	0	5,683	3,694	1,773	11,150
Y	0	80	158	227	465
Other	0	5	38	313	356
Total	0	13,570	12,880	13,341	39,791

Table 2-3 shows the number of customers who were sent the first mailing in each wave; the number of months since wave inception through December 2012; and the average monthly attrition rate due

to account closure from the beginning of the wave through December 2012. As is evident in this table, the size of the control group was substantially reduced in proportion to the treatment group starting in Wave One.

Table 2-3: Monthly Attrition Rate by Wave and Fuel Type

Wave		Beta	Gamma			Wave One	
			Dual		Electric-only	Dual	Electric-only
			Standard	Reduced			
# of Customers at Launch of Wave	Control	58,528	70,529	70,529	43,396	89,026	9,825
	Treatment	58,493	70,518	70,547	43,363	356,419	39,124
# of Months of HERs*		17	14	14	14	11	11
Monthly Rate of Attrition (%)	Control	0.8%	0.9%	0.9%	1.4%	0.9%	1.4%
	Treatment	0.8%	0.9%	0.9%	1.4%	0.9%	1.4%

*Although HERs are ongoing, current analysis ends after December 2012.

2.2 Experimental Design

The impacts of HERs have been tested in several utility jurisdictions and have been found to vary from about 1% to about 3% for electricity customers and from 1% to 1.5% for gas customers. Accurately estimating such small impacts requires an RCT with quite large sample sizes. Non-experimental methods, such as within-subjects regression models, have biases that in this context are likely to be as large as the effects being measured, making them completely useless for this purpose.

Opower's HER program lends itself well to an RCT because there is no recruiting process: it is an opt-out design whereby customers are simply assigned either to treatment or control groups according to inclusion criteria established at the onset of each wave. Because HERs can be sent out to customers without their prior knowledge or approval; and control customers are not aware that an experiment is occurring and are therefore unlikely to become dissatisfied. Treated customers can choose not to respond to the reports if they wish. The reports generate very few complaints and opt-outs.

2.2.1 Testing HERs in Waves

Previous evaluations of the Opower HER programs have established that there is some benefit in targeting specific segments of the population in order to maximize program performance. Because the cost per report is fixed, there is significant interest in getting the highest reduction per HER sent. In order to accurately predict the energy use reduction potential of certain segments of the population, the HER experiments were divided into waves targeting specific usage quartiles. The initial two test waves were known as Beta and Gamma. The Beta sample design had the following objectives:

- To capture substantial energy savings from the subset of customers hypothesized to be most receptive to the messaging in the home energy reports; and
- To provide early feedback from customers who receive the reports.

The Gamma sample design had two main objectives. The first objective was to support the estimation of gross program impacts that are sufficiently precise that, with a total size of 120,000 receiving the experimental treatment (not including reduced-frequency treatment condition), it would be possible to measure the effect of the program to within plus or minus 0.7 percentage points with a 95% probability. In effect, this means that if the true value of the population parameter is 1% energy savings then 95% of the time the estimate obtained from a sample of 120,000 will be between 0.3% and 1.7%. This was intended to support claimed savings estimates and the objective was exceeded due to the similar restrictions on the precision within each Gamma wave cell as described below.

The second objective of the Gamma wave was to provide estimates of program impacts for specific market segments (that may be targeted or excluded from treatment as the company expands the delivery of HERs to other customers). These segments include:

- Customers receiving different commodity combinations (e.g., dual-fuel, electricity-only and natural gas-only);
- Customers located in different baseline territories;
- Customers with varying levels of energy consumption; and
- Assess the impacts on energy savings of reducing the frequency of delivery of reports from every other month to quarterly for different market segments. The purpose of this experimental condition is to inform the decision as to whether a less frequent delivery is more cost effective (i.e., energy savings vs. program cost) for the various market segments under study.

The Gamma wave is intended to provide information needed to select the optimal combination of targeting and frequency for the various market segments within PG&E's market.

Following the Gamma wave was the first non-test wave, intended only to provide energy savings. Referred to as Wave One, it consisted of 400,000 PG&E customers plus a 100,000 customer control group, randomly chosen from all of PG&E's residential customers who satisfied the criteria for inclusion (as listed in section 2.4) and who had not been included in the Beta or Gamma waves.

2.3 Determining Minimal Sample Sizes for Each Experimental Wave

To determine the sample sizes appropriate for the test waves, a simulation approach was used in which regression calculations were performed on a sample of customers who are not subjected to HERs, using the same specification used in actual estimation. This process used 24 months of monthly billing data from a randomly-drawn sample of 10,000 PG&E residential customers, which were then randomly divided into 2 groups of 5,000 customers. One group was designated as the simulated treatment group (recognizing that it received no treatment) and a specified treatment variable was in effect for that group for the second 12 months of the sample. An equation (1) was then estimated on the full group of customers, with standard errors calculated allowing for arbitrary correlation of errors within individual customer data. This procedure provided standard error estimates for a situation almost identical to the actual analysis to be done for estimation. Standard error calculations were also done using bootstrapping for corroboration and were found to be virtually identical using both methods. Standard error estimates for this sample size can be scaled to estimate standard errors for other sample sizes by recognizing that the regression essentially estimates an

adjusted difference between two groups, so that the expected standard error of the treatment effect for any other group sizes would be:

$$\sqrt{\frac{1}{2}\left(k\sqrt{\frac{5{,}000}{n_1}}\right)^2+\left(k\sqrt{\frac{5{,}000}{n_2}}\right)^2}$$

Where k is the standard error estimate when each group size is 5,000 and n_1 and n_2 are the treatment and control group sizes of interest.[5] With this procedure, it was determined that, with a sample size of 15,000 treatment and 15,000 control households within cells of interest in the Gamma wave, it would be possible to measure the effect of the program to within plus or minus 0.7% with 80% probability (a higher level of probability would have required even higher sample sizes) within the experimental cells which were segmented into usage quartile and baseline territory groups. In effect, this means that if the true value of the population parameter is 1% then 80% of the time the estimate obtained from a sample of 15,000 within each cell will be between 0.3% and 1.7%.

Sample sizes for the Beta wave and Wave One were determined based on non-statistical factors, recognizing that based on the Gamma wave design exercise, the desired sizes of 60,000 customers and 400,000, respectively, would be easily large enough to support savings estimation. Similarly, the sample size for the entire Gamma wave, which would be the aggregate of all of its cells, would be easily large enough to support estimation.

PG&E anticipated that overall opt-out rates for recipients of HERs would be approximately 2% over the course of the experiment. So far the actual number has been much less, at a fraction of a percentage point. Average rates for moving of households is approximately 12% annually as estimated by the U.S. Department of the Census, PG&E estimated an attrition rate of approximately 25% over the course of two years.[6]

2.4 Criteria for Inclusion

Opower's HERs can only be produced for customers satisfying certain proprietary criteria. There are few significant differences in geographic distribution or average usage distribution between the customers Opower deemed eligible and the PG&E residential population, although FSC did not look into the issue extensively.

Moreover, there were several segments of the population that were excluded for other reasons. Below is a comprehensive list of restrictions on eligibility for Wave One. Customers must:

- Have a full year of bills;
- Have had a functioning SmartMeter for greater than one year;
- Be on selected rate schedules (E-1, E-6, E-7, and interval metered versions of these rates);
- Be in top the three quartiles of usage;
- Neither be on a medical baseline rate, nor flagged as "vulnerable or disabled" in PG&E databases;

[5] For further explanation, see Appendix B.

[6] http://www.census.gov/newsroom/releases/archives/mobility_of_the_population/cb12-240.html.

- Not be master metered;
- Not be net metered;
- Not live in a mobile home;
- Not be on an electric vehicle rate;
- Not on a natural gas vehicle rate;
- Not be in the Beta or Gamma waves;
- Not live in a multifamily dwelling;
- Not be billed by a municipality; and
- Haven't previously requested not to receive marketing materials from PG&E.

The restrictions for the Beta wave were similar, but they also included the stipulation that the customer had to live in a specific set of zip codes and had to be in the top quartile energy users. The restrictions for the Gamma wave were also similar except that customers from all quartiles of energy user were included.

3 Experimental Validation

FSC's approach to impact estimation requires that the control group provide a highly-accurate representation of what the treatment group's behavior would have been if HERs had never been sent. To have confidence in this estimate, it is necessary that the control and treatment groups be as similar as possible prior to the onset of the HERs experiment. This is accomplished through a combination of random assignment to treatment/control, and to large sample sizes. The random assignment ensures that, on average, the two groups to have no systematic differences. The large sample sizes ensure that, through the law of large numbers, all meaningful differences between the groups that arise randomly will become trivially small. This section outlines the evidence that this randomization on large samples was implemented correctly.[7]

Tables 3-1 through 3-5 demonstrate the successful randomization of customers onto control and treatment groups. The tables show both the percentage of customers with observed characteristics as well as mean values for quantitative variables.[8] The observed characteristics in the table include baseline territory, CARE status (a rate class for lower income households), income level as estimated by a third party, homeownership status as estimated by a third party, home attributes, and monthly electricity usage prior to treatment. As the tables show, the distribution of each characteristic is similar across treatment and control groups.

The tables also show the results of statistical tests that tell us whether there is any evidence that the distribution of a given characteristic is correlated with treatment status. For metrics with more than two categories, the test used was Fisher's exact test; which is a common method of judging whether distributions of two variables are correlated within a population. In this case, small values in the far right column of the table would be evidence that there was a meaningful correlation between the distribution of the characteristic and treatment status. This might suggest that some type of selection bias had entered the experiment. Generally, values below 0.05 would be cause for further investigation. The test for binary variables is a t-test, which is used to determine if the means of two populations differ. Once again, values in the far right column of the table below 0.05 would be evidence of statistically significant differences.

In both cases, though, by chance alone it would be expected that 1 out of 20 such tests to have values below 0.05, so it is important also to consider whether the absolute magnitude of the difference suggests a meaningful difference between groups and whether there is other evidence of corrupted randomization. For example, in Table 3-1, the difference in the fraction of customers on CARE rates (a program for low-income households offering subsidized rates) has a p-value of 0.04, which might be cause for concern. However, the actual difference is quite small, 14.1% versus 14.5%, and there is no other significant difference in the table. This suggests that it is unlikely that the randomization was corrupted in this case.

[7] This may seem like a trivial point, but it is not. There have been many recent examples of RCTs in the utility industry where this step failed.

[8] Data for tables 3-1 through 3-5 come from a combination of PG&E and third party databases licensed by PG&E. FSC has not independently verified the accuracy of the data.

Table 3-1: Distributions of Characteristics Across Treatment and Control Groups (Beta Wave)

Metric	Category	Unit	Treatment	Control	P-value
Baseline Territory	**S**	% of group	6.9%	7.0%	0.71
	X		93.1%	93.1%	
CARE Rate			14.5%	14.1%	0.04
Estimated Household Income	**<$30k**		3.8%	3.7%	0.64
	$30k-$50k		4.9%	4.8%	
	$50k-$80k		15.6%	15.4%	
	>$80k		75.7%	76.1%	
Renter Status			1.6%	1.6%	0.57
Presence of Pool or Spa			27%	27%	0.57
Estimated Number of Residents		number of residents	3.26	3.27	0.57
Living Space		square feet	2223.9	2225.8	0.71
Year Home Built		year	1971.0	1971.0	0.98
Estimated Age of Head of Household		years	55.0	55.0	0.36
Pre-HER Usage	**Jul-10**	monthly kWh	1,006	1,005	0.56
	Aug-10		990	988	0.54
	Sep-10		954	953	0.67
	Oct-10		934	933	0.63
	Nov-10		947	946	0.62
	Dec-10		1,059	1,058	0.48
	Jan-11		1,000	999	0.68
	Feb-11		865	864	0.89
	Mar-11		923	922	0.75
	Apr-11		840	840	0.96
	May-11		860	861	0.59
	Jun-11		944	945	0.69
	Jul-11		1,016	1,016	0.86

Table 3-2: Distributions of Characteristics Across Treatment and Control Groups (Gamma Wave, Duel-fuel and Standard Treatment)

Metric	Category	Unit	Treatment	Control	P-value
Baseline Territory	R	(% of group)	22.0%	22.0%	1.00
	S	(% of group)	21.2%	21.2%	
	T	(% of group)	18.0%	18.0%	
	W	(% of group)	22.0%	22.0%	
	X	(% of group)	16.8%	16.8%	
CARE Rate		(% of group)	36.6%	36.6%	0.91
Estimated Household Income	<$30k	(% of group)	20.8%	20.8%	0.43
	$30k-$50k	(% of group)	18.1%	18.2%	
	$50k-$80k	(% of group)	30.1%	30.5%	
	>$80k	(% of group)	31.0%	30.6%	
Renter Status		(% of group)	6.8%	6.8%	0.91
Presence of Pool or Spa		(% of group)	13.8%	13.8%	0.69
Estimated Number of Residents		(number of residents)	2.7	2.7	0.16
Living Space		(square feet)	1651.7	1649.2	0.71
Year Home Built		(year)	1968.6	1968.4	0.21
Estimated Age of Head of Household		(years)	53.3	53.3	0.95
Pre-HER Usage	Oct-10	(monthly kWh)	558	555	0.21
	Nov-10	(monthly kWh)	531	529	0.26
	Dec-10	(monthly kWh)	597	595	0.31
	Jan-11	(monthly kWh)	575	574	0.40
	Feb-11	(monthly kWh)	493	492	0.31
	Mar-11	(monthly kWh)	518	516	0.20
	Apr-11	(monthly kWh)	477	476	0.24
	May-11	(monthly kWh)	508	507	0.40
	Jun-11	(monthly kWh)	675	673	0.42
	Jul-11	(monthly kWh)	834	831	0.45
	Aug-11	(monthly kWh)	836	833	0.39
	Sep-11	(monthly kWh)	718	716	0.46
	Oct-11	(monthly kWh)	558	556	0.29

Table 3-3: Distributions of Characteristics Across Treatment and Control Groups (Gamma Wave, Dual-fuel and Reduced Treatment)

Metric	Category	Unit	Treatment	Control	P-value
Baseline Territory	R	(% of group)	22.0%	22.0%	1.00
	S	(% of group)	21.2%	21.2%	
	T	(% of group)	18.0%	18.0%	
	W	(% of group)	22.0%	22.0%	
	X	(% of group)	16.8%	16.8%	
CARE Rate		(% of group)	37.0%	36.6%	0.13
Estimated Household Income	<$30k	(% of group)	20.9%	20.8%	0.93
	$30k-$50k	(% of group)	18.3%	18.2%	
	$50k-$80k	(% of group)	30.4%	30.5%	
	>$80k	(% of group)	30.4%	30.6%	
Renter Status		(% of group)	6.8%	6.8%	0.80
Presence of Pool or Spa		(% of group)	13.7%	13.8%	0.57
Estimated Number of Residents		(number of residents)	2.7	2.7	0.69
Living Space		(square feet)	1660.7	1649.2	0.17
Year Home Built		(year)	1968.5	1968.4	0.60
Estimated Age of Head of Household		(years)	53.3	53.3	0.70
Pre-HER Usage	Oct-10	(monthly kWh)	556	555	0.64
	Nov-10	(monthly kWh)	529	529	0.98
	Dec-10	(monthly kWh)	595	595	0.79
	Jan-11	(monthly kWh)	574	574	0.94
	Feb-11	(monthly kWh)	491	492	0.90
	Mar-11	(monthly kWh)	516	516	0.99
	Apr-11	(monthly kWh)	476	476	0.95
	May-11	(monthly kWh)	507	507	1.00
	Jun-11	(monthly kWh)	674	673	0.68
	Jul-11	(monthly kWh)	833	831	0.49
	Aug-11	(monthly kWh)	836	833	0.38
	Sep-11	(monthly kWh)	717	716	0.76
	Oct-11	(monthly kWh)	557	556	0.62

Table 3-4: Distributions of Characteristics Across Treatment and Control Groups (Gamma Wave, Electric-only Segment)

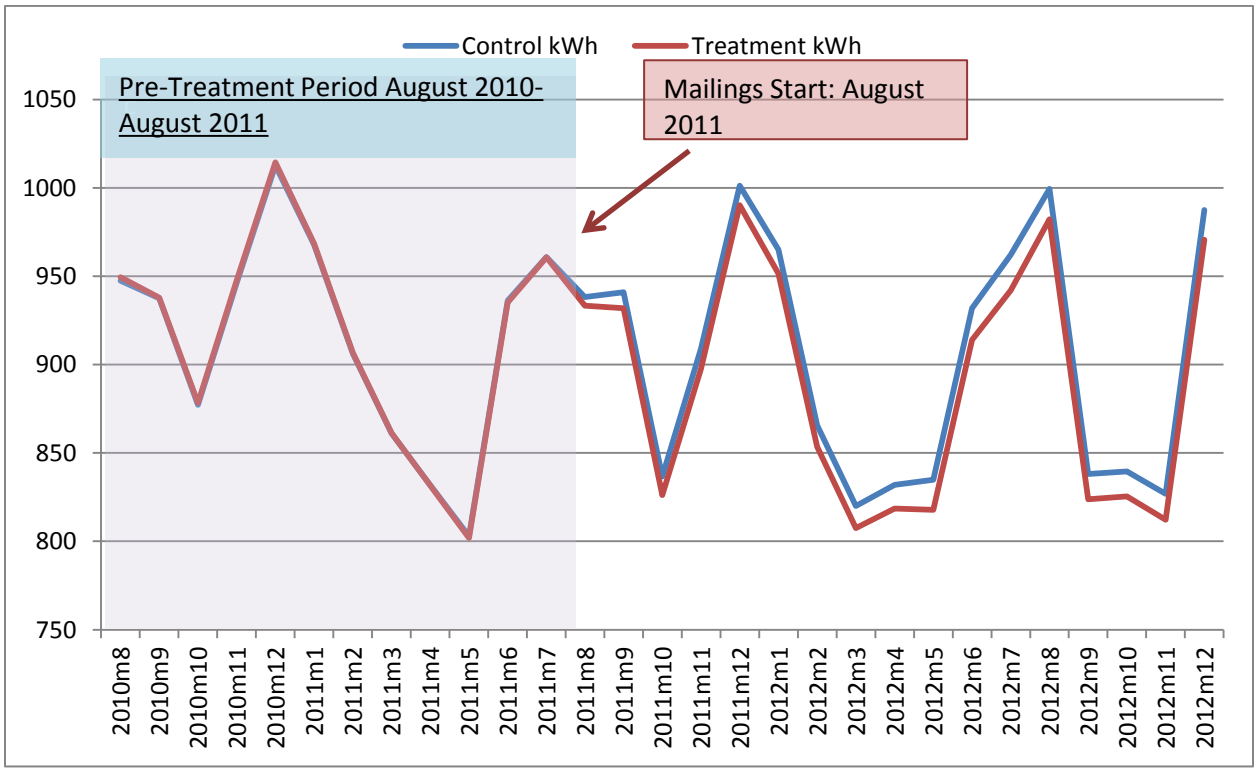
Metric	Category	Unit	Treatment	Control	P-value
Baseline Territory	P	(% of group)	17.2%	17.3%	0.98
	R	(% of group)	19.6%	19.6%	
	S	(% of group)	15.0%	14.9%	
	X	(% of group)	48.2%	48.2%	
CARE Rate		(% of group)	38.4%	38.5%	0.91
Estimated Household Income	<$30k	(% of group)	19.2%	19.0%	0.74
	$30k-$50k	(% of group)	16.6%	16.9%	
	$50k-$80k	(% of group)	33.0%	32.9%	
	>$80k	(% of group)	31.2%	31.2%	
Renter Status		(% of group)	16.8%	17.0%	0.56
Presence of Pool or Spa		(% of group)	8.8%	8.4%	0.04
Estimated Number of Residents		(number of residents)	2.3	2.3	0.85
Living Space		(square feet)	1837.3	1843.5	0.92
Year Home Built		(year)	1980.6	1980.2	0.04
Estimated Age of Head of Household		(years)	54.3	54.3	0.98
Pre-HER Usage	Oct-10	(monthly kWh)	529	530	0.69
	Nov-10	(monthly kWh)	594	596	0.53
	Dec-10	(monthly kWh)	701	703	0.50
	Jan-11	(monthly kWh)	695	696	0.69
	Feb-11	(monthly kWh)	600	601	0.69
	Mar-11	(monthly kWh)	615	616	0.60
	Apr-11	(monthly kWh)	516	517	0.68
	May-11	(monthly kWh)	514	514	0.86
	Jun-11	(monthly kWh)	568	567	0.86
	Jul-11	(monthly kWh)	653	653	0.87
	Aug-11	(monthly kWh)	658	657	0.95
	Sep-11	(monthly kWh)	586	587	0.86
	Oct-11	(monthly kWh)	525	526	0.64

Table 3-5: Distributions of Characteristics Across Treatment and Control Groups (Wave One)

Metric	Category	Unit	Treatment	Control	P-value
Baseline Territory	P	(% of group)	1.1%	1.1%	0.36
	Q	(% of group)	0.0%	0.0%	
	R	(% of group)	11.3%	11.4%	
	S	(% of group)	23.9%	23.9%	
	T	(% of group)	12.2%	12.0%	
	V	(% of group)	0.0%	0.0%	
	W	(% of group)	6.0%	6.0%	
	X	(% of group)	45.4%	45.5%	
	Y	(% of group)	0.1%	0.1%	
Dual-fuel		(% of group)	90.1%	90.0%	0.60
CARE Rate		(% of group)	29.7%	29.8%	0.43
Estimated Household Income	<$30k	(% of group)	12.8%	12.8%	0.79
	$30k-$50k	(% of group)	13.3%	13.5%	
	$50k-$80k	(% of group)	29.6%	29.4%	
	>$80k	(% of group)	44.3%	44.3%	
Renter Status		(% of group)	5.4%	5.4%	0.98
Presence of Pool or Spa		(% of group)	13.4%	13.5%	0.47
Estimated Number of Residents		(number of residents)	2.8	2.9	0.16
Living Space		(square feet)	1734.3	1702.8	0.61
Year Home Built		(year)	1972.1	1972.1	0.93
Estimated Age of Head of Household		(years)	52.2	52.4	0.05
Pre-HER Usage	Jan-11	(monthly kWh)	637	638	0.29
	Feb-11	(monthly kWh)	598	598	0.84
	Mar-11	(monthly kWh)	558	558	0.68
	Apr-11	(monthly kWh)	535	536	0.64
	May-11	(monthly kWh)	521	521	0.93
	Jun-11	(monthly kWh)	664	666	0.32
	Jul-11	(monthly kWh)	728	729	0.24
	Aug-11	(monthly kWh)	722	725	0.10
	Sep-11	(monthly kWh)	690	692	0.38
	Oct-11	(monthly kWh)	549	550	0.29
	Nov-11	(monthly kWh)	593	594	0.16
	Dec-11	(monthly kWh)	662	663	0.15
	Jan-12	(monthly kWh)	638	639	0.38

Figure 3-1 is a clear illustration of the advantages of random assignment with large samples. In the year prior to treatment customers receiving HERs, the monthly electricity usage of the treatment group is nearly identical to the control group. It was only when treatment customers began receiving HERs in August 2011 that the usage between the two groups started to diverge by about 1-2%. At that point it was possible to obtain quite accurate treatment effects through finding the difference in average usage between groups. The actual regression method is only slightly more complicated, and also includes a small adjustment for whatever small differences existed between groups prior to treatment. Figure 3-1 is illustrative; similar figures exist for the Gamma wave and Wave One, and are available in Appendix B.

Figure 3-1: Beta Wave Average Usage by Month



3.1 Additional Concerns

Any ongoing experiment studying a population of residential customers will have attrition. One type of attrition is customers who opt out of receiving the reports. The opt-out rate has been a trivial fraction of the population of each wave – less than 1%.

Another source of attrition is customers who move. Because HERs are linked not only to a specific customer, but also to their residence, customers moving out of the sampled residence effectively remove themselves from the experiment. This removal is noted in customer records kept by PG&E, and Opower subsequently stops sending HERs to these customers. This removal is also reflected by default in the residential population billing records used by FSC because a customer's identification information will change upon their relocation and will make them incapable of being matched up to the original identification variables used in sampling. In other words, a customer's billing information is

included in FSC's analysis so that households are retained in the treatment or control groups up until their date of attrition.

The attrition rate for the sampled population tends to be between 0.7% and 0.9% monthly and is consistent with estimates from the U.S. Census. Moving is the primary reason for customer attrition rates in the HER samples, but other reasons may include a change of service provider (in the case of areas with Community Choice Aggregation) or a change of billing rate code due to factors such as the installation of solar panels or the purchase of an electric vehicle. Both of these cases were previously identified as exclusion criteria for the HER experiment, so it is justifiable that these customers be removed from the analysis.

It is highly unlikely that HERs themselves cause customers to attrit, which means that selection bias should not be an issue. However, the attrition does mean that the population will have different characteristics over time if those who attrit differ from those who don't. To address this possibility, FSC compared the traits of customers that left the sample to those who stayed. Tables 3-6 through 3-8 show the population characteristics for dual-fuel customers from each wave, respectively for the month the sample for the wave was selected; the halfway point between the wave's launch and August 2012. The tables show that there are meaningful differences between those who attrit and those who do not. For example, in the Gamma wave, CARE rate customers appear more likely to attrit. However, the fraction of customers who attrit is small enough that the overall population characteristics hardly changed at all between the onset of each wave and August 2012.

In order to limit the already large number of tables in this evaluation and because dual-fuel customers are the majority of each wave, these tables for electric-only and gas-only customers are not included. Additionally, for the sake of evaluation efficiency, these tables have not been updated past August 2012, which was the most recent data available when they were made. They do not suggest any major problem or reason to continually update them.

Table 3-6: Beta Wave Population Attrition

Category		Unit	Jul-11	Feb-12		Aug-12	
				Still in Sample	Attrited	Still in Sample	Attrited
Baseline Territory	S	% of group	6.8%	6.7%	13.6%	6.4%	8.4%
	X	% of group	93.2%	93.3%	86.4%	93.6%	91.6%
CARE Rate		% of group	14.4%	14.2%	27.0%	14.7%	13.6%
Estimated Household Income Level	<$30k	% of group	3.8%	3.8%	4.5%	3.9%	3.3%
	$30k-$50k	% of group	4.9%	4.9%	6.2%	5.1%	4.0%
	$50k-$80k	% of group	15.6%	15.5%	21.8%	16.4%	13.1%
	>$80k	% of group	75.7%	75.8%	67.5%	74.5%	79.7%
Renter Status		% of group	1.6%	1.6%	3.3%	1.7%	1.6%
Presence of Pool or Spa		% of group	27.2%	27.3%	22.3%	26.4%	29.9%
Estimated Number of Residents		avg. #	3.3	3.3	3.0	3.3	3.3
Living Space		avg. sq. ft.	2,224	2,225	2,121	2,187	2,342
Year Home Built		avg. year	1971	1971	1973	1970	1974
Estimated Age of Head of Household		avg. # of years	54.9	55.0	52.6	55.2	54.3
Monthly Bill	Jul-10	avg. kWh	1,006	1,006	1,001	991	1,052
	Aug-10	avg. kWh	990	990	978	970	1,047
	Sep-10	avg. kWh	954	955	933	936	1,004
	Oct-10	avg. kWh	934	935	916	920	973
	Nov-10	avg. kWh	947	948	922	936	978
	Dec-10	avg. kWh	1,060	1,061	1,021	1,046	1,099
	Jan-11	avg. kWh	1,000	1,001	982	988	1,034
	Feb-11	avg. kWh	864	865	852	857	886
	Mar-11	avg. kWh	923	923	907	913	949
	Apr-11	avg. kWh	840	841	819	830	869
	May-11	avg. kWh	862	864	832	853	888
	Jun-11	avg. kWh	949	951	905	935	989
	Jul-11	avg. kWh	1,018	1,023	924	1,003	1,062

Table 3-7: Gamma Wave Dual-fuel, Standard Report Frequency Population Attrition

Category		Unit	Oct-11	Apr-12		Aug-12	
				Still in Sample	Attrited	Still in Sample	Attrited
Baseline Territory	P	% of group	0.0%	0.0%	0.0%	0.0%	0.0%
	R	% of group	21.8%	21.6%	25.7%	20.9%	25.0%
	S	% of group	21.1%	21.0%	22.6%	21.3%	20.5%
	T	% of group	18.3%	18.5%	14.4%	19.5%	13.8%
	W	% of group	21.9%	21.8%	23.2%	21.2%	24.1%
	X	% of group	17.0%	17.1%	14.1%	17.1%	16.6%
CARE Rate		% of group	36.4%	35.8%	46.6%	35.5%	39.5%
Estimated Household Income Level	<$30k	% of group	20.8%	20.6%	27.1%	20.5%	22.3%
	$30k-$50k	% of group	18.1%	18.0%	20.6%	17.8%	19.2%
	$50k-$80k	% of group	30.1%	30.2%	29.6%	30.1%	30.3%
	>$80k	% of group	30.9%	31.3%	22.7%	31.6%	28.1%
Renter Status		% of group	6.8%	6.6%	12.1%	6.5%	8.0%
Presence of Pool or Spa		% of group	13.7%	13.8%	12.4%	13.6%	14.2%
Estimated Number of Residents		avg. #	2.7	2.7	2.4	2.7	2.7
Living Space		avg. sq. ft.	1,651	1,651	1,637	1,657	1,626
Year Home Built		avg. year	1969	1968	1972	1967	1973
Estimated Age of Head of Household		avg. # of years	53.3	53.5	48.3	53.7	52.0
Monthly Bill	Oct-10	avg. kWh	558	559	536	554	571
	Nov-10	avg. kWh	531	534	498	531	532
	Dec-10	avg. kWh	597	600	551	597	597
	Jan-11	avg. kWh	576	578	539	575	577
	Feb-11	avg. kWh	494	496	465	494	491
	Mar-11	avg. kWh	519	521	485	519	518
	Apr-11	avg. kWh	478	480	450	477	482
	May-11	avg. kWh	509	510	483	507	513
	Jun-11	avg. kWh	675	675	669	667	702
	Jul-11	avg. kWh	834	834	838	823	872
	Aug-11	avg. kWh	837	837	837	827	874
	Sep-11	avg. kWh	721	722	704	717	737
	Oct-11	avg. kWh	559	563	497	558	563

Table 3-8: Wave One Dual-fuel Population Attrition

Category		Unit	Jan-12	May-12		Aug-12	
				Still in Sample	Attrited	Still in Sample	Attrited
Baseline Territory	P	% of group	0.7%	0.7%	0.8%	0.7%	0.8%
	R	% of group	12.0%	11.7%	15.9%	11.4%	14.6%
	S	% of group	26.0%	25.6%	31.1%	26.0%	26.2%
	T	% of group	12.3%	12.5%	9.6%	12.8%	10.3%
	V	% of group	0.0%	0.0%	0.0%	0.0%	0.0%
	W	% of group	1.8%	1.7%	3.1%	1.7%	2.1%
	X	% of group	47.1%	47.8%	39.4%	47.4%	45.9%
	Y	% of group	0.0%	0.0%	0.0%	0.0%	0.0%
CARE Rate		% of group	28.9%	28.0%	39.6%	28.5%	30.6%
Estimated Household Income Level	<$30k	% of group	12.1%	11.7%	16.8%	11.9%	12.9%
	$30k-$50k	% of group	12.8%	12.7%	14.7%	12.7%	13.1%
	$50k-$80k	% of group	29.2%	29.1%	30.6%	29.4%	28.4%
	>$80k	% of group	45.9%	46.6%	37.9%	46.0%	45.6%
Renter Status		% of group	5.0%	4.6%	10.8%	4.8%	5.8%
Presence of Pool or Spa		% of group	13.1%	13.3%	11.4%	12.9%	13.9%
Estimated Number of Residents		avg. #	2.9	2.9	2.6	2.9	2.8
Living Space		avg. sq. ft.	1,733	1,735	1,691	1,737	1,715
Year Home Built		avg. year	1971	1971	1973	1971	1972
Estimated Age of Head of Household		avg. # of years	52.3	52.8	46.8	52.5	51.5
Monthly Bill	Jan-11	avg. kWh	632	634	612	635	618
	Feb-11	avg. kWh	592	594	573	592	594
	Mar-11	avg. kWh	555	557	535	554	556
	Apr-11	avg. kWh	533	534	515	532	536
	May-11	avg. kWh	517	518	502	515	526
	Jun-11	avg. kWh	651	650	662	645	676
	Jul-11	avg. kWh	711	709	738	707	729
	Aug-11	avg. kWh	706	703	738	697	741
	Sep-11	avg. kWh	679	677	700	686	649
	Oct-11	avg. kWh	546	547	536	544	557
	Nov-11	avg. kWh	589	592	560	586	599
	Dec-11	avg. kWh	654	658	611	655	652
	Jan-12	avg. kWh	634	639	576	641	606

4 Methods and Results

Program impacts on electricity consumption are estimated using a panel regression model in which monthly energy consumption for treatment and control group customers is modeled using an indicator variable for month of the study, a treatment indicator variable and a customer-level indicator variable:

$$kWh_{it} = customer_i \cdot b_i + \sum_{m=1}^{12} \sum_{y=2010}^{2012} I_{my} \cdot b_{my} + \tau \cdot treatment_{it} + \varepsilon_{it} \qquad (1)$$

Variable	Definition
kWh_{it}	Customer *i*'s usage in month *t*.
$customer_i$	An indicator variable that equals one for customer *i* and zero otherwise. This variable models each customer's average energy use separately.
b_i	The coefficient on the customer indicator variable. Equal to the mean energy use for each customer.
I_{my}	An indicator variable that equals one for during month *m*, year *y* and zero otherwise. This variable models each month of each year's deviation from average energy use over the control population.
b_{my}	The coefficient on the month x year indicator variable.
$treatment_{it}$	The treatment variable. Equal to one when the treatment is in effect for the treatment group. Zero otherwise. Always zero for the control group.
τ	The estimated treatment effect in kWh/month; the main parameter of interest.
ε_{it}	The error term.

This specification applies to all waves, with some variables equaling zero for some waves.[9] In each case, the estimation included one year of pre-treatment billing data for each customer. This allowed the regression to account for any small differences that existed in average usage between treatment and control customers prior to treatment. As shown in Section 3, these differences are quite small, so estimation without the inclusion of pre-treatment data yields almost identical estimates (although customer-level indicator variables cannot be included in the specification in that case).

Standard errors were estimated allowing for arbitrary correlation among errors within each customer's set of data.

The analyses for each wave of the HER program were performed independently, and within each of the waves the savings for each fuel type were calculated independently. The reason for this is twofold: there are certain inherent differences between dual-fuel and single-fuel customers that could add noise to any aggregate analysis, and the experiments were designed to test the respective impacts of receiving HERs on customers of different fuel types.

In addition to the estimates used for claiming savings, which are the most precise estimates for measuring the average HER effect, month-specific treatment effects have also been estimated in order to examine the trajectory of treatment effects over time. To estimate these effects, the specification

[9] This specification is a recommended specification for estimating treatment effects in this context. See equation 1.3, page 76 of "Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations," published by SEE Action, May 2012.

is the same as above, but the single treatment variable is replaced with a set of month-specific treatment variables and associated coefficients.

In order to maintain comparability between treatment and control groups, opt-outs are retained in the treatment groups. Because the experiment uses an opt-out design whereby households in the treatment group do not self-select to receive the reports, households subsequently opting out of the treatment group did receive at least one report. Consequently, opt-outs are retained in the treatment group even though report delivery stops upon receipt of the request to opt-out. Doing otherwise would jeopardize the internal validity of the estimated savings. HERs are assumed not to affect the rate at which customers close their accounts due to moving or other reasons; this appears to be true since the attrition rate between treatment and control groups are virtually identical. Customers are retained in each sample until their accounts close.

4.1 Method for Calculating Aggregate Savings Claim

The aggregate savings claim for PG&E/Opower's HER program is calculated using output from the main regression model. The aggregate savings estimates by wave are shown in Table 4-1, which does not include the result of the double-counting adjustment for CFLs and downstream measures which are discussed in sections 5 and 6.

Table 4-1: August 2011 through December 2012 HER Savings

Aggregate Savings	Beta	Gamma				Wave One		Total
		Dual		Electric-only	Gas-only	Dual	Electric-only	
		Standard	Reduced					
Electric (in GWh)	12.7	5.8	4.8	4.4	NA	25.9	3.1	56.7
Standard Error	(0.9)	(0.6)	(0.6)	(0.5)	NA	(1.6)	(0.7)	(4.9)
Gas (in ,000 thms)	538	224	232	-	13	461	-	1,469
Standard Error	(68)	(42)	(42)	-	(2)*	(125)	-	(280)

*The Gamma gas-only values have currently been estimated using a highly approximate method not amenable to accurate standard error estimates.

Tables 4-2 and 4-3 show roughly how the aggregate savings values are calculated. It shows the number of treatment months, the estimated percentage impact,[10] the average usage in the control group during the treatment period and the average number of customers in each wave over the treatment period. Multiplying these values together gives the estimated number of GWh or 1,000 thm of savings from each segment of each wave, which are shown in the right-most column.

[10] In the actual calculation, the regression produces a kWh value rather than a percentage value. The kWh value is used directly rather than using a percentage applied to a control load. The percentage and the average load are presented here for expositional purposes.

Table 4-2: Primary Inputs into the Electric Savings Estimates

Wave	# of Treatment Months	% Impact	Average Monthly Control Load (kWh)	Average # of Treatment Customers	Aggregate kWh Impact	Aggregate MWh Impact
Beta	17	1.5%	902	54,320	12,733,167	12.7
Gamma Dual Standard	14	1.1%	608	65,150	5,847,023	5.8
Gamma Dual Reduced	14	0.9%	608	65,135	4,791,369	4.8
Gamma Electric-only	14	1.4%	584	39,395	4,390,094	4.4
Wave One Dual	11	1.1%	613	336,435	25,870,729	25.9
Wave One Electric-only	11	1.1%	685	36,296	3,089,063	3.1

Table 4-3: Primary Inputs into the Gas Savings Estimates

Wave	# of Treatment Months	% Impact	Average Monthly Control Load (thm)	Average # of Treatment Customers	Aggregate thm Impact	Aggregate ,000 thm Impact
Beta	17	0.9%	67	54,441	538,446	538
Gamma Dual Standard	14	0.6%	41	65,622	224,071	224
Gamma Dual Reduced	14	0.6%	41	65,645	232,034	232
Wave One Dual	11	0.4%	35	330,725	461,468	461

4.2 Electricity Savings

For the purposes of this analysis, examining both the average monthly impact by customer as well as the average impact by customer by month yields interesting information as to the impact of HERs on customer usage both on average and over time. For every wave of the HER experiment that is currently out in the field, both real and percentage impacts increase over time with the first month's impacts yielding very low impacts compared to the average. Table 4-4 presents the average percentage impact by month and the average monthly impact through the end of 2012.

Table 4-4: Average Percentage Impact on Electricity Usage by Wave

Month	Beta	Gamma			Wave One	
		Dual		Electric-only	Dual	Electric-only
		Standard	Reduced			
August-11	0.6%	–	–	–	–	–
September-11	1.1%	–	–	–	–	–
October-11	1.4%	–	–	–	–	–
November-11	1.4%	0.3%	0.3%	0.6%	–	–
December-11	1.2%	0.9%	0.8%	1.1%	–	–
January-12	1.4%	1.3%	1.0%	1.5%	–	–
February-12	1.4%	1.3%	1.0%	1.6%	0.1%	0.2%
March-12	1.6%	1.2%	1.0%	1.5%	0.2%	0.1%
April-12	1.6%	1.3%	0.9%	1.5%	0.8%	1.1%
May-12	2.0%	1.0%	1.0%	1.3%	1.3%	1.1%
June-12	1.9%	0.9%	0.6%	1.2%	1.7%	1.1%
July-12	2.1%	0.7%	0.6%	1.2%	1.6%	1.1%
August-12	1.9%	0.7%	0.7%	0.9%	1.4%	1.3%
September-12	1.9%	0.9%	0.9%	1.1%	1.3%	1.4%
October-12	1.8%	1.4%	1.2%	1.6%	1.3%	1.8%
November-12	1.7%	1.8%	1.4%	2.1%	1.3%	1.9%
December-12	1.7%	1.7%	1.3%	2.5%	1.5%	1.3%
Average*	**1.5%**	**1.1%**	**0.9%**	**1.4%**	**1.1%**	**1.1%**

Positive values indicates positive savings, negative values indicate negative savings (greater usage by treatment customers than control customers).

*The average value is based on a separate regression and does not necessarily equal the average of the monthly coefficients, although it is close to that.

The Beta wave has been out in the field since August 2011 and targets customers in the highest quartile of energy usage in selected baseline territories. Beta HER recipients have the highest average monthly percentage energy savings at 1.5% and the average percentage savings by month grow steadily through the summer of 2012 and show less variation month-on-month over time.

The Gamma wave of HERs is separated into dual-fuel "standard report frequency," dual-fuel "reduced report frequency," and electric-only customers. This stratification allows for the comparison of the frequency of HERs on energy usage as well as the effect of HERs on customers with different fuel-types delivered by PG&E.[11] The difference in savings between customers who receive standard frequency reports (every other month) as compared to those who receive reduced frequency reports

[11] Some electric-only customers have only electricity, while others have propane from a different supplier.

(every three months) is about 20% with the standard frequency customers producing an average monthly savings of 1.1% and the reduced frequency customers producing an average monthly savings of 0.9%. Gamma electric-only customers have a higher percentage savings than both dual-fuel groups with a 1.4% average monthly savings and a peak savings of 2.5% in December 2012, which is the highest peak percentage monthly savings achieved in all of the waves.

Wave One dual-fuel and electric-only customers have been receiving reports for less than a year and are both generating an average monthly electric savings of 1.1%. Electric-only customers have a higher peak savings than Wave One dual-fuel customers with 1.9% savings in November 2012 as opposed to the dual-fuel peak savings of 1.7% in June 2012.

While percentage savings provide context for understanding the scale of the impact of receiving HERs on individual customer electricity usage, the real savings (in terms of kWh) allow for a much better comparison of savings levels of individual customers across the different waves. Table 4-5 presents the average monthly savings and average savings by month in real (kWh) terms:[12]

Table 4-5: Average per Customer Impact on Electricity Usage by Wave (kWh)

Month	Beta	Gamma			Wave One	
		Dual		Electric-only	Dual	Electric-only
		Standard	Reduced			
August-11	5.5	–	–	–	–	–
September-11	10.0	–	–	–	–	–
October-11	11.3	–	–	–	–	–
November-11	12.3	1.8	1.4	3.4	–	–
December-11	11.6	5.6	4.8	7.8	–	–
January-12	13.9	7.5	6.0	10.2	–	–
February-12	12.3	6.7	5.2	9.3	0.4	1.2
March-12	12.8	5.8	4.7	8.5	0.9	0.4
April-12	13.2	6.5	4.4	7.7	4.2	6.4
May-12	16.4	5.7	5.5	6.3	7.3	7.3
June-12	17.9	6.6	4.5	6.9	11.4	9.0
July-12	19.7	5.5	4.5	7.5	11.3	10.0
August-12	18.7	6.1	5.7	6.4	11.0	12.8
September-12	16.1	6.4	6.0	6.3	8.2	10.9
October-12	15.2	7.2	6.5	7.8	7.1	10.5
November-12	14.4	8.8	6.9	9.5	7.1	9.7
December-12	16.5	10.4	8.0	15.0	9.6	8.1
Average*	**13.8**	**6.4**	**5.3**	**8.0**	**7.0**	**7.7**

Positive values indicates positive savings, negative values indicate negative savings (greater usage by treatment customers than control customers).

*The average value is based on a separate regression and does not necessarily equal the average of the monthly coefficients, although it is close to that.

[12] Because the energy usage profile of each wave varies, tables showing savings in percentage terms and in kWh terms will not show exactly the same patterns across months.

As seen in Table 4-4, Beta treatment customers save a higher percentage of their overall electric usage compared to customers in other waves, but only by a fairly slim margin, which is not statistically significant. However, the average real kWh saved by Beta customers is significantly higher than the average number for the other waves at 13.8 kWh. This result is expected, due to the relatively higher usage of Beta customers (all being in the highest quartile of energy consumption) compared to the other recipients. In other words, because Beta customers use more electricity on average than the other wave customers, they have more opportunities to reduce their usage.

In real terms, Gamma standard frequency HER recipients still save about 20% more on average than the Gamma reduced frequency HER recipients with 6.4 kWh in average monthly savings compared to 5.3 kWh. Again, both groups show lower kWh reductions than the Gamma electric-only customers who have an average monthly savings of 8 kWh. Gamma electric-only customers save markedly more kWh in the fall and winter months than in the spring and summer months with a winter peak of 15 kWh savings in December 2012 compared to 7.7 in April 2012. This result is likely due to the different usage habits of electric-only customers who are more likely to use electric heating in the winter than their dual-fuel counterparts. This difference between dual-fuel and electric-only savings exists in Wave One as well, but to a lesser degree: the average monthly savings of the Wave One dual-fuel group is 7.0 kWh and is 7.7 kWh in the electric-only group.

4.3 Gas Savings

As with the electricity savings analysis, gas savings was assessed using both the average monthly impact by customer as well as the average impact by customer by month. For every wave of the HER experiment that is currently out in the field, both real and percentage impacts increase over time with the first month's impacts yielding very low impacts compared to the average. Table 4-6 presents the average percentage impact by month and the average monthly impact through the end of 2012.

Table 4-6: Average Percentage Impact on Gas Usage by Wave

Month	Beta	Gamma		Wave One
		Dual		Dual
		Standard	Reduced	
August-11	-0.9%	–	–	–
September-11	0.0%	–	–	–
October-11	0.5%	–	–	–
November-11	0.8%	0.2%	0.0%	–
December-11	0.7%	0.4%	0.6%	–
January-12	1.2%	0.7%	0.8%	–
February-12	1.2%	0.6%	0.7%	0.2%
March-12	1.2%	0.7%	0.6%	0.2%
April-12	1.3%	0.8%	0.6%	0.3%
May-12	0.7%	1.0%	0.7%	0.3%
June-12	0.5%	0.9%	0.8%	-0.1%

Month	Beta	Gamma		Wave One
		Dual		Dual
		Standard	Reduced	
July-12	-0.1%	0.8%	0.5%	-0.3%
August-12	0.1%	0.7%	0.5%	-0.4%
September-12	0.4%	0.6%	0.6%	-0.1%
October-12	0.4%	0.7%	0.4%	0.5%
November-12	1.2%	0.8%	0.9%	1.1%
December-12	1.2%	0.4%	0.6%	0.9%
Average*	**0.9%**	**0.6%**	**0.6%**	**0.4%**

Positive values indicates positive savings, negative values indicate negative savings (greater usage by treatment customers than control customers).

*The average value is based on a separate regression and does not necessarily equal the average of the monthly coefficients, although it is close to that.

The gas savings rates of customers are much lower as a percentage usage than electric savings rates across all of the waves. Only the Beta wave shows a consistent trend of higher percentage thm savings in the winter (highest gas usage savings), and also shows higher thm savings at 0.9% overall than the other waves. Table 4-7 shows these savings in real (thm) terms.

Table 4-7: Average per Customer Impact on Gas Usage by Wave (in thms)

Month	Beta	Gamma		Wave One
		Dual		Dual
		Standard	Reduced	
August-11	-0.23	–	–	–
September-11	0.01	–	–	–
October-11	0.19	–	–	–
November-11	0.83	0.08	0.02	–
December-11	0.99	0.34	0.49	–
January-12	1.67	0.56	0.60	–
February-12	1.27	0.33	0.41	0.10
March-12	1.18	0.34	0.30	0.10
April-12	0.85	0.28	0.19	0.09
May-12	0.24	0.20	0.13	0.07
June-12	0.16	0.16	0.15	-0.01
July-12	-0.04	0.13	0.09	-0.04
August-12	0.03	0.11	0.08	-0.07

Month	Beta	Gamma		Wave One
		Dual		Dual
		Standard	Reduced	
September-12	0.11	0.10	0.10	-0.02
October-12	0.15	0.14	0.08	0.11
November-12	0.90	0.33	0.38	0.45
December-12	1.55	0.28	0.46	0.66
Average*	**0.58**	**0.24**	**0.25**	**0.13**

Positive values indicates positive savings, negative values indicate negative savings (greater usage by treatment customers than control customers).

*The average value is based on a separate regression and does not necessarily equal the average of the monthly coefficients, although it is close to that.

The Beta wave customers have significantly higher thm savings per month than each of the other waves at 0.58 average thms per month saved.

5 Attribution of Savings to HERs and Downstream Programs

PG&E offers a variety of energy efficiency programs through which a customer can receive a rebate directly from PG&E for taking an energy saving purchase, such as installing a variable speed pool pump or purchasing a highly efficient refrigerator. Through a separate savings claim process, PG&E receives credit for the savings achieved through those programs. The details of those programs are not discussed here, but the possibility that some part of the estimated HER savings could also be brought about by measures rebated and claimed elsewhere by PG&E is analyzed below.

Table 5-1 shows the kWh savings attributable to HER control and treatment customer participation in downstream rebated programs. These values were calculated by prorating the annual kWh savings attributable to each of these programs by the number of months customers in each group participated in these programs since the initial mailing date of HERs for each wave to get the total number.[13] The kWh savings number attributed to control customers was then subtracted from the treatment group's kWh savings to get the difference in savings during the treatment period. After adding up each of these values by wave, the total difference in savings due to downstream rebated measures since August 2011 is 230,317 kWh or 0.23 GWh. This fairly low value indicates that savings from the HER program are largely not due to the use of downstream rebated energy efficiency measures.

Table 5-1: Difference in kWh Savings due to Downstream Measures Adopted by HER Customers

HER Wave	Control	Treatment	Difference
Beta	751,156	861,126	109,970
Gamma Standard Dual	223,698	266,658	42,960
Gamma Reduced Dual	223,698	257,330	33,632
Gamma Electric-only	98,210	138,089	39,879
Wave One All	843,764	847,641	3,877
Total Difference in Rebated Savings (kWh)			230,317
Total Difference in Rebated Savings (GWh)			0.23

As a back-up to Table 5-1, Tables 5-2 through 5-5 show the number of customers who had received rebates through PG&E's downstream programs in the treatment and control groups of each wave in the year prior to the start of the program and after the start of the program as of August 2012, when these data were provided. Table 5-6 shows percentage take-up within each group rather than absolute because it did not have the same number of customers in each group (this also helps emphasize the very small take-up rate for each program). The total row is included only for general interest and is not meant to suggest that these programs can be added up.

[13] PG&E provided the claimed annual kWh savings for each measure for each customer. The decision to start counting savings from the first date of HER mailing for each customer in each wave was made in order to be maximally cautious about eliminating all possible double-counting.

Over the entire 58,000 customers receiving reports in the Beta wave, an estimated 314 took advantage of PG&E's second fridge removal program that may be due to the HER treatment, and this is by far the largest difference in any category across all five tables. Differences in uptake of downstream rebates between the treatment and control conditions are even smaller for the Gamma wave and for Wave One.

Table 5-2: Beta Customers Downstream Programs Summary

Rebated Activity	Rebates Pre-treatment			Rebates Post-treatment		
	Control	Treatment	Difference	Control	Treatment	Difference
A/C Improvements	16	20	4	13	10	-3
AFUE Gas Furnace	229	205	-24	171	197	26
Cool Roof	0	2	2	3	1	-2
Efficient Clothes Washer	2,550	2,659	109	2,924	2,816	-108
Efficient Dishwasher	774	754	-20	766	836	70
Efficient Fridge	0	0	0	47	53	6
Efficient Water Heater	27	29	2	34	42	8
Improve Insulation	93	96	3	100	122	22
Low Flow Shower Head	1	0	-1	0	0	0
Remove Second Freezer	27	27	0	59	87	28
Remove Second Fridge	627	537	-90	882	1,196	314
Replace Second Freezer	54	53	-1	102	111	9
Test Ducts/Seals	5	0	-5		0	0
Variable Speed Pool Pump	181	181	0	367	419	52
Whole House Retrofit	57	86	29	258	263	5
Total	**4,641**	**4,649**	**8**	**5,726**	**6,153**	**427**

Table 5-3: Gamma Customers Downstream Programs Summary

Rebated Activity	Rebates Pre-treatment			Rebates Post-treatment		
	Control	Treatment	Difference	Control	Treatment	Difference
A/C Improvements	26	19	-7	11	13	2
AFUE Gas Furnace	106	127	21	62	70	8
Air Flow Correction	0	0	0	28	16	-12
Cool Roof	2	1	-1	0	1	1
Efficient Clothes Washer	1,373	1,369	-4	942	909	-33
Efficient Dishwasher	580	607	27	276	288	12
Efficient Fridge	0	0	0	58	46	-12
Efficient Water Heater	26	29	3	22	23	1
Improve Insulation	101	73	-28	58	47	-11
Low Flow Shower Head	11	6	-5	4	5	1
Other	35	16	-19	83	49	-34
QM Service Agreement	0	0	0	42	24	-18
Remove Second Freezer	42	38	-4	24	28	4
Remove Second Fridge	404	446	42	308	340	32
Replace Second Freezer	20	20	0	10	6	-4
Test Ducts/Seals	424	442	18	0	0	0
Variable Speed Pool Pump	37	34	-3	79	70	-9
Whole House Retrofit	37	49	12	56	82	26
Total	**3,305**	**3,342**	**37**	**2,167**	**2,135**	**-32**

Table 5-4: Gamma Reduced Frequency Customers Downstream Programs Summary

Rebated Activity	Rebates Pre-treatment			Rebates Post-treatment		
	Control	Treatment	Difference	Control	Treatment	Difference
A/C Improvements	26	24	-2	11	16	5
AFUE Gas Furnace	106	123	17	62	71	9
Air Flow Correction	0	0	0	28	20	-8
Cool Roof	2	0	-2	0	3	3
Efficient Clothes Washer	1,373	1,338	-35	942	886	-56
Efficient Dishwasher	580	592	12	276	258	-18
Efficient Fridge	0	0	0	58	60	2
Efficient Water Heater	26	36	10	22	18	-4
Improve Insulation	101	97	-4	58	62	4
Low Flow Shower Head	11	5	-6	4	1	-3
Other	35	7	-28	83	56	-27
QM Service Agreement	0	0	0	42	37	-5
Remove Second Freezer	42	38	-4	24	22	-2
Remove Second Fridge	404	426	22	308	378	70
Replace Second Freezer	20	10	-10	10	2	-8
Test Ducts/Seals	424	399	-25	0	0	0
Variable Speed Pool Pump	37	51	14	79	68	-11
Whole House Retrofit	118	90	-28	160	195	35
Total	**3,305**	**3,236**	**-69**	**2,167**	**2,153**	**-14**

Table 5-5: Gamma Electric-only Customers Downstream Programs Summary

Rebated Activity	Rebates Pre-treatment			Rebates Post-treatment		
	Control	Treatment	Difference	Control	Treatment	Difference
A/C Improvements	17	9	-8	21	8	-13
AFUE Gas Furnace	0	0	0	1	0	-1
Air Flow Correction	0	0	0	10	7	-3
Cool Roof	1	1	0	0	0	0
Efficient Clothes Washer	336	370	34	190	220	30
Efficient Dishwasher	208	217	9	129	126	-3
Efficient Fridge	0	0	0	25	11	-14
Efficient Water Heater	1	2	1	1	2	1
Improve Insulation	21	29	8	8	17	9
Low Flow Shower Head	0	1	1	1	0	-1
Other	0	6	6	29	9	-20
QM Service Agreement	0	0	0	10	6	-4
Remove Second Freezer	20	24	4	20	10	-10
Remove Second Fridge	174	162	-12	134	154	20
Replace Second Freezer	8	2	-6	2	2	0
Test Ducts/Seals	316	328	12	0	0	0
Variable Speed Pool Pump	16	16	0	30	25	-5
Whole House Retrofit	37	49	12	56	82	26
TOTAL	**1,155**	**1,216**	**61**	**667**	**679**	**12**

Table 5-6: Wave One Customer Downstream Programs Summary[14]

Rebated Activity	Rebates Pre-treatment			Rebates Post-treatment		
	Control	Treatment	Difference	Control	Treatment	Difference
A/C Improvements	0.03%	0.04%	0.01%	0.01%	0.01%	0.00%
AFUE Gas Furnace	0.24%	0.24%	0.00%	0.05%	0.07%	0.02%
Air Flow Correction	0.00%	0.00%	0.00%	0.03%	0.03%	0.00%
Cool Roof	0.01%	0.00%	-0.01%	0.00%	0.00%	0.00%
Efficient Clothes Washer	3.76%	3.84%	0.08%	1.34%	1.38%	0.04%
Efficient Dishwasher	1.44%	1.40%	-0.04%	0.30%	0.25%	-0.05%
Efficient Fridge			0.00%	0.08%	0.09%	0.01%
Efficient Water Heater	0.05%	0.07%	0.02%	0.02%	0.02%	0.00%
Improve Insulation	0.18%	0.16%	-0.02%	0.06%	0.07%	0.01%
Low Flow Shower Head	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%
Other	0.04%	0.02%	-0.02%	0.07%	0.09%	0.02%
QM Service Agreement			0.00%	0.05%	0.06%	0.01%
Remove Second Freezer	0.08%	0.06%	-0.02%	0.03%	0.04%	0.01%
Remove Second Fridge	0.96%	1.09%	0.13%	0.46%	0.45%	-0.01%
Replace Second Freezer	0.05%	0.04%	-0.01%	0.02%	0.03%	0.01%
Test Ducts/Seals	0.42%	0.42%	0.00%	0	0	0.00%
Variable Speed Pool Pump	0.12%	0.10%	-0.02%	0.08%	0.09%	0.01%
Whole House Retrofit	0.21%	0.21%	0.00%	0.23%	0.20%	-0.03%
Total	**7.58%**	**7.71%**	**0.10%**	**2.84%**	**2.87%**	**0.05%**

[14] Because the Wave One treatment and control groups are different sizes, the proportion of rebated measures is compared rather than the number of rebated measures.

6 Attribution of Savings Between HERs and Upstream Programs

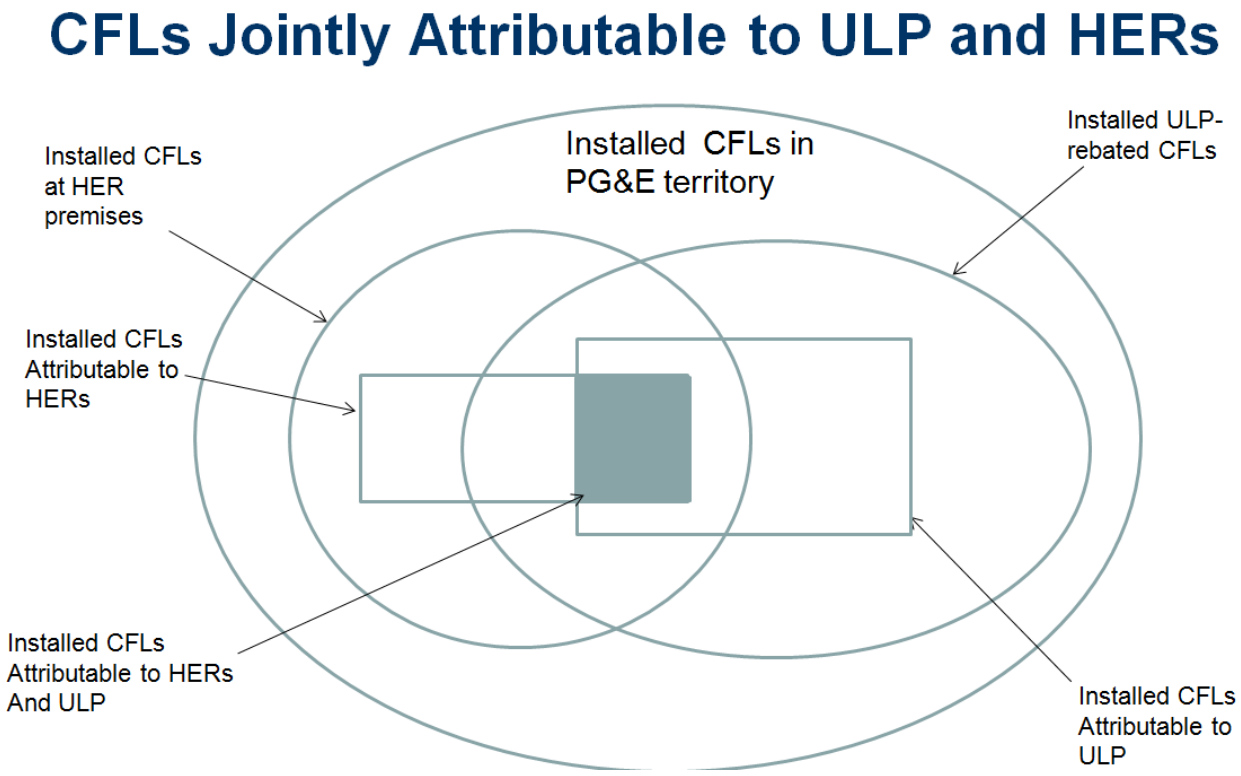
Similarly to the issue in Section 5, PG&E has two other programs that provide monetary incentives for residential customers to invest in energy efficient CFLs and TVs, but these incentives are provided to manufacturers or retailers to change stocking practices. Therefore, PG&E has no way of tracking which customers purchase CFLs that have reduced prices (due to the ULP) or which customers have purchased energy efficient TVs (due to the BCE program). However, it is still true that some energy savings observed in the treatment group may be due to the ULP and the BCE programs. To avoid double counting of those savings, the amount of energy savings that HER recipients have realized that may also be claimed by the ULP and TV programs is calculated below.

First, the method for ensuring that PG&E's savings claim from HERs does not include savings being claimed through the ULP is presented. The method relies on estimated values reported in two evaluation documents pertaining to the 2006-2008 program cycle.[15] Ultimately, the method here should be updated based on the new values of these parameters, presumably to be calculated in similar evaluation documents for the 2009-2012 cycle. Those documents are not currently available.

Figure 6-1 is meant to help describe which CFLs are included in this analysis. Only CFLs that are installed jointly due to HERs and the ULP could lead to potentially double-counted savings.

[15] "Final Evaluation Report: Upstream Lighting Program" and "Compact Fluorescent Lamps Market Effects Final Report," both prepared primarily by KEMA and Cadmus, with additional support from several other consultants. Both released in the first half of 2010.

Figure 6-1: Venn Diagram Illustrating Which CFLs Lead to Potentially Double-counted Savings



The Home Inventory documented in Section 7 has produced an estimated difference in the number of installed CFLs between HER treatment and control customers. This difference between treatment and control customers is assumed to lead to energy savings and is at least partially attributable to HERs. Some of the difference in CFL use is also likely attributable to the ULP and will be claimed as such. In this analysis, there is no differentiation between CFL savings being attributable to the ULP and CFL savings being claimed by the ULP. The ULP evaluation methods are taken as valid, pre-determined and yielding an estimate of attributable savings equivalent to the ULP claimed savings. The objective is to calculate how much of the estimated HER energy savings will be claimed through the ULP to avoid double counting.

The method used consists of three major steps:

- Determining the aggregate expected number of installed CFLs in HER-recipient homes as compared to the expected number in absence of HERs (referred to as excess CFLs) and the expected duration that those excess CFLs had been installed in years. This is the number of CFL-years at least partially attributable to HERs;
- Determining what fraction of the excess CFLs are also partially attributable to the ULP; and
- Determining the expected total energy savings per year from the typical installed excess CFL, as compared to the baseline of an installed incandescent.

The latter two values will be derived completely from values reported in the two ULP evaluation documents, in order to make these calculations consistent with the ULP savings claim. These three values will be multiplied together to produce an estimate of the total energy savings that would be

double-counted if those savings were claimed by both programs. This process is illustrated in the equation below and our calculation of this equation is shown in the paragraphs below:

$$kWh\ attributable\ to\ both\ programs$$
$$= (CFLs\ installed\ due\ to\ HERs) \times (years\ CFLs\ have\ been\ installed) \times \left(\frac{rebated\ CFLs}{total\ CFLs}\right)$$
$$\times \left(\frac{CFLs\ attributable\ to\ ULP}{rebated\ CFLs}\right) \times (CFL\ savings\ per\ year)$$

The first value will be determined partially through the Home Inventory and partially through assumptions about CFL installation timing. The Home Inventory will provide an estimate of excess CFLs per HER recipient. It is necessary make an assumption about the rate at which these excess CFLs were installed since the beginning of each wave of the HER program to round out the calculation. To be conservative, it is assumed that the excess CFLs were installed immediately at the beginning of each wave. This is a conservative assumption in the sense that it produces the highest possible value for potentially double-counted savings. This leads to the assumption that in the Beta wave, the average excess CFL had been installed for a total of 17 months (from the inception of the wave through the end of the cycle); for Gamma, the average excess CFL has been installed for 14 months; and for Wave One the average excess CFL has been installed for 9 months. These values must be multiplied by the average number of electric-service treatment group customers in each wave over this period, which is 55,000 for Beta, 172,000 for Gamma and 377,000 for Wave One (in each case accounting for attrition based on the values in Table 2-3 and rounding to the nearest thousand). This yields a total of 7.49 million customer-months of excess CFL installation or 624,000 customer-years.

In the Home Inventory,[16] FSC found an average of 12.99 installed CFLs in each control group household and an average of 13.94 installed CFLs in each treatment group household. The p-value of this difference was 0.33, which indicates the difference is not statistically significant. Despite that, FSC has used the point estimate of the difference – 0.95 – to calculate the potentially double-counted savings. There is an estimated 0.95 excess installed CFLs per HER recipient, giving a final value for the first bulleted step of 0.95 x 624,000=593,000 excess CFL-years at least partially attributable to HERs.[17]

The second bulleted value can be determined based on two values in the ULP evaluation reports. First, it is important to know what fraction of CFLs received rebates through the ULP. The value 0.74 is used, which is equal to the total rebated CFLs for 2006-2008 for California from Table 23 of the Market Effects evaluation divided by the total CFLs sold in California for 2006-2008 from Table 22 of the same report. The data is not reported at the IOU level. This fraction should be updated if and when new sales data are available. Second, the fraction of rebated CFLs attributable to the ULP needs to be identified. This is the net-to-gross ration (NTGR). The Final Evaluation Report of the ULP estimates and uses a NTGR of 0.49 for PG&E. This value also should be updated when a new NTGR is

[16] Documented in section 7.

[17] In the ULP evaluation, installations that occur in a given year are assumed to provide savings for the entire year, which is a standard assumption in energy efficiency calculations. This is not a rationale for using the same assumption here because the HER program is not claiming savings for any time prior to the onset of each wave. Therefore, the savings being claimed by the ULP for the time period prior to actual installation are not potentially double-counted. They are not counted here; they are an inaccuracy in the ULP method due to a simplifying assumption, which should not lead to a deduction from the HER savings claim.

available. This means that of all excess CFLs in this study, 0.74*0.49=0.33 of them are assumed to be attributable to the ULP.

Finally, the third bulleted value can be calculated based on values reported in the Final Evaluation Report of the ULP. In that report it is estimated that the typical ULP CFL in PG&E's territory is in use for 1.9 hours per day and that it uses 44.3 fewer watts than the bulb that would be there otherwise. Therefore, the third bulleted value is 1.9*365*44.3/1000=30.7 kWh per year per excess CFL.

Multiplying these values together gives us 593,000 x 0.74 x 0.49 x 30.7 = 6.6 GWh of potentially double-counted savings. This value has been deducted from the regression-based HER savings calculation documented in section 4.

Our process for adjusting TV sets is in concept the same; however, there is no evidence of an increase in the take-up of rebated TVs in treatment households as compared to control households. Again, from the Home Inventory results, 7% of households receiving HERs purchased rebated TVs, as compared to 8% in the control population.[18] This difference is not close to statistically significant and in any case it suggests a slight decrease in rebated TV purchases in treatment households due to HERs, which indicates no potential double-counting of upstream-rebated TV energy savings. Additionally, the average usage per year of rebated TVs in the treatment group was 121 kWh, as compared to 113 kWh in the control group, again indicating no possible double-counting of savings due to treatment customers using more efficient rebated TVs.

[18] In addition to counting TVs, which was done in the Home Inventory, determining which TVs were subject to rebates under the BCE required several extra steps which are discussed in Appendix C.

7 Home Inventory

In this section the field study used to develop estimates of the difference between treatment and control households in take up of downstream measures is discussed. This study was a door-to-door Home Inventory in which surveyors: counted installed CFLs, took down makes, models and serial numbers of TVs installed in 2011 or 2012, and asked a series of questions intended to help understand what actions HER recipients took to save energy. The field sample was drawn equally from the treatment and control groups of HER dual-fuel recipients. First is the discussion of the field work design, followed by the inventory and interview protocol, and finally the results of the study.

7.1 Home Inventory Design

The primary goal of the Home Inventory was to determine the additional uptake of upstream measures in HER recipients' homes as compared to control group homes. This was to aid in the analysis in Section 6. However, previous efforts to find differences between treatment and control households in other HER evaluations have failed to find much. Additionally, in order to avoid selection bias, as high a completion rate as possible was necessary among sampled households. The mode most likely to achieve a high completion rate is door-to-door. That method is expensive, and the budget available would support approximately 400 treatment and 400 control inventories. The reason for the concern with upstream measures was to avoid double-counting of savings. Early results indicated that on a percentage of usage basis, customers provided approximately equal savings throughout the distribution of average usage. This implies that expected savings per household are proportional to household usage; this in turn led us to sample households in proportion to their average usage so that high users would be proportionally more likely to be sampled than low users.

Sampling was done amongst the aggregated treatment and control groups of the Beta, Gamma and Wave One populations in order to produce results that could apply to all three populations.[19] Two-stage cluster sampling was done in order to produce a random sample of households that could be visited relatively efficiently. In two-stage cluster sampling, the first 26 zip codes were randomly chosen from among the zip codes in which HER recipients and control group members lived. Zip codes were sampled with replacements, so some were selected multiple times. Then 30 treatment and 30 control households were selected within each zip code, with zip codes selected multiple times having more than one group of 30 treatment and 30 control customers selected. At the zip code selection stage, zip codes were sampled in proportion to the recipient and control households' aggregate energy usage; and within zip codes, households were sampled in proportion to their average energy usage. So a zip code with twice the total usage among resident HER households as another would have been twice as likely to be sampled; similarly, a household with twice the energy usage as another would have been twice as likely to be sampled. This provided a pool of 780 treatment households and 780 control households, of which a random 1/3 were designated as replacements only to be used if primary sample points were invalid. This provided 520 treatment and 520 control households as primary targets for surveyors.

[19] Because the Wave One treatment group was four times bigger than the control group, Wave One control group customers were over-sampled by a factor of four. This made the overall treatment sample comparable to the overall control sample.

Figure 7-1 shows the geographic distribution of Beta, Gamma and Wave One households and of the sampled clusters. The map differentiates between pre-test customers and other sampled customers. The pre-test was a fully operational first phase of the inventory in the Bay Area to ensure that the survey protocol worked smoothly. Its results are fully integrated into the broader results.

Figure 7-1: Map of Program Population and Sampled Customers

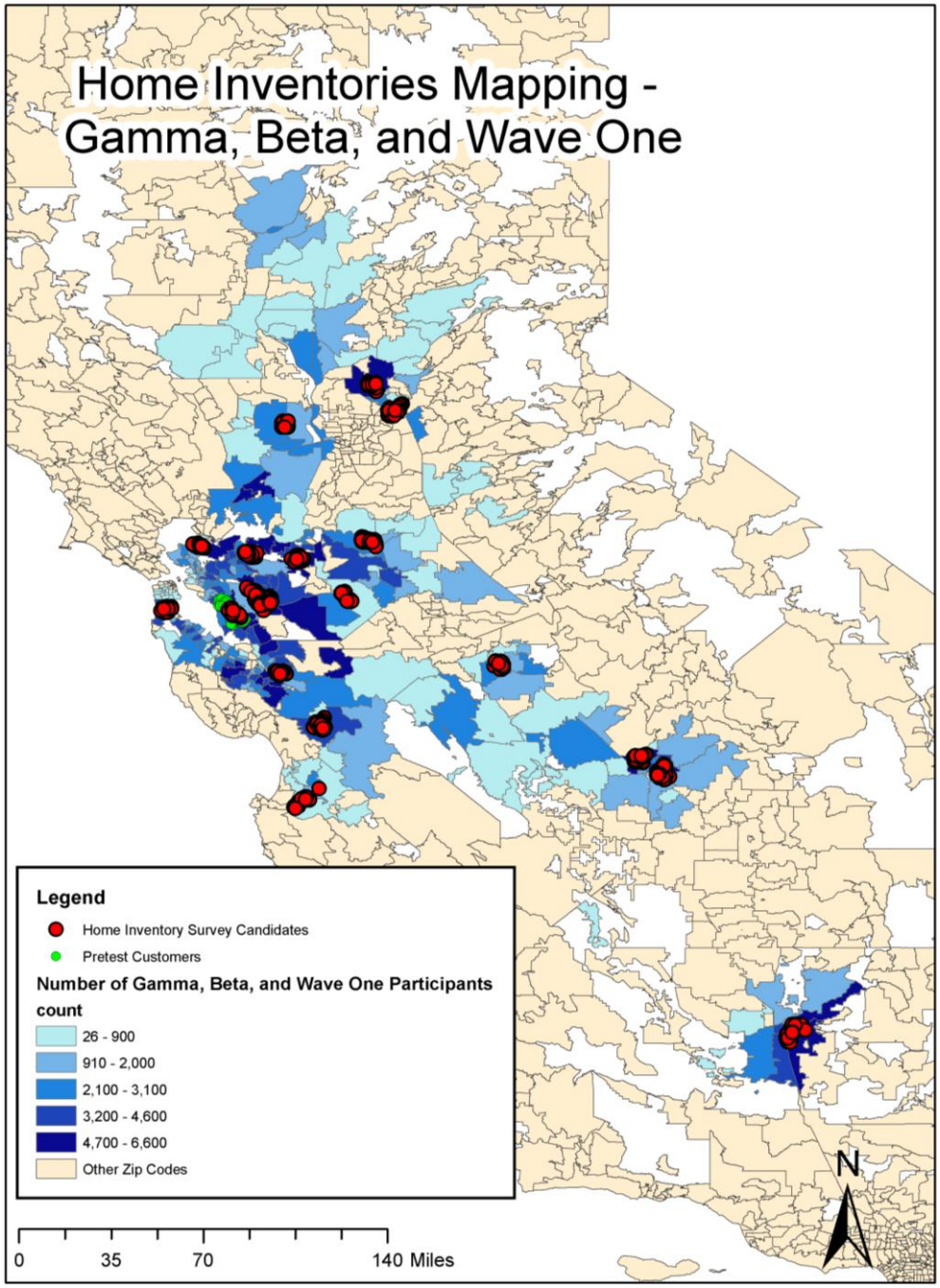


Table 7-1 shows the completion results for the Home Inventory. It shows tabulations of incomplete inventories for valid and invalid records. The distinction between valid and invalid was primarily for

internal purposes. Premises were considered invalid if there was no English speaker (HERs are available in English only), if the premise was vacant, if there was no bill payer who lived there or if the premise was inaccessible (such as in a gated community). In all but the last case, it is likely that the premise would show no response to HERs. The table shows calculations of the response rate in the case of including or excluding invalid records from the denominator. In either case, the rate is near 60%.

Table 7-1: Completion Results for the Home Inventory

Record Type	Final Disposition	Total Households
Incomplete Invalid Records	Language Barrier	32
	Vacant	12
	No Bill Payer	3
	Inaccessible	30
	Total	77
Incomplete Valid Records	Come Back	13
	Door Hanger	84
	No Answer	66
	Refused	252
	Total	415
Completed Records		702
Total Valid Records		1,117
Total Attempted		1,194
Raw Response Rate		59%
Valid Response Rate		63%

Table 7-2 shows a comparison of characteristics between sampled customers and the combined Beta, Gamma and Wave One populations with those populations weighted by average annual energy usage. The sampled group is quite similar to the broader population. The table also shows the same set of characteristics for customers who completed the inventory. Due to the high response rate, and an apparent lack of strong selection bias, the customers who completed the inventory have observable characteristics highly comparable to the sampled customers, and in turn highly comparable to the population they are meant to represent.

Table 7-2: Comparison of Home Inventory Sample to HER Population

Category		Unit	Beta, Gamma and Wave One Populations	Home Inventory (Sampled)	Home Inventory (Completed)
Baseline Territory	P	(% of group)	0.5%	0.0%	0.0%
	R	(% of group)	13.2%	15.8%	15.6%
	S	(% of group)	23.6%	23.8%	23.0%
	T	(% of group)	8.1%	8.1%	8.1%
	V	(% of group)	0.0%	0.0%	0.0%
	W	(% of group)	6.0%	4.1%	4.1%
	X	(% of group)	49.0%	48.2%	49.3%
	Y	(% of group)	0.0%	0.0%	0.0%
CARE		(% of group)	27.8%	26.2%	28.5%
Household Income	<$30k	(% of group)	12.3%	6.9%	6.5%
	$30k-$50k	(% of group)	12.5%	10.9%	10.5%
	$50k-$80k	(% of group)	27.2%	31.3%	28.5%
	>$80k	(% of group)	48.1%	50.9%	45.1%
Rent		(% of group)	4.7%	2.3%	2.7%
Have Pool		(% of group)	15.6%	18.5%	17.3%
Residents		(number of residents)	2.9	3.1	3.1
Living Space		(square feet)	1,807	1,949	1,908
Year Home Built		(year)	1971	1979	1977
Head of Household Age		(years)	53	52	52
Average Pre-Treatment Monthly Usage	10-Jan	(monthly kWh)	975	928	926
	10-Feb	(monthly kWh)	818	772	770
	10-Mar	(monthly kWh)	863	817	805
	10-Apr	(monthly kWh)	813	777	759
	10-May	(monthly kWh)	871	830	820
	10-Jun	(monthly kWh)	1,005	977	935
	10-Jul	(monthly kWh)	1,155	1132	1062
	10-Aug	(monthly kWh)	1,110	1085	1048
	10-Sep	(monthly kWh)	1,006	980	950
	10-Oct	(monthly kWh)	936	894	865
	10-Nov	(monthly kWh)	920	877	864
	10-Dec	(monthly kWh)	1,027	984	975
	11-Jan	(monthly kWh)	978	943	927

7.2 HEUS Field Protocol

Customers who were selected for participation in the study first received an announcement letter by U.S. Mail with California Public Utilities Commission (CPUC) and PG&E insignia and signatories. The letter described the general purpose of the study and that participating in the study would entail both an interview and an inventory of household appliances. Recipients were informed that a Population Research Systems (PRS) employee would be visiting their home within a week to conduct the interview and inventory. The announcement letter also invited the customer to contact PRS by telephone (toll-free) to schedule an appointment for the interview and inventory at a time convenient for them. The letter further indicated that the interviewer's visit would last about 15-25 minutes, and that, in return for participating, the customer would receive $50 incentive payment.

Aside from the initial announcement letter, solicitation and data collection for the HEUS relied exclusively on the use of in-person introductions, interviews and inventories on site at the respondent's home. Limited exceptions for an attempt at initial contact by telephone were made for customers residing in gated communities. Otherwise, customers in gated communities were excluded as inaccessible.

The PRS employees visiting homes to conduct the interviews and inventories submitted to personal background checks prior to their employment with PRS. All but two interviewers visited the PRS offices for several hours of project orientation, training and hands-on inventory practice at the homes of PRS/FSC employees and colleagues. The two interviewers who did not travel to San Francisco for training were trained in-field by lead PRS field personnel.

Interviewers were trained on all aspects of the interview and inventory questions and protocol so as to be able to answer follow-up or clarifying questions and to be able to follow the survey and inventory protocol correctly at every household visited. Most critically, they were trained to bear in mind their personal safety and courtesy to the customer above all other considerations. Interviewers were instructed to be vigilant and aware of their surroundings at all times while on the job and not to enter into any situations where they felt unsafe. Similarly, while part of the interviewer's task was to earn the customer's trust and willingness to participate in the study, they were also explicitly expected to graciously defer to the customer's wishes regarding participating in the study and to behave with courtesy and respect while inside the respondent's home. Towards that end, the interviewers were also supplied with shoe covers in the case that customers requested they be worn in the home.

Uniformed PRS interviewers carried PG&E-issued picture identification badges. When approaching a participant's home, the interviewers also carried laminated copies of the announcement letter to aid the customer's memory in case they did not recall receiving the letter. In the case that customers could not recall receiving the letter and requested a new one, PRS office employees mailed a second, duplicate, announcement letter.

Prior to beginning the interview, the PRS interviewer began with a few screening questions, designed to confirm that the correct home was being visited, that the participant was at least 18 years of age and that the participant was responsible or shared responsibility for paying the monthly PG&E bill. If, in the course of administering the screening questions, it was established that the person in the household was not able to participate in the interview due to illness or infirmity, or due to a language barrier, another member of the household was sought to assist as a helper to facilitate or translate.

If the member of the household responsible for paying the bill was not present, a PRS business card with the PRS toll-free telephone number was left behind. In the case that the interviewer visited the home and found nobody at home, a door-hanger with the PRS toll-free telephone number was left behind. A maximum of 10 visits and re-visits were made before closing out a household as a non-responder. Interviewers were trained, when encountering a home with no one present to answer the door, to make re-attempts at different times of day and days of week, to maximize the chances of finding the customer at home.

In practice, the home visits generally lasted 30 minutes. Upon completion of the interview and inventory, the interviewer gave the customer a $50 Visa gift card. Upon receipt of the card, the customer signed a remittance sheet, and was asked to call the PRS telephone number to register the card. During the call, the customer was asked a few short evaluation questions about the interviewer that visited their home. Those customers that did not call in to register the card were later contacted by PRS for registration and interviewer evaluation.

7.3 Oral Interview Results

In addition to the home inventory, interviewees were asked several questions regarding their demographics, home characteristics and energy usage habits. These survey results will be outlined in a future report, and are not included here.

7.4 Results Relevant to the Savings Claim

There were two results from the home inventory that are relevant when discussing a potential savings claim: installed CFL counts and the number of recently purchased rebated TVs. The method for determining whether a recently purchased TV was eligible for an upstream rebate is outlined in Appendix C. Tables 7-3 and 7-4 outline these results. As mentioned in more detail in Section 6, the average difference of 0.95 CFLs between treatment and control households is used to calculate a 6.6 GWh difference in household usage during the HER treatment period.

Table 7-3: Weighted Home Inventory CFL Counts

CFLS Counted during Home Inventory	Control	Treatment	Difference in CFL Count	Standard Error of the Difference	95% Confidence Interval	
					Lower Bound	Upper Bound
CFLs Not in Storage	12.99	13.94	0.95	0.98	-0.96	2.87
CFLS in Storage	2.95	3.55	0.60	0.43	-0.25	1.44

Table 7-4 shows the percentage of households in the home inventory population that purchased a rebated TV during the HER treatment period. The proportion of households in the treatment and control groups with rebated TVs is nearly identical, so there was no reduction the HER savings claim for rebated TVs.

Table 7-4: Proportion of Rebated TVs in Home Inventory Population

TV Rebate Status	Control	Treatment
No Rebated TV	92%	93%
Rebated TV	8%	7%

8 Final Estimates and Next Steps

The final gas savings claim comes directly from Table 4-1 and is equal to 1,469 Therms. The final electricity savings claim is equal to 56.7 – 0.2 – 6.6 =49.9 GWh. The value 56.7 GWh is shown in Table 4-1 and is explained in that section. The values 0.2 GWh and 6.6 GWh are due to the reduction due to double counting and are discussed in sections 5 and 6, respectively.

Although the primary aim of the program and this evaluation is to produce and verify electricity and gas savings, another important goal is to better understand customer behavior and preferences through the program. To this end, FSC will perform follow-up analysis on the Gamma wave and on the data collected during the Home Inventory. The design of the Gamma wave allows for several comparisons of load impacts across customer segments that may be informative for future targeting. Similarly, the Home Inventory gathered substantial data on customer choices and preferences that may help better to understand the effects of the HER program. This work is forthcoming.

Appendix A A Calculation of Simulated Standard Errors

As discussed in Section 3, 24 months of monthly billing data were obtained for a randomly-drawn sample of 10,000 PG&E residential customers, which were then randomly divided into two groups of 5,000 customers. One group was assigned to be the simulated treatment group (recognizing that it received no treatment) and specified a treatment variable in effect for that group for the second 12 months of the sample. The equation (1) was then estimated on the full group of customers, with standard errors calculated allowing for arbitrary correlation of errors within individual customer data. This procedure provided standard error estimates for a situation almost identical to the actual analysis to be done for estimation. The standard error of interest was that of the parameter τ in equation (1).

Standard error estimates for this sample size can be scaled to estimate expected standard errors for other sample sizes. To do this it should be noted that parameter τ is an estimate of the difference in means between regression-adjusted average usage values in the treatment and control groups. The standard error of a difference in means for two independent samples is equal to

$$\sqrt{\frac{sd_1^2}{n_1}+\frac{sd_2^2}{n_2}} \qquad \text{(A-1)}$$

Where n_1 and n_2 are the sample sizes of each sample and sd_1 and sd_2 are the standard deviations of the values in each sample. In this case, the values sd_1 and sd_2 are not directly measured since they refer to standard deviations of regression-adjusted usage values. These values are solved for by noting first that by construction of the samples, $sd_1=sd_2$ (since the samples are randomly drawn from the same group of customers) and $n_1=n_2$ =5,000 customers.[20] Then the standard error on τ in the initial simulation is

$$se_\tau = \sqrt{\frac{sd_1^2}{n_1}+\frac{sd_2^2}{n_2}} = \sqrt{\frac{2\cdot sd_1^2}{5{,}000}}$$

Which, solving for sd_1 gives

$$sd_1 = \sqrt{\frac{5{,}000 se_\tau^2}{2}}$$

This value can be substituted into expression (A-1) to provide estimates of the standard error of the treatment effect for any other sample sizes of interest (measured in terms of the number of customers with 24 months of data and assuming that all included customers have a full 24 months). The expected standard error of the treatment effect for any other group sizes would be:

$$se_\tau \sqrt{\frac{5{,}000}{2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$$

where se_τ is the standard error estimate when each group size is 5,000 and n_1 and n_2 are the treatment and control group sizes of interest.

[20] In this analysis, clusters of customer data 24 months long are treated as units of data and scale based only on the customer count, assuming that each customer will always have 24 months of data. This is one way that the simulation for sample size calculation differed from the actual analysis. In the actual analysis attrition causes some customers to have less than 24 months of data.

As noted, this calculation does not account for population attrition. It also assumes that the variance in model error from equation (1) will be the same in the future as it was in the historical data used for the calculation. It also assumes that the random sample of customers used in the calculation is representative of the HER recipient and control populations.

Appendix B Gamma and Wave One Electricity Usage Over Time

This appendix contains figures analogous to Figure 3-1. Each figure shows the close comparability of treatment and control usage prior to the onset of the HER program and then the deviation between the groups after the program onset.

Figure B-1: Gamma Dual Standard Frequency Average Usage by Month

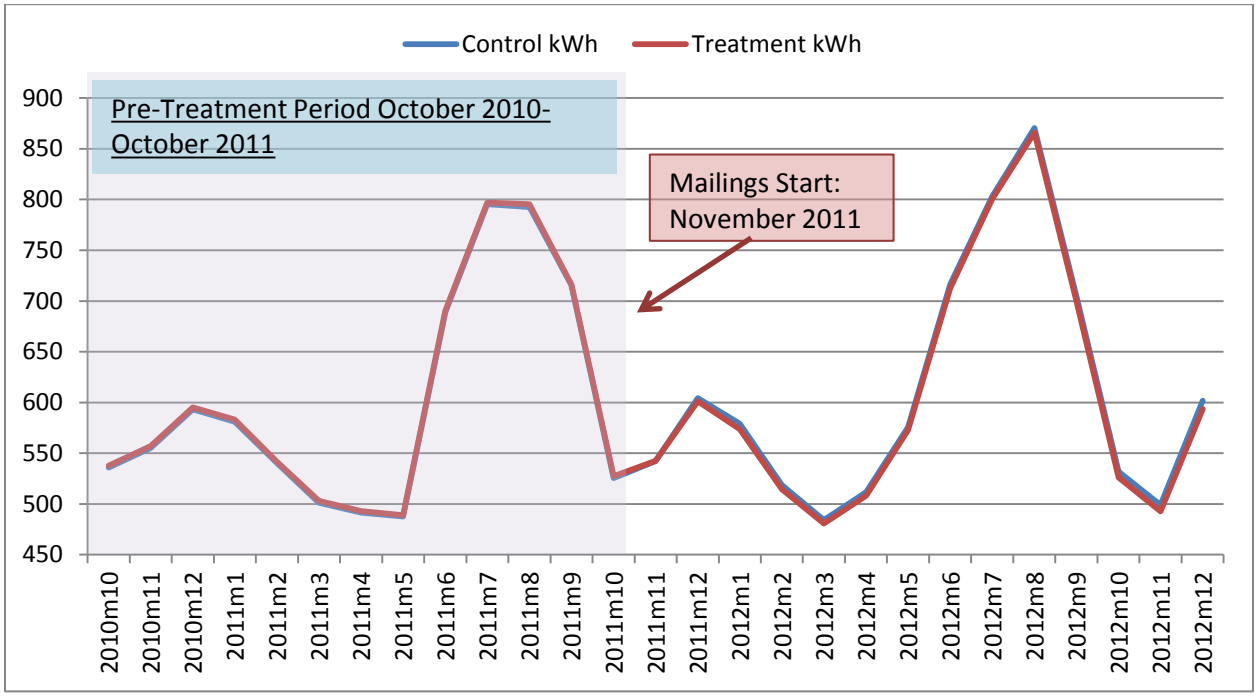


Figure B-2: Gamma Dual Reduced Frequency Average Usage by Month

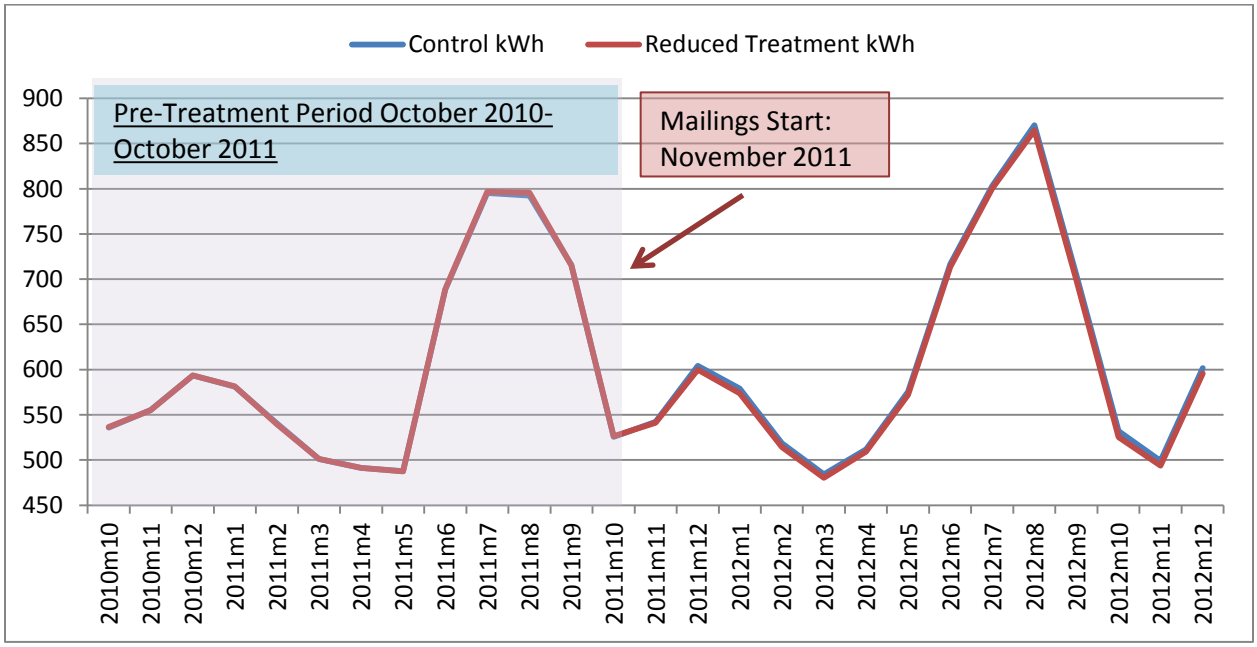


Figure B-3: Gamma Electric-only Average Usage by Month

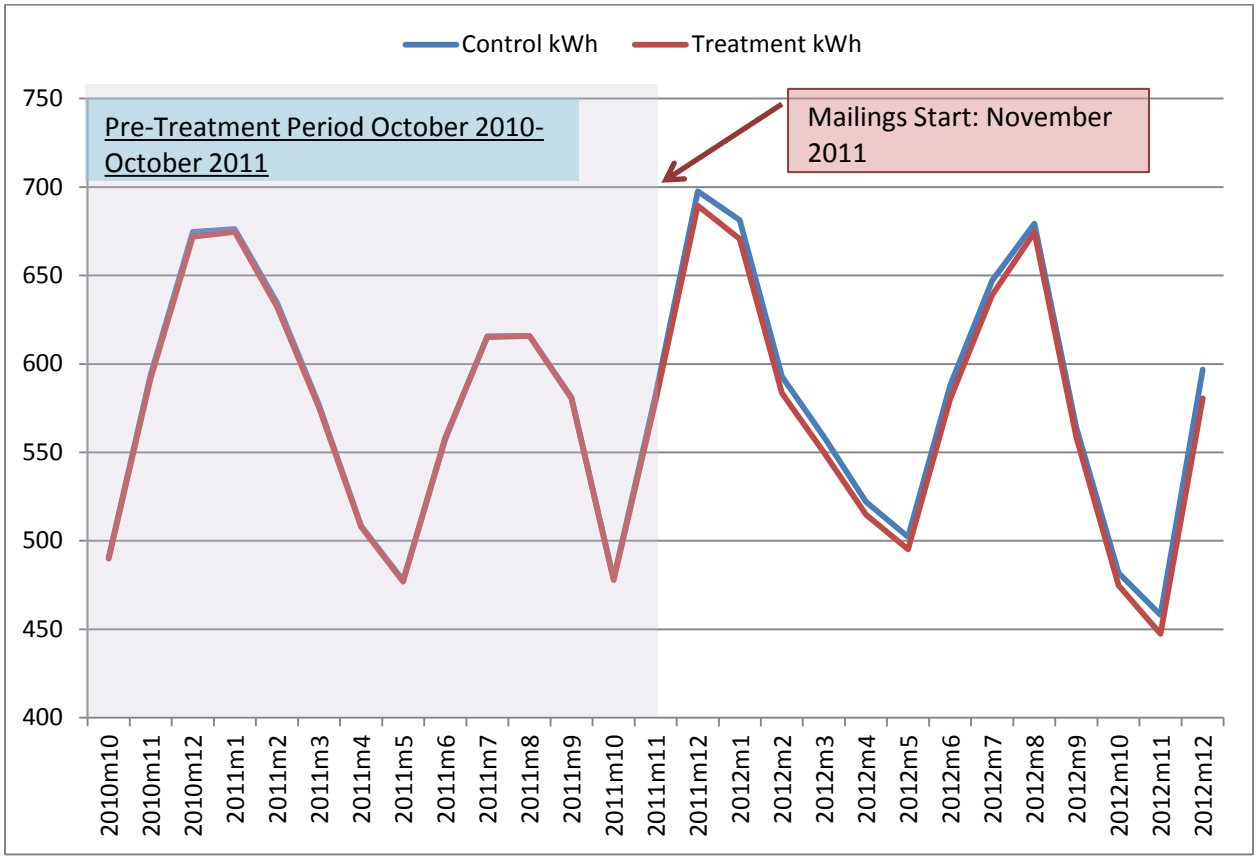


Figure B-4: Wave One Dual Average Usage by Month

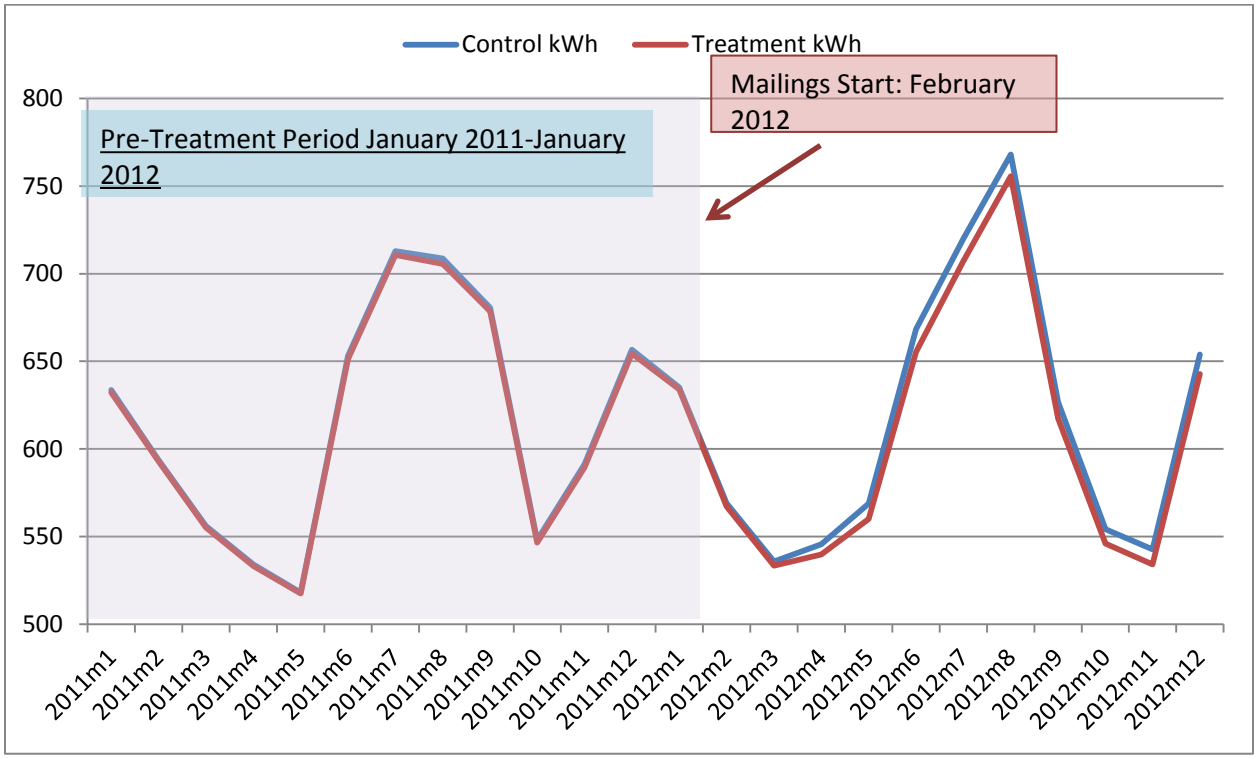
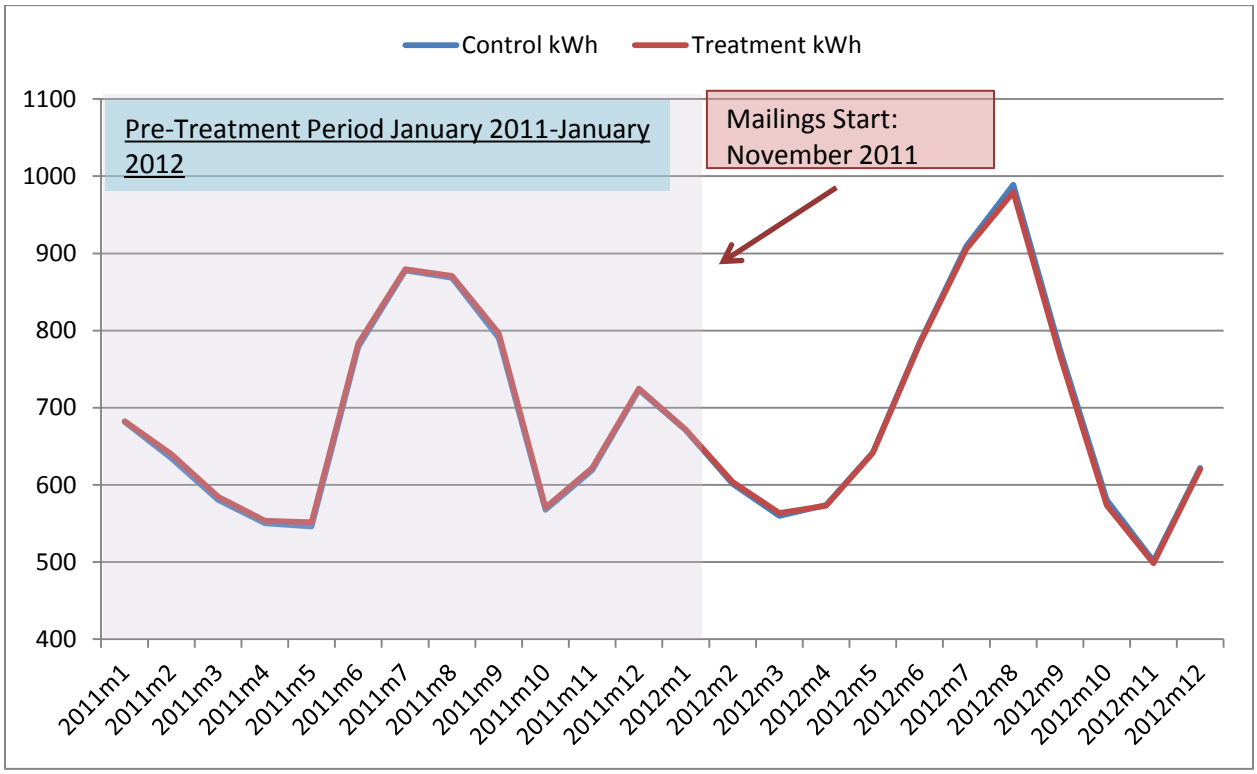


Figure B-5: Wave One Electric-only Average Usage by Month



Appendix C Methodology for Measuring Television Savings

This appendix outlines a methodology for measuring energy savings from the purchase of BCE program-qualified televisions by participants in the Home Energy Report (HER) program. The intention is to determine if there is a measureable difference in the average energy consumption of newly purchased televisions among the treatment and control groups in the trial. If the average energy consumption of newly purchased televisions in the treatment group is measurably less than in the control group due to increased purchases of BCE program-qualified televisions, the HER trial savings will have to be decreased by this amount to avoid double counting the savings in both the HER trial and BCE program.

C.1 Available Data

The calculation of television energy savings for the HER trial relies on the following data:

1. Onsite data, collected during the Home Inventory, of televisions that respondents indicated had been purchased over the last year, including:
    a. Make
    b. Model
    c. Screen size
2. Additional information on each television model from the Energy Solutions database, including:
    a. On mode power and standby power data from the Energy Star qualified products lists (QPL) or Energy Guide data for television models that can be matched to the lists
    b. Assumed On mode power and standby power based on the proxy model developed by Energy Solutions based on screen size and display type for units not matched to the Energy Star QPL lists or the Energy Guide data
    c. Highest BCE Program qualifying level in April-March 2011 and April-March 2012
    d. Screen size and area
    e. Display type (e.g., LCD-CCFL, LCD-LED, Plasma, oLED)
    f. Date added to the Energy Star list

C.2 Research Approach

The first step in this analysis is to determine if there are any measurable differences between the television purchasing habits between the treatment and control groups. If there are differences among the two groups that indicate that treatment group may have purchased more higher efficiency televisions than the control group, the second step will be to attempt to measure the energy savings among the treatment group that is attributable to the BCE program and subtract that savings from the HER trial savings to avoid double counting of these energy savings between the two programs.

The BCE program is a midstream program targeted at increasing the stocking and sales of high efficiency televisions at retailers. While the program includes promotional materials to identify more energy-efficient televisions, and retail salesperson training, the program was designed primarily as a midstream program because independent research has shown that consumers rank energy efficiency as a very low priority when purchasing televisions.

C.3 Research Questions

There are two primary questions addressed through this analysis:

- Is there a difference in the rate of BCE Program-qualified purchases between the treatment and control groups?
- Is there a difference in the average energy consumption of BCE Program-qualified televisions purchased by the treatment and control groups?

The answers to both questions were negative.

C.4 Analysis Methodology

This section describes the analysis methodology, including data matching, the analysis of purchase characteristics and the analysis of energy savings attributable to the BCE Program.

C.4.1 Data Matching

Energy Solutions performed the model matching between the data on television purchases among trial participants and their data base of UEC data and model characteristics. The data was put into four main categories:

- Exact matches, where the make and model match the Energy Star or Energy Guide lists perfectly.
- Approximate matches, where a model is found on one of the available lists that is an approximate match to the recorded model and then deemed to be an appropriate match in terms of energy consumption and model characteristics to the recorded model.
- No matches, where no model is found that is an exact or approximate match deemed appropriate for the analysis.
- Not available, where data on make and model is missing or incomplete.

C.4.2 Analysis of Purchase Characteristics

As noted above, the first step will be determining if there are any measurable differences between the television purchasing habits between the treatment and control groups. To accomplish this, the research team should calculate the following values:

1. Percentage of participants in the treatment and control groups that indicated they purchased a new television in the last 12 months.
2. Frequencies of the characteristics of televisions purchased by both treatment and control groups, including:
    a. Display type (LCD-CCFL, LCD-LED, Plasma, oLED, other) among exact and approximately matched models (display type was not asked in onsite surveys).
    b. Screen size in inches for all televisions with available screen size information using matched data on screen size when available and survey data for non-matched models. For screen size, the mean and median values should also be included for treatment and control.
    c. Rate of Energy Star purchases. For this analysis, only data with available make and model numbers from the onsite surveys should be used. All models where make and model number are missing or unavailable should not be included the analysis. Any products with an exact or approximate match to the Energy Star version 5 list should be considered Energy Star-qualified. Any products with model information that does not match the Energy Star QPL list should be considered non-qualified.
    d. Rate of BCE Program qualification. For this analysis, the team determined if each model was likely BCE program-qualified at the time of purchase based on whether the

unit was purchased at a participant store chain, the highest qualifying level from 2011 and 2012, and the date the product was posted on the Energy Star QPL list. If the product was posted prior to the fall of 2011, it was assumed available and purchased in the 2011 program year (PY) (i.e., prior to April 2012) and base qualification determination on PY 2011 criteria. Anything posted after Fall 2011 was considered a potential PY2012 unit and assessed based on that program year's criteria.

3. Calculate the average energy consumption of televisions purchased by the treatment and control groups. These values were very similar across treatment and control groups, with the overall average usage higher for treatment group.

Appendix D Map of PG&E Baseline Territories