SAFER, SMARTER, GREENER

Impact Evaluation Report

Home Energy Reports – Residential Program Year 2017

CALIFORNIA PUBLIC UTILITIES COMMISSION
CALMAC ID: CPU0194.01

May 1, 2019

Information	Details
Residential Sector Lead	Gomathi Sadhasivan
Project Manager	Lullit Getachew
Telephone Number	(510) 891-0446
Mailing Address	155 Grand Avenue, Suite 500, Oakland, CA 94612
Email Address	gomathi.sadhasivan@dnvgl.com, lullit.getachew@dnvgl.com
Report Location	http://calmac.org/ (CALMAC ID: CPU0194.01)

Table of contents

List of figures

List of tables

1 EXECUTIVE SUMMARY

This report provides the results of the California Public Utilities Commission's (CPUC) evaluation of Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric's (SDG&E) Home Energy Reports (HER) programs for 2017. The evaluation conducted by DNV GL includes calculated energy and demand savings estimates that can be used to support SCE, SDG&E, and PG&E's savings claims for behavioral programs in 2017.

1.1 Background

The residential sector accounts for 17% of the state's energy usage, with over 14 million single- and multi-family homes that house more than 39 million Californians. The primary purpose of energy efficiency behavioral programs is to reduce energy consumption by motivating no-cost and low-cost energy conservation actions and self-installation of energy saving measures. The HER programs aim to overcome market barriers and leverage social norms to nudge customer behavior. PG&E and SDG&E began sending home energy reports in 2011 and SCE began in 2012.

The reports sent to customers contain a mix of energy usage information, comparison of that usage with similar neighbors, and customized tips for saving energy. Over time, each program administrator has introduced new HER waves that draw from different populations and apply slightly different treatments. In this report, a "wave" is a sample of customers that are drawn for the HER program at a point in time. The waves are mutually exclusive, meaning a customer selected for one wave will not be in any other subsequent wave. Each wave has a treatment and control group to be studied, where both groups are exactly alike in all relevant ways, except the treatment group receives the home energy reports. The HER

evaluation for program year 2017 includes thirteen HER program waves for PG&E, eight for SDG&E, and four for SCE.

The HER programs use a randomized controlled trial (RCT) experimental design. The RCT experimental design is widely considered to be the most effective way to establish causality between a treatment and its effect. The approach uses substantial numbers of households in both treatment and control groups to produce an unbiased and precise estimate of savings. Opower, which implements the HER program for the program administrators, has used the RCT approach to support the credibility of program-related savings required by Commission decision.

1.2 Research questions and objectives

The primary objective of this evaluation is to provide independent verification of energy and demand savings attributable to the HER program. Specific research questions include the following:

- Did the randomization process produce a balanced sample design for new waves? Was the sample design balance maintained after attrition for existing waves?
- What are the energy and demand savings for each HER wave?
- How much energy and demand savings can be jointly reported by both rebate programs and the HER program?
- What are the final energy and demand savings for each HER wave?

1.3 Study approach

To answer these research questions, DNV GL conducted an evaluation for the 2017 program year to estimate energy savings caused by the program, referred to as the program's "impact." We calculated the following energy and demand savings components:

- *Unadjusted savings.* These savings measure the overall impact of the HER program on average household energy consumption and demand usage before applying an adjustment for joint savings achieved in conjunction with other rebate programs. Unadjusted energy savings are estimated using a regression model that compares the difference between the treatment group's energy consumption to that of the control group, both before and after the home energy report receipt. Demand savings are estimated using another type of regression framework to estimate the reduction in peak load between the treatment group and control group during the hottest heatwave, also before and after the home energy report receipt.
- *Joint savings.* Joint savings represent an uplift in the treatment group's rebate program participation induced by HER. We estimated joint savings for downstream programs, where the rebate is offered downstream directly to the customer, and for upstream programs, where the rebate is offered upstream to the manufacturer:
  - *Downstream joint savings*. These savings occur when treatment group customers increase their participation in tracked energy efficiency programs relative to the control group customers. As these savings are tracked for each customer, we can measure savings uplift directly.
  - *Upstream joint savings.* These savings occur when treatment group customers increase their purchases of lamps rebated through the upstream lighting program. Because these savings cannot be tied directly to individual customers, survey results are used to measure uplift and other assumptions

to estimate joint savings. Lamp uplift for HER program year 2017 was estimated based on over 19,000 responses to an online survey from treatment and control group customers across the three program administrators.

- *Adjusted savings.* These savings represent the final program savings after deducting both the downstream and upstream joint savings which are claimed by the rebated programs.

1.3.1 Total HER program savings

The HER program generated approximately 255,000 MWh in electric savings and 4.8 million therms in gas savings for program year 2017 across the three program administrators (Table 1-1). The HER program sample design continues to adhere to RCT standards for the majority of the cases enabling full program attribution for estimated savings.[1]

While the HER program has consistent savings of 1%-3% per household over time, total HER savings can erode due to attrition. However, the addition of new waves allows the program to continue contributing substantially to residential sector savings. Savings in program year 2017 either exceed or are in line with program year 2016 evaluated savings of approximately 199,000 MWh of electricity and 4.8 million therms of gas.

Table 1-1. Total HER Program savings in program year 2017

Type of Savings	PG&E	SDG&E	SCE
Electric (MWh)			
Unadjusted	132,525	39,933	97,590
Adjusted	122,026	39,439	93,979
Gas (therms)			
Unadjusted	3,869,129	911,382	N/A
Adjusted	3,942,213	881,235	
Peak Demand (MW)			
Unadjusted	20	11	21
Adjusted	19	10	21

[1] Apart from a couple of waves for one PA, balance tests indicate that the majority of cases adhere to the RCT standard.

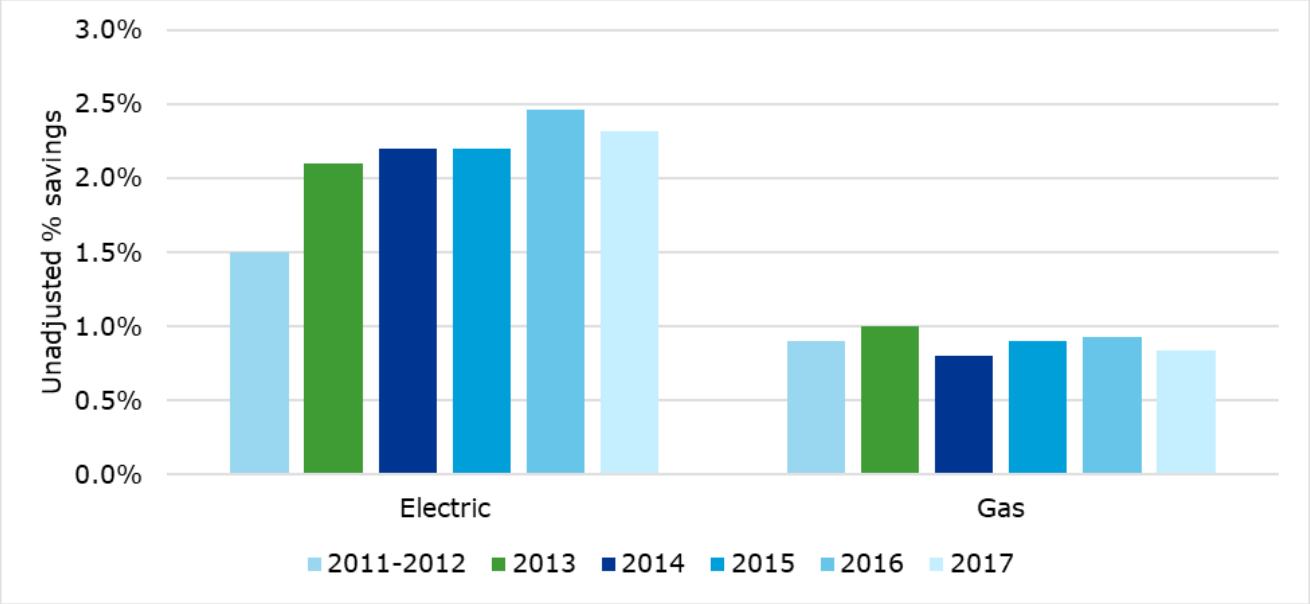
1.3.2 HER program savings trends

We conducted a trend analysis of HER program savings for each wave. The chart below illustrates this analysis and summarizes performance of PG&E's HER program introductory beta wave (Figure 1-1). The figure provides percent electric and gas savings from the launch of the program until 2017.

Electric savings are consistently higher than gas savings. Gas savings remain relatively lower and consistent over time. A plausible explanation for this observed difference between electric and gas savings is that gas use is tied to essential end-uses such as cooking and heating and hence customers have relatively less potential for gas reductions based on behavioral changes. Electric savings link to essential end-uses like lighting and cooling and also some non-essential ones such as entertainment and pool usage, which could explain the relatively higher magnitude of savings.

Electric savings ramp up after the first year and then stabilize as the program matures. As customers learn more about their consumption and actions they may take to be more energy efficient, program savings start to increase. Savings stabilize as the number of energy-saving actions taken by customers begins to approach its maximum achievable potential.

Figure 1-1. PG&E HER program introductory beta wave % of household savings over time



1.3.3 HER program efficacy

The 2017 evaluation of the HER program shows that it achieved significant savings, a finding consistent with prior evaluations of the HER program. The chart below summarizes first-year percent electric and gas savings achieved for the introductory HER beta wave launched in 2011 and more recent waves 3, 4, 5, and 6 that were launched between 2013 and 2015 (Figure 1-2).

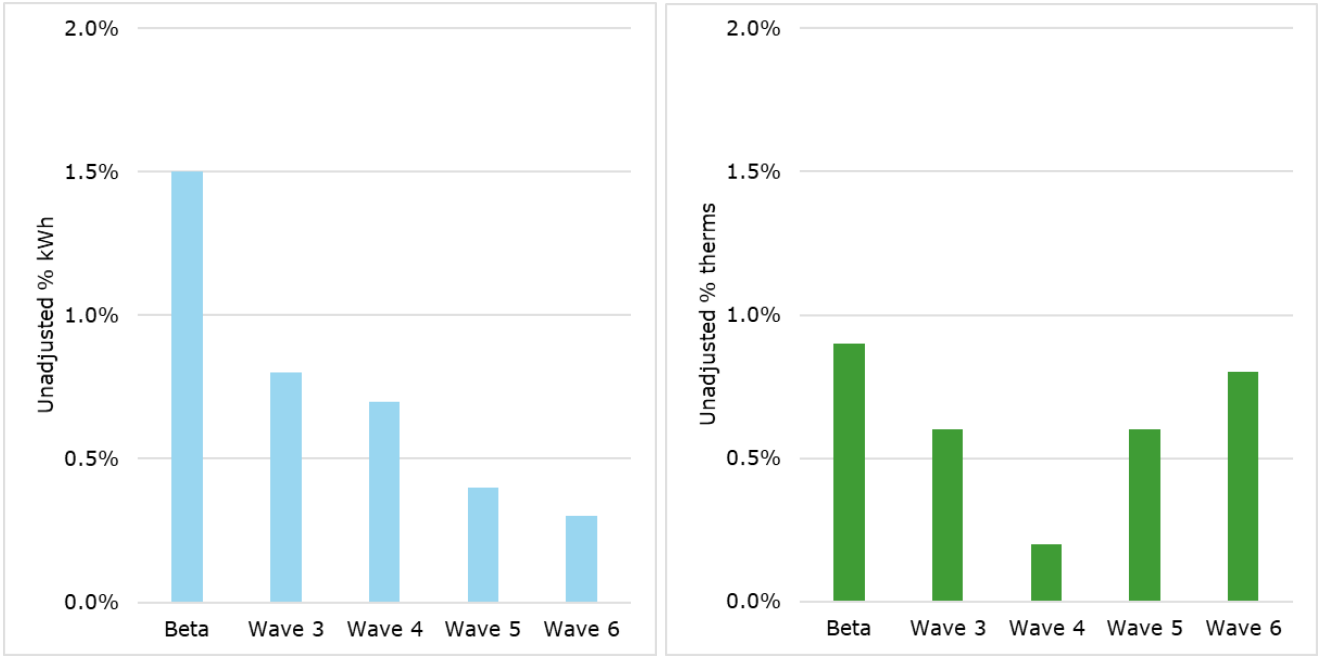
First-year electric savings achieved by more recent waves are notably lower than those that were achieved by the beta wave. Factors outside the program's influence contributing to this include an increased number of electronic devices in the home and electrification trends such as heat pumps, heat pump water heaters, electric vehicles etc. Additionally, the composition of recent HER waves includes customers drawn from lower

consumption quartiles of energy usage, not just the top quartile of highest-users where there is greater opportunity for savings.

Customers with lower levels of baseline energy consumption might have less potential for energy efficiency. There could also be changes in the energy consumption levels of the control group due to a variety of factors including increased awareness of the link between energy use and climate change.

It may also be the case that customers introduced to the HER program in more recent waves are receiving more information from other sources than new participants in prior years received and therefore may engage less with the HER report. Future evaluations should continue to monitor this and use insights to refine implementation for improved program performance.

Figure 1-2. First-year estimated savings for introductory and recent PG&E HER waves



1.3.4 HER program influence

Independent evaluations of the HER program across various utilities have shown consistent savings in the range of 1%-3%. While the RCT experiment enables attributing all of the savings directly to the HER program, it does not shed light on the source of the savings.

Table 1-2 summarizes the results of an innovative analysis that contrasts treatment and control group customers that reported changes in energy usage behavior. Customers are profiled on key dimensions such as changes in energy consumption based on billing data, demographics, program administrator engagement, and technology adoption.

Treatment group customers who reported taking action(s) to save energy achieved significantly higher reductions in electric consumption. Results indicate that the treatment group is more engaged, receptive, participates more in programs, and adopts new technologies in higher proportions relative to the control group. While differences are not dramatic between the treatment and control groups, they are statistically significant and shed light on the potential contributing factors that cumulatively contribute to HER program savings.

Table 1-2. Profile of customers reporting energy saving actions

	Control (n=1,162)	Treatment (n=5,861)
Energy consumption		
Pre-evaluation period electric consumption (kWh)	7,820	7,368
Reduction in electric consumption	15%	18%*
Energy Use Intensity (kWh/SQFT)	5.5	5.2*
Percent reduction in Energy Use Intensity (electric)	14%	18%*
Demographics		
Dwelling vintage – post 1980	44%	51%*
Education - college degree or higher	67%	69%
PA engagement		
Critical peak pricing programs	9%	11%*
Demand response programs	5%	7%*
Seasonal Savings	2%	3%*
Universal Audit Tool	7%	9%*
Technology adoption		
Smart thermostats	43%	45%
Smart LED bulbs	44%	47%
Smart appliances	26%	30%*

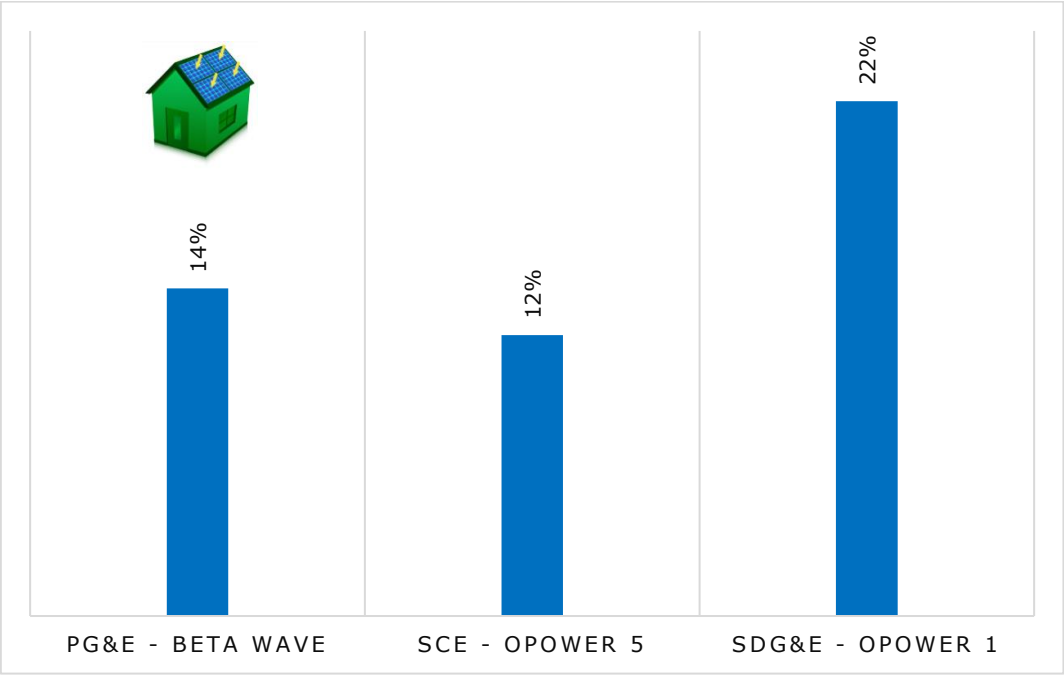
Asterisk (*) denotes significant difference at 90% confidence level.

1.3.5 Solar photovoltaic adoption

California will move to 100% renewable electricity by 2045 per the terms set forth in Senate Bill 100. Rooftop solar installations are proliferating in California. Evidence of this trend is revealed in the data used for this evaluation.

Figure 1-3 presents a snapshot of the HER program waves with the highest prevalence of solar photovoltaic (PV) systems in program year 2017 by program administrator. The share of HER net-metered customers with solar PV is substantial, particularly for longer-running waves. This trend of increasing solar PV adoption has implications for future HER evaluations as billing data does not currently provide a measure of consumption that includes the share from self-generation.

Figure 1-3. Prevalence of solar PV in PY 2017 in the HER program



Additionally, co-adoption of solar PV with electric vehicles (EV) represents an important segment. Responses to the HER survey indicate that while EV adoption is at 7% among customers in the HER program, it more than doubles to 19% among the subset that have solar PV. Factoring adoption of these large load end-uses into the HER design and evaluation should be a consideration for future program years.

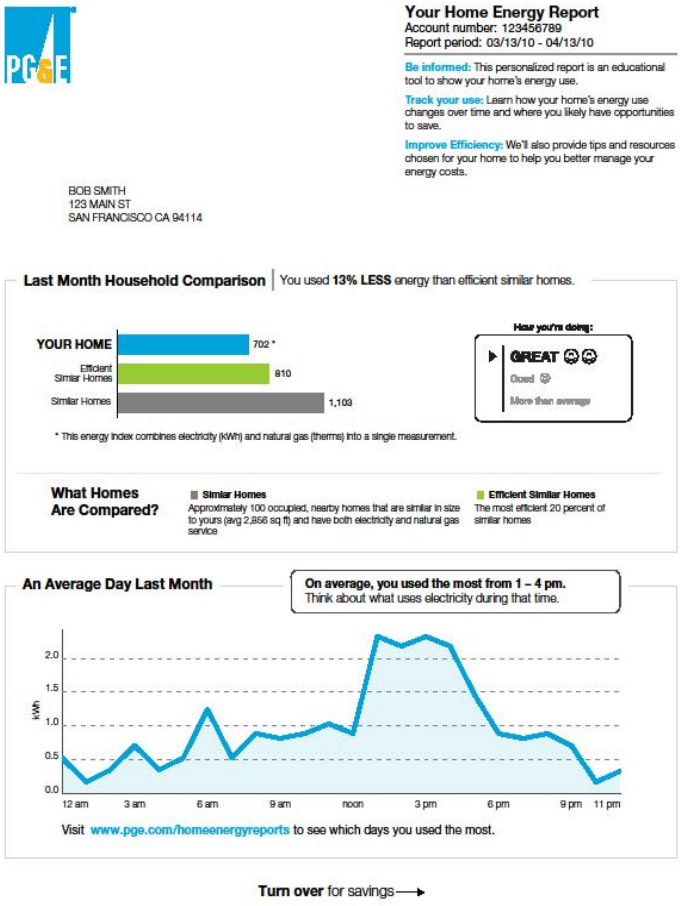
2 INTRODUCTION

2.1 Program description and participation

The residential sector accounts for 17% of the state's energy usage, with over 14 million single- and multi-family homes that house more than 39 million Californians. In 2012, the California Public Utilities Commission (CPUC) directed the California PAs to offer behavioral programs to at least 5% of households they serve. The CPUC further mandated that the offering employ a strategy of comparative energy usage following an experimental design approach.

Home Energy Reports (HERs) sent to customers contain a mix of energy usage information, comparison of that usage with similar neighbors, and customized tips for saving energy. An example of PG&E's HER is shown below (Figure 2-1). The primary purpose of the HER behavioral program is to reduce energy consumption by motivating no-cost and low-cost energy conservation actions and self-installation of energy saving measures. The evaluation also assesses whether the reports cause customers to participate in other energy efficiency programs as tracked by internal databases.

Figure 2-1. Example of a Home Energy Report



All of the PAs have comparative energy usage pilot programs that comply with the CPUC decision. Opower is the program implementer of the HER program for all PAs in California. PG&E and SDG&E began their HER programs in 2011 and SCE began in 2012. By the end of 2015, these reports constituted the largest single residential measure based on kilowatt-hours saved.[2] SoCalGas launched its HER program under its AMI data project in 2013, shifted the program under its energy efficiency portfolio in 2017, and plans to claim savings starting in 2018. The HER program evaluation for 2017 includes PG&E, SCE, and SDG&E.

Over time, each program administrator has introduced new HER waves that draw from different populations and apply slightly different treatments. New waves are also introduced as replacements for program attrition. This attrition ranged from 8%-10% in the 2017 program year. Table 2-1 presents a summary of the HER program status as of 2017 for each of the PAs.

Table 2-1. HER 2017 program status

PA	Piloted in	Number of waves	Total 2017 residential households	Treatment	Control	Total active accounts in HER program in December 2017[3]	Program additions and changes
PG&E	August 2011	13	5,644,326	2,139,366	665,266	1,846,849	Most waves target highest usage quartiles. Gamma wave expanded targeting to all usage quartiles.
SCE	December 2012	4	4,428,883	1,108,162	212,526	1,136,111	5 waves launched. Opower 1 (introductory wave) discontinued
SDG&E	July 2011	8	1,301,585	899,173	158,516	819,497	Low-income cohort in Opower 2. Digital reports added for waves launched from 2014 onwards (Opower 2- Opower 5).

2.2 Evaluation objectives

The primary objective of this evaluation is to provide independent verification of electricity and gas savings attributable to the HER program. Specific research questions and objectives include the following:

- Did the randomization process produce a balanced sample design for new waves? Was the sample design balance maintained after attrition for existing waves?
- What is the energy and demand savings for each HER wave?
- How much energy and demand savings can be jointly claimed by both the downstream and upstream rebate programs and the HER program?

[2] CPUC Energy Efficiency Portfolio Report (May 2018). http://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/About_Us/Organization/Divisions/Office_of_Governmental_Affairs/Legislation/2018/13-15%20Energy%20Efficiency%20Report_Final.pdf

[3] Active accounts are a subset of the sum of treatment and control customers enrolled in the HER program. This is due to attrition.

- What is the final adjusted energy and demand savings for each HER wave by PA at the household and program levels? What percentage of consumption do these savings represent?

3 METHODOLOGY

3.1 Data sources

3.1.1 Program participants

Each of the PAs provided data on HER participants from all active waves. Appendix B includes a disposition of the customers involved in each PA's HER program. The data the PAs provided include participant account numbers (service agreement, customer, and premise numbers), the HER waves that each participant is in along with starting dates. Additional information such as if and when accounts become inactive, and email recipient and online accounts status are also included. These data served as the roster of program participants for the HER evaluation.

3.1.2 Monthly billing data

DNV GL used each PA's monthly billing data of HER customers to obtain energy use information for 12 pre- and for post-program months in 2017. The billing data included account numbers, premise numbers, billing cycle start and end dates, consumption reads, net metering flags, and the type of reading (i.e., actual meter reading/estimated reading).

3.1.3 Downstream program tracking data

DNV GL used CPUC program tracking data to collect information on PA's HER customers who participated in downstream rebate programs after the inception of the HER program. The CPUC tracking data included participant information, account numbers, program name, measures installed, installation dates, and claimed savings. This dataset facilitated calculating downstream joint savings for the program.

3.1.4 Online survey data

DNV GL conducted an online survey to assess efficient bulb uptake of all the PA's HER participants. The online survey collected information on the number of CFL and LED lamps purchased and installed by HER participants in the treatment and control groups. This survey facilitated calculating upstream joint savings for the program.

3.1.5 Hourly consumption data

DNV GL obtained sub-hourly or hourly electricity use data of HER customers for pre- and post-program summers for peak demand impact analysis of the HER program. The interval data included account numbers, service point id and 15-minute or 60-minute interval reading.

3.2 Energy savings

The baseline conditions for behavioral programs are the absence of the comparative reports. The RCT control group post-report data provides a robust proxy of treatment group baseline conditions. In the difference in difference structure, the difference between pre-report consumption offers an additional bias correction for minor random differences between the two groups. Household energy consumption is affected by a wide range of factors and it is difficult to establish the causality of the reports as the driver of pre- to post-installation changes. Random assignment of a control group that does not receive the reports allows for the most robust possible representation of baseline conditions.

DNV GL used a fixed effects regression model, a standard for evaluating behavioral programs like HER, for this evaluation, making it possible to compare consumption of the treatment group to the control group before and after program implementation. The change that occurs in the treatment group is adjusted to reflect any change that occurs in the control group, to isolate changes attributable to the program.

Below is the fixed-effects model specification used in this study:

$$E_{it} = \mu_i + \lambda_t + \beta_t P_{it} + \varepsilon_{it}$$

where:

E_{it} = Average daily energy consumption for account i during month t
P_{it} = Binary variable: one for households in the treatment group in the post period month t, zero otherwise
λ_t = Binary variable: one for a specific month/year, zero otherwise
μ_i = Account level fixed effect
ε_{it} = Regression residual

The average monthly savings are given by:

$$\bar{S}_t = \hat{\beta}_t$$

where:

$\bar{S}_t$ = Average treatment-related consumption reduction during month t
$\hat{\beta}_t$ = Estimated parameter measuring the treatment group difference in the post period month t

The model includes site-specific and month/year fixed effects. The site-specific effects control for mean differences between the treatment and control groups that do not change over time. The month/year fixed effects account for changes over time that affect both the treatment and control groups. The monthly post-program dummy variables pick up the average monthly effects of the treatment.

Households that moved out were dropped from the model as of the month they leave. The total savings are a sum of the monthly average savings combined with the count of households still eligible for the program in that month. Also, households that actively opted out of the program remain in the model as long as they remain in their house. In this respect, the treatment can be considered "intent to treat." This model is consistent with best practices as delineated in State and Local Energy Efficiency Action Network's Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations.[4]

3.3 Peak demand savings

Reductions in demand at peak times that result from HER program participation can be measured through a variety of approaches. The preferred approach in California is to examine differences in demand that occur during pre- and post-program peak periods. The peak period definition provided by the Database for Energy Efficiency Resources (DEER) was used for this purpose.[5] This definition considers the average temperature, average afternoon temperature (12 p.m.–6 p.m.), and maximum temperature over the course of three-day

[4] State and Local Energy Efficiency Action Network. 2012. *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. http://behavioranalytics.lbl.gov.

[5] http://www.cpuc.ca.gov/NR/rdonlyres/4F93F9C2-434E-4B06-8D80-B2CB7E0A4198/0/DEER2013UpdateDocumentation_792013.pdf

heatwave (HW) candidates. Each candidate HW is a combination of three consecutive non-holiday weekdays occurring between June 1 and September 30.

Using this definition, the optimal HW for each climate zone is ultimately selected by choosing the single candidate three-day-period with the highest peak score (Score_k) among all possible candidates.

The mathematical expression used to compute the peak score is given below:

$$HW = \max_{1 \le k \le K} (\text{Score}_k)$$

$$\text{Score}_k = \max_{1 \le d \le 3} (temp_{d,k}) + \frac{1}{d} \sum_{d=1}^{3} (daily\_mean_{d,k}) + \frac{1}{d} \sum_{d=1}^{3} (afternoon\_avg_{d,k})$$

Where

HW	=	Zone-specific set of three consecutive non-holiday weekdays that has the highest value of Score_k for heat wave candidate k across all possible candidates K
Score_k	=	The summation of maximum, average daily, and afternoon average temperature
$daily\_max_{d,k}$	=	The maximum hourly temperature value across all hours on day d, for heat wave candidate k.
$daily\_mean_{d,k}$	=	The average hourly temperature across all hours on day d, for heat wave candidate k.
$afternoon\_avg_{d,k}$	=	The average hourly temperature between 12 and 6 PM on day d, for heat wave candidate k.

DNV GL collected 15-minute and 60-minute interval data during the hours of 2 p.m.–5 p.m. of the most common heat wave in the pre- and post-periods for both treatment and control households. DNV GL then used a regression model based on average kW pre-post differences to estimate demand savings due to the HER program. The model estimates the difference-in-difference between treatment and control average DEER-defined demand and is specified as follows:

$$\Delta\overline{kW}_i = \alpha + \beta T_i + \varepsilon_i$$

Here:

$\Delta\overline{kW}_i$	=	Average pre-post demand difference for household i during the DEER-defined peak period
T_i	=	Treatment binary variable that takes the value of 1 if household i is in the treatment group and 0 if it is in the control
α, β	=	Model coefficients - β captures HER treatment effect on peak demand
ε_i	=	Model error term

3.4 Downstream rebate joint savings

One possible effect of the HER program is to increase rebate activity in other utility energy-efficiency programs. The RCT experimental design facilitates the measurement of this effect. DNV GL compared the average savings from rebate measures installed by the treatment group with the savings from measures installed by the control group. An increase in treatment group rebate program savings represents savings caused by the HER program jointly with the rebate programs. While these joint savings are an added benefit of the HER program, it is essential that these joint savings are only reported once. The most common and simple approach is to remove all joint savings from the HER program savings rather than remove program-specific joint savings from all of the associated rebate programs. This approach was used historically to adjust the savings from the behavioral programs.

The savings estimates from the fixed effects regressions include all differences between the treatment and control group in the post-report period. Joint savings are picked up by the regressions and are included in the overall savings estimate. These joint savings are also included in utility rebate program tracking databases and are claimed as part of those programs' savings unless further actions were taken to remove them. Savings from the HER program are adjusted using the joint savings estimates to avoid double counting of savings.

DNV GL used the following approach for rolling up individual rebate savings and calculating joint savings overall:

- Used accepted deemed savings values (those being used to claim the savings for the rebate program).
- Determined accumulated savings beginning from the installation date moving forward in time.
- Assigned daily savings on a load-shape-weighted basis (more savings are expected for periods when the measure is used more).
- Maintained the load-shape-weighted savings over the life of the measure.

This approach uses the deemed annual savings values and transforms them into realistic day-to-day savings values given the installation of that measure. DNV GL determined the daily share of annual savings using 2011 DEER hourly load shapes[6] for each PA.[7] These load shapes indicate when a measure is used during the year and, by proxy, when efficiency savings would occur.[8]

Savings for each installed measure start to accrue at the time of installation (or removal for refrigerator recycling). Average monthly household rebate program savings were calculated for the treatment and control groups including zeroes for the majority of households that did not take part in any rebate program. An increase in average per-household tracked program savings among the treatment group versus the control group indicates joint savings. DNV GL's recommended method for estimating joint savings analysis is consistent with the approach recommended in the SEE Action (State and Local Energy Efficiency Action Network) report.[9]

[6] DEER load shapes are in an 8760-hourly format. DNV GL aggregated the hourly shares to daily shares in order to estimate daily savings.

[7] http://deeresources.com/DEER2011/download/DEER2011-UpdatedImpactProfiles-v2.zip

[8] This is more accurate and equitable than subtracting out the first-year savings values that are used in DEER, because most measures are not in place from the first day to the last day of the year.

[9] State and Local Energy Efficiency Action Network, 2012. *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. http://behavioranalytics.lbl.gov.

DNV GL used a similar approach to calculate potentially double counted savings in HER demand (kW) savings estimates, based on the use of deemed kW savings from measures installed during the treatment period but before the start of the peak period. The average deemed kW savings per household of the control group were subtracted from the average deemed kW savings per household of the treatment group to calculate joint savings between HER program and PG&E downstream rebate programs during the peak period.

3.5 Upstream joint savings

Upstream joint savings occur when a treatment group increases their purchases of CFL or LED lamps rebated through the upstream lighting program. Unlike tracked programs, it is not possible to directly compare all treatment and control group member activity. This makes it more challenging to determine if the HER program does increase savings in upstream programs.

DNV GL used survey results to measure uplift and then estimate upstream joint savings for each program year. The upstream joint savings equation used for calculating the annual electric savings and gas interactive effects is presented below:

$$Joint\ savings\ per\ household = Excess\ lamps\ due\ to\ HER\ x\ Rebated\ sales\ fraction\ x\ NTG\ x\ Installation\ rate\ x\ Installed\ proportion\ of\ 2017\ x\ Savings\ per\ lamp$$

Table 3-1 describes each upstream lighting joint savings input and lists the sources that are used for lamps installed between 2011 and 2017. Program administrator specific inputs are presented in Appendix D.

Table 3-1. Upstream lighting energy savings inputs

Variable	Description	Sources
Excess lamps (uplift) due to HER	Lamp uplift due to HER	2012 PG&E in-home survey, 2013 PSE HER phone survey (DNV GL), 2014 PSE HER phone survey (DNV GL), 2015 PA Residential Behavioral Programs: Online Survey Results (DNV GL, 2017), 2016-2017 PA Residential Behavioral Programs: Online Survey Results (DNV GL, 2019)
Rebated sales fraction	Proportion of lamps sold within the program administrator's territory that are rebated through the upstream lighting program	2014 and 2015 TRC HER lighting overlap studies
Installed share of 2017	Share of the year the lamps have been installed	Prior to 2017, 1; For 2017, .54 which assumes lamps are installed equally throughout the year, calculated as the average number of months a lamp is installed
Installation rate	Upstream lighting program lamp installation rate[10]	2013-14 ULP Evaluation (DNV GL, 2016)
Net-to-gross	Upstream lighting program average ex post net-to-gross factor	2010-12 ULP Evaluation (DNV GL, 2014), 2013-14 ULP Evaluation (DNV GL, 2016), 2015 ULP Evaluation (DNV GL, 2017)
Annual electric savings per lamp	Average ex post unit energy savings per lamp in the year of installation	2010-12 ULP Evaluation (DNV GL, 2014), 2014 TRC HER lighting overlap study, Program tracking data (DEER 2013-14), 2015 ULP Evaluation (DNV GL, 2017)
Gas interactive effects per lamp	Average ex-post interactive effects unit energy savings per lamp in the year of installation	2013-14 ULP Evaluation (DNV GL, 2016), 2015 ULP Evaluation (DNV GL, 2017)

In 2017, DNV GL conducted an online survey to update the efficient bulb uplift due to HER programs. The online survey included both treatment and control group households and collected information on their purchase and installation of CFLs and LEDs for the past year. The survey results were used to estimate the uplift in installed LEDs and CFLs in 2017.

Not all of the extra lamps installed due to the HER program may have been rebated through the upstream lighting program. The rebated sales fraction is used to adjust the uplift to the rebated proportion of excess lamps. It is assumed that excess lamps were installed evenly throughout the year; therefore, not all of the lamps installed in 2017 were installed in every month of the year. The average fraction of months that a bulb is installed out of a year is referred to as the installed proportion of 2017.[11]

Beginning in 2015, when DNV GL began the online survey, the measure of uplift shifted to installed lamps rather than purchased lamps; therefore, an installation rate was no longer necessary. DNV GL uses the

[10] Not applicable after 2014 when the excess lamps due to HER switched to installed uplift rather than purchased uplift.

[11] A bulb installed in January is installed for 12 out of 12 months, a bulb installed in February is installed for 11 out of 12 months, and a bulb installed in December is installed for 1 out of 12 months. When these fractions are averaged, we get 0.54 which is what we use for the installed fraction of 2017.

installation rate from the 2013-2014 Upstream Lighting Program evaluation for lamps installed in earlier years (2011-2014).

The net-to-gross value and annual electric savings per lamp come primarily from past Upstream Lighting Program evaluations. The net-to-gross value is the average ex post net-to-gross CFL and LED factor weighted by the ex post quantity rebated for each IOU. The annual electric savings for 2016 and 2017 is the quantity weighted average ex post unit energy savings.

California recognizes the potential for interactive effects across fuels when assigning savings. Interactive effects are explicitly accounted for in the downstream rebate program tracking database. For the untracked Upstream Lighting Program, the quantity weighted average ex post unit energy savings (or dissavings) from past Upstream Lighting Program evaluations is used. The interactive effects produce negative gas joint savings and therefore increase the overall adjusted gas savings. This adjustment is important because the replacement of inefficient lighting measures with more efficient lamps can increase heating load consumption due to lower heat emissions from CFLs and LEDs.

The equation below shows the formula for the total upstream joint electric savings and interactive effects by wave:

$$Total\ upstream\ joint\ savings = Sum\Big(Treatment\ households_m\ x\ Sum\big(CFL\ joint\ savings\ per\ household_{m,y} + LED\ joint\ savings\ per\ household_{m,y}\big)\Big)$$

Total joint savings is calculated by first dividing the annual per household joint savings by 12 to calculate the monthly per household savings by lamp type (CFL and LED). Then, the CFL and LED monthly per household savings for all years are summed[12] and multiplied by the number of 2017 active treatment households in that month.[13] Finally, the monthly total savings are summed. Negative uplift, in which the control group installs more lamps than the treatment group, is included. This is done in order to adjust for changes in lamp installation over time. If the total upstream joint savings is negative, it is treated as a zero as no savings would be claimed jointly with the Upstream Lighting Program.

The upstream joint demand reduction equation is presented below, followed by Table 3-2 which describes the parameters used that are not addressed in Table 3-1.

$$Demand\ reduction\ per\ household = Excess\ lamps\ due\ to\ HER\ x\ Rebated\ sales\ fraction\ x\ NTG\ x\ Installation\ rate\ x\ Proportion\ of\ lamps\ installed\ at\ peak\ x\ Delta\ watts/1000\ x\ Peak\ coincidence\ factor$$

[12] None of the lamps installed due to HER uplift have reached their estimated useful life. For CFLs installed between 2011 and 2015, we are using an estimated useful life of 9.7 years based on DEER 2014. For CFLs installed after 2015, we are using an estimated useful life of 3.5 from DEER 2016. All LEDs have an estimated useful life of 16 years from DEER 2014 and DEER 2016. Once a lamp reaches its estimated useful life, it will no longer be included in the upstream lighting calculation.

[13] For example, we sum all of the January joint savings per household across years and then multiply that by the number of active treatment households in January 2017.

Table 3-2. Upstream lighting peak demand reduction inputs

Variable	Description	Sources
Percentage of lamps installed at peak	The percentage of lamps that are expected to be installed when the heatwave occurs	Calculated as the percent of days up through when heatwave occurs
Delta watts	The measure of instantaneous demand reductions in watts that results from replacing an inefficient incandescent bulb with a CFL, LED, or another bulb type	2015 ULP Evaluation (DNV GL, 2017)
Peak coincidence factor	the average percent of time that a lamp is switched on during the peak period	2015 ULP Evaluation (DNV GL, 2017)

Assuming equal installation throughout the year, not all lamps installed in 2017 would have been installed at the time of the peak period. This is adjusted by applying a factor calculated as the day of the year when the peak event began divided by 365 days. The impact of the watts reduction at peak is estimated by using the delta watts and the peak coincidence factor from the most recent Upstream Lighting Program evaluation.

The following is the equation used to calculate total peak demand reduction due to joint savings with the upstream program:

$$Total\ upstream\ joint\ peak\ demand\ reduction = Sum(Treatment\ households\ at\ peak\ x\ (CFL\ peak\ demand\ reduction\ per\ household + LED\ peak\ demand\ reduction\ per\ household)$$

4 SDG&E IMPACT RESULTS

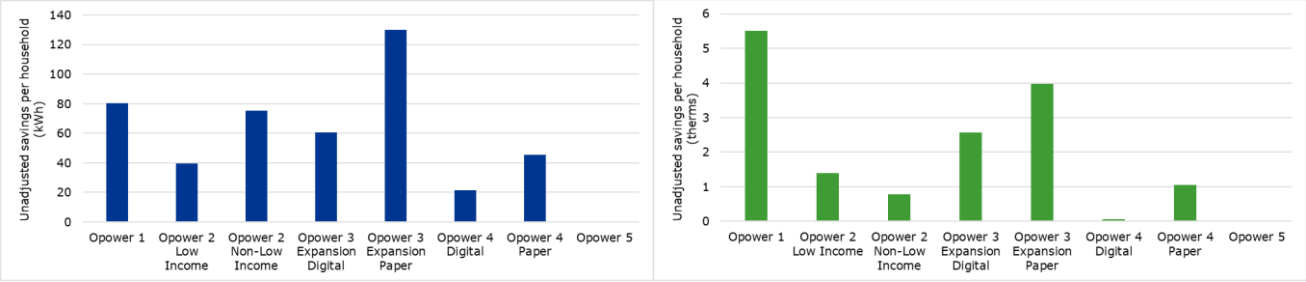
4.1 Unadjusted kWh and therm savings estimates

There are eight experimental waves in the SDG&E HER program in 2017. Opower 1 and the two groups in Opower 2 (low and non-low-income) have been around since 2011 and 2014, respectively. The rest are newer waves that have not been evaluated before. Opower 3 groups have been in the field for 2 years while participant households in Opower 4 and Opower 5 began receiving reports in 2017.

Opower 3 consists of two expansion groups that were initially set up as digital and paper groups. Despite the name, the roster from Opower indicates that 60% of the paper group received HER reports both digitally and via paper in 2017. Almost all members of Opower 3 digital treatment households received both digital and paper HER reports in 2017. The situation is the same for Opower 4 digital and paper groups. Opower 5, which has only been in the field since the end of 2017, consists of participants that are split between receiving paper-only, and paper and digital participants.

Figure 4-1 presents the unadjusted electric and gas savings per household. The extent of energy use reduction per household does not seem to depend on how long the HER experimental wave has been in the field. Opower 1, the oldest wave, shows among the highest reduction while Opower 3 paper group, one of the more recent waves, also shows relatively high energy use reductions.

Figure 4-1. SDG&E unadjusted electric and gas savings per household per year



What is associated with energy use reduction from HER treatment is baseline energy use. Households with the highest baseline energy use have the greatest reductions. As Table 4-1 also shows, the highest per household electric (kWh) and gas (therm) savings are for Opower 3 paper and Opower 1 treatment households. These are composed of households with the highest baseline electric and gas consumption. Opower 2 non-low-income group also has high electric baseline use and the third highest per household kWh reduction.

Table 4-1. SDG&E unadjusted electric and gas savings

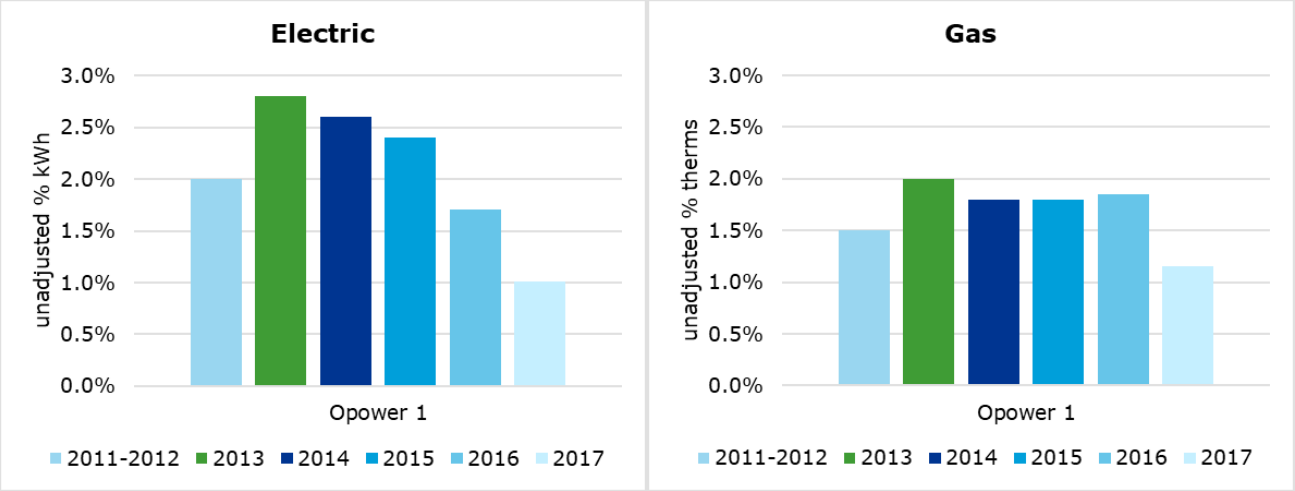
Wave	Baseline Consumption	Average Treatment Participants	Unadjusted Savings				
			Per Household per Year	Total	Lower Bound 90% CI	Upper Bound 90% CI	Percent Savings
Electric (kWh)							
Opower 1	7,927	12,620	80	1,013,461	-155,335	2,182,258	1.0%
Opower 2 Low Income	5,044	16,206	39	637,388	-319,096	1,593,872	0.8%
Opower 2 Non-Low Income	4,693	35,888	75	2,707,350	1,319,183	4,095,517	1.6%
Opower 3 Expansion Digital	4,757	186,657	61	11,305,853	7,967,646	14,644,060	1.3%
Opower 3 Expansion Paper	9,310	162,283	130	21,096,131	13,974,297	28,217,965	1.4%
Opower 4 Digital	2,972	53,233	22	1,145,692	513,508	1,777,876	0.7%
Opower 4 Paper	5,581	44,533	46	2,027,612	841,561	3,213,663	0.8%
Opower 5	300	219,549	<1	92,436	-150,570	335,443	0.1%
Gas (therms)							
Opower 1	477	12,788	6	70,423	4,895	135,950	1.2%
Opower 2 Low Income	259	12,713	1	17,836	-15,752	51,424	0.5%
Opower 2 Non-Low Income	244	27,560	<1	21,708	-28,393	71,809	0.3%
Opower 3 Expansion Digital	251	132,781	3	339,902	192,519	487,285	1.0%
Opower 3 Expansion Paper	376	107,764	4	429,030	158,240	699,820	1.1%
Opower 4 Digital	125	40,398	<1	2,299	-31,268	35,866	0.0%
Opower 4 Paper	179	28,850	1	30,184	-22,428	82,795	0.6%
Opower 5	25	139,430	<1	295	-24,599	25,188	0.0%

Note: The average number of treatment participants are reported to indicate wave size. Total unadjusted savings are based on monthly treatment counts.

Moreover, per household reductions as a percent of baseline energy use are higher for electricity than for gas. This could be because electricity use has more discretionary elements (such as entertainment) and elements that are more amenable to behavioral changes (e.g., turning off lights and unplugging electrical loads when not in use). Gas use tends to be for necessities, such as cooking and heating, which are less amenable to behavioral changes.

Figure 4-2 also illustrates that savings as a percent of baseline energy use are greater for electricity use than for gas. It shows that after initial ramp-up periods, electric savings as a percent of baseline energy use decline. Gas savings, relative to baseline gas use, on the other hand, are stable and do not exhibit any particular pattern. This is fitting with the conjecture that electric savings are tied more to behavioral changes that can give an initial boost in savings, but are may not contribute to sustained reductions.

Figure 4-2. SDG&E unadjusted percent electric and gas savings over time



4.2 Joint savings: downstream programs

Downstream joint savings are identified by comparing savings of the treatment and control groups from downstream program installations. These savings from measure installations build up over time in the post-treatment period. If the HER program also motivates increased participation in other SDG&E programs, then the treatment group downstream savings will accrue faster than the control group. The difference in savings between the treatment and control groups represents the savings jointly attributable to both the HER program and other downstream programs.

Figure 4-3 and Figure 4-4 provide the estimates of average joint electric and gas savings per customer in kWh and therms, respectively. These figures along with their confidence bounds indicate very limited increased uptake of downstream rebate programs among treatment groups in 2017.

Figure 4-3. SDG&E electric downstream joint savings per household per year

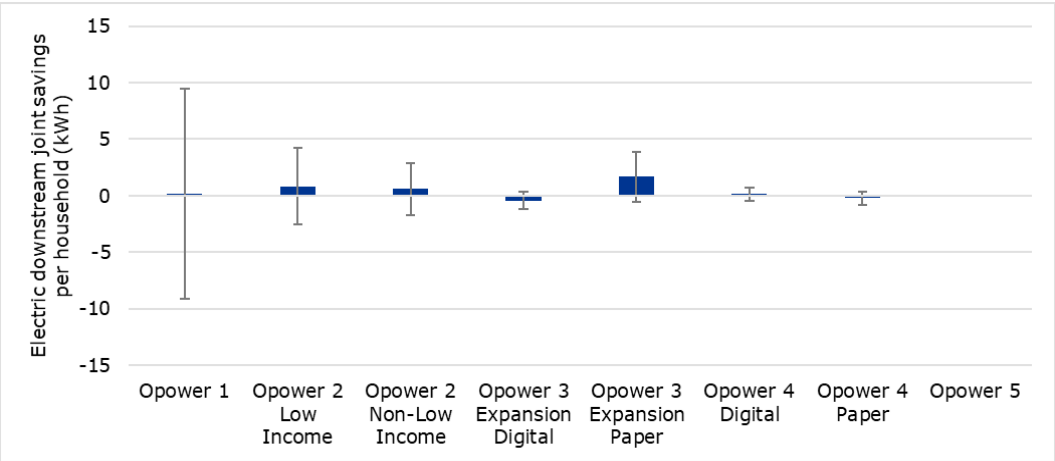
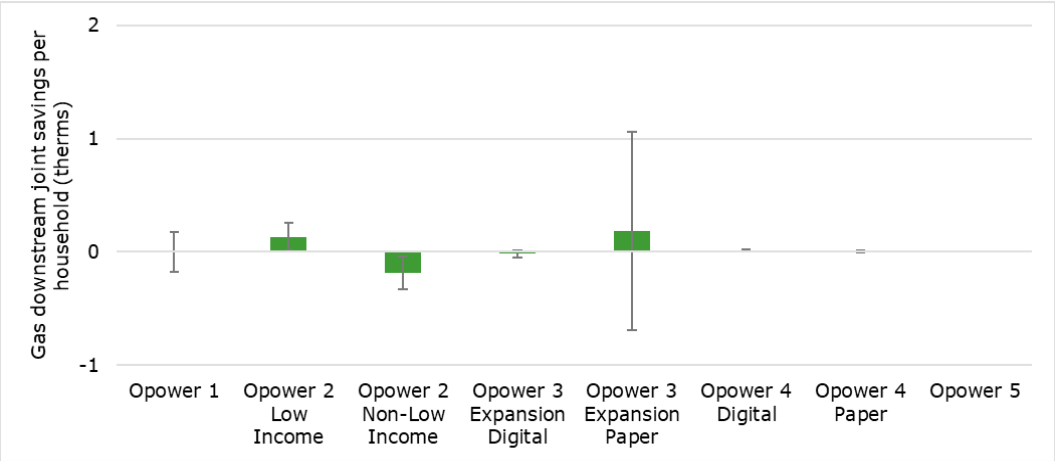


Figure 4-4. SDG&E gas downstream joint savings per household per year



The issue of potential double counting also applies to demand impacts to the extent that HER programs successfully motivate increased uptake in other energy efficiency programs and those programs claim demand savings. DNV GL calculated joint savings that are attributed to downstream rebated measures by using deemed demand values contained in downstream rebate tracking data and only by using those measures installed prior to August 30, 2017, the first day of the most common heat wave in 2017.

Figure 4-5 shows the downstream kW savings per household. Together these figures indicate the presence of limited joint savings from increased uptake of downstream rebate programs due to HER among the treatment group in 2017.

Figure 4-5. SDG&E downstream joint peak demand reduction per household per year

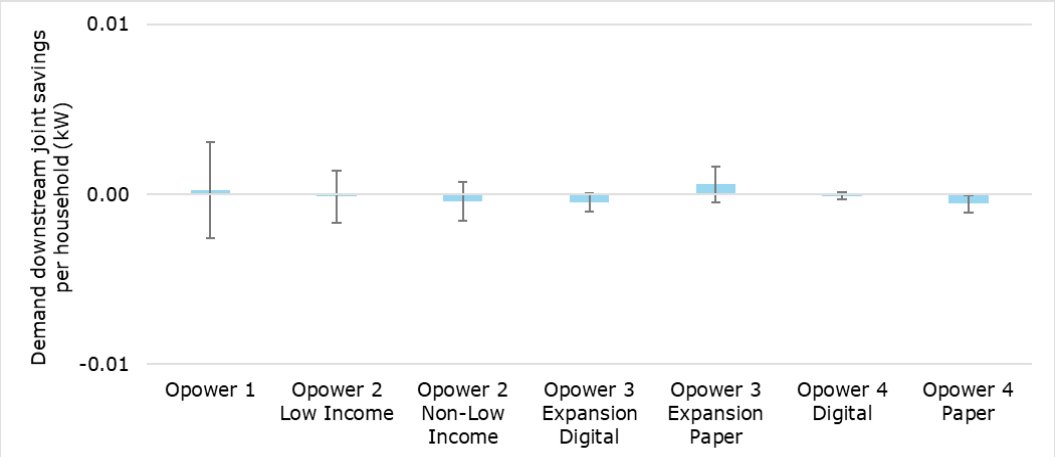


Table 4-2 provides total downstream joint savings by wave. SDG&E HER treatment groups had 315 MWh, 33 thousand therms, and 0.1 MW of peak demand joint savings in 2017 motivated by the HER program.

Table 4-2. Total SDG&E downstream joint savings by wave

Wave	Electric (kWh)	Gas (therms)	Peak Demand (kW)
Opower 1	2,821	0	3.3
Opower 2 Low Income	13,939	2,125	0
Opower 2 Non-Low Income	21,370	0	0
Opower 3 Expansion Digital	0	0	0
Opower 3 Expansion Paper	270,378	30,058	97.0
Opower 4 Digital	6,936	609	0
Opower 4 Paper	0	66	0
Opower 5	0	0	NA

4.3 Joint savings: upstream programs

Upstream joint savings are like downstream joint savings, except that upstream savings are not tracked at the customer level. SDG&E upstream savings still represent a source of savings that the HER program could potentially double count. Unlike tracked programs, it is not possible to directly compare all treatment and control group member activity. This makes it more challenging to determine if the HER program does increase savings in upstream programs.

The alternative to the downstream census-level approach is to do a comparison of treatment and control group uptake of the upstream program measures on a sample basis. This approach also takes advantage of the RCT experimental design that provides the structure to produce an un-biased estimate of upstream savings. In 2017, DNV GL conducted an online survey to assess uptake of upstream measures (specifically, CFLs and LEDs) due to HER. The surveys included treatment and control customers from the SDG&E HER program.

Table 10-8 in Appendix D presents the uplift of CFL and LEDs for each of SDG&E's experimental waves. The table includes the results of the HER uplift study. The results show there were uplifts of 0.74 LEDs for Opower 1 and of 0.2 for both CFL and LEDs for Opower 5. The rest of the waves had negative bulb uplift indicating that the control group purchased and installed more efficient bulbs than the treatment group.

Table 4-3 shows the kWh joint savings estimates per household. The total upstream joint savings per household for Opower 1 are 9.7 kWh per household for CFLs and 4.4 kWh for LEDs. HER program savings are adjusted downwards by the upstream joint savings amounts for these waves. The corresponding values for Opower 5 are positive, but less than 1. On the other hand, the upstream joint savings per household for the rest of SDG&E's waves are negative, which indicates that the control group purchased and installed more bulbs than the treatment group. No adjustments due to upstream joint savings are applied to waves with negative uplift.

The replacement of inefficient lighting measures with efficient lamps is associated with an increase in heating load due to lower heat emissions from CFLs and LEDs. These interactive effects translate to a gas penalty that would have been double counted by HER. Table 4-4 presents total interactive therm effects by wave. Negative numbers are subtracted from unadjusted gas savings to remove the gas penalty associated with the removal of electric joint savings from upstream programs.

Table 4-3. SDG&E upstream joint savings per household per year

Wave	Upstream Joint Savings per Household per Year				
	Electric (kWh)			Interactive Effects (therms)	Peak Demand (kW)
	CFL	LED	Total		
Opower 1	9.7	4.4	14.1	>-1	<0.1
Opower 2	-0.2	-1.8	0.0	0.0	0
Opower 3	-1.4	-7.0	0.0	0.0	0
Opower 4	-0.5	-0.8	0.0	0.0	0
Opower 5	<0.1	<0.1	0.1	>-1	<0.1

Overall, total program joint savings due to participation in the upstream program are 179 MWh and 12 kW for Opower 1, and 12 MWh and 1 kW for Opower 5 (Table 4-4).

Table 4-4. SDG&E total upstream joint savings

Wave	Total Upstream Joint Savings		
	Electric (kWh)	Interactive Effects (therms)	Peak Demand (kW)
Opower 1	178,603	-2,710	12
Opower 2 Low Income	0	0	0
Opower 2 Non-Low Income	0	0	0
Opower 3 Expansion Digital	0	0	0
Opower 3 Expansion Paper	0	0	0
Opower 4 Digital	0	0	0
Opower 4 Paper	0	0	0
Opower 5	12,204	-457	1

4.4 Demand savings estimates

Peak demand savings estimates are based on peak period (heat wave) definitions. The period that defines peak demand conditions used to estimate peak demand reductions is presented in section 4.4.1. Peak demand reductions for SDG&E's HER waves are presented in section 4.4.2.

4.4.1 Heat waves

DNV GL identified the 2017 heat waves using weather data from NOAA that contained hourly temperatures from weather stations across the SDG&E service territory from 2013 – 2017. The 3-day heat wave for 2017, August 30 through September 1, 2017, coincided with the heat waves of the other 2 PAs (Table 4-5).

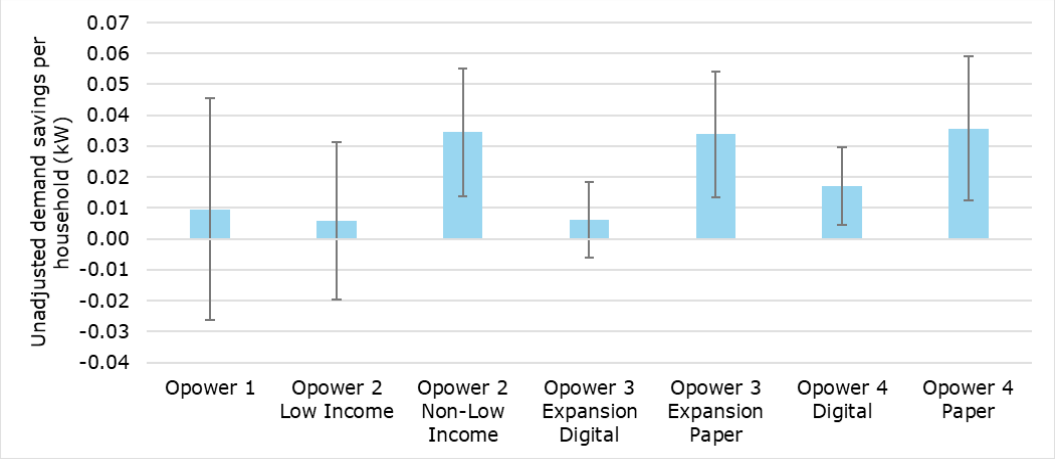
Table 4-5. SDG&E DEER Heatwaves

Wave	DEER Heatwave			
	Pre-Period			2017 Post-Period
Opower 1	9/27/2010	-	9/29/2010	8/30/2017 - 9/1/2017
Opower 2 Low Income	9/15/2014	-	9/17/2014	
Opower 2 Non-Low Income	9/15/2014	-	9/17/2014	
Opower 3 Expansion Digital	9/8/2015	-	9/10/2015	
Opower 3 Expansion Paper	9/8/2015	-	9/10/2015	
Opower 4 Digital	9/26/2016	-	9/28/2016	
Opower 4 Paper	9/26/2016	-	9/28/2016	

4.4.2 Peak demand reductions

The average three-hour reduction during the peak period for all SDG&E HER waves were a small fraction of a kW, with estimated values that are less than 0.1 kW. These values are statistically significantly different for four out of the seven waves under consideration (Figure 4-6). Opower 2 Non-Low-Income, Opower 3 Expansion Paper, and Opower 4 Paper all produced around 0.03 kW savings.

Figure 4-6. SDG&E unadjusted peak demand reduction per household per year



The estimated values, although small, are used to arrive at total peak demand reduction that result due to HER. Opower 3 Expansion Paper produced the highest unadjusted total peak savings at 5.4 MW (Table 4-6).

Table 4-6. SDG&E total unadjusted peak demand reduction

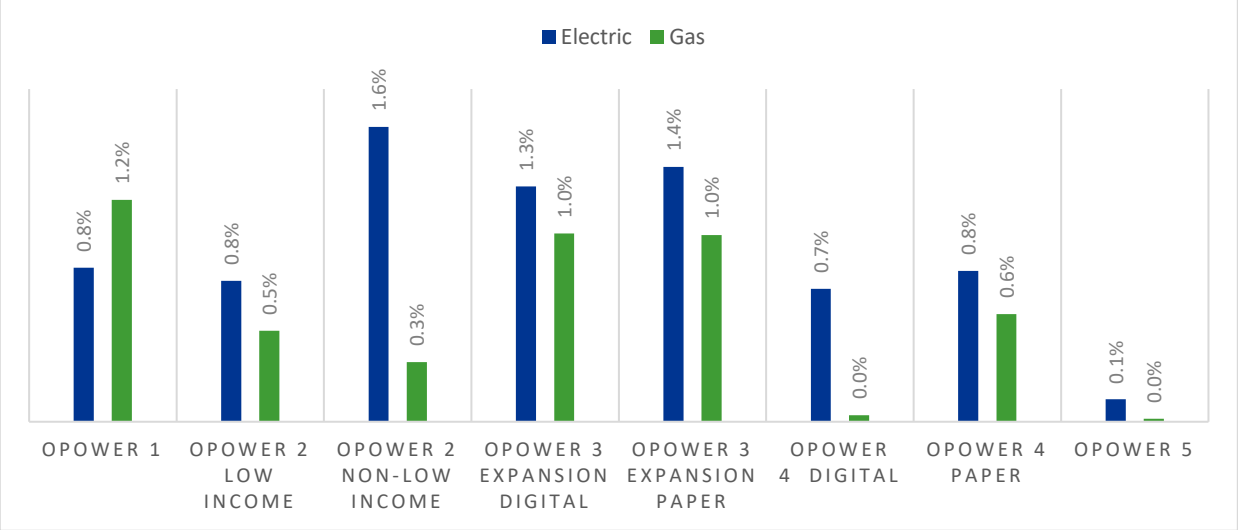
Wave	Active Accounts during Peak Period (Aug. 30 - Sept. 1, 2017)	Total Peak Reduction (kW)	Lower Bound 90% CI	Upper Bound 90% CI
Opower 1	12,559	120.4	-329.9	570.6
Opower 2 Low Income	16,053	92.7	-314.1	499.5
Opower 2 Non-Low Income	35,340	1,217.4	482.3	1,952.5
Opower 3 Expansion Digital	181,364	1,113.1	-1,097.0	3,323.3
Opower 3 Expansion Paper	160,402	5,416.0	2,140.2	8,691.9
Opower 4 Digital	55,071	938.2	249.7	1,626.6
Opower 4 Paper	45,180	1,613.6	562.5	2,664.7

4.5 Total program savings

Results in prior sections on unadjusted kWh and therm savings per household, and downstream and upstream joint savings per household are combined to determine adjusted savings per household. Figure 4-7 presents adjusted electric and gas savings per household as a percent of baseline consumption for each of SDG&E's waves. As the figure illustrates, percent electric savings are greater than gas savings. Adjusted savings as a percent of total consumption range from 1% to 2% for electric and from less than 0.5% to 1% for gas.

The newest waves (Opower 4 and Opower 5) that have been in the field for less than a year have the lowest savings, although these waves are expected to register savings that are in line with the others in upcoming program cycles. Table 10-11 and Table 10-12 in Appendix E present these results along with the tracked downstream and untracked upstream adjustments at the wave level.

Figure 4-7. SDG&E percent electric and gas savings by wave



SDG&E's HER program generated total savings of 39,439 MWh, 881,235 therms, and 10.4 MW in program year 2017 in Table 4-7 and Figure 10-1.

Table 4-7. SDG&E total savings for the 2017 HER programs

Type of Savings	Total Program Savings
Electric (kWh)	
Unadjusted	39,933,487
Joint Downstream	315,444
Joint Upstream	178,603
Adjusted	39,439,440
Gas (therms)	
Unadjusted	911,382
Joint Downstream	32,858
Joint Upstream	-2,710
Adjusted	881,235
Peak Demand (kW)	
Unadjusted	10,511.3
Joint Downstream	100.3
Joint Upstream	11.9
Adjusted	10,399.1

5 PG&E IMPACT RESULTS

5.1 Unadjusted kWh and therms savings estimates

PG&E has the greatest number of HER waves in the field. We present energy savings from these waves in 2017 in this section. As Figure 5-1 indicates, the Beta wave produced the highest per-household savings at 220 kWh in 2017. Unlike all other waves, participants for this wave are drawn from the highest usage quartile in the San Francisco Bay Area. Other waves include participants either from the highest 3 usage quartiles or from all usage quartiles.

Although the difference in per household savings is not always tied to baseline usage levels, there is a general pattern of higher savings for waves with higher baseline usage levels; the top 3 per household savings are for waves with baseline usage that among the 4 biggest. Gas reductions indicate similar patterns. Per household savings are highest for Beta wave and the top savings per household are for waves with the highest baseline use.

Figure 5-1. PG&E unadjusted electric and gas savings per household per year

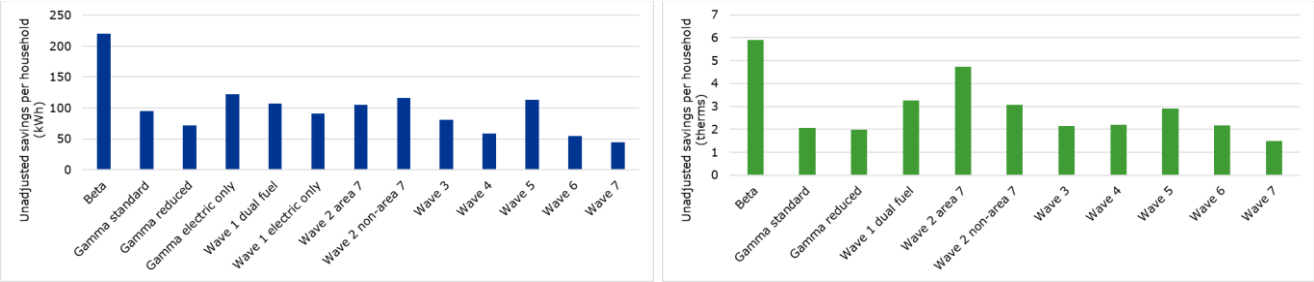


Table 5-1 presents percent savings in electric and gas use. Percent reductions in electric use ranged from about 1% to 2%. The Beta wave produced the highest electric percent savings at 2.3%. Percent reduction in gas use relative to baseline ranged from 0.5% to 1% in program year 2017. Gas reductions are similarly lower than electric savings as percent of baseline use.

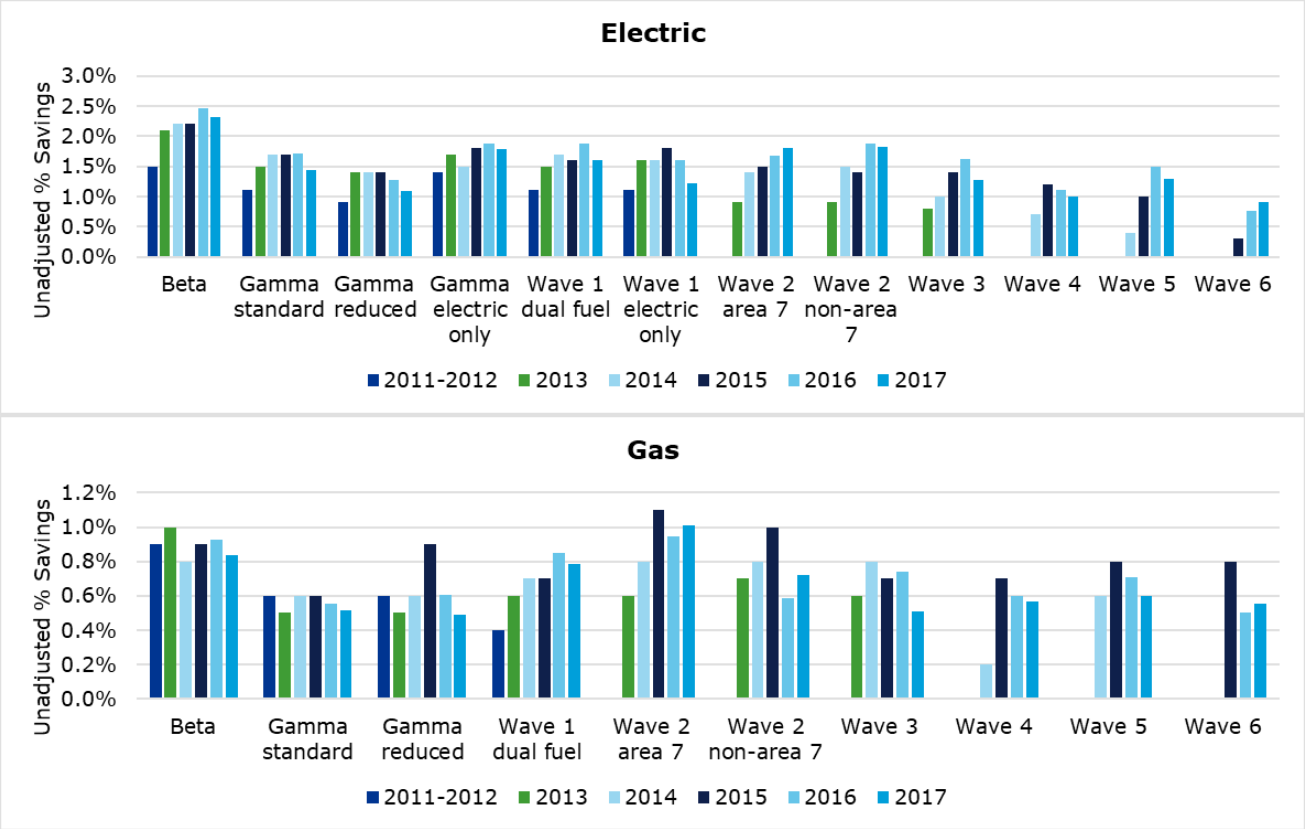
Table 5-1. PG&E unadjusted electric and gas savings

Wave	Baseline Consumption	Average Treatment Participants	Unadjusted Savings				
			Per Household per Year	Total	Lower Bound 90% CI	Upper Bound 90% CI	Percent Savings
Electric (kWh)							
Beta	9,494	40,112	220	8,829,919	6,893,144	10,766,694	2.3%
Gamma standard	6,652	45,756	95	4,356,269	2,611,460	6,101,078	1.4%
Gamma reduced	6,652	45,816	72	3,311,285	1,606,572	5,015,998	1.1%
Gamma electric only	6,851	22,255	122	2,724,567	1,600,002	3,849,132	1.8%
Wave 1 dual fuel	6,667	238,676	107	25,507,388	19,997,071	31,017,706	1.6%
Wave 1 electric only	7,446	21,905	91	1,996,841	-116,963	4,110,645	1.2%
Wave 2 area 7	5,783	56,541	105	5,920,153	4,194,618	7,645,687	1.8%
Wave 2 non-area 7	6,371	218,209	116	25,277,063	19,608,977	30,945,150	1.8%
Wave 3	6,373	147,179	81	11,932,098	8,046,371	15,817,824	1.3%
Wave 4	5,870	125,392	58	7,313,374	4,137,045	10,489,703	1.0%
Wave 5	8,757	148,103	113	16,762,833	11,494,608	22,031,058	1.3%
Wave 6	6,088	223,081	55	12,289,867	7,271,775	17,307,960	0.9%
Wave 7	5,600	142,483	44	6,302,943	4,110,518	8,495,368	0.8%
Gas (therms)							
Beta	705	40,238	6	237,774	126,933	348,615	0.8%
Gamma standard	403	45,974	2	95,369	17,897	172,841	0.5%
Gamma reduced	403	46,173	2	90,845	13,595	168,094	0.5%
Wave 1 dual fuel	417	239,367	3	782,358	512,797	1,051,920	0.8%
Wave 2 area 7	467	56,707	5	268,269	175,283	361,254	1.0%
Wave 2 non-area 7	424	218,695	3	668,799	366,719	970,880	0.7%
Wave 3	423	147,762	2	316,990	138,616	495,364	0.5%
Wave 4	389	125,720	2	277,747	131,272	424,221	0.6%
Wave 5	487	147,813	3	429,848	206,348	653,347	0.6%
Wave 6	392	225,561	2	488,975	247,462	730,488	0.6%
Wave 7	280	142,220	1	212,156	93,326	330,986	0.5%

Note: The average number of treatment participants are reported to indicate wave size. Total unadjusted savings are based on monthly treatment counts.

Figure 5-2 shows the historical electric and gas savings trends for all PG&E HER waves. In general, the electric savings show a similar pattern of ramping up over time whereas gas savings do not exhibit a consistent ramp-up period. The beta wave targeted the highest usage quartile, the gamma waves targeted all usage quartiles, and waves 1 through 6 targeted the highest 3 usage quartiles. When we compare savings for wave 1 to 6, which target the same usage quartiles, we note later waves (waves 3 to 6) have lower savings (averaging 1%) than earlier waves (waves 1 and 2, with 1% average savings).

Figure 5-2. PG&E unadjusted percent electric and gas savings over time



5.2 Joint savings: downstream programs

Downstream joint savings are identified by comparing savings of the treatment and control groups from downstream program installations. These savings from measure installations build up over time in the post-treatment period. If the HER program also motivates increased participation in other PG&E programs, then the treatment group downstream savings will accrue faster than the control group. The difference in savings between the treatment and control groups represents the savings jointly attributable to both the HER program and other downstream programs.

Figure 5-3 through Figure 5-5 provide the estimates of average joint electric and gas savings per customer in kWh, and therms, respectively. The majority of the waves produced positive and relatively small joint savings per household that do not exceed 11 kWh. All waves produced statistically insignificant therm savings that do not exceed 1 therm per household; in fact, no wave has joint downstream HER savings that exceed a fraction of a therm.

Figure 5-3. PG&E electric downstream joint savings per household per year

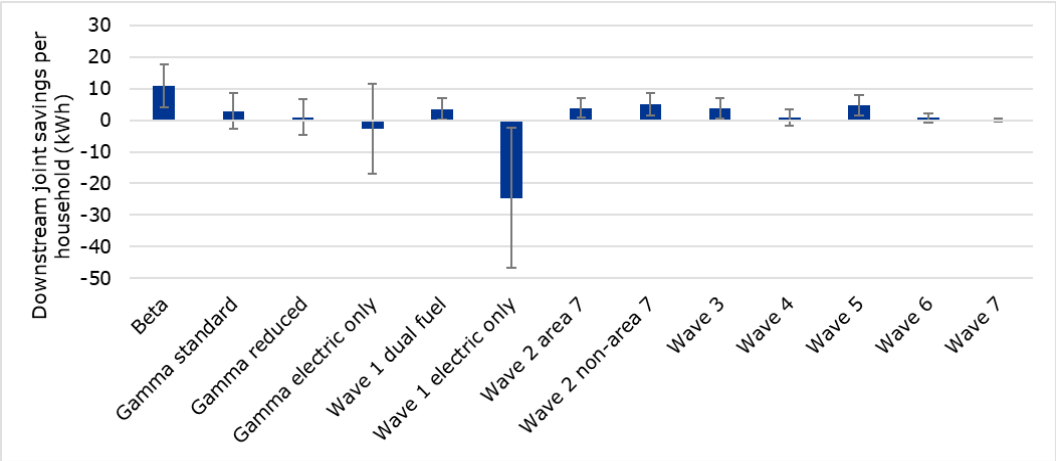
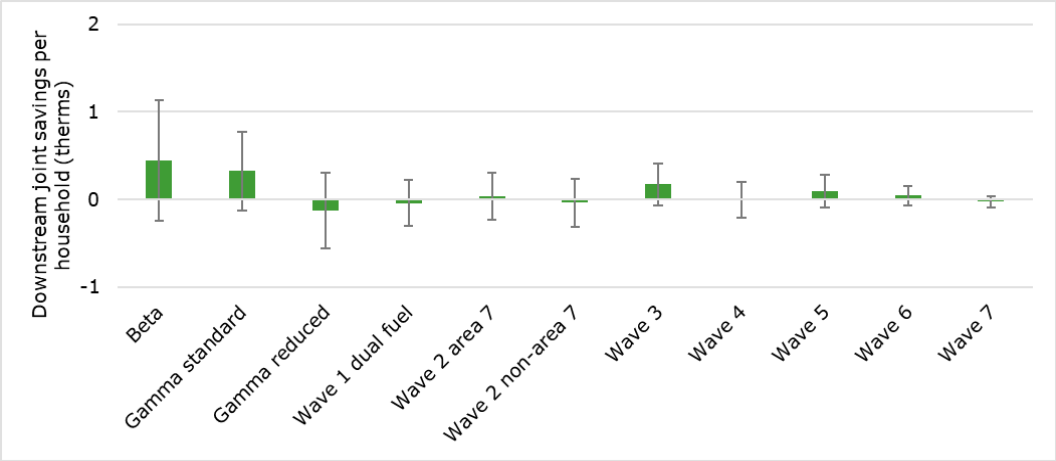


Figure 5-4. PG&E gas downstream joint savings per household per year



The issue of potential double counting also applies to demand impacts to the extent that HER programs successfully motivate increased uptake in other energy efficiency programs and those programs claim demand savings. DNV GL calculated joint savings that are attributed to downstream rebated measures by using deemed demand values contained in downstream rebate tracking data and only by using those measures installed prior to August 30, 2017, the first day of the most common heat wave in 2017.

Figure 5-5 shows the per-household downstream kW savings per household. Together these figures indicate the presence of limited joint savings from increased uptake of downstream rebate program due to HER among the treatment group in 2017.

Figure 5-5. PG&E downstream joint peak demand reduction per household per year

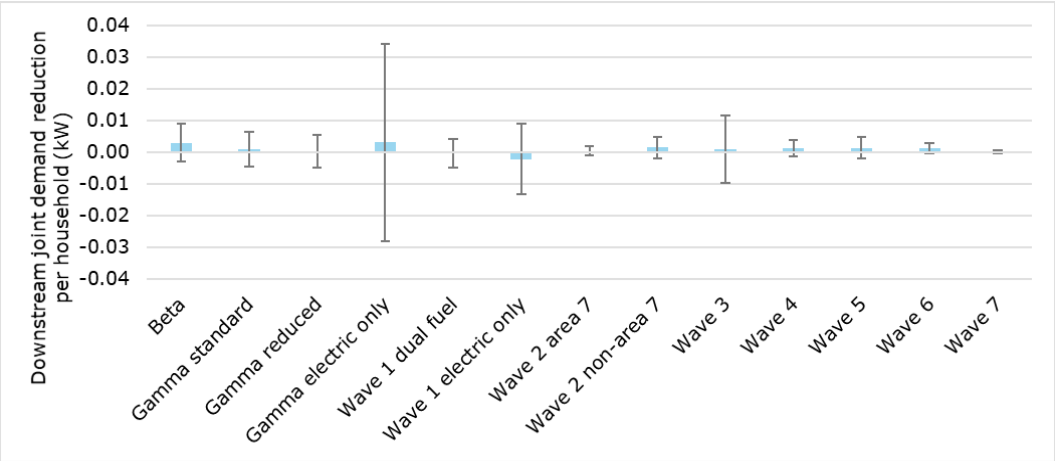


Table 5-2 summarizes the total downstream joint savings for PG&E HER participants. In total, PG&E HER participants generated 4,285 MWh, 82,266 therms, and 1.3 MW of downstream rebate savings due to HER.

Table 5-2. Total PG&E downstream joint savings by wave

Wave	Electric (kWh)	Gas (therms)	Peak Demand (kW)
Beta	438,425	17,627	118.2
Gamma standard	129,351	14,670	35.6
Gamma reduced	42,975	0	8.4
Gamma electric only	0		66.1
Wave 1 dual fuel	839,882	0	0.0
Wave 1 electric only	0		0.0
Wave 2 area 7	218,567	2,011	16.0
Wave 2 non-area 7	1,095,023	0	303.1
Wave 3	562,713	25,169	114.2
Wave 4	112,477	0	155.7
Wave 5	684,126	13,837	191.5
Wave 6	154,552	8,952	256.2
Wave 7	6,498	0	0.0

5.3 Joint savings: upstream programs

Upstream joint savings are like downstream joint savings, except that upstream savings are not tracked at the customer level. PG&E upstream savings still represent a source of savings that the HER program could potentially double count. Unlike tracked programs, it is not possible to directly compare all treatment and control group member activity. This makes it more challenging to determine if the HER program does increase savings in upstream programs.

The alternative to the downstream census-level approach is to do a comparison of treatment and control group uptake of the upstream program measures on a sample basis. This approach also takes advantage of the RCT experimental design that provides the structure to produce an un-biased estimate of upstream savings. In 2017, DNV GL conducted an online survey to assess uptake of upstream measures (specifically, CFLs and LEDs) due to HER. The surveys included samples of treatment and control customers from the PG&E HER program.

Table 10-9 in Appendix D presents the uplift of CFL and LEDs for each of PG&E's experimental waves. The table includes the results of the HER uplift study. These results show seven of PG&E's HER waves had CFL bulb uplifts ranging from 0.02 to 1.09 bulbs. In addition, 6 of PG&E's HER waves had 0.16 to 1.95 excess LED bulb purchase due to HER. No adjustments due to upstream joint savings are applied to waves with negative uplift.

Table 5-3 shows the kWh joint savings estimates per household. The total upstream joint savings per household range from 13.4 kWh to 0.4 kWh. HER program savings are adjusted downwards by the upstream joint savings amounts for these waves. Only two waves (wave 4 and 7) had no upstream joint savings that can be attributed to HER uplift. No adjustments due to upstream joint savings are applied to program savings for these two waves.

The replacement of inefficient lighting measures with efficient lamps is associated with an increase in heating load due to lower heat emissions from CFLs and LEDs. These interactive effects translate to a gas penalty that would have been double counted by HER. Table 5-4 gives total interactive therm effects by

wave. Negative numbers are subtracted from unadjusted gas savings to remove the gas penalty associated with the removal of electric joint savings from upstream programs.

Table 5-3. PG&E upstream joint savings per household per year

Wave	Upstream Joint Savings per Household per Year				
	Electric (kWh)			Interactive Effects (therms)	Peak Demand (kW)
	CFL	LED	Total		
Beta	9.0	1.3	10.3	-0.3	<0.1
Gamma standard	9.2	-0.7	8.5	-0.2	<0.1
Gamma reduced	8.4	0.3	8.7	-0.3	<0.1
Gamma electric only	7.2	6.3	13.4	NA	<0.1
Wave 1 dual fuel	7.0	5.6	12.5	-0.3	<0.1
Wave 1 electric only	7.3	4.5	11.9	NA	<0.1
Wave 2 area 7	1.6	-1.3	0.3	<-0.1	<0.1
Wave 2 non-area 7	0.0	4.1	4.0	-0.1	<0.1
Wave 3	0.9	1.2	2.1	-0.1	<0.1
Wave 4	-0.8	-0.4	0.0	0.0	0
Wave 5	0.8	-0.4	0.4	<-0.1	<0.1
Wave 6	0.8	0.1	0.9	<-0.1	<0.1
Wave 7	-0.1	-0.9	0.0	0.0	0

Overall, total upstream joint savings for program year 2017 are 6214 MWh and 0.4 MW (Table 5-4).

Table 5-4. PG&E total upstream joint savings

Wave	Total Upstream Joint Savings		
	Electric (kWh)	Interactive Effects (therms)	Peak Demand (kW)
Beta	414,062	-11,951	22.0
Gamma standard	387,850	-11,403	20.1
Gamma reduced	397,812	-11,743	21.0
Gamma electric only	299,508	NA	18.8
Wave 1 dual fuel	2,986,045	-80,313	194.8
Wave 1 electric only	258,809	NA	16.2
Wave 2 area 7	17,231	-1,394	0.1
Wave 2 non-area 7	880,027	-23,887	66.6
Wave 3	311,909	-8,630	23.0
Wave 4	0	0	0
Wave 5	62,970	-1,677	5.7
Wave 6	198,135	-4,352	17.3
Wave 7	0	0	0

5.4 Demand savings estimates

Peak demand savings estimates are based on peak period (heat wave) definitions. The period that defines peak demand conditions used to estimate peak demand reductions is presented in section 5.4.1. Peak demand reductions for PG&E's HER waves are presented in section 5.4.2.

5.4.1 Heat waves

Using hourly temperature data from weather stations across PG&E's service territory, DNV GL identified heat wave periods for the summers of 2011 – 2017. The 3-day heatwave in 2017 fell on August 30 – September 1.

Table 5-5 shows the 3-day heatwaves based on DEER definition for the pre- and post-period of the HER participants.

Table 5-5. PG&E DEER Heatwaves

Wave	DEER Heatwave			
	Pre-Period			2017 Post-Period
Beta	6/20/2011	-	6/22/2011	8/30/2017 - 9/1/2017
Gamma standard	6/20/2011	-	6/22/2011	
Gamma reduced	6/20/2011	-	6/22/2011	
Gamma electric only	6/20/2011	-	6/22/2011	
Wave 1 dual fuel	6/20/2011	-	6/22/2011	
Wave 1 electric only	6/20/2011	-	6/22/2011	
Wave 2 area 7	8/13/2012	-	8/15/2012	
Wave 2 non-area 7	8/13/2012	-	8/15/2012	
Wave 3	8/13/2012	-	8/15/2012	
Wave 4	7/1/2013	-	7/3/2013	
Wave 5	7/30/2014	-	8/1/2014	
Wave 6	7/30/2014	-	8/1/2014	
Wave 7	9/26/2016	-	9/28/2016	

5.4.2 Peak demand reductions

Peak demand savings are calculated using a difference-in-differences modeling framework. This approach involves identifying the peak period during the pre-period in addition to the peak period during the program year being evaluated. A difference-in-differences approach is a more appropriate method for controlling for pre-existing differences in demand between the treatment and the control groups.

Figure 5-6 shows unadjusted peak demand reductions per household by wave along with their confidence intervals. The Beta wave produced the highest amount of kW savings while half of the waves produced statistically insignificant savings.

Figure 5-6. PG&E unadjusted peak demand reduction per household per year

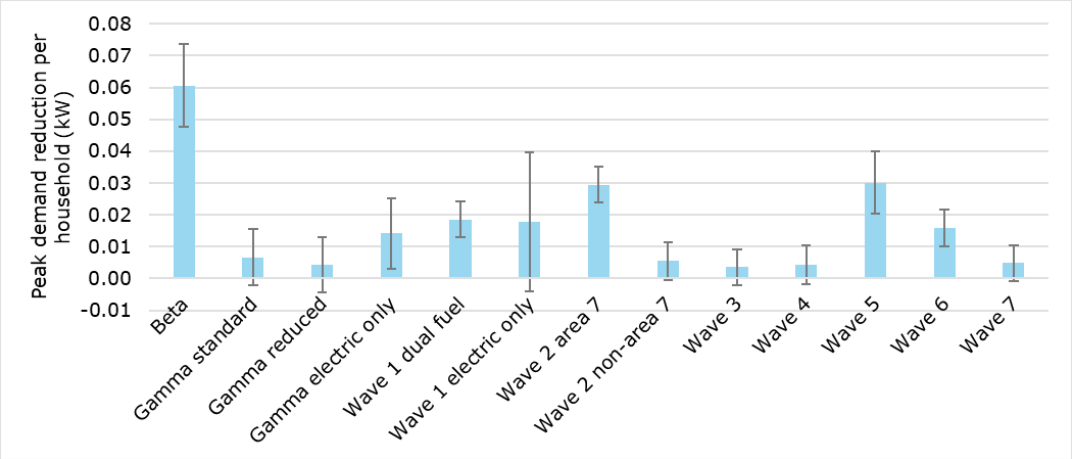


Table 5-6. shows total unadjusted peak demand reductions per wave. In total, PG&E HER participants saved 20.5 MW during the program year 2017.

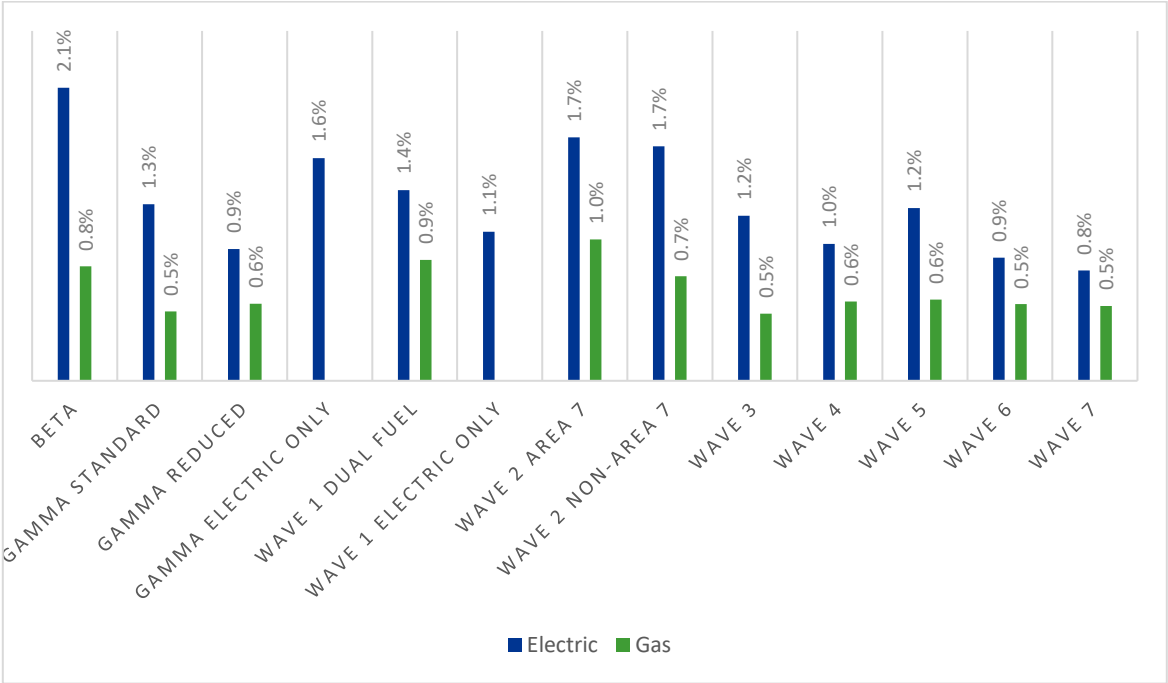
Table 5-6. PG&E total unadjusted peak demand reduction

Wave	Active Accounts during Peak Period (Aug. 30 - Sept. 1, 2017)	Total Peak Reduction (kW)	Lower Bound 90% CI	Upper Bound 90% CI
Beta	39,824	2,414.7	1,893.5	2,935.8
Gamma standard	45,465	305.0	-90.2	700.2
Gamma reduced	45,547	194.1	-199.0	587.3
Gamma electric only	22,008	311.9	67.2	556.6
Wave 1 dual fuel	236,992	4,378.7	3,054.6	5,702.8
Wave 1 electric only	21,663	386.7	-86.6	860.1
Wave 2 area 7	56,233	1,656.9	1,347.3	1,966.6
Wave 2 non-area 7	216,553	1,190.2	-101.7	2,482.1
Wave 3	145,578	512.7	-292.2	1,317.6
Wave 4	123,506	535.7	-234.1	1,305.5
Wave 5	145,781	4,392.4	2,981.9	5,802.9
Wave 6	219,564	3,474.9	2,216.4	4,733.4
Wave 7	143,827	697.8	-113.6	1,509.3

5.5 Total program savings

DNV GL determines total program results based by combining household savings and the number of treatment households in each of PG&E's HER waves. Adjusted household electric and gas savings as a percent of baseline use range from 1% to 2% for electric and 0.5% to 1% for gas (Figure 5-7). Electric savings are in the range of findings for behavioral programs have typically saved 1% to 3% of energy use. Gas savings are lower than electric savings, probably indicating that gas consumption has elements that are less amenable to behavioral changes. More details on per household and total savings by wave can be found in Table 10-13 and Table 10-14 in Appendix E.

Figure 5-7. PG&E percent electric and gas savings by wave



PG&E's HER residential customers saved a total of 122 MWh, 3,942,213 therms and 18.8 MW in program year 2017. These findings are summarized in Table 5-7. and Figure 10-2 at the program level. Total adjusted values reflect savings that can be directly attributed only to HER.

Table 5-7. PG&E total savings for the 2017 HER programs

Type of Savings	Total Program Savings
Electric (kWh)	
Unadjusted	132,524,601
Joint Downstream	4,284,589
Joint Upstream	6,214,359
Adjusted	122,025,652
Gas (therms)	
Unadjusted	3,869,129
Joint Downstream	82,266
Joint Upstream	-155,350
Adjusted	3,942,213
Peak Demand (kW)	
Unadjusted	20,451.7
Joint Downstream	1,265.1
Joint Upstream	405.7
Adjusted	18,780.9

6 SCE IMPACT RESULTS

6.1 Unadjusted kWh savings estimates

Figure 6-1 shows the unadjusted electric savings per household for the legacy wave (Opower 2) along with the new waves (Opower 3, 4, and 5). The savings for Opower 2 through 4 cover 1 year, but Opower 5's savings cover only 9 months.

The magnitude of savings per household is closely tied to baseline energy use in that the higher the baseline energy consumption the higher the savings per household among SCE's HER households. Opower 4 has the highest energy baseline use and savings per household at 153 kWh. This pattern is quite clear in the SCE HER program. Opower 5 had been in the field less than a full year in 2017 and has measured per household savings that are the lowest. Based on experience with other SCE HER waves, generated savings are expected to be in line with other waves in the coming years.

Figure 6-1. SCE unadjusted electric savings per household per year

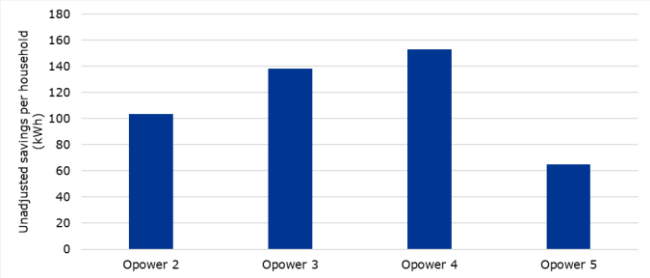


Table 6-1 presents unadjusted savings as a percent of baseline use. Percent savings for SCE's HER program are between 1% to 2% and reflect outcomes that are in the range of typical HER savings.

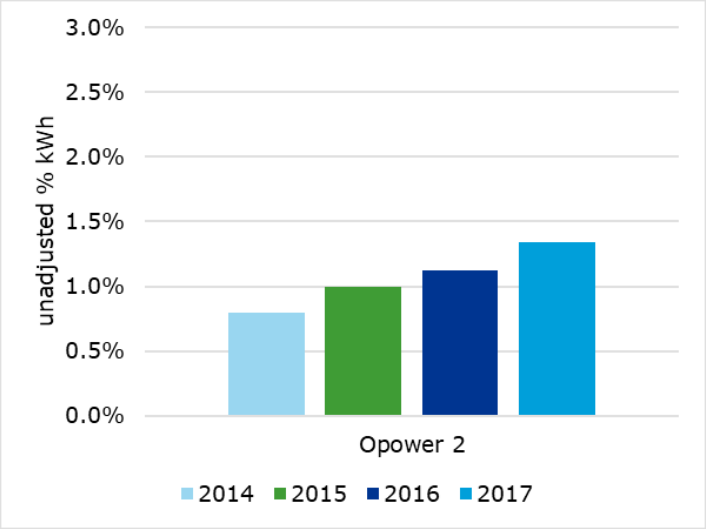
Table 6-1. SCE unadjusted electric savings

Wave	Baseline Consumption	Average Treatment Participants	Unadjusted Savings				
			Per Household per Year	Total	Lower Bound 90% CI	Upper Bound 90% CI	Percent Savings
Opower 2	7,716	62,061	103	6,411,910	5,171,108	7,652,712	1.3%
Opower 3	8,819	142,647	138	19,739,627	16,978,408	22,500,846	1.6%
Opower 4	12,454	226,975	153	34,738,526	27,772,504	41,704,549	1.2%
Opower 5	7,234	562,914	65	36,699,488	30,015,146	43,383,831	0.9%

Note: We report the average number of treatment participants as a reference point for the size of the wave only. We calculate total unadjusted savings using monthly treatment counts, not the annual number of treatment participants.

Among SCE's HER waves, Opower 2 has been in the field the longest. Its savings over time are still trending upwards (Figure 6-2). Increasing trends in savings for SCE's HER waves are expected in the coming few program cycles.

Figure 6-2. SCE Opower 2 unadjusted electric percent savings over time



6.2 Joint savings: downstream programs

Downstream joint savings are identified by comparing savings of the treatment and control groups from downstream program installations. These savings from measure installations build up over time in the post-treatment period. If the HER program also motivates increased participation in other SDG&E programs, then the treatment group downstream savings will accrue faster than the control group. The difference in savings between the treatment and control groups represents the savings jointly attributable to both the HER program and other downstream programs.

Figure 6-3 and Figure 6-4 provide the estimates of average joint electric and peak demand savings per customer in kWh and kW, respectively. These figures indicate that HER has encouraged notable joint downstream savings for Opower 2, but not for the rest of SCE's HER waves in 2017.

Figure 6-3. SCE electric downstream joint savings per household per year

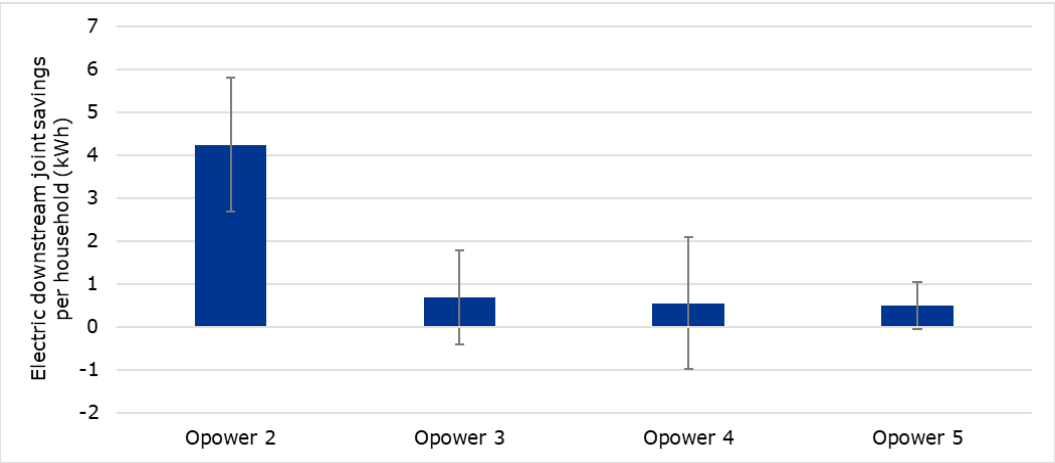


Figure 6-4. SCE downstream joint peak demand reduction per household per year

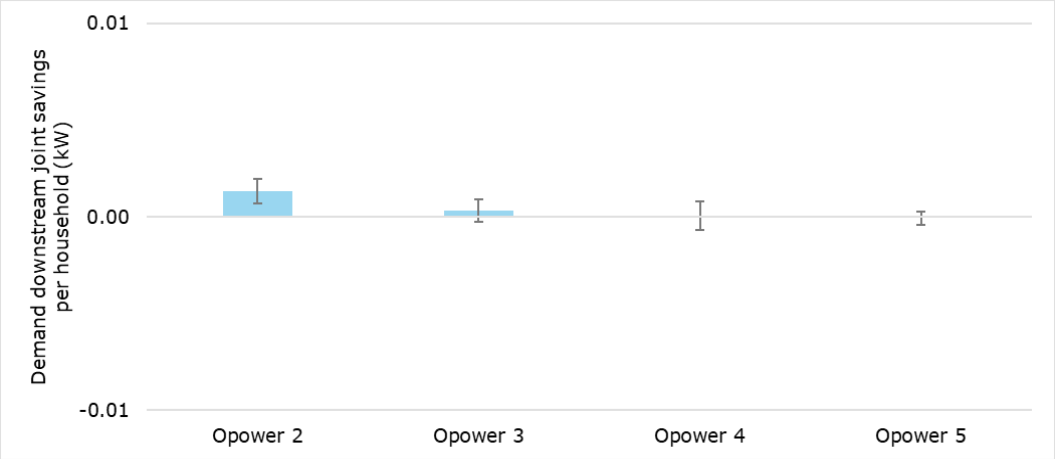


Table 6-2 provides total downstream joint savings by wave. SCE HER treatment groups had 761 MWh and 0.1 MW of peak demand joint savings in 2017 motivated by the HER program.

Table 6-2. Total SCE downstream joint savings by wave

Wave	Electric (kWh)	Peak Demand (kW)
Opower 2	262,571	80.7
Opower 3	97,369	43.8
Opower 4	121,308	13.0
Opower 5	280,361	0

6.3 Joint savings: upstream programs

Upstream joint savings are like downstream joint savings, except that upstream savings are not tracked at the customer level. SCE upstream savings still represent a source of savings that the HER program could potentially double count. Unlike tracked programs, it is not possible to directly compare all treatment and control group member activity. This makes it more challenging to determine if the HER program does increase savings in upstream programs.

The alternative to the downstream census-level approach is to do a comparison of treatment and control group uptake of the upstream program measures on a sample basis. This approach also takes advantage of the RCT experimental design that provides the structure to produce an un-biased estimate of upstream savings. In 2017, DNV GL conducted an online survey to assess uptake of upstream measures (specifically, CFLs and LEDs) due to HER. The surveys included samples of treatment and control customers from the SCE HER program.

Table 10-10 in Appendix D presents the uplift of CFL and LEDs for each of SCE's experimental waves. The table includes the results of the HER uplift study. These results show there were uplifts of 1.09 and 0.57 CFLs for Opower 2 and Opower, and 1.22 of LEDs for Opower 4 and of less than 0.2 of LEDs for Opower 2 and Opower 5. The rest of the waves had negative bulb uplift indicating that the control group purchased and installed more efficient bulbs than the treatment group.

Table 6-3 shows the kWh joint savings estimates per household. The total upstream joint savings per household are 22.1 kWh per household for Opower 2 and 10.4 for Opower 3. The upstream joint savings per household the rest of SCE's waves are negative, which indicates that the control group purchased and installed more bulbs than the treatment group. No adjustments due to upstream joint savings are applied to program savings for these waves.

Table 6-3. SCE upstream joint savings per household per year

Wave	Upstream Joint Savings per Household			
	Electric (kWh)			Peak Demand (kW)
	CFL	LED	Total	
Opower 2	20.6	1.5	22.1	<0.1
Opower 3	11.5	-1.1	10.4	<0.1
Opower 4	-14.8	4.4	0.0	0.0
Opower 5	-0.8	0.1	0.0	0.0

Overall, total program joint savings due to participation in upstream program are 2849 MWh and 0.2 MW program year 2017 (Table 6-4).

Table 6-4. SCE total upstream joint savings

Wave	Total Upstream Joint Savings	
	Electric (kWh)	Peak Demand (kW)
Opower 2	1,371,301	109.7
Opower 3	1,477,619	112.1
Opower 4	0	0
Opower 5	0	0

6.4 Demand savings estimates

The heat wave definitions, based on DEER criteria, used to estimate peak demand reduction from the HER program are discussed in section 6.4.1. Section 6.4.2 provides estimates of peak demand reduction for SCE's 2017 HER program.

6.4.1 Heat waves

DNV GL identified the 2017 heat waves using weather data from NOAA that contained hourly temperatures from weather stations across the SCE service territory from 2013 – 2017. The three-day heat wave for 2017, August 30 through September 1, 2017, coincided with those PG&E and SDG&E (Table 6-5).

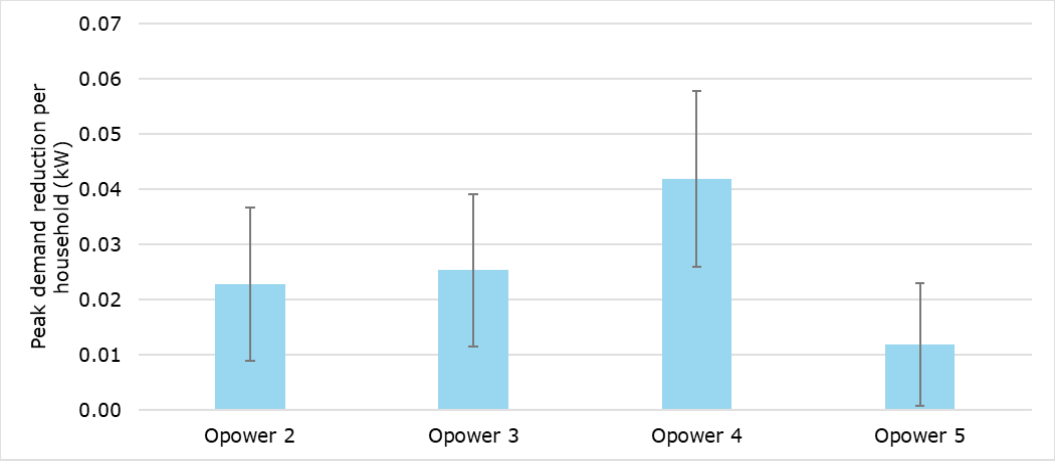
Table 6-5. SCE DEER Heatwaves

Wave	DEER Heatwave			
	Pre-Period			2017 Post-Period
Opower 2	9/4/2013	-	9/6/2013	8/30/2017 - 9/1/2017
Opower 3	9/15/2014	-	9/17/2014	
Opower 4	9/8/2015	-	9/10/2015	
Opower 5	7/20/2016	-	7/22/2016	

6.4.2 Peak demand reductions

All 4 waves produced statistically significant per-household kW savings. However, these savings are a small fraction of a kWh. For instance, Opower 4's estimated peak demand reduction amounted to 0.04 kW while Opower 5's estimated peak demand reduction per household totaled 0.01 kW (Figure 6-5).

Figure 6-5. SCE unadjusted peak demand reduction per household per year



The estimated peak demand reductions per household for SCE HER waves are used to compute total peak demand reduction. In program year 2017, SCE HER participants generated 21 MW of savings (Table 6-6).

Table 6-6. SCE total unadjusted peak demand reduction

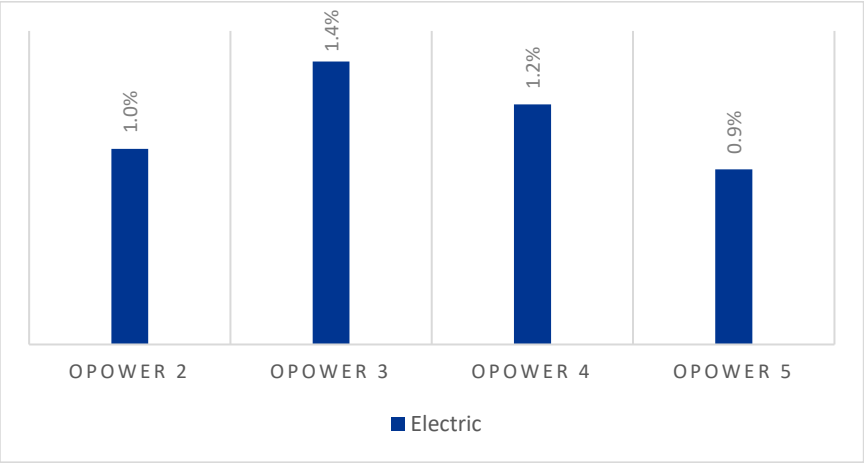
Wave	Active Accounts during Peak Period (Aug. 30 - Sept. 1, 2017)	Total Peak Reduction (kW)	Lower Bound 90% CI	Upper Bound 90% CI
Opower 2	61,647	1,402.0	548.4	2,255.7
Opower 3	141,364	3,580.5	1,623.6	5,537.4
Opower 4	223,652	9,350.0	5,797.8	12,902.2
Opower 5	564,760	6,734.9	461.9	13,007.9

6.5 Total Program Savings

Total HER savings in 2017 are based on total savings by wave. Total wave level savings reflect savings per household and the number of people that received HER in each wave. Further, program level totals reflect adjustment for any uplift in downstream and upstream programs.

This section presents adjusted program level savings. Figure 6-6 presents adjusted electric savings per household as a percent of baseline conditions. Electric savings from SCE's HER program produced between 1% and 2% of savings per household. Like the state's other HER programs, these findings are in line with savings that are achieve from such behavioral programs.

Figure 6-6. SCE percent electric savings by wave



Overall, SCE HER participants saved 93,979 MWh and 20.7 MW in 2017 (Table 6-7 and Figure 10-3). Estimated peak demand savings by wave can be found in Table 10-15 and Table 10-16.

Table 6-7. SCE total savings for the 2017 HER programs

Type of Savings	Total Program Savings
Electric (kWh)	
Unadjusted	97,589,552
Joint Downstream	761,608
Joint Upstream	2,848,920
Adjusted	93,979,024
Peak Demand (kW)	
Unadjusted	21,067.4
Joint Downstream	137.4
Joint Upstream	221.8
Adjusted	20,708.2

7 HER SURVEY

The main objective of the HER survey was to inform the efficient lamp uplift adjustment to HER impact evaluation savings estimates due to the overlap with upstream lighting programs. The survey also included questions that aimed to understand customers' energy usage behavior, adoption of emerging technologies and smart energy offers, and potential differences, if any, between treatment and control.

7.1 Survey approach

This section summarizes survey approach including mode choice, survey design, sample disposition, and sample weighting.

7.1.1 Survey mode and design

DNV GL used a web survey for the HER impact evaluation. All treatment and control group customers for whom email addresses are known were invited to participate in the survey. DNV GL employed the same approach for the 2015 impact evaluation and this provided the evaluation team the ability to quickly deliver results. Customers received invitations with a hyperlink containing customized household information which enabled service address verification. The survey included the following topics:

- **Lamp purchase**
  - Quantity of light bulbs purchased in the past 12 months by bulb type (e.g. LED, CFL)
  - Bulb installation rates and how non-installed bulbs are handled
  - Reasons for bulb replacement and type of bulbs replaced
  - Awareness of PA discounts on energy efficient lightbulbs
- **Household Changes**
  - Energy usage behavior changes related to lighting, heating, cooling, pool, spa etc.
  - Changes in occupancy and living space
  - Installation of technologies such as a smart thermostat or home automation systems
- **Adoption of Smart Energy Offers and Emerging Technologies**
  - Universal Audit Tool, Critical Peak Pricing, Time-of-Use rates
  - Smart LEDs, thermostats, appliances, home hubs, and battery storage
  - EVs, Solar PV, heat pumps, heat pump water heaters
- **Home Energy Report Experience (treatment group customers only)**
  - HER recall, unaided and aided
  - Time spent reviewing their HER
  - Undertaking energy efficiency actions recommended by HER
  - Reaction to HER
- **Demographics**
  - Dwelling vintage
  - Household size and seasonal changes in occupancy
  - Education and Income

7.1.2 Sample disposition

The HER survey for PY 2017 was fielded using an online software service provider (Form.com). The survey was active from early December 2018 to mid-January 2019. A copy of the HER survey may be found in Appendix G. Emails were issued in batches ranging from 10,000 to 200,000 over the course of ten days. The team included incentives to boost response rates and the invitation informed respondents that they would be entered into a drawing for a $100 pre-paid incentive card upon completion of the survey. Respondents were reminded to participate in the survey once during the field period.

The sample frame for the study was all customers in the HER program for whom email addresses were available. The starting sample was 2,048,554, of which only 53% (1,095,800) was delivered by the survey platform while the remaining invitations (47%) were blocked due to the high volume of email received from a single IP address by email service providers.[14] Additionally, 27% of all delivered survey invitations bounced due to invalid email addresses thus reducing the total eligible sample to 544,770. The final response rate was 3.6%. Details are as shown in Table 7-1.

Table 7-1.HER survey sample disposition

	PG&E	SCE	SDG&E	Total	Percentage
Starting sample				2,048,554	
Delivered sample				1,095,800	53.5%
Bounced sample				551,030	26.9%
Total eligible sample				544,770	
Completed	7,928	4,324	3,745	15,997	2.94%
In-progress	1,767	918	818	3,503	0.64%
Total completed and in-progress	**9,695**	**5,242**	**4,563**	**19,500**	**3.58%**

7.1.3 Sample weights

In order to balance the survey sample to the population proportions by each PA, wave, and treatment and control combination, the team applied sample weights. Details of the weighting procedure may be found in Appendix H. No trimming of weights was required with the maximum weight, minimum weight, and the ratio of the maximum to minimum sample weight at 0.5, 1.8, and 3.5 respectively. Minimum cell size to which weights were applied was 94. This indicates a generally balanced survey sample requiring minor corrections for over and under representation thus reducing the design effect on the data and any potential inflation of standard errors for estimated statistics.

[14] High volume email traffic to recipients that used mail service providers Google and Yahoo/AOL resulted in mail service providers blocking the invitations issued from DNV GL's domain/from a single IP address, preventing the delivery of nearly one million emails during the field period. While separate surveys were fielded for each PA allowing tracking of completed surveys, the response rate is calculable overall and not by PA as survey platform forensics for (un)delivered messages looked across all 3 PAs' HER surveys with no breakdown available by PA.

7.2 Survey results

7.2.1 Sample characteristics

The HER program draws from specific segments of each PA's customer base which represent varying levels of energy consumption and demographics. As of December 2017, 37% of all active residential customer accounts in California are part of the HER program across PG&E, SCE, and SDG&E and several waves target higher energy usage quartiles. The evaluation team examined the total HER sample by treatment and control on key demographic characteristics and compared these against statewide statistics for California (Table 7-2).

Respondents to the HER survey live in larger homes, have higher incomes, and higher levels of education than the general population in the state. High energy usage, which is a factor in HER program sample design, is related to other demographic factors such as dwelling size which in turn is related to income and education. Survey findings presented in this report are representative of California's residential customers in the HER program and findings are not extendable to the whole population of the state's residential customers.

Table 7-2. Sample characterization

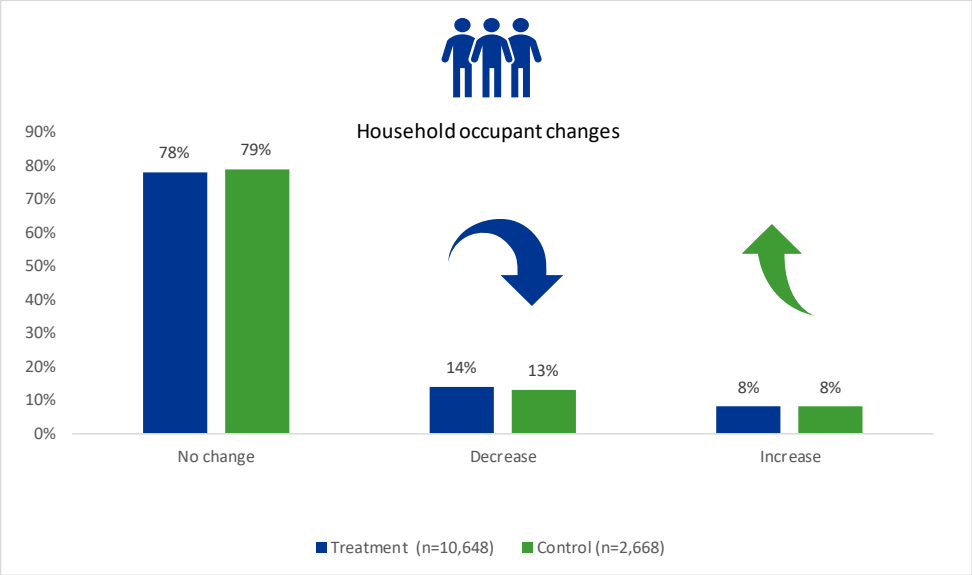
Demographic	CA	Treatment (n=11,987)	Control (n=2,987)
Income over $75,000	42%*	65%	68%*
Education – Bachelor's degree or higher	31%*	70%	70%
Number of members in the household	2.9	2.6	2.4
Number of bedrooms in home	2.6	4.1	3.8
Area of home (square feet)		1,937	1,772
Pre–1980 dwelling vintage		58%	62%*

Note: * Indicates statistically significant difference at the 95% confidence level between the treatment group and the control group or CA census data. A total of 15,575 respondents in the treatment group and 3,816 respondents in the control group completed the survey, although only 11,987 respondents in the treatment group and 2,987 respondents in the control group responded to the demographic questions.

The RCT design would lead us to expect similar demographic levels in the treatment and control groups. These results indicate statistically significant differences for income and dwelling vintage. These differences could reflect self-selection within treatment and control groups or differential response across waves or PAs.

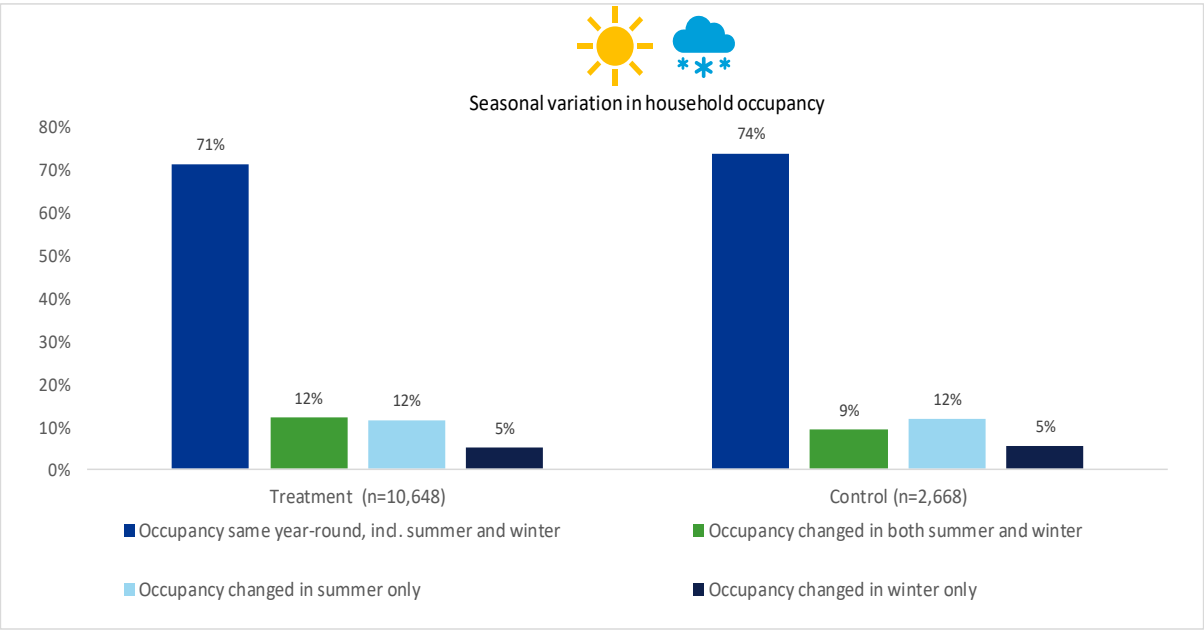
Research shows that home occupancy strongly influences household energy use. The survey asked respondents about the number of year-round occupants in the household in 2016, 2017, and 2018 which represented years prior to, during, and after the program year 2017. While four-fifths of all respondents reported no change in household size from 2016 to 2018, 8% reported an increase in household size and a relatively higher 14% reported a decrease (Figure 7-1). There are no significant differences in these occupancy trends by treatment and control.

Figure 7-1. Change in household size from 2016 to 2018



The survey probed respondents on seasonal changes in household occupancy in 2017 that may have resulted in their household size increasing or decreasing in summer or winter due to part-time residents who stayed or left for a month or more. Responses indicate that around three-fourths of all respondents indicated no seasonal changes in household occupancy (Figure 7-2). Customers in the treatment group reported changes in household size in both summer and winter at higher rates than those in the control group at 12% to 9% respectively, and comparable rates of change that were isolated to just summer or just winter at 12% and 5% each respectively.

Figure 7-2. Seasonal changes in household occupancy



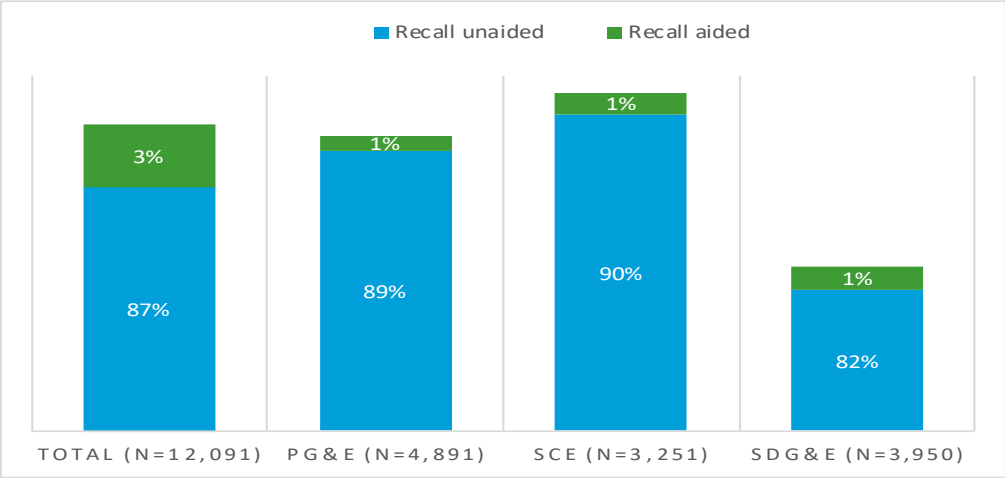
7.2.2 Customer experience with HERs

Results based on the customer experience (treatment group only) with the Home Energy Report (HER) are summarized in this section.

7.2.2.1 Recall of HER receipt

Treatment group respondents were asked if they received HERs. Respondents that said that they did not receive the reports or stated that they did not know, were aided with an image of the HERs sent by their PA. Figure 7-3 summarizes unaided and aided customer recall of receipt of HERs. Recall of receiving HERs is high for treatment group customers for all PAs, with the greatest recall among SCE respondents at 90%, closely followed by PG&E at 89%, and the lowest recall among SDG&E respondents at 82%. Aided recall ranged from 1% - 3%.

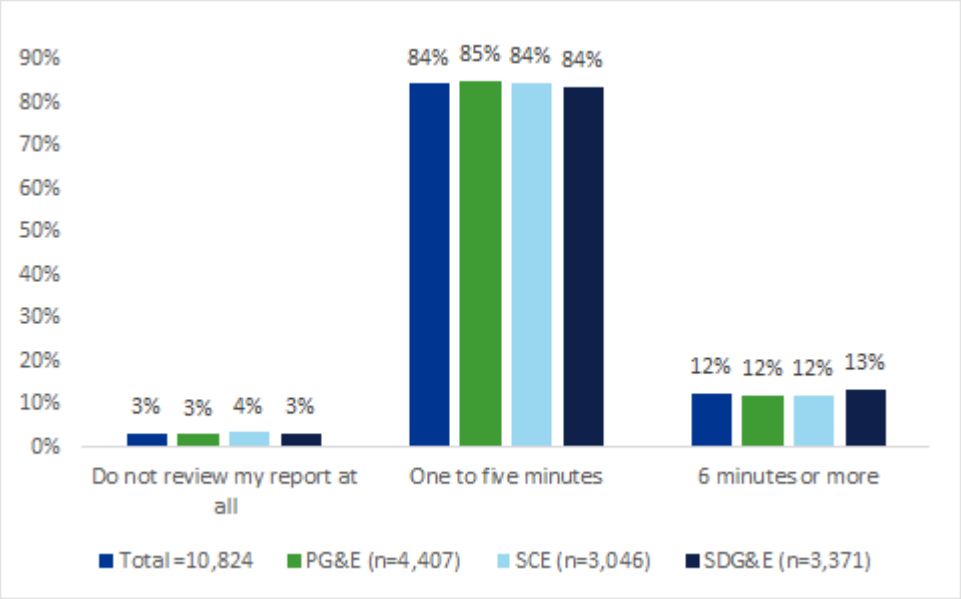
Figure 7-3. Recall of HER receipt



7.2.2.2 Time spent reviewing HERs

The survey asked treatment group customers who recalled receipt of HERs about the time they spent reviewing HERs (Figure 7-4). Results were identical across all utilities, with four-fifths indicating spending less than 5 minutes.

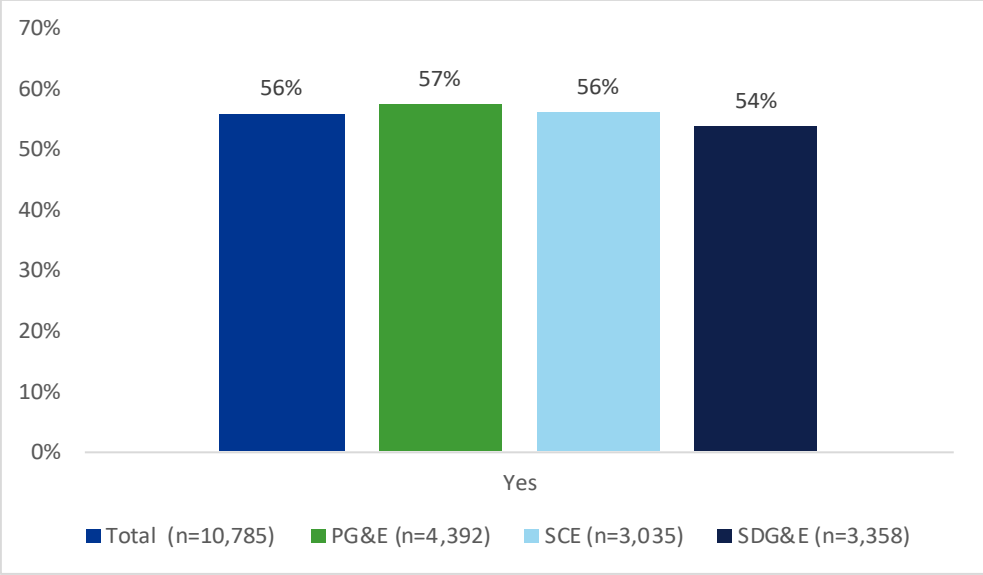
Figure 7-4. Time spent reviewing HERs



7.2.2.3 Recommendations for energy efficiency undertaken due to HERs

The survey asked respondents whether they had undertaken any energy efficiency actions recommended by the HERs such as changing the setpoint on their thermostat, installing a programmable or smart thermostat, caulking windows and doors to reduce leakage etc. As shown in Figure 7-5, more than half of all respondents (56%) stated that they undertook recommendations included in the HERs.

Figure 7-5. Customers undertaking recommendations from HERs

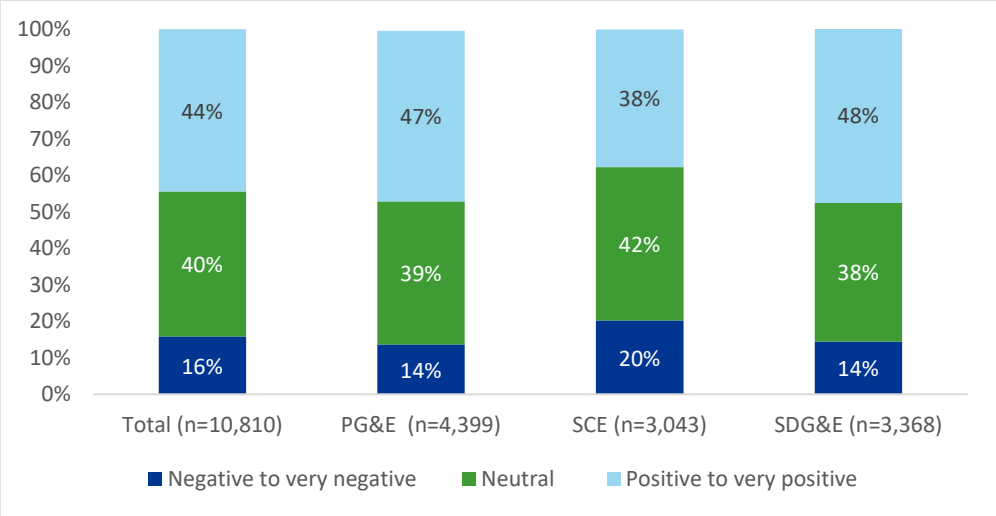


7.2.2.4 Reaction to HERs

The final question on the HER customer experience series asks respondents for their reaction to HERs on a scale ranging from very negative to very positive. Results show similar reactions to HERs among PG&E and

SDG&E respondents at 47% and 48%, while SCE's are notably lower with just 38% expressing a positive reaction (Figure 7-6).

Figure 7-6. Reaction to HERs



7.2.3 Efficient lamp uplift due to HERs

The survey asked HER survey respondents to indicate the number of CFL and LED lamps they purchased and how many of these purchased bulbs they installed. For PG&E and SCE, the treatment group has marginally higher purchases and installations of both CFLs and LEDs than the control group, but the difference is not statistically significant. For SDG&E, this difference is negative for both CFLs and LEDs indicating that control group respondents purchased and installed in marginally higher numbers than the treatment group, but this difference is not significant either. LED lamp purchases are significantly higher for SCE's treatment group customers compared to control group customers (Table 7-3 and Table 7-4).

Table 7-3. CFL purchases and installations by IOU for treatment and control group customers

PA	Purchased vs Installed CFLs	N Control	Average Control Lamps	N Treatment	Average Treatment Lamps	Difference (T-C)	Lower 90% Bound	Upper 90% Bound
PG&E	Purchased	689	4.93	1908	4.94	0.01	-0.28	0.31
	Installed	657	3.70	1820	3.79	0.09	-0.14	0.33
SCE	Purchased	225	5.13	1283	5.38	0.25	-0.27	0.77
	Installed	213	4.14	1227	4.25	0.12	-0.34	0.57
SDG&E	Purchased	169	4.96	976	4.56	-0.4	-0.94	0.13
	Installed	164	3.73	944	3.54	-0.18	-0.61	0.25

Table 7-4. LED purchases and installations by IOU for treatment and control group customers

PA	Purchased vs Installed LEDs	N Control	Average Control Lamps	N Treatment	Average Treatment Lamps	Difference (T-C)	Lower 90% Bound	Upper 90% Bound
PG&E	Purchased	1392	8.9	4059	8.97	0.06	-0.31	0.44
	Installed	1369	7.49	3993	7.56	0.07	-0.28	0.43
SCE	Purchased	416	8.23	2367	8.99	0.76	0.12	1.4
	Installed	405	7.15	2338	7.71	0.56	-0.05	1.17
SDG&E	Purchased	366	9.01	1961	8.43	-0.58	-1.28	0.13
	Installed	361	7.89	1933	7.34	-0.55	-1.22	0.12

The above results do not indicate a significant uplift. This result should be monitored. If future evaluations show a trend of insignificant uplift, the need for a survey among HER customers to assess uplift should be reconsidered.

7.2.4 Influence on energy use behavior due to HERs

Independent impact evaluations of the HER program across various utilities have shown consistent savings in the range of 1% - 3%. While the randomized control trial design of the experiment enables full program attribution of these savings estimated using a difference-in-difference model, it does not shed light on the source of the savings. The Home Energy Report survey aimed to gain insight into potential contributors of savings with the inclusion of questions related to changes in energy usage behavior, utility engagement, and adoption of energy related technologies.

The analysis explores the relationship between self-reported changes in energy use behavior, energy consumption, utility engagement, customer demographics, and technology adoption. Survey respondents were asked a series of questions to capture whether their actions would contribute to an increase or decrease in energy consumption related to end-uses such as lighting, heating, and cooling, among others. All respondents that reported any energy saving actions were then profiled in analysis that contrasts treatment and control group customers along several key dimensions (Table 7-5).

Treatment group customers who reported energy saving actions achieved significantly higher reductions in electric consumption. They also reduced the energy use intensity of their home in higher proportion than those in the control group. Contrasting treatment with control group customers reveals that they reported significantly higher engagement with their utility across programs like critical peak pricing, demand response, seasonal savings, and the universal audit tool. A significantly higher proportion of treatment group customers live in newer homes built after 1980 compared to customers in the control group. Higher proportions of treatment group customers report adopting emerging technologies like smart appliances, smart thermostats, and smart LEDs.

The customer profile of the treatment group that achieves significant reductions in electric consumption indicates a relatively more engaged and receptive customer group. While the differences are not dramatic between the two groups, they are statistically significant and shed light on the potential contributing factors that cumulatively result in the savings achieved by the HER program.

Table 7-5. Profile of customers reporting energy saving actions

	Control (n=1,162)	Treatment (n=5,861)
Energy consumption		
Pre-evaluation period electric consumption (kWh)	7,820	7,368
Percent reduction in electric consumption	15%	18%*
Energy Use Intensity (kWh/SQFT)	5.5	5.2*
Percent reduction in Energy Use Intensity (electric)	14%	18%*
Pre-evaluation period gas consumption (therm)	458	372
Percent reduction in gas consumption	13%	12%
Demographics		
Dwelling vintage – post 1980	44%	51%*
Education - college degree or higher	67%	69%
Utility engagement		
Familiarity with utility energy efficiency programs	60%	62%
Critical peak pricing programs	9%	11%*
Demand response programs	5%	7%*
Seasonal Savings	2%	3%*
Universal Audit Tool	7%	9%*
Technology adoption		
Smart thermostats	43%	45%
Smart LED bulbs	44%	47%
Smart appliances	26%	30%*

Asterisk (*) denotes significant difference at 90% confidence level.

8 ELECTRIFICATION TRENDS

8.1 Solar PV adoption

Rooftop solar installations are proliferating in California and the state's requirement to move to 100% renewable electricity by 2045, per the terms set forth in Senate Bill 100, will only accelerate this trend. Evidence of increasing solar adoption is revealed in the data used for the HER evaluation. The share of HER net-metered customers with solar PV is substantial, particularly for longer-running waves.

The charts below summarize the prevalence of net-metered customers by HER wave and program administrator (Figure 8-1 through Figure 8-3). Increased solar PV adoption has implications for future HER evaluations as billing data does not currently provide a measure of consumption that includes the share from self-generation.

Figure 8-1. PG&E net metered customers in 2017

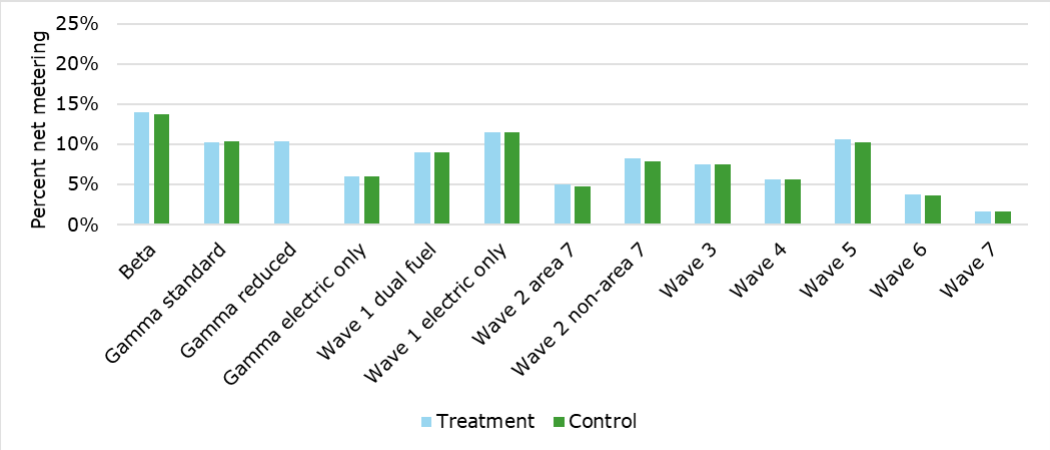


Figure 8-2. SCE net metered customers in 2017

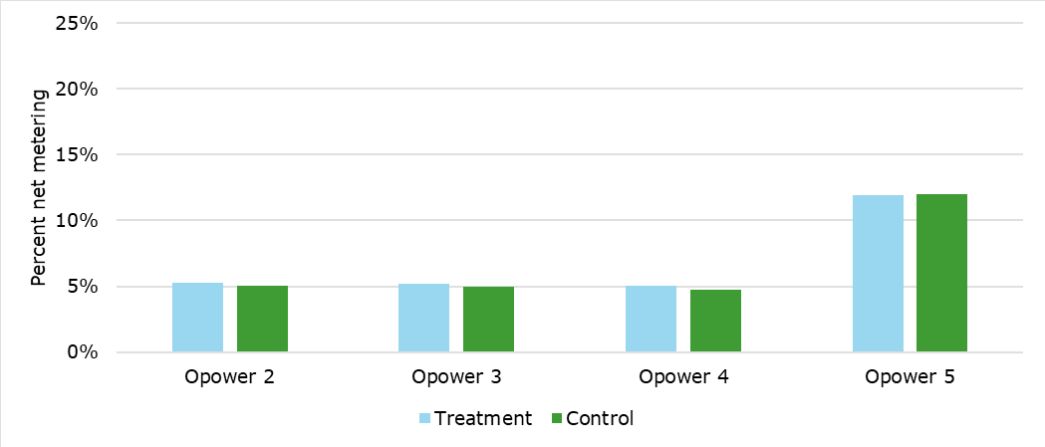
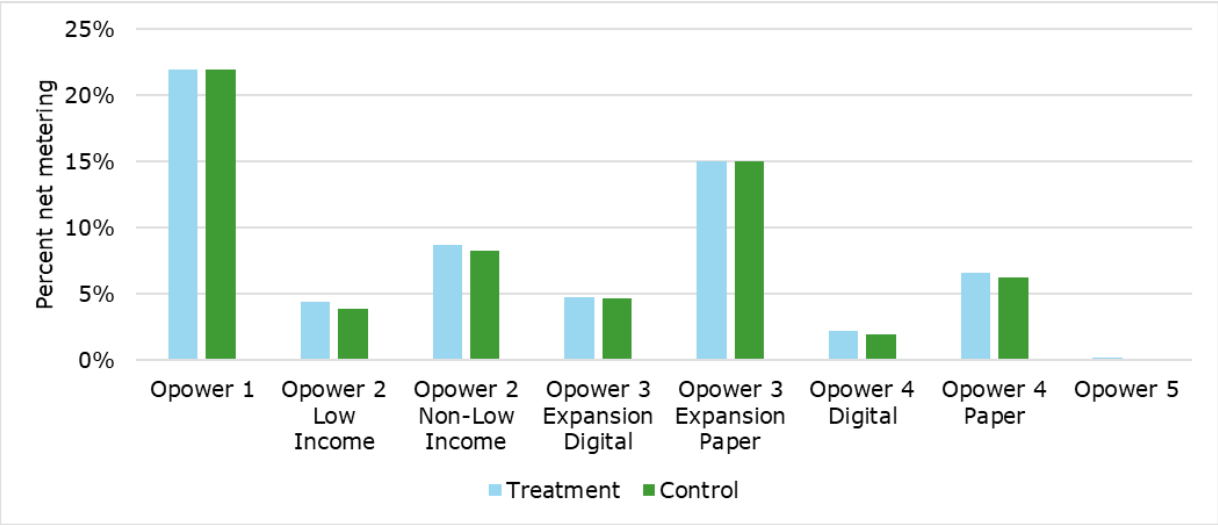


Figure 8-3. SDG&E net metered customers in 2017

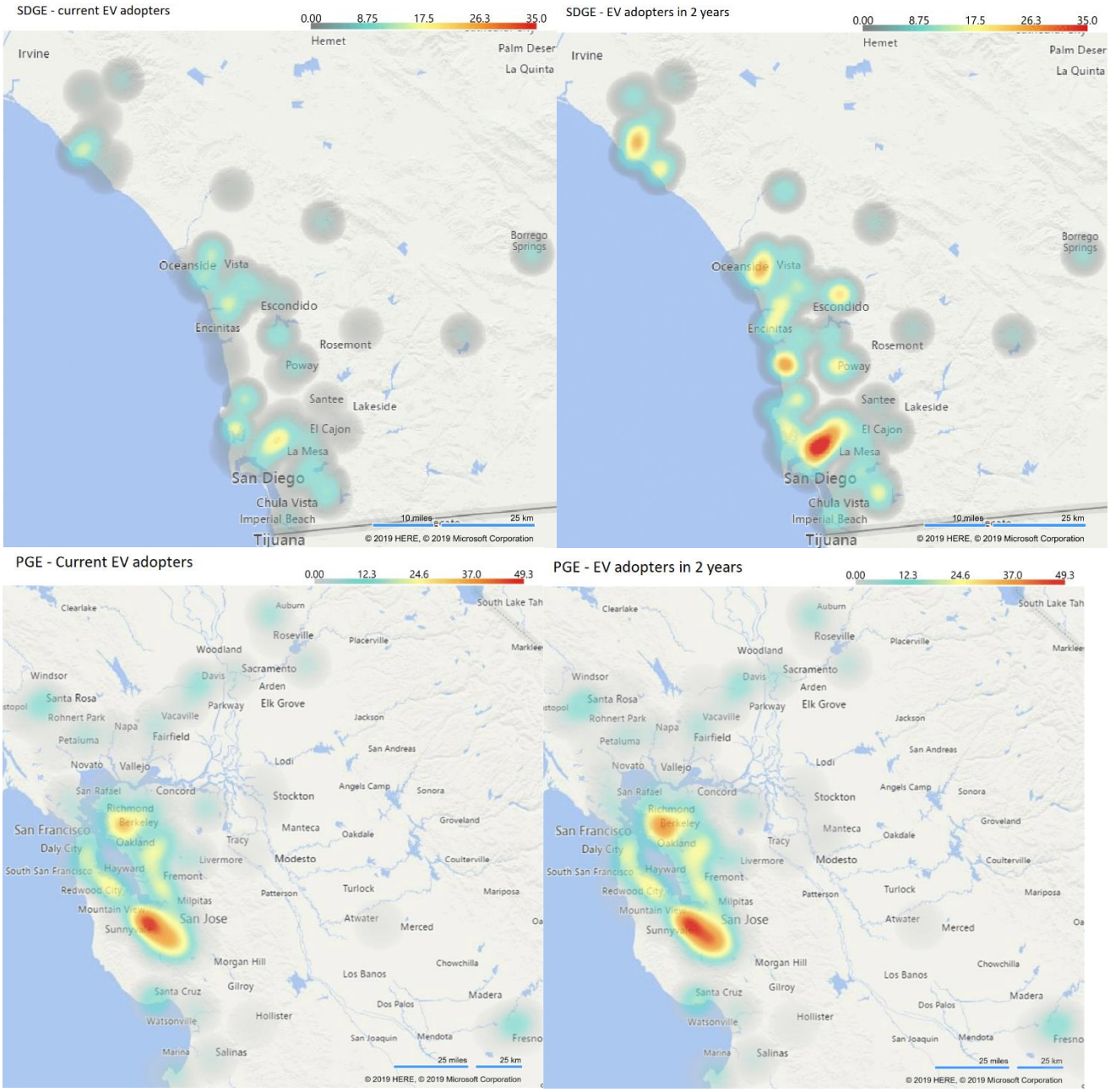


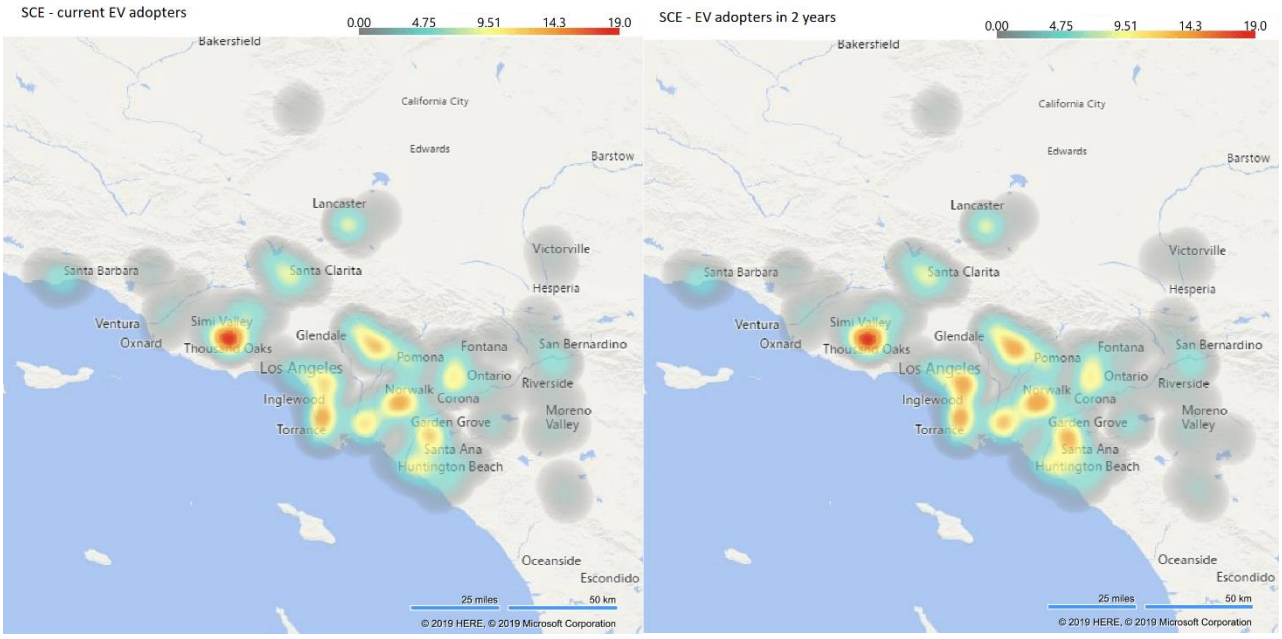
8.2 EV adoption

Like solar, improvements in battery technologies and the resultant advances in electric vehicles indicate that the market is poised for growth in the next decade with some estimates at 22% EV penetration by 2025 from less than 3% today. The evaluation team examined EV adoption based on responses to the HER survey to understand this trend in the context of the HER program.

Current adoption of EVs is at 7% based on responses to the HER survey and current owners of EVs indicated that 82% of their charging is done at home. 21% of customers without EVs indicated they would consider purchase or use of EVs in the next 2 years. The series of maps in Figure 8-4 represent current and future EV adopters based on responses to the HER survey and is indicative of potential locational trends in changes in customers' energy use.

Figure 8-4: EV adoption by PA - current and in 2 years

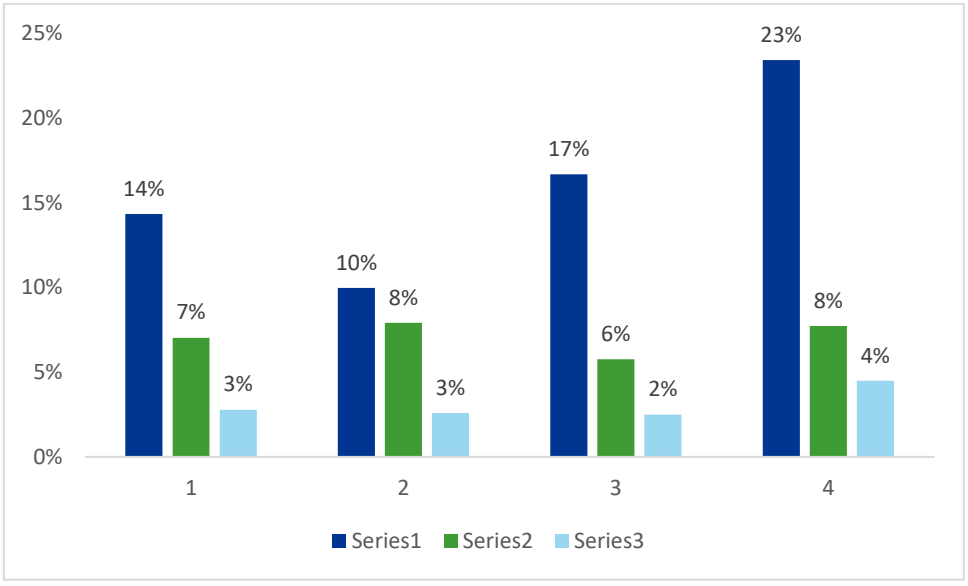




8.3 Co-adoption of solar and EV

Co-adoption of solar PV with electric vehicles (EV) represents a growing customer segment that could affect impact evaluation results. Responses to the HER survey indicate that while EV adoption is at 7% among customers in the HER program, it more than doubles to 19% among the subset that have solar PV. Current adoption of solar and EVs does not differ significantly by treatment and control. The analysis includes examining adoption and co-adoption of these technologies by climate zone. There are significant differences in solar use with higher prevalence among customers inland. Conversely, there is higher prevalence of EV use among customers in coastal climate zones. There is also a significant level of co-adoption of these technologies across all climate zones (Figure 8-5).

Figure 8-5. Self-reported solar and EV use among HER customers by climate zone



8.4 Related trends – storage, TOU rates, and heat pumps

The confluence of related trends in storage technologies, rates, and HVAC technologies that will have a major impact on households' electric consumption are summarized below.

- **Storage.** Developments in storage technologies which can serve as both source and sink of energy will accelerate customer adoption of renewables and EVs. The codependent trends of electrified transportation and storage will result in the development of enormous infrastructure of rechargeable batteries in the coming decades. These developments will have a ripple effect on the storage of grid electricity as well.
  - While current adoption of battery storage is at under 5% among respondents to the HER survey, 23% indicate that they would consider adoption of this technology in the next 2 years.
- **TOU rates.** In 2015, CPUC ordered the state's 3 PAs to transition to "default" rates by 2019 that would require customers to pay time-of-use (TOU) rates unless they opt out. TOU rates aim to move customer use toward periods when low cost renewables are in greater supply on utility systems, which saves costs for customers and utilities.
  - While current adoption of TOU rates among HER survey respondents is at 22%, an additional 22% indicate they would consider adoption of TOU rates in the next 2 years.
- **Heat pump and heat pump water heaters.** In California homes, heating and cooling combined account for 31% of total energy use and water heating accounts for another 25%. Heat pumps are efficient at converting energy to heat and have the ability to provide both heating and cooling. Heat pump water heaters can be two to three times more energy efficient than conventional electric resistance water heaters. Adoption of these technologies is poised to increase as well given potential customer benefits in ongoing energy savings and upfront incentives.[15]
  - Current adoption of heat pumps and heat pump water heaters among HER survey respondents is under 5%, and an additional 12% and 14% respectively indicate they would consider adoption of these technologies in the next two years.

Factoring adoption of large load end-uses like EVs, heat pumps, heat pump water heaters, and other relevant customer characteristics such as solar PV and TOU rates into the HER design and evaluation should be a consideration for future years for the HER program.

[15] Marin Clean Energy provides incentives to low income households in multifamily properties for energy efficiency upgrades, including measures such as heat pump and heat pump water heaters.

9 CONCLUSIONS AND RECOMMENDATIONS

The HER program impact evaluation results indicate that savings in program year 2017 either exceed or are in line with program year 2016 evaluated savings. The HER program continues to generate significant savings and contributes a high share of total residential energy efficiency portfolio savings. Tests indicate that the sample design adheres to RCT standards and the balanced sample design enables full program attribution for estimated savings.

The sound experimental design of the HER program and the significant savings realized by each PA year after year support the continued inclusion of HERs as a key tool in the residential EE program arsenal.

Analysis that links survey data to billing data indicates that treatment group customers are significantly more engaged with PA-offered programs and more likely to adopt smart energy technologies. Programs that offer time-of-use rates and critical peak pricing seek to shift load and/or shave peak energy consumption. Smart appliances enable customers to program appliances to operate on a schedule that maximizes the use of less expensive rates. These programs and technologies both nudge and enable customers to use energy on a schedule that provides them and the utility with benefits.

These results validate program theory. Providing customers with information on various demand side management programs and energy technologies can help them achieve savings.

An examination of electric savings over time compared to gas savings reveal that percent savings for electric are consistently higher than gas over time. Gas savings remain relatively lower and consistent over time. One possible explanation for this difference is that gas use is tied to essential end-uses such as cooking and heating and hence customers have relatively less potential for gas reductions based on behavioral changes. Electric savings link to essential end-uses like lighting and cooling and also some non-essential ones such as entertainment and pool usage, which could explain the relatively higher magnitude of savings.

First-year electric savings achieved by more recent waves are notably lower than those that were achieved by the Beta wave. Factors outside the program's influence contributing to this include an increased number of electronic devices in the home and electrification trends such as heat pumps, heat pump water heaters, and electric vehicles. Survey findings confirm that customer adoption of EVs, heat pumps, heat pump water heaters, and co-adoption of solar and EVs will grow in the next two years.

As households continue to increase electricity consumption due to electrification, the HER program, with its proven ability to deliver electric savings, will become an even more important program in the residential energy efficiency portfolio. The HER program should continue to provide information on ways for customers to achieve electric savings.

Net metered customers are an increasing customer segment in the HER program. Evidence of increasing solar adoption is revealed in the data used for the HER evaluation. The share of HER net-metered customers with solar PV is substantial, particularly for longer-running waves. Billing data does not currently provide a measure of consumption that includes the share from self-generation, and this is a barrier to true measurement of savings due to the HER program for these customers.

Additionally, co-adoption of solar PV with electric vehicles (EV) represents an important growing customer segment. Responses to the HER survey indicate that while EV adoption is at 7% among customers in the HER program, it more than doubles to 19% among the subset that have solar PV. Factoring adoption of these large load end-uses into the HER design and evaluation should be a consideration for future program years.

1. PAs/program implementers should consider devices to measure energy production at the customer site and linking measurements to billing data. This will enable an accurate measurement of energy consumption from the household load for net-metered customers.
2. Future waves should factor in solar and EV adoption as stratification variables in the sample design and also include these as parameters in the models used to estimate savings.

10 APPENDICES

10.1 Appendix AA Gross and Net Lifecycle Savings

Gross and net lifecycle savings are presented in the tables beginning on the next page.

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HER	116,541	122,026	1.05	0.0%	1.05
PGE	**Total**	**116,541**	**122,026**	**1.05**	**0.0%**	**1.05**
SCE	HER Opower Wave 2	5,455	4,778	0.88	0.0%	0.88
SCE	HER Opower Wave 3	16,955	18,165	1.07	0.0%	1.07
SCE	HER Opower Wave 4	31,290	34,617	1.11	0.0%	1.11
SCE	HER Opower Wave 5	32,669	36,419	1.11	0.0%	1.11
SCE	**Total**	**86,370**	**93,979**	**1.09**	**0.0%**	**1.09**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	39,439			
SDGE	**Total**	**0**	**39,439**			
	Statewide	***202,911***	***255,444***	***1.26***	***0.0%***	***1.26***

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HER	122,368	128,127	1.05	100.0%	1.05	1.05		
PGE	**Total**	**122,368**	**128,127**	**1.05**	**100.0%**	**1.05**	**1.05**		
SCE	HER Opower Wave 2	3,273	5,017	1.53	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 3	10,173	19,073	1.87	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 4	18,774	36,348	1.94	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 5	19,602	38,240	1.95	0.0%	0.60	1.05	0.60	1.05
SCE	**Total**	**51,822**	**98,678**	**1.90**	**0.0%**	**0.60**	**1.05**	**0.60**	**1.05**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	41,411				1.05		
SDGE	**Total**	**0**	**41,411**				**1.05**		
	Statewide	***174,190***	***268,216***	***1.54***	***70.2%***	***0.86***	***1.05***	***0.60***	***1.05***

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HER	0.0	18.8			
PGE	**Total**	**0.0**	**18.8**			
SCE	HER Opower Wave 2	1.0	1.2	1.22	0.0%	1.22
SCE	HER Opower Wave 3	2.4	3.4	1.40	0.0%	1.40
SCE	HER Opower Wave 4	8.8	9.3	1.06	0.0%	1.06
SCE	HER Opower Wave 5	11.0	6.7	0.61	0.0%	0.61
SCE	**Total**	**23.2**	**20.7**	**0.89**	**0.0%**	**0.89**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0.0	10.4			
SDGE	**Total**	**0.0**	**10.4**			
	Statewide	***23.2***	***49.9***	***2.15***	***0.0%***	***2.15***

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HER	0.0	19.7				1.05		
PGE	**Total**	**0.0**	**19.7**				**1.05**		
SCE	HER Opower Wave 2	0.6	1.3	2.14	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 3	1.5	3.6	2.46	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 4	5.3	9.8	1.86	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 5	6.6	7.1	1.07	0.0%	0.60	1.05	0.60	1.05
SCE	**Total**	**13.9**	**21.7**	**1.56**	**0.0%**	**0.60**	**1.05**	**0.60**	**1.05**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0.0	10.9				1.05		
SDGE	**Total**	**0.0**	**10.9**				**1.05**		
	Statewide	***13.9***	***52.4***	***3.76***	***0.0%***	***0.60***	***1.05***	***0.60***	***1.05***

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HER	3,780	3,942	1.04	0.0%	1.04
PGE	**Total**	**3,780**	**3,942**	**1.04**	**0.0%**	**1.04**
SCE	HER Opower Wave 2	0	0			
SCE	HER Opower Wave 3	0	0			
SCE	HER Opower Wave 4	0	0			
SCE	HER Opower Wave 5	0	0			
SCE	**Total**	**0**	**0**			
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	881			
SDGE	**Total**	**0**	**881**			
	Statewide	***3,780***	***4,823***	***1.28***	***0.0%***	***1.28***

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HER	3,969	4,139	1.04	100.0%	1.05	1.05		
PGE	**Total**	**3,969**	**4,139**	**1.04**	**100.0%**	**1.05**	**1.05**		
SCE	HER Opower Wave 2	0	0						
SCE	HER Opower Wave 3	0	0						
SCE	HER Opower Wave 4	0	0						
SCE	HER Opower Wave 5	0	0						
SCE	**Total**	**0**	**0**						
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	925				1.05		
SDGE	**Total**	**0**	**925**				**1.05**		
	Statewide	***3,969***	***5,065***	***1.28***	***100.0%***	***1.05***	***1.05***		

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HER	116,541	122,026	1.05	0.0%	1.05
PGE	**Total**	**116,541**	**122,026**	**1.05**	**0.0%**	**1.05**
SCE	HER Opower Wave 2	5,455	4,778	0.88	0.0%	0.88
SCE	HER Opower Wave 3	16,955	18,165	1.07	0.0%	1.07
SCE	HER Opower Wave 4	31,290	34,617	1.11	0.0%	1.11
SCE	HER Opower Wave 5	32,669	36,419	1.11	0.0%	1.11
SCE	**Total**	**86,370**	**93,979**	**1.09**	**0.0%**	**1.09**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	39,439			
SDGE	**Total**	**0**	**39,439**			
	Statewide	***202,911***	***255,444***	***1.26***	***0.0%***	***1.26***

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HER	122,368	128,127	1.05	100.0%	1.05	1.05		
PGE	**Total**	**122,368**	**128,127**	**1.05**	**100.0%**	**1.05**	**1.05**		
SCE	HER Opower Wave 2	3,273	5,017	1.53	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 3	10,173	19,073	1.87	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 4	18,774	36,348	1.94	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 5	19,602	38,240	1.95	0.0%	0.60	1.05	0.60	1.05
SCE	**Total**	**51,822**	**98,678**	**1.90**	**0.0%**	**0.60**	**1.05**	**0.60**	**1.05**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	41,411				1.05		
SDGE	**Total**	**0**	**41,411**				**1.05**		
	Statewide	***174,190***	***268,216***	***1.54***	***70.2%***	***0.86***	***1.05***	***0.60***	***1.05***

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HER	0.0	18.8			
PGE	**Total**	**0.0**	**18.8**			
SCE	HER Opower Wave 2	1.0	1.2	1.22	0.0%	1.22
SCE	HER Opower Wave 3	2.4	3.4	1.40	0.0%	1.40
SCE	HER Opower Wave 4	8.8	9.3	1.06	0.0%	1.06
SCE	HER Opower Wave 5	11.0	6.7	0.61	0.0%	0.61
SCE	**Total**	**23.2**	**20.7**	**0.89**	**0.0%**	**0.89**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0.0	10.4			
SDGE	**Total**	**0.0**	**10.4**			
	Statewide	***23.2***	***49.9***	***2.15***	***0.0%***	***2.15***

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HER	0.0	19.7				1.05		
PGE	**Total**	**0.0**	**19.7**				**1.05**		
SCE	HER Opower Wave 2	0.6	1.3	2.14	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 3	1.5	3.6	2.46	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 4	5.3	9.8	1.86	0.0%	0.60	1.05	0.60	1.05
SCE	HER Opower Wave 5	6.6	7.1	1.07	0.0%	0.60	1.05	0.60	1.05
SCE	**Total**	**13.9**	**21.7**	**1.56**	**0.0%**	**0.60**	**1.05**	**0.60**	**1.05**
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0.0	10.9				1.05		
SDGE	**Total**	**0.0**	**10.9**				**1.05**		
	Statewide	***13.9***	***52.4***	***3.76***	***0.0%***	***0.60***	***1.05***	***0.60***	***1.05***

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	HER	3,780	3,942	1.04	0.0%	1.04
PGE	**Total**	**3,780**	**3,942**	**1.04**	**0.0%**	**1.04**
SCE	HER Opower Wave 2	0	0			
SCE	HER Opower Wave 3	0	0			
SCE	HER Opower Wave 4	0	0			
SCE	HER Opower Wave 5	0	0			
SCE	**Total**	**0**	**0**			
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	881			
SDGE	**Total**	**0**	**881**			
	Statewide	***3,780***	***4,823***	***1.28***	***0.0%***	***1.28***

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	HER	3,969	4,139	1.04	100.0%	1.05	1.05		
PGE	**Total**	**3,969**	**4,139**	**1.04**	**100.0%**	**1.05**	**1.05**		
SCE	HER Opower Wave 2	0	0						
SCE	HER Opower Wave 3	0	0						
SCE	HER Opower Wave 4	0	0						
SCE	HER Opower Wave 5	0	0						
SCE	**Total**	**0**	**0**						
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0	925				1.05		
SDGE	**Total**	**0**	**925**				**1.05**		
	Statewide	***3,969***	***5,065***	***1.28***	***100.0%***	***1.05***	***1.05***		

10.2 Appendix AB Per Unit (Quantity) Gross and Net Energy Savings

Per unit (quantity) gross and net energy savings are presented in the tables beginning on the next page.

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HER	0	0.0%	0.0%	1.0	0.5	0.5	0.5
SCE	HER Opower Wave 2	0	0.0%	0.0%	1.0	2,389,019.0	2,389,019.0	2,389,019.0
SCE	HER Opower Wave 3	0	0.0%	0.0%	1.0	9,082,320.0	9,082,320.0	9,082,320.0
SCE	HER Opower Wave 4	0	0.0%	0.0%	1.0	17,308,609.5	17,308,609.5	17,308,609.5
SCE	HER Opower Wave 5	0	0.0%	0.0%	1.0	18,209,564.0	18,209,564.0	18,209,564.0
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0		0.0%	1.0	39,439,440.0	39,439,440.0	39,439,440.0

Per Unit (Quantity) Gross Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HER	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 2	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 3	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 4	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 5	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	0		0.0%	1.0	881,235.0	881,235.0	881,235.0

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HER	1	0.0%		1.0	0.5	0.5	0.5
SCE	HER Opower Wave 2	0	0.0%	0.0%	1.0	2,508,470.0	2,508,470.0	2,508,470.0
SCE	HER Opower Wave 3	0	0.0%	0.0%	1.0	9,536,436.0	9,536,436.0	9,536,436.0
SCE	HER Opower Wave 4	0	0.0%	0.0%	1.0	18,174,040.0	18,174,040.0	18,174,040.0
SCE	HER Opower Wave 5	0	0.0%	0.0%	1.0	19,120,042.2	19,120,042.2	19,120,042.2
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	1			1.0	41,411,412.0	41,411,412.0	41,411,412.0

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	HER	1	0.0%		1.0	0.0	0.0	0.0
SCE	HER Opower Wave 2	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 3	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 4	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SCE	HER Opower Wave 5	0	0.0%	0.0%	1.0	0.0	0.0	0.0
SDGE	HER EVALUATION ON 2017 OPOWER PROGRAM	1			1.0	925,296.8	925,296.8	925,296.8

10.3 Appendix AC Recommendations

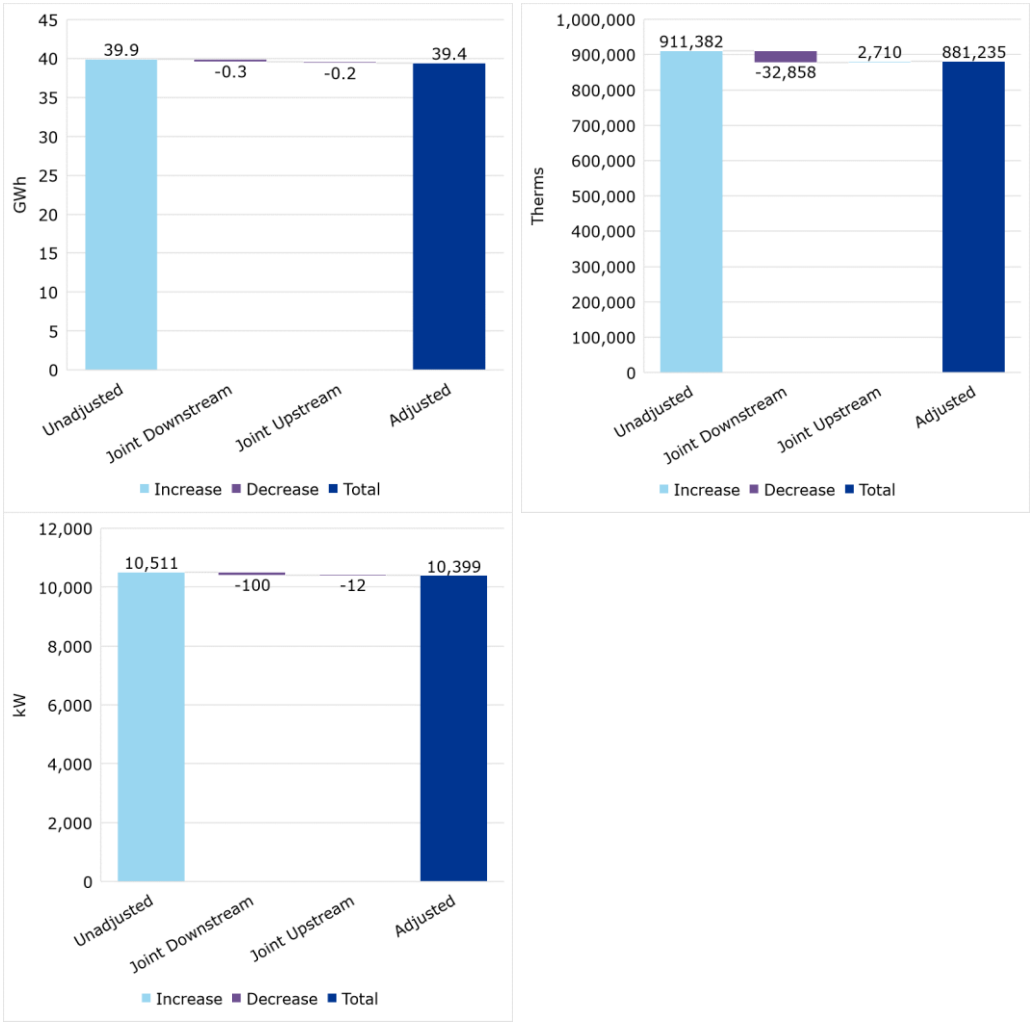
Table 10-1. Home Energy Report PY 2017 Recommendations

Study ID	Study Type	Study Title/Program	Study Manager
CALMAC ID: CPU0194.01	Impact Evaluation	Home Energy Reports Impact Evaluation PY 2017 (Residential)	CPUC Energy Division
Recommendations (Recipients - All IOUs)	**Summary of Findings**	**Additional Supporting Information**	**Best Practice / Recommendations**
1	An examination of electric savings over time compared to gas savings reveal that percent savings for electric are consistently higher than gas over time.	Sections 4.1, 5.1, and 8	As households continue to increase electricity consumption due to electrification, the HER program, with its proven ability to deliver electric savings, will become an even more important program in the residential energy efficiency portfolio. The HER program should continue to provide information on ways for customers to achieve electric savings.
2	Net metered customers are an increasing customer segment in the HER program. Evidence of increasing solar adoption is revealed in the data used for the HER evaluation.	Section 8.1	PAs/program implementers should consider devices to measure energy production at the customer site and linking measurements to billing data. This will enable an accurate measurement of energy consumption from the household load for net-metered customers. Future waves should factor in solar and EV adoption as stratification variables in the sample design and also in the models to estimate savings.

10.4 Appendix A Total savings at a glance

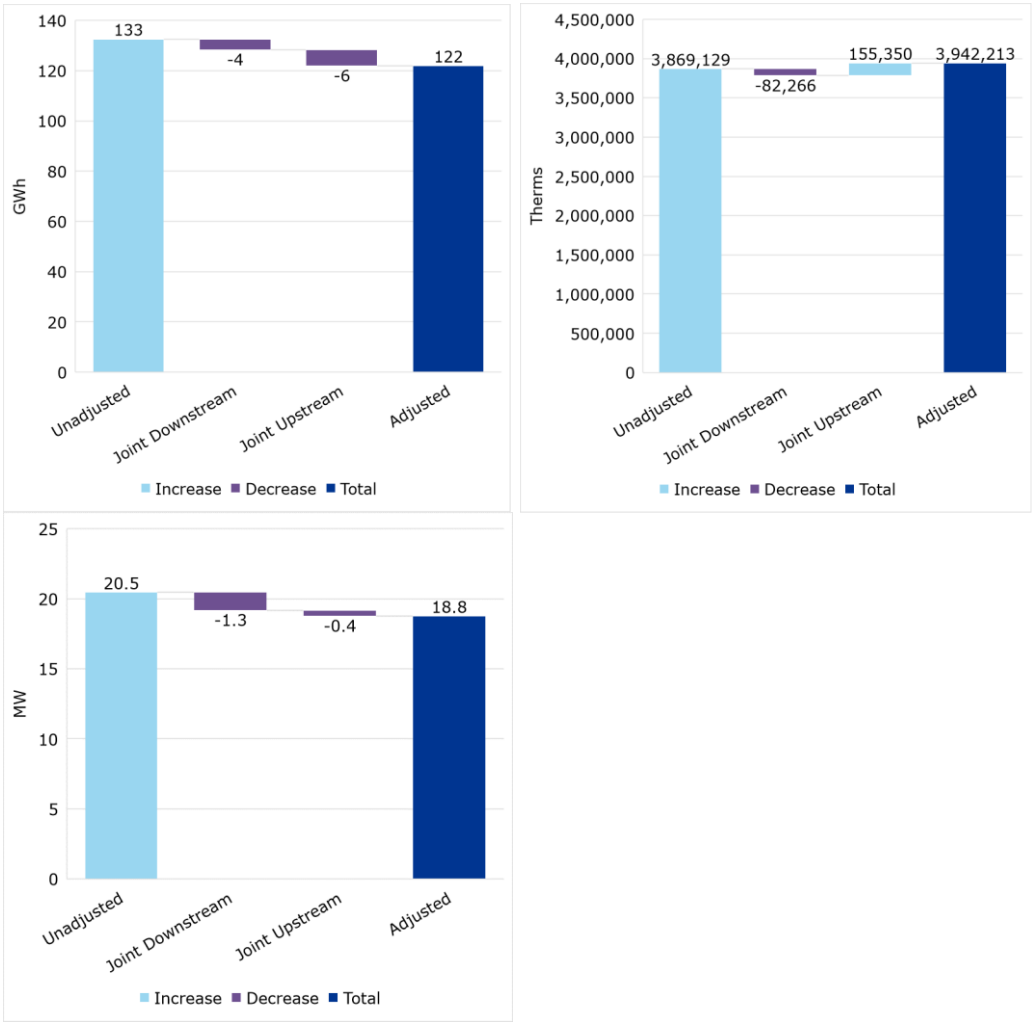
Figure 10-1 is a visual indication of the total SDG&E HER program savings. Negative joint savings values indicate the amount of tracked downstream and untracked upstream savings that are removed from measured program savings to obtain net total net savings for the HER program.

Figure 10-1. SDG&E total savings for the 2017 HER programs



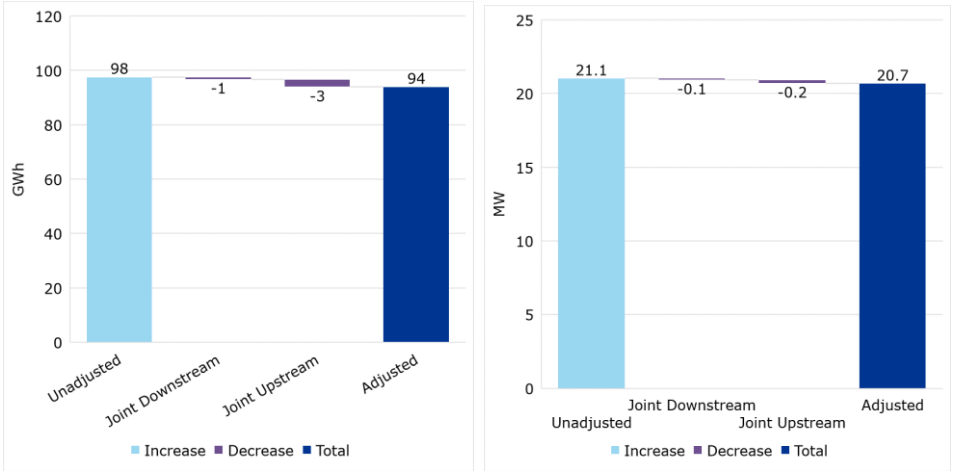
PG&E's program level total savings and tracked downstream and untracked upstream adjustments are illustrated in Figure 10-2.

Figure 10-2. PG&E total savings for the 2017 HER programs



SCE's program level total savings and tracked downstream and untracked upstream adjustments are illustrated in Figure 10-3.

Figure 10-3. SCE total savings for the 2017 HER programs



10.5 Appendix B HER program waves and population counts

The section provides participant rosters with starting counts for each experimental wave of each PA. The disposition for SDG&E's HER waves is presented in Table 10-2. A total of close to 900,000 SDG&E residential customers have received home energy reports since the start of the program in 2011. At the end of 2017, close to 700,000 (78%) of the original recipients remain in the program.

Table 10-2. SDG&E disposition

Sample	Treatment	Control
Opower 1		
Original sample	19,977	19,909
Move-outs	6,945	6,948
Active customers, Jan. 2017	13,032	12,961
Active customers, Dec. 2017	12,310	12,205
Opower 2 Low Income		
Original sample	26,018	7,074
Move-outs	8,597	2,411
Active customers, Jan. 2017	17,421	4,663
Active customers, Dec. 2017	15,388	4,141
Opower 2 Non-Low Income		
Original sample	57,175	15,850
Move-outs	19,168	5,421
Active customers, Jan. 2017	38,007	10,429
Active customers, Dec. 2017	34,073	9,373
Opower 3 Expansion Digital		
Original sample	265,902	24,687
Move-outs	61,868	5,788
Active customers, Jan. 2017	204,034	18,899
Active customers, Dec. 2017	171,622	15,888
Opower 3 Expansion Paper		
Original sample	195,670	24,697
Move-outs	24,658	3,074
Active customers, Jan. 2017	171,012	21,623
Active customers, Dec. 2017	155,310	19,654
Opower 4 Digital		
Original sample	63,178	17,406
Move-outs	314	86
Active customers, Jan. 2017	62,864	17,320
Active customers, Dec. 2017	47,905	13,240
Opower 4 Paper		
Original sample	48,753	13,893
Move-outs	205	59
Active customers, Jan. 2017	48,548	13,834
Active customers, Dec. 2017	42,304	11,995
Opower 5		
Original sample	222,500	35,000
Move-outs	2,951	460
Active customers, Jan. 2017	219,549	34,540
Active customers, Dec. 2017	219,549	34,540

Table 10-3 provides a disposition of PG&E's HER program participants. In this report we evaluate the energy use impact of home energy reports from PG&E's 13 experimental waves that are underway. The table provides the name, starting treatment and control household counts, and dates for each wave. Since the start of the program, close to 2.1 million of PG&E's residential customers have received home energy reports.

Earlier waves have lost notable number of customers in treatment due to move-outs. By the end of 2017, 1.4 million (66% of the original) of PG&E's residential customers were receiving the reports.

Table 10-3. PG&E disposition

Sample	Treatment	Control
Beta		
Original sample	59,994	59,994
Move-outs	18,830	18,627
Active customers, Jan. 2017	41,164	41,367
Active customers, Dec. 2017	39,083	39,287
Gamma standard		
Original sample	72,287	72,292
Move-outs	25,200	25,165
Active customers, Jan. 2017	47,087	47,127
Active customers, Dec. 2017	44,550	44,517
Gamma reduced		
Original sample	72,286	See Gamma standard
Move-outs	25,122	
Active customers, Jan. 2017	47,164	
Active customers, Dec. 2017	44,614	
Gamma electric only		
Original sample	44,985	44,992
Move-outs	21,783	21,861
Active customers, Jan. 2017	23,202	23,131
Active customers, Dec. 2017	21,425	21,358
Wave 1 dual fuel		
Original sample	360,200	89,993
Move-outs	115,009	28,573
Active customers, Jan. 2017	245,191	61,420
Active customers, Dec. 2017	232,275	58,225
Wave 1 electric only		
Original sample	39,787	9,999
Move-outs	17,172	4,320
Active customers, Jan. 2017	22,615	5,679
Active customers, Dec. 2017	21,110	5,310
Wave 2 area 7		
Original sample	80,051	50,071
Move-outs	21,777	13,708
Active customers, Jan. 2017	58,274	36,363
Active customers, Dec. 2017	54,490	33,993
Wave 2 non-area 7		
Original sample	305,284	47,708
Move-outs	81,390	12,706
Active customers, Jan. 2017	223,894	35,002
Active customers, Dec. 2017	212,352	33,154
Wave 3		
Original sample	224,996	75,020
Move-outs	72,683	24,430
Active customers, Jan. 2017	152,313	50,590
Active customers, Dec. 2017	141,781	47,046

Sample	Treatment	Control
Wave 4		
Original sample	200,000	75,000
Move-outs	68,632	25,767
Active customers, Jan. 2017	131,368	49,233
Active customers, Dec. 2017	119,387	44,839
Wave 5		
Original sample	210,000	50,200
Move-outs	55,754	13,448
Active customers, Jan. 2017	154,246	36,752
Active customers, Dec. 2017	141,071	33,583
Wave 6		
Original sample	312,000	50,000
Move-outs	71,769	11,767
Active customers, Jan. 2017	240,231	38,233
Active customers, Dec. 2017	209,373	33,509
Wave 7		
Original sample	157,496	39,997
Move-outs	1,585	420
Active customers, March 2017	155,911	39,577
Active customers, Dec. 2017	136,027	34,490

Table 10-4 presents the disposition of the HER population for SCE. SCE has 4 active HER experimental waves underway. A total of 1.1 million SCE residential customers have received home energy report since the start of the program. Close to 8 out 10 (86% of the original) households received the reports by the end of 2017 due to customer attrition (moveouts).

Table 10-4. SCE disposition

Sample	Treatment	Control
Opower 2		
Original sample	75,000	75,000
Move-outs	11,508	11,460
Active customers, Jan. 2017	63,492	63,540
Active customers, Dec. 2017	60,658	60,658
Opower 3		
Original sample	164,800	50,315
Move-outs	17,567	5,564
Active customers, Jan. 2017	147,233	44,751
Active customers, Dec. 2017	138,327	42,099
Opower 4		
Original sample	265,650	37,107
Move-outs	27,411	3,893
Active customers, Jan. 2017	238,239	33,214
Active customers, Dec. 2017	216,027	30,129
Opower 5		
Original sample	602,712	50,104
Move-outs	12,049	1,031
Active customers, Jan. 2017	590,663	49,073
Active customers, Dec. 2017	543,044	45,169

10.6 Appendix C Data quality

Table 10-5, Table 10-6, and Table 10-7 present the quality of the data used in the gross savings models. These summaries are for treatment and control households active in 2017. The summary for zero reads, negative reads, and missing reads look across fuel type when the household is dual fuel, meaning that both the gas and electric consumption data would need to have the issue in the bill period in order for it to be flagged. Extreme reads are flagged if both or either the electric or gas read is extreme. A household may have zero reads, negative reads, missing reads, and extreme reads, so the percentages may be greater than 100%.

Table 10-5. SDG&E data quality summary

Data Issues	Treatment	Control
Opower 1		
Zero Reads	9.4%	9.1%
Negative Reads	9.1%	9.3%
Missing Reads	0.0%	0.0%
Extreme Reads	4.2%	5.0%
No Issues	77.7%	77.0%
Opower 2 Low Income		
Zero Reads	2.7%	2.7%
Negative Reads	0.5%	0.5%
Missing Reads	0.0%	0.0%
Extreme Reads	0.2%	0.3%
No Issues	96.6%	96.6%
Opower 2 Non-Low Income		
Zero Reads	4.8%	4.7%
Negative Reads	2.1%	2.0%
Missing Reads	0.0%	0.0%
Extreme Reads	0.3%	0.2%
No Issues	92.9%	93.1%
Opower 3 Expansion Digital		
Zero Reads	3.5%	3.4%
Negative Reads	0.0%	0.0%
Missing Reads	0.0%	0.0%
Extreme Reads	0.1%	0.1%
No Issues	96.4%	96.5%
Opower 3 Expansion Paper		
Zero Reads	11.5%	11.4%
Negative Reads	0.1%	0.0%
Missing Reads	0.0%	0.0%
Extreme Reads	2.9%	2.9%
No Issues	85.6%	85.6%
Opower 4 Digital		
Zero Reads	1.4%	1.2%
Negative Reads	0.0%	0.0%
Missing Reads	0.0%	0.0%
Extreme Reads	0.0%	0.0%
No Issues	98.6%	98.7%

Data Issues	Treatment	Control
Opower 4 Paper		
Zero Reads	4.1%	4.0%
Negative Reads	0.0%	0.0%
Missing Reads	0.0%	0.0%
Extreme Reads	2.0%	1.9%
No Issues	94.0%	94.2%

Table 10-6. PG&E data quality summary

Data Issues	Treatment	Control
Beta		
Zero Reads	0.51%	0.50%
Negative Reads	10.33%	10.14%
Missing Reads	0.00%	0.01%
Extreme Reads	5.23%	5.83%
No Issues	84.62%	84.34%
Gamma standard		
Zero Reads	0.58%	0.56%
Negative Reads	8.50%	8.31%
Missing Reads	0.01%	0.02%
Extreme Reads	1.61%	1.68%
No Issues	89.66%	89.81%
Gamma reduced		
Zero Reads	0.53%	See Gamma standard
Negative Reads	8.43%	
Missing Reads	0.01%	
Extreme Reads	1.59%	
No Issues	89.74%	
Gamma electric only		
Zero Reads	0.73%	0.55%
Negative Reads	4.79%	4.66%
Missing Reads	0.01%	0.01%
Extreme Reads	1.85%	2.03%
No Issues	92.87%	92.99%
Wave 1 dual fuel		
Zero Reads	0.34%	0.34%
Negative Reads	7.21%	7.10%
Missing Reads	0.01%	0.01%
Extreme Reads	1.04%	1.08%
No Issues	91.59%	91.70%
Wave 1 electric only		
Zero Reads	0.46%	0.41%
Negative Reads	9.83%	9.81%
Missing Reads	0.01%	0.00%
Extreme Reads	2.97%	2.70%
No Issues	87.47%	87.83%
Wave 2 area 7		
Zero Reads	0.33%	0.31%
Negative Reads	3.71%	3.47%
Missing Reads	0.00%	0.01%
Extreme Reads	1.20%	1.23%
No Issues	94.86%	95.07%

Data Issues	Treatment	Control
Wave 2 non-area 7		
Zero Reads	0.28%	0.32%
Negative Reads	6.65%	6.13%
Missing Reads	0.01%	0.01%
Extreme Reads	0.87%	0.97%
No Issues	92.34%	92.75%
Wave 3		
Zero Reads	0.27%	0.25%
Negative Reads	5.92%	5.93%
Missing Reads	0.01%	0.02%
Extreme Reads	1.13%	1.27%
No Issues	92.82%	92.70%
Wave 4		
Zero Reads	0.33%	0.31%
Negative Reads	4.49%	4.45%
Missing Reads	0.02%	0.01%
Extreme Reads	1.05%	1.03%
No Issues	94.24%	94.33%
Wave 5		
Zero Reads	0.19%	0.14%
Negative Reads	8.44%	8.25%
Missing Reads	0.02%	0.01%
Extreme Reads	3.29%	3.33%
No Issues	88.40%	88.60%
Wave 6		
Zero Reads	0.20%	0.21%
Negative Reads	2.86%	2.73%
Missing Reads	0.01%	0.01%
Extreme Reads	0.78%	0.87%
No Issues	96.19%	96.21%
Wave 7		
Zero Reads	0.28%	0.26%
Negative Reads	0.89%	0.86%
Missing Reads	0.01%	0.01%
Extreme Reads	1.41%	1.33%
No Issues	97.45%	97.56%

Table 10-7. SCE data quality summary

Data Issues	Treatment	Control
Opower 2		
Zero Reads	0.52%	0.48%
Negative Reads	0.00%	0.00%
Missing Reads	0.00%	0.00%
Extreme Reads	0.56%	0.54%
No Issues	98.92%	98.97%
Opower 3		
Zero Reads	0.27%	0.27%
Negative Reads	0.00%	0.00%
Missing Reads	0.00%	0.00%
Extreme Reads	1.27%	1.22%
No Issues	98.46%	98.51%

Data Issues	Treatment	Control
Opower 4		
Zero Reads	0.49%	0.48%
Negative Reads	0.00%	0.00%
Missing Reads	0.00%	0.00%
Extreme Reads	5.85%	5.79%
No Issues	93.66%	93.73%
Opower 5		
Zero Reads	0.11%	0.10%
Negative Reads	0.00%	0.00%
Missing Reads	0.00%	0.00%
Extreme Reads	1.63%	1.74%
No Issues	98.26%	98.16%

10.7 Appendix D Key inputs for upstream joint savings calculations

Table 10-8, Table 10-9. PG&E upstream joint savings calculation inputs, and present the input assumptions used in the upstream joint savings calculations by program administrator. For SDG&E and PG&E, the excess lamps due to HER were applied based on the year of the wave rather than calendar year until 2015. This means, if a wave began in July 2011, it would use the year 1 excess lamps from July 2011 through June 2012 and then use the year 2 excess lamps for the next wave year until calendar year 2015. Beginning in 2015, excess lamps due to HER was also calculated separately for each wave. All other inputs are not wave specific. In 2014, with the introduction of LEDs, the uplift was split between LEDs and CFLs using the fraction of lamps in 2014 from the 2014 TRC HER lighting overlap study. See section 3.5 for further information about how we calculated upstream joint savings.

Table 10-8. SDG&E upstream joint savings calculation inputs

Assumptions	CFL	LED	Source
Opower 1 excess lamps due to HER			
Year 1	0.95	NA	2013 PG&E in-home survey
Year 2	0.40	NA	Interpolated from PG&E ad PSE values (DNV GL)
Year 3	0.15	NA	2013 PSE HER phone survey (DNV GL)
Year 4	0.08	0.08	2013 PSE HER phone survey (DNV GL)
2015	0.32	0.20	2015 Online Survey (DNV GL, 2017)
2016 - 2017	-0.30	0.74	2016-2017 Online Survey (DNV GL, 2019)
Opower 2 excess lamps due to HER			
2015	-0.07	-0.65	2015 Online Survey (DNV GL, 2017)
2016 - 2017	-0.04	-0.03	2016-2017 Online Survey (DNV GL, 2019)
Opower 3 excess lamps due to HER			
2016 - 2017	-0.35	-1.32	2016-2017 Online Survey (DNV GL, 2019)
Opower 4 excess lamps due to HER			
2017	-0.55	-0.63	2016-2017 Online Survey (DNV GL, 2019)
Opower 5 excess lamps due to HER			
2017	0.20	0.20	2016-2017 Online Survey (DNV GL, 2019)
Rebated sales fraction			
2011	0.57	NA	2014 TRC HER lighting overlap study
2012	0.68	NA	2014 TRC HER lighting overlap study
2013	0.4	NA	2014 TRC HER lighting overlap study
2014	0.18	0.32	2014 TRC HER lighting overlap study
2015 - 2017	0.2	0.31	2015 TRC HER lighting overlap study
Net-to-gross			
2011 - 2012	0.61	NA	2010-12 ULP Evaluation (DNV GL, 2014)
2013 - 2015	0.30	0.32	2013-14 ULP Evaluation (DNV GL, 2016)
2016 - 2017	0.80	0.41	2015 ULP Evaluation (DNV GL, 2017)

Assumptions	CFL	LED	Source
Installation rate			
2011 - 2014	0.97	0.99	2013-14 ULP Evaluation (DNV GL, 2016)
2015 - 2017	1.00	1.00	NA
Years lamps have been installed in 2017			
2011 - 2016	1.00	1.00	NA
2017	0.54	0.54	
Fraction of lamps in 2014			
2011 - 2013	1	1	NA
2014	0.66	0.34	2014 TRC HER lighting overlap study
2015-2017	1	1	NA
Annual electric savings per lamp			
2011	23.3	NA	2010-12 ULP Evaluation (DNV GL, 2014)
2012	22.6	NA	2010-12 ULP Evaluation (DNV GL, 2014)
2013 - 2015	17.9	21.8	2014 TRC HER lighting overlap study
2016 - 2017	16.4	27.4	2015 ULP Evaluation (DNV GL, 2017)
Gas interactive effects per lamp			
2011 - 2014	-0.4	-0.4	2013-14 ULP Evaluation (DNV GL, 2016)
2015 - 2017	-1.0	-0.5	2015 ULP Evaluation (DNV GL, 2017)
Delta Watts			
2011 - 2017	29.8	34.8	2015 ULP Evaluation (DNV GL, 2017)
Peak Coincidence Factor			
2011 - 2017	0.0	0.1	2015 ULP Evaluation (DNV GL, 2017)
Proportion of lamps in place during peak			
2011 - 2016	1.0	1.0	NA
2017	0.7	0.7	Peak period began on the 242 day of the year; 242/365

Table 10-9. PG&E upstream joint savings calculation inputs

Assumptions	CFL	LED	Source
Excess lamps due to HER prior to 2015 for all waves			
Year 1	0.95	0.95	2012 PG&E in-home survey
Year 2	0.40	0.40	Interpolated from PG&E and PSE values (DNV GL)
Year 3	0.15	0.15	2013 PSE HER phone survey (DNV GL)
Year 4	0.08	0.08	2014 PSE HER phone survey (DNV GL)
Beta excess lamps due to HER			
2015	-0.17	0.09	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.02	0.36	2016-2017 Online Survey (DNV GL, 2019)
Gamma standard excess lamps due to HER			
2015	0.17	0.33	2015 Online Survey (DNV GL, 2017)
2016 - 2017	1.09	-0.53	2016-2017 Online Survey (DNV GL, 2019)
Gamma reduced excess lamps due to HER			
2015	0.01	0.44	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.41	-0.27	2016-2017 Online Survey (DNV GL, 2019)
Gamma electric only excess lamps due to HER			
2015	-0.07	0.23	2015 Online Survey (DNV GL, 2017)
2016 - 2017	-0.69	1.95	2016-2017 Online Survey (DNV GL, 2019)
Wave 1 dual fuel excess lamps due to HER			
2015	0.02	0.71	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.13	1.32	2016-2017 Online Survey (DNV GL, 2019)

Assumptions	CFL	LED	Source
Wave 1 electric only excess lamps due to HER			
2015	0.61	0.24	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.13	1.32	2016-2017 Online Survey (DNV GL, 2019)
Wave 2 area 7 fuel excess lamps due to HER			
2015	0.02	0.51	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.4	-0.95	2016-2017 Online Survey (DNV GL, 2019)
Wave 2 non-area 7 excess lamps due to HER			
2015	0.01	0.55	2015 Online Survey (DNV GL, 2017)
2016 - 2017	-1.14	0.86	2016-2017 Online Survey (DNV GL, 2019)
Wave 3 excess lamps due to HER			
2015	0.09	0.09	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.1	0.16	2016-2017 Online Survey (DNV GL, 2019)
Wave 4 excess lamps due to HER			
2015	-0.16	-0.09	2015 Online Survey (DNV GL, 2017)
2016 - 2017	-0.95	-0.28	2016-2017 Online Survey (DNV GL, 2019)
Wave 5 excess lamps due to HER			
2015	0	0.11	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.72	-0.28	2016-2017 Online Survey (DNV GL, 2019)
Wave 6 excess lamps due to HER			
2015	0.03	0.29	2015 Online Survey (DNV GL, 2017)
2016 - 2017	0.74	-0.03	2016-2017 Online Survey (DNV GL, 2019)
Wave 7 excess lamps due to HER			
2017	-0.41	-1.08	2016-2017 Online Survey (DNV GL, 2019)
Rebated sales fraction			
2011	0.5	NA	2014 TRC HER lighting overlap study
2012	0.45	NA	2014 TRC HER lighting overlap study
2013	0.16	NA	2014 TRC HER lighting overlap study
2014	0.07	0.21	2014 TRC HER lighting overlap study
2015 - 2017	0.09	0.2	2015 TRC HER lighting overlap study
Net-to-gross			
2011 - 2012	0.63	NA	2010-12 ULP Evaluation (DNV GL, 2014)
2013 - 2014	0.31	0.45	2013-14 ULP Evaluation (DNV GL, 2016)
2016 - 2017	0.47	0.33	2015 ULP Evaluation (DNV GL, 2017)
Installation rate			
2011 - 2014	0.97	0.99	2013-14 ULP Evaluation (DNV GL, 2016)
2015 - 2017	1	1	NA
Years lamps have been installed in 2017			
2011 - 2016	1	1	NA
2017	0.54	0.54	
Fraction of lamps in 2014			
2011 - 2013	1	1	NA
2014	0.66	0.34	2014 TRC HER lighting overlap study
2015-2017	1	1	NA
Annual electric savings per lamp (kWh)			
2011	26.8	NA	2010-12 ULP Evaluation (DNV GL, 2014)
2012	26.2	NA	2010-12 ULP Evaluation (DNV GL, 2014)
2013 - 2015	23.5	24.8	Program tracking data (DEER 2013-14)
2016 - 2017	16	28.5	2015 ULP Evaluation (DNV GL, 2017)
Gas interactive effects per lamp (therms)			
2011 - 2014	-0.78	-0.71	2013-14 ULP Evaluation (DNV GL, 2016)
2015 - 2017	-0.34	-0.63	2015 ULP Evaluation (DNV GL, 2017)
Delta watts			
2011 - 2017	25.2	36.7	2015 ULP Evaluation (DNV GL, 2017)
Peak coincidence factor			
2011 - 2017	0.05	0.06	2015 ULP Evaluation (DNV GL, 2017)

Assumptions	CFL	LED	Source
Proportion of lamps in place during peak			
2011 - 2016	1	1	NA
2017	0.66	0.66	Peak period began on the 242 day of the year; 242/365

Table 10-10. SCE upstream joint savings calculation inputs

Assumptions	CFL	LED	Source
Opower 2 excess lamps due to HER			
2014	0.68	0.27	2012 PG&E in-home survey multiplied (0.95) by TRC estimate for fraction of CFL bulbs sold in SCE territory (.72) and by the fraction of LED bulbs sold in SCE territory (0.28)
2015	-0.2	0.15	2015 Online Survey (DNV GL, 2017)
2016 - 2017	1.09	0.23	2016-2017 Online Survey (DNV GL, 2019)
Opower 3 excess lamps due to HER			
2016 - 2017	0.57	-0.22	2016-2017 Online Survey (DNV GL, 2019)
Opower 4 excess lamps due to HER			
2016 - 2017	-1.07	1.22	2016-2017 Online Survey (DNV GL, 2019)
Opower 5 excess lamps due to HER			
2017	-0.19	0.12	2016-2017 Online Survey (DNV GL, 2019)
Rebated sales fraction			
2014	0.40	0.20	2014 TRC HER lighting overlap study
2015 - 2017	0.53	0.23	2015 TRC HER lighting overlap study
Net-to-gross			
2014 - 2015	0.45	0.31	2013-14 ULP Evaluation (DNV GL, 2016)
2016 - 2017	0.90	0.36	2015 ULP Evaluation (DNV GL, 2017)
Installation rate			
2014	0.97	0.99	2013-14 ULP Evaluation (DNV GL, 2016)
2015 - 2017	1	1	NA
Years lamps have been installed in 2017			
2014 - 2016	1.00	1.00	
2017	0.54	0.54	
Annual electric savings per lamp (kWh)			
2014 - 2015	45.2	19.9	2014 TRC HER lighting overlap study
2016 - 2017	22.5	34.0	2015 ULP Evaluation (DNV GL, 2017)
Gas interactive effects per lamp (therms)			
2014	-0.7	-0.5	2013-14 ULP Evaluation (DNV GL, 2016)
2015 - 2017	-2.4	-0.6	2015 ULP Evaluation (DNV GL, 2017)
Delta Watts			
2014 - 2017	29.5	41.5	2015 ULP Evaluation (DNV GL, 2017)
Peak Coincidence Factor			
2014 - 2017	0.1	0.1	2015 ULP Evaluation (DNV GL, 2017)
Proportion of lamps in place during peak			
2014 - 2016	1.0	1.0	
2017	0.7	0.7	Peak period began on the 242 day of the year; 242/365

10.8 Appendix E Total program savings by wave

Table 10-11 presents unadjusted and adjusted savings per household for each of SDG&E's HER waves.

Table 10-11. SDG&E per household electric and gas savings

Wave	Baseline Consumption	Per Household Savings				% Savings	
		Unadjusted	Joint Downstream	Joint Upstream	Adjusted	Unadjusted	Adjusted
Electric (kWh)							
Opower 1	7,927	80	<1	14	66	1.0%	0.8%
Opower 2 Low Income	5,044	39	<1	0	38	0.8%	0.8%
Opower 2 Non-Low Income	4,693	75	<1	0	75	1.6%	1.6%
Opower 3 Expansion Digital	4,757	61	0	0	61	1.3%	1.3%
Opower 3 Expansion Paper	9,310	130	2	0	128	1.4%	1.4%
Opower 4 Digital	2,972	22	<1	0	21	0.7%	0.7%
Opower 4 Paper	5,581	46	0	0	46	0.8%	0.8%
Opower 5	300	<1	0	<1	<1	0.1%	0.1%
Gas (therms)							
Opower 1	477	6	0	<1	6	1.2%	1.2%
Opower 2 Low Income	259	1	<1	0	1	0.5%	0.5%
Opower 2 Non-Low Income	244	<1	0	0	<1	0.3%	0.3%
Opower 3 Expansion Digital	251	3	0	0	3	1.0%	1.0%
Opower 3 Expansion Paper	376	4	<1	0	4	1.1%	1.0%
Opower 4 Digital	125	<1	<1	0	<1	0.0%	0.0%
Opower 4 Paper	179	1	<1	0	1	0.6%	0.6%
Opower 5	25	<1	0	<1	<1	0.0%	0.0%

Table 10-12, we present the total unadjusted and adjusted savings by wave for SDG&E's HER program.

Table 10-12. SDG&E total savings by wave

Wave	Program Total			
	Unadjusted	Joint Downstream	Joint Upstream	Adjusted
Electric (kWh)				
Opower 1	1,013,461	2,821	178,603	832,038
Opower 2 Low Income	637,388	13,939	0	623,449
Opower 2 Non-Low Income	2,707,350	21,370	0	2,685,980
Opower 3 Expansion Digital	11,305,853	0	0	11,305,853
Opower 3 Expansion Paper	21,096,131	270,378	0	20,825,753
Opower 4 Digital	1,145,692	6,936	0	1,138,756
Opower 4 Paper	2,027,612	0	0	2,027,612
Gas (therms)				
Opower 1	70,423	0	-2,710	73,133
Opower 2 Low Income	17,836	2,125	0	15,711
Opower 2 Non-Low Income	21,708	0	0	21,708
Opower 3 Expansion Digital	339,902	0	0	339,902
Opower 3 Expansion Paper	429,030	30,058	0	398,973
Opower 4 Digital	2,299	609	0	1,690
Opower 4 Paper	30,184	66	0	30,118
Peak Demand (kW)				
Opower 1	120.4	3.3	11.9	105.2
Opower 2 Low Income	92.7	0.0	0.0	92.7
Opower 2 Non-Low Income	1,217.4	0.0	0.0	1,217.4
Opower 3 Expansion Digital	1,113.1	0.0	0.0	1,113.1
Opower 3 Expansion Paper	5,416.0	97.0	0.0	5,319.0
Opower 4 Digital	938.2	0.0	0.0	938.2
Opower 4 Paper	1,613.6	0.0	0.0	1,613.6

Table 10-13 summarizes the electric and gas savings per household for each of PG&E HER waves. Adjusted percent savings that account for both downstream and upstream savings are largely the same as the unadjusted percent savings, changing by at most 0.2%. The adjusted savings calculation only considered average joint savings that are positive despite being statistically insignificant, as they provide some evidence of possible double counting.

Table 10-13. PG&E per household electric and gas savings

Wave	Baseline Consumption	Per Household Savings				% Savings	
		Unadjusted	Joint Downstream	Joint Upstream	Adjusted	Unadjusted	Adjusted
Electric (kWh)							
Beta	9,494	220	11	10	199	2.3%	2.1%
Gamma standard	6,652	95	3	8	84	1.4%	1.3%
Gamma reduced	6,652	72	<1	9	63	1.1%	0.9%
Gamma electric only	6,851	122	0	13	109	1.8%	1.6%
Wave 1 dual fuel	6,667	107	4	13	91	1.6%	1.4%
Wave 1 electric only	7,446	91	0	12	79	1.2%	1.1%
Wave 2 area 7	5,783	105	4	<1	101	1.8%	1.7%
Wave 2 non-area 7	6,371	116	5	4	107	1.8%	1.7%
Wave 3	6,373	81	4	2	75	1.3%	1.2%
Wave 4	5,870	58	<1	0	57	1.0%	1.0%
Wave 5	8,757	113	5	<1	108	1.3%	1.2%
Wave 6	6,088	55	<1	<1	54	0.9%	0.9%
Wave 7	5,600	44	<1	0	44	0.8%	0.8%
Gas (therms)							
Beta	705	6	<1	>-1	6	0.8%	0.8%
Gamma standard	403	2	<1	>-1	2	0.5%	0.5%
Gamma reduced	403	2	0	>-1	2	0.5%	0.6%
Wave 1 dual fuel	417	3	0	>-1	4	0.8%	0.9%
Wave 2 area 7	467	5	<1	>-1	5	1.0%	1.0%
Wave 2 non-area 7	424	3	0	>-1	3	0.7%	0.7%
Wave 3	423	2	<1	>-1	2	0.5%	0.5%
Wave 4	389	2	0	0	2	0.6%	0.6%
Wave 5	487	3	<1	>-1	3	0.6%	0.6%
Wave 6	392	2	<1	>-1	2	0.6%	0.5%
Wave 7	280	1	0	0	1	0.5%	0.5%

Table 10-14 summarizes the total savings by wave for PG&E. Negative joint downstream and upstream savings were not deducted except negative upstream savings for gas.

Table 10-14. PG&E total savings by wave

Wave	Program Total			
	Unadjusted	Joint Downstream	Joint Upstream	Adjusted
Electric (kWh)				
Beta	8,829,919	438,425	414,062	7,977,432
Gamma standard	4,356,269	129,351	387,850	3,839,068
Gamma reduced	3,311,285	42,975	397,812	2,870,499
Gamma electric only	2,724,567	0	299,508	2,425,059
Wave 1 dual fuel	25,507,388	839,882	2,986,045	21,681,461
Wave 1 electric only	1,996,841	0	258,809	1,738,032
Wave 2 area 7	5,920,153	218,567	17,231	5,684,355
Wave 2 non-area 7	25,277,063	1,095,023	880,027	23,302,013
Wave 3	11,932,098	562,713	311,909	11,057,476
Wave 4	7,313,374	112,477	0	7,200,898
Wave 5	16,762,833	684,126	62,970	16,015,736
Wave 6	12,289,867	154,552	198,135	11,937,180
Wave 7	6,302,943	6,498	0	6,296,445
Gas (therms)				
Beta	237,774	17,627	-11,951	232,097
Gamma standard	95,369	14,670	-11,403	92,103
Gamma reduced	90,845	0	-11,743	102,588
Wave 1 dual fuel	782,358	0	-80,313	862,672
Wave 2 area 7	268,269	2,011	-1,394	267,651
Wave 2 non-area 7	668,799	0	-23,887	692,686
Wave 3	316,990	25,169	-8,630	300,451
Wave 4	277,747	0	0	277,747
Wave 5	429,848	13,837	-1,677	417,687
Wave 6	488,975	8,952	-4,352	484,375
Wave 7	212,156	0	0	212,156
Peak Demand (kW)				
Beta	2,414.7	118.2	22.0	2,274.4
Gamma standard	305.0	35.6	20.1	249.3
Gamma reduced	194.1	8.4	21.0	164.7
Gamma electric only	311.9	66.1	18.8	227.0
Wave 1 dual fuel	4,378.7	0.0	194.8	4,183.9
Wave 1 electric only	386.7	0.0	16.2	370.5
Wave 2 area 7	1,656.9	16.0	0.1	1,640.8
Wave 2 non-area 7	1,190.2	303.1	66.6	820.5
Wave 3	512.7	114.2	23.0	375.5
Wave 4	535.7	155.7	0	380.0
Wave 5	4,392.4	191.5	5.7	4,195.1
Wave 6	3,474.9	256.2	17.3	3,201.4
Wave 7	697.8	0.0	0	697.8

Table 10-15 summarizes SCE's kWh and kW savings per household by wave.

Table 10-15. SCE per household electric savings

Wave	Baseline Consumption	Per Household Savings				% Savings	
		Unadjusted	Joint Downstream	Joint Upstream	Adjusted	Unadjusted	Adjusted
Opower 2	7,716	103	4	22	77	1.3%	1.0%
Opower 3	8,819	138	<1	10	127	1.6%	1.4%
Opower 4	12,454	153	<1	0	153	1.2%	1.2%
Opower 5	7,234	65	<1	0	65	0.9%	0.9%

Table 10-16 summarizes SCE's total kWh and kW savings by wave.

Table 10-16. SCE total savings by wave

Wave	Program Total			
	Unadjusted	Joint Downstream	Joint Upstream	Adjusted
Electric (kWh)				
Opower 2	6,411,910	262,571	1,371,301	4,778,038
Opower 3	19,739,627	97,369	1,477,619	18,164,640
Opower 4	34,738,526	121,308	0	34,617,219
Opower 5	36,699,488	280,361	0	36,419,128
Peak Demand (kW)				
Opower 2	1,402.0	80.7	109.7	1,211.7
Opower 3	3,580.5	43.8	112.1	3,424.6
Opower 4	9,350.0	13.0	0	9,337.0
Opower 5	6,734.9	0	0	6,734.9

10.10 Appendix F HER savings by PA from 2011 to 2017

Table 10-17. Historical HER kWh and therm savings per household across PAs from 2011 to 2014

Year/PA	Wave	No. of Treatment Months	Unadjusted kWh Savings per Household	Percent kWh Savings	Unadjusted therms Savings per Household	Percent therms Savings
2011-12						
PG&E	Beta	17	234	1.5%	10	0.9%
	Gamma Dual Standard	14	90	1.1%	3	0.6%
	Gamma Dual Reduced	14	74	0.9%	4	0.6%
	Gamma Electric only	14	111	1.4%	NA	NA
	Wave One Dual	11	77	1.1%	1	0.4%
	Wave One Electric only	11	85	1.1%	NA	NA
SDG&E	Pilot	18	310	2.0%	12	1.5%
2013						
PG&E	Beta	12	221	2.1%	8	1.0%
	Gamma Dual Standard	12	112	1.5%	2	0.5%
	Gamma Dual Reduced	12	101	1.4%	2	0.5%
	Gamma Electric only	12	118	1.7%	NA	NA
	Wave One Dual	12	112	1.5%	3	0.6%
	Wave One Electric only	12	128	1.6%	NA	NA
	Wave Two Area 7	11	52	0.9%	3	0.6%
	Wave Two Not Area 7	11	60	0.9%	3	0.7%
	Wave Three	6	27	0.8%	1	0.6%
SCE	Opower1	12	123	1.2%	NA	NA
SDG&E	Pilot	12	282	2.8%	11	2.0%
2014						
PG&E	Beta	12	222	2.2%	5	0.8%
	Gamma Dual Standard	12	121	1.7%	2	0.6%
	Gamma Dual Reduced	12	99	1.4%	2	0.6%
	Gamma Electric only	12	105	1.5%	NA	NA
	Wave One Dual	12	117	1.7%	3	0.7%
	Wave One Electric only	12	129	1.6%	NA	NA
	Wave Two Area 7	12	92	1.4%	3	0.8%
	Wave Two Not Area 7	12	86	1.5%	3	0.8%
	Wave Three	12	69	1.0%	3	0.8%
	Wave Four	10	37	0.7%	1	0.2%
	Wave Five	3	10	0.4%	1	0.6%
SCE	Opower2	9	52	0.8%	NA	NA
SDG&E	Pilot	12	259	2.6%	8	1.8%
2015						
PG&E	Beta	12	224	2.3%	7.4	1.1%
	Gamma Dual Standard	12	110	1.6%	2.4	0.6%
	Gamma Dual Reduced	12	94	1.4%	2.8	0.7%
	Gamma Electric only	12	128	1.9%	NA	NA
	Wave One Dual	12	121	1.8%	3.6	0.9%
	Wave One Electric only	12	137	1.8%	NA	NA
	Wave Two Area 7	12	97	1.7%	5.2	1.3%
	Wave Two Not Area 7	12	116	1.8%	4	1.0%
	Wave Three	12	102	1.6%	3.4	0.9%
	Wave Four	12	73	1.2%	3.3	0.9%
	Wave Five	12	108	1.2%	2.7	0.6%
	Wave Six	4	9	0.5%	0.7	0.5%
SCE	Opower2	12	77.7	1.0%	NA	NA
SDG&E	Opower 1	12	232	2.4%	8	1.8%
	Opower 2	12	41	0.8%	0	0.1%

Year/PA	Wave	No. of Treatment Months	Unadjusted kWh Savings per Household	Percent kWh Savings	Unadjusted therms Savings per Household	Percent therms Savings
2016						
PG&E	Beta	12	233	2.5%	6	0.9%
	Gamma Dual Standard	12	114	1.7%	2	0.6%
	Gamma Dual Reduced	12	84	1.3%	2	0.6%
	Gamma Electric only	12	125	1.9%	NA	NA
	Wave One Dual	12	124	1.9%	3	0.9%
	Wave One Electric only	12	119	1.6%	NA	NA
	Wave Two Area 7	12	96	1.7%	4	0.9%
	Wave Two Not Area 7	12	120	1.9%	2	0.6%
	Wave Three	12	103	1.6%	3	0.7%
	Wave Four	12	64	1.1%	2	0.6%
	Wave Five	12	130	1.5%	3	0.7%
	Wave Six	12	46	0.8%	2	0.5%
SCE	Opower 2	12	86	1.1%	NA	NA
	Opower 3	12	115	1.3%	NA	NA
	Opower 4	9	50	0.5%	NA	NA
SDG&E	Opower 1	12	141	1.7%	9	1.8%
	Opower 2 Low Income	12	58	1.1%	<1	0.1%
	Opower 2 Non-Low Income	12	67	1.4%	<1	-0.2%
	Opower 3 Expansion Digital	12	37	0.8%	2	0.7%
	Opower 3 Expansion Paper	12	71	0.7%	3	0.9%
2017						
PG&E	Beta	12	220	2.3%	6	0.8%
	Gamma Dual Standard	12	95	1.4%	2	0.5%
	Gamma Dual Reduced	12	72	1.1%	2	0.5%
	Gamma Electric only	12	122	1.8%	NA	NA
	Wave One Dual	12	107	1.6%	3	0.8%
	Wave One Electric only	12	91	1.2%	NA	NA
	Wave Two Area 7	12	105	1.8%	5	1.0%
	Wave Two Not Area 7	12	116	1.8%	3	0.7%
	Wave Three	12	81	1.3%	2	0.5%
	Wave Four	12	58	1.0%	2	0.6%
	Wave Five	12	113	1.3%	3	0.6%
	Wave Six	12	55	0.9%	2	0.6%
	Wave Seven	10	44	0.8%	1	0.5%
SCE	Opower 2	12	103	1.3%	NA	NA
	Opower 3	12	138	1.6%	NA	NA
	Opower 4	12	153	1.2%	NA	NA
	Opower 5	9	65	0.9%	NA	NA
SDG&E	Opower 1	12	80	1.0%	6	1.2%
	Opower 2 Low Income	12	39	0.8%	1	0.5%
	Opower 2 Non-Low Income	12	75	1.6%	<1	0.3%
	Opower 3 Expansion Digital	12	61	1.3%	3	1.0%
	Opower 3 Expansion Paper	12	130	1.4%	4	1.1%
	Opower 4 Digital	8	22	0.7%	<1	0.0%
	Opower 4 Paper	8	46	0.8%	1	0.6%
	Opower 5	1	<1	0.1%	<1	0.0%

10.11 Appendix G HER survey

1. Introduction

INTRODUCTION EMAIL

From: research@survey.dnvgl.com

To: [customer@email.com]

Subject line: Take the CPUC's Lighting & Energy Survey for a chance to win $100!

Dear [Customer First Name],

Your opinions are important! Your utility and the California Public Utilities Commission (CPUC) would like your input and perspectives to understand how to best structure residential energy efficiency programs in the future. Your household has been selected to participate in a survey to learn about household energy using equipment.

To be entered into a drawing to win a $100 prepaid cash incentive card, please complete this 10-minute [**online survey**] by midnight December 31, 2018. Winners will be notified by email. The information gathered will be used solely for research purposes and your individual response will be kept completely confidential.

DNV GL is the research provider retained by the CPUC to help administer this survey. The above survey link is unique to your household, please do not forward it. To validate the legitimacy of this survey, visit the CPUC website for a listing of this and other CPUC approved research efforts underway: http://cpuc.ca.gov/validsurvey

Thank you in advance for your participation! You are helping to improve energy efficiency programs in California.

155 Grand Ave. Suite 500
Oakland, CA 94612
www.dnvgl.com

This link is unique to you. Please do not forward it. If you would like to be removed from this survey, click on this link: **Remove from list**

ONLINE SURVEY INTRODUCTION SCREEN

Hello [Name],

Hello {Q2}, To help make improvements to existing energy efficiency programs and rebates, the California Public Utilities Commission (CPUC) is surveying you and other customers to learn more about how you use energy and the lighting purchases you made in the past 12 months.

This survey should only take 10 minutes and your responses are completely anonymous. Please answer all questions as completely and accurately as possible.

SURVEY SCREENING

Any terminate points in the screening portion of the survey can be redirected to a link or to a screen asking if they would like more information and offer a link or multiple links to PG&E's programs or the main PG&E site.

Redirect link: https://www.pge.com/en_US/residential/save-energy-money/savings-solutions-and-rebates/rebates-by-product/rebates-by-product.page

Screening termination points:

- Works or someone in household works for PG&E or other utility – *collect info. do not terminate*
- Wrong address – *collect info. do not terminate*
- Unfamiliar with household light bulb purchases - *Generic end screen with thank you or screen offering more program information.*

2. Background

Customer Questions. First, we want to ask you a few background questions before we proceed to energy use questions.

I1. First, we want to ask you a few background questions before we proceed to energy use questions. Does anyone in your household currently work for PG&E or another gas or electric company?

1	Yes	SPECIFY: _____ **➔GO TO I2**
2	No	**➔GO TO I2**

I2. Do you live at this location <ADDRESS>?

1	Yes	➔GO TO I3
2	No	➔ collect correct address. GO TO I3;

I2a. What is your home address?

I3. Are you familiar with this household's purchases of light bulbs in the past 12 months?

1	Yes	➔ GO TO L1
2	No	➔ THANK & TERMINATE
97	DON'T KNOW	➔ THANK & TERMINATE

3. Lighting Introduction

Lighting Introduction: We are interested in the light bulbs purchased and installed in the past 12 months by you or anyone else in your home, especially the most common screw-based light bulbs. Please think about these three categories of light bulbs separately. For your reference, the images shown here display these typical products available in retail and home improvement stores. LED (Light-Emitting Diode) bulbs: CFL (Compact Fluorescent Light) bulbs: Incandescent and halogen bulbs:

Light Bulb Purchases

G0. Approximately how many total light bulbs did your household purchase in the past 12 months?

In case of multi-packs purchases, please list the total number of bulbs purchased. For example, two multi-packs with three bulbs each would count as six bulbs. Your best estimate is fine.

1. None > ➔ Go to "Household Changes"
2. One or more, specify quantity:_____ ➔ Go to G1

G1. What type of light bulbs did you purchase? Check all that apply.

1. LEDs
2. CFLs
3. Incandescent/Halogen
4. Other types ➔ SKIP to Household Changes

LED

LED Use - In this section, please limit responses to LEDs that you or anyone else may have purchased for your home in the past 12 months. LEDs are the most efficient light bulbs available today and come in many shapes and sizes

Source: U.S. Department of Energy, http://energy.gov.

L1 How many of the [#ALL LAMPS] total light bulbs purchased in the past 12 months, were LEDs? You've entered {#LEDS# }/{#ALL LAMPS}

L2 How many of the [#LEDS]/ LED bulb(s) purchased are currently installed inside and outside your home?

1. All of them (100%)
2. Most of them (75%)
3. Some of them (50%)
4. A few of them (25%)
5. None (0%)
6. ➔ GO TO L4

L4 [If L3 <100% then ask] What have you done with the purchased LED(s) that are NOT currently installed? Did you....

1. Store them in your home
2. Give them away
3. Returned them to the store
4. Removed them
5. Don't know
6. Did something else with them? (SPECIFY: _____)

L4a. [If L4=5 then ask else Go to L5] Why did you remove the LED(s)? [check all that apply]

1. Bulb burned out
2. Defective bulb
3. Poor light output
4. Removed fixture
5. Other reason:

L5 What type of light bulb did the majority of the LED(s) replace? Was it...

1. Incandescent/halogen bulbs
2. CFLs
3. LED bulbs
4. A mix of CFL and other bulbs, or
5. Did not replace other bulbs – empty sockets
6. DON'T KNOW
7. OTHER, SPECIFY___

➔ GO TO CFL if= CFL SELECTED

CFL

Compact Fluorescent Light (CFL) Bulb Purchases. In this section please only think about CFL bulbs that you purchased for your home in the last year. Remember, CFL bulbs come in many shapes and sizes. The most common type of CFL is made with a glass tube bent into a "twisty" shape and fits in a regular light bulb socket.

Source: U.S. Department of Energy, http://energy.gov.

C1. How many of the {#ALL LAMPS} total bulb(s) purchased in the past 12 months were CFLs?
You've entered {#CFLs}/{#ALL LAMPS}

C2. Approximately, how many of the [C] CFL(s) were high-wattage CFLs? A high wattage CFL is greater than 30 watts and is typically larger and brighter than a standard CFL

You've entered {#CFLs}/{#ALL LAMPS} CFLs, the high-wattage bulb total should not exceed{#ALL LAMPS}

[Free-form entry] ➔ GO TO C3

C4. How many of the {#CFLs} CFL(s) purchased in the past 12 months are currently installed inside and/or outside your home?

1. All of them (100%)
2. Most of them (75%)

3. Some of them (50%)
4. A few of them (25%)
5. None (0%) ➔ **GO TO C4a**

C4a. [If C4 is less than 100%] What have you done with the purchased CFL(s) that are NOT currently installed? Did you...

1. Store them in your home
2. Give them away
3. Returned them to the store
4. Removed them
5. Don't know
6. Did something else with them? (SPECIFY: _____)

C5. What type of bulb did the majority of these CFL bulbs replace? Was it . . .

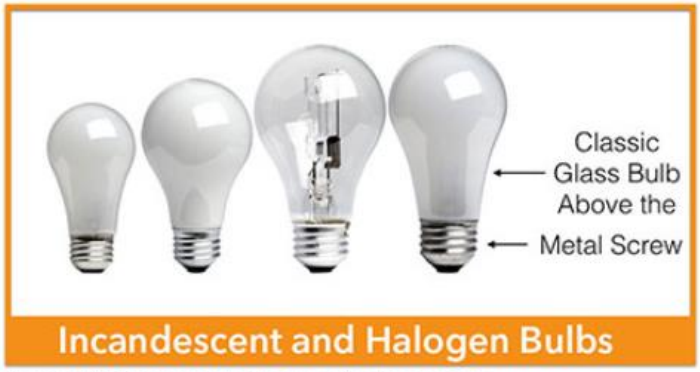
1. Incandescent bulbs
2. Halogen bulbs
3. LED bulbs
4. Other CFL bulbs,
5. A mix of CFL and other bulbs, or
6. Did not replace other bulbs
7. 9OTHER, SPECIFY___
8. DON'T KNOW

➔ **GO TO H1**

Incandescent/Halogen

Incandescent/Halogen Light Bulb Use

In this section please only think about incandescent and halogen bulbs that you purchased for your home in the last year. Incandescent and halogen bulbs are the least efficient and often the cheapest light bulbs on the market.



Source: U.S. Department of Energy, http://energy.gov.

H1. How many of the total bulb(s) purchased, in the past 12 months, are incandescent or halogen? You've entered{#INCs}/{#ALL LAMPS}

H2. How many of the {#INCs} incandescent and halogen bulb(s) purchased are currently installed inside and/or outside your home?

1. All of them (100%)
2. Most of them (75%)
3. Some of them (50%)
4. A few of them (25%)
5. None (0%) ➔ GO TO H3a

H3a. [If H4 is less than 100%] What have you done with the incandescent and halogen bulb(s) that are not currently installed? Did you...

1. Store them in your home
2. Give them away
3. Returned them to the store
4. Removed them
5. Don't know
6. Did something else with them? (SPECIFY: _____)

H4. What type of bulb did the majority of these incandescent and halogen bulb(s) replace? Was it...

1. Incandescent
2. /Halogen bulbs
3. CFL(s)
4. LED(s)
5. A mix of CFLs and other bulb(s)
6. Did not replace other bulbs
7. Don't know
8. Other, specify:

4. Household Changes

CH1. Which of the following changes, if any, have you made in your home since January 2017?

Select all changes that apply or if none please scroll down and select "no changes made"

Living space	1	Increased living area/square footage of your home (finished basement to add media room or bedroom, for example)	11	Decreased living area/square footage of your home (converted a bedroom to a store room, for example)
Heating Areas	2	Heating **additional areas** in your home	12	Heating **fewer areas** in your home
Heating Usage	3	Using **more heating** in your home	13	Using **less heating** in your home
Cooling Areas	4	Cooling **additional areas** in your home	14	Cooling **fewer areas** in your home
Cooling Usage	5	Using **more cooling** in your home	15	Using **less cooling** in your home
Lighting	6	Using more lighting	16	Using less lighting
Refrigerator	7	Using an additional refrigerator	17	Got rid of/recycled/stopped using an additional refrigerator
Pool	8	Added a pool	18	Eliminated/stopped using your pool
Spa	9	Added a spa/whirlpool	19	Eliminated/stopped using your spa/whirlpool
Occupancy	10	Occupied your home for more days in the year compared to previous years	20	Occupied your home for fewer days in the year compared to previous years
21. Thermostat or home automation		Installed a learning/smart thermostat (e.g. Nest, EcoBee)		
		Installed a home automation system or home energy management (e.g. Amazon's Echo/Alexa or Applies Home Kit)		
22 No changes made		**No changes**		

CH2. How familiar are you with PG&E's residential energy efficiency programs that are designed to help lower your bill and use less energy?

1. Not at all familiar
2. Not very familiar
3. Somewhat familiar
4. Very familiar

CH3. Are you aware that PG&E offers discounts on energy efficient light bulbs in retail and home improvement stores? These discounts are sometimes shown on store shelves as instant rebates on the price.

1. Yes
2. No

5. Emerging Technologies and Smart Energy Offers

SE01. PG&E provides customers with additional information on rates and technologies like solar. Which of the following have you either sought information on, received information on or used from or your utility?

1. **Rate plan options:** To learn about alternate electric rates and time-of-use pricing options.
2. **Solar estimator:** Used your utility's solar calculator to evaluate the right size solar electric system for your home
3. **Neither of these**

SE02. Which of the following products or services do you currently have, are you considering purchasing or using sometime in the next two years?

Product/Program/Service	Used/had prior to 2017	Use/have since 2017	Would consider use/purchase in the next 2 years	Would not consider use/purchase in the next 2 years	Don't know
Smart thermostat (Hover text: A smart thermostat, also known as a connected or communicating thermostat, allows you to create automatic and programmable temperature settings based on daily schedules, weather conditions, and heating and cooling needs)					
Smart LED light bulbs (Hover text: Smart LED light bulbs can wirelessly connect with phone apps and be controlled remotely. They also offer capabilities such as dimming, color changing, and music playing via built in speakers)					
Smart appliances (Hover text: Smart appliances connect to your smartphone, tablet or computer to give you more information and control than ever before. Your smart appliance can send you alerts, for example, so you'll know exactly when the laundry is clean or the cookies are ready)					
Home hub (Hover text: e.g. Technologies like Amazon Alexa, Google Home etc. that respond to voice commands)					
Battery storage (Hover text: e.g. Like Enphase, Powerwall etc.)					
Time-of-use rates					

(Hover text: Time-of-use rates vary according to the time of day, season, and day type (weekday or weekend/holiday). Higher rates are charged during the peak demand hours and lower rates during off-peak (low) demand hours. This rate structure provides price signals to energy users to shift energy use from peak hours to off-peak hours)					
Electronic energy bills or e-bills (i.e. receive bills via email versus paper bills sent through the post)					
Automatic bill payments (i.e. pay bills automatically)					

IF SEO2=SMART TSTAT=Use/have then ask SEO3, else SEO4

SE03. If you have a Nest smart thermostat, your PG&E's Seasonal Savings program can give your Nest thermostat's temperature schedule a tune-up in the early winter and summer by automatically making small changes to some temperatures in your schedule to make them more efficient. It uses everything your Nest thermostat has learned about your home and temperature preferences to find ways to save energy without compromising comfort. How willing would you be to participate in this program/such a program?

1. Very unwilling
2. Somewhat unwilling
3. Neutral
4. Somewhat willing
5. Very willing
6. Already participate in this program/such a program
7. I have a smart thermostat, but it is not a Nest

If SEO3=6=Already use the tool, ask SEO4.

SE04. Home Energy Checkup is a free web-based service or tool that gathers basic information from customers like you about your homes and habits to provide you with an online energy "audit" that includes personalized recommendations for energy saving actions. Based on answers you provide to a few questions about your home and your energy using appliances, you receive energy saving tips and can set up an energy savings action plan on the tool. You can also update the tool with your progress, monitor changes, and continue to engage with the tool and receive tips for ongoing energy savings. How willing would you be to use such a web-based service or tool?

1. Very unwilling
2. Somewhat unwilling
3. Neutral
4. Somewhat willing
5. Very willing
6. Already use this online tool

SE05. Which of the following best describes your level of engagement with Home Energy Checkup. [CHECK ALL THAT APPLY]

1. Have checked out the tool, but have not completed an audit/survey about your home
2. Have completed a survey about your home

3. Have created a plan on the tool for energy efficiency actions you can undertake
4. Have created a plan and updated the tool about energy efficiency actions you completed
5. None of these

SEO6. Which of the following products or services do you currently have or are you considering purchasing or using in the next two years?

Product/program/service	Used/Had prior to 2017	Use/have since 2017	Would consider use/purchase in the next 2 years	Would not consider use/purchase in the next 2 years	Don't know
Solar panels (Hover text: Residential/ on-site solar systems are solar photovoltaic (PV) panels that can be installed on-site/at your home – on your rooftop or ground-mounted - to generate electricity from the sun for your home)					
Community solar (Hover text: 'Community solar' refers to either community-owned or third party-owned solar installations whose electricity is shared by a community. For example, condominium owners, renters in an apartment complex, or fellow members of community groups such as a church who "co-own" a solar panel system situated in their community)					
Battery electric vehicle (BEV) (Hover text: e.g. Nissan Leaf, Tesla Model S, BMW i3, Fiat 500e, etc. that can be recharged/re-fueled by plugging in to an electrical outlet)					
Plug-in hybrid electric vehicle (PHEV) (Hover text: e.g. Chevrolet Volt, Toyota Prius Plug-in, Ford Fusion Energi, Ford C-Max Energi, etc. that can be recharged/re-fueled by plugging in to an electrical outlet)					
Heat pump (Hover text: Heat pumps are part of a central heating and cooling system which use the outside air to both heat a home in winter and cool it in summer)					
Heat pump water heaters (Hover text: Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly. Therefore, they can be two to three times more energy efficient than conventional electric resistance water heaters)					

If SEO6=BEVs or PHEVs=Use/have currently is checked, then ask SEO7-SEO14

SEO7. Do you charge your electric vehicle (BEV or PHEV) at home?

Yes > Go to SEO8

No > Go to SE012

SE08. [Show if SEO7 = YES] Please indicate the type of charger you use at home.

Tip: 120V=Level 1 charger (slower charge) 240V=Level 2 charger (faster charge)

1. Level 1
2. Level 2
3. Uncertain

Miles per hour:_____ *(Internal note: Range – 4 to 340. 200-340 per hr is for level 3 and 4…but we can allow for that)*

[Show if SEO7 = YES] SE09. Are you enrolled in a special TOU rate for EVs?

1. Yes
2. No

[Show if SEO7 = YES] SE010. Is your electric bill higher, lower, or about the same since you purchased an EV?

1. Higher
2. Lower
3. About the same

[Show if SEO7 = YES] SEO11. What percent of your charging is done at home versus away from home? (should add to 100%)

1. Home_____
2. Away from home _____

SEO12. When charging away from home which charging station type do you most often use? [Pick one]

Charging stations

1. Level 2 e.g. ChargePoint, JuiceBox, EVgo, etc.
2. Level 3 e.g. EVgo charging Station
3. Tesla Super Charging station
4. Don't know
5. Other, specify:

SEO13. When away from home which of the following locations do you typically charge your EV at? Check all that apply.

1. At your place of work
2. Automobile showroom
3. Education school, college, university, etc.
4. Existing gas stations

5. Existing highway rest stops
6. Grocery stores (e.g. Whole Foods, Lucky's, Ralphs/Von's)
7. Gym/workout location
8. Hotels/lodging
9. Parking garage
10. Public spaces, e.g. parks
11. Restaurants, cafe's, quick service restaurant
12. Retail shopping centers
13. Street parking
14. Worship/civic location
15. Don't know
16. Other, specify:

SE14. If public charging stations were more readily available where would you prefer to charge? Pick your three most preferred locations.

1. At your place of work
2. Automobile showroom
3. Education school, college, university, etc.
4. Existing gas stations
5. Existing highway rest stops
6. Grocery stores (e.g. Whole Foods, Lucky's, Ralphs/Von's)
7. Gym/workout location
8. Hotels/lodging
9. Parking garage
10. Public spaces, e.g. parks
11. Restaurants, cafe's, quick service restaurant
12. Retail shopping centers
13. Street parking
14. Worship/civic location
15. Don't know
16. Other, specify:

Randomize SEO14 and SEO15

SE015. The Critical Peak Pricing (CPP) is an electric rate in which a utility charges a higher price for consumption of electricity during peak hours on selected days, referred to as critical peak days or event days. The higher price during peak hours on critical event days is designed to encourage customers to shift when they consume energy in order to prevent blackouts. Utilities typically call event days 5 to 15 times a year based on their system conditions when demand is high and supply is short. How willing would you be to participate in a CPP program?

1. Very unwilling
2. Somewhat unwilling
3. Neutral
4. Somewhat willing
5. Very willing
6. Already participate in CPP events

SE016. Utilities call demand response (DR) events a few times a year to encourage customers by financially incentivizing them to shift when they consume energy in order to prevent blackouts. Customers can opt into such programs that aim to affect energy usage – according to the consumer's own preferences and settings – by adjusting lighting systems, pool pumps, electric vehicle charging, electric water heater systems, heating and air-conditioning systems – during a DR event. How willing would you be to participate in such DR programs?

1. Very unwilling
2. Somewhat unwilling
3. Neutral
4. Somewhat willing
5. Very willing
6. Already participate in DR programs that directly control my appliances

SE17. Which of the following types of apps do you use? (Check all that apply) [RANDOMIZE 01-08]

1. Ride-hailing apps (For example: Uber, Lyft etc.)
2. Electric scooter rental apps (For example: Lime, Bird, Skip, Scoot etc.)
3. Navigation (For example: Waze, Google Maps, Apple Maps, etc.)
4. Food delivery (For example: UberEats, Grubhub, Doordash etc.)
5. Social Media (For example: Facebook, Instagram, Snapchat, etc.)
6. Restaurant Reviews (For example: Yelp, Foursquare, Urbanspoon, etc.)
7. Banking and Finances (For example: Venmo, PayPal, Wells Fargo Mobile, etc.)
8. Location Sharing Apps (For example: Swarm, Find My Friends, etc.)
9. I do not use any apps [EXCLUSIVE]

If SEO17=1=Yes (ride-hailing apps), then ask SEO18

On average, how many trips per month do you take on ride-hailing apps like Uber and Lyft combined?

1. 1-2
2. 3-5
3. 5-10
4. 10 or more
5. Prefer not to say

If SEO17=2=Yes (electric scooters), then ask SEO19

SEO18. How many trips per month do you take on electric scooters or bike share like Lime, Bird, Ford GoBike, JUMP, MetroBike, Scoot, combined?

1. 1-2
2. 3-5
3. 5-10
4. 10 or more
5. Prefer not to say

SEO19. How willing would you be to travel in a self-driving vehicle if/when these technologies become available in the market to customers?

1. Very unwilling
2. Somewhat unwilling
3. Neutral
4. Somewhat willing
5. Very willing

6. HER Experience (Treatment Only for this section)

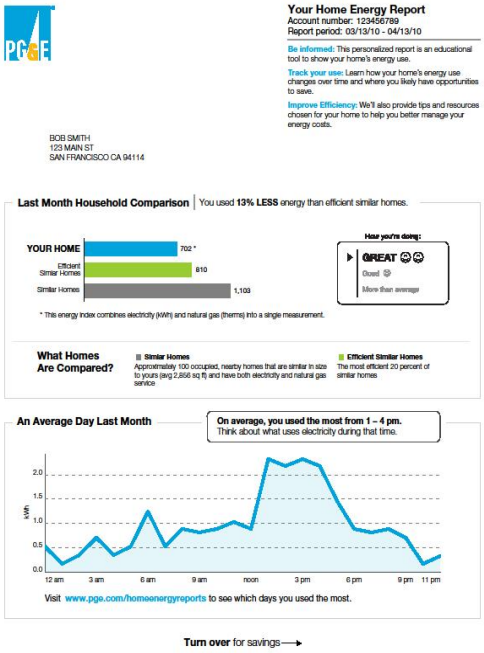
HOME ENERGY REPORT

HER1. Has your household received a Home Energy Report listing your home's energy use and compares it with similar homes in the area?

1. Yes ➔ GO TO HER3
2. No ➔ GO TO HER2
3. DON'T KNOW ➔ GO TO HER2

HER2. [IF HER1 = 2 or 97] This is what the Home Energy Report looks like. Do you recall receiving the following report by mail from PG&E?

[Internal note: Need to customize for each PG&E. Currently have PG&E HER report image here]



1. Yes ➔ GO TO HER3
2. No ➔ GO TO HH1
3. 97 DON'T KNOW ➔ GO TO HH1

HER3. Roughly, about how much time do you spend reviewing your Home Energy Report?

1. I do not review my report at all
2. Less than 2 minutes
3. 2-5 minutes
4. 6-10 minutes
5. 10 minutes or more

HER3. Have you undertaken any energy efficiency actions recommended by your Home Energy Report such as changing the setpoint on your thermostat, installing a programmable or smart thermostat, caulking windows and doors to reduce leakage etc.?

1. Yes
2. No

HER4. Overall, what is your reaction to your Home Energy Report?

1. Very Negative
2. Negative
3. Neutral
4. Positive

7. Respondent and Household Characteristics

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

HH1. What year was your home built? [SINGLE RESPONSE]

1. Before the 1970s
2. 1970s
3. 1980s
4. 1990-1994
5. 1994-1999
6. 2000s
98. Don't know

HH2. How many bedrooms are there in your home?

1. Studio
2. 1
3. 2
4. 3
5. 4 or more

HH3. Roughly, how large is your home (in square feet): _____

HH4. Which of the following best describes your education?

1. Some high school or less
2. Graduated high school
3. Trade or technical school
4. Some college
5. College graduate
6. Post graduate work or degree
98. Prefer not to answer

Research shows that home occupancy strongly influences household energy use. In the next few questions, we would like to better understand how many people were living in your home for all or part of the year. Individual responses will be kept confidential and will be averaged to understand occupancy trends across all survey respondents.

HH5. How many people, including yourself, lived year-round in your household at [address]?

***If were not at your current residence in the years 2016 or 2017, please select "not applicable".**

- In 2016 [Repeat for each list option for each row]
- In 2017 [Repeat for each list option for each row]
- In 2018 [Repeat for each list option for each row]

List option:

1. None
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6 or more
8. Prefer not to answer
9. Not applicable

HH6. [HIDE IF HH6 IS 8 OR 9] You mentioned that {HH5.2017} people lived at your home year-round in 2017. Did anyone stay/visit or leave for a month or longer? For example: students leaving home for college, elderly family members moving in part-way through the year etc.

Scale: None - 1 - 2 - 3 - 4 - 5 - 6 or more - prefer not to answer - not applicable

Number of additional members in summer
Number of fewer members in summer
Number of additional members in winter
Number of fewer members in winter

HH7. Which of the following categories best describes your employment status?

1. Employed full-time
2. Employed part-time
3. Unemployed
4. Retired
5. Homemaker
6. Temporarily laid off
7. Student
8. Other, please specify: [OPEN-ENDED RESPONSE]
9. Prefer not to answer

HH8. Which of the following categories best describe your family's total household income in 2017 before taxes?

1. Under $25,000
2. $25,000 to under $50,000
3. $50,000 to under $75,000
4. $75,000 to under $100,000
5. $100,000 to under $150,000
6. $150,000 to under $200,000
7. $200,000 or more
8. Prefer not to answer

8. Wrap-Up

Thank you very much for your time and opinions.

PROGRAM NOTE: THE SURVEY ENDS ON THIS LANDING PAGE:
If you would like more information about PG&E programs and rebates available in your area click on the "more information" button below. [PG&E program/rebate landing page]

10.12 Appendix H HER survey – sample weights

The team applied sample weights, in order to balance the survey sample to the population proportions by each PA, wave, and treatment and control combinations. No trimming of weights was required with the maximum weight, minimum weight, and the ratio of the maximum to minimum sample weight at 0.5, 1.8, and 3.5 respectively. Minimum cell size to which weights were applied was 94. This indicates a generally balanced survey sample requiring minor corrections for over and under representation thus reducing the design effect on the data and any potential inflation of standard errors for estimated statistics.

Table 10-18. HER survey sample weights

IOU	wave	Treatment =1 Control=0	Sample frame - Frequency	Sample frame - percent	Survey sample - frequency	Survey sample - percent	Proportional sample weight
PG&E	**BETA**	**0**	20513	0.89%	287	1.49%	0.60
PG&E	**BETA**	**1**	20878	0.91%	307	1.59%	0.57
PG&E	**GAMMA**	**0**	30122	1.31%	335	1.74%	0.76
PG&E	**GAMMA**	**1**	30532	1.33%	332	1.72%	0.77
PG&E	**GAMMA REDUCED**	**1**	18964	0.83%	226	1.17%	0.71
PG&E	**WAVE 1**	**0**	28172	1.23%	346	1.79%	0.68
PG&E	**WAVE 1**	**1**	115184	5.02%	1441	7.47%	0.67
PG&E	**WAVE 2 Area 7**	**0**	14169	0.62%	230	1.19%	0.52
PG&E	**WAVE 2 Area 7**	**1**	23044	1.00%	348	1.80%	0.56
PG&E	**WAVE 2 Not Area 7**	**0**	14630	0.64%	172	0.89%	0.72
PG&E	**WAVE 2 Not Area 7**	**1**	94959	4.14%	1114	5.77%	0.72
PG&E	**WAVE 3**	**0**	23855	1.04%	250	1.30%	0.80
PG&E	**WAVE 3**	**1**	71645	3.12%	774	4.01%	0.78
PG&E	**WAVE 4**	**0**	24587	1.07%	207	1.07%	1.00

IOU	wave	Treatment =1 Control=0	Sample frame - Frequency	Sample frame - percent	Survey sample - frequency	Survey sample - percent	Proportional sample weight
PG&E	**WAVE 4**	**1**	65828	2.87%	531	2.75%	1.04
PG&E	**WAVE 5**	**0**	18962	0.83%	167	0.87%	0.95
PG&E	**WAVE 5**	**1**	80258	3.50%	702	3.64%	0.96
PG&E	**WAVE 6**	**0**	21939	0.96%	161	0.83%	1.15
PG&E	**WAVE 6**	**1**	137597	5.99%	976	5.06%	1.19
PG&E	**WAVE 7**	**0**	22552	0.98%	135	0.70%	1.40
PG&E	**WAVE 7**	**1**	89213	3.89%	489	2.53%	1.53
SCE	**Wave 2**	**0**	21154	0.92%	228	1.18%	0.78
SCE	**Wave 2**	**1**	21160	0.92%	193	1.00%	0.92
SCE	**Wave 3**	**0**	22984	1.00%	225	1.17%	0.86
SCE	**Wave 3**	**1**	75465	3.29%	770	3.99%	0.82
SCE	**Wave 4**	**0**	17716	0.77%	124	0.64%	1.20
SCE	**Wave 4**	**1**	128307	5.59%	892	4.62%	1.21
SCE	**Wave 5**	**0**	22581	0.98%	197	1.02%	0.96
SCE	**Wave 5**	**1**	271305	11.82%	2482	12.86%	0.92
SDG&E	**OPower1**	**0**	10686	0.47%	113	0.59%	0.80
SDG&E	**OPower1**	**1**	10639	0.46%	94	0.49%	0.95
SDG&E	**OPower2**	**0**	15173	0.66%	121	0.63%	1.05
SDG&E	**OPower2**	**1**	55637	2.42%	453	2.35%	1.03
SDG&E	**OPower3**	**0**	36367	1.58%	238	1.23%	1.28
SDG&E	**OPower3**	**1**	342717	14.93%	2306	11.95%	1.25
SDG&E	**OPower4**	**0**	26714	1.16%	127	0.66%	1.77
SDG&E	**OPower4**	**1**	95909	4.18%	450	2.33%	1.79
SDG&E	**OPower5**	**0**	20797	0.91%	111	0.58%	1.58
SDG&E	**OPower5**	**1**	132409	5.77%	646	3.35%	1.72

10.13 Appendix I Response to comments

Table 10-19. Response to comments – HER PY 2017

Response ID	Commenter	Page # (as shown in Word document footer)	Comment	Response
1	OpenEE		Given that the impact evaluation results from this study (as well as the last several) are very close to the claimed savings the CPUC should consider an approach by which additional evaluation adjustments could be made by the utilities as part of the savings claim and the HER could come off of the Uncertain Measure List. If other insights can be gleaned from the evaluation those priorities could be addressed. Overall, uncertainty metrics should be part of the savings claim for this an all meter-based quantification approaches embedded in programs to determine if it should remain on the uncertain measure list.	Due to the one-year measure life, regular new waves and changing savings, HER savings need to be evaluated on an annual, ex post basis. In prior years, CPUC evaluations validated utility results as well as perform the impact evaluations for utilities that did not employ an outside evaluator. For 2017, only PG&E retained an outside evaluator.
2	PG&E	28	On page 28, DNV GL states that electric savings show a similar pattern of ramping up over time, that older electric waves have a higher percentage of savings than more recent waves, and that gas savings do not exhibit any ramp-up period. Figure 5-2 on page 29 is offered as evidence. In fact, the selection criteria for these waves differs: the beta wave includes customers in the highest quartile of energy use, the gamma wave includes customers in all quartiles of energy use, and the successive few waves includes customers in the top three quartiles of energy use. Would it be possible for DNV GL to include all the experiments in this figure? If this is not possible for space considerations, could DNV GL modify this figure to include waves 2 through 6 instead?	We now include all of the waves in Figure 5-2 and discuss the differences in savings we see within the context of the groups targeted by each wave. The statements re trends are trends across years within waves not across waves. Different selection criteria are likely to affect overall level across waves, but we believe our statement re ramping stands despite that.

Response ID	Commenter	Page # (as shown in Word document footer)	Comment	Response
3	PG&E	11	On page 11, DNV GL observes that "DNV GL used a fixed effects regression model, a standard for evaluating behavioral programs like HER, for this evaluation, thus making it possible to compare consumption of the treatment group to the control group before and after program implementation." We would like to point out that Nexant's use of a lagged dependent variable model in which monthly energy consumption for treatment and control customers was estimated using consumption data from the pretreatment period also is a reasonable approach.	Noted.
4	PG&E		We are gratified that the analyses undertaken by DNV GL as documented in the draft HER evaluation corroborate estimates of savings found by Nexant in its 2017 Energy and Demand Savings Early EM&V Study. We would like to point out the following: • DNV GL estimates 122 GWh, 3.94 million therms, and 18.78 MW Peak Demand savings for 2017 for PG&E, adjusted for possible double-counting by both upstream and downstream programs. • Nexant estimates 127 GWh, 4.1 million therms, and 18.1 MW Peak Demand savings for 2017 for PG&E, adjusted for possible double-counting by only downstream programs. Had Nexant used a similar adjustment for upstream programs that DNV GL used, the aggregate savings estimates for 2017 would have been essentially equal.	Noted.
5	PG&E		The experiment most recently put into the field with savings measurable in 2017, Wave Seven, was estimated to have resulted in average per-household electricity (kWh) and gas (Therms) consumption savings of 0.8% and 0.5% by DNV GL and 0.7% and 0.4% by Nexant, respectively for calendar year 2017.	Noted.

Response ID	Commenter	Page # (as shown in Word document footer)	Comment	Response
6	PG&E		DNV GL's unadjusted Peak Demand savings estimate for 2017, 20.5 MW, is 13% greater than Nexant's unadjusted estimate of 18.1 MW. We note that a key driver of DNV GL's higher estimate, approximately 13% higher than Nexant's, can be explained by customer counts. In Nexant's evaluation, customers who were initially assigned to treatment or control conditions but who were ultimately removed prior to launch due to ineligibilities before the wave launch were removed from the analysis datasets but not from the experiment rolls. This discrepancy between the count of two customer lists was caused by a new availability of data from Oracle.	We do not have an updated list (roster) that excludes treatment and control households due to ineligibilities. Since household exclusions are not correlated with treatment status resulting savings estimates are not going to be biased. Differences in estimates that is indicated here can, thus, may be attributed to random noise or perhaps differences in methodology.
7	SCE	12	In page 12, the report describes how demand savings were calculated. It is not clear but appears that the described method does not calculate demand savings based on the regression analysis with controlling other factors that might influence the outcome, instead, it uses simple algebraic differences of means approach. What are the reasons for choosing simple differences approach over the regression-based analysis? If you did control other factors, could you please explain them?	DNV GL uses a regression model that specifies pre-post peak demand as a function of treatment dummy. Since this is an RCT, the presence of the control group accounts for other confounding factors and there is no need to include additional control variables in the regression model. We have updated our report to include the model specification we use in the analysis.

Response ID	Commenter	Page # (as shown in Word document footer)	Comment	Response
8	SCE		SCE believes that distributional analysis instead of only single impact value would have been very valuable. The report does not discuss the distributional effect of HER program which would have been more nuanced and helpful in understanding the impact. The average treatment effects are not the best estimate when there are large sample sizes – averages reduce an entire impact distribution to a single number and heterogeneity in treatment effects will gone unnoticed.	First, we want to note that DNV GL is tasked with evaluating savings achieved by the program in program year 2017. Distributional analysis is a program implementation issue, which is not related to evaluation. Second, distributional analysis requires the identification of treatment and control pairs, which is not possible in an RCT. Unlike quasi-experimental settings, where it is possible to identify matched treatment and comparison pairs, an RCT involves randomization at the group level and does not identify treatment and control pairs. As a result, distributional analysis of the sort SCE is suggesting is not a straightforward undertaking. Having said this, DNV GL will work with SCE and other interested stakeholders to identify ways to address such analysis in future evaluations.
9	SCE		SCE believes that since its HER waves expanded significantly during 2015, it would have been beneficial to understand the impact for 2016 as well. Given that data was provided, we expected some results to understand the effects particularly for waves 2 and 3.	DNV GL is currently evaluating HER 2016 program year activities and will have these results ready for public review in mid-April.
10	SCE		SCE would like the scope of work and research plan of HER impact evaluation methodology to be provided ahead of time, during the data request process or even earlier. This would allow us to provide better feedback, have better understanding of the methodology, and setting the right expectations from the study.	The workplan for the residential impact evaluation was posted to the PDA site and stakeholders were able to review and provide comments early on. We received comments from SDG&E, SCG, PG&E, BayREN, and NRDC through this process.

Response ID	Commenter	Page # (as shown in Word document footer)	Comment	Response
11	SCE		Is it possible to provide a table of sample sizes for each wave that was used towards the final kWh calculations in the main section of the report? It is difficult to determine the final numbers from the varying table in the report.	We now include the average number of treatment households for each wave in program year 2017 in the tables that provide unadjusted savings by wave. For SCE, these numbers can be found in Table 6-1. Please note that the total savings for each wave are the sum of monthly total savings that reflect the number of households present in each month. Monthly households counts vary due to attrition. Therefore, total savings for each wave in the table are going to be close to but not equal to the per household savings times the average number of treatment households reported in the table. We include a note to this effect in the footnote of the table. Please also note we give starting and ending treatment and control household counts by wave in Appendix A.
12	SCE		Are the results from Table 6-3 and Figure 6-3 per year or per month? Could you please provide clarification?	Table 6-3 and Figure 6-3 present savings per household per year. We have adjusted the table names to reflect this.