REPORT

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PG&E HER 2019 Energy and Demand Savings Early EM&V

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Principal authors:

Aimee Savage, Consultant II
Daniel Lesperance, Project Analyst I
Andrew Hauser, Analyst

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1 Executive Summary

This report documents the energy and demand savings resulting from the Home Energy Reports (HERs) Program administered by Pacific Gas and Electric Company (PG&E) for program year 2019 (PY2019). It includes estimated energy savings impacts from a study of the persistence of the treatment effect over time (after reports are no longer provided to customers) and incremental savings from electronic delivery (by email) of HERs (eHERs) provided as a supplement to the standard reports delivered by mail. The experimental waves that are included in this report are outlined in Table 1-1. All experimental waves have remained in the field since their initial launch.[1]

Table 1-1: Experimental Waves in Field in PY2019

Experimental Wave	Energy Usage Quartiles	Treatment[2]	Control	First Report Generated
Beta	Top 1	60,000	60,000	7/2011
Gamma Standard Dual	All Quartiles	72,000	72,000	11/2011
Gamma Reduced Dual	All Quartiles	72,000	72,000	11/2011
Gamma All Electric	All Quartiles	45,000	45,000	11/2011
Gamma Gas Only	All Quartiles	15,000	15,000	11/2011
Wave 1	Top 3	360,000	90,000	3/2012
Wave 1 All Electric	Top 3	40,000	10,000	3/2012
Wave 2 Area 7[3]	Top 3	80,000	50,000	2/2013
Wave 2 Not Area 7	Top 3	305,000	48,000	2/2013
Wave 3	Top 3	225,000	75,000	7/2013
Wave 4	Top 3	200,000	75,000	3/2014
Wave 5	Top 2	210,000	50,000	10/2014
Wave 6	Top 3	312,000	50,000	9/2015
Wave 7	Top 3	157,500	40,000	3/2017
Wave 8	Top 15 16ths	143,000	22,000	11/2017
Wave 9	Top 2	105,000	20,000	9/2018
Wave 10	Top 3	290,000	50,000	9/2019
Wave 11	Top 3	160,000	40,000	9/2019

[1] Additional information about the Home Energy Reports measure is contained in its work paper, Statewide Measure ID SWWB004-01, available from http://www.deeresources.net/workpapers.

[2] Customer counts presented in this table represent the number of customers assigned to treatment and control when the wave was launched, not the number of customers included in the analysis presented in this report.

[3] PG&E's service territory is divided into 7 service areas. Area 7, located in the north coast, was not planned to be included in the Wave Two sample frame initially. When it was decided to be included subsequently, a separate experiment was launched concurrently for this service area.

Table 1-2 presents key findings from program year 2019. Before adjusting for joint savings between the HER program and other PG&E measures, the total electric and gas energy savings were equal to 125.4 GWh and 5,021 thousand therms (i.e. 5 million therms), respectively. The unadjusted peak megawatt load reduction (PMLR) was estimated to be 34.5 MW during the DEER-defined heat wave from June 10 to June 12, 2019. After adjustments, aggregate electric and PMLR savings are equal to to 118.6 GWh and 34.0 MW, respectively. Aggregate gas savings increased to 5,099.9 thousand (approximately 5.1 million) therms after adjustments.

Table 1-2: PY2019 Energy Savings and Peak Megawatt Load Reduction

Savings Metric	Percent Savings	Aggregate Savings	Joint Savings Adjustment			Adjusted Savings
			Downstream Rebate Program	Upstream Lighting Program	Home Energy Checkup	
Electric Energy Savings (GWh)	1.3%	125.4	1.2	5.1	0.5	**118.6**
Gas Energy Savings (1,000 therms)	0.8%	5,021.3	40.3	-130.6	11.7	**5,099.9**
PMLR (MW)	1.5%	34.5	0.1	0.4	-	**34.0**

Key findings from the Early M&V of the HER program include:

- Electric energy savings ranged from 0.3% to 2.6%, and were consistent with findings from PY2018 (0.4% to 2.7%). Similarly, gas savings were in line with 2018 savings (0.4% to 1.3% in 2019 vs. 0.6% to 1.2% in 2018). Waves in the field longer tended to realize greater percentage savings as compared to waves more recently. This general trend is observed for both electric energy and natural gas use.
- Wave 1 customers were responsible for the largest share of electric savings (22.3 GWh). This wave is the largest of the 18 experiments. Wave 1 All Electric customers generated the least electric savings (0.8 GWh). This wave is the smallest of the experiments.
- The estimated demand savings (referred to as peak megawatt load reduction or PMLR for energy efficiency programs) of 34.5 MW is greater than what was observed in 2018 (27.2 MW). Demand reductions during the peak ranged from 0% in Wave 8 and Wave 9 to 3.9% in Wave Two (Not Area 7).
- After six years in the persistence study, customers withdrawn from treatment ("discontinued customers") in the Gamma Standard wave retained 26% of baseline electric savings, and customers in the Gamma Reduced wave retained 59% of baseline savings, but the decline in savings was not statistically significant.
- Discontinued customers in the Gamma Standard wave saved 36% of baseline natural gas savings, and customers in the Gamma Reduced wave saved 7% of baseline natural gas savings, but this estimate was not statistically significant.
- The addition of eHERs did not lead to statistically significant incremental electric energy savings in the sixth year of the eHER study.

The remainder of this report is organized as follows:

- Section 2 describes the methodology used to estimate energy savings, PMLR, and the energy savings impacts associated with the Persistence and eHER studies;
- Section 3 presents energy savings findings;
- Section 4 presents PMLR findings;
- Section 5 presents 6th year findings from the Persistence Study; and
- Section 6 presents 6th year findings from the eHER Study.

2 Methodology

This section summarizes the methodological approach used to estimate energy savings and the PMLR for PG&E's HER program in 2019. It also includes the approach used to estimate energy savings persistence for the HER measure in a Persistence Study launched in May 2014. Finally, this section documents the methodology used to estimate the incremental energy savings effect of eHERs when combined with paper HERs.

Each experimental wave in PG&E's HER program is designed as a randomized controlled trial (RCT). Further details about the program are documented in a report published by Freeman, Sullivan and Company (now Nexant) in 2013.[4] This report documents the HER evaluation design, participant and control group selection, initial energy savings estimation methodology, and the initial field research and analysis employed to avoid double-counting of savings due to the uptake of other measures in the portfolio as a result of assignment to a treatment group (that is, exposure to the reports). Subsequent early M&V reports published by Nexant in subsequent years document methodological refinements and other improvements in the evaluation of PG&E's Home Energy Reports Program.

[4] Evaluation of Pacific Gas and Electric Company's Home Energy Report Initiative for the 2010-2012 Program (2013). Freeman, Sullivan, and Co. CALMAC ID 0329.01.

2.1 Energy Savings

Program impacts on electricity consumption were estimated using a lagged dependent variable model in which monthly energy consumption for treatment and control customers was estimated using consumption data from the pretreatment period.[5] The regression specification is presented in Equation 2-1 with definitions for each term shown in Table 2-1.

Equation 2-1: Energy Savings Regression Specification

$$kWh_{it} = a + b_t + c_t \cdot treatment_i + d \cdot pretreatment\_kwh_{it} + e_t \cdot pretreatment\_kwh_{it} + \varepsilon_{it}$$

Table 2-1: Lagged Dependent Variable Model Definitions

Variable	Definition
kWh_{it}	Customer *i*'s usage in month *t*.
a	The estimated constant for energy consumption (average for all customers in all periods).
b_t	The estimated coefficient for the month indicator variable.
c_t	The estimated coefficient for the month indicator variable for treatment customers. This is the treatment effect for a particular month *t*.
$treatment_i$	The treatment indicator variable for customer *i*. Equal to 1 for treatment customers and 0 otherwise.
d	The estimated coefficient for pretreatment consumption.
$pretreatment\_kwh_{it}$	Pretreatment usage for customer *i* for month *t*. Pretreatment consumption for a particular month in the post treatment period refers to the same calendar month in the pretreatment period.
e_t	The estimated coefficient for pretreatment consumption on a particular month *t*.
ε_{it}	The error term.

This specification applies to all experimental waves, with fewer months included in the model for the waves that began during 2019 given the shorter time between the launch of the experiment and the end of the year.[6] Estimates were created separately for each month to account for differences in behavior throughout the calendar year and for the purposes of observing trends in treatment effects over time. For each customer, the model incorporated one year of pre-treatment billing data. Standard errors were estimated to allow for arbitrary correlation among errors within each customer's data.

[5] A fixed-effects panel regression model in which monthly energy consumption for treatment and control group customers is estimated using an indicator variable for month of the study, a treatment month indicator variable and a customer-level indicator variable is an alternative methodology frequently used to determine impacts of similar programs. It produces a "difference-in-difference" calculation by comparing the pre- to post-treatment difference for the treatment group to the pre- to post-treatment difference for the control group.

[6] This specification is a recommended specification for estimating treatment effects in this context. See equation 1.3, page 76 of "Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations," published by SEE Action, May 2012. Available at https://emp.lbl.gov/sites/all/files/behavior-based-emv-ppt.pdf

The impacts for each experimental wave of the HER program were estimated separately (i.e., unique model coefficients were calculated for each wave), and within each wave the savings for each fuel type (gas, electric, or both) were calculated independently. This approach was used because there are inherent differences between dual-fuel and single-fuel customers that would add noise to an aggregate analysis and because one purpose of the experiments was to test for these differences.

There are two key points to note regarding the comparability of treatment and control groups:

- First, it is assumed that receiving HERs does not affect the rate at which customers close their accounts. This appears to be true given the nearly identical attrition rate between the treatment and control groups. Customers who close their accounts are retained in each sample until their close date. Consequently, the populations of interest for each experimental wave grow smaller for both treatment and control groups as time progresses.
- Second, in order to maintain comparability, opt-outs (that is, customers assigned to treatment groups who make a request to stop receiving reports) are retained in their treatment groups for the entire analysis year. There are two reasons that underlie this decision:
    - First, because the experiment uses an opt-out delivery design (treatment households receive the reports without initially requesting them), any households that opt out have received at least one report. Strictly speaking, this means they have been treated.
    - Second, there is no way to identify households in the control group who would have opted out of the program: Removing the opt-outs from only the treatment group compromises the internal validity of the savings estimates, and so they are retained throughout the analysis dataset.[7]

2.2 Peak Megawatt Load Reduction

The deployment of Smart Meter technology has enabled PG&E to collect electric usage data at one-hour intervals (interval data) for residential customers throughout its service territory.[8] This granularity of data provides the means to estimate reductions in usage attributable to the HER program for specific hours throughout the day. This section documents the methodology used to estimate demand savings of PG&E's Home Energy Reports program calculated using hourly interval data obtained from PG&E's Smart Meter system for 2019.

The Peak Megawatt Load Reduction (PMLR) is the difference between the electricity demand of HER-treated households and their expected demand in the absence of treatment during specific weather conditions. In this analysis, the peak periods are identified using the DEER definition of weather conditions that are expected to produce a regional grid peak event. These peaks

[7] In practice, the proportion of customers opting out of HER treatment is negligible (less than 0.5%).

[8] The system captures usage data at more frequent intervals, but only hourly interval data is stored for most PG&E residential customers.

comprise the hours of 2 PM to 5 PM during a "heat wave," which is defined as three consecutive weekdays of especially warm weather conditions. A single extreme heat wave for the year is also identified for the PG&E territory. This particular heat wave is defined as being the period that contains the three consecutive weekdays with the greatest sum of the following:

- Average daily temperature;
- Average temperature between 12 PM and 6 PM; and
- The maximum daily temperature.

According to the DEER criteria, three-day peak periods must be non-holiday contiguous weekdays falling between June 1 and September 30. Although customers will experience multiple heat waves throughout the summer, the DEER criteria are used to select a single, maximum heat wave. The goal of using these criteria is to estimate the heat wave that had the largest impact on the system as a whole. Further details of DEER's definition can be found by accessing the CPUC Energy Efficiency Policy Manual.[9]

Using DEER's definition of a three-day heat wave, peak periods in 2019 were estimated for PG&E's territory using weather data provided by PG&E. This weather data consists of hourly temperature values for each weather station within PG&E's territory. Because there are multiple weather stations within the territory, a weighted average of weather station temperatures was used to estimate the hourly temperatures at the territory level. The weights in this calculation are the number of residential PG&E customers residing in each weather station's area. Based on the data obtained for the current analysis, the 2019 maximum heat wave was identified to have occurred from Monday, June 10, 2019 to Wednesday, June 12, 2019. Demand savings are also reported for the CAISO and PG&E system peak hours.

To calculate the demand savings for the heat wave and for the PG&E and CAISO system peaks, 60-minute interval data were collected for each treatment and control customer within each of 16 experimental HER waves in the field over the summer of 2019.[10]

The methodology for estimating the PMLR is similar to that used in the energy savings estimation. Program impacts on peak electricity demand were estimated using a lagged dependent variable model in which energy demand during the hours of 2 PM to 5 PM during the DEER-defined heatwave customers was estimated for treatment and control customers using AMI data from the pretreatment period.[11] The regression specification is presented in Equation

[9] https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/EEPolicyManualV5forPDF.pdf

[10] Wave Two consists of two separate experiments with unique control groups for PG&E Service Territory Area 7 (known as North Coast and comprises Humboldt, Mendocino, and Lake counties, as well as most of Sonoma County and portions of Marin County) and for the remainder of the service territory. The Gamma Wave and Wave One each have separate treatment and control groups for dual-fuel and all-electric experiments. Wave Nine was launched after the summer of 2018 and is not included in the heat wave or peak demand savings calculations. The result is 14 unique experiments with summer data available for 2018.

[11] The pretreatment peak period varies by wave,and is the last DEER-defined heatwave prior to the launch of treatment.

2-2 with definitions for each term shown in Table 2-1. Demand savings are estimated separately for each experimental wave.

Equation 2-2: PMLR Regression Specification

$$kW_i = a + b \cdot treatment_i + c \cdot pretreatment\_kw_i + \varepsilon_i$$

Table 2-2: Lagged Dependent Variable Model Definitions

Variable	Definition
kW_i	Customer *i*'s usage during the peak period.
a	The estimated constant for energy consumption (average for all customers in all periods).
b	The estimated for treatment customers. This is the treatment effect.
$treatment_i$	The treatment indicator variable for customer *i*. Equal to 1 for treatment customers and 0 otherwise.
c	The estimated coefficient for pretreatment demand.
$pretreatment\_kw_i$	Pretreatment demand for customer *i*.
ε_i	The error term.

2.3 Joint Savings Adjustments

This report includes the total estimated impact of the HER program for 2019, both before and after applying an adjustment for joint savings. The potentially double-counted downstream energy savings result from various energy efficiency programs offered by PG&E: the downstream rebate program, the Upstream Lighting Program (ULP), and the online Home Energy Check-up (HEC). PG&E receives credit for the savings achieved by these programs through a separate savings claim process. The messaging included in HERs likely drive customers to participate in the other programs PG&E has to offer, resulting in an uplift in savings for those programs. The "uplift" is defined to be the additional savings in each energy efficiency program attributable to customers under HER treatment conditions. In this report, the uplift in energy and peak demand savings was calculated for each energy efficiency program on a per-customer basis, by experimental wave. Those per-customer values were then multiplied by the number of treatment customers in 2019 to estimate the program-level adjustment.

The approach to estimating per-customer uplift in energy savings varies by energy efficiency program. In the downstream rebate program, customers received rebates for purchasing and installing energy efficient equipment (such as smart thermostats and/or variable-speed pool pumps and/or through participation in a whole home upgrade program). The energy savings attributable to each measure was estimated by multiplying measure-specific annual savings by the percent of program year savings achieved after installation and before the end of the effective useful lifetime (EUL). Installation dates (or participation dates of record), measure-specific annual kWh and therm savings, and EULs were determined using PG&E's MDSS

system data. DEER load profiles[12] were used to determine the percent of measure-specific annual savings concentrated within the specified time frame. Finally, the sum of each measure's calculated program year savings was divided by the number of treatment and control customers to determine per-customer downstream rebate program savings for each group. The uplift is the difference between these two values. Detailed tables documenting the joint savings estimates can be found in **Error! Reference source not found.**.

Equation 2-3: Downstream Rebate Program Energy Savings Uplift

$$\boldsymbol{Additional\ kWh\ or\ therm\ effects\ attributable\ to\ downsteam\ rebate\ program} = \frac{\sum(\boldsymbol{annual\ kWh\ or\ therm\ effects\ per\ measure} \times \%\ \boldsymbol{of\ annual\ effects\ realized\ in\ program\ year})}{\boldsymbol{number\ of\ customers}}$$

This same methodology was used in the 2015 through 2018 early M&V reports, in which the total estimated double-counted downstream electric energy savings were between 0.8 and 2.4 GWh. These comparatively low values, as compared to the magnitude of program savings, underscore the diminishing size of the downstream residential measure portfolio. The estimate of double-counted therm savings is calculated using the same methodology.

Upstream programs, principally the ULP, present a unique challenge in the estimation of potentially double-counted savings because participation in these programs is not tracked at the customer level, and therefore cannot be tied back to participation in HER treatment and control households for comparison. In this evaluation, we use the findings of previous research in this area to assume likely spillover into PG&E's ULP; no new research was conducted for this purpose.

The analysis presented in this report accounts for the potential overlap in electric savings claims between the HER program and the ULP, as well as the increase in heating load caused by lower heat emissions from the replacement of less efficient bulbs with CFLs and LEDs. The equation for estimating upstream joint savings and gas interactive effects for each month since the onset of treatment is shown in Equation 2-4. Joint savings are estimated separately for each wave, treatment month, and bulb type (CFL or LED).

Equation 2-4: ULP Energy Savings Uplift

$$\begin{aligned}\boldsymbol{Additional\ kWh\ or\ therm\ effects\ attributable\ to\ ULP} &= \boldsymbol{kWh\ or\ therm\ effects\ per\ bulb} \\ &\times \boldsymbol{additional\ bulbs\ per\ treatment\ customer} \\ &\times \boldsymbol{percent\ of\ bulbs\ installed\ per\ month\ in\ 2019} \\ &\times \boldsymbol{percent\ of\ bulb\ sales\ that\ received\ rebates} \times \boldsymbol{installation\ rate} \times \boldsymbol{NTG}\end{aligned}$$

The residential HEC is an online survey designed to identify no- and low-cost energy savings actions that renters and homeowners can undertake to save energy. Customers log in using

[12] DEER Load Profiles for the 2019 evaluation were sourced from the 2011 DEER Database published by the CPUC. The 2011 DEER load profiles have been used in every HER evaluation since 2015, allowing for consistent load shapes and multiplicative effects over the years Given that the load profiles used in the 2019 evaluation will be 10 years out of date if they are used in the 2020 evaluation, it might be beneficial to update load shapes to a newer DEER release to better reflect recent energy demand plots.

their PG&E customer credentials and are ported to the tool which provides residential customers with advice on energy efficiency, insight into areas of high energy use, and tips and suggestions for saving both energy and money based on responses to a series of questions regarding household appliances, occupancy, and other dwelling characteristics. The percent of HER participants under treatment and control conditions was compared using login data provided by Oracle to determine the additional uptake in participation. That value was multiplied by the per-customer 2018 HEC energy savings estimated by Nexant[13] (104.7 kWh) to determine the uplift in energy savings among HER treatment customers.

Equation 2-5: HEC Energy Savings Uplift

$$\begin{aligned}&\textit{Additional kWh or therm effects attributable to HEC}\\&= \textit{kWh or therm effects per HEC participant}\\&\times \textit{percent uplift in HEC participation}\end{aligned}$$

Similar to the process used to deduct the joint kWh and therm savings resulting from PG&E's downstream energy efficiency programs, the overlap with demand savings for all measures installed under downstream PG&E programs was estimated for both treatment and control group members using data contained in the PG&E MDSS system. The double-counted demand savings were obtained by subtracting the control group downstream savings from the treatment group downstream savings for each measure.

The overlap in demand savings with PG&E's Upstream Lighting Program was estimated using Equation 2-6.

Equation 2-6: ULP Demand Savings Uplift

$$\begin{aligned}&\textit{Additional kW savings attributable to ULP}\\&= \textit{kW savings per bulb} \times \textit{additional bulbs per treatment customer}\\&\times \textit{percent of bulbs installed during 2019 peak}\\&\times \textit{percent of bulb sales that received rebates} \times \frac{\textit{delta watts}}{1000}\\&\times \textit{peak coincidence factor} \times \textit{NTG}\end{aligned}$$

Peak demand reductions attributable to the HEC were not available at the time of reporting, and therefore an adjustment to the PMLR was not estimated for that program.

2.4 Persistence Study and Electronic HERs Study

PG&E's HER Persistence Study was launched in May 2014. The objective of the study is to understand how long the savings effects of the treatment endure after it is stopped. Customers in the Gamma Dual Standard and Gamma Dual Reduced experimental waves were randomly assigned to "continued" and "terminated" groups, the second of which did not receive any reports after the launch of the persistence study, which began two and a half years following the onset of the treatment. Between the two waves, a total of 28,000 customers were assigned to stop receiving treatment: 14,000 from the Gamma Dual Standard wave and 14,000 from

[13] Phase One Report: Early M&V to Inform PG&E's 2019 Savings Claims for Universal Audit Tool (UAT)

Gamma Dual Reduced wave. Gamma Standard customers had received the reports every two months while Gamma Reduced customers had received the reports quarterly. Both waves were launched in November 2011. Table 2-3 presents the number of customers in the continued, discontinued, and control groups by experimental wave.

Table 2-3: Persistence Study Households by Experimental Wave

Experimental Wave	Continued	Discontinued	Control
Gamma Dual Standard	43,962	13,950	57,802
Gamma Dual Reduced	44,034	13,945	

The methodology for estimating HER persistence is identical to that used for measuring the program energy savings with one key difference: rather than using pre-treatment and post-treatment periods, the persistence model uses pre-termination and post-termination periods. The pre-termination period is defined to be the full year prior to the launch of the persistence study. Additionally, "treatment" in this context is defined as the termination of receiving reports. The following model, with terms described in Table 2-4, measures the difference in energy savings between the continued and terminated groups.

Equation 2-7: Persistence Study Regression Specification

$$kWh_{it} = a + b_t + c_t \cdot termination_i + d \cdot pre\_termination\_kwh_{it} + e_t \cdot pre\_termination\_kwh_{it} + \varepsilon_{it}$$

Table 2-4: Lagged Dependent Variable Model Definitions

Variable	Definition
kWh_{it}	Customer *i*'s usage in season or year *t*
a	The energy consumption constant
b_t	The coefficient for the year-season or year indicator variable
c_t	The coefficient for the year-season or year indicator variable for terminated customers. This is the persistence effect for the particular season or year *t*
$termination_i$	Termination indicator variable for customer *i*. Equal to 1 for terminated customers and 0 otherwise
d	The coefficient for pre-termination consumption
e_t	The coefficient on pre-termination consumption for a particular season or year *t*
$pre\_termination\_kwh_{it}$	Pre-termination energy usage for customer *i* for season or year *t*. Pre-termination consumption for a particular season in the post termination period refers to the same season in the pre-termination period
ε_{it}	The error term

In April 2014, approximately 220,000 HER recipients in Wave One, Wave Two, and Wave Three began receiving electronic HERs (eHERs) in addition to the standard paper HERs. These households receive eHERs on the months that they do not receive paper reports (i.e., every

other month), so that customers receiving eHERs are effectively receiving 12 reports per year. Electronic HERs were withheld from a sample of 81,000 HER recipients in the same experimental waves (the baseline group), thereby allowing for the measurement of the incremental effect of eHERs (as compared to the effect of paper HERs alone). Additionally, a sample of 72,000 non-recipient households served as a control group for both the treatment and baseline groups (for the purpose of measuring energy savings). All three samples consist of PG&E customers who are eligible to receive e-mails from PG&E (i.e., PG&E had e-mail addresses on file and customer permission to send e-mails). These customers have slightly higher electricity consumption than customers for whom PG&E does not have email addresses, which means the results reported in this section are not directly comparable to those reported in Section 3. Table 2-5 presents the number of customers in the baseline, treatment, and control groups by experimental wave.

Table 2-5: eHER Households by Experimental Wave

Experimental Wave	Baseline	Treatment	Control
Wave One	21,367	93,500	28,348
Wave Two	20,850	82,500	16,111
Wave Three	39,041	44,000	27,697

The methodology for estimating the incremental savings of eHERs is similar to that used for measuring energy impacts of the persistence test. The pre-treatment period is defined to be the full year prior to the launch of eHERs. This methodology requires at least one year of HER treatment data prior to the introduction of eHERs. Wave Three was launched in July 2013, which means there is not a full year of HER treatment data prior to the introduction of eHERs that can be used to estimate the incremental savings. As such, the incremental impacts of eHERs were only estimated for Wave One and Wave Two.

3 Energy Savings

Nexant estimated energy savings resulting from PG&E's Home Energy Reports Program for 2019 as part of its contract to provide early measurement and verification (early M&V) of the HERs Program. Early M&V provides an independent estimate of savings to substantiate PG&E's energy savings claims made to the California Public Utilities Commission. Early M&V also seeks to validate key savings assumptions and better understand how savings are achieved for the purpose of improving programs.

Table 3-1 presents per-customer and aggregate electric savings for each experimental wave in the field in 2019. Waves 10 and 11 were launched in September 2019 and as a result, only the months of September through December were available for analysis. Average annual customer impacts were 68.3 kWh per customer, or 1.3% of annual control group consumption. When the average impact was applied to the roughly 1.8 million treatment customers present in all waves, the aggregate impact was estimated to be 125.4 GWh annually. After adjusting for joint savings with other PG&E energy efficiency programs, the final adjusted aggregate savings estimate is 118.6.

In general, per-customer annual impacts fell between 6.8 kWh in Wave 10 (the experiment with the least time in the field) and 236.5 kWh in the Beta wave (the experiment with the most time in the field). Five waves exhibited per-customer impacts greater than 100 kWh in 2019. The Beta wave is comprised of larger than average customers (customers in the top quartile of energy consumption), which likely is the key reason for its much larger impacts.

There is strong evidence to indicate that customers who receive HERs appreciably reduced their energy consumption compared to customers who did not receive HERs. With the exception of the Wave 1 All Electric group, electric energy savings were statistically significant in all experimental waves. Wave 1 All Electric is the smallest wave in field in terms of the number of control (n=4,554) and treatment (n=17,970) customers, which likely played a factor in the lack of statistical significance.

Unadjusted program impacts declined in 2019 compared to 2018, which showed aggregate electric energy savings of 129.8 GWh. Most waves that were in field in both years showed reductions in aggregate savings, however percent impacts remained steady for each wave with changes of less than half of a percent in nearly every experimental wave. The changes in energy savings can be explained in part by customer attrition from year to year; approximately 15% of treatment customers across all waves. Four waves exhibited increases in aggregate impacts from 2018 to 2019: Gamma Dual Standard, Gamma Dual Reduced, Wave One Dual, and Wave Eight.

Table 3-1: PY2019 Electric Energy Savings

Experimental Wave	Control Customers	Treatment Customers	Average Annual Control Consumption (kWh)	Average Annual Treatment Consumption (kWh)	Per Customer Impact (kWh)	90% Confidence Interval		Percent Impact	Energy Savings (GWh)
Beta	33,789	33,590	9,241.4	9,004.8	236.5	192.4	280.7	2.6%	7.9
Gamma Standard Dual	38,703	38,609	6,421.2	6,306.6	114.6	81.2	148.1	1.8%	4.4
Gamma Reduced Dual	38,703	38,687	6,396.8	6,298.9	97.8	64.4	131.2	1.5%	3.8
Gamma All Electric	18,286	18,281	6,470.3	6,374.5	95.8	51.4	140.2	1.5%	1.8
Wave 1 Dual	51,370	205,041	6,423.8	6,315.2	108.6	87.9	129.3	1.7%	22.3
Wave 1 All Electric	4,554	17,970	7,156.7	7,111.5	45.2	-33.3	123.8	0.6%	0.8
Wave 2 Area 7	30,364	48,635	5,662.2	5,582.4	79.8	51.4	108.3	1.4%	3.9
Wave 2 Not Area 7	29,057	185,859	6,187.2	6,073.7	113.5	88.7	138.3	1.8%	21.1
Wave 3	40,981	122,910	6,195.3	6,095.5	99.8	74.7	124.9	1.6%	12.3
Wave 4	37,816	100,657	5,686.0	5,639.3	46.7	21.4	72.0	0.8%	4.7
Wave 5	27,967	117,132	8,448.9	8,348.8	100.1	67.2	133.0	1.2%	11.7
Wave 6	27,173	169,959	5,913.5	5,846.0	67.5	41.1	93.9	1.1%	11.5
Wave 7	27,256	107,005	6,417.7	6,344.6	73.2	44.4	102.0	1.1%	7.8
Wave 8	17,554	114,047	2,666.4	2,638.6	27.8	15.1	40.6	1.0%	3.2
Wave 9	16,157	84,685	8,225.2	8,172.0	53.2	22.1	84.3	0.6%	4.5
Wave 10	47,952	277,847	1,956.9	1,950.1	6.8	2.1	11.6	0.3%	1.9
Wave 11	38,683	154,559	2,234.8	2,222.6	12.2	6.1	18.4	0.5%	1.9
Total/Average	**526,362**	**1,835,474**	**5,284.8**	**5,216.5**	**68.3**	**60.2**	**76.5**	**1.3%**	**125.4**

Table 3-2 presents per-customer and aggregate natural gas savings for each experimental wave in the field in 2019. Similar to the electric savings analysis, Wave 10 was launched in September 2019 and as a result, only the months of September through December were available for analysis. Customers experienced an average annual impact of 2.9 therms per customer (0.8% of annual control group consumption). When summed across the roughly 1.7 million treatment customers present in all waves, the annual aggregate impact was approximately 5.0 million therms. The final adjusted aggregate therms savings estimate, after accounting for joint savings across PG&E energy efficiency programs, is 5.1 million therms.

Gas impacts for individual waves were between 0.1 therms from the Gamma Gas Only wave and 9.5 therms in the Beta wave. Percent impacts for natural gas savings were in a narrower range than electric savings percent impacts, spanning from 0% to 1.3%. The two waves with the largest gas impacts also had the largest percent impacts at 1.2% (Wave Two Area 7) and 1.3% (Beta wave), which is in line with findings from the electrical savings analysis.

Natural gas energy savings were statistically significant in all but two experimental waves (Gamma Gas Only and Wave 10). Both exceptions had the smallest estimated impacts (0.2 and 0.1 therms) which fell below the next lowest impact of 1.8 therms. These extremely small impacts likely play a factor in the observed significance values. Gas savings findings support findings from the electrical analysis that customers who receive HERs generally consume less gas than those who do not.

The unadjusted aggregate program impacts increased slightly from 4,917 thousand therms in 2018. On a percentage basis, natural gas impacts remained largely the same from 2018 to 2019 across all waves in the field in both years (Beta through Wave 8), however aggregate impacts decreased slightly in part due to year-over-year attrition. Attrition for gas customers across all waves was approximately 15%, which was similar to the attrition rate for electric customers.

Table 3-2: PY2019 Natural Gas Energy Savings

Experimental Wave	Control Customers	Treatment Customers	Average Annual Control Consumption (therms)	Average Annual Treatment Consumption (therms)	Per Customer Impact (therms)	90% Confidence Interval		Percent Impact	Energy Savings (1,000 therms)
Beta	35,116	34,927	711.3	701.8	9.5	6.6	12.4	1.3%	331.9
Gamma Standard Dual	40,206	40,118	414.7	410.9	3.8	2.1	5.5	0.9%	153.7
Gamma Reduced Dual	40,206	40,193	414.5	412.6	1.9	0.2	3.6	0.4%	74.9
Gamma Gas Only	8,222	8,302	444.8	444.7	0.1	-3.6	3.7	0.0%	0.7
Wave 1 Dual	53,028	211,679	430.8	426.9	3.9	2.7	5.0	0.9%	819.4
Wave 2 Area 7	30,828	49,476	476.7	471.0	5.7	3.9	7.5	1.2%	282.5
Wave 2 Not Area 7	29,872	191,415	439.0	434.6	4.3	2.9	5.8	1.0%	828.5
Wave 3	42,096	126,260	439.1	435.3	3.8	2.4	5.2	0.9%	479.7
Wave 4	38,585	102,781	402.6	399.5	3.1	1.7	4.5	0.8%	322.5
Wave 5	29,043	121,790	508.3	505.2	3.1	1.2	5.0	0.6%	375.7
Wave 6	27,630	172,922	411.0	407.9	3.1	1.6	4.6	0.7%	530.3
Wave 7	27,589	108,356	428.5	425.9	2.6	1.1	4.0	0.6%	276.8
Wave 8	17,604	114,362	258.4	255.6	2.9	1.7	4.0	1.1%	326.5
Wave 9	16,307	85,397	468.6	466.8	1.8	0.1	3.5	0.4%	155.4
Wave 10	54,425	315,433	145.9	145.7	0.2	-0.1	0.5	0.1%	62.9
Total/Average	**490,755**	**1,723,410**	**378.6**	**375.7**	**2.9**	**2.4**	**3.4**	**0.8%**	**5,021.3**

Table 3-3 and Table 3-4 show the monthly percent impacts for the electric and gas savings analysis, respectively. One trend observable in the data is the impact of length of exposure to the reports on savings: with some exceptions, customers participating in the waves in the field for longer lengths of time tend to save more electricity.

Table 3-3: Average Percentage Impact on Electricity Usage by Wave

Month	Beta	Gamma			Wave One		Wave Two		Wave Three	Wave Four	Wave Five	Wave Six	Wave Seven	Wave Eight	Wave Nine	Wave Ten	Wave Eleven
		Dual		Electric-Only	Dual	Electric-Only	Area 7	Not Area 7									
		Standard	Reduced														
Jan-19	2.0%	1.9%	1.4%	1.2%	1.6%	1.3%	1.2%	1.3%	1.5%	0.9%	1.0%	1.4%	0.8%	1.2%	0.4%	-	-
Feb-19	2.5%	1.7%	1.2%	1.1%	1.8%	1.2%	1.3%	1.4%	1.4%	0.7%	1.2%	1.3%	1.4%	1.6%	0.6%	-	-
Mar-19	2.4%	1.7%	1.5%	1.5%	1.9%	1.3%	1.3%	1.5%	1.7%	0.8%	1.3%	1.6%	1.1%	1.2%	1.1%	-	-
Apr-19	2.8%	1.9%	1.5%	1.6%	2.0%	0.2%	1.1%	1.8%	1.8%	0.8%	1.3%	1.4%	0.9%	0.9%	0.8%	-	-
May-19	2.8%	1.6%	1.3%	1.3%	1.9%	1.1%	1.5%	2.0%	1.6%	0.9%	1.7%	1.2%	0.9%	0.7%	0.7%	-	-
Jun-19	2.9%	1.9%	1.7%	1.4%	1.7%	0.9%	1.3%	2.3%	1.6%	0.8%	1.7%	1.1%	1.0%	1.3%	1.0%	-	-
Jul-19	2.7%	1.4%	1.3%	1.2%	1.5%	-0.7%	1.4%	2.2%	1.7%	0.6%	1.2%	0.9%	1.1%	1.2%	0.5%	-	-
Aug-19	2.7%	1.8%	1.4%	1.4%	1.5%	-0.8%	1.4%	2.4%	1.9%	0.7%	1.0%	0.8%	1.3%	1.6%	0.3%	-	-
Sep-19	2.4%	2.0%	1.6%	1.8%	1.7%	0.8%	1.7%	2.1%	1.8%	0.9%	1.2%	1.0%	1.2%	0.8%	0.4%	0.0%	0.2%
Oct-19	2.7%	2.1%	2.0%	1.7%	1.8%	1.4%	1.7%	1.9%	1.8%	1.1%	1.5%	1.3%	1.4%	0.5%	0.9%	0.3%	0.5%
Nov-19	2.7%	2.0%	1.9%	2.2%	1.7%	1.5%	1.6%	1.7%	1.4%	1.0%	0.7%	1.0%	1.3%	0.6%	0.6%	0.4%	0.8%
Dec-19	2.2%	1.6%	1.6%	1.7%	1.5%	1.2%	1.4%	1.2%	1.2%	0.8%	0.5%	1.0%	1.3%	0.7%	0.5%	0.7%	0.7%
Avg.*	**2.6%**	**1.8%**	**1.5%**	**1.5%**	**1.7%**	**0.6%**	**1.4%**	**1.8%**	**1.6%**	**0.8%**	**1.2%**	**1.1%**	**1.1%**	**1.0%**	**0.6%**	**0.3%**	**0.5%**

*Positive values indicate a real savings rate, negative values indicate a negative savings rate (greater usage by treatment customers than control customers).

The Beta wave has been in the field since July 2011 and is the only wave that targets customers in the highest quartile of energy usage in selected baseline territories. It is the first wave of PG&E's HER program, and at 771 kWh, these recipients have the highest average monthly control load of any wave. The Beta wave's average monthly savings rate of 2.6%, and a peak savings of 2.9% in June, combined with the high monthly control load, results in markedly higher per-household electric savings than any other wave. Higher savings rates can be observed in summer months and comparatively lower savings in the winter months, but these are not statistically significant. Other waves display similar seasonal fluctuations in savings as well: for example, the few electric-only waves provide greater savings in the fall and winter than in spring and summer, suggesting that much of the savings come from changes in heating- and cooling-related behavior.

The Gamma waves are the only waves that target customers in all quartiles of energy use. The Gamma waves comprise three separate experiments, the first being dual-fuel customers and "standard report frequency," the second being dual-fuel customers and "reduced report frequency," and the third being electric-only customers (who receive reports in the standard cadence), and were launched altogether in November 2011. This stratification allows for a comparison of the impact of HER delivery frequency on energy savings as well as the effect of HERs on customers with different fuel types delivered by PG&E.[14] The difference in savings between customers who receive standard-frequency reports (every other month) and those who receive reduced-frequency reports (every three months) is small, with the standard-frequency customers producing an average monthly savings of 1.8% and the reduced-frequency customers producing an average monthly savings of 1.5%. To reiterate, the incremental gain in savings associated with delivering the reports every other month instead of quarterly is statistically insignificant.

Beginning with Wave One, the typical sample frame for PG&E's HER program was dual-fuel customers in the top three quartiles of energy use throughout the service territory. Wave One, launched in March 2012, is two separate experiments: one with dual-fuel customers and one with electric-only customers. Dual-fuel customers saved 1.7% of monthly energy use on average in 2019, while electric-only customers saved 0.7%. This difference in average savings rates is due in large part to very low (and negative) savings rates observed in the summer months among electric-only customers. The difference in savings rates between dual-fuel and electric-only customers is not statistically significant due to the small sample of electric-only customers included in the wave.

Wave Two is two separate experiments as well: Area 7 and Non-Area 7 of PG&E's service territory, each with its own control group. Customers in Area 7 are located in the northernmost portion of the PG&E service territory (i.e., Humboldt, Mendocino, Lake, and Sonoma counties, primarily). Initially conceived as a single wave comprising the entire service territory with the exclusion of Area 7, PG&E management determined to include Area 7 just prior to the launch of this wave, and so these customers were added relatively late in the process as a separate experiment. Both groups of Wave Two customers have been receiving reports since February

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

2013 and had energy savings of 1.8% and 1.4% for Non-Area 7 and Area 7, respectively, in 2019.

Waves Three, Four, Six and Seven share many characteristics. They are comprised of large groups of dual-fuel customers in the top three quartiles of energy use residing throughout PG&E's service territory. These waves had similar electric reference loads in 2019.

- Wave Three customers have been receiving reports since July 2013. In 2019 they provided average monthly savings of 1.6%. The highest savings achieved by these customers was in August 2019, with a savings of 1.9%.
- Wave Four customers began receiving reports in March 2014. In 2019 they provided average monthly savings of 0.8%, with peak savings of 1.1% in October.
- Wave Six customers began receiving reports about one year later (September 2015). Their average monthly savings in 2019 were 1.1%, with peak savings of 1.6% in March.
- Wave Seven customers began receiving reports in March 2017. The average monthly savings in 2019 for this wave was 1.1%, with the highest savings occurring in February and again in October, at a peak of 1.4%.

Wave Five, launched in October of 2014, was comprised of dual-fuel customers in the top half of energy use. Given the sample composition, it is not surprising that the monthly electric reference load in 2019 of 707 kWh was substantially higher than most HER waves. Average monthly savings in 2019 were 1.2%, with peak savings of 1.7% in May and June.

Wave Eight customers began receiving reports in November 2017. Like other waves launched before it, one goal of this wave was to maintain an average number of customers in treatment to counteract the shrinkage due to normal attrition due to customer move-outs. The proportion of qualifying customers had been reduced by several factors (including restrictions on qualifying rates, customers with rooftop solar and electric vehicles), and this resulted in the need to broaden the sample frame to include customers with lower average energy use to meet sample size targets. This wave includes customers in all but the lowest sixteenth of energy use, resulting in the lowest 2019 monthly reference load of 223 kWh—less than half the average per-household energy use of any HER wave. The average percent electric savings for this wave was 1.0%.

Wave Nine was launched in September 2018 and was similar to previous waves in most aspects. This wave was limited to customers in the top two quartiles of energy use (as opposed to the top 3). This resulted in slightly smaller numbers of treatment customers who had a much higher than average reference load of 686 kWh per month. It was the lowest performing of the waves that contain a full year of billing data to analyze with an average savings of 0.6%. Reasons for this low performance is likely due in part to the relatively recent initiation of the wave, and in future years we would expect these savings to generally increase.

The most recently-launched waves included in this analysis are Waves Ten and Eleven. These cohorts of customers began receiving reports in September 2019, and for this reason, analysis for this wave only contained the months of September through December. Like the other HER waves, both Waves Ten and Eleven drew customers from the top three quartiles of energy users. Wave Ten drew from all available customers, while Wave Eleven is representative of

electric only customers. The average monthly savings was 0.3% for Wave Ten and 0.5% for Wave Eleven, while savings peaked in December for Wave 10 were (0.7%) and in November for Wave 11 (0.8%).

As with the electricity savings analysis, gas savings were assessed on a per-month and yearly basis. In general, the percent natural gas savings is below the yearly average in the summer months and above the yearly average in the winter months. This is because more gas is used in the winter for heating, which allows for larger potential reductions. Table 3-4 presents the average percentage impact by month and the average monthly impact through the end of 2019. With the exception of Wave Two customers in Area 7 Gas savings are lower than percentage electric savings for every wave.

Table 3-4: Average Percentage Impact on Gas Usage by Wave

Month	Beta	Gamma			Wave One	Wave Two		Wave Three	Wave Four	Wave Five	Wave Six	Wave Seven	Wave Eight	Wave Nine	Wave Ten
		Dual		Gas-Only	Dual	Area 7	Not Area 7								
		Standard	Reduced												
Jan-19	1.3%	0.8%	0.5%	0.2%	0.9%	1.2%	0.7%	0.8%	0.8%	0.4%	0.7%	0.3%	0.5%	0.4%	-
Feb-19	1.5%	0.8%	0.4%	0.7%	0.7%	0.8%	1.1%	0.9%	0.5%	0.7%	0.7%	0.7%	1.1%	0.4%	-
Mar-19	1.3%	0.9%	0.6%	-0.6%	0.7%	1.1%	1.3%	0.9%	0.6%	0.9%	0.6%	0.6%	1.1%	0.6%	-
Apr-19	1.5%	1.5%	0.7%	0.0%	1.2%	1.3%	1.2%	1.2%	0.9%	0.9%	0.7%	0.7%	1.4%	0.8%	-
May-19	1.6%	1.5%	0.8%	0.3%	1.0%	1.7%	1.2%	0.9%	1.3%	0.8%	0.9%	0.8%	1.4%	0.9%	-
Jun-19	1.5%	1.2%	0.5%	-0.4%	0.9%	1.1%	1.1%	0.6%	1.1%	0.8%	0.5%	1.0%	0.5%	0.2%	-
Jul-19	0.6%	0.6%	-0.1%	0.8%	1.0%	1.1%	1.1%	0.9%	0.4%	0.6%	0.6%	0.8%	0.8%	-0.3%	-
Aug-19	1.2%	0.5%	-0.2%	-0.3%	1.0%	0.8%	0.9%	0.6%	0.4%	0.4%	0.8%	1.3%	0.9%	0.2%	-
Sep-19	1.0%	0.7%	0.0%	0.6%	1.2%	1.7%	1.0%	1.1%	1.0%	0.0%	1.2%	0.6%	1.2%	0.4%	-0.1%
Oct-19	0.9%	1.5%	0.9%	-1.4%	1.5%	1.8%	1.3%	1.2%	1.2%	1.0%	1.0%	0.7%	1.3%	1.0%	0.0%
Nov-19	1.5%	1.1%	0.6%	-0.4%	0.9%	1.8%	0.9%	0.8%	0.7%	0.8%	0.6%	0.4%	1.7%	0.1%	0.2%
Dec-19	1.4%	0.6%	0.2%	0.1%	0.8%	0.9%	0.6%	0.7%	0.9%	0.2%	0.9%	0.4%	1.4%	0.0%	0.3%
Avg.*	**1.3%**	**0.9%**	**0.4%**	**0.0%**	**0.9%**	**1.2%**	**1.0%**	**0.9%**	**0.8%**	**0.6%**	**0.7%**	**0.6%**	**1.1%**	**0.4%**	**0.1%**

*Positive values indicate a real savings rate, negative values indicate a negative savings rate (greater usage by treatment customers than control customers).

4 Peak Megawatt Load Reduction

Table 4-1 on the following page presents the demand reductions for the peak heatwave period of June 10 through June 12, 2019. Customers experienced temperatures around 96 degrees Fahrenheit during the heatwave. This is roughly 10 degrees higher than the 2018 heatwave analyzed for peak demand savings. The aggregate peak reduction in 2019, before adjusting for joint savings, is estimated to be 34.5 MW, which is notably greater than the reduction of 27.2 MW estimated in 2018. There are two possible explanations for this increase. First, per customer electricity savings increased from 0.019 kW in 2018 to 0.023 kW in 2019. The warmer temperatures may have provided more opportunities for customers to reduce their air conditioning usage. The second factor is the introduction of Wave 9 to the analysis, in total about 20,000 additional customers were included compared to the previous year. This increase in customers contributed to the increase in aggregate load impact.

Customers in Wave Two (Not Area 7) provided the greatest reductions in peak load of 3.9% per customer, on average. Customers in both Wave Two experimental waves had statistically significant percent impacts over 3%. In addition to the Wave Two groups; the Beta Wave, Wave 3, Wave 5, and Wave 6 had significant reductions in usage at the 90% level. The lack of statistically significant reductions across all Gamma waves could be explained by their composition: these are the only HER waves that include customers in the lowest quartile of energy usage, which means there are more customers in these waves that have fewer opportunities to reduce their electric usage.

Table 4-1: Peak Heat Wave Demand Reductions by Experimental Wave

Wave	Control Customers	Treatment Customers	Control (kW)	Treatment (kW)	Per-Customer Impact (kW)	90% Confidence Interval		Percent Impact (%)	Aggregate Impact (MW)	Average Temperature
Beta	36,783	36,598	2.80	2.75	0.05	0.02	0.08	1.8%	1.9	99
Gamma Dual	41,710	41,636	1.73	1.72	0.01	-0.01	0.02	0.4%	0.3	99
Gamma Dual Reduced	41,710	41,712	1.73	1.72	0.00	-0.01	0.02	0.2%	0.2	99
Gamma Electric	19,452	19,489	1.39	1.37	0.02	0.00	0.04	1.3%	0.4	98
Wave 1 Dual	54,237	216,631	1.69	1.68	0.01	0.00	0.02	0.7%	2.5	97
Wave 1 Electric	4,880	19,226	1.67	1.67	-0.01	-0.05	0.04	-0.4%	-0.1	99
Wave 2 Area 7	31,728	50,872	1.25	1.21	0.04	0.02	0.05	3.1%	2.0	95
Wave 2 Not Area 7	30,873	198,212	1.49	1.44	0.06	0.04	0.07	3.9%	11.6	95
Wave 3	43,280	129,757	1.44	1.42	0.02	0.01	0.03	1.3%	2.5	95
Wave 4	39,947	106,439	1.40	1.39	0.01	0.00	0.02	0.8%	1.2	95
Wave 5	30,140	126,345	2.35	2.30	0.05	0.03	0.07	2.0%	5.8	98
Wave 6	28,489	178,216	1.45	1.42	0.03	0.02	0.05	2.1%	5.5	95
Wave 7	28,547	112,284	1.69	1.68	0.01	-0.01	0.03	0.6%	1.1	96
Wave 8	18,039	117,037	0.51	0.51	0.00	-0.01	0.01	-0.1%	0.0	93
Wave 9	16,806	88,174	2.27	2.27	0.00	-0.02	0.02	-0.1%	-0.2	97
Average/Total	**466,621**	**1,482,628**	**1.60**	**1.58**	**0.02**	**0.02**	**0.03**	**1.5%**	**34.5**	**96**

The joint savings adjustment to the aggregate demand reduction was estimated to be 0.5 MW, resulting in a final adjusted aggregate PMLR of 34.0 MW. Detailed joint savings estimates can be found in Appendix A and the aggregate demand impacts for the CAISO and PG&E system load peak can be founded in Appendix B.

5 Persistence Study

PG&E's HER Persistence Study was launched in May 2014. The objective of the study is to understand how long the savings effects of the treatment endure after it is stopped. Customers in the Gamma Dual Standard and Gamma Dual Reduced experimental waves were randomly assigned to "continued" and "terminated" groups, the second of which did not receive any reports after the launch of the persistence study, which began two and a half years following the onset of the treatment. Between the two waves, a total of 28,000 customers were assigned to stop receiving treatment: 14,000 from the Gamma Dual Standard wave and 14,000 from Gamma Dual Reduced wave. Gamma Standard customers had received the reports every two months while Gamma Reduced customers had received the reports quarterly. Both waves were launched in November 2011. Table 5-1 presents the number of customers in the continued, discontinued, and control groups by experimental wave.

Table 5-1: Persistence Study Households by Experimental Wave

Experimental Wave	Continued	Discontinued	Control
Gamma Dual Standard	43,962	13,950	57,802
Gamma Dual Reduced	44,034	13,945	

The four figures and associated tables in the following section present electric energy savings estimates for customers with treatment withdrawn (terminated) and those who continued receiving reports, for each year of the study, for each of the two experimental waves. The values presented in the "Savings Reduction for Terminated Group" column were derived using the model described in Table 2-4. The savings estimates for continued customers were derived using the model described in Table 2-1 with the limitation that only customers who were active at the time of random assignment to the terminated and continued groups were included. As a result, the energy savings presented here differ slightly from those presented in the earlier sections.

5.1 Persistence of Electricity Savings

This section summarizes the persistence of electric energy savings for the Gamma Standard and Gamma Reduced experimental waves for each successive season of the experiment. The figures in this section and the following section provide the clearest illustration of how HER impacts persist after cessation of treatment. The figures present the percent of electric energy savings that persist across the first five years of the study for each experimental wave, with each year being the period from May to April of the following calendar year (i.e., Year 1 includes the months from May 2014 through April 2015). By estimating persistence on an annual and seasonal level we are able to observe long-term trends in the data that may be obfuscated by more granular, month-to-month variations. The y-axis represents the percent of the continued group savings that the terminated group achieved (i.e., a persistence of 80% indicates that the

energy savings of the terminated group is estimated to be 80% of the energy savings of the continued group). The 90% confidence interval of the estimate is included as dashed lines in the figure. For the Gamma Standard experimental wave, there is an apparent downward trend in electric energy savings of the terminated customers relative to the customers who continue to receive HERs.

- In the first year of the study, the difference in savings rates between the continued and terminated groups was about 18%. In other words, savings from customers who had been withdrawn from treatment dropped by an average of around 18% over the first year. However, this difference was not statistically significant, indicating that savings persisted during the first year.
- The savings decay increased to about 32% in the second year. In other words, about one third of the savings produced by HER was lost within two years following the withdrawal of the reports – however this decay was not statistically significant at the 90% confidence level.
- The savings decay increased in the third year to 68. In other words, about two thirds of the savings produced by HER was lost within three years following the withdrawal of the reports. This was the first year to show statistically significant differences in savings between the continued and discontinued groups, meaning the savings from HERs persisted for approximately two years after the discontinuation of treatment.
- The savings decay decreased to 53% in the fourth year and increased to 69% in the fifth year. The fourth and fifth year differences in energy savings between the continued and discontinued groups were statistically significant.
- Savings decay grew to 75% in the sixth year. Thus, a full three-quarters of HER savings are lost within six years following the cessation of reports. The difference in impacts between continued and discontinued groups were again statistically significant at the 90% confidence level, continuing the trend seen over the previous three years.

It is important to bear in mind that, although the difference in savings between the continued and terminated groups appears substantial and is statistically significant for four of the six years, the magnitude of the change in savings cannot be precisely estimated. This stems from the low statistical power in the test that was conducted. For the 2019 analysis year, the impact on annual electricity usage of the Gamma Standard treatment group is approximately 1.8% (see Table 3-3). This is a relatively small change in usage that requires a relatively large sample size (i.e., in excess of 10,000) to reliably detect. Removing treatment from 14,000 customers for 72 months reduced the treatment effect by 75%. This large percentage change in the treatment effect represents a small change in annual electricity usage, since it is 75% of the original 1.8% impact – around 1.4%. This very small difference requires a very large sample size to reliably detect. Based on the width of the 90% confidence interval, we can say with 90% confidence that the decay in the treatment effect in the sixth year after removal is in the range of 23% to 125%. Although this is a wide confidence interval, the entire interval shows a positive treatment decay. This, along with viewing the overall trends in Figure 5-1, suggests that the terminated group of the Gamma Standard wave has statistically significant lower electric savings than the continued group after six years.

Table 5-2 presents a seasonal breakdown of the savings and persistence of savings in the Gamma Standard wave. The difference in savings between the continued and terminated customers are statistically significant in every summer from Year 2 through Year 5, indicating that the fall-off in savings in the customers no longer receiving HERs begins in the summer, when customers are likely using more energy to cool their homes. There were no statistically significant seasonal impacts in Year 6, however this may be due to the fact that the confidence bands grow wider each year due to customer attrition (and therefore a reduction in sample size and statistical power). In spite of the lack of statistical significance, the figure suggests a downward trend in the influence of the reports on energy savings over time.

Figure 5-1: Annual Electric Savings Persistence - Gamma Standard Wave

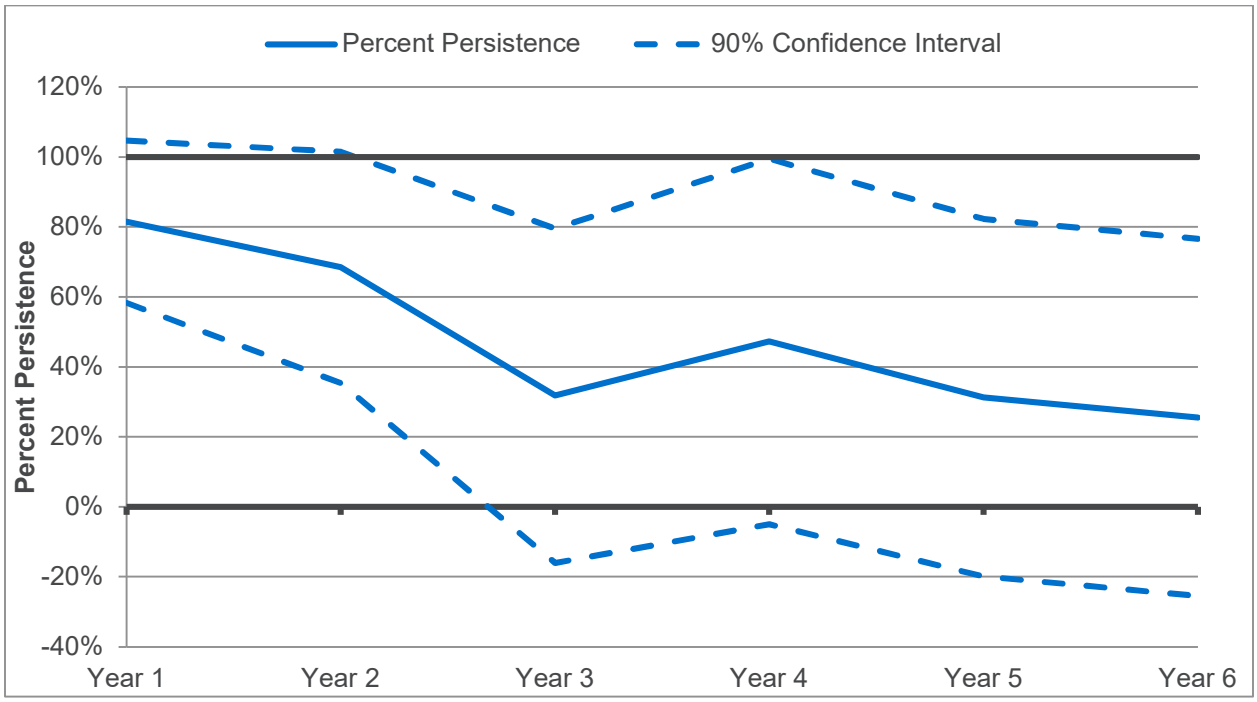

Table 5-2: Seasonal Electric Savings - Gamma Standard Wave

Season	Time Frame	Monthly kWh Savings		Savings Reduction for Terminated Group	Percent Persistence	Percent Persistence 90% Confidence Interval	
		Continued	Terminated				
Spring 1	May 2014	8.3	7.3	1.0	88%	51%	125%
Summer 1	June 2014 - Aug. 2014	12.2	9.1	3.1	75%	45%	104%
Autumn 1	Sept. 2014 - Nov. 2014	9.6	8.6	1.0	89%	61%	118%
Winter 1	Dec. 2014 - Feb. 2015	8.7	6.9	1.8	79%	50%	109%
Spring 2	Mar. 2015 - May 2015	8.1	6.5	1.6	81%	41%	121%
Summer 2	June 2015 - Aug. 2015	12.7	5.7	7.0	45%	8%	83%
Autumn 2	Sept. 2015 - Nov. 2015	10.3	7.1	3.2	69%	35%	104%
Winter 2	Dec. 2015 - Feb. 2016	9.8	8.9	0.9	91%	57%	125%
Spring 3	Mar. 2016 - May 2016	8.3	5.0	3.3	60%	9%	112%
Summer 3	June 2016 - Aug. 2016	12.6	2.0	10.6	16%	-29%	61%
Autumn 3	Sept. 2016 - Nov. 2016	8.4	2.9	5.5	34%	-12%	80%
Winter 3	Dec. 2016 - Feb. 2017	6.7	3.4	3.3	51%	-8%	109%
Spring 4	Mar. 2017 - May 2017	5.1	2.3	2.8	45%	-52%	142%
Summer 4	June 2017 - Aug. 2017	10.8	1.2	9.5	11%	-50%	73%
Autumn 4	Sept. 2017 - Nov. 2017	8.0	5.7	2.4	71%	16%	126%
Winter 4	Dec. 2017 - Feb. 2018	9.1	5.8	3.3	63%	17%	109%
Spring 5	Mar. 2018 - May 2018	8.5	4.3	4.2	51%	-14%	115%
Summer 5	June 2018 - Aug. 2018	11.9	2.8	9.1	23%	-34%	81%
Autumn 5	Sept. 2018 - Nov. 2018	8.3	3.5	4.7	43%	-13%	99%
Winter 5	Dec. 2018 - Feb. 2019	9.5	3.4	6.2	35%	-13%	83%
Spring 6	Mar. 2019 - May 2019	8.2	1.3	6.9	15%	-114%	145%
Summer 6	June 2019 – Aug. 2019	13.4	1.1	12.3	8%	-94%	110%
Fall 6	Sept. 2019 – Nov. 2019	10.7	4.7	6.0	44%	-44%	132%
Winter 6	Dec. 2019 – Feb. 2020	9.6	3.1	6.5	33%	-68%	133%
Spring 7	Mar. 2020 – May 2020	8.0	0.2	7.8	3%	-145%	150%

Figure 5-2 and the accompanying Table 5-3 present the difference in electric savings for the Gamma Reduced wave for each of the six years and for each season of the experiment, respectively. Like the Gamma Standard wave, there is a downward trend in savings year-to-year; however, unlike Gamma Standard wave, none of the years show statistically significant differences between the terminated and continued groups.

On average, customers in the terminated group had larger savings than those in the continued group by about 20% in the first year, 16% in the second year, and 11% in the third year. Starting in the fourth year, the terminated group began to see lower savings than the continued group, with savings 13% smaller in the fourth year, 22% smaller in the fifth year and 41% in the sixth year. Much like what was found in the Gamma Standard results, the confidence intervals on these savings impacts are large. In the sixth year, for example, the 90% confidence interval on the savings persistence after terminating HERs ranges from -4% to 120%. In other words, there is no statistically significant difference between the terminated and continued groups for six years after the discontinuation of reports in the terminated group. As mentioned earlier in this section, the persistence study would have benefitted from greater statistical power by inclusion of more customers in the experiment.

On a seasonal level, as shown in Table 5-3, there are no estimates throughout the six years of the study that show a statistically significant difference between the groups. This includes the summers, which were the first seasons to show differences in the Gamma Standard wave. In summary, the persistence of savings from HERs for the Gamma Reduced wave have persisted for six years, although the year-to-year trend is still downward. If the persistence study is continued in future years, one might expect to start seeing statistically significant differences in the summer.

Figure 5-2: Annual Electric Savings Persistence - Gamma Reduced Wave

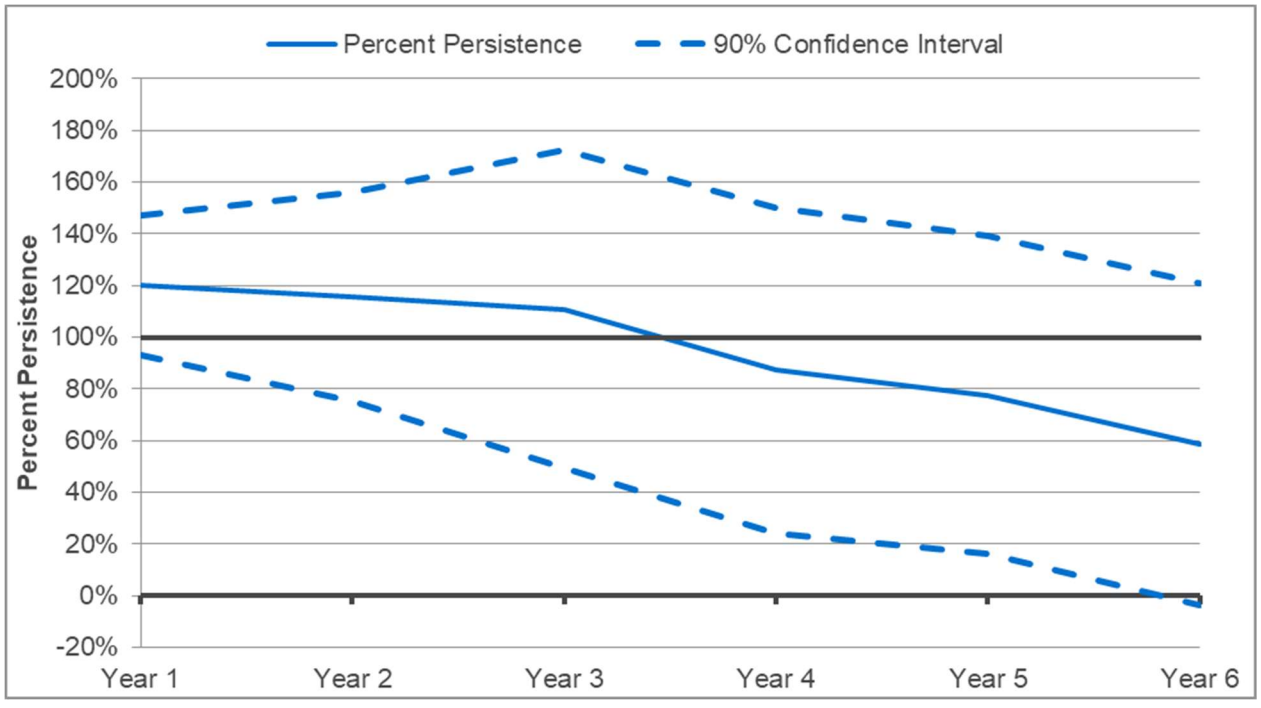

Table 5-3: Seasonal Electric Savings - Gamma Reduced Wave

Season	Time Frame	Monthly kWh Savings		Savings Reduction for Terminated Group	Percent Persistence	Percent Persistence 90% Confidence Interval	
		Continued	Terminated				
Spring 1	May 2014	6.1	8.5	-2.4	140%	88%	192%
Summer 1	June 2014 - Aug. 2014	7.8	12.3	-4.5	157%	114%	201%
Autumn 1	Sept. 2014 - Nov. 2014	7.8	9.0	-1.2	115%	85%	146%
Winter 1	Dec. 2014 - Feb. 2015	7.2	7.0	0.2	97%	67%	128%
Spring 2	Mar. 2015 - May 2015	6.7	6.9	-0.2	102%	61%	144%
Summer 2	June 2015 - Aug. 2015	8.6	11.3	-2.6	130%	79%	181%
Autumn 2	Sept. 2015 - Nov. 2015	7.5	9.7	-2.2	129%	87%	171%
Winter 2	Dec. 2015 - Feb. 2016	6.9	6.1	0.8	88%	44%	133%
Spring 3	Mar. 2016 - May 2016	5.7	6.3	-0.6	111%	45%	177%
Summer 3	June 2016 - Aug. 2016	7.6	10.1	-2.6	134%	64%	204%
Autumn 3	Sept. 2016 - Nov. 2016	5.8	6.8	-1.0	117%	59%	176%
Winter 3	Dec. 2016 - Feb. 2017	5.3	3.8	1.5	72%	8%	137%
Spring 4	Mar. 2017 - May 2017	4.0	3.5	0.5	87%	-22%	195%
Summer 4	June 2017 - Aug. 2017	6.6	6.7	0.0	100%	7%	193%
Autumn 4	Sept. 2017 - Nov. 2017	6.8	6.6	0.2	97%	40%	154%
Winter 4	Dec. 2017 - Feb. 2018	6.5	4.4	2.1	67%	10%	125%
Spring 5	Mar. 2018 - May 2018	7.4	5.9	1.5	80%	11%	149%
Summer 5	June 2018 - Aug. 2018	9.0	10.2	-1.2	113%	40%	187%
Autumn 5	Sept. 2018 - Nov. 2018	7.0	6.2	0.7	90%	29%	150%
Winter 5	Dec. 2018 - Feb. 2019	6.6	2.8	3.8	42%	-24%	107%
Spring 6	Mar. 2019 - May 2019	5.9	1.8	4.1	31%	-141%	203%
Summer 6	June 2019 – Aug. 2019	9.2	7.3	1.9	79%	-64%	222%
Fall 6	Sept. 2019 – Nov. 2019	8.0	4.9	3.1	61%	-48%	170%
Winter 6	Dec. 2019 – Feb. 2020	8.3	5.7	2.6	68%	-36%	173%
Spring 7	Mar. 2020 – May 2020	7.5	3.7	3.8	49%	-98%	196%

5.2 Persistence of Gas Savings

In the electricity section, we observed that the electricity savings decay first became apparent for the Gamma Standard wave in the summer, which is when load is typically highest due to air conditioning usage. For gas energy savings, we would expect a similar trend where the gas savings decay becomes apparent in the winter months.

Figure 5-3 and Table 5-4 show the year-to-year and season-to-season gas savings and persistence, respectively, of the Gamma Standard experimental wave. Unlike in the electric savings results, the difference in savings between the terminated and continued customers is statistically significant in the first five years, including the first year of the persistence study. The sixth year is slightly insignificant, but it falls outside of the range of significance by one percent which is marginal. From Table 5-4, it is apparent that there are statistically significant differences in savings in the first five winters (when the most gas is used) and occasionally in the spring or autumn seasons. These results indicate that the customers in the Gamma Standard wave were quick to forget the natural gas-saving habits they had formed, losing approximately 95% of their winter gas savings by the first winter – approximately 7 months after stopping HERs. Additionally, unlike in the electric savings results, Figure 5-3 does not appear to show a year-to-year decline in savings of the terminated group relative to the continued group. The trend is remarkably flat, which could be indicative of a behavioral shift back to that of the control customers, but with the small amount of continued savings from energy-saving technological improvements. In the sixth year, the terminated group had savings of approximately 35% of the continued group savings, with a 90% confidence interval of -30% to 101%.

Figure 5-3: Annual Gas Savings Persistence - Gamma Standard Wave

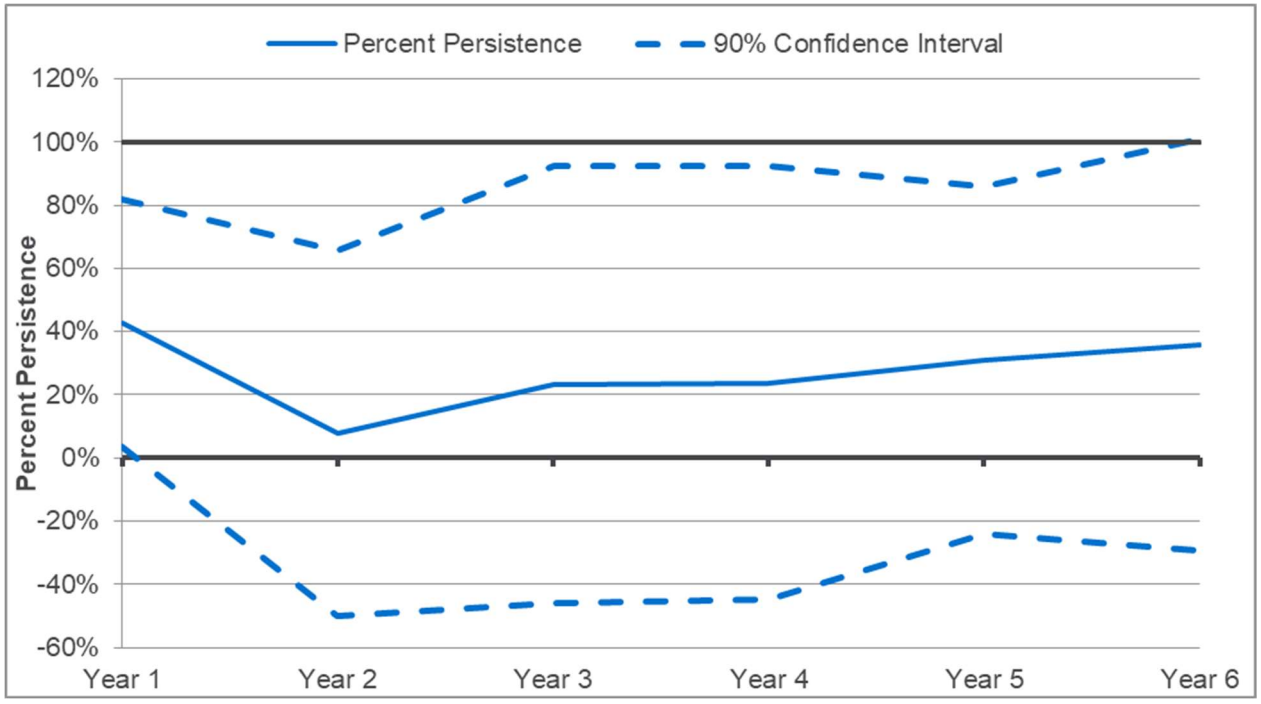

Table 5-4: Seasonal Gas Savings - Gamma Standard Wave

Season	Time Frame	Monthly Therm Savings		Savings Reduction for Terminated Group	Percent Persistence	Percent Persistence 90% Confidence Interval	
		Continued	Terminated				
Spring 1	May 2014	0.2	0.2	0.0	99%	52%	145%
Summer 1	June 2014 - Aug. 2014	0.1	0.1	0.0	178%	26%	330%
Autumn 1	Sept. 2014 - Nov. 2014	0.2	0.2	0.0	81%	21%	142%
Winter 1	Dec. 2014 - Feb. 2015	0.5	0.0	0.5	5%	-35%	46%
Spring 2	Mar. 2015 - May 2015	0.2	0.1	0.1	58%	8%	107%
Summer 2	June 2015 - Aug. 2015	0.1	0.0	0.1	25%	-108%	157%
Autumn 2	Sept. 2015 - Nov. 2015	0.2	-0.1	0.3	-27%	-97%	43%
Winter 2	Dec. 2015 - Feb. 2016	0.4	0.0	0.4	-2%	-74%	69%
Spring 3	Mar. 2016 - May 2016	0.2	0.1	0.1	54%	-15%	123%
Summer 3	June 2016 - Aug. 2016	0.1	0.1	0.0	112%	-3%	228%
Autumn 3	Sept. 2016 - Nov. 2016	0.2	0.1	0.1	38%	-30%	106%
Winter 3	Dec. 2016 - Feb. 2017	0.4	-0.1	0.5	-15%	-104%	73%
Spring 4	Mar. 2017 - May 2017	0.2	0.1	0.1	40%	-36%	116%
Summer 4	June 2017 - Aug. 2017	0.1	0.1	0.0	130%	-14%	274%
Autumn 4	Sept. 2017 - Nov. 2017	0.2	0.1	0.1	54%	-47%	154%
Winter 4	Dec. 2017 - Feb. 2018	0.5	0.0	0.5	1%	-71%	72%
Spring 5	Mar. 2018 - May 2018	0.3	0.0	0.3	10%	-55%	76%
Summer 5	June 2018 - Aug. 2018	0.2	0.2	0.0	119%	31%	207%
Autumn 5	Sept. 2018 - Nov. 2018	0.3	0.1	0.3	25%	-32%	83%
Winter 5	Dec. 2018 - Feb. 2019	0.6	0.1	0.6	9%	-61%	79%
Spring 6	Mar. 2019 - May 2019	0.1	0.1	0.0	135%	-114%	385%
Summer 6	June 2019 – Aug. 2019	0.3	0.2	0.1	70%	-71%	211%
Fall 6	Sept. 2019 – Nov. 2019	0.6	0.0	0.6	-3%	-162%	156%
Winter 6	Dec. 2019 – Feb. 2020	0.3	0.0	0.2	17%	-184%	218%
Spring 7	Mar. 2020 – May 2020	0.1	0.1	0.0	135%	-114%	385%

Figure 5-4 and Table 5-5 show the year-to-year and season-to-season gas savings, respectively, of the Gamma Reduced wave. Unlike in the gas savings results for the Gamma Standard wave, but like the results in the electric savings section, there is a downward trend in savings of the terminated group relative to the continued group. Given the wide confidence intervals, however, only the difference in Year 5 was statistically significant at the 90% level. The savings of the terminated customers in the sixth year was 7% of the savings of the continued customers, with a confidence interval of -124% to 139%.

Unlike the gas savings for the Gamma Standard wave, the statistical significance of savings for the Gamma Reduced wave does not appear to have any seasonal trend. The first winter season and the fifth summer season are the only statistically significant estimates. As was the case with the electric savings of the Gamma Reduced wave, although most years have no statistical significance overall, the trend is downward, and if the persistence study is continued into future years, there are likely to be additional results that reach the bar for statistical significance.

Figure 5-4: Annual Gas Savings Persistence - Gamma Reduced Wave

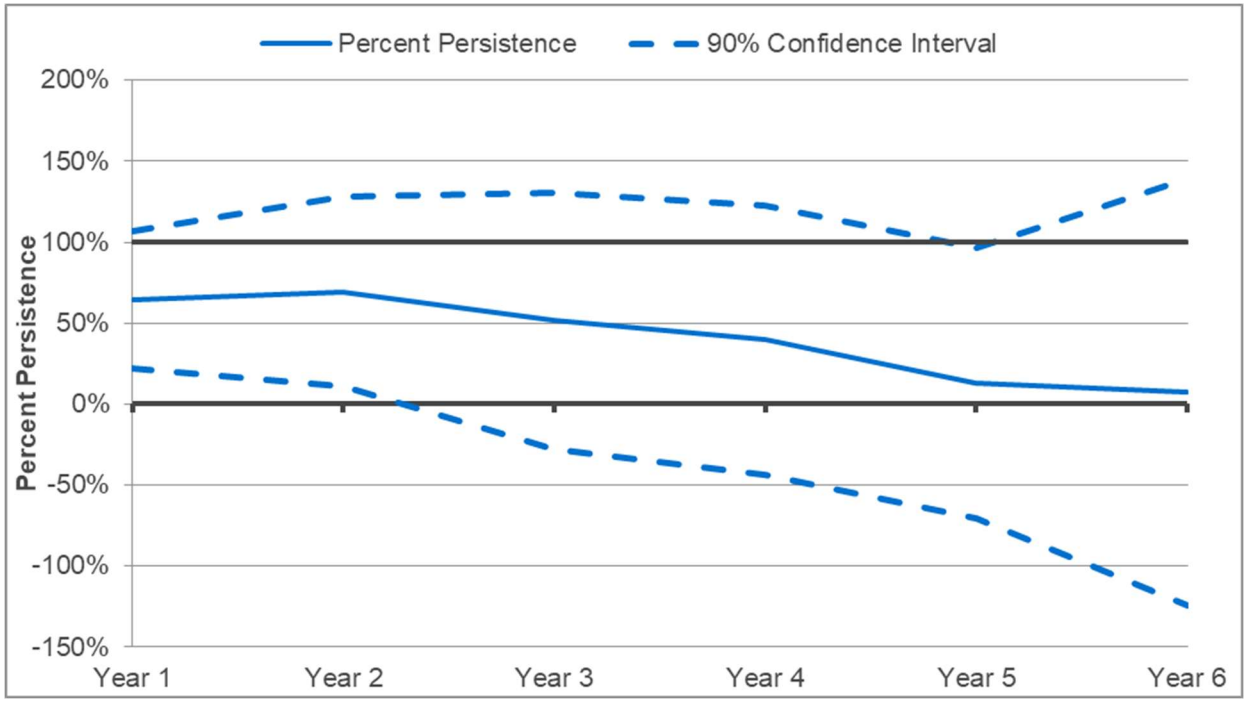

Table 5-5: Seasonal Gas Savings - Gamma Reduced Wave

Season	Time Frame	Monthly Therm Savings		Savings Reduction for Terminated Group	Percent Persistence	Percent Persistence 90% Confidence Interval	
		Continued	Terminated				
Spring 1	May 2014	0.2	0.2	0.0	88%	24%	151%
Summer 1	June 2014 - Aug. 2014	0.0	0.0	0.1	-78%	-281%	125%
Autumn 1	Sept. 2014 - Nov. 2014	0.2	0.2	0.0	111%	41%	180%
Winter 1	Dec. 2014 - Feb. 2015	0.6	0.3	0.2	59%	19%	98%
Spring 2	Mar. 2015 - May 2015	0.2	0.1	0.1	64%	-1%	129%
Summer 2	June 2015 - Aug. 2015	0.0	0.0	0.1	-94%	-437%	249%
Autumn 2	Sept. 2015 - Nov. 2015	0.2	0.1	0.0	81%	-13%	175%
Winter 2	Dec. 2015 - Feb. 2016	0.6	0.4	0.1	75%	20%	129%
Spring 3	Mar. 2016 - May 2016	0.2	0.2	0.0	88%	12%	163%
Summer 3	June 2016 - Aug. 2016	0.1	0.0	0.1	-31%	-244%	182%
Autumn 3	Sept. 2016 - Nov. 2016	0.2	0.1	0.1	56%	-46%	158%
Winter 3	Dec. 2016 - Feb. 2017	0.5	0.2	0.3	39%	-42%	120%
Spring 4	Mar. 2017 - May 2017	0.2	0.2	0.0	108%	20%	196%
Summer 4	June 2017 - Aug. 2017	0.0	0.0	0.0	10%	-376%	396%
Autumn 4	Sept. 2017 - Nov. 2017	0.1	0.0	0.1	19%	-117%	155%
Winter 4	Dec. 2017 - Feb. 2018	0.5	0.1	0.3	32%	-47%	110%
Spring 5	Mar. 2018 - May 2018	0.3	0.1	0.1	48%	-35%	131%
Summer 5	June 2018 - Aug. 2018	0.1	-0.1	0.2	-80%	-227%	67%
Autumn 5	Sept. 2018 - Nov. 2018	0.2	0.1	0.1	64%	-34%	162%
Winter 5	Dec. 2018 - Feb. 2019	0.4	0.0	0.4	4%	-99%	106%
Spring 6	Mar. 2019 - May 2019	0.3	0.0	0.3	-10%	-187%	167%
Summer 6	June 2019 – Aug. 2019	0.0	-0.1	0.1	-261%	-983%	462%
Fall 6	Sept. 2019 – Nov. 2019	0.2	0.1	0.1	64%	-175%	302%
Winter 6	Dec. 2019 – Feb. 2020	0.3	0.0	0.3	-9%	-338%	321%
Spring 7	Mar. 2020 – May 2020	0.2	0.1	0.1	29%	-293%	352%

6 Electronic HERs Study

In April 2014, approximately 220,000 HER recipients in Wave One, Wave Two, and Wave Three began receiving electronic HERs (eHERs) in addition to the standard paper HERs. These households receive eHERs on the months that they do not receive paper reports (i.e., every other month), so that customers receiving eHERs are effectively receiving 12 reports per year. Electronic HERs were withheld from a sample of 81,000 HER recipients in the same experimental waves (the baseline group), thereby allowing for the measurement of the incremental effect of eHERs (as compared to the effect of paper HERs alone). Additionally, a sample of 72,000 non-recipient households served as a control group for both the treatment and baseline groups (for the purpose of measuring energy savings). All three samples consist of PG&E customers who are eligible to receive e-mails from PG&E (i.e., PG&E had e-mail addresses on file and customer permission to send e-mails). These customers have slightly higher electricity consumption than customers for whom PG&E does not have email addresses, which means the results reported in this section are not directly comparable to those reported in Section 3. Table 6-1 presents the number of customers in the baseline, treatment, and control groups by experimental wave.

Table 6-1: eHER Households by Experimental Wave

Experimental Wave	Baseline	Treatment	Control
Wave One	21,367	93,500	28,348
Wave Two	20,850	82,500	16,111
Wave Three	39,041	44,000	27,697

Figure 6-1 and Figure 6-2 provide the clearest illustration of the incremental impact of eHERs across the six years of the study, and Table 6-2 and Table 6-3 display the electric energy savings estimates for the baseline and eHER treatment groups for Wave One and Wave Two, respectively, for each successive season of the experiment. The annual incremental impacts for receiving eHERs in addition to paper reports are not statistically significant for either experimental wave for any year, with the exception of Year 4 for Wave Two. To reiterate, the addition of eHERs on the months where customers would not have received any report was generally not found to add any measurable incremental energy savings. The data in the tables is presented at a seasonal level in order to aid in observing long-term trends in the data, although in both waves there is no clear seasonal trend. The lack of statistical significance overall is primarily due to three factors: the small magnitude of the incremental savings, the high month-to-month variability of savings, and the relatively small eHER population.

PG&E has not tested the impact of sending only eHERs to customers, but this idea has been tested elsewhere. Other studies have found that the savings achieved by programs that include eHERs alone are generally smaller than those achieved by paper HERs, but this varies by geographic location.

Figure 6-1: Annual Incremental Electric Savings – Wave One

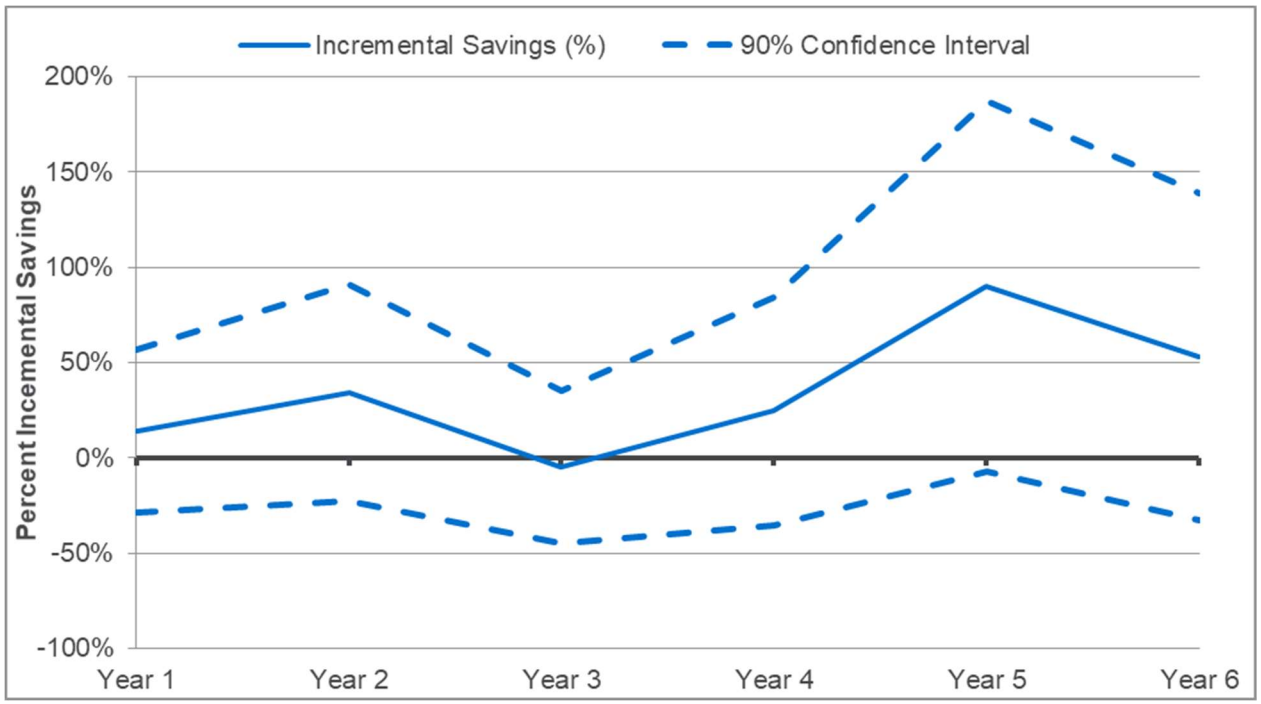

Table 6-2: Seasonal Electric Savings – Wave One

Season	Time Frame	Monthly kWh Savings		Incremental Savings from eHERs	% Incremental Savings	90% Confidence Interval	
		No eHERs	eHERs				
Spring 1	Apr. 2014 - May 2014	3.1	3.6	0.5	14%	-49%	78%
Summer 1	June 2014 - Aug. 2014	2.1	3.1	0.9	43%	-75%	161%
Autumn 1	Sept. 2014 - Nov. 2014	4.3	4.4	0.1	2%	-42%	46%
Winter 1	Dec. 2014 - Feb. 2015	5.6	6.2	0.6	11%	-22%	45%
Spring 2	Mar. 2015 - May 2015	1.3	2.6	1.2	91%	-86%	268%
Summer 2	June 2015 - Aug. 2015	3.5	6.0	2.5	74%	-21%	168%
Autumn 2	Sept. 2015 - Nov. 2015	4.2	5.3	1.1	26%	-34%	86%
Winter 2	Dec. 2015 - Feb. 2016	6.9	7.3	0.4	6%	-29%	41%
Spring 3	Mar. 2016 - May 2016	5.8	5.4	-0.4	-7%	-59%	46%
Summer 3	June 2016 - Aug. 2016	9.3	7.8	-1.5	-16%	-60%	27%
Autumn 3	Sept. 2016 - Nov. 2016	5.9	6.2	0.3	5%	-42%	51%
Winter 3	Dec. 2016 - Feb. 2017	7.4	7.9	0.5	7%	-31%	45%
Spring 4	Mar. 2017 - May 2017	3.6	4.5	0.9	25%	-74%	123%
Summer 4	June 2017 - Aug. 2017	8.4	9.4	1.0	12%	-45%	69%
Autumn 4	Sept. 2017 - Nov. 2017	5.0	6.5	1.5	30%	-34%	93%
Winter 4	Dec. 2017 - Feb. 2018	5.3	6.3	1.0	19%	-39%	78%
Spring 5	Mar. 2018 - May 2018	0.9	5.1	4.2	464%	19%	910%
Summer 5	June 2018 - Aug. 2018	5.7	8.7	3.0	53%	-35%	142%
Autumn 5	Sept. 2018 - Nov. 2018	3.9	7.3	3.4	89%	1%	176%
Winter 5	Dec. 2018 – Feb. 2019	6.0	8.6	2.6	44%	-15%	103%
Spring 6	Mar. 2019 - May 2019	0.8	4.4	3.5	429%	-523%	1380%
Summer 6	June 2019 - Aug. 2019	7.7	8.1	0.5	6%	-125%	137%
Autumn 6	Sept. 2019 - Nov. 2019	4.9	7.0	2.1	42%	-103%	187%
Winter 6	Dec. 2019 - Feb. 2020	5.0	7.7	2.7	54%	-24%	133%

Figure 6-2 presents the annual incremental electric savings for Wave Two customers receiving eHERs (versus those who receive paper-only HERs). With the exception of the fourth year, the incremental savings are not statistically significant in any year.

Figure 6-2: Annual Incremental Electric Savings – Wave Two

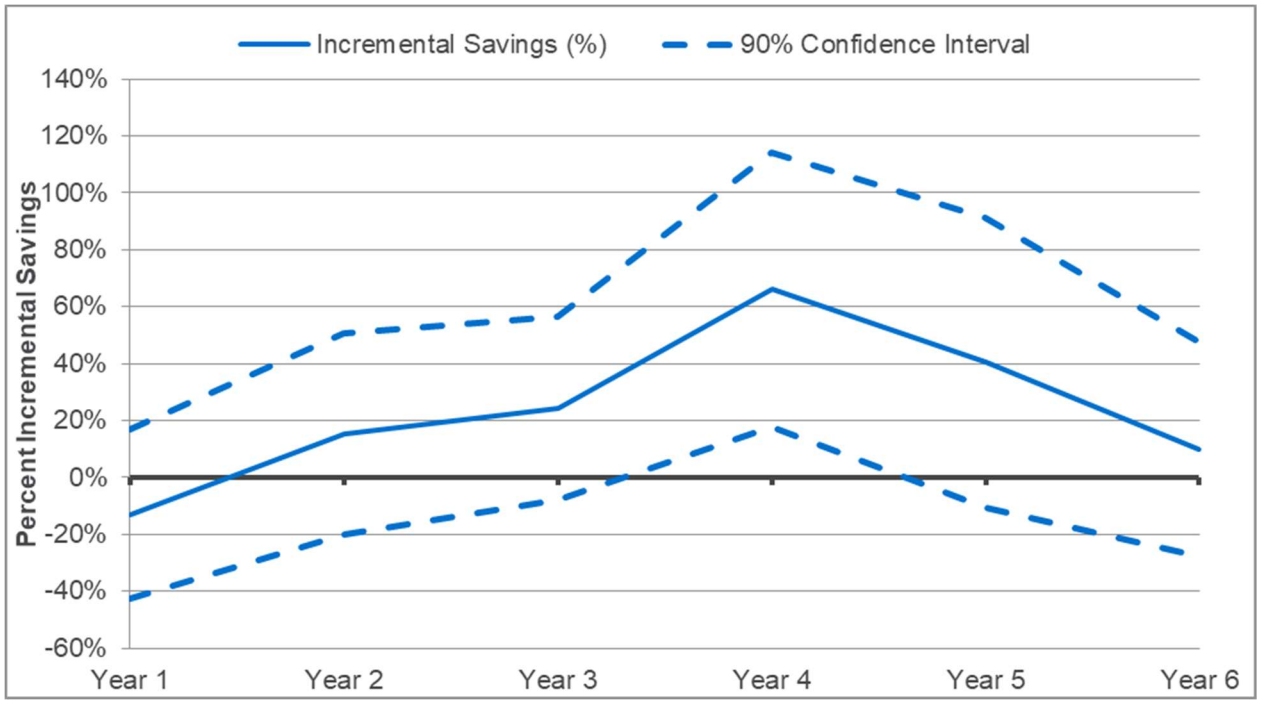

Table 6-3: Seasonal Electric Savings – Wave Two

Season	Time Frame	Monthly kWh Savings		Incremental Savings from eHERs	% Incremental Savings	90% Confidence Interval	
		No eHERs	eHERs				
Spring 1	April 2014 - May 2014	5.1	3.1	-2.0	-39%	-84%	5%
Summer 1	June 2014 - Aug. 2014	6.2	5.7	-0.4	-7%	-48%	34%
Autumn 1	Sept. 2014 - Nov. 2014	4.8	4.4	-0.4	-8%	-51%	36%
Winter 1	Dec. 2014 - Feb. 2015	7.0	6.1	-0.9	-13%	-42%	16%
Spring 2	Mar. 2015 - May 2015	3.5	4.2	0.6	17%	-51%	86%
Summer 2	June 2015 - Aug. 2015	7.1	9.1	2.0	28%	-18%	74%
Autumn 2	Sept. 2015 - Nov. 2015	7.8	8.0	0.2	3%	-30%	36%
Winter 2	Dec. 2015 - Feb. 2016	7.3	8.2	0.9	12%	-23%	47%
Spring 3	Mar. 2016 - May 2016	7.0	8.2	1.2	18%	-25%	60%
Summer 3	June 2016 - Aug. 2016	10.7	13.3	2.7	25%	-12%	63%
Autumn 3	Sept. 2016 - Nov. 2016	8.8	10.3	1.5	16%	-15%	48%
Winter 3	Dec. 2016 - Feb. 2017	8.7	11.1	2.4	28%	-6%	62%
Spring 4	Mar. 2017 - May 2017	6.4	10.3	4.0	62%	7%	118%
Summer 4	June 2017 - Aug. 2017	9.5	15.9	6.4	68%	18%	117%
Autumn 4	Sept. 2017 - Nov. 2017	6.9	10.1	3.2	47%	1%	93%
Winter 4	Dec. 2017 - Feb. 2018	4.2	8.4	4.3	103%	24%	181%
Spring 5	Mar. 2018 - May 2018	5.4	8.7	3.4	62%	-12%	137%
Summer 5	June 2018 - Aug. 2018	8.4	13.5	5.2	62%	2%	122%
Autumn 5	Sept. 2018 - Nov. 2018	7.9	9.6	1.7	22%	-24%	68%
Winter 5	Dec. 2018 - Feb. 2019	10.3	10.8	0.5	5%	7%	99%
Spring 6	Mar. 2019 - May 2019	6.2	8.5	2.2	36%	-92%	164%
Summer 6	June 2019 - Aug. 2019	14.7	16.2	1.5	10%	-58%	78%
Autumn 6	Sept. 2019 - Nov. 2019	11.4	11.4	0.0	0%	-65%	65%
Winter 6	Dec. 2019 - Feb. 2020	9.5	9.5	0.0	0%	-43%	43%

Figure 6-3 and Figure 6-4 present the yearly trends of incremental gas energy savings across the five years of the study for Wave One and Wave Two, respectively, and Table 6-4 and Table 6-5 show the estimated incremental gas savings for Wave One and Wave Two, respectively, for each successive season of the experiment. Unlike in the results for electric savings, sending eHERs to customers in Wave One resulted in statistically significant incremental gas savings for every year of the study. On average over the entire 71-month life of the study, Wave One customers receiving eHERs saved an additional 0.19 therms per month as compared to Wave One customers not receiving eHERs. Conversely, the Wave Two results, presented in Table 6-5, show statistically significant negative incremental savings for years two, five and six of the study. This result is in part driven by negative incremental savings estimates during winter seasons, which drives the yearly estimate down due to the typically higher gas usages during the winter.

Figure 6-3: Annual Incremental Gas Savings – Wave One

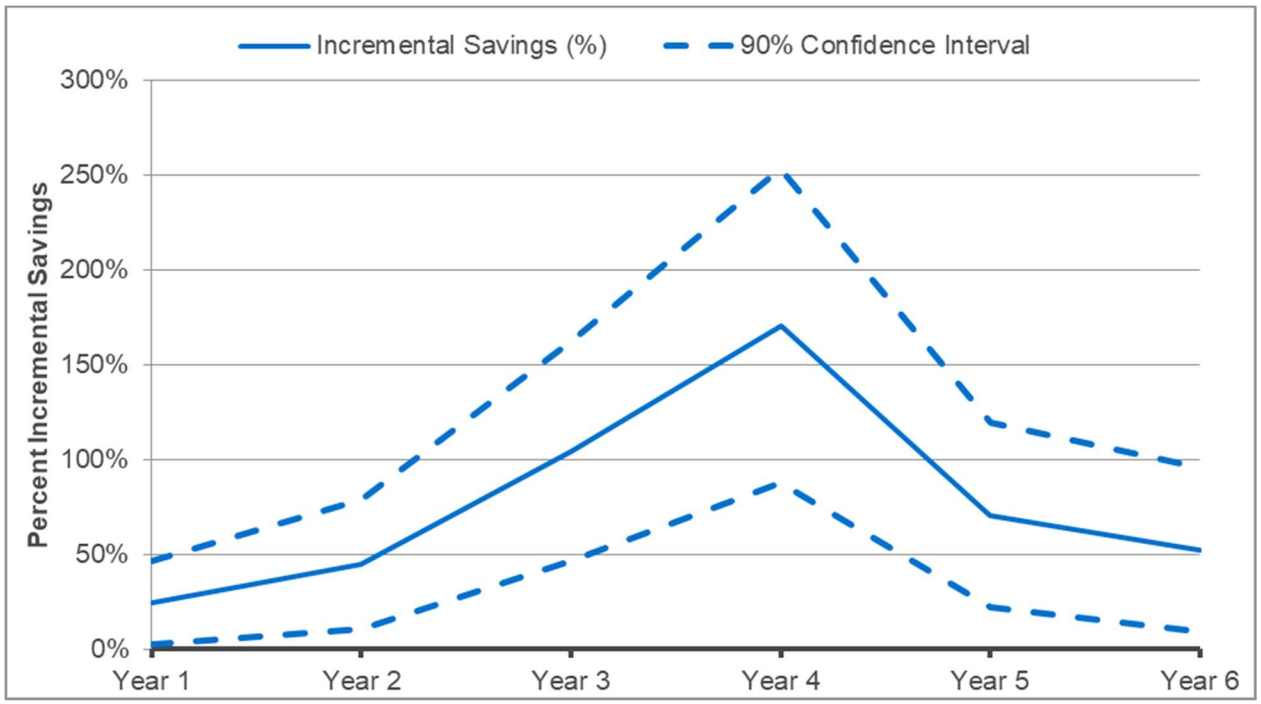

Table 6-4: Seasonal Gas Savings – Wave One

Season	Time Frame	Monthly Therm Savings		Incremental Savings from eHERs	% Incremental Savings	90% Confidence Interval	
		No eHERs	eHERs				
Spring 1	April 2014 - May 2014	0.5	0.4	0.0	-3%	-23%	18%
Summer 1	June 2014 - Aug. 2014	0.2	0.3	0.0	7%	-23%	37%
Autumn 1	Sept. 2014 - Nov. 2014	0.3	0.3	0.1	20%	-12%	52%
Winter 1	Dec. 2014 - Feb. 2015	0.4	0.6	0.3	75%	29%	121%
Spring 2	Mar. 2015 - May 2015	0.3	0.4	0.1	17%	-15%	48%
Summer 2	June 2015 - Aug. 2015	0.2	0.2	0.1	37%	-9%	84%
Autumn 2	Sept. 2015 - Nov. 2015	0.3	0.5	0.1	33%	0%	65%
Winter 2	Dec. 2015 - Feb. 2016	0.4	0.6	0.3	73%	11%	135%
Spring 3	Mar. 2016 - May 2016	0.3	0.5	0.1	39%	3%	75%
Summer 3	June 2016 - Aug. 2016	0.2	0.3	0.1	70%	18%	121%
Autumn 3	Sept. 2016 - Nov. 2016	0.2	0.4	0.2	118%	49%	186%
Winter 3	Dec. 2016 - Feb. 2017	0.2	0.5	0.4	250%	59%	441%
Spring 4	Mar. 2017 - May 2017	0.2	0.4	0.2	86%	17%	156%
Summer 4	June 2017 - Aug. 2017	0.2	0.3	0.1	48%	4%	92%
Autumn 4	Sept. 2017 - Nov. 2017	0.1	0.4	0.2	194%	88%	301%
Winter 4	Dec. 2017 - Feb. 2018	0.1	0.6	0.5	705%	311%	1098%
Spring 5	Mar. 2018 - May 2018	0.2	0.6	0.4	168%	80%	257%
Summer 5	June 2018 - Aug. 2018	0.3	0.3	0.1	32%	-10%	74%
Autumn 5	Sept. 2018 - Nov. 2018	0.3	0.5	0.2	54%	6%	102%
Winter 5	Dec. 2018 - Feb. 2019	0.3	0.7	0.3	99%	-70%	202%
Spring 6	Mar. 2019 - May 2019	0.3	0.5	0.2	47%	-66%	161%
Summer 6	June 2019 - Aug. 2019	0.2	0.3	0.1	36%	-58%	130%
Autumn 6	Sept. 2019 - Nov. 2019	0.3	0.5	0.2	48%	-63%	160%
Winter 6	Dec. 2019 - Feb. 2020	0.3	0.7	0.4	116%	-5%	236%

Figure 6-4: Annual Incremental Gas Savings – Wave Two

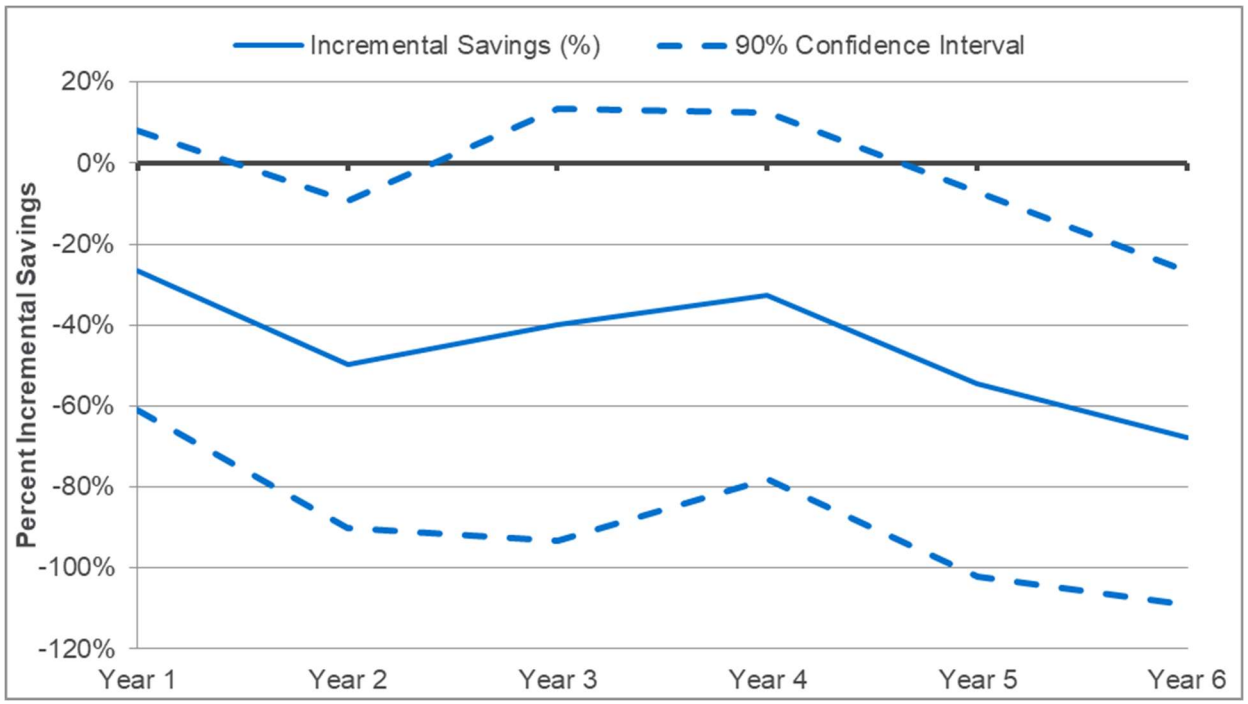

Table 6-5: Seasonal Gas Savings – Wave Two

Season	Time Frame	Monthly Therm Savings		Incremental Savings from eHERs	% Incremental Savings	90% Confidence Interval	
		No eHERs	eHERs				
Spring 1	April 2014 - May 2014	0.3	0.2	-0.1	-30%	-65%	5%
Summer 1	June 2014 - Aug. 2014	0.1	0.1	0.0	-35%	-95%	25%
Autumn 1	Sept. 2014 - Nov. 2014	0.2	0.1	0.0	-18%	-76%	41%
Winter 1	Dec. 2014 - Feb. 2015	0.3	0.2	-0.1	-40%	-91%	11%
Spring 2	Mar. 2015 - May 2015	0.3	0.3	0.0	-7%	-42%	28%
Summer 2	June 2015 - Aug. 2015	0.1	0.1	0.0	0%	-58%	58%
Autumn 2	Sept. 2015 - Nov. 2015	0.3	0.2	-0.1	-30%	-68%	9%
Winter 2	Dec. 2015 - Feb. 2016	0.3	-0.1	-0.4	-125%	-198%	-52%
Spring 3	Mar. 2016 - May 2016	0.1	0.1	0.0	-24%	-112%	65%
Summer 3	June 2016 - Aug. 2016	0.1	0.1	0.0	0%	-75%	76%
Autumn 3	Sept. 2016 - Nov. 2016	0.2	0.2	0.0	-15%	-83%	53%
Winter 3	Dec. 2016 - Feb. 2017	0.5	0.1	-0.3	-71%	-133%	-9%
Spring 4	Mar. 2017 - May 2017	0.3	0.3	0.0	8%	-55%	71%
Summer 4	June 2017 - Aug. 2017	0.1	0.2	0.1	75%	-47%	197%
Autumn 4	Sept. 2017 - Nov. 2017	0.3	0.2	-0.1	-34%	-88%	20%
Winter 4	Dec. 2017 - Feb. 2018	0.6	0.2	-0.4	-71%	-118%	-23%
Spring 5	Mar. 2018 - May 2018	0.3	0.2	-0.1	-25%	-86%	36%
Summer 5	June 2018 - Aug. 2018	0.2	0.1	-0.1	-48%	-126%	30%
Autumn 5	Sept. 2018 - Nov. 2018	0.3	0.1	-0.2	-61%	-110%	-12%
Winter 5	Dec. 2018 - Feb. 2019	0.6	0.1	-0.6	-90%	-35%	115%
Spring 6	Mar. 2019 - May 2019	0.5	0.3	-0.2	-40%	-129%	49%
Summer 6	June 2019 - Aug. 2019	0.2	0.1	-0.1	-53%	-168%	63%
Autumn 6	Sept. 2019 - Nov. 2019	0.3	0.1	-0.2	-63%	-177%	52%
Winter 6	Dec. 2019 - Feb. 2020	0.6	-0.1	-0.6	-111%	-178%	-43%

Appendix A Detailed Joint Savings Estimates

Table A-1: Joint Savings Adjustments for the Downstream Rebate Program

Wave	Number of Treatment Customers		Additional Savings per Treatment Customer (Uplift)			Aggregate Joint Savings		
	2019 Avg.	2019 Peak	kWh	Therms	kW	GWh	1,000 Therms	MW
Beta	33,590	36,598	1.45	-0.08	0.00	0.0	-2.8	0.0
Gamma Dual	38,609	19,489	1.35	0.21	0.00	0.1	8.1	0.0
Gamma Dual Reduced	38,687	41,636	1.64	-0.08	0.00	0.1	-3.1	0.0
Gamma Electric	18,281	41,712	-2.38	-	0.00	0.0	-	0.0
Wave 1 Dual	205,041	216,631	1.57	0.06	0.00	0.3	11.8	0.0
Wave 1 Electric	17,970	19,226	-3.12	-	0.00	-0.1	-	0.0
Wave 2 Area 7	48,635	50,872	1.35	0.00	0.00	0.1	-0.2	0.1
Wave 2 Not Area 7	185,859	198,212	0.94	0.02	0.00	0.2	3.0	-0.2
Wave 3	122,910	129,757	1.28	0.10	0.00	0.2	12.5	0.5
Wave 4	100,657	106,439	0.23	0.03	0.00	0.0	2.7	0.1
Wave 5	117,132	126,345	1.54	0.10	0.00	0.2	11.9	-0.2
Wave 6	169,959	178,216	0.77	-0.01	0.00	0.1	-0.9	-0.3
Wave 7	107,005	112,284	0.99	0.04	0.00	0.1	4.0	0.2
Wave 8	114,047	117,037	0.03	-0.04	0.00	0.0	-5.1	-0.1
Wave 9	84,685	88,174	0.18	-0.02	0.00	0.0	-1.8	0.0
Wave 10	277,847	-	-0.01	0.00	-	0.0	0.0	-
Wave 11	154,559	-	-0.01	-	-	0.0	-	-
2019 Total	**1,835,473**	**1,482,628**	**0.67**	**0.02**	**0.00**	**1.2**	**40.3**	**0.1**

Table A-2: Aggregate Joint Savings Adjustments for the Home Energy Check-Up (HEC) Program

Wave	Number of Treatment Customers	Additional Savings per Treatment Customer (Uplift)		Aggregate Joint Savings	
	2019 Avg.	kWh	Therms	GWh	1,000 Therms
Beta	33,590	0.54	0.01	0.0	0.4
Gamma Dual	38,609	0.14	0.00	0.0	0.1
Gamma Dual Reduced	38,687	0.06	0.00	0.0	0.1
Gamma Electric	18,281	0.33	0.01	0.0	0.1
Wave 1 Dual	205,041	0.34	0.01	0.1	1.7
Wave 1 Electric	17,970	0.00	0.00	0.0	0.0
Wave 2 Area 7	48,635	0.57	0.01	0.0	0.7
Wave 2 Not Area 7	185,859	0.32	0.01	0.1	1.4
Wave 3	122,910	0.14	0.00	0.0	0.4
Wave 4	100,657	0.18	0.00	0.0	0.4
Wave 5	117,132	0.32	0.01	0.0	0.9
Wave 6	169,959	0.30	0.01	0.1	1.2
Wave 7	107,005	0.28	0.01	0.0	0.7
Wave 8	114,047	0.35	0.01	0.0	0.9
Wave 9	84,685	0.36	0.01	0.0	0.7
Wave 10	277,847	0.16	0.00	0.0	1.0
Wave 11	154,559	0.22	0.01	0.0	0.8
2019 Total	**1,835,473**	**0.27**	**0.01**	**0.5**	**11.7**

Table A-3: Aggregate Joint Savings Adjustments for the Upstream Lighting Program (ULP)

Wave	Number of Treatment Customers		Additional Savings per Treatment Customer (Uplift)			Aggregate Joint Savings		
	2019 Avg.	2019 Peak	kWh	Therms	kW	GWh	1,000 Therms	MW
Beta	33,590	36,598	10.35	-0.30	0.00	0.3	-10.1	0.0
Gamma Dual	38,609	19,489	9.01	-0.26	0.00	0.3	-10.1	0.0
Gamma Dual Reduced	38,687	41,636	9.18	-0.27	0.00	0.4	-10.4	0.0
Gamma Electric	18,281	41,712	12.09	0.00	0.00	0.2	0.0	0.0
Wave 1 Dual	205,041	216,631	11.02	-0.30	0.00	2.3	-61.6	0.2
Wave 1 Electric	17,970	19,226	10.36	0.00	0.00	0.2	0.0	0.0
Wave 2 Area 7	48,635	50,872	1.50	-0.05	0.00	0.1	-2.5	0.0
Wave 2 Not Area 7	185,859	198,212	3.94	-0.11	0.00	0.7	-19.8	0.1
Wave 3	122,910	129,757	2.30	-0.06	0.00	0.3	-7.7	0.0
Wave 4	100,657	106,439	-0.21	0.00	0.00	0.0	-0.3	0.0
Wave 5	117,132	126,345	0.85	-0.02	0.00	0.1	-2.5	0.0
Wave 6	169,959	178,216	1.05	-0.02	0.00	0.2	-4.0	0.0
Wave 7	107,005	112,284	0.35	-0.01	0.00	0.0	-0.8	0.0
Wave 8	114,047	117,037	0.21	0.00	0.00	0.0	-0.5	0.0
Wave 9	84,685	88,174	0.10	0.00	0.00	0.0	-0.2	0.0
Wave 10	277,847	-	0.02	0.00	0.00	0.0	-0.1	-
Wave 11	154,559	-	0.02	0.00	0.00	0.0	-0.1	-
2019 Total	**1,835,473**	**1,482,628**	**2.80**	**-0.07**	**0.00**	**5.1**	**-130.6**	**0.4**

Appendix B Demand Savings CAISO & PG&E Peaks

In addition to estimating demand savings for the 2019 heat wave, peak reductions were also estimated for the CAISO and PG&E peak demand hours. The 2019 CAISO and PG&E system peaks both occurred on August 15th at 6 p.m. The estimated impact of HERs during these hours was 32.9 MW (1.1%), shown in Table B-1. The impact (kW) values were calculated by running a lagged dependent variable model comparing usage between the control and treatment groups during the peak time. The savings during the system peak times were lower than 2018, where we found savings of 32.6 MW (1.2%). The lower savings could stem from high temperatures during the 2019 system peak. With almost half of the sample seeing temperatures above 98 degrees, there may have been less willingness to lower electricity usage.

Table B-1: PG&E and CAISO System Peak Demand Reductions by Experimental Wave

Wave	Control Customers	Treatment Customers	Control (kW)	Treatment (kW)	Per-Customer Impact (kW)	90% Confidence Interval		Percent Impact (%)	Aggregate Impact (MW)	Average Temperature
Beta	36,381	36,175	3.54	3.50	0.05	0.02	0.07	1.3%	1.7	100.1
Gamma Dual	41,267	41,187	2.39	2.38	0.01	-0.01	0.03	0.3%	0.3	101.3
Gamma Dual Reduced	41,267	41,278	2.38	2.39	-0.01	-0.03	0.01	-0.4%	-0.4	101.3
Gamma Electric	19,188	19,220	2.02	1.99	0.03	0.00	0.05	1.4%	0.5	100.5
Wave 1 Dual	53,656	214,328	2.28	2.27	0.02	0.00	0.03	0.8%	3.8	98.2
Wave 1 Electric	4,809	18,988	2.53	2.58	-0.06	-0.10	-0.01	-2.3%	-1.1	100.3
Wave 2 Area 7	31,369	50,281	1.56	1.53	0.03	0.01	0.04	1.7%	1.3	97.8
Wave 2 Not Area 7	30,551	196,089	1.98	1.93	0.05	0.03	0.07	2.6%	10.0	94.6
Wave 3	42,747	128,160	1.94	1.90	0.04	0.02	0.05	2.0%	5.0	94.7
Wave 4	39,283	104,687	1.86	1.85	0.01	0.00	0.03	0.7%	1.3	95.6
Wave 5	29,691	124,470	3.20	3.19	0.02	0.00	0.04	0.5%	2.1	101.3
Wave 6	27,864	174,491	1.88	1.86	0.02	0.00	0.03	0.9%	3.1	95.1
Wave 7	27,924	109,757	2.13	2.11	0.02	0.00	0.04	1.1%	2.7	97.1
Wave 8	17,638	114,563	0.64	0.62	0.01	0.00	0.02	1.7%	1.2	91.7
Wave 9	16,275	85,299	2.82	2.80	0.02	-0.01	0.04	0.5%	1.3	99.2
Average/Total	459,910	1,458,973	2.12	2.09	0.02	0.02	0.03	1.1%	32.9	96.8

Nexant

Headquarters

49 Stevenson Street, Suite 700

San Francisco CA 94105

Tel: (415) 369-1000

Fax: (415) 369-9700

www.nexant.com