

Neighbor Comparison Reports Produce Savings, but HOW?

Brian Arthur Smith and Lucy Morris, Pacific Gas and Electric Company

ABSTRACT

Neighbor comparison energy reports provide residential utility customers with mail-based feedback of how their energy use compares to that of similar households. Energy savings resulting from these “home energy reports” (HERs) comprise an ever-increasing portion of residential energy efficiency portfolios at utilities throughout the U.S. and abroad. Typically, HERs programs are run as experiments that employ randomized control trials which provide a robust basis for savings estimates. However, identifying the precise sources of energy savings resulting from HERs has proven to be challenging: when asked about their household purchases and behaviors, treatment and control respondents give similar responses. This paper reviews survey-based and more sophisticated lines of evidence from data collected from HER experiments run at Pacific Gas and Electric Company (PG&E) to ascertain the drivers of these energy savings. Specifically, the paper presents and discusses the results of home inventories and oral interviews (N=702) in treatment and control households, compares utility rebate redemptions for treatment and control households, and presents HER savings load shapes that reveal the times of day when savings occur. Taken together, these evidence streams point to a multitude of behavioral changes comprising the bulk of savings observed in households treated with HERs. To a lesser degree, some savings observed in treatment households are a result of reports driving customers to utility rebate programs and to make purchases of other energy efficient equipment. The implications of these findings are that the regulatory frameworks in place for determining cost effectiveness need to adapt to reflect this information.

Introduction

Home Energy Reports (HERs) has proven to be a successful energy efficiency (“EE”) program at Pacific Gas and Electric Company (PG&E) as it has elsewhere. PG&E’s HER program began its first major randomized control trial (“experiment”) in August, 2011 with the “Beta” wave that targeted households in the top quartile of energy use located in portions of the East Bay area of the San Francisco metropolitan area. The Beta wave represents the most successful HER experiment to date for PG&E because of its targeting of high-consumption households: because of their greater energy consumption, these households have greater capacity to use less. Out of the 60,000 households that received the initial mailing, the Beta wave had an average of 50,868 customers in treatment throughout 2013 (the loss of 15% of the households from the initial mailing is due to households moving). On average customers in the treatment group used 2.0% less electricity and 1.0% less natural gas in 2013 compared to customers in the control group (Nexant, 2014). In aggregate, customers in the Beta wave saved 10.6 GWh and 381,000 Therms in 2013. Currently PG&E has five HERs experiments ongoing with 1.2 million households in treatment and some 600,000 households serving as controls (see Table 1). PG&E’s HER program continues to develop in 2014 with the addition of email-based reports to a subset of treatment households, the launch of a study to measure the persistence of savings over time in the treatment group following the withdrawal of the usage feedback, and the continued

refinement of the report content itself so that it resonates to specific subsets of PG&E’s residential customer base.

Table 1. Recap of PG&E’s home energy reports experiments

| Experiment (Key Goal) | Households Beginning Treatment (Approx.) | Dual-fuel | Electric Only | Gas Only | Report Frequency (S=Standard, R=Reduced) | Energy Use Quartiles (Low to High) | Launch Date |
|----------------------------|--|-----------|---------------|----------|--|------------------------------------|-------------|
| Beta (High Savings) | 60,000 | Y | N | N | S | 4 | Aug-11 |
| Gamma (Evaluation Test) | 200,000 | Y | Y | Y | S, R | 1, 2, 3, 4 | Nov-11 |
| Wave One (Broad Rollout) | 400,000 | Y | N | N | S | 2, 3, 4 | Feb-12 |
| Wave Two (Broad Rollout) | 609,000 | Y | Y | Y | S | 2, 3, 4 | Feb-13 |
| Wave Three (Broad Rollout) | 225,000 | Y | Y | Y | S | 2, 3, 4 | Jul-13 |
| Wave Four (Broad Rollout) | 200,000 | Y | N | N | S | 2, 3, 4 | May-14 |

Source: PG&E (2014)

In spite of the success of the PG&E’s HER program, questions linger about the underlying drivers of the observed energy savings: regulators accustomed to traditional widget-based EE measures with known parameters (such as incremental measure costs and estimated useful life) tend to be wary of large “black box” savings claims resulting from HERs in spite of the rigors of randomized control trials that support the observed savings impacts. The reports themselves promote no-cost behavioral actions (such as turning off lights and adjusting thermostats) as well as the purchase and use of low-cost products not rebated by PG&E (such as power strips), higher-cost products formerly rebated by PG&E (such as televisions exceeding Energy Star specifications), and products currently in PG&E’s EE portfolio (including lower-cost efficient products such as CFLs and higher-cost products such as high-efficiency washers and refrigerators). A better understanding of the drivers of energy savings resulting from HERs will be of interest to EE program administrators, regulators, and social scientists alike. This paper reviews a few sources of evidence—most of it resulting from data collected from HER participants at PG&E—that point to behavioral change as the source for the majority of savings resulting from exposure to HERs.

Downstream Measures Contribute Little to Savings

In its evaluation of PG&E's HER program, Nexant (formerly Freeman, Sullivan and Company (FSC)) estimated savings attributable to PG&E's downstream programs to avoid double-counting (Nexant, 2014). The process was straightforward: using rebate records, total savings values were calculated for the treatment and control populations (beginning with the first month that reports were mailed) using the total kWh savings values (determined by multiplying the number of days since installation of the measures rebated) as determined by the date of purchase by the kWh savings per day (calculated from the first-year savings values as provided by the Database for Energy Efficient Resources, known as DEER). The kWh savings attributed to control customers (weighted so these groups were the same in size as the treatment groups) was subtracted from the treatment group's kWh savings to calculate the difference in total savings during the treatment period attributable to all downstream measures. After adding up each of these values by wave, the total difference in savings from the onset of the experiments (as early as August 2011 for one experimental wave) is 0.7 GWh—less than 0.8 per cent of the savings estimated for HER for 2013. The bottom line is that the savings from HERs attributable to an increased uptake of downstream measures by customers receiving the reports represents a small fraction of the savings observed. Even though households receiving the reports do have a slight tendency to redeem more rebates compared to control households, the low difference underscores that the majority of savings observed from the HER program are due to sources other than from the EE measures that PG&E sponsors (e.g., recycling of older refrigerators and the use of downstream-rebated products such as high-efficiency refrigerators, washers, hot water heaters, pool pumps, and attic insulation).

Home Inventories Tell Us (A Little) That Self-Report Does Not

In the first evaluation of PG&E's HER program (Freeman, Sullivan and Company (FSC), 2013), FSC¹ estimated savings attributable to PG&E's upstream programs. The key upstream measures of interest were compact fluorescent lamps (CFLs) (rebated through the Upstream Lighting Program (ULP)) and televisions exceeding Energy Star specifications (rebated through the Business and Consumer Electronics Program (BCE)).² The purpose of estimating the incidence of CFLs and highly efficient TVs in HER treatment and control households was to avoid double-counting of electric savings already reported through the ULP and BCE programs. Inventories were conducted in 702 HER treatment and control homes from the Beta, Gamma, and Wave One experiments early in 2013 that were comparable with respect to location, size, composition, and energy use.³ In addition to its primary goal of estimating the incidence of CFLs and high-efficiency TVs, a secondary goal of the home inventories was to determine whether respondents in the treatment group reported more energy-saving behaviors and purchases than respondents in the control group.

Although complicated and expensive, PG&E undertook the home inventories because a survey-based approach to identify differences in behaviors and purchases between treatment and control households using self-report methodologies has yielded inconsistent results in research

¹ Since acquired by Nexant, Inc.

² PG&E's television measures have since been discontinued.

³ See FSC's evaluation for details of the home inventory available at www.calmac.com, study ID PGE0329.01.

conducted by other utilities running similar experiments. This lack of consistent survey research findings in light of the similarity of the central “neighbor comparison” message of the mailers is consistent with the differing impacts of the experiments run by different utilities (Davis, 2011). Not only are there differences in the customer targeting criteria. Differences in report design, report content, frequency of report delivery, weather extremes, building stock characteristics, and customer perception of the utilities all appear to influence the extent to which HERs save energy. And even though evaluation practices on estimating total savings have become reasonably standardized (Todd, 2012), techniques for estimating attribution are less systematic in practice.

Specifically at PG&E, survey research conducted via telephone by PG&E’s customer insights organization of 2,500 adults residing in HER treatment and control households found no significant differences in self-reported energy-saving behaviors and purchases (see Figure 1).

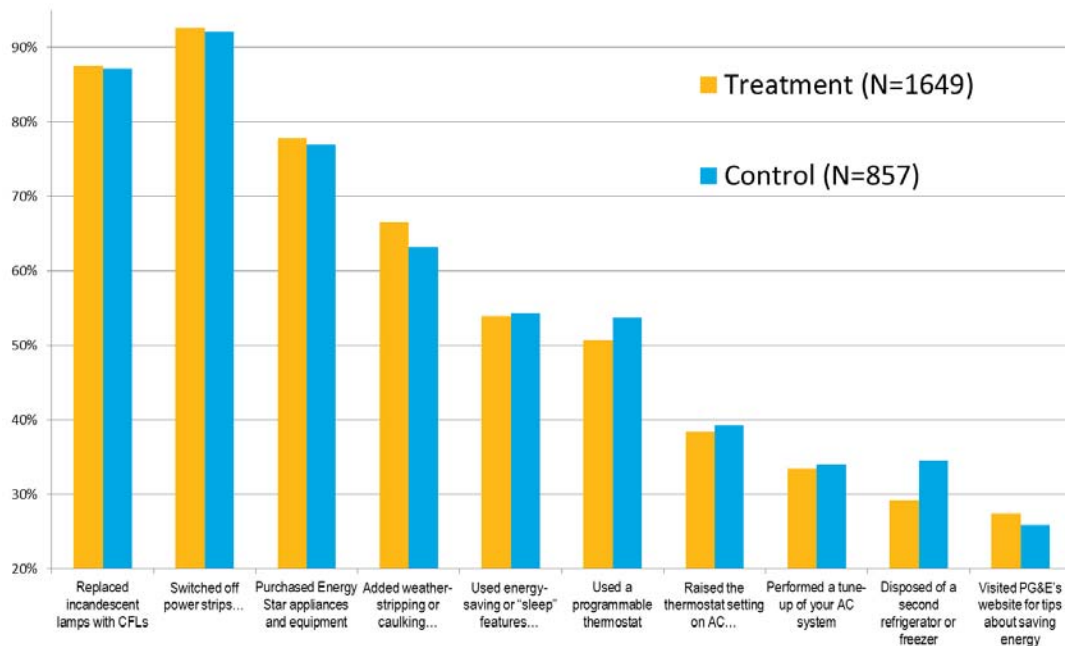


Figure 1. Self-reported actions taken in the past year as reported by adults surveyed by telephone living in homes receiving Home Energy Reports (treatment) or in control groups. *Source:* PG&E 2012.

Top-Line Finding: Increased Use of CFLs Drives Roughly One Quarter of HER Savings

The key finding of the home inventories was that treated households had, on average, one more CFL in use than control households (see Table 2). Even though this difference of roughly one CFL in service (actually the difference was 0.95 CFL as shown in the table) is within the 95% confidence interval, this point estimate is the best estimate we have. We interpret this “extra CFL” observed in treatment households as accounting for approximately 24% (21.7 GWh) of the total electric savings (89.2 GWh) estimated for 2013.

Table 2. Weighted Home Inventory CFL Counts

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

Source: FSC (2013)

Then there is the related question of attribution: what portion of those CFL savings have been claimed by PG&E’s ULP program now that the number of “excess CFLs” in service in treatment households was estimated? As documented in FSC’s evaluation, approximately three-quarters of CFLs sold were rebated in the 2006-08 program cycle, and approximately one-half of those CFLs were attributable to the ULP. To account for these, an estimated one-third of the “excess CFLs” were assumed to be attributable to the ULP and a downward adjustment of 21.7 GWh was made to the HER savings claim.

As far as TVs is concerned, the other major upstream measure, respondents in control group households were more likely to report having purchased a television in the past year. No difference was found between the treatment and control groups in the presence of high-efficiency TVs, however. Consequently no adjustment was made to the HER savings claim for TVs.

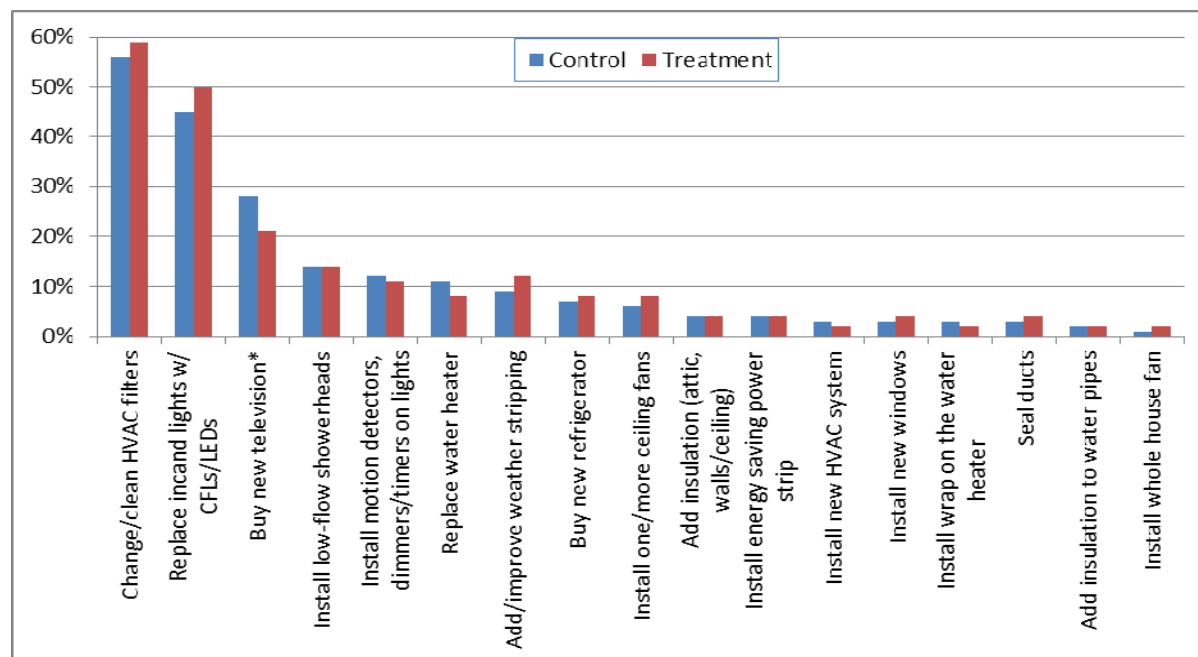


Figure 2. Self-reported purchases and actions taken in the past year as reported by adults surveyed face-to-face in homes receiving Home Energy Reports (treatment) or in control groups. Source: FSC 2013.

Aside from counting CFLs and TVs, the home inventory research involved administering extensive question batteries to ascertain whether differences in thermostat settings, lighting usage, purchase/installation of energy-saving appliances, and in the operation of appliances could be measured between treatment and control households. No statistically significant differences were found in any of these batteries.

In the final analysis, aside from the finding that treatment households had an additional CFL in service (a borderline result with zero hovering at the border of the confidence interval, see Table 2), only two differences were found between respondents in treatment and control households participating in the home inventories:

- Respondents in control households were more likely to have reported buying a television more recently than respondents in treatment households (28% vs. 21%, $p = .04$), and
- Respondents in treatment households were more likely to have rated “reducing energy use in your home” as “very important” or “somewhat important” (71% vs. 62%, $p = .02$).

Taken as a whole, the phone survey and home inventory research conducted at PG&E leads us to conclude:

- About one-quarter of the savings observed for HERs in 2013 is attributable to the increased uptake of CFLs in the treatment groups. About one-third of the savings from CFLs was claimed from PG&E’s ULP program and was deducted from the HER reported savings.
- Self-report is a challenging methodology to identify changes to household behavior and of household purchases of energy efficient products for many reasons. The number of possible behaviors and products is sufficiently large and diverse to make the approach of using checklists burdensome for respondents. Individual respondents may not be reliable reporters for other household members—or even for themselves in the behaviors or purchases took place in the past and/or were relatively low involvement. In-person interviews may be more accurate, but prove to be even more expensive.

Differences in Savings Rates between Treatment Households with Different Demographic Characteristics

Since our inspection of rebate records, our direct questioning of customers in treatment and control conditions, and our in-home visits all have failed to pinpoint any specific major savings drivers resulting from exposure to HERs, we turned to a closer examination of the characteristics of the treatment population that we hypothesized might drive their ability and motivation to invest in the purchase and installation of energy-efficient products. Our reasoning went as follows: if the purchase and installation of energy-efficient products drives the savings observed in HERs treatment households, then we should observe greater savings in households with greater motivation and ability to acquire these types of goods—even if these purchase differences weren’t apparent in rebate redemptions or in home inventories. To conduct these analyses, we turned to a third party that supplies PG&E with estimates of household income and other statistics.

Savings Differences between Households Likely to be Eligible to Qualify for Low Income Utility Rates

We hypothesized that home owners might evidence greater motivation to purchase and install energy-efficient products than renters, but were unable to test this theory. Because PG&E’s HER program relies on identifying a sizeable number of residences with similar characteristics, the majority of HER households live in single-family homes. Given the large sample necessary to measure differences between treatment and control households—even comparisons between 10,000 households with a lax 80% level of probability yields a confidence interval of plus or minus 0.5% difference—we discovered that we had an insufficient number of renters in our sample to create a meaningful analysis between homeowners and renters. Moreover because PG&E must rely on third-party sources to provide estimates of customer attributes such as owner/renter status, the reliability of the data is unknown. Consequently we turned to an indicator computed from multiple variables that is used to identify households that are likely to qualify for PG&E’s low-income residential rate (“CARE”). The CARE Eligibility Likelihood variable is created by a combination of attributes including: paying utility bills in-person; proportion of households within a Census bloc with incomes under 200% of federal poverty guidelines; estimated household annual income below \$50K, and number of utility late payment notices generated.

When we examined the uptake of downstream energy efficiency rebates by CARE eligibility decile, we see that the greater the likelihood that a customer is eligible for the CARE rate, the lower the likelihood that a customer has received an EE rebate (see Table 3). This finding suggests that our hypothesis advanced earlier in this paper, that lower-income households are less likely to invest in energy-efficient products, may be correct.

Table 3. Proportion of PG&E customers receiving downstream rebates by CARE eligibility decile

| CARE ELIGIBILITY LIKELIHOOD DECILE | | No Rebates (2011-2013) | Received Downstream Rebate(s) |
|------------------------------------|----|------------------------|-------------------------------|
| ↑ More likely | 1 | 97% | 3% |
| | 2 | 95% | 5% |
| | 3 | 94% | 6% |
| | 4 | 93% | 7% |
| | 5 | 92% | 8% |
| | 6 | 92% | 8% |
| Less likely ↓ | 7 | 90% | 10% |
| | 8 | 90% | 10% |
| | 9 | 88% | 12% |
| | 10 | 87% | 13% |

Source: PG&E (2014)

We hypothesized that, if the primary driver of savings resulting from household exposure to HERs is changes in behavior rather than in purchase and use of energy-efficient products, we would see no difference in the impact of HERs on the rate of reduction of electricity or natural gas usage between households most likely to be eligible for CARE (“CARE” likely, deciles 1-3) and all other treatment households within each HER experiment (deciles 4-10). As can be seen in Figures 3 and 4, there is no pattern in terms of either electric or gas savings between CARE-likely households and all other households receiving HERs, and none of the differences are statistically significant.

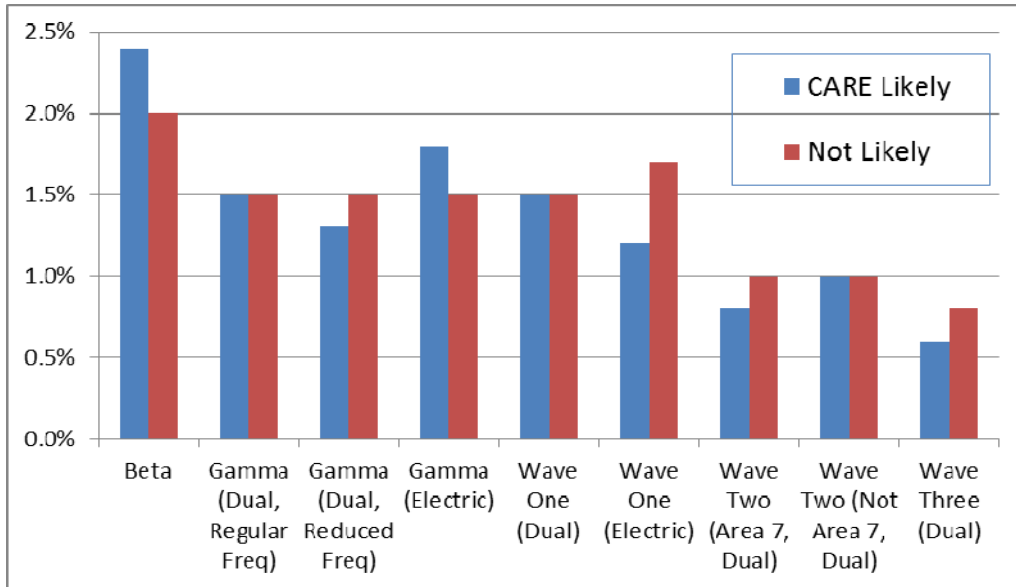


Figure 3. Electric savings for 2013 by experiment split by CARE eligibility variable. *Source:* Nexant.

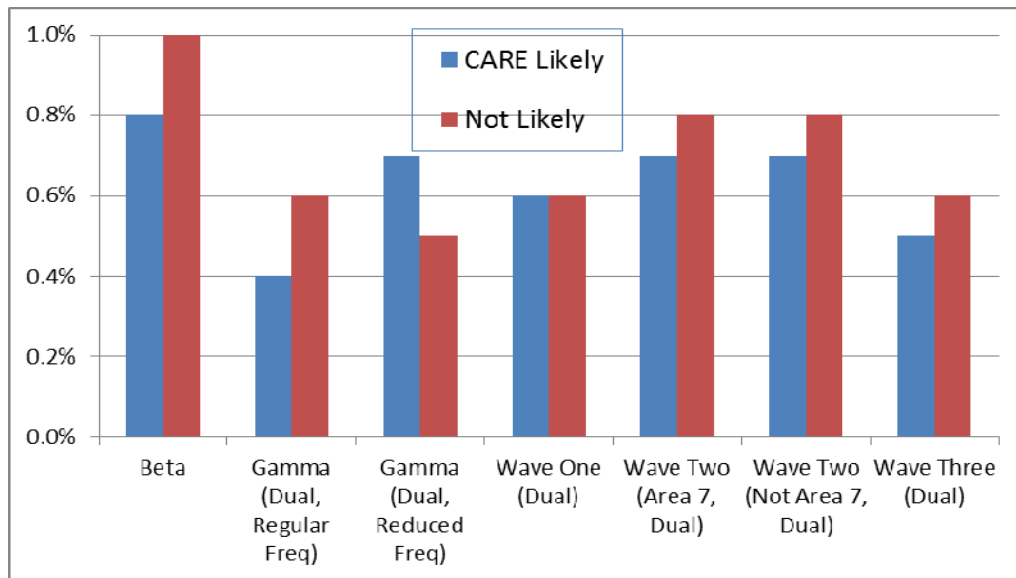


Figure 4. Natural gas savings for 2013 by experiment split by CARE eligibility variable. *Source:* Nexant.

We interpret the lack of differences in HER savings rates between households with a lower and higher propensity to be eligible for PG&E's low-income residential rates to be suggestive that the primary drivers for the observed savings are behavioral in nature.

Insights from When Savings Occur: Interval Data Analysis

The availability of electric usage data at 15-minute intervals from PG&E's "smart meters" is another source of data that we examined to identify evidence of savings drivers for the HERs program. PG&E has completed installation of smart meters to virtually all customers throughout its service territory, and all customers in HER experiments have smart meters. Lawrence Berkeley Laboratories, in collaboration with Nexant, examined the interval data from PG&E's HER experiments under a grant from the U.S. Department of Energy (Todd et al., forthcoming).

Two analyses from this research, essentially calculated by subtracting total electricity used by the treatment group from total electricity used by the control group of the same size, offer insight into the drivers of HER savings. Both of these analyses were conducted on data from PG&E's Wave One, following the mailing of the first report to treatment households in August 2012. It should be noted that this period was very hot in the PG&E service territory generally, and included 6 of the 10 highest demand hours of 2012. These key analyses of interval data reveal the following insights:

- The impacts of the reports are evident within days of households having received the first reports. As shown in Figures 5 and 6, savings from the reports are evident within days of the first reports being mailed to the treatment households and, after an initial ramp-up period, continue at a steady state through the successive month.⁴ This rapid appearance of treatment effects, and their continuation throughout the second month, is suggestive that a significant portion of the initial savings observed from HER is attributable to a change in household habits and/or one-time actions such as the changing of heating and air conditioning thermostat settings.
- Savings from the reports occur at all hours. As shown in Figure 6, savings from the reports are evident at all times of the night and day. Even though statistically significant electricity savings are observed for every hour of the day, higher kWh savings are seen during peak hours, relative to the energy usage during those hours. The fact that savings occurs at all hours is evidence that savings occurs due to changes in settings on equipment including heating, air conditioning, water heating, lighting timers, and other equipment operating throughout nighttime and daytime hours.

⁴ Note that, for the first three months, all PG&E HER participants in Wave One received reports on a monthly basis.

Even though a great deal more work can be done with the analysis of interval data, we interpret the top-line findings to corroborate our evidence presented elsewhere in this paper: that the majority of savings observed in PG&E's HER experiments are attributable to changes in behavior in households exposed to the reports. The behavioral changes are varied, and are often sufficiently subtle so as not to be measurable through self-report with any degree of confidence.

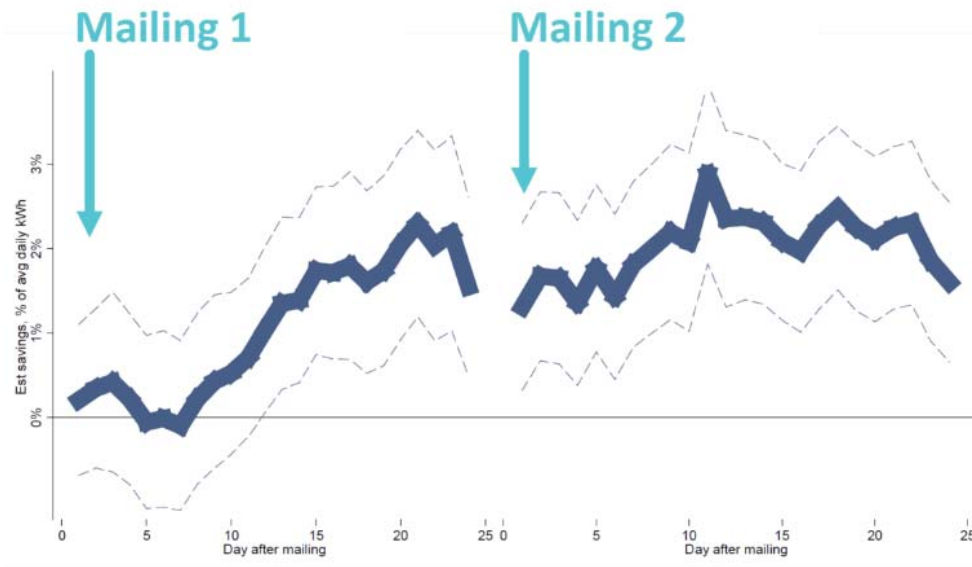


Figure 5. Electric savings for the first two months of Wave one occurring in August and September of 2012. The blue line indicates estimated % savings; dotted lines indicate 95% confidence interval. *Source:* Lawrence Berkeley National Laboratory.

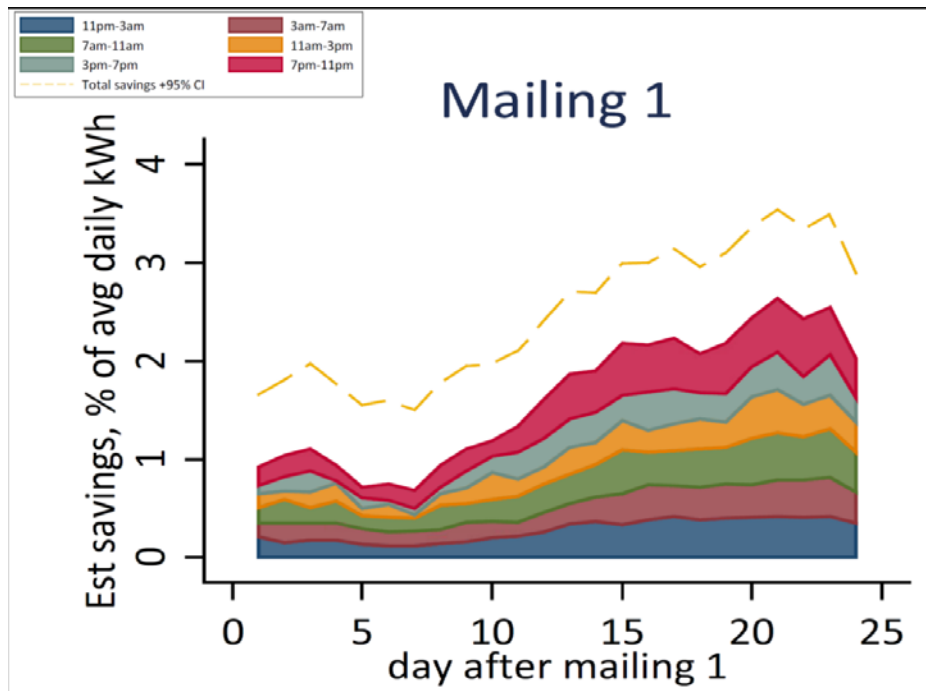


Figure 6. Statistically-significant savings are observable within a few days of the mailing of the first report, and for all 24 hours within each day. Source: Lawrence Berkeley National Laboratory.

References

- Davis, M. 2011. Behavior and Energy Savings: Evidence from a Series of Experimental Interventions. Environmental Defense Fund.
- Freeman, Sullivan and Company. Evaluation of Pacific Gas and Electric Company's Home Energy Report Initiative for the 2010–2012. 2013.
- Nexant, Inc. 2013. Energy Efficiency Savings Estimates for Pacific Gas and Electric Company's Home Energy Reports Program.
- Provencher, Bill. 2010. "Evaluation Report: OPOWER Pilot." Commonwealth Edison. Navigant Consulting, Chicago, IL.
- Todd, A. et al. 2012. Evaluation, Measurement and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations. State and Local Energy Efficiency Action Network.
- Todd, A., M. Perry, B. Smith, M. Sullivan, P. Cappers, and C. Goldman. 2014. Insights from Smart Meters: Ramp-up, Reliability, and Short-term Persistence of Savings from Home Energy Reports. Lawrence Berkeley National Laboratory. LBNL, forthcoming.