Home Energy Reports and Program Rebates: A Quantitative Assessment of Customer Engagement

Mersiha McClaren, Research Into Action
Benjamin Messer, Research Into Action
Jesse Smith, Demand Side Analytics
Paul Schwarz, Research Into Action

ABSTRACT

Energy efficiency programs operate in a continually evolving environment in which changing baselines and market adoption of new technologies (e.g., LEDs) limit the savings potential for traditional rebate programs. In this environment, program administrators must seek innovative approaches to either capture new or amplify existing savings. Relatively little research exists on how program interventions, when combined, could be used to quantify customer engagement. We present an example whereby consumer participation in one or more utility rebate programs plus a behavioral program, receiving Home Energy Reports (HERs), results in above average savings, which is a proxy for customer engagement.

Using a quasi-experimental design, we analyzed differences in electricity consumption among four groups: households that did not receive a utility program intervention (baseline), households that received HERs, households that received a utility rebate(s), and households that received HERs plus utility rebate(s). Households receiving HERs were randomly selected (but could opt out), whereas participation in a rebate program was voluntary (opt in). We analyzed average daily household electricity usage for 80,000+ households in the Pacific Northwest over a 46 month period (30 month treatment period and a 16 month pre-treatment period). We found that the combination of rebates and HERs (households that received a rebate plus HERs) compared to the baseline group, resulted in average estimated electricity savings of 5.7%. These savings were significantly higher than the sum of the average savings attributed to the rebate programs alone (1.7%; rebate group versus baseline) and the behavioral program alone (1.7%; HERs group versus baseline).

Introduction

Utility-run energy efficiency programs operate in a dynamic environment. Government-mandated incremental improvements to standard equipment efficiencies are affecting the baselines of several energy-efficient technologies.[1] The manufacturers also have introduced efficient technologies that are quickly penetrating the market. For example, 1 of 20 A-line bulbs sold nationally was an LED in third quarter of 2014, whereas in the quarter prior to that, it was 1 in 30 (Bonneville Power Administration, 2015). These changes in the market will likely lead to a

[1] The lighting standard, established by the Energy Independence and Security Act of 2007, requires that light bulbs use about 25% less energy by 2014. New efficiency heating and cooling standards from the U.S. Department of Energy (DOE), which went into effect Jan. 1, 2015, will increase the efficiency of heating, ventilation, and air-conditioning (HVAC) equipment in certain regions. Homeowners in the Northern U.S., for example, will be able to buy equipment that adheres to the old minimum efficiency standard (of 13 SEER[1]) – while homeowners in the South and the Southwest will have to buy equipment that is at least 14 SEER.

decline over time in energy savings from energy efficiency programs administered by utilities and others. In such an evolving environment, these program administrators should regularly review and optimize their portfolios of measures or technologies by seeking innovative approaches to either capture new savings or find ways to better engage customers to save energy with existing program offerings.

Behavior change programs are a promising avenue for either capturing new savings or finding ways to optimize savings from existing programs. Utility-funded behavior change programs typically promote changes in customer energy usage via home energy usage reports (HERs), building operator training, information feedback on energy usage, or other strategies that do not rely on financial incentives. Research indicates that these types of strategies can result in meaningful energy savings (Abrahamse et al. 2005, Allcott & Rogers 2012, Delmas et.al. 2013, and Research Into Action 2015), which explains why many program administrators have incorporated behavior programs or strategies into their portfolios. We know from prior but limited research that certain combinations of strategies could lead to more energy savings (that is, higher customer engagement toward saving energy) than a single strategy could on its own. Abrahamse et.al. (2005), for example, reviewed 38 peer-reviewed experimental studies and found that a strategy whereby households that received a combination of information, feedback, and rewards saved more energy than a strategy in which households received only information or feedback or rewards.

This study investigates effectiveness of one particular combination of program strategies: HERs plus rebates for energy efficient product purchases. HER, which is a typically "feedback+norms"[2] strategy, compares a customer's monthly electricity usage to the average usage of similar homes and/or the average usage of a group (e.g., neighbors) to engage customers in electricity saving behavior. Rebates, which are a financial incentive strategy, encourage customers to install high efficiency equipment, which is generally more expensive than standard or less efficient equipment.

Please note this paper is not reporting on the standard impact analyses that were conducted for the HER program in the program administrator's territory. The standard impact analyses that were conducted used the best practices[3] of estimating impacts from behavior programs such as taking into the account double counting of savings from the utility rebate programs. The standard impact methods of behavior programs resulted in savings estimates of behavior programs minus the savings from rebate program participation. For example, across the entire treatment period of the HERs randomized controlled trial (RCT), those who received the HER saved 1.92% or 0.901 kWh/day, after subtracting out savings from utility rebate participation, compared to the control group that did not receive the HER. The standard analyses of the HERs RCT also found that those receiving HERs, compared to those who did not receive HERs, had done more rebate projects as well as received larger rebates. What that analysis did not answer was the effect of the interaction between the HERs and rebates – that is, whether the rebate participants show above average HERs savings. Analyses in this paper explore this question.

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[2] Feedback interventions include strategies where energy use information or relevant information is given to the customer frequently. Norm-relates interventions includes strategies that activate some type of norm (e.g., social norms) with respect to energy efficiency and/or energy curtailment behavior. Norms are commonly accepted ways of behaving in a group or some type of standard that is typically expected of a group.

[3] . The State and Local Energy Efficiency Action Network (2012) and Uniform Methods Project (2015) outline best practices of estimating impacts from behavior programs.

Data and Methodology

Data

We used randomized-control trial HERs participation data combined with utility energy efficiency rebate participation data to analyze differences in electricity savings across four groups of customers in the Pacific Northwest in a quasi-experimental study.[4] The four customer groups we analyzed were:

- *HERs+Rebate participants* (participated in the HERs program and a rebate program)
- *HERs-only participants* (participated in the HERs program but not in a rebate program)
- *Rebate-only participants* (participated in a rebate program but not in the HERs program)
- *Nonparticipants* (did not participate in either the HERs program or in one of the rebate programs)

We obtained electricity usage data (kWh) for a sample of 80,701 residential utility customers who were selected and randomly assigned to two experimental groups in June 2013: a treatment group that received HERS (HERs participants) and a control group that did not receive HERs (HERs nonparticipants). The majority of customers were assigned to the treatment group.

Table 1: Number of HERs Participants and Nonparticipants

Group	Number of Customers	Percent
HERs participants	63,502	78.7%
HERs nonparticipants	17,199	21.3%
TOTAL	80,701	100%

Data for selected customers were available during the 16 months prior to the start of the HERs experiment (March 2012 to June 2013, the pre-treatment period; Table 2) and, as part of the experimental design, selected customers had similar pre-treatment electricity usage. HERs participants began receiving the reports in June and July of 2013, and continued receiving reports through December 2015 (treatment period; Table 2).[5] However, due to a change to the utility's customer billing system in the first half of 2015, none of the HERs participants received reports between February and July of 2015 (pause period; Table 2). HERs participants began receiving reports again from August 2015 through December 2015, the end of the treatment period.

Table 2: HERs Experimental Periods and Dates

Period	Beginning Date	Ending Date
Pre-Treatment Period	March 2012	June 2013
Treatment Period	July 2013	December 2015
Pause Period	February 2015	July 2015

[4] Our study is limited to analyzing electricity savings because the HERs program focused on electricity usage (kWh) or electric savings tips only.
[5] HERs participants received eight home energy reports in a year, or two per quarter of a year.

During the treatment period between July 2013 and December 2015, about four percent of the HERs participants and nonparticipants participated in one or more of the utility's energy efficiency rebate programs (Table 3**Error! Reference source not found.**).[6] The rebate participation rates between HER participants and nonparticipants are very similar and the difference (0.2%) is not statistically significant.

Table 3: Number of HERS and Rebate Participants and Nonparticipants

	HERs Participant		**HERs Nonparticipant**		**Total**	
	N	%	N	%	N	%
Rebate Participant	2,531	4.0%	656	3.8%	3,187	3.9%
Rebate Nonparticipant	60,971	96.0%	16,543	96.2%	77,514	96.1%
TOTAL	63,502	100%	17,199	100%	80,701	100%

We merged the rebate program participation data with the HERS program participation data, and made the following changes to prepare the data for analysis:

- Billing calendarization by pro-rating customer monthly billing data that begins/ends after the first of each month (e.g., June 15 to July 15) into actual calendar months;
- Removing customers with duplicate billing data, customers with no billing data after the month when the HERs began, and customers with no billing data for at least 12 months before the HERs began; and,
- Excluding outliers from the data, which includes customers with average electricity usage greater than 500kWh per day (n=48).

The calendarized monthly electricity usage data from billing records, including total monthly kWhs and average daily kWhs, were available for all customers in the dataset for the 16-month pre-treatment period (March 2012 to June 2013). These data were also available for up to 30 months during the treatment period (July 2013 to December 2015). The data were structured such that each row represented a calendar month of customer billing data, in which each unique customer could have up to 46 rows, or months, of billing data.

About 2% of customers opted-out of the HERs program and 19% moved residences at some point during the treatment period such that 63,283 customers remained in the dataset through the entire treatment period. We included the customers that opted out or moved residences in the analyses to not bias the results.[7]

For the analysis, we used the following variables:

- Customer_ID: unique identifier for each customer.
- Daily_Average_kWh: average daily kWh usage for each customer and month.
- Daily_Average_kWh_Logged: logarithmic measure of Daily_Average_kWh.

[6] Residential "rebate" programs include rebates for high efficiency heating, ventilation, and air conditioning equipment upgrades, high efficiency water heating equipment upgrades, conversions from electric to natural gas space and water heating equipment, insulation and windows, and high efficiency equipment for ENERGY STAR® homes; we also included direct install duct sealing upgrades and incentives for appliance recycling.

[7] Nonparticipants could not "opt out" since they were not receiving HERs, and we had no way to identify which Nonparticipants would have opted out if they had been receiving the HERs.

- Daily_Average_kWh_Preusage: average daily kWh usage for each customer and month in the pre-treatment period, coded to respective months in the treatment period.
- Year_Month: measure of time specifying the year and month of each electric bill.
- Pre_Post: indicator of the pre-treatment period (coded ‘0’ for each pre-treatment period month) and treatment period (coded ‘1’ for each treatment period month).
- HERs_Participant: indicator of whether the customer is an HERs participant (coded ‘1’ for all months) or HERs nonparticipant (coded ‘0’ for all months).
- Rebate_Participant: indicator of whether the customer is a rebate participant (coded ‘1’ for the month in which they participated and all subsequent months and coded ‘0’ for all months prior to participation) or nonparticipant (coded ‘0’ for all months).

Analysis

We analyzed the data to determine whether there was a “multiplier effect” associated with customer participation in both the HERs program and the rebate programs. To do this, we constructed cumulative and monthly lagged dependent variable (LDV) regression models that estimate electricity savings (β) of HERs-only, Rebate-only, and HERs+Rebate program participation, compared to Nonparticipants, using daily average kWh usage as the dependent variable and controlling for electricity usage during the pre-treatment period.

We used two different statistical regression methods to estimate the differences in electricity savings among the different customer groups. With the first method, we included binary (yes/no) indicator variables to denote participation in the HERs and rebate programs along with another indicator variable (an interaction term) that indicated whether the customer was a participant in both programs.[8] In the second method, we conducted separate regression models for each of the following six group comparisons.[9] The group comparison models do not control for the excluded groups like the interaction models do but we performed these group comparison models as verification that results from the interaction models are robust.[10]

Electricity savings (β) were measured in these models by comparing the actual daily average kWh usage (from monthly billing data) in the treatment period across the four groups, controlling for average daily kWh usage during the months in the pre-treatment period. The percent electricity savings were measured by replacing actual daily average kWh usage with the logarithmic measure of daily average kWh usage. In addition, due to the quasi-experimental design of the study, in which customers participated in rebate programs in different months of the treatment period, there were too few Rebate-only participants in the first three months of the treatment period (n < 45) to have the statistical power needed to include these data in the analyses.

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8 <u>LDV Cumulative interaction model:</u> Daily_average_kWh_usage = HERs_participant(β) + Rebate_participant (β) + HERs_participant (β)*Rebate_participant (β) + year_month+ daily_average_kWh_preusage + ε (error term)
<u>LDV Monthly interaction model:</u> Daily_average_kWh_usage = ([HERs_participant_group(β) + Rebate_participant_group(β) + HERs_participant_group(β)*Rebate_participant_group(β)] by year_month) + year_month + daily_average_kWh_preusage + ε (error term)

9 <u>LDV Cumulative comparison models:</u> Daily_average_kWh_usage = group1vsgroup2(β) + year_month + daily_average_kWh_preusage + ε (error term)
<u>LDV Cumulative comparison models:</u> Daily_average_kWh_usage = group1vsgroup2(β) by year_month + year_month + daily_average_kWh_preusage + ε (error term)

10 Group models were: Nonparticipants (0) vs. HERs-only participants (1); Nonparticipants (0) vs. Rebate-only participants (1); Nonparticipants (0) vs. HERs+Rebate participants (1); HERs-only (0) vs. Rebate-only participants (1); and Rebate-only (0) vs. HERs+Rebate participants (1)

Note that because HERs promote rebate programs, rebate activity may not be independent of the effects of the HERs, and thus, this possible endogeneity[11] issue could be introducing bias and influencing the results of the regression models. To explore this possibility, we examined the model residuals for evidence of bias, and we concluded that any bias due to endogeneity is likely very small (see Appendix, Figure 1 and Table 2).

Findings

We estimated the average daily electricity usage differences and percent electricity savings across the four customer groups: Nonparticipants, HERs-only participants, Rebate-only participants, and HERs+Rebate participants. This section first describes differences between these groups and then answers the question about whether the combined HERs+Rebate results in more electricity savings than the sum of the savings attributed to each program separately.

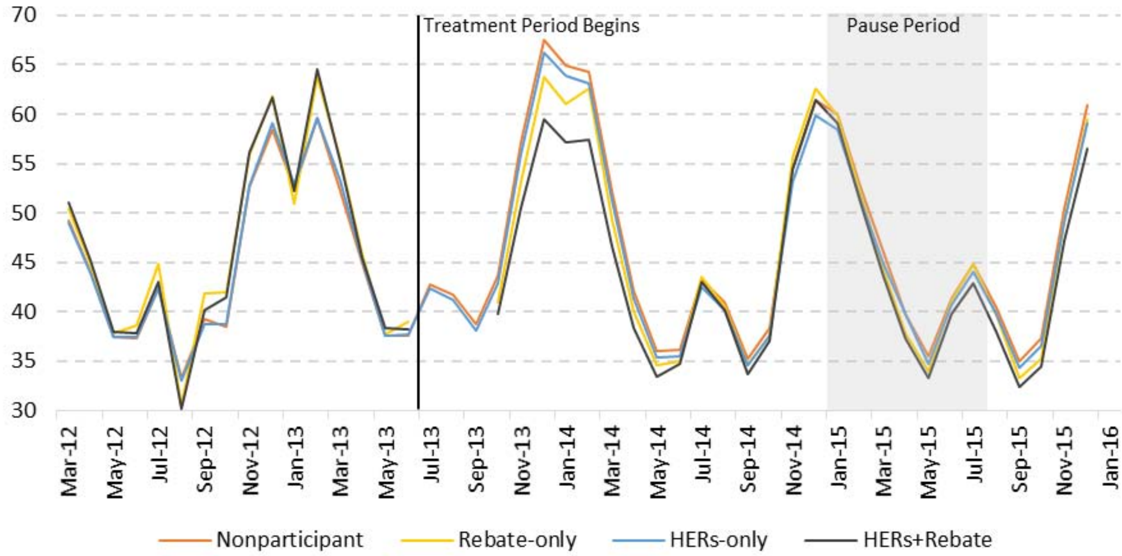
During the pre-treatment period, Nonparticipants and HERs-only participants had the lowest average daily kWh usage, followed by the HERs+Rebate participants and Rebate-only participants. However, during the treatment period, these trends changed such that HERs+Rebate participants had the lowest average daily kWh usage, followed by Rebate-only participants, HERs-only participants, and, lastly, Nonparticipants (Table 4). These trends are illustrated across each month of the pre-treatment and treatment periods in Figure 1, and it is important to note that differences are greater in winter and smaller in summer due to the colder winter and milder summer climate of the Pacific Northwest.

Table 4: Average Daily kWh Usage Before and During the Treatment Period by Group

	Nonparticipant	HERs-only	Rebate-only	HERs+Rebate
Pre-treatment period	44.8	44.9	46.4	46.2
Treatment period	46.9	46.0	44.9	43.6

Figure 1: Monthly Average Daily Electricity Usage by Group

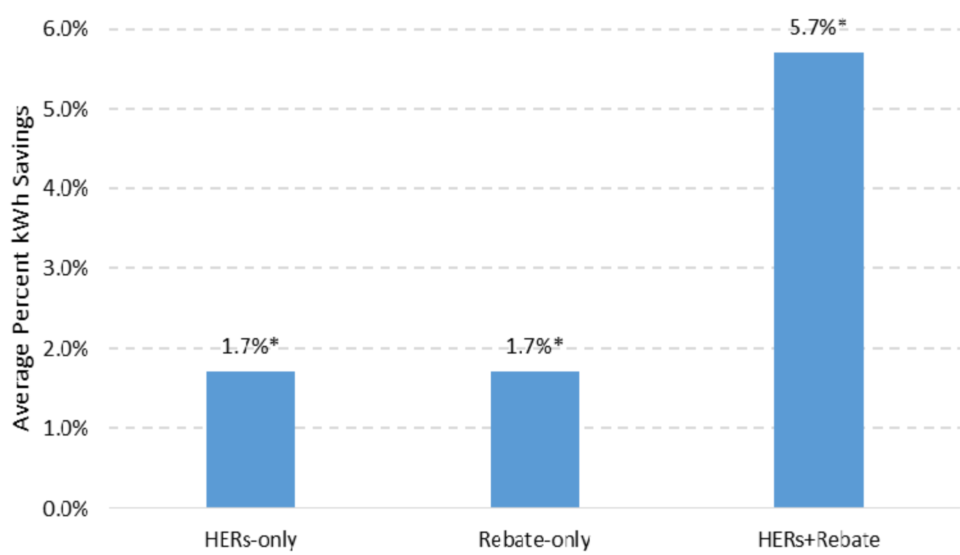
[11] Endogeneity concern occurs when an independent or explanatory variable is correlated with the model's error term.



Cumulative LDV Model Results

The combination of the home energy reports and rebates appears to amplify electricity savings. HERs+Rebate participants saved significantly more electricity during the entire treatment period, on average, than the other groups (Figure 2; Table 1 in Appendix A). HERs+Rebate participants, compared with Nonparticipants (or the baseline), resulted in average estimated electricity savings of 5.7%, or 2.82 kWh/day. These savings were significantly greater than the sum of the average savings attributed to the rebate programs alone (1.7%, or 1.35 kWh/day; Rebate-only group versus baseline) plus the HERs program alone (1.7%, or 0.90 kWh/day; HERs-only group versus baseline). The sum of the savings from the two groups of customers individually resulted in 3.4% savings, or 2.25 kWh/day.

Figure 2: Average Cumulative Percent Savings Compared to Nonparticipants



* statistically significant at $p \leq .05$

These results were determined using the LDV cumulative regression model with the interaction term (see equation in footnote 3 and full results in Table 1 in Appendix A). The model results are similar to but more conservative than the results from using the group comparison LDV cumulative regression models; these more conservative results were expected since the group comparison models do not include all customer groups in the same model (the group comparison models are available upon request).

Also note the HERs program primarily targeted electricity usage and our findings only take into account electric (kWh) savings. About 14% of rebate participants in both the HERs treatment and control groups participated in a fuel switching rebate program, which means they converted from electric to natural gas space and/or water heating. These customers thus had an increase in natural gas consumption (therms) that is not accounted for in this and subsequent analyses. We did conduct the cumulative regression analyses excluding the fuel switching rebate participants and the results were similar to those reported here: HERs+Rebate participants saved significantly more electricity than the combination of HERs-only participants and Rebate-only participants. Note that excluding the fuel switching rebate participants did not result in a significant difference in electricity usage between Rebate-only participants and Nonparticipants and also resulted in a smaller number of Rebate-only participants (from n=656 to n=579) in the analysis.

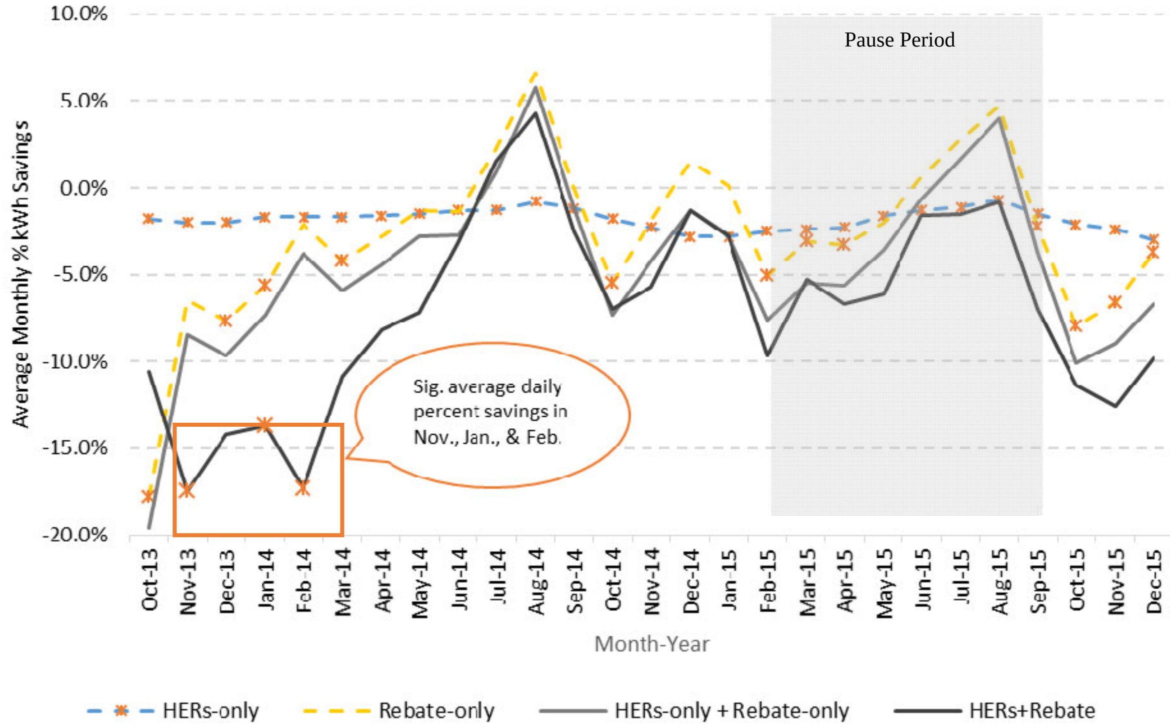
Monthly LDV Model Results

Although the electricity usage difference between the HERs+Rebate group and the other customer groups is significant, further analyses revealed that HERs+Rebate participation significantly affected savings only during the early months of the treatment period. Figure 3 shows the average daily percent electricity savings for each group compared with Nonparticipants and for each month in the treatment period from October 2013 to December 2015.[12] The HERs+Rebate participants, compared with Nonparticipants, saved significantly more electricity per day, on average, during three months of the heating season early in the treatment period of the HERs program: November 2013, January 2014, and February 2014.

As shown in Figure 3, although the average daily savings were not significantly different during the following 2014-2015 heating season, these months coincide with the pause period for distributing the home energy reports to participating customers. We lacked the data to extend its analysis through the 2015-2016 heating season; Figure 3 however, does show some evidence that HERs+Rebate participants may have been saving more electricity during these months.

Figure 3: Average Daily Percent Savings for Each Month Compared to Nonparticipants*

[12] We excluded the months of July 2013 to September 2013 due to the small number of rebate participants in the dataset for these months; the number of rebate participants is too small (n<45) to have the statistical power to perform the analysis.



* Orange asterisks (✶) indicate statistically significant average daily percent savings at p≤.10

The results from the LDV monthly regression model with the interaction term are similar to but more conservative than the results from the group comparison LDV monthly regression models (see equation in footnote 3 and full results in Table 2 in Appendix A). The more conservative results were expected since the group comparison models do not include all groups in the same model (The group comparison models are available upon request). In addition, results from monthly regression models excluding the fuel switching rebate participants were very similar to those reported here: HERs+Rebate participants saved significantly more electricity in November 2013, and January and February 2014, than the combination of HERs-only and Rebate-only participants.

Discussion

It appears that there is a multiplier effect when rebate participants receive home energy reports. The amplified HERs+Rebate savings could be the result of additional electricity saving actions these customers undertook in their homes. Furthermore, the home energy reports could be influencing the type and number of rebate programs in which these customers are participating. For example, a significantly higher percentage of HERs+Rebate participants participated in the fuel switching rebate program to convert from electric to natural gas space and/or water heating compared with Rebate-only participants (14.1% vs. 11.7%, respectively; p≤.10). In addition, HERs+Rebate participants participated in significantly more rebate programs, on average, compared with Rebate-only participants (1.55 vs. 1.46 rebate programs, respectively; p≤.05). However, HERs+Rebate participants did not participate in rebate programs at a higher rate compared with Rebate-only participants (4% vs. 3.8%, respectively; not significantly different).

Collectively, these findings suggest the home energy reports can be effective at engaging customers and motivating them to take actions such as participating in rebate programs. These findings validate strategy to promote the rebate programs via the home energy reports.

These findings also suggest that customers who receive both home energy reports and rebates are saving even more electricity than would be expected based on the average per-customer savings associated with each program. Furthermore, our results suggest that HER treatment group homes that participate in rebate programs are different than HER treatment group homes who do not participate in rebate programs. This is not surprising: people that participate in rebate programs are likely more engaged with the utility and with conservation in general than people who do not participate, and thus, are more likely to read and take actions based on HERs. However, based on the current analysis, it is unclear whether the additional savings are only seasonal, or if the additional savings are a temporary phenomenon and lack persistence. Nevertheless, the possibility of a multiplier effect could have important implications for future program planning.

Please note that the findings in this paper are not saying that there is a huge uplift in energy efficiency participation in the HER treatment group. The findings indicate that the HER effect is stronger in the type of homes that participate in energy efficiency rebate programs.

Future research should continue exploring the question of whether a combination of the home energy reports and rebate program participation results in saving more energy compared with participating in each program alone. For example, it is important to try to replicate these findings to ensure they are not an isolated outcome. It is also important to analyze the savings to determine whether the savings are persistent and/or whether they are only realized during certain portions of the year (e.g., the heating season). Future research also should examine the heterogeneity in the response to HERs. Many homes in our 80,000+ household dataset saved nothing and some saved much more than 2%. What this paper does is identify an observable characteristic (rebate program participation) that is positively correlated with HER impacts. A logical next step is to look at the characteristics of these homes or which demographic or socioeconomic characteristics that are prevalent in these homes that make them good targets for utility energy efficiency programs.

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Appendix:

Table 1 displays the results from the cumulative and monthly regression models.

Table 1: Average Daily kWh Savings (β) Compared to Nonparticipants from Cumulative and Monthly Lagged Dependent Variable Interaction Models

	HERs Group[1]		**Rebate Group[1]**		**HERs Group X Rebate Group[1]**	
	β	%	**β**	%	**β**	%
Cumulative Model[2]:	**-0.90**	-1.7%	**-1.35**	-1.7%	**-0.56**	-2.3%
Monthly Model[3]:						
October 2013	**-0.85**	**-1.8%**	**-6.94**	**-17.8%**	2.89	9.0%
November 2013	**-1.16**	**-2.0%**	-1.65	-6.5%	**-6.09**	**-9.0%**
December 2013	**-1.31**	**-2.0%**	**-3.64**	**-7.7%**	-3.20	-4.5%
January 2014	**-1.13**	**-1.7%**	**-3.43**	**-5.6%**	**-3.38**	**-6.4%**
February 2014	**-1.14**	**-1.7%**	-0.85	-2.1%	**-8.33**	**-13.5%**
March 2014	**-1.00**	**-1.7%**	**-2.88**	**-4.2%**	-1.71	-5.0%
April 2014	**-0.79**	**-1.6%**	-1.86	-2.8%	-1.11	-3.8%
May 2014	**-0.58**	**-1.5%**	-0.86	-1.3%	-1.45	-4.4%
June 2014	**-0.58**	**-1.3%**	-1.30	-1.4%	0.20	-0.4%
July 2014	**-0.75**	**-1.3%**	-0.39	2.2%	0.48	0.6%
August 2014	**-0.58**	**-0.8%**	1.26	6.6%	-0.03	-1.5%
September 2014	**-0.66**	**-1.2%**	-0.78	0.0%	-0.19	-1.3%
October 2014	**-0.85**	**-1.8%**	**-2.95**	**-5.5%**	0.46	0.3%
November 2014	**-1.20**	**-2.3%**	-1.20	-1.9%	-0.61	-1.5%

	HERs Group[1]		**Rebate Group[1]**		**HERs Group X Rebate Group[1]**	
December 2014	**-1.60**	**-2.8%**	1.08	1.5%	0.48	0.0%
January 2015	**-1.56**	**-2.8%**	0.12	0.1%	0.49	-0.1%
February 2015	**-1.24**	**-2.5%**	**-2.98**	**-5.1%**	-0.92	-2.1%
March 2015	**-1.16**	**-2.4%**	**-1.83**	**-3.1%**	0.57	0.2%
April 2015	**-0.97**	**-2.3%**	**-1.90**	**-3.3%**	0.37	-1.1%
May 2015	**-0.69**	**-1.6%**	-1.27	-2.0%	-0.29	-2.5%
June 2015	**-0.67**	**-1.3%**	-0.67	0.6%	-0.06	-0.9%
July 2015	**-0.72**	**-1.1%**	-0.70	2.8%	-0.39	-3.2%
August 2015	**-0.53**	**-0.7%**	0.51	4.7%	-1.07	-4.8%
September 2015	**-0.67**	**-1.5%**	**-1.88**	**-2.2%**	-0.12	-3.3%
October 2015	**-0.81**	**-2.1%**	**-3.72**	**-8.0%**	0.26	-1.3%
November 2015	**-1.15**	**-2.4%**	**-3.12**	**-6.6%**	-1.01	-3.6%
December 2015	**-1.81**	**-3.0%**	**-1.49**	**-3.7%**	-1.21	-3.1%
Observations	2,114,861					
R-squared	0.37					

[1] All bolded βs are significant at p≤ 0.10. βs & percentages are for the interaction term, and the actual values for the HERs+Rebate group are the sum of columns 2, 4, and 6 for βs and the sum of columns 3, 5, & 7 for percentages.

[2] Cumulative lagged dependent variable regression model: *Daily_average_kWh_usage = HERs_participant(β) + Rebate_participant (β) + HERs_participant (β)* Rebate_participant (β) + year_month+ daily_average_kWh_preusage + ε*

[3] Monthly lagged dependent variable regression model: *Daily_average_kWh_usage = ([HER_participant_group(β) + Rebate_participant_group(β) + HER_participant_group(β)*Rebate_participant_group(β)] by year_month) + year_month + daily_average_kWh_preusage + ε*

As shown in Figure 1, the distribution of residuals from the monthly regression model is close to normal. Table 2 shows that the monthly regression model residual means are statistically different for the HERs-only vs. Nonparticipants (left-tailed) comparison and for the Rebate-only vs. Nonparticipants (right-tailed) comparison but are not significantly different for the HERs+Rebate vs. Nonparticipant comparison. These results indicate that endogeneity could be present in the models, but given the closeness of the residuals to a normal distribution and a few significant results from the t-tests, bias in the models' results stemming from endogeneity is likely to be small.

Figure 1: Monthly Regression Model Residuals Histogram

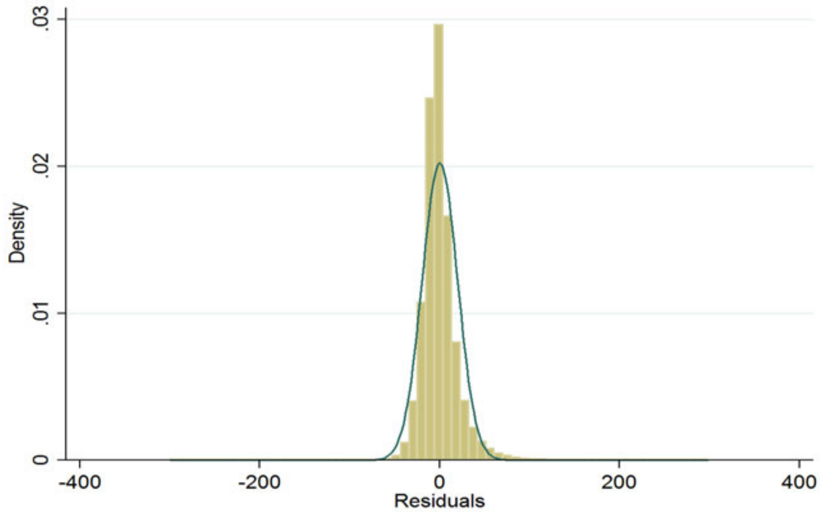

Table 2: T-tests of Monthly Regression Model Residual Means, Group Comparisons[1]

	N	t	Difference in Means	P-values		
				Left-tailed T-test	Two-tailed T-test	Right-tailed T-test
HERs-only vs. Nonparticipants	2,127,393	2.016	0.07	0.9781	**0.0438**	**0.0219**
Rebate-only vs. Nonparticipants	463,702	-1.624	-0.32	**0.0522**	0.1063	0.9478
HERs+Rebate vs. Nonparticipants	493,126	-0.913	-0.09	0.1806	0.3612	0.8194

[1] **Bold** = significant at $p \leq .05$