FINAL REPORT

Evaluation of Residential Customer Behavioral Savings Pilot

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Executive Summary

The Vermont Public Service Department (PSD) contracted with Cadmus to evaluate Efficiency Vermont's (EVT) Residential Customer Behavioral Savings (RCBS) Pilot. Starting in November 2014, OPower, the RCBS Pilot implementer, delivered home energy reports (HERs) to residential customers of Green Mountain Power (GMP). The HERs provided energy efficiency education and tips to encourage customers to reduce their energy use. The PSD tasked Cadmus with estimating the RCBS Pilot's energy and peak efficiency savings impacts and to identify specific behavior changes and energy-efficient measures prompted by the HERs.

Specifically, Cadmus set out to answer the following research questions:

- What were the RCBS Pilot's impacts on household electricity consumption in 2014 and 2015?
- What impacts did the RCBS Pilot have on customer energy use behaviors? How much savings were attributable to behavior change, as opposed to measure adoption?
- How did RCBS Pilot savings and behavior change vary across high, medium, and low energy use groups?
- What impact did the RCBS Pilot have on participation in EVT's energy efficiency programs?
- What was the RCBS Pilot's benefit to cost ratio (cost-effectiveness)?
- How might the HERs or RCBS Pilot design be improved?

Cadmus conducted a variety of evaluation tasks. In particular, Cadmus performed:

- In-depth interviews with program stakeholders
- A document review of program materials
- Surveys of treatment and control group customers
- A regression analysis of GMP customer billing data
- Energy efficiency program participation and savings uplift analysis to measure possible double counted savings and determine uptake in program participation.
- A cost-effectiveness analysis
- Provided technical expertise and consultation to produce findings that inform actionable recommendations for the RCBS Pilot

The PSD and EVT will use this evaluation's findings to make RCBS Pilot design changes and decisions about expanding, extending, or terminating the RCBS Pilot program.

Key Findings

This section summarizes key findings drawn from across the different research tasks. Cadmus provides additional details for these findings in subsequent report chapters.

Energy Savings

The RCBS Pilot saved approximately 0.2% of electricity use during 2014 and 0.8% during 2015. The pilot achieved 80% of the implementer's forecast of 2015 savings.[1] The program likely achieved savings lower than those forecasted because EVT suspended delivery of HERs between March 2015 and August 2015. During this period, savings decayed significantly but increased to pre-suspension levels after delivery of reports resumed. Also, RCBS savings were lower than those achieved by OPower HER programs in other utility service areas. Vermont utility customers have lower average electricity consumption due to low penetration rates of electric space heating and central air conditioning. In addition, the RCBS Pilot included low, medium, and high energy usage customers instead of targeting medium and high usage customers as many utility HER programs have done.

Recommendation: EVT should closely monitor the monthly savings to track program performance and to enact timely implementation changes, if necessary. By tracking the monthly savings against the monthly forecasts, the RCBS Pilot can develop an early contingency plan in the event that savings remain below those forecast. A contingency plan might include testing for the effect of changes to the HERs delivery such as adding modules, seasonal readiness letters, and reminder tools.

Energy Use Group Effects

In 2015, high energy users produced the largest average daily kWh savings per customer (0.36 kWh) and the largest savings as a percentage of energy use (1.03%). High-energy usage customers received the most HERs per customer each year and likely had the greatest potential for saving energy. Medium-energy users and low energy users achieved small average daily savings per customer of 0.11 kWh and 0.07 kWh, respectively.

Recommendation: Consider identifying and adding more high-energy usage customers to increase the Pilot savings. As EVT and OPower discovered during the RCBS Pilot design phase, there were a limited number of high-usage customers eligible for the RCBS Pilot. EVT and OPower included the maximum number of high-usage customers from Green Mountain Power possible. To increase savings, EVT could consider adding more high-usage customers from other Vermont utility service areas. EVT will need to balance the desire for increasing program savings and cost-effectiveness by targeting high-usage customers with considerations regarding equity and serving all of Vermont's utility customers.

Implications of RCBS Pilot's Suspended Delivery of HERs

RCBS Pilot savings increased during the RCBS Pilot's first six months, reaching approximately 1% of electricity consumption, and then decreased while EVT suspended delivery of HERs between March

[1] OPower made this forecast in October 2014, just before the November 2014 launch of the program. In August 2013, OPower originally forecasted first-year annual savings of 14,040 MWh. OPower then revised the forecast downward to 6,986 MWh after obtaining Vermont utility customer billing data and applying a new savings forecast model. OPower revised its forecast downward again to 6,453 MWh due to the temporary delivery suspension of the HERs. OPower reported savings of 5,395 MWh between November 2014 and October 2015 and savings of 6,284 MWh between January 2015 and December 2015. Cadmus estimated savings of 5,621 MWh between January 2015 and December 2015.

2015 and August 2015. After delivery resumed, savings increased, returning to a steady state of approximately 1%. EVT suspended the HERS due to feedback received from recipient customers, particularly concerns raised about the definition and accuracy of the neighbor comparison. In response, OPower and EVT made wording and design changes to the HERs' neighbor comparison component. While savings recovered after the report suspension, overall savings in 2015 did not recover sufficiently to reach the forecasted savings. The decay of savings while delivery was suspended and the recovery of savings after delivery was resumed provide additional evidence that the HERs caused customers to save energy.

Recommendation: Continue to send redesigned reports and evaluate the design changes. For the remainder of the program trial period in 2016 and beyond as appropriate**,** EVT and OPower should consider evaluating future changes to the report design by employing randomized controlled experiments or quasi-experimental methods. With the randomized control approach, only some randomly selected customers would receive reports with the design changes, while others would continue to receive reports with the existing design. An evaluator would then compare satisfaction and savings between customers receiving the existing and redesigned reports. A quasi-experimental method, which would not be as rigorous, might involve sending redesigned reports to all customers and then surveying customers about the design changes.

Peak Energy Savings

The RCBS Pilot did not save energy during ISO-New England peak hours for summer 2015, but it did save 1.3% of electricity consumption during ISO-New England peak hours for winter 2015–2016. This finding drew upon analysis of hourly energy use of treatment and control group customers during ISO-New England system peak hours when energy-efficiency resources may be bid into the capacity market. Treated customers did not save energy during summer peak hours as the RCBS Pilot suspended delivery of the HERs in March 2015, and savings decayed after treatment stopped. During winter, peak-hour savings averaged 0.017 kWh per customer per hour or 1.3% of consumption. However, maximum weekday hourly savings did not coincide with the ISO-New England system peak (5:00 p.m. to 7:00 p.m.). Between 7:00 p.m. and 10:00 p.m., savings averaged about 0.03 kWh per customer per hour or about 2% of consumption.

Recommendation: Continue to measure RCBS Pilot peak energy savings and promote measures that can save energy on peak. EVT should consider measuring peak energy savings during summer 2016 to determine how much energy the RCBS program saved during summer peak hours. Evaluators should follow this study's methodology, using customer AMI data and comparing the peak electricity consumption of treatment group and control group customers. Also, EVT and Opower should consider promoting measures that save energy on peak, such as for lighting, appliances, and home electronics in winter and for appliances and space cooling during summer.

Energy Saving Actions, Behaviors, and Customer Awareness

The HERs appear to have ambiguous effects on energy saving actions, behaviors, customer awareness, purchases, and installation of efficient lighting products. Treatment group respondents reported implementing energy-saving improvements at a lower rate than control group respondents. Survey responses indicated no statistically significant differences regarding the number of CFL bulbs purchased between the treatment and control group customers. However, a statistically significant higher proportion of treatment group respondents reported purchasing LEDs compared to control group respondents, and 20% of the treatment group respondents reported the HERs prompted them to install CFLs or LEDs. Moreover, a statistically significant higher proportion of treatment group respondents said EVT "reduces the cost of light bulbs" when asked "what Efficiency Vermont does", while a statistically significant higher proportion of control group respondents said EVT "saves energy." These findings align with the HERs' lighting promotions and suggest the HERs' may have had at least some effectiveness in promoting efficient lighting.

Recommendation: Focus HER savings tips on lighting measures and behavior changes. Encouraging customers to install efficient lighting products may result in more customers initiating an energy-saving behavior than encouraging customers to install space heating and space cooling measures, which may not apply to as many households due to the low penetrations of electric space heating and central air conditioning in Vermont homes. Energy-saving tips should also point out new or unique ideas that appeal to customers that already consider themselves doing as much as possible to save energy.

Efficiency Program Uplift

Although the RCBS Pilot and HERs were designed primarily to influence energy-saving behaviors, behavior changes may lead residents to incorporate additional energy-saving measures in their homes, which can have a longer-term savings effect, extending beyond the HERs treatment period. Consequently, HERs could potentially also produce deeper and long-lasting savings by encouraging investments in energy-saving measures, which may be eligible for incentives offered through EVT programs.

In 2015, the RCBS Pilot lifted the participation rate in EVT's other efficiency programs by about 8%, but savings from this lift in participation was small. The RCBS Pilot increased the efficiency program's participation rate of low-energy users by about 7%, medium-energy users by 3%, and high-energy users by 14%. HERs provided the greatest lift in participation for hot water efficiency and refrigeration measures. HER electricity savings from efficiency program participation was less than 1% of total RCBS savings. The energy savings from lift in program participation was very small, because most customers did not heat or cool their homes with electricity and therefore could not produce large electricity savings by adopting high-impact space conditioning measures.

Recommendation: Continue cross-program marketing through the HERs. HERs appear to be an effective medium for increasing awareness of and participation in EVT programs. Focus marketing on programs likely to produce more substantial savings such as lighting, refrigeration, and water heating.

RCBS Pilot Design Implications and Improvements

Changes made to the HERs' neighbor comparisons resulted in improved customer perceptions of the neighbor comparison's accuracy. Survey respondents exhibited relatively high readership of the HERs

(75%) and a very high recall of the neighbor comparison element (91%). The 12-month survey showed an improvement from the six-month survey on customer perceptions of the neighbor comparison's accuracy; the proportion of survey respondents agreeing with the statement "I believe the neighbor comparison is generally accurate" increased from 50% to 57%.

Efficiency Vermont's Net Promoter Score (NPS) improved from the six-month to 12-month periods, largely due to changes in the NPS of non-recipients. The NPS is an absolute number between -100 and +100 based on the customers' "likelihood to recommend EVT" survey question. A positive score indicates more promoters (respondents assigning a score of 9 or 10) than detractors (respondents assigning a score of 0 to 6). HERs appear to have had a negative impact on NPS. In Cadmus' 12-month survey, surveyed HERs recipients and non-recipients generated an overall NPS of -7; specifically, recipient respondents generated a NPS of -14 and the non-recipient respondents generated a NPS of +1. In OPower's six-month survey, surveyed recipients and non-recipients generated an overall NPS of -25, with recipients specifically yielding a NPS of -27.

Recommendation: Re-evaluate the RCBS Pilot in July 2016 and determine whether the NPS improved. Cadmus is under contract with the PSD to perform a mid-2016 year evaluation of the RCBS Pilot.

Cost-Effectiveness

The RCBS Pilot was not cost-effective when accounting for pilot start-up costs in 2014. The RCBS Pilot did not prove cost-effective (0.89) during the pilot's first 14 months as measured by the societal cost test (SCT). The suspension of HER report delivery in March 2015 reduced the pilot savings and likely diminished the pilot's cost-effectiveness. Cadmus estimated that the pilot would have been cost-effective for 2014-2015 if savings in 2015 had been 15% higher. However, the pilot showed potential for operating cost-effectively. When estimating pilot cost-effectiveness for 2015, which excluded the pilot set-up costs and 2014 savings, the RCBS Pilot proved cost-effective (1.33).

Recommendation: Re-evaluate the pilot cost-effectiveness at the end of 2016. It is likely that the RCBS pilot was not cost-effective for 2014-2015 because of the suspension of report delivery. However, over a longer period, the pause in report delivery and the resulting loss of savings will have a diminishing impact on the pilot cost-effectiveness. The pilot may prove to be cost-effective when evaluated at the end of 2016.

Introduction

This section provides a detailed description of the Residential Customer Behavioral Savings (RCBS) Pilot design and implementation and presents the evaluation research questions.

RCBS Pilot Program Design

The RCBS Pilot uses the home energy reports (HERs) to inform customers about their home energy use and to encourage energy-efficient behavior change. The RCBS Pilot seeks to accomplish the following objectives:

- Achieve verifiable, cost-effective savings for Vermont
- Increase customer awareness of energy efficiency
- Encourage customers to adopt energy-saving behaviors and measures
- Promote Efficiency Vermont's (EVT) energy efficiency programs and drive customers towards participation

The RCBS Pilot does not provide financial incentives to customers for adoption of energy efficiency measures, though it encourages them to obtain rebates for adopting efficiency measures through EVT's energy efficiency programs.

EVT administers the RCBS Pilot and OPower implements it. In addition to producing and distributing the HERs, OPower researched and selected customers eligible for the RCBS Pilot and took responsibility for forecasting and tracking monthly savings.

From November 2014 to October 2015, EVT and OPower delivered HERs to approximately 100,000 Green Mountain Power residential customers. OPower produced the HERs and distributed these reports to customers via mail, e-mail, and web portal. Each printed HER (delivered via mail) contained the customer's household energy-use data, a comparison of neighbors' energy use, and three energy-saving tips. Customers with valid e-mail addresses also received electronic HERs (delivered via e-mail), featuring only the neighbor comparison. An option to create an account for accessing the HERs web portal to receive more information on saving energy was also provided to all recipient customers. The HERs also cross-promoted energy efficiency programs offered by EVT, such as residential lighting and audit programs.

OPower and EVT designed the RCBS Pilot as a large-scale field experiment (i.e., a randomized control trial), with customers randomly assigned to a treatment group or a control group. Treatment group customers received energy reports, but could opt not to receive them by calling the customer service center. The control group did not receive energy reports and acted as a comparison group for measuring the treatment group's energy savings. At the beginning of the RCBS Pilot, Cadmus performed the random assignment of eligible customers to the treatment and control groups.

Further, the RCBS Pilot design stratified customers into three energy usage bands: high, medium, and low. The number of printed HERs delivered over the course of the year differed depending on the customer's energy use band, with high users receiving a greater number of HERs. Table 1 shows the RCBS Pilot program's design by group and energy use band.

Table 1. RCBS Pilot Program Design

Group and Use Band	HERs Delivery Frequency	Number of Customers	Average Pre-Program Monthly Energy User per Customer (kWh)
Treatment Group			
High Users	7 printed HERs; 6 electronic HERs; web portal access	26,232	1,065
Medium Users	5 printed HERs; 6 electronic HERs; web portal access	26,291	659
Low Users	3 printed HERs; 6 electronic HERs; web portal access	52,456	406
Total Treatment Group		**104,979**	
Control Group			
High Users	N/A	5,262	1,082
Medium Users	N/A	5,203	671
Low Users	N/A	10,532	410
Total Control Group		**20,997**	

Notes: Average monthly energy use per customer estimated using customer billing consumption data between November 2013 and October 2014.

In March 2015, EVT suspended delivery of the energy reports after customers expressed concerns about the appropriateness and validity of the neighbor comparisons in the reports. When EVT suspended the reports, the low energy use group had received two reports, the medium energy use group had received three reports, and the high use group had received four reports. During the suspension, EVT worked with OPower to redesign the neighbor comparison, providing more context about the comparison and more prominently displaying EVT's management of the program. EVT and OPower also excluded the "efficient neighbors" comparison bar graph in the reports sent to high-energy users (reports still included the "all neighbors" comparison bar graph). In addition, when delivery of the reports resumed in August 2015, OPower included an insert letter from EVT with the redesigned energy report to acknowledge customer concerns and to explain the changes to the reports.

Research Questions

The evaluation objectives were to measure the energy savings from HERs, to document the program design and implementation, and to assess the customer experience. Cadmus developed an evaluation plan to address the following research questions regarding the RCBS Pilot:

- What were the RCBS Pilot's impacts on household electricity consumption in 2014 and 2015?
- What impacts did the RCBS Pilot have on customer energy use behaviors? How much savings were attributable to behavior change, as opposed to measure adoption?

- How did RCBS Pilot savings and behavior change vary across high, medium, and low energy use groups?
- What impact did the RCBS Pilot have on participation in EVT's energy efficiency programs (efficiency program uplift)?
- What was the RCBS Pilot's benefit to cost ratio (cost-effectiveness)?
- How might the HERs or RCBS Pilot design be improved?

Based on the research findings, Cadmus also made recommendations for improving RCBS Pilot evaluation and implementation.

Methodology

This section describes the research methodologies for the following evaluation tasks included in the research plan:

- Document Review
- Staff Interviews
- Customer Surveys
- Energy Savings Analysis
- Efficiency Program Uplift Analysis
- Advanced Metering Infrastructure (AMI) Data Analysis
- Cost-Effectiveness Analysis

To answer research questions addressing program design, processes, delivery, and performance, Cadmus conducted staff interviews, customer surveys, and a document review. Further, Cadmus used a customer billing regression analysis to estimate RCBS Pilot energy savings; an analysis of EVT's energy efficiency program's tracking database that allowed Cadmus to estimate the RCBS Pilot's impact on participation in EVT's efficiency programs.

In addition, Cadmus analyzed AMI data for the RCBS treatment and control group to estimate the HER savings achieved during utility system peak hours and savings by hour of the day for summer and winter weekdays and weekends.

Finally, Cadmus conducted an analysis to assess the cost-effectiveness of the RCBS Pilot and of potential future program designs, involving different mixes of low-usage, medium-usage, and high-usage customers.

Document Review

During the first three months of the evaluation, Cadmus conducted a document review by gathering and examining critical RCBS Pilot documents provided by EVT. These included the following documents:

- EVT and GMP 2014 Behavioral Demand Response RCBS Pilot results and planning workshop presentation
- EVT HER program design presentation
- HER detailed distribution timeline
- OPower program design, eligibility, selection, and review memos
- HER welcome letter
- Printed and electronic HERs for high, medium, and low energy users
- Vermont single-family existing homes report
- Vermont single-family retrofit market research report
- Vermont single-family retrofit market process evaluation report

Staff Interviews

Cadmus conducted in-person and telephone interviews with key RCBS Pilot program staff at the Vermont Public Service Department (PSD), EVT, and OPower, as shown in Table 2. Interviews addressed the following topics:

- RCBS Pilot history
- Program design and implementation
- HERs' content and how this encourages behavior change
- Program challenges and barriers
- Data management

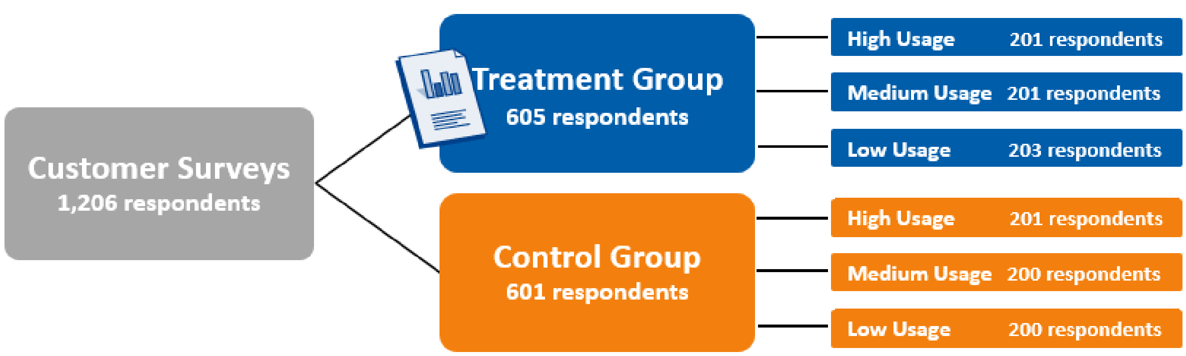
Table 2. Staff Interviews

Stakeholders	Number of Interviews	Number of Interviewees
PSD program staff	1	4
EVT program staff	2	4
OPower program staff	1	3
Total	**4**	**11**

Customer Surveys

At the RCBS Pilot's 12-month mark, Cadmus administered telephone surveys—one with treatment group customers and one with control group customers—to correspond with the experimental design. We selected a stratified random sample of customers by group and energy usage band. Figure 1 shows the survey sample's design and the number of survey respondents achieved.

Figure 1. Customer Survey Sample Design and Sample Size



The surveys sought to assess the HERs' influence on specific behavior changes, energy efficiency program awareness and participation, and satisfaction with EVT. Cadmus posed most of the same questions to the treatment and control group, allowing for group comparisons. The treatment group, however, received additional questions about HERs. Prior to the fielding of these customer surveys, OPower fielded its customer engagement tracker surveys at the RCBS Pilot's six-month mark. Cadmus coordinated with OPower in utilizing similar survey questions to compare and trend survey results over time.

The surveys employed a self-report method, which potentially can result in validity issues and biases (e.g., self-selection, recall, social desirability). Cadmus constructed the customer surveys to minimize such validity issues and biases using the following best practices:

- Drafted questions that were not leading, ambiguous, or double-barreled
- Designed a single survey instrument to identically order the survey flow for the treatment and control groups
- Moved identical group questions to the beginning of the survey, and moved group-specific questions near the end of the survey (creating an initial "double blind" effect for interviewers)
- Employed randomization of list-based survey items to reduce order effects
- Made comparisons between randomly-assigned treatment and control group customers, increasing confidence that any estimated differences are causal program effects

"Appendix A. Survey Instrument" contains a copy of the HERs customer survey instrument.

Energy Savings Analysis

Cadmus estimated the program's energy savings and the RCBS Pilot's effects on participation in EVT's residential efficiency programs. Following the evaluation methods prescribed in the U.S. Department of Energy's (DOE) Uniform Methods Project[2] and SEE Action Protocol[3], EVT and OPower implemented the program as a large, randomized control trial. In March 2016, Cadmus collected monthly energy-use billing data for all months between November 2013 and December 2015 of all customers assigned to the treatment and control groups and used panel regression analysis of monthly consumption to estimate the program's electricity savings. Cadmus also linked customers to EVT's efficiency program tracking database, and compared participation rates and measure savings of treatment and control group customers to estimate the lift in efficiency program participation and the RCBS Pilot energy savings counted by other efficiency programs.

Cadmus' impact evaluation of the RCBS Pilot involved the following five tasks:

1. Perform and verify random assignment of customers to treatment and control groups

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2 See Stewart, James, and Annika Todd. "Residential Behavioral Protocol." *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures.* National Renewable Energy Laboratory. 2015. Available at: http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter17-residential-behavior.pdf.

3 State and Local Energy Efficiency Action Network. 2012. Evaluation, Measurement, and Verification of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. Available at: https://www4.eere.energy.gov/seeaction/system/files/documents/emv_behaviorbased_eeprograms.pdf.

2. Data collection and preparation
3. Billing analysis
4. Savings estimation
5. Energy efficiency program uplift analysis

Perform and Verify Random Assignment of Customers to Treatment and Control Groups

In October 2014, Cadmus randomly assigned 126,000 customers eligible for the RCBS Pilot to either the treatment group or the control group. Per the agreement of the PSD, EVT, and OPower, Cadmus provided OPower with five different randomizations of the eligible customers into treatment and control groups, and OPower selected the randomization that, according to their statistical tests[4], was most balanced. Cadmus verified that all five sets of randomized customers were closely balanced in terms of pre-treatment energy use and that selecting any of the five randomizations would result in a valid research design. Cadmus performed this task as the independent evaluator to avoid any perceived conflicts of interest with randomization, as recommended in DOE's and SEE Action's behavior-based program evaluation guidelines.

Table 3 shows the counts of customers assigned to the treatment and control groups by energy use group. Approximately 83% of customers were assigned to the treatment group, and the remaining customers were assigned to the control group. Cadmus verified that the treatment and control group sizes would be large enough to allow detection of expected savings using statistical analysis.

Table 3. Random Assignment of Customers to Treatment and Control Group

Energy Use Group	Treatment Group	Control Group	Total
High	26,232	5,262	31,494
Medium	26,291	5,203	31,494
Low	52,456	10,532	62,988
Uncategorized	21	3	24
Total	105,000	21,000	126,000

As part of the evaluation, Cadmus verified again that the control and treatment customers showed no statistically significant differences in pre-program consumption. Table 4 shows the results from this test. The 95% confidence interval of the difference between the two groups includes zero; so the difference is not statistically significant at the 95% level.

Table 4. Pre-Program Consumption of Control and Treatment Groups

Group	Pre-Program Average Daily kWh	95% CI Lower Bound	95% CI Upper Bound
Control	21.07	21.02	21.13
Treatment	21.08	21.06	21.11
Difference	**-0.01**	**-0.07**	**0.05**

[4] Based on proprietary data and methods.

Data Collection and Preparation

In preparation for the impact evaluation, Cadmus collected the following data:

- Monthly energy use billing data between November 2013 and December 2015
- Customer participation data
- Energy efficiency program participation data
- Daily weather data for 17 weather stations located in Vermont, New Hampshire, and Massachusetts

After collecting these data, Cadmus performed the following data-cleaning steps:

- Make adjustments to customer billing consumption for estimated reads.[5]
- Drop each customer's first and last bill.[6]
- Drop billing records containing average daily consumption over 300 kWh per day or less than -300 kWh per day.
- Exclude customers whose accounts became inactive before November 1st, 2014, when OPower generated the first report.

To prepare the cleaned data for regression analysis, Cadmus performed the following steps:

- Calculate heating degree days (HDDs) and cooling degree days (CDDs) for each customer billing cycle using daily mean temperature data.[7]
- Allocate customer billing consumption, HDDs, and CDDs to calendar months, so that observations in the panel data corresponds to a customer's consumption during a calendar month.
- Merge customer program participation data.
- Express consumption, HDDs, and CDDs as daily averages for the month.

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5 The first non-estimated bill after an estimated bill contains consumption during the non-estimated period and an estimate correction for the estimated bills. As the non-estimated bills' usage value contains consumption from the previous estimated bills, Cadmus combined any estimated bills with the first following non-estimated bill. For example, if an estimated bill spanned September 15, 2015, to October 15, 2015, and it was followed by a non-estimated bill for October 16, 2015, to November 16, 2015, Cadmus summed usage across both bills, resulting in one bill, spanning September 15 through November 16.

6 A customer's first and last bills may start or end at any point during a calendar month, meaning that the calendar month during which a customer's first bill begins or last bill ends may not cover electricity consumption for all days during the month.

7 Cadmus used a base temperature of 65 degrees to calculate CDDs and HDDs.

Finally, to prepare the final analysis sample, Cadmus merged customer program data with billing data for the treatment and control group customers.

Perform Regression Analysis of Customer Energy Use

Cadmus used a difference-in-differences (D-in-D) panel regression of customer monthly energy use to estimate the average daily savings per customer for the 2014 and 2015 calendar years. The regression was expected to yield an unbiased estimate of savings due to the random assignment of customers to treatment and control groups. (Both UMP and SEE Action recommend D-in-D analysis to estimate savings.) As a check of the D-in-D savings estimates, Cadmus also estimated the average daily savings per customer using only post-period data, per the approach of Allcott and Rogers (2014).[8]

The panel regression included customer fixed effects, month-by-year fixed effects, and HDDs and CDDs to control for differences in baseload energy use between customers, changes in energy use over time, and demand for space heating and space cooling:

$$ADC_{it} = \alpha_i + \beta_1 \, PART_{it} \times POST2014_{it} + \beta_2 \, PART_{it} \times POST2015_{it} + \gamma_1 \, HDD_{it} + \gamma_1 \, CDD_{it} + \tau_t + \varepsilon_{it}$$

(Equation 1)

Where:

ADC_{it}	=	Average daily electricity use for customer i in period t.
α_i	=	Average energy use for customer ‘i’ not sensitive to time or weather. The model controls for baseload energy use by including customer fixed effects.
$PART_{it}$	=	An indicator variable for assignment of the customer to the treatment group (= 1 if the customer was in the treatment group; = 0 otherwise).
$POST2014_{it}$	=	Indicator variable for whether the month was a Program Year 1 post-treatment month for customer i. This variable equaled one if the month was a month in 2014 and the month that the first report was received or a subsequent month. This variable equaled zero for all other months.
$POST2015_{it}$	=	Indicator variable for whether the month was a calendar year 2015 post-treatment month for customer i. This variable equaled one if the month was a month in 2015 and the month that the first report was received or a subsequent month. This variable equaled zero for all other months.
HDD_{it}	=	Monthly heating degree days for customer i in period t.
CDD_{it}	=	Monthly cooling degree days for customer i in period t.

[8] Allcott, H., & Rogers, T. (2014). “The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation.” American Economic Review 104 (10), 3003-3037.

τ_t = Average energy use in month 't' reflecting unobservable factors specific to the month. The model controls for these effects by including month-by-year fixed effects.[9]

ε_{it} = Error term for customer 'i' in month 't.'

β_1 = Coefficient indicating the average effect of receiving a home energy report on daily electricity use in calendar year 2014. Average daily kWh savings per treated customer equal -1* β_1.

β_2 = Coefficient indicating the average effect of receiving a home energy report on daily electricity use in calendar year 2015. Average daily kWh savings per treated customer equal -1* β_2.

Cadmus estimated the model by ordinary least squares (OLS) and reported standard errors adjusted for the correlation of each home's energy use over time (Huber-White standard errors).[10] This estimation produced an estimate of average daily savings per treated customer for 2014 and 2015.[11]

Cadmus estimated several versions of Equation 1 to check the robustness of the savings estimates to changes in model specifications. Such specifications tested the effects of including (or excluding) customer fixed effects, month-by-year fixed effects, HDDs, and CDDs.

In addition (as noted above), Cadmus estimated average daily savings per customer using only post-treatment energy-use data for treatment and control group customers, following the approach of Allcott and Rogers (2014). This approach included customer pre-treatment energy-use variables as regressors

9 POST was not included as a standalone variable in the regression as very little variation occurred between treatment group homes in the month of the first report delivery. If little such variation occurs, the model can be estimated with POST or month-by-year fixed effects, but not with both.

10 Bertrand, Marianne, Esther Duflo, Sendil Mullainathan, 2004. "How Much Should We Trust Difference-in-Differences Estimates?" Quarterly Journal of Economics 119:1, 249-275.

11 A small number of customers (N=936) assigned to the treatment group did not receive HERs. After random assignments to treatment or control groups, Opower determined that some customers did not have valid addresses or did not have sufficient billing histories to generate reports. To preserve the randomized control trial's validity and the treatment and control groups' equivalence, Cadmus left these customers in the impact evaluation analysis sample. (To drop treatment group customers from the analysis sample would have required dropping control customers for which it would be infeasible to deliver a HERs. Opower did not provide this information to Cadmus.) Consequently, the regression analysis yielded an estimate of the average *intent-to-treat* (ITT) effect, not the average treatment effect for the treated (ATT). The ITT effect equaled the average daily savings per customer for customers that Opower intended to send a HERs (i.e., the average savings across customers who received a report and customers to whom Opower intended to deliver a report but could not). This differs from the ATT—the average daily savings per customer of customers receiving a report. The difference between the ITT effect and the ATT effect, however, was negligible due to the very small percentage of customers in the treatment group not receiving a report.

to control for variation between customers' average monthly energy use. Cadmus expected the results would not be sensitive to changes in the model specifications due to the evaluation's randomized control design and the large size of the analysis sample. The impact evaluation results described below show the savings estimates proved very robust.

In addition, Cadmus estimated average daily savings per customer for each month of the post-treatment period between November 2014 and December 2015. These estimates revealed how savings evolved over the course of the program's first and second calendar years. The estimates also indicated whether savings varied seasonally.

Finally, Cadmus estimated savings for the low, medium, and high energy-use homes. OPower assigned customers to an energy use group based on the customer's energy use during the year preceding treatment. Estimation of savings for each usage group revealed how savings depended on a customer's pre-treatment energy use.

Estimate Program Savings

Cadmus estimated program savings for the periods November 2014 to December 2014 and January 2015 to December 2015 by multiplying the estimate of average daily savings per customer, derived from the regression Equation 1, by the number of treatment days during that period for customers in the treatment group.

Let i=1, 2, …, N index the number of customers in the treatment group. The RCBS Pilot savings for calendar year j is given by the following equation:

$$\text{RCBS Pilot Savings} = -\beta_j * \left(\sum_{i=1}^{N} \text{Treatment Days}_i\right)$$

Where:

β_j	=	Average daily savings per customer for calendar year j from estimation of regression Equation 1.
Treatment Days_i	=	Number of days during calendar year j that the customer account remained active after the first report date and when.

Energy Efficiency Program Uplift Analysis

As HERs provided personalized savings recommendations (including recommendations to install high-efficiency lighting, space conditioning, and water heating measures) and promoted some of EVT's efficiency program offerings, the RCBS Pilot was expected to increase participation in EVT's other efficiency programs; this report refers to HERs' impact on participation as "efficiency program uplift." Cadmus estimated this uplift and its resulting savings for EVT's programs.

Estimating savings uplift is important for two reasons:

- First, as an important effect of the energy reports and as a potential savings source, it should be measured.

- Second, savings from efficiency program uplift is measured in both the regression-based estimate of savings (described above in the regression analysis) and in impact evaluations of EVT's other efficiency programs. Therefore, an evaluation must measure uplift savings and subtract them from the residential portfolio savings to avoid double-counting.

Cadmus estimated efficiency program uplift for downstream programs in each of the calendar years 2014 and 2015. Downstream efficiency programs provide rebates to customers who install efficient measures and then apply for rebates. Participants in these programs can be identified.

Cadmus also estimated program uplift for the upstream efficient lighting program. As upstream lighting programs provide rebates to customers at the point of sale, in general, it is not possible to link purchases of rebated lighting measures to specific customers.

Cadmus measured efficiency program participation uplift as the difference between treatment group customers' and control group customers' rates of program participation:

$$\text{Participation Uplift} = \Delta\rho = \rho_T - \rho_C$$

Where:

ρ_j	=	The efficiency program participation rate during treatment for group j (j="T", for treated customers, and "C" for control customers), with the participation rate defined as the ratio of number of efficiency program participants in the treatment [control] group to the number of treatment [control] group customers.

The difference $\Delta\rho$ was expected to be small as the baseline participation rate and HERs' effect on the participation rate were expected to be small.

Percent uplift expresses the participation uplift relative to the baseline participation rate for control group homes:

$$\text{Percent Participation Uplift} = \%\Delta\rho = \Delta\rho/\rho_C$$

This would produce a RCBS Pilot's effect on participation in percentage terms. For example, if HER participation uplift was 0.2% and the baseline participation rate in the control group was 0.4%, $\%\Delta\rho$ would equal 50%, indicating the RCBS Pilot increased program participation by 50%.

Cadmus estimated RCBS savings from participation uplift similarly, by replacing the program participation rate with the average efficiency program savings per customer in group j σ_j, j in {C,T}:

$$\text{Uplift savings per customer} = \sigma_T - \sigma_C$$

With σ_j as the average efficiency program savings per treated (control) customer. Multiplying uplift savings per customer by the number of customers (N_T) assigned to the treatment group homes yielded an estimate of RCBS Pilot savings from participation in EVT's efficiency program:

$$\text{Program uplift savings} = \Delta\sigma * N_T$$

Estimating Uplift for Downstream Rebate Programs

To estimate participation uplift and uplift savings for downstream rebate programs, Cadmus linked the RCBS Pilot treatment and control group customers to EVT's efficiency program tracking database. Each row of the tracking database corresponded to the installation of a specific efficiency measure (e.g., heat pump, attic ceiling insulation) at a particular premise on a particular date. The database contained: the premises ID, customer account, location (e.g., street address, city, zip code), EVT program name, program measure name, installation date, and deemed annual savings.

For estimating the savings uplift, Cadmus made the following adjustments to deemed annual savings:

- Prorated savings of non-weather sensitive measures for the installation date. (Cadmus assumed savings were distributed uniformly across days of the calendar year.)
- Prorated savings of weather sensitive measures for the installation date. (Cadmus assumed savings were distributed throughout the year in accordance with the distribution of weather-normal HDDs for space heating measures and weather-normal CDDs for space cooling measures.)
- Prorated savings for customers with accounts becoming inactive during the calendar year.

Estimating Uplift for Upstream Rebate Programs

As EVT's efficiency program tracking database did not provide data about utility customers' purchases of CFLs and LEDs, Cadmus could not use the database to estimate participation uplift and savings uplift for efficient lighting products. Rather, Cadmus surveyed a large number of treatment and control group customers about their purchases and installations of CFLs and LEDs, and then used information from this survey to estimate uplift for upstream lighting measures. While Cadmus inquired about the specific number of CFLs purchased, we did not inquire about the specific number of LEDs because of budget constraints and potential survey fatigue. As a result, the estimate for CFL purchases is conservative, based on self-report, and we were unable to measure the impacts of HERs on LEDs and other upstream measure purchases.

AMI Data Analysis

Cadmus conducted an econometric analysis of customer AMI data to provide additional insights about RCBS Pilot impacts. While analysis of customer monthly consumption data can indicate trends in savings across months, it cannot indicate when during the day customers saved energy or how they saved energy: analysis of higher-frequency energy-use data can provide further insights.

The AMI data analysis sought to achieve two main objectives:

- To estimate RCBS Pilot energy savings that occurred during ISO-New England system peak hours when energy efficiency resources can be bid into the forward capacity market; and
- To estimate average RCBS Pilot energy savings for each hour of the weekday and weekend during winter and summer

Although achieving peak savings was not a pilot objective, the RCBS Pilot may have provided savings during ISO-New England peak hours, which would help to reduce GMP's cost of supplying energy on peak and to reduce electricity costs for the utility's customers.[12, 13]

AMI Data Preparation and Collection

Cadmus obtained an AMI data set from Opower. This data set included interval kWh consumption for all RCBS Pilot treatment and control group customers, per 15-minute intervals during the following periods:

- December 2013–January 2014 (Pre-treatment period)
- June 2014–August 2014 (Pre-treatment period)
- June 2015–August 2015 (Treatment period)
- December 2015–January 2016 (Treatment period)

Cadmus used these data to estimate RCBS Pilot peak energy savings and savings by hour of day.

For analysis, Cadmus aggregated these data to the hourly level, specifically taking the following steps to prepare the interval data:

- Flagged 15-minute intervals with estimated usage readings, and flagged 15-minute intervals with actual usage readings that immediately followed estimated reads.
- Flagged 15-minute intervals on weekends or holidays.
- Aggregated 15-minute interval data to the hourly level, and flagged hourly kWh readings that exceeded 20 kWh.
- Merged hourly weather with customer hourly kWh readings using weather data from the nearest NOAA weather station.
- Merged RCBS program data, indicating whether a customer belonged to the treatment or control group, the first print report date, and the account inactive date (for customers with closed accounts) with interval kWh data.

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12 For example, see Lawrence Berkley National Laboratory (Prepared by Todd, Annika, M. Perry, B. Smith, M. Sullivan, P. Cappers, and C. Goldman). "Insights from Smart Meters: The Potential for Peak-Hour Savings from Behavior-Based Programs." (2014). Lawrence Berkeley National Paper LBNL-6598E. 2014. Available online at: http://escholarship.org/uc/item/2nv5q42n.

13 Cadmus also attempted to estimate the energy savings from lighting efficiency, as lighting constituted a significant share of energy consumption in Vermont homes. We expected that savings from lighting efficiency could be detected by analyzing 15-minute interval meter data. However, the savings were not precisely estimated, and so we have not reported them. Space heating and space cooling measures likely achieved small savings, based on low penetration rates of residential electric space heating and central air conditioning.

Cadmus obtained the final AMI analysis sample by discarding the following observations:

- Hours with fewer than four valid 15-minute kWh readings. Specifically, Cadmus dropped hours with one or more estimated readings, hours immediately following hours with one or more estimated readings, or hours with one or more missing readings.
- Hours after the date when the account became inactive.
- Hours before the customer received the first HER.
- Hours with energy use greater than 20 kWh/hour.

Table 5 shows the following: the number of customer 15-minute interval kWh readings in the raw data; the number of customer hour interval kWh readings in the final analysis sample; and the number of customers in the final analysis sample for each of the four periods. Most attrition in the raw data (approximately 80% of the 15-minute interval readings dropped) could be attributed to readings occurring after the account became inactive or to hours having fewer than four valid readings. AMI data also were available for only about 50,000 treatment and control group customers during December 2013–January 2014 as GMP continued to deploy residential AMI meters at this time. This explains the smaller number of hourly energy-use observations and customers in the final analysis sample for this period.

Table 5. AMI Data Analysis Sample

Date Range	Period	15-Minute Interval kWh Readings in Raw Data	Hour Interval kWh Readings in Final Analysis Sample	Customers in Final Analysis Sample
December 2013–January 2014	Pre-treatment	288,314,375	72,116,075	49,561
June 2014–August 2014	Pre-treatment	1,055,631,357	257,620,391	116,035
June 2015–July 2015	Treatment suspended	1,063,492,909	234,245,472	110,618
December 2015–January 2016	Treatment	713,661,981	151,709,098	104,667

Peak Energy Savings Analysis

Vermont follows ISO-New England's definition of coincident peak demand period for *passive demand resources*, which are used to save electricity at all times and may be bid into the forward capacity market.[14] Specifically, Vermont defines peak coincident demand in summer and winter as non-holiday, weekday hours when system demand is likely to peak:

- *Summer coincident peak demand reduction,* defined as the average demand reduction during the summer coincident peak period (i.e., June–August, Monday–Friday, non-holidays, between the hours of 1:00 p.m. and 5:00 p.m.)
- *Winter coincident peak demand reduction,* defined as the average demand reduction during the winter coincident peak period (i.e., December and January, Monday–Friday, non-holidays, between the hours of 5:00 p.m. and 7:00 p.m.)

Cadmus estimated average peak savings per treated customer for summer 2015 and for winter 2015–2016. We did not estimate peak savings for winter 2014–2015 as customers had just received the first HERs, and the estimated energy savings were very small and not statistically significant.

Peak Energy Savings Estimation

Cadmus conducted separate analyses of AMI data for winter and summer and subset the data to hours meeting the ISO-New England definition of system peak for passive demand resources. Using an approach similar to that employed by Allcott and Rogers (2014), we then regressed customer kWh per hour on the following variables:

- Indicator variables for peak hours of the day *j,* j=1 to J, where J is the number of hours during a peak day (J=4 for summer and J=2 for winter).
- Customer average energy use per hour for each peak hour of the day (e.g., 5:00 p.m.–6:00 p.m. and 6:00 p.m. –7:00 p.m. for winter), during the same months and hours of the pre-treatment period. These variables were interacted with the hour-of-day variables.
- Customer heating degree hours for winter and cooling degree hours during summer and heating and cooling degree hours during the shoulder seasons.
- Interaction variables between the hour of day and whether the customer had previously received an energy report.

Pre-treatment energy use variables accounted for differences in average energy use between customers during peak hours. Estimated coefficients on the interaction variables indicated average savings per customer during weekday or weekend hours. Appendix C describes the full model specification. Cadmus estimated the model by ordinary least squares and clustered the standard errors on the customer. Coefficients on the interaction variables between the hour of day and the energy reports indicator indicate the average energy savings per customer during the peak hours.

[14] See *ISO New England Demand Resources in ISO Wholesale Electricity Markets*: http://www.iso-ne.com/markets-operations/markets/demand-resources/about

HER Savings by Weekday and Weekend Hour

The objective of this analysis was to determine when during days of the week and weekend treated customers saved electricity. Cadmus conducted separate analyses for weekdays and weekends for summer 2015 and winter 2015-2016, resulting in the estimation of four models. We estimated the average savings per customer by hour of day using a regression similar to Equation 2.

Specifically, we regressed customer electricity use per hour on:

- Indicator variables for hour of the day *j*, j=0, 1, 2, … ,23;
- Customer average energy use per hour for four periods of the day (11:00 pm – 5:00 a.m., 6:00 a.m. – 9:00 a.m., 10:00 – 4:00 p.m., and 5:00 p.m. – 10:00 p.m.) during the same season of the pre-treatment period. Each of the pre-treatment energy us variables was interacted with the hour of the day variables.
- Customer heating degree hours for winter and cooling degree hours for summer;
- Interaction variables between hour of the day and whether the customer had previously received a HER.

The pre-treatment energy use variables accounted for differences between customers in average energy use during each hour of the days. The estimated coefficients on the interaction variables between the treatment indicator and hour of the day indicated the average savings per customer during weekday or weekend hours. The full model specification is described in Appendix C. Cadmus estimated the model by ordinary least squares and clustered the standard errors on the customer.

Evaluation Findings

This section describes findings from the document review, staff interviews, and customer surveys.

Document Review and Staff Interviews

Cadmus summarized the following key information from the document review and staff interviews.

Savings Goals and Expectations

Due to its pilot status, behavioral savings from the RCBS Pilot were not included in EVT's 2012–2014 performance period savings goals. Therefore, no Quantifiable Performance Indicators were established for the RCBS Pilot.

In August 2013, OPower forecasted first-year annual savings of 14,040 MWh.[15] OPower later revised this forecast downward to 11,054 MWh after obtaining and analyzing Vermont utility customer billing data. OPower revised this forecast downward to 6,989 MWh after applying an improved forecasting model. Finally, in 2015 OPower updated the forecast of first-year annual saving to 6,918 MWh to reflect the temporary suspension of HER delivery. This report's Implementation Challenges and Changes section provides details on the HERs suspension. At the end of the first year, OPower reported that the RCBS Pilot met 86% of its revised forecasted savings.

Customer Eligibility, Selection, and Randomization

When selecting the HER recipient population, OPower conducted site-level and customer-level eligibility tests to ensure collection of valid data. After selecting the eligible customers, Cadmus randomly assigned these customers to treatment or control groups. Cadmus performed the randomization and generated five, independent samples for OPower. OPower then tested each of the five samples and selected one to be used for the RCBS Pilot.

HERs Content

OPower designed the HERs to accomplish the following four objectives:

1. **Generate awareness of customer's energy use** through a neighbor-to-neighbor comparison. The HERs show the customer's energy use in context with neighbors' use, hence capturing the reader's attention and motivating action.
2. **Provide insights** through a personal comparison of customers' own energy use over time.
3. **Provide a call to action** by providing customers with actionable steps they can take to save energy in their homes.
4. **Push participation** to EVT's energy efficiency programs by cross-promoting available rebates and program offerings.

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[15] Source: Opower presentation to EVT, November 3, 2014. T 141103 EVT Savings Forecast Explanation.pptx.

The HERs manifest these objectives as, respectively, the neighbor comparison, personal comparison, action steps, and cross-program promotion.

Neighbor Comparison

The neighbor comparison component graphically shows how a customer's household energy use compares to that of similar nearby households. OPower stated that the neighbor comparison typically serves as the most influential HERs component and—therefore—the most effective at encouraging behavioral change.

Personal Comparison

The personal comparison component graphically compares the customer's current electricity use to the same period from the previous year.

Action Steps

The action steps provide customers with three energy-saving tips, drawn from a library of hundreds of tips and customized based on the customer's profile. The action steps feature three types of tips:

1. **Quick Fixes** focus on energy-saving behaviors (e.g., unplug electronics when not in use) and ways to use energy-consuming equipment differently to achieve savings.
2. **Smart Purchases** focus on small energy-saving investments, such as buying energy-efficient light bulbs or installing efficient showerheads.
3. **Great Investments** describe how to achieve greater savings with larger investments, such as replacing an old refrigerator with an ENERGY STAR®-certified unit or applying more comprehensive weatherization (e.g., insulation).

OPower customizes the action steps by running an algorithm that uses the customer's usage data, demographic data, weather data, and proprietary data. EVT reported spending considerable time revising the eligible action steps with OPower to ensure provided tips proved relevant to Vermont customers.

Brand Marketing and Cross-Program Promotions

The HERs included EVT branding to raise brand awareness and listed the web address of EVT's energy efficiency program website (www.efficiencyvermont.com/connect) to drive customers to the site. The HERs and the web portal promoted EVT energy efficiency programs and rebate offerings (e.g., lighting, audits, weatherization).

Implementation Challenges and Changes

The PSD expressed concerns regarding the RCBS Pilot's large size, as it left little flexibility to test the RCBS Pilot on a smaller scale and to make changes based on test results for broader implementation. OPower explained that measuring the savings results of a residential behavior program to achieve a certain confidence level would require 10,000 control customers per usage band. EVT and OPower decided to set the treatment group at 100,000 customers, thereby maximizing the statistical threshold for the control group and achieving economies of scale due to set program costs. EVT reported that, after OPower screened Green Mountain Power's customer data for eligibility, only 130,000 eligible accounts remained. This meant the 126,000 customers in the RCBS Pilot constituted almost the entirety of Green Mountain Power's customer base. Furthermore, EVT noted that Vermont consists of roughly 260,000 total residential electric accounts, indicating that the RCBS Pilot includes nearly 50% of Vermont electric customers.

Given the rural nature of Vermont's customer population (i.e., primarily that many customers do not have proximate neighbors), the PSD staff expressed concerns that recipients would question the neighbor comparison. OPower clarified that the comparison may not require homes on the same block or street. Rather, the comparison addresses 100 nearby, occupied homes with similar characteristics (e.g., square footage, fuel types). EVT reported, however, that accurate square footage data does not exist for homes in Vermont, therefore limiting OPower's ability to project an accurate neighbor comparison with high precision.

To ensure customers did not misinterpret the neighbor comparison, OPower used the *Home Energy Report Welcome Letter* sent to customers to describe the method used to compile the neighbor comparisons. Additionally, EVT trained its customer service representatives on how to address questions and concerns about the neighbor comparison. Despite these efforts, EVT received negative customer feedback on the neighbor comparison, which resulted in the RCBS Pilot temporarily suspending HERs delivery for three-to-five months. The delivery pause occurred at the RCBS Pilot's five-month mark (March). Delivery resumed in August and incorporated the following changes:

- Sent a new welcome letter to familiarize customers with the HERs and EVT
- Featured the details and an FAQ addressing the neighbor comparison on a top section of the HERs
- Expanded the neighbor comparison language to ask, "Are we comparing you correctly? Tell us more about your home: EfficiencyVermont.com/Connect."
- Took out the "efficient" neighbor comparison bar graph for customers in the high-usage band
- Made opting out available through the web portal
- Added specificity that HERs focus on "electricity" use rather than general energy use

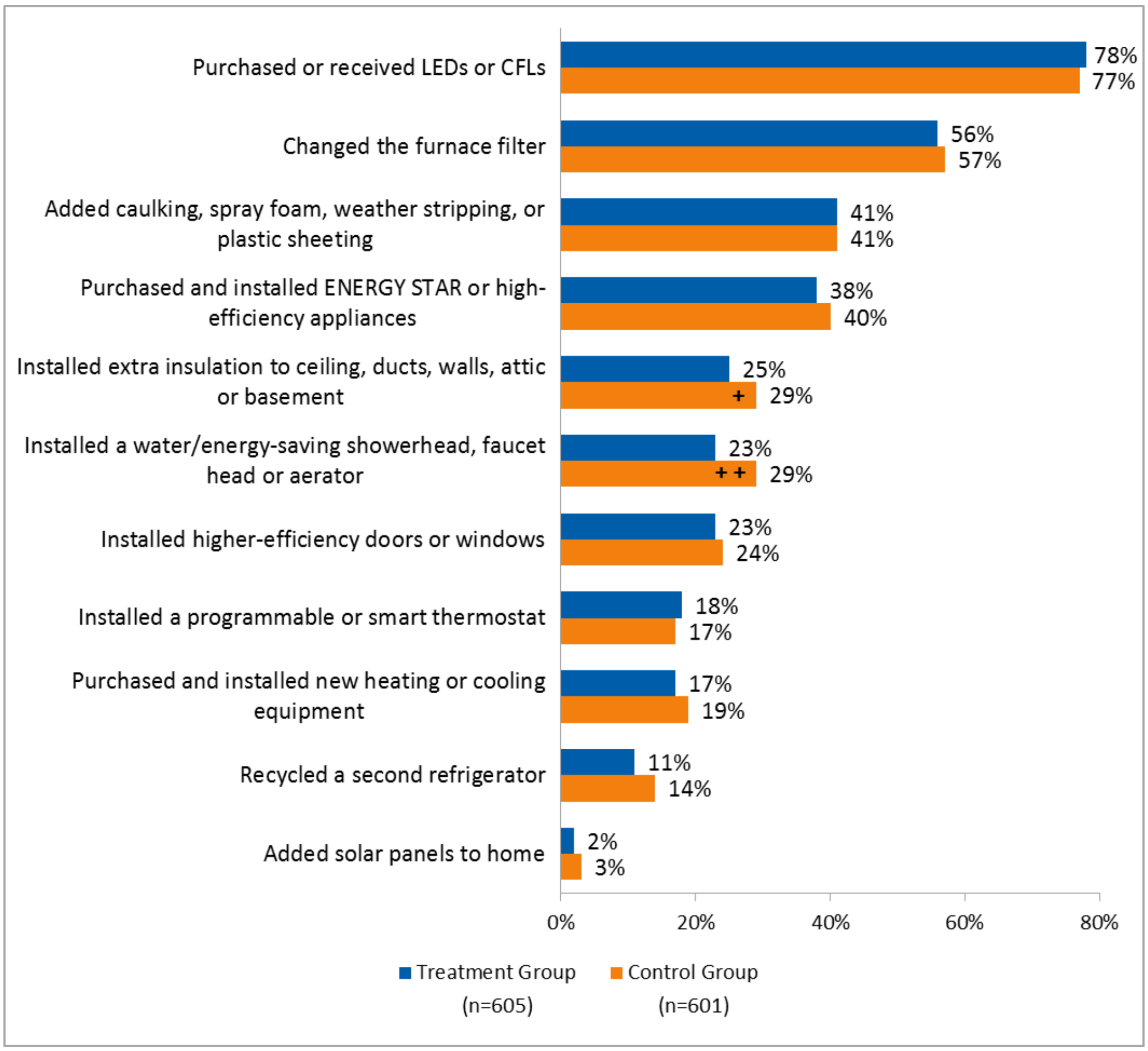
Customer Surveys

To assess the HERs' influence, Cadmus analyzed the customer survey data, using a t-test to compare proportions and means between groups and energy usage bands, and applying the test at the 5% ($p \leq 0.05$) and 10% ($p \leq 0.10$) significance levels. The following sections on the survey findings use plus signs to denote a statistically significant finding. A single plus sign (+) denotes 10% significance level and double plus signs denote (++) denote 5% significance level. Appendix B. Survey Results contains a copy of the survey results.

Self-Reported Energy-Saving Improvements

Treatment group respondents reported implementing energy-saving improvements at a lower rate than control group respondents. In eight out of 11 improvements shown in Figure 2, control group respondents reported a higher implementation rate. Two of these improvements—installed extra insulation+ and installed an energy-saving faucet head or aerator++—were statistically significant. Cadmus looked at differences at the energy usage level and found that, regardless of group, high-user respondents reported implementing improvements at a statistically significant higher rate than low-user respondents.++

Figure 2. Self-Reported Energy-Saving Improvements



+ Statistically significant difference at 10% level. ++ Statistically significant difference at 5% level.

Treatment and control group respondents reported no statistically significant differences in the broad category of purchasing or receiving energy-efficient light bulbs. When probed further, however, a statistically significant higher proportion of treatment group respondents (16%, n=461) reported purchasing LEDs compared to control group respondents (12%, n=450).[++] Although the survey did not ask about the number of LED bulbs purchased, it did ask the number of CFL bulbs purchased. No statistically significant differences emerged regarding respondents' reported number of CFL bulbs purchased; in the past 12 months, treatment group respondents purchased a mean of 10.1 CFL bulbs (n=312) and control group respondents purchased a mean of 9.6 CFL bulbs.

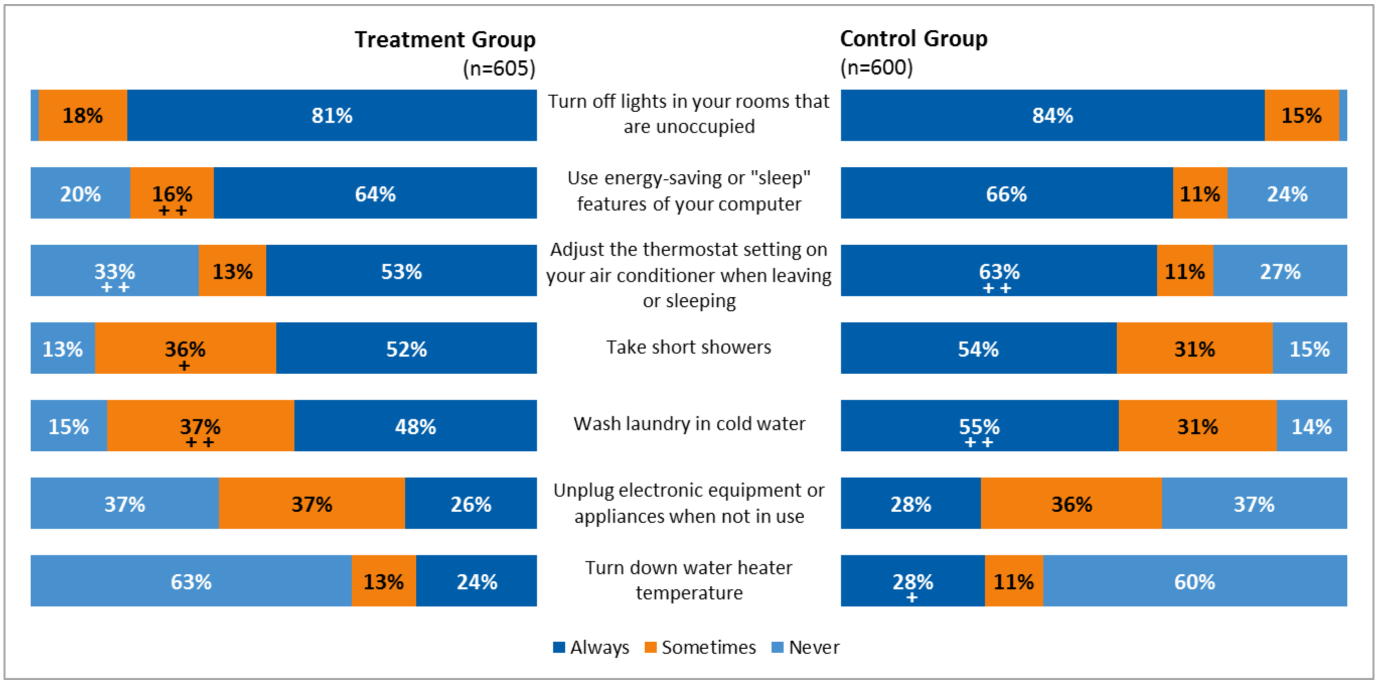
When asked to rate on how important they found the HERs in prompting energy-saving improvements, on a zero to 10 scale (where zero means "not at all important" and 10 means "very important"), treatment group respondents assigned a mean rating of 5.1 (n=442). At the energy-usage level, high- and low-user respondents assigned statistically significant higher mean ratings than medium-user respondents.[++] High-user respondents assigned a mean rating of 5.4 (n=155), medium-user respondents assigned a mean rating of 4.4 (n=144), and low-user respondents assigned a mean rating of 5.3 (n=143).

Cadmus followed up the HERs importance rating question with a question about specific energy-saving improvements the HERs prompted respondents to make. The top response was "none" or they had "already made improvements before receiving the HERs" (44%, n=442). The second most frequent response was "install CFLs or LEDs" (20%, n=442), which aligns with the HERs' lighting promotions.

Self-Reported Frequency of Energy-Saving Actions

Treatment group respondents reported taking energy-saving actions less frequently than control group respondents. For all seven actions shown in Figure 3, a higher proportion of control group respondents reported "always" taking these actions. Three of these actions—adjusting thermostat settings when leaving/sleeping,[++] washing laundry in cold water,[++] and turning down water heater temperatures[+]—proved statistically significant.

Figure 3. Self-Reported Frequency of Taking Energy-Saving Actions



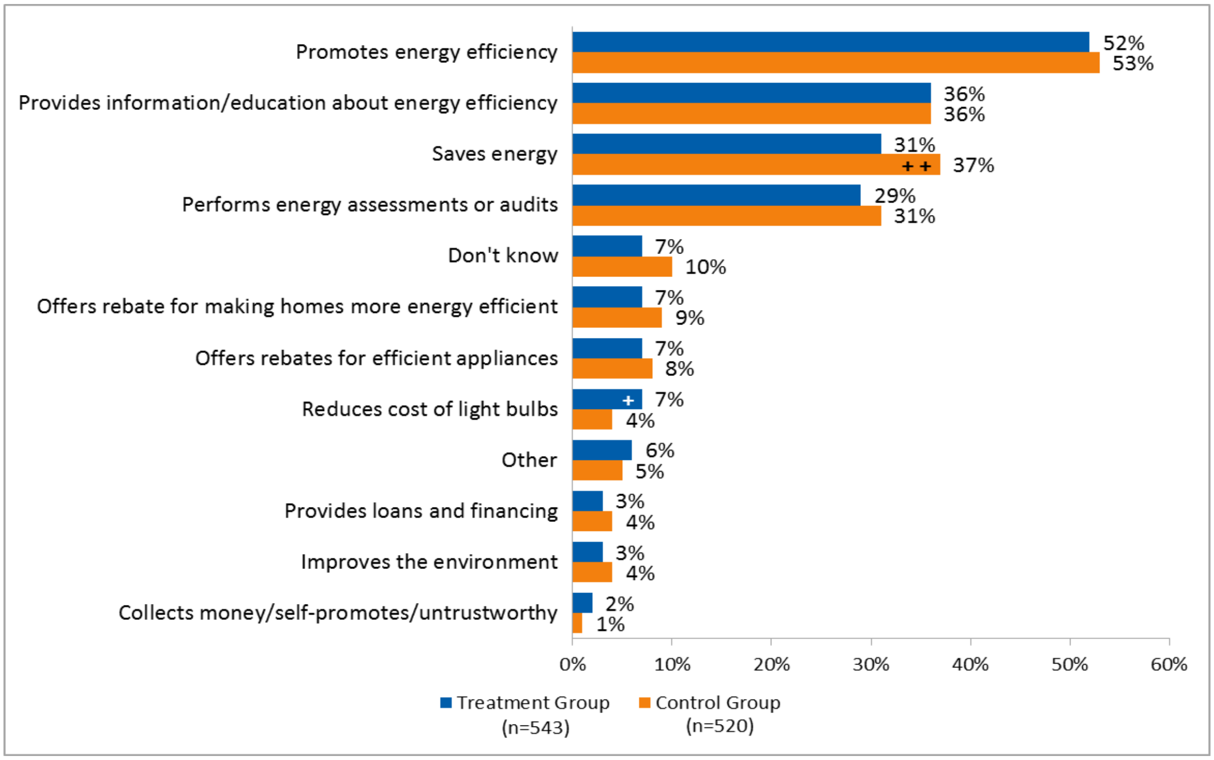
+ Statistically significant difference at 10% level. ++ Statistically significant difference at 5% level.

Cadmus looked at differences at the energy-usage level and found, within the treatment group, a statistically significant higher proportion of medium-user respondents reported "always" washing laundry in cold water and unplugging electronic equipment when not in use.[+] Within the control group, a statistically significant higher proportion of high-user respondents reported "always" unplugging electronic equipment when it was not in use[+] and turning down water heater temperatures.[++]

Awareness of Efficiency Vermont

A statistically significant higher proportion of treatment group respondents had heard of EVT, with 91% of treatment group respondents (n=600) having heard of EVT compared to 87% of control group respondents (n=596).[++] Cadmus did not find significant differences at the usage level. As shown in Figure 4, when probed further for EVT brand descriptions, a statistically significant higher proportion of treatment group respondents said EVT "reduces the cost of light bulbs"[+] while a statistically significant higher proportion of control group respondents said EVT "saves energy."[++] The significant finding on the treatment group's brand description aligns with the HERs' lighting promotions.

Figure 4. Efficiency Vermont Brand Descriptions



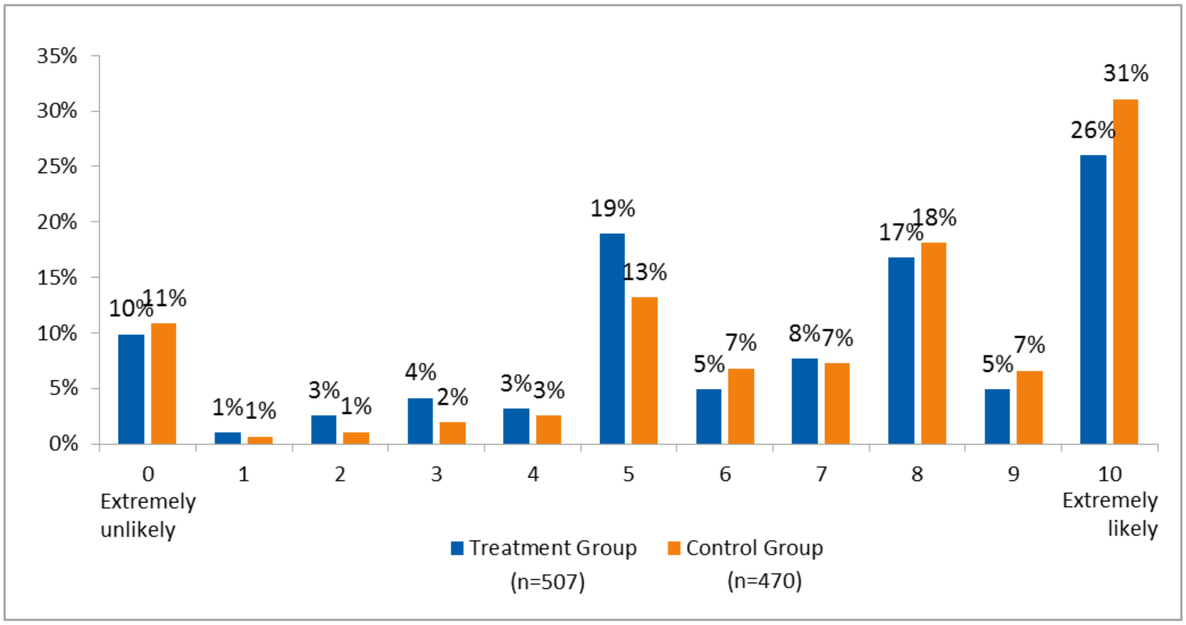
[+] Statistically significant difference at 10% level. [++] Statistically significant difference at 5% level.

Satisfaction with Efficiency Vermont

To assess satisfaction with EVT, treatment and control group respondents answered a question about "the likelihood to recommend EVT to a colleague or friend" on a zero to 10 scale (where zero means "extremely unlikely" and 10 means "extremely likely"). Only respondents who indicated they had heard of EVT answered this question.

Combining both groups, respondents on average assigned a rating of 6.7 (n=977). Control group respondents showed a statistically significant higher likelihood of recommending EVT.[++] Treatment group respondents assigned a mean rating of 6.5 (n=507), and control group respondents assigned a mean rating of 6.9 (n=470). Cadmus did not find statistically significant differences at the usage levels within the treatment group, but low-user respondents in the control group assigned significantly higher mean ratings (7.3, n=171).[+] Figure 5 shows the distribution of ratings for the likelihood to recommend EVT.

Figure 5. Satisfaction: Likelihood to Recommend Efficiency Vermont



Net Promoter Score

Cadmus also calculated a net promoter score (NPS), based on responses to the "likelihood to recommend EVT" question. The NPS is not expressed as a percentage, but rather as an absolute number between -100 and +100 that represents the difference between the percentage of promoters (respondents assigning a score of 9 or 10) and detractors (respondents assigning a score of 0 to 6). A positive score indicates more promoters than detractors.

Combined, the treatment and control group assigned an overall NPS of -7, though the control group generated a higher NPS than the treatment group. Specifically, the treatment group generated a NPS of -14, and the control group generated a NPS of +1.

Energy Efficiency Attitudes and Barriers

The two groups showed statistically significant differences in attitudes towards energy efficiency, with the control group respondents appearing more eco-friendly. Treatment group (n=603) and control group (n=600) respondents reported statistically significant different agreement levels on three out of the eight attitudinal statements asked in the survey:

- A significantly higher proportion of control group respondents strongly agreed with the statement "I am committed to actions that help the environment" (treatment 59%; control 65%).[++]
- A significantly higher proportion of control group respondents strongly agreed with the statement "I actively look for ways to reduce my carbon footprint" (treatment 43%; control 49%).[++]

- A significantly higher proportion of control group respondents strongly disagreed with the statement "energy-efficient products are too expensive" (treatment 19%; control 23%).+

Moreover, control group respondents perceived saving energy in the home to be easier than treatment group respondents. When asked to rate the ease of saving energy in the home on a zero to 10 scale (where zero means "extremely difficult" and 10 means "extremely easy"), control group respondents assigned a statistically significant higher rating;++ control group respondents assigned a mean rating of 6.5 (n=593) and treatment group respondents assigned a mean rating of 6.1 (n=581).

Cadmus also reviewed the demographic survey items for possible differences between the treatment and control group. No major differences emerged between treatment and control group respondents, except regarding homeownership. A statistically significant higher proportion of treatment group respondents (96%, n=605) owned their homes compared to control group respondents (93%, n=600)++ Appendix B. Survey Results presents full results for the demographic survey items.

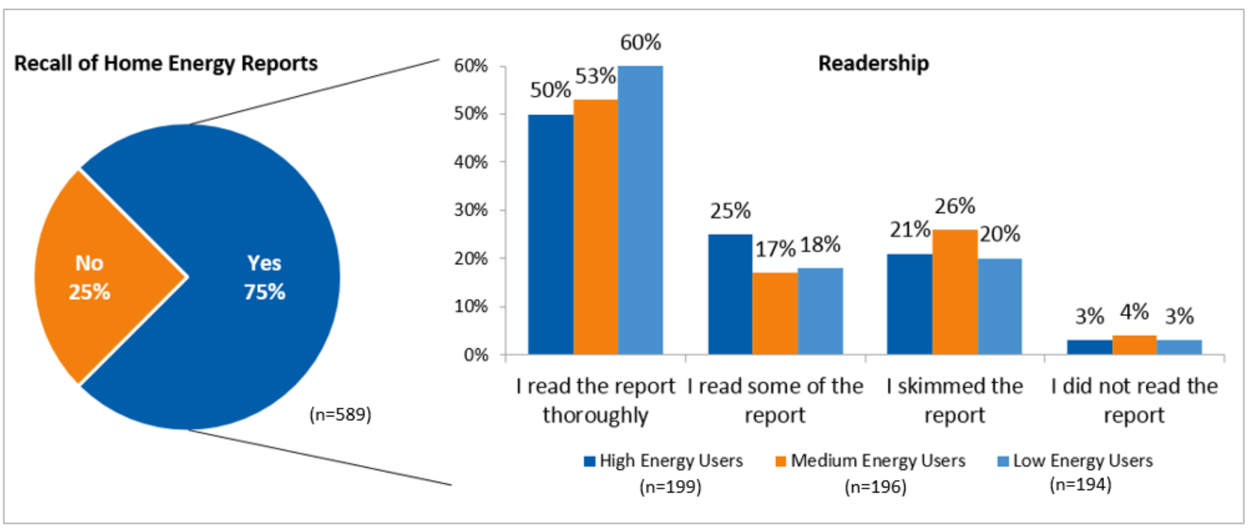
Reception to HERs

This section presents findings specific to the treatment group's reception of HERs.

Recall and Readership

Respondents had high recall of the HERs: 75% of respondents remembered receiving the reports. Of respondents recalling the HERs: 54% read the report thoroughly; 20% read some of the report, 22% skimmed the report; and 3% did not read the report. At the energy-usage level, low-user respondents displayed the strongest readership level, with 60% indicating they read the report thoroughly. Figure 6 shows HER recall and readership levels.

Figure 6. Recall and Readership of HERs



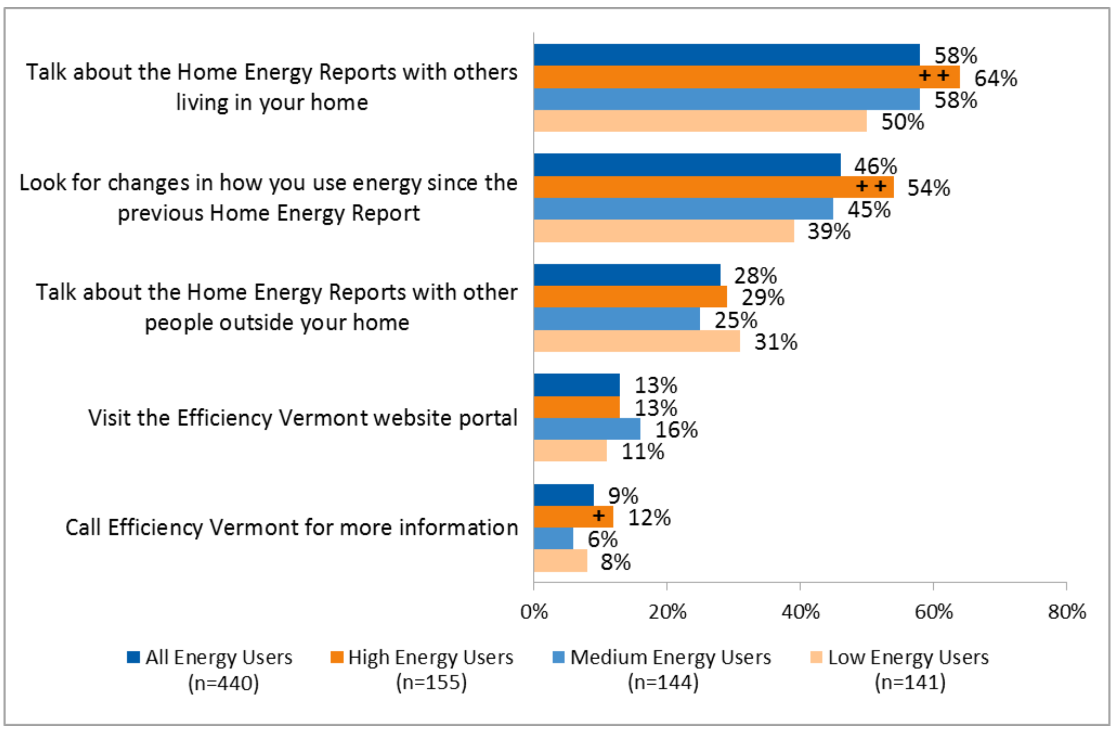
Neighbor Comparison

The HER neighbor comparison component also generated very strong recall levels: 91% of respondents (n=436) remembered seeing the neighbor comparison. Notably, a statistically significant higher proportion of high-user respondents (94%) remembered the neighbor comparison.[++] Of respondents who recalled seeing the neighbor comparison (n=343), 57% agreed with the statement “I believe the neighbor comparison is generally accurate.” In particular, a statistically significant higher proportion of low-user respondents (65%) agreed with the neighbor comparison accuracy statement.[++]

Engagement

HERs appeared to prompt household member discussions about energy use, but HERs did not move households to seek information from EVT. As shown in Figure 7, 58% of respondents reported talking about HERs with others in the home, while only 13% reported visiting the EVT website, and 9% called EVT for more information. Figure 7 also shows that high-user respondents showed statistically significant higher engagement levels with HERs in three out of five engagement categories.

Figure 7. Engagement with HERs



[+] Statistically significant difference at 10% level. [++] Statistically significant difference at 5% level.

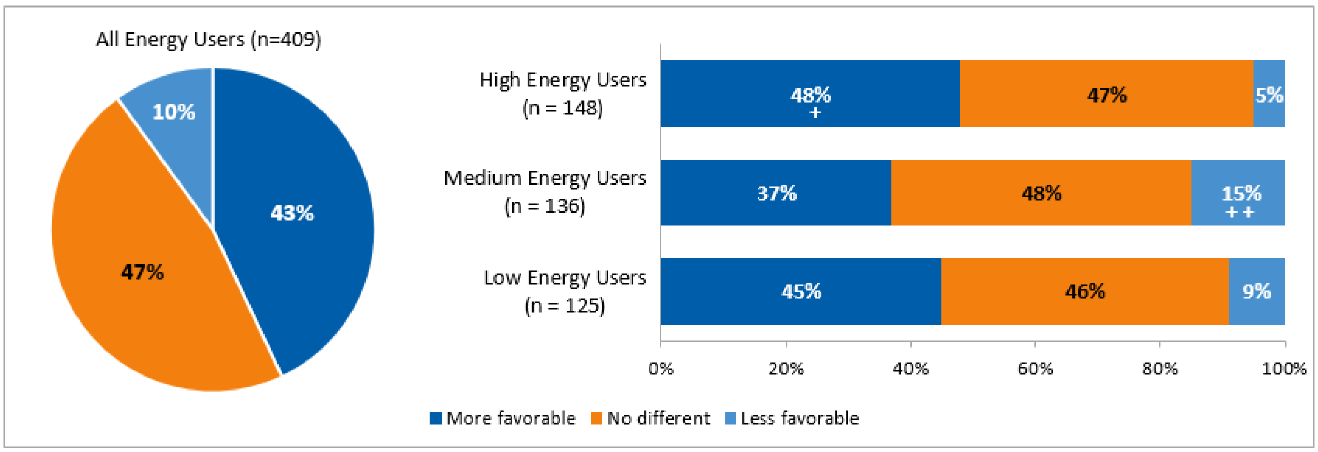
Satisfaction with HERs

Overall, respondents were moderately satisfied with the HERs, providing a mean satisfaction rating of 5.9 (n=434) on a zero to 10 scale (where zero means “extremely dissatisfied” and 10 means “extremely satisfied”). Notably, low-user respondents gave a statistically significant higher mean satisfaction rating of 6.5 (n=140) compared to high-user respondents (5.6, n=150) and medium-user respondents (5.6, n=144).[++]

Opinion of EVT After Receiving HERs

The majority of respondents did not change their opinion of EVT after receiving the HERs. As shown in Figure 8, 47% of respondents reported no differences in their opinions of EVT after receiving the HERs, though a close 43% did report a more favorable opinion of EVT. Specifically, a statistically significant higher proportion of high-user respondents reported a more favorable opinion of EVT,[+] while a statistically significant higher proportion of medium-user respondents reported a less favorable opinion of EVT.[++]

Figure 8. Opinion of EVT After Receiving HERs



[+] Statistically significant difference at 10% level. [++] Statistically significant difference at 5% level.

Six-Month vs. 12-Month Survey Results

Table 6 shows a side-by-side comparison of the six-month OPower survey results and the 12-month Cadmus survey results. Five out of the seven categories showed improvements at the 12-month mark, including NPS, awareness of EVT, and the accuracy of the neighbor comparison. Only two categories—satisfaction with the HERs and opinions of EVT—showed a downward trend.

Table 6. Six-Month vs. 12-Month Survey Results

Category	6-Month OPower Survey Results	12-Month Cadmus Survey Results	Trend (Difference)
NPS – Likelihood to recommend EVT	-25 overall	-7 overall	↑ 18 pts
	-27 treatment	-14 treatment	↑ 13 pts
Awareness of EVT	79% overall aware	89% overall aware	↑ 10%
	83% treatment aware	91% treatment aware	↑ 8%
Recall of HERs	71% recalled HERs	75% recalled HERs	↑ 4%
Readership of HERs	66% read to some extent	74% read to some extent	↑ 8%

Category	6-Month OPower Survey Results	12-Month Cadmus Survey Results	Trend (Difference)
Neighbor comparison is accurate	50% agreed with statement	57% agreed with statement	↑ 7%
Satisfaction with HERs	6.4 mean	5.9 mean	↓ 0.5 pts
Opinion of EVT after receiving HERs	48% more favorable of EVT	43% more favorable of EVT	↓ 5%

Energy-Savings Analysis

Cadmus analyzed customer monthly billing consumption to estimate the RCBS savings. Table 7 shows the results from Cadmus' preferred D-in-D model (Model 1) along with four other models used to test the robustness of the savings estimates.

Table 7. Customer Consumption Regression Results

Model:	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6 (Post-Only)
Average daily savings per customer (kWh), November 2014 - December 2014	0.0545 (0.050)	0.0626 (0.108)	0.0530 (0.052)	0.0621 (0.052)	0.0571 (0.051)	0.0364 (0.0478)
Average daily savings per customer (kWh), January 2015-December 2015	0.1571*** (0.038)	0.1393 (0.091)	0.1592*** (0.038)	0.164*** (0.038)	0.1609*** (0.038)	0.1596*** (0.0367)
Customer Fixed Effects	Yes	No	Yes	Yes	Yes	No
Weather Variables	Yes	No	No	Yes	No	Yes
Month-Year Fixed Effects	Yes	No	No	No	Yes	Yes
Model R-squared	**0.116**	0.001	0.002	0.110	0.107	0.928

Notes: The dependent variable is: customer average daily electricity consumption for a month and year during the analysis period. Models estimated by OLS and standard errors in parentheses clustered on customers. All models use pre-treatment and post-treatment monthly consumption data except Model 6.
***denotes statistically significant at the 1% level, ** denotes 5%, and * denotes 10%.

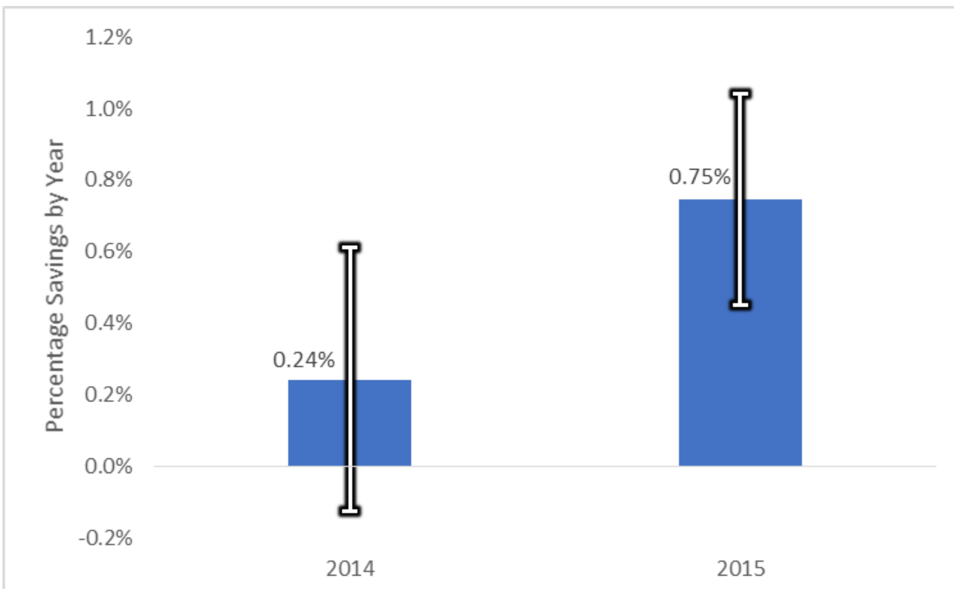
Average daily savings per customer are estimated separately for the program's first two months (November–December 2014) and for calendar year 2015. Cadmus' preferred model includes customer fixed effects, month-by-year fixed effects, and HDD and CDD weather variables.

During 2014, savings averaged 0.055 kWh per day per customer, but this savings estimate was not statistically significant. During 2015, customers saved an average of 0.157 kWh per day—a savings estimate statistically significant at the 1% level. For perspective, the 2015 estimated savings could be achieved by turning off a 100-watt incandescent lamp for about 1.5 hours per day or by replacing one 60-watt incandescent lamp, used for three hours each day, with one 8-watt LED.

Models 2 through 5 test the robustness of Model 1 by alternately removing customer fixed effects, weather variables, and month-year fixed effects. Cadmus' estimated savings for 2014 and 2015 remain highly robust to changes in model specification, as including or removing terms from the model did not affect the point estimates. Cadmus' savings estimate for 2015 proved significant across the majority of models—an expected result, as estimates of treatment effects in large randomized field experiments typically prove robust to changes in model specifications. Cadmus' savings estimate for 2014 was not significant in any of the models, but this should not be surprising: the program had only just started sending reports to customers in November 2014. Model 6 employs the post-only approach of Allcott and Rogers (2014), and it also yielded a savings estimate similar to that of Model 1.

Figure 9 shows average daily savings per customer as a percentage of average daily consumption of control group customers.

Figure 9. Percentage Savings by Year



Notes: Percentage savings estimated as estimates of average daily savings per customer from Model 1 to average daily consumption of control group customers.

Treatment customers achieved savings of 0.24% during 2014 and 0.75% during 2015. These percent savings were lower than those typically found for a first-year OPower HER program. Typically, such programs average between 1% and 2%. This result, however, can be explained by three factors unique to Vermont and EVT's RCBS Pilot program.

First, Cadmus' pre-program research suggested that the vast majority of Vermont customers do not heat their homes with electricity, with most customers relying on heating oil, natural gas, propane, and/or wood.[16] Also, Vermont's relatively cool summers and the low penetration of central air conditioning in Vermont homes also likely result in smaller air conditioning loads.[17] Cadmus' analysis of pre-program consumption during the random assignment of homes also indicated most homes in the sample already used much less electricity than homes in most other areas of the country. Across all fuels and sectors, Vermont's total energy consumption per capita in 2013 was the fifth-lowest in the United States.[18]

Second, suspension of HERs during 2015 reduced savings for the program. Cadmus' previous research has shown that energy savings from home energy reports decay after treatment stops. Savings decay is usually rapid if the treatment duration lasted less than one year.[19] Given the RCBS pilot ran for less than a year when suspended, customers may have not had enough time to internalize behavioral messaging and to implement behavioral changes or energy-saving measures when report delivery was suspended.

Third, the RCBS Pilot's savings potential was less than that for most other utility HER programs as it included a significant number of low- and medium-usage customers. Many HER programs have focused on high-usage customers, who offer the greatest savings potential.

Figure 10 shows the program savings by month. The effect of the HER delivery suspension from March through August 2015 can be seen clearly in the figure, as savings dropped off after the April pause and remained low throughout the summer until the resumption of HER delivery after August. Then, savings increased quickly, reaching pre-suspension levels within two months. The decrease in savings after the suspension and the increase in savings after resumption of delivery provide additional evidence that the HERs cause customers to save energy.

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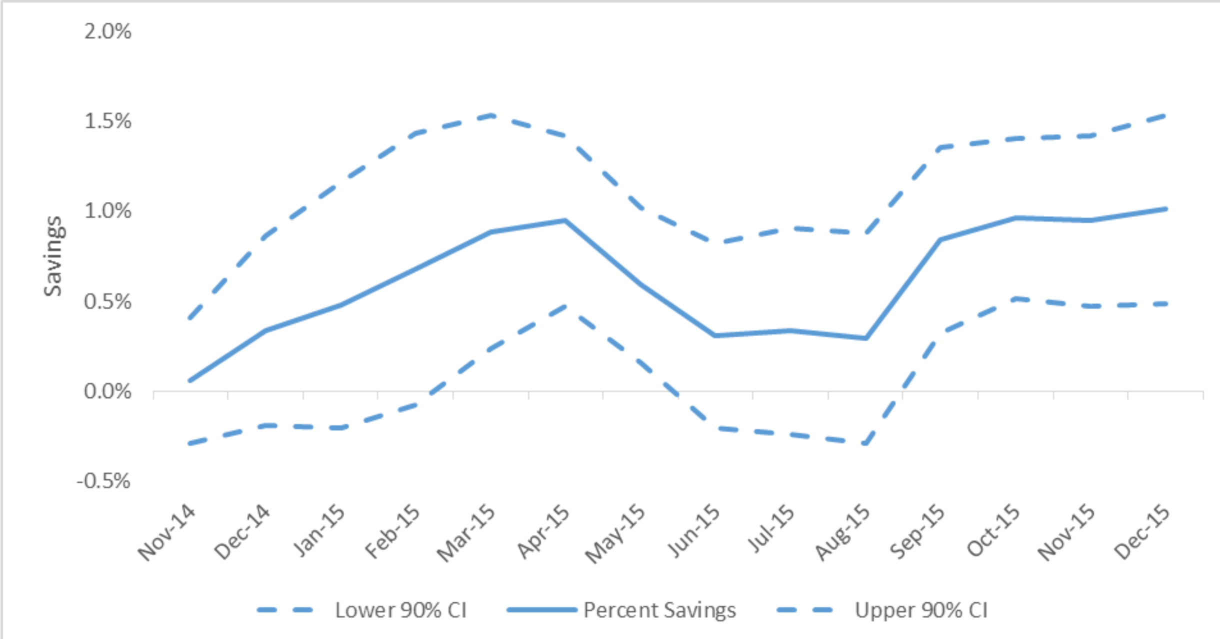
16 See NMR Group, Inc. 2013. *Vermont Single-Family Existing Homes Onsite Report FINAL 2/15/2013.* Available at: http://publicservice.vermont.gov/sites/dps/files/documents/Energy_Efficiency/EVT_Performance_Eval/VT%20SF%20Existing%20Homes%20Onsite%20Report%20-%20final%20021513.pdf

17 Among NMR Group's onsite inspection group, just 17% of homes had a window air conditioning unit, and only 2% had a central AC system.

18 U.S. Energy Information Administration. Rankings: Total Energy Consumed per Capita, 2013 (million Btu). Available at: http://www.eia.gov/state/rankings/?sid=VT#series/12

19 For evidence about HER savings decay after treatment stops, see Khawaja, M. Sami, and James Stewart. 2014. *Long Run Savings and Cost-Effectiveness of Home Energy Report Programs.* Available at: http://www.cadmusgroup.com/papers-reports/long-run-savings-cost-effectiveness-home-energy-report-programs/.

Figure 10. Program Savings by Month



Notes: Savings estimates based on D-in-D regression analysis of customer monthly energy use on month-year fixed effects, HDD and CDD weather variables, customer fixed effects, and month-year fixed effects interacted with treatment indicator variable. Confidence intervals estimated using standard errors clustered on customers.

Also note that the lower bound of the 90% confidence interval drops below zero during this period, meaning savings during summer 2015 were not statistically different from zero. Finally, RCBS Pilot savings did not appear to exhibit seasonality, owing to the low penetration of central electric heating and air conditioning in Vermont homes.

Regression Results for Usage Groups

Cadmus also estimated HER savings for the low-, medium-, and high-use customers. To estimate savings by usage group, Cadmus separately estimated the preferred model specification (described above) for each of the three usage groups, producing the results shown in Table 8.

Table 8. Regression Results for Energy Use Groups

Energy Use Group:	High	Medium	Low
Average daily savings per customer (kWh), November 2014–December 2014	0.0916 -0.152	0.0098 -0.0886	0.059 -0.0471
Average daily savings per customer (kWh), January 2015–December 2015	0.3638*** -0.108	0.108 -0.0699	0.0723* (0.0370)
Model R^2	0.1845	0.1412	0.1074
Number of Homes	31338	31356	62019
Number of Monthly Observations	788565	784465	1528560

Notes: The dependent variable is: customer average daily electricity consumption for a month and year during the analysis period. All models include customer fixed effects, month-by-year fixed effects, and HDD and CDD weather variables. Models estimated by OLS and standard errors in parentheses were clustered on customers.
***, **, *denotes statistically significant at the 1%, 5%, and 10% levels, respectively.

As expected, the high-use group exhibited the greatest savings, with an average of 0.364 kWh per day saved during 2015. This result proved statistically significant at the 1% level. The low-use group saved the least: 0.072 kWh per day on average (statistically significant at the 10% level). The medium-use group saved slightly more than low users, but their savings were not statistically significant. The analysis sample, however, was much smaller when estimating savings separately by usage group, and the medium-use group also was the smallest of the three. As expected, 2014 savings estimates did not prove statistically significant for any usage group.

Figure 11 shows these results as a percentage of each control group's consumption during the program period. In 2015, high-use customers saved approximately 1% of consumption. Medium-use and low-use customers saved about 0.5% of consumption.

Figure 11. Percentage Savings by Year and Energy Usage Group

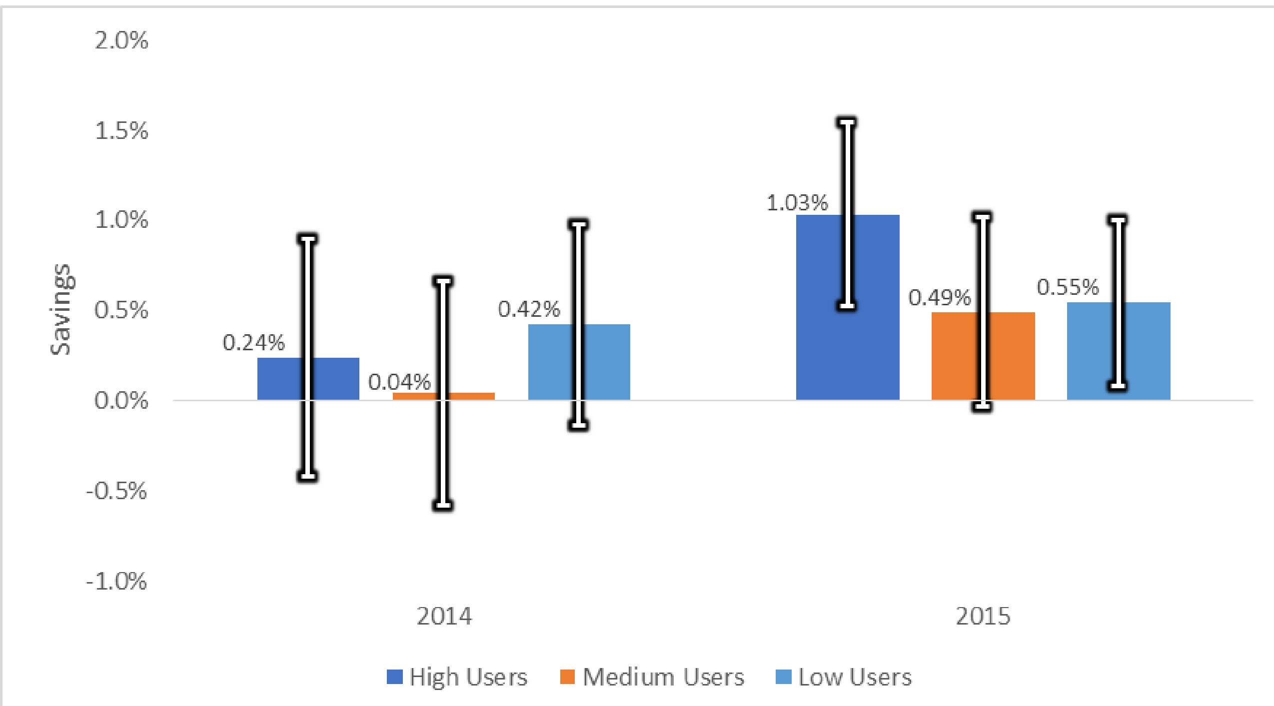
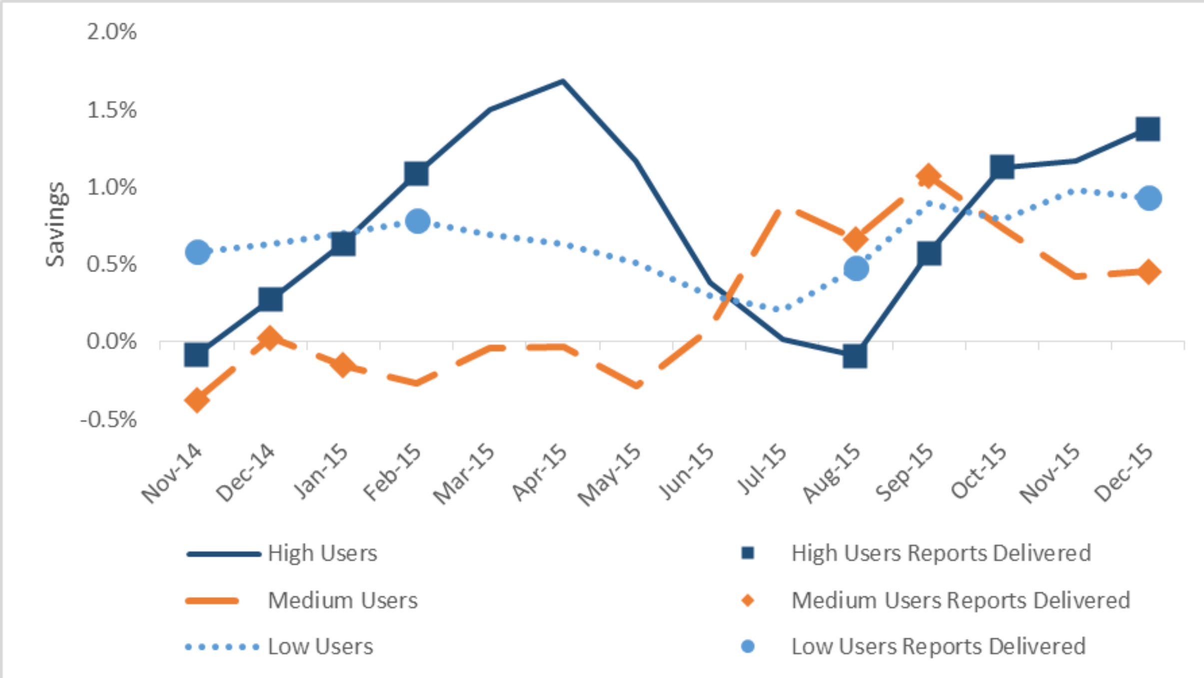


Figure 12 shows point estimates of monthly program savings for each energy usage group. To not obscure the savings estimates, the figure does not display estimated confidence intervals.

Figure 12. Program Savings by Month and Usage Group



High-energy users' savings decayed rapidly after the program temporarily suspended delivery of HERs, suggesting customers had not yet fully internalized efficiency behaviors and needed additional reinforcement to continue to save energy. Savings of high users also appeared to exhibit some seasonality, with energy use peaking during the winter months. This result would be consistent with many high users employing electricity for space heating or having large lighting loads.

Medium users, however, did not produce the expected savings. They saved less energy than low users and none for the program's first eight months. During summer 2015, medium users began to save energy and at about the same rate as low users in the fall.

Program Savings Estimates

Table 9 shows annual savings achieved by the program in 2014 and 2015. Cadmus estimated these savings by multiplying the estimate of average daily savings per home by the total number of program days for treated homes.[20]

[20] The number of program days per customer is defined as follows: the number of days between the date that Opower generated the customer's first print report and either the end of the calendar year (December 31) or the home's inactive date, whichever comes first. A few treatment group customers' accounts remained active after November 2014, but lacked a first print report date. In such cases, Cadmus assigned the customer the average first report date of all other customers with non-missing data.

Table 9. Total RCBS Pilot Savings by Year

Year	Average Daily Savings per Customer (kWh)	Number of Customer Treated Days	Total Program Savings (MWh)	Lower Bound 90% CI	Upper Bound 90% CI
2014	0.0545	5,569,450	304	-158	765
2015	0.1571	35,777,990	5,621	3,390	7,851
Total		**41,347,440**	**5,925**	**2,983**	**8,866**

Notes: Estimates of average daily savings per customers in 2014 and 2015 obtained from Model 1 of Table 7.

Between November 2014 and December 2014, the RCBS Pilot saved 304 MWh. During 2015, the RCBS Pilot saved 5,621 MWh, with an estimated 90% confidence interval for the savings of [3,390 MWh, 7,851 MWh].

Table 10 shows total savings achieved for each energy usage group in 2014 and 2015. As usage group savings were estimated using separate regression analyses, the sum of usage-group savings may does not equal the estimated program savings in Table 9.

Table 10. Total Program Savings by Year and Energy Usage Group

Year	Usage Group	Average Daily Savings per Customer (kWh)	Number of Customer Treated Days	Total Program Savings (MWh)	Lower Bound 90% CI (MWh)	Upper Bound 90% CI (MWh)
2014	High	0.0916	1,406,137	129	-224	481
	Medium	0.0098	1,405,694	14	-191	219
	Low	0.0590	2,757,619	163	-51	376
2015	High	0.3638	9,110,200	3,314	1,690	4,939
	Medium	0.1080	9,063,156	979	-63	2,021
	Low	0.0723	17,6046,34	1,273	201	2,344

Notes: Estimates of average daily savings per customers in 2014 and 2015 obtained from Model 1 of Table 8. Program savings estimates equal the product of average daily savings per customer and the number of customer treatment days (see the text for details).

In 2015, customers in the high-usage group saved 3,314 MWh, and customers in the low-usage group saved 1,273 MWh. Medium-use customers saved just less than 1,000 MWh.

Comparison of OPower Reported Savings and Evaluation Savings Estimates

Table 11 compares OPower's forecasts of annual savings, OPower's savings estimates, and Cadmus' savings estimates for 2014 and 2015. OPower forecasted savings of 465 MWh for 2014 and 8,012 MWh for 2015. OPower reported savings of 460 MWh in 2014 and 6,284 MWh in 2015. Cadmus estimated savings of 304 MWh in 2014 and 5,621 MWh in 2015 or 88% of Opower's reported savings for both years. Though OPower's savings estimates were greater than the evaluation savings estimates (by 150 MWh in 2014 and by 663 MWh in 2015), the 90% confidence intervals for the evaluated savings contained OPower's estimates.

Table 11. Comparison of Cadmus and OPower Savings Estimates

Year	Opower Savings Forecast**		OPower Savings Estimate*		Cadmus Evaluation Savings Estimate		OPower Estimate Within Evaluation 90% Confidence Interval?
	MWh	MWh	MWh	Percent Savings	MWh	Percent Savings	
2014	465	460	460	0.31%	304	0.24%	Yes
2015	8,012	6,284	6,284	0.84%	5,621	0.75%	Yes
Total	**8,477**	**6,744**	**6,744**	**0.76%**	**5,925**	**0.49%**	**Yes**

*Source: EVT - Monthly Savings Results - Jan 2016.xlsx. Workbook provided to Cadmus from EVT and originally provided to EVT by Opower.

**Opower made forecasts in October 2014 and October 2015. Source: EVT – Monthly Savings Results – Oct 2015.xlsx and EVT – Monthly Savings Results – Jan 2016.xlsx . Workbooks provided to Cadmus from EVT and originally provided to EVT by Opower.

Cadmus attempted to reconcile the differences between the evaluation and OPower savings estimates. Cadmus obtained a description of the steps OPower took to prepare the customer billing data and to

estimate the savings and compared them to those taken by Cadmus. Cadmus used almost identical steps for preparing the data, so this is unlikely the source of the difference in savings. As shown in Table 7, Cadmus estimated multiple model specifications, including post-only model specifications (Allcott and Rogers), the method employed by OPower, and obtained savings estimates similar to the D-in-D specifications. In addition, we attempted other tests, such as dropping energy use observations for October 2014, which, after the allocation of billing cycle consumption to calendar months, might contain some post-treatment energy use. These tests produced similar results.

EVT Efficiency Program Uplift Analysis

This section reports estimates of HER impacts on participation in EVT's efficiency programs. The analysis compared participation rates and average savings per customer for customers in the program treatment and control groups.

Downstream Rebate Programs

Table 12 shows participation uplift and savings uplift for EVT's downstream rebate programs:

- The first column (Baseline Participation Rate) shows the participation rate of customers in the control group.
- The second column (Participation Uplift) shows HERs' effect on the participation rate, measured as the difference in the participation rate between treatment and control group customers.
- The third column (% Participation Uplift) presents the treatment effect, expressed relative to the baseline rate.

The uplift analysis covered participation in and savings from EVT efficiency programs between November and December 2014 and between January and December 2015.[21] Cadmus does not report standard errors because the uplift analysis included the whole program population and did not involve econometric or statistical modeling.

21 The programs or measure groups included: Air Conditioning Efficiency; Cooking and Laundry; Hot Water Efficiency; Hot Water Replacement; Light Bulb Lamp (Direct Install); Lighting Hardwired Fixtures; Office Equipment and Electronics; Refrigeration; Space Heat Efficiency; Space Heat Fuel Switch; Space Heat Replacement; Thermal Shell; and Ventilation. In addition, a small number of customers participated in: Health and Safety; Industrial Process Efficiency; Lighting Efficiency Controls; Motors; Motor Controls; and Water Conservation. Even though HERs encouraged home energy efficiency, the reports may have caused some recipients to undertake efficiency improvements in their workplaces, including in home offices or shops. The following nine programs accounted for 88% of all installed measures: Air Conditioning Efficiency (6.7%); Cooking and Laundry (10.6%); Hot Water Efficiency (7.8%); Lighting Hardwired Fixtures (12.6%); Light Bulb Lamp (14.9%); Office Equipment Electronics (6.4%); Refrigeration (14.1%); Space Heat Efficiency (10.6%); and Thermal Shell (3.8%).

Table 12. EVT Energy Efficiency Program Participation and Savings Uplift

Year	Baseline Participation Rate (per 1,000 Customers)*	Participation Uplift (Treatment Effect on Participation Rate)	% Participation Uplift	Uplift Savings (kWh)
2014	16.0	1.4	8.5%	-7,430**
2015	41.9	3.2	7.6%	14,327

Notes: Results based on analysis of EVT energy efficiency program tracking data and HER program participation data (see text for variable definitions).
*Baseline participation rate was the rate of participation of GMP customers in the randomized control group.
**Positive participation uplift and negative uplift savings can occur if the treated customers participate at a higher rate than control customers, but control customers save more energy per installed measure.

In 2014, the EVT downstream rebate program baseline participation rate was about 16 per 1,000 customers. The treatment group customers' participation rate during the same period was about 1.4 per 1,000 customers higher, implying the HERs increased efficiency program participation by 9%. However, as the year 2014 covered only the first two program months, the 2014 analysis only provides a picture of the initial uplift.

During calendar year 2015, the EVT program baseline participation rate was about 42 per 1,000 customers. The HERs' treatment effect increased the participation rate by about 3.2 per 1,000 customers (about 14%). This effect probably would have been greater had HER delivery not been suspended for several months.

Table 12 also shows the savings uplift. As noted in the uplift analysis methodology, Cadmus pro-rated the annualized deemed savings to account for mid-year installation dates of measures and normal HDD/CDD distributions during the calendar year for weather sensitive measures. Also, savings uplift reflected HER effects on both participation rates and savings per program measure. If control group customers proved more likely than treatment group customers to install high-impact measures, negative savings uplift could result, even if treatment group customers participated at a higher rate.

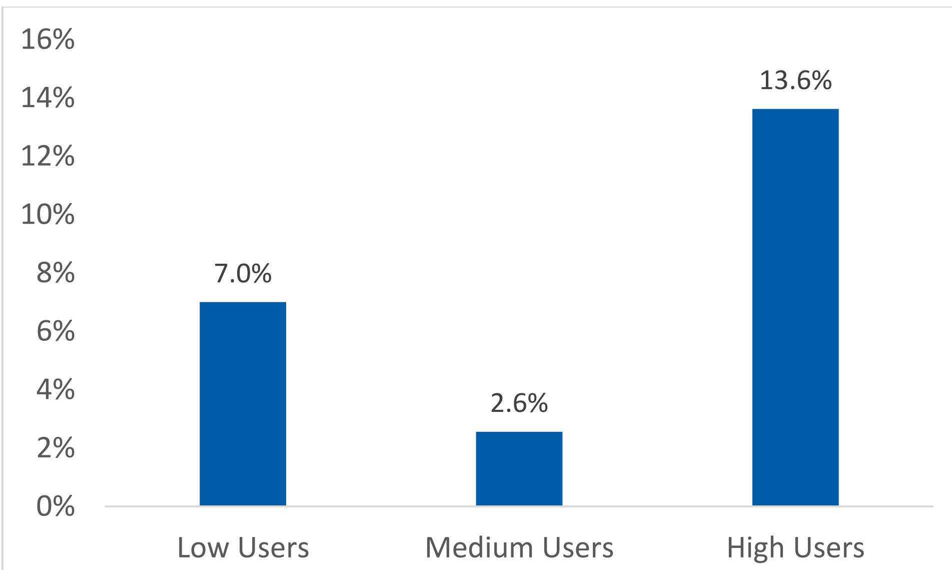
In 2014, uplift savings were -7.4 MWh. Though HERs increased the participation rate, control group customers saved more energy per customer from program participation than treatment group customers. In 2015, savings uplift equaled about 14 MWh or about 0.3% of the estimated savings (5,621 MWh). In comparison to uplift savings for downstream program estimated for other utility HER programs implemented by OPower, the uplift savings constituted a relatively small percentage of HER savings. The likely explanation for this difference was that the RCBS Pilot included both low and medium use customers and that most EVT customers had neither electric heat nor central air conditioning and therefore were ineligible to receive rebates for installing high-impact electric efficiency space heating and cooling measures.[22]

[22] Most Opower HER program evaluations during the first program year have realized savings from participation uplift of between 1% and 5%.

EVT programs counted savings from all rebated measures, including savings from measures attributable to HERs. The regression analysis used to estimate HER savings also counted savings from rebated measures attributable to HERs. Therefore, to avoid double counting the uplift savings, EVT should subtract the uplift savings from the portfolio savings. Specifically, EVT should subtract 14.3 MWh from the portfolio savings for the 2015 program year.

Figure 13 shows results of the 2015 uplift analysis for each energy-use group. Participation uplift relative to the baseline participation rate was 7% for low-energy users, 3% for medium-energy users, and 14% for high-energy users.[23] Treatment group customers with the highest pre-treatment energy use were most likely to participate in EVT's efficiency programs after treatment. The percent uplift for high-energy users was about twice as high as that for low-energy users and five times as high as that for medium-energy users. As HERs helped educate customers about energy-savings opportunities and EVT offerings, this correlation suggests that high-energy users either expected the greatest benefits from participation or that high-energy users were least constrained in their ability to take action, perhaps because they had more financial resources with which to make efficiency investments.

Figure 13. EVT Energy Efficiency Program Participation Uplift for 2015 by Energy-Use Group



Note: Results based on analysis of EVT energy efficiency program tracking data and HER program participation data (see text for variable definitions). Figure shows for each energy use group participation uplift relative to baseline rate of participation.

Table 13 reports results of the uplift analysis for the EVT programs accounting for the largest number of measure installations: Cooking and Laundry, Hot Water Efficiency, Light Bulb Lamp [Commercial Direct Install], Lighting Hardwired Fixture, Refrigeration, and Space Heating Efficiency). Treatment's effect on

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[23] The baseline rate of participation was 2.5% for low usage customers, 3.1% for medium-usage customers, and 3.0% for high-usage customers.

the rate of participation varied across these programs, ranging from lows of -8% for Cooking and Laundry, 3% for Lighting Hardwired Fixture and 5% for Space Heating Efficiency to highs of 23% for Refrigeration and 40% for Hot Water Efficiency.

Table 13. Participation Uplift in 2015 for EVT Energy Efficiency Programs

Program	Baseline Participation Rate (per 1,000 Customers)	Participation Uplift (Treatment Effect on Participation Rate per 1,000 Customers)	% Participation Uplift
Cooking and Laundry	7.9	-0.6	-8%
Hot Water Efficiency	4.2	1.7	40%
Light Bulb Lamp (Direct Install)	10.5	1.2	11%
Lighting Hardwired Efficiency	8.7	0.2	3%
Refrigeration	7.4	1.8	23%
Space Heat Efficiency	5.8	0.3	5%

Note: Results based on analysis of EVT energy efficiency program tracking data and HER program participation data (see text for variable definitions).

Finally, it is important to note these uplift effects were estimated for the rebates offered by EVT in 2014 and 2015. Different rebate amount or other program incentives, eligible products, and application processes may have produced different participation and savings uplift results. For example, if EVT rebates had been 50% higher, it is possible that participation uplift and savings uplift would have been greater.[24]

Upstream Rebate Programs

Cadmus also estimated uplift and savings uplift for upstream rebate lighting. Unlike for downstream measures, a database did not exist that recorded purchases of rebated CFLs and LEDs that could be linked to individual treatment and control group customers. Consequently, Cadmus surveyed treatment and control group customers about their purchases of CFLs and LEDs, and used survey responses to estimate HERs' impacts on efficient lighting purchases.

As described in the customer survey analysis section, Cadmus asked survey respondents questions about the following regarding their purchases of efficient lighting products during the previous 12 months:

- Whether they had purchased or received CFLs
- Whether they had purchased LEDs
- If they purchased CFLs, how many had they purchased

When Cadmus administered the survey, the RCBS program had been running for about 13 months.

As shown in Figure 2, small and statistically insignificant differences occurred in the percentage of treatment group and control group customers who reported purchasing a CFL or LED (i.e., 77% of

24 If HERs increase awareness of utility customers about EVT rebates, then, for a given rebate level, some customers who become aware because of HERs will participate in the program while others who become aware will not. Assuming higher rebates increase the probability that an aware customer will adopt, HERs will have a greater effect on adoption for a larger rebate than for a smaller one.

treatment group customers and 78% of control group customer reported purchasing a CFL during the previous 12 months). Treatment group customers, however, were 25% more likely to have reported purchasing an LED (16% vs. 12%)—a statistically significant difference.

Table 14 shows the average number of CFLs per customer that respondents in the treatment and control group reported purchasing in the previous 12 months. Treatment group customers reported purchasing an average of 0.5 CFLs per customer more than control group customers. By multiplying this difference by the annualized deemed unit savings, Cadmus estimated that the average annual savings per customer from the purchase of an upstream program CFL was 12.0 kWh/year.[25] However, the difference in number of CFLs purchased was not statistically significant.

Table 14. Self-Reported CFL Purchases

Year	Average Number of CFLs Purchased per Treatment Group Customer	Average Number of CFLs Purchased per Control Group Customer	Difference	p-value from Significance Test
All Customers (N=902)	7.1	6.6	0.5	0.31
Customers Who Reported Purchasing a CFL (N=633)	10.1	9.6	0.5	0.35

Note: Data obtained from customer survey responses to questions about CFL purchases during the previous 12 months.

Table 14 also shows the average number of CFLs purchased per customer for treatment and control group customers who reported purchasing at least one CFL in the previous 12 months. Again, the 0.5 CFLs per customer difference between the treatment and control groups was not statistically significant.

Cadmus recommends that EVT not subtract the uplift savings for efficient lighting products from the portfolio savings. First, the difference in self-reported CFL purchases between treatment and control group customers statistically did not differ from zero, indicating a high probability that the difference occurred by chance. Second, the survey did not ask respondents if the purchased CFLs had been rebated by EVT. Only savings from rebated CFLs would have been double-counted and should be subtracted from the portfolio savings. Cadmus did not ask if the purchased bulbs were rebated by EVT as customers would likely be unaware of upstream CFL incentives.

AMI Data Analysis

This section presents the results and findings of the peak savings analysis, the hourly savings analysis, and the lighting efficiency savings analysis.

[25] In the 2015 Vermont Technical Resource Manual, a CFL produced annualized deemed unit savings of 23.9 kWh.

Peak Savings Analysis

Table 15 shows average savings per customer per hour and RCBS Pilot savings per hour for New England-ISO summer peak hours when energy-efficiency resources may be bid into the forward capacity market. Cadmus estimated RCBS Pilot savings by multiplying the estimate of the average hourly savings per customer by the average number of treated customers during the peak season.

The RCBS Pilot did not achieve peak savings during summer 2015. The point estimate of average savings per customer per hour (-0.002 kWh) was negative and statistically insignificant. The RCBS Pilot did not save energy during summer peak hours because EVT and Opower suspended delivery of HERs in March 2015, and savings decayed after treatment stopped. Delivery did not resume until August 2015.

Table 15. Summer 2015 Peak Savings Estimates

	Point Estimate	Standard Error	Lower Bound 90% Confidence Interval	Upper Bound 90% Confidence Interval	Percent Savings
Average Savings per Customer (kWh/hour)	-0.002	0.002	-0.006	0.002	-0.3%
RCBS Pilot Savings (MWh/hour)	-0.22	0.23	-0.599	0.164	-0.3%

Notes: Average savings per customer per peak hour obtained from OLS regression of customer kWh/hr for summer peak hours when passive demand resources can be bid into New England-ISO market (non-holiday weekdays between 1:00 p.m. and 5:00 p.m., during June, July, and August). Regressions controlled for the peak hour of the day, pre-treatment peak hour energy use, and customer HDDs. Standard errors clustered on customers. RCBS Pilot savings estimated by multiplying per-customer savings, per hour, by the number of treated customers with active accounts on July 15, 2015 (N=97,616).

In contrast, in winter 2015–2016, the RCBS Pilot saved energy during peak hours. Table 16 shows average savings per hour, per customer and for the RCBS Pilot during New England-ISO winter peak hours when energy efficiency resources may be bid into the forward capacity market.

Table 16. Winter 2015-2016 Peak Savings Estimates

	Point Estimate	Standard Error	Lower Bound 90% Confidence Interval	Upper Bound 90% Confidence Interval	Percent Savings
Average Savings per Customer (kWh/hour)	0.017	0.006	0.007	0.027	1.3%
RCBS Pilot Savings (MWh/hour)	1.57	0.57	0.638	2.506	1.3%

Notes: Average savings per customer per peak hour obtained from OLS regression of customer kWh/hr for winter peak hours when passive demand resources can be bid into New England-ISO market (non-holiday weekdays between 5:00 and 7:00 p.m., during December and January). Regressions controlled for peak hour of the day, pre-treatment peak hour energy use, and customer HDDs. Standard errors clustered on customers. RCBS Pilot savings estimated by multiplying per customer savings, per hour, by the number of treated customers with active accounts on January 1, 2016 (N=92,888).

The RCBS Pilot saved an average of about 0.017 kWh per hour per customer, or 1.3% during winter peak hours. This estimate proved statistically significant at the 90% confidence level. These savings could have been achieved by turning off one 17-watt CFL in an unoccupied room during peak hours. For perspective, during all hours of 2015, average energy savings per hour per treated customer were 0.0065 kWh. Thus, winter peak savings were about 2.6 times as large as average savings per hour. During weekday hours of winter 2015–2016, energy savings per hour per treated customer were 0.012 kWh. Thus, winter peak savings were 1.4 times as large as average winter savings per hour.

Total peak energy savings during winter averaged about 1.6 MWh per hour.

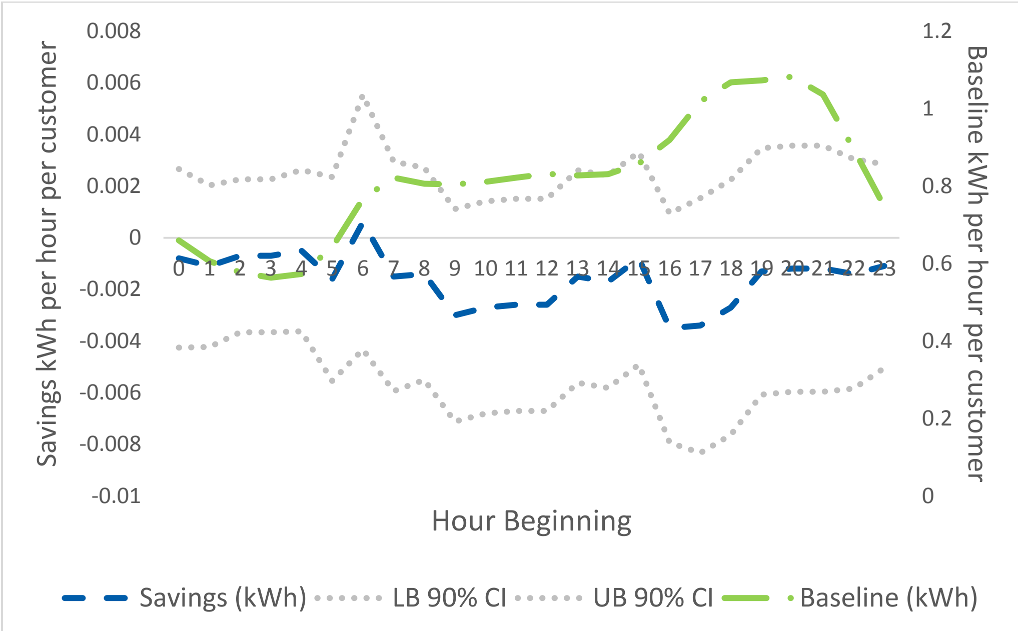
Hourly Savings Analysis

Cadmus also estimated average savings per customer by hour of the day for weekday and weekend hours between June 2015 and August 2015 and between December 2015 and January 2016. Figures 14 through 21 present estimates of kWh savings per customer and kWh savings per customer as a percentage of control group customer consumption. The dashed lines show point estimates of savings per customer; dotted lines show 90% confidence intervals; and dashed-dotted lines shows baseline consumption.

Summer 2015 Weekday Hourly Electricity Savings

Figure 14 and Figure 15 show kWh and percent savings for weekday hours during summer 2015. According to the point estimates, the RCBS Pilot did not save energy during weekday hours. Point estimates of savings were slightly negative, but the 90% confidence intervals were very wide, ranging between savings of -0.8% and 0.8%, and included zero during every hour of the day. Even during weekday peak consumption in late afternoons and early evenings, the program did not save energy. These results based on AMI data analysis are consistent with those based on analysis of customer monthly billing data (see Figure 10), which found no statistically significant savings during summer 2015. The program did not save energy during summer weekday hours because of the pause in program delivery.

Figure 14. Summer 2015 kWh Savings per Hour



Notes: .Figure 14 shows kWh savings per hour, per customer for summer 2015 (June 2015–August 2015) weekday hours. Savings were estimated with regression of customer hour kWh. Confidence intervals were estimated with standard errors clustered on homes.

Figure 15. Summer 2015 Percent Savings Per Hour

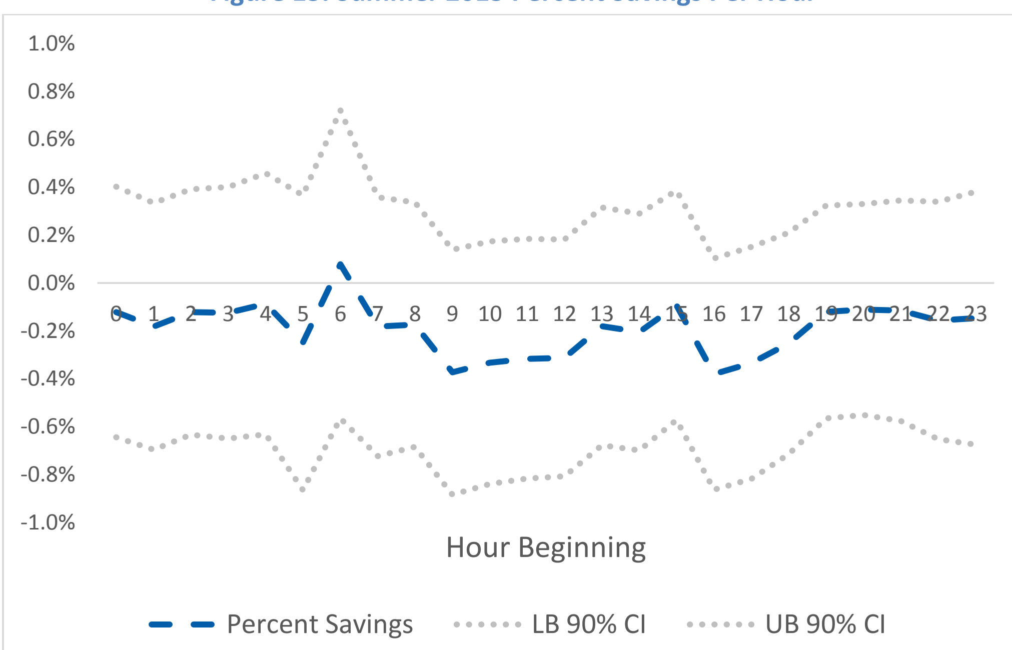


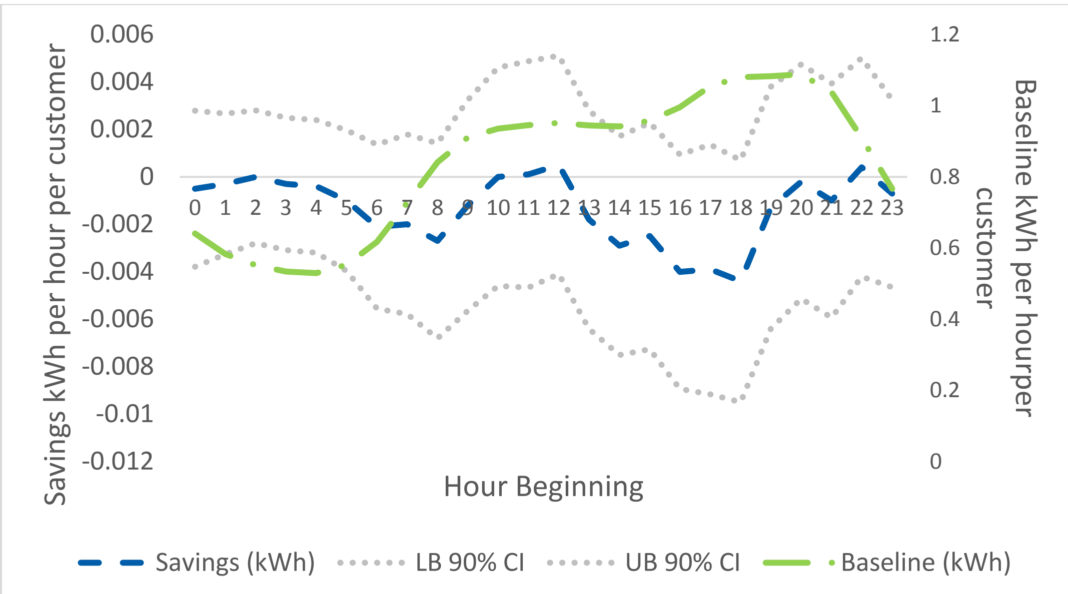
Figure 15 shows savings as a percent of control group customer kWh consumption per hour.

Summer 2015 Weekend Hourly Electricity Savings

Figure 16 and Figure 17 show kWh and percent savings estimates for weekend hours during summer 2015. Again, estimates indicate that the program did not save energy during weekend hours.

As noted, the RCBS Pilot did not save energy during summer peak hours as it suspended delivery of HERs in March 2015. The absence of savings during any hours of summer 2015 was consistent with the gradual decay of monthly savings evident in Figure 10. By summer 2010, the estimated savings based on analysis of customer monthly billing data were statistically insignificant.

Figure 16. Summer 2015 Weekend kWh Savings



Notes: Figure 16 shows kWh savings per hour, per customer for summer 2015 (June 2015–August 2015) weekend hours. Savings were estimated using regression of customer hour kWh. Confidence intervals were estimated with standard errors clustered on homes.

Figure 17. Summer 2015 Weekend Percent Savings

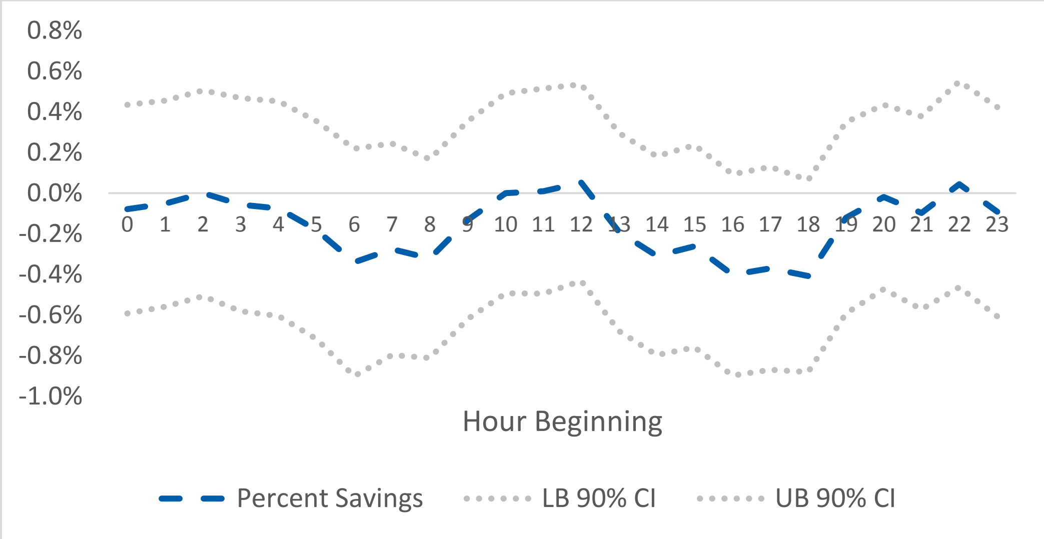


Figure 17 shows savings as a percent of control group customer kWh consumption/hr.

Winter 2015-2016 Weekday Hourly Electricity Savings

Figure 18 shows estimates of average savings per customer per hour for weekday hours during winter 2015–2016. In August 2015, delivery of reports resumed, and, by December 2015, each treated customer had received two or more additional reports. During winter weekdays, the RCBS Pilot achieved statistically significant savings during most hours.

Between 12:00 a.m. and 5:00 p.m., savings averaged about 0.1 kWh per hour per customer, or about 1% of baseline consumption (see Figure 19). The lower bound of the 90% confidence interval just bordered zero for hours between 6:00 a.m. and 12:00 p.m., indicating savings were just statistically different from zero. After 7:00 p.m., savings increased rapidly, peaking at about 0.3 kWh per hour per customer at about 9:00 p.m. As this peak in savings began at the conclusion of the ISO-New England peak period for passive demand resources, maximum HER savings did not coincide with when energy-efficiency resources may be bid into the forward capacity markets. Between 8:00 p.m. and 10:00 p.m., savings averaged about 2% of consumption. After 9:00 p.m. average savings per customer decreased quickly to 0.1 kWh per hour.

This analysis indicates that the RCBS Pilot achieved the greatest savings during late afternoon and evening hours—a time of maximum occupancy, when customers likely used electricity for lighting and to power home appliances (e.g., dishwashers, water heaters, clothes washers) and home electronics (e.g., TVs and DVRs). Interestingly, treated customers saved a much smaller percentage of consumption in the morning, despite a noticeable increase in baseline energy use after 5:00 a.m. Comparison of kWh savings and baseline kWh savings in Figure 18 shows that during weekday mornings and afternoons savings remained flat while baseline energy use doubled. This suggests that customers were not saving electricity for end uses that increased consumption during the morning and early afternoon hours.

Figure 18. Winter 2015-2016 Weekday kWh Savings Per Hour

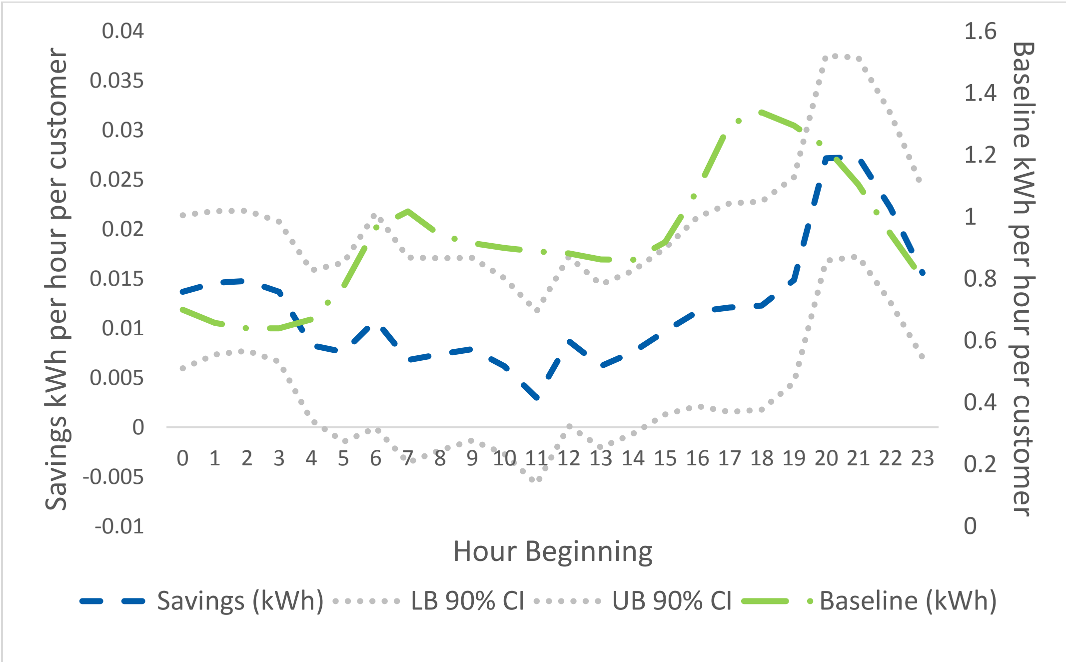


Figure 18 shows kWh savings per hour, per customer for winter (December 2015–January 2016) weekday hours. Savings were estimated with regression of customer hour kWh. Confidence intervals were estimated with standard errors clustered on homes.

Figure 19. Winter 2015-2015 Percent Savings Per Hour

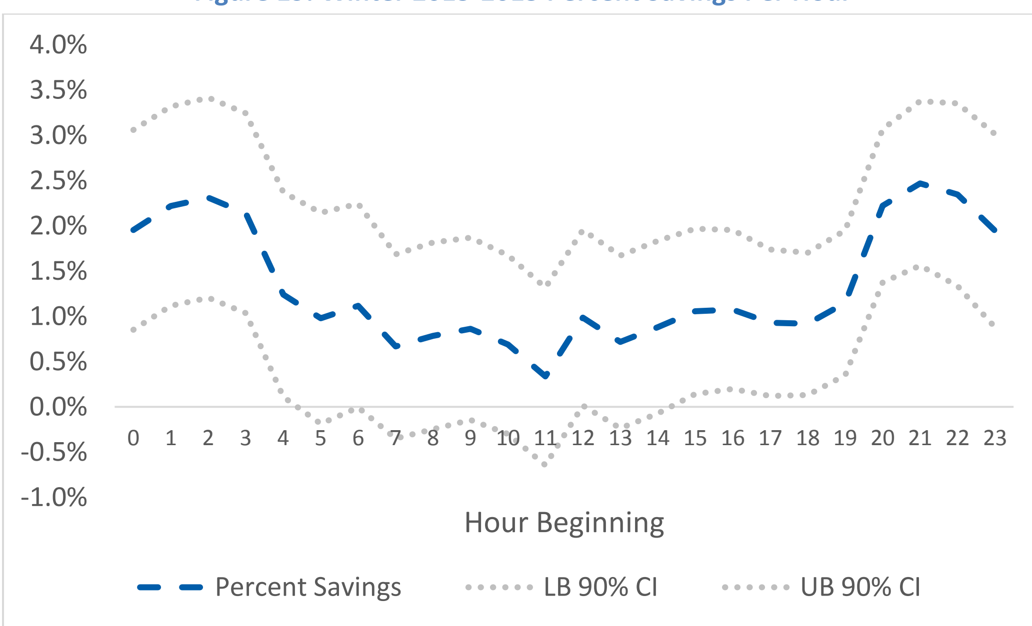


Figure 19 shows savings as a percent of control group customer kWh consumption/hr.

Winter Weekend Hourly Electricity Savings

Figure 20 and Figure 21 show estimates of average savings per customer per hour during weekend hours of winter 2015–2016. Homes were occupied more likely during daytime hours and during weekends than weekdays, and the RCBS Pilot achieved statistically significant savings during most weekend hours. Savings per customer ranged between 0.1 kWh per hour and 0.2 kWh per hour, or between about 1% and 2% of baseline consumption. Savings were highest between 9:00 a.m. and 2:00 p.m. and between 8:00 and 10:00 p.m., though maximum weekend hour savings were not as high as maximum weekday hour savings.

Figure 20. Winter 2015-2016 Weekend kWh Savings Per Hour

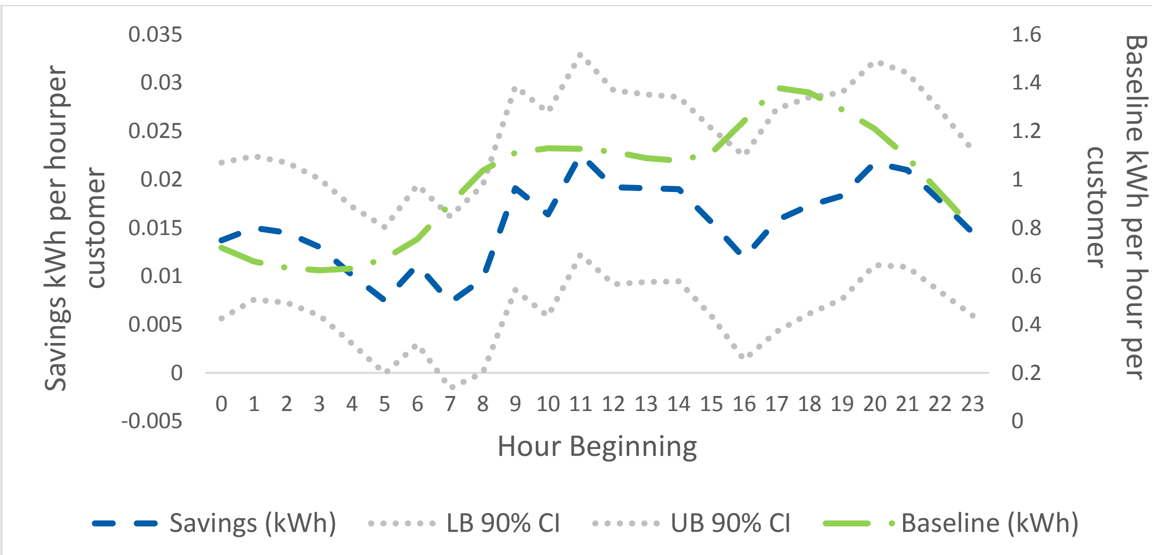


Figure 20 shows kWh savings per hour, per customer for winter (December 2015–January 2016) weekend hours. Savings were estimated with regression of customer hour kWh. Confidence intervals were estimated with standard errors clustered on homes.

Figure 21. Winter Weekend Percent Savings per Hour

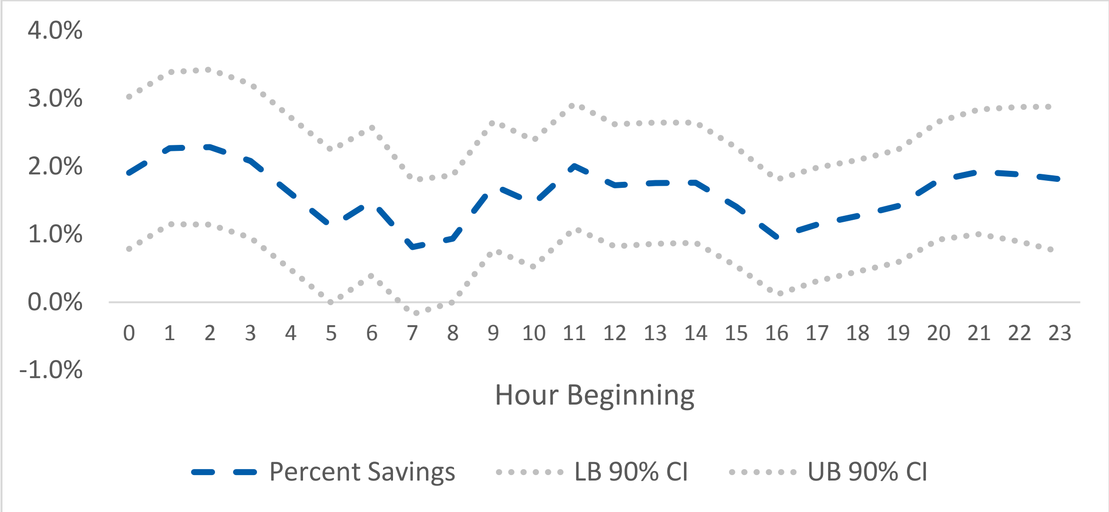


Figure 21 shows savings as a percent of control group customer kWh consumption/hr.

Cost-Effectiveness

Cadmus estimated the RCBS Pilot's cost-effectiveness for 2014 and 2015. This section describes the inputs, methodology, and results of the cost-effectiveness calculation.

Methodology

Camus conducted the cost-effectiveness analysis using the VT 2016 Statewide Screening Tool, which EVT provided to Cadmus.[26] EVT uses the societal cost test (SCT) to screen Vermont's energy efficiency programs. Table 17 presents the benefits and costs included in the SCT for the RCBS Pilot.

Table 17. SCT Benefits and Costs

Benefits	Costs
Electric Energy	Program Administration
Electric Capacity	
DRIPE*	
Electric Externalities	
Non-Energy Benefits	

*Demand Reduction Induced Price Effects: DRIPE is a measure of impacts from reduced electricity consumption due to energy efficiency investments on regional energy and capacity market clearing prices.

Cadmus obtained the energy savings estimate for 2014 and 2015 from its analysis of customer monthly electricity billing data. Further, we obtained peak demand savings estimates from our analysis of customer AMI data. EVT provided the RCBS Pilot administrative costs. As the VT screening tool did not include a whole-house load profile reflecting the programs savings, we calculated a whole-house load profile using hourly load data from the DOE.[27]

Summary and Findings

Table 18 shows RCBS program inputs for the cost-effectiveness calculation. In 2015, administrative program costs slightly exceeded $756,000, with total energy savings of 5,621 MWh. The combined 2014–2015 years include 2014 program administrative implementation costs ($426,561) and a small amount of savings (≈300 MWh) occurring in December 2014.[28]

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26 Cadmus's analysis utilized 2015 data included in the tool: 2015 DRIPE values were set equal to 2016, as 2015 values had not been included in the tool.

27 The base load model for a residential home in Burlington derived from: http://en.openei.org/doe-opendata/dataset/eadfbd10-67a2-4f64-a394-3176c7b686c1/resource/cd6704ba-3f53-4632-8d08-c9597842fde3/download/buildingcharacteristicsforresidentialhourlyloaddata.pdf

28 As the VT cost-effectiveness tool did not include data for 2014, and 2014 savings occurred in December, 2014 additional costs and benefits were modeled as occurring in 2015.

Table 18. Statewide Screening Tool Inputs

Parameter	2015	2014-2015
Savings (kWh)	5,621,000	5,925,000
Savings (kW)	343	343
Program Costs	$756,344	$1,182,905
EUL (Years)		1
Load Profile		
Winter Peak		39%
Winter Off		50%
Summer Peak		5%
Summer Off		6%

Table 19 shows the program cost-effectiveness results for the RCBS Pilot.[29] The 2015 RCBS Pilot proved cost-effective, with a 1.33 benefit-to-cost ratio. Vermont received $220,708 in net benefits from the pilot's implementation in 2015. However, the pilot was not cost-effective when benefits and costs in program years 2014 and 2015 were included. During, 2014-2015, the pilot had a benefit-to-cost ratio of 0.89 and net societal benefits of -$119,929. Cadmus estimated that the pilot would have been cost-effective (a B/C ratio =1) in 2014-2015 if the kWh savings in 2015 had been 15% higher.

Table 19. RCBS SCT Cost-Effectiveness Results

Parameter	2015	2014–2015
Benefits	$898,804	$940,598
Costs	$678,096	$1,060,528
Net Benefits	$220,708	($119,929)
Levelized $/kWh	$0.121	$0.179
Benefit/Cost Ratio	**1.33**	**0.89**

The five-month report delivery suspension, beginning in March 2015, lowered the pilot's cost-effectiveness. Though suspension of report delivery reduced both energy savings and program administration costs, it probably had a more lasting impact on savings. When report delivery resumed in August 2015, savings were close to zero and statistically insignificant (see Figure 10), and it took several months for savings to ramp up to pre-suspension levels. During this ramping process, the program incurred administration costs but achieved savings much lower than those that would have occurred had report delivery not been suspended.

Cost-Effectiveness of Alternative Program Designs

Cadmus also analyzed the cost-effectiveness of two hypothetical RCBS Pilot designs to illustrate how changes in the customer mix served by the program served could have affected the program's cost-

[29] The VT cost-effectiveness tool discounts program costs 10% for risks and values costs as accrued midyear; hence, the costs in Table 18 and Table 19 do not match.

effectiveness. In performing this analysis, Cadmus had to make a number of assumptions about program costs, the distributions of Vermont utility customers across the low, medium, and high usage strata, and expected savings of Vermont utility customers not served by GMP. As a result, these results should be considered suggestive of alternative program design may have affected the pilot cost-effectiveness.

The RCBS Pilot was implemented for a customer population of about 25% high-energy usage customers, 25% medium-energy usage customers, and 50% low-energy usage customers. Cadmus estimated the program's cost-effectiveness for the following hypothetical customer populations:

- High-low blend: 33% high-usage customers (N=42,000) and 67% low-usage customers (N=84,000)
- Medium-low blend: 33% medium-usage customers (N=42,000) and 67% low-usage customers (N=84,000)

Cadmus estimated that Vermont would have a sufficient number of high-, medium-, and low-usage customers eligible for the RCBS Pilot to allow EVT to implement these alternative RCBS Pilot designs.[30]

Using the usage-group estimates of energy savings per customer and the average number of report days per customer, Cadmus estimated savings for the high-low blend and the medium-low blend programs. We assumed the alternative program designs would have had the same program administrative costs as the 2015 RCBS program.[31]

Table 20 lists savings used for cost-effectiveness analyzes of the alternatives scenarios. All other inputs were held constant.

[30] At the end of 2014, GMP had 219,910 residential electric customers (EIA Form 861, 2014). Approximately, 126,000 (57%) were eligible for the RCBS Pilot. The state of Vermont had a total of 304,934 residential electric utility customers. If the state had the same percentage of customers eligible for the RCBS Pilot as in GMP's service area, 174,715 would have been eligible statewide. Assuming Vermont had the same distribution of low-, medium-, and high-usage customers as in GMP service area, 43,671 high-usage customers, 43,671 medium-usage customers, and 87,374 low-usage customers would be eligible for the RCBS Pilot.

[31] This assumption ignores any impacts on program administration cost because of differences in the number of reports received by low, medium, and high usage customers. It is likely that the total number of reports sent and the program administrative costs for the high-low blend would have similar to those of the actual program. The total number of reports for the low-medium blend would have been lower than the number of reports actually sent, so the actual program costs may be an over-estimate of the program administrative costs for the medium-low blend program.

Table 20. Savings for Alternative Scenarios

Scenario	Parameter	2015	2014-2105
KWh Savings			
Medium-low	Savings (kWh)	3,601,883	3,778,359
High-low	Savings (kWh)	7,344,716	7,636,218
KW Savings			
Medium-low	Savings (kW)		343
High-low	Savings (kW)		691

Table 21 shows program cost-effectiveness for the alternative scenarios. The medium-low scenario would not have proved cost-effective for 2015 or 2014–2105, with respective benefit-to-cost ratios of 0.83 and 0.55. The high-low scenario would have proved cost-effective for 2015 and 2014–2015, with respective benefit-to-cost ratios of 1.69 and 1.12.

Table 21. RCBS SCT Alternative Scenario Results

Scenario	Parameter	2015	2014–2015
Medium-low	Benefits	$564,041	$588,303
	Costs	$678,096	$1,060,528
	Net Benefits	($114,055)	($472,224)
	Levelized $/kWh	$0.188	$0.281
	Benefit/Cost Ratio	**0.83**	**0.55**
High-low	Benefits	$1,148,344	$1,188,419
	Costs	$678,096	$1,060,528
	Net Benefits	$470,247	$127,892
	Levelized $/kWh	$0.092	$0.139
	Benefit/Cost Ratio	**1.69**	**1.12**

This scenario analysis suggests that the number of high-usage customers, which have the highest average savings per customer, strongly affects program cost-effectiveness. In this hypothetical example, replacing medium-usage customers with high-usage ones would cause the program to become cost-effective for 2014-2015.

Note that in the high-low blend program, it would be possible to replace any number of low-usage customers with medium-usage customers without reducing the program's cost-effectiveness, given the average savings per customer were greater for medium-usage customers than for low-usage customers. Thus, a program targeting as many high-usage and medium-usage customers as possible with a remainder of low-usage customers would also prove cost-effective. This assumes program

administration costs do not depend significantly on the population's composition and would have remained at 2014–2015 levels.[32]

[32] The difference in number of reports sent between the implemented program and the hypothetical examples would have been small and therefore the program costs for the counterfactual scenarios would have been close to the actual program implementation costs. Cadmus obtained an estimate of the total number of reports sent annually, taking into account attrition of customer accounts. We then estimated the expected number of reports sent for the two counterfactual scenarios. In the low-medium scenario, the number of delivered reports during the first program year would have been approximately 3% less than that expected under the planned implementation in November 2014. In the high-low scenario, it would have been necessary to send 15% more reports than planned in October 2014.

Conclusions and Recommendations

Overall, the RCBS Pilot produced statistically significant but smaller than expected energy savings, prompted some participation uplift in EVT programs, and generated HER readership. The suspension of HERs in the treatment period likely contributed to the lower than expected overall electricity savings and further questions about the treatment's effectiveness.

Energy Savings

The RCBS Pilot saved approximately 0.2% of electricity use during 2014 and 0.8% during 2015. The pilot achieved 80% of the implementer's forecast of 2015 savings.[33] The program likely achieved savings lower than those forecasted because EVT suspended delivery of HERs between March 2015 and August 2015. During this period, savings decayed significantly but increased to pre-suspension levels after delivery of reports resumed. Also, RCBS savings were lower than those achieved by OPower HER programs in other utility service areas. Vermont utility customers have lower average electricity consumption due to low penetration rates of electric space heating and central air conditioning. In addition, the RCBS Pilot included low, medium, and high energy usage customers instead of targeting medium and high usage customers as many utility HER programs have done.

Recommendation: EVT should closely monitor the monthly savings to track program performance and to enact timely implementation changes, if necessary. By tracking the monthly savings against the monthly forecasts, the RCBS Pilot can develop an early contingency plan in the event that savings remain below those forecast. A contingency plan might include testing for the effect of changes to the HERs delivery such as adding modules, seasonal readiness letters, and reminder tools.

Energy Use Group Effects

In 2015, high energy users produced the largest average daily kWh savings per customer (0.36 kWh) and the largest savings as a percentage of energy use (1.03%). High-energy usage customers received the most HERs per customer each year and likely had the greatest potential for saving energy. Medium-energy users and low energy users achieved small average daily savings per customer of 0.11 kWh and 0.07 kWh, respectively.

Recommendation: Consider identifying and adding more high-energy usage customers to increase the Pilot savings. As EVT and OPower discovered during the RCBS Pilot design phase, there were a limited number of high-usage customers eligible for the RCBS Pilot. EVT and OPower included the maximum number of high-usage customers from Green Mountain Power possible. To increase savings, EVT could

33 OPower made this forecast in October 2014, just before the November 2014 launch of the program. In August 2013, OPower originally forecasted first-year annual savings of 14,040 MWh. OPower then revised the forecast downward to 6,986 MWh after obtaining Vermont utility customer bills and applying a new savings forecast model. OPower revised its forecast downward again to 6,453 MWh due to the temporary delivery suspension of the HERs. OPower reported savings of 5,395 MWh between November 2014 and October 2015 and savings of 6,284 MWh between January 2015 and December 2015. Cadmus estimated savings of 5,621 MWh between January 2015 and December 2015.

consider adding more high-usage customers from other Vermont utility service areas. EVT will need to balance the desire for increasing program savings and cost-effectiveness by targeting high-usage customers with considerations regarding equity and serving all of Vermont's utility customers.

Implications of RCBS Pilot's Suspended Delivery of HERs

RCBS Pilot savings increased during the RCBS Pilot's first six months, reaching approximately 1% of electricity consumption, and then decreased while EVT suspended delivery of HERs between March 2015 and August 2015. After delivery resumed, savings increased, returning to a steady state of approximately 1%. EVT suspended the HERS due to feedback received from recipient customers, particularly concerns raised about the definition and accuracy of the neighbor comparison. In response, OPower and EVT made wording and design changes to the HERs' neighbor comparison component. While savings recovered after the report suspension, overall savings in 2015 did not recover sufficiently to reach the forecasted savings. The decay of savings while delivery was suspended and the recovery of savings after delivery was resumed provide additional evidence that the HERs caused customers to save energy.

Recommendation: Continue to send redesigned reports and evaluate the design changes. For the remainder of the program trial period in 2016 and beyond as appropriate**,** EVT and OPower should consider evaluating future changes to the report design by employing randomized controlled experiments or quasi-experimental methods. With the randomized control approach, only some randomly selected customers would receive reports with the design changes, while others would continue to receive reports with the existing design. An evaluator would then compare satisfaction and savings between customers receiving the existing and redesigned reports. A quasi-experimental method, which would not be as rigorous, might involve sending redesigned reports to all customers and then surveying customers about the design changes.

Peak Energy Savings

The RCBS Pilot did not save energy during ISO-New England peak hours for summer 2015, but it did save 1.3% of electricity consumption during ISO-New England peak hours for winter 2015–2016. This finding drew upon analysis of hourly energy use of treatment and control group customers during ISO-New England system peak hours when energy-efficiency resources may be bid into the capacity market. Treated customers did not save energy during summer peak hours as the RCBS Pilot suspended delivery of the HERs in March 2015, and savings decayed after treatment stopped. During winter, peak-hour savings averaged 0.017 kWh per customer per hour or 1.3% of consumption. However, maximum weekday hourly savings did not coincide with the ISO-New England system peak (5:00 p.m. to 7:00 p.m.). Between 7:00 p.m. and 10:00 p.m., savings averaged about 0.03 kWh per customer per hour or about 2% of consumption.

Recommendation: Continue to measure RCBS Pilot peak energy savings and promote measures that can save energy on peak. EVT should consider measuring peak energy savings during summer 2016 to determine how much energy the RCBS program saved during summer peak hours. Evaluators should follow this study's methodology, using customer AMI data and comparing the peak electricity consumption of treatment group and control group customers. Also, EVT and Opower should consider promoting measures that save energy on peak, such as for lighting, appliances, and home electronics in winter and for appliances and space cooling during summer.

Energy Saving Actions, Behaviors, and Customer Awareness

The HERs appear to have ambiguous effects on energy saving actions, behaviors, customer awareness, purchases, and installation of efficient lighting products. Treatment group respondents reported implementing energy-saving improvements at a lower rate than control group respondents. Survey responses indicated no statistically significant differences regarding the number of CFL bulbs purchased between the treatment and control group customers. However, a statistically significant higher proportion of treatment group respondents reported purchasing LEDs compared to control group respondents, and 20% of the treatment group respondents reported the HERs prompted them to install CFLs or LEDs. Moreover, a statistically significant higher proportion of treatment group respondents said EVT "reduces the cost of light bulbs" when asked "what Efficiency Vermont does", while a statistically significant higher proportion of control group respondents said EVT "saves energy." These findings align with the HERs' lighting promotions and suggest the HERs' may have had at least some effectiveness in promoting efficient lighting.

Recommendation: Focus HER savings tips on lighting measures and behavior changes. Encouraging customers to install efficient lighting products may result in more customers initiating an energy-saving behavior than encouraging customers to install space heating and space cooling measures, which may not apply to as many households due to the low penetrations of electric space heating and central air conditioning in Vermont homes. Energy-saving tips should also point out new or unique ideas that appeal to customers that already consider themselves doing as much as possible to save energy.

Efficiency Program Uplift

Although the RCBS Pilot and HERs were designed primarily to influence energy-saving behaviors, behavior changes may lead residents to incorporate additional energy-saving measures in their homes, which can have a longer-term savings effect, extending beyond the HERs treatment period. Consequently, HERs could potentially also produce deeper and long-lasting savings by encouraging investments in energy-saving measures, which may be eligible for incentives offered through EVT programs.

In 2015, the RCBS Pilot lifted the participation rate in EVT's other efficiency programs by about 8%, but savings from this lift in participation was small. The RCBS Pilot increased the efficiency program's participation rate of low-energy users by about 7%, medium-energy users by 3%, and high-energy users by 14%. HERs provided the greatest lift in participation for hot water efficiency and refrigeration measures. HER electricity savings from efficiency program participation was less than 1% of total RCBS savings. The energy savings from lift in program participation was very small, because most customers did not heat or cool their homes with electricity and therefore could not produce large electricity savings by adopting high-impact space conditioning measures.

Recommendation: **Continue cross-program marketing through the HERs**. HERs appear to be an effective medium for increasing awareness of and participation in EVT programs. Focus marketing on programs likely to produce more substantial savings such as lighting, refrigeration, and water heating.

RCBS Pilot Design Implications and Improvements

Changes made to the HERs' neighbor comparisons resulted in improved customer perceptions of the neighbor comparison's accuracy. Survey respondents exhibited relatively high readership of the HERs (75%) and a very high recall of the neighbor comparison element (91%). The 12-month survey showed an improvement from the six-month survey on customer perceptions of the neighbor comparison's accuracy; the proportion of survey respondents agreeing with the statement "I believe the neighbor comparison is generally accurate" increased from 50% to 57%.

Efficiency Vermont's Net Promoter Score (NPS) improved from the six-month to 12-month periods, largely due to changes in the NPS of non-recipients. The NPS is an absolute number between -100 and +100 based on the customers' "likelihood to recommend EVT" survey question. A positive score indicates more promoters (respondents assigning a score of 9 or 10) than detractors (respondents assigning a score of 0 to 6). HERs appear to have had a negative impact on NPS. In Cadmus' 12-month survey, surveyed HERs recipients and non-recipients generated an overall NPS of -7; specifically, recipient respondents generated a NPS of -14 and the non-recipient respondents generated a NPS of +1. In OPower's six-month survey, surveyed recipients and non-recipients generated an overall NPS of -25, with recipients specifically yielding a NPS of -27.

Recommendation: **Re-evaluate the RCBS Pilot in July 2016 and determine whether the NPS improved.** Cadmus is under contract with the PSD to perform a mid-2016 year evaluation of the RCBS Pilot.

Cost-Effectiveness

The RCBS Pilot was not cost-effective when accounting for pilot start-up costs in 2014. The RCBS Pilot did not prove cost-effective (0.89) during the pilot's first 14 months as measured by the societal cost test (SCT). The suspension of HER report delivery in March 2015 reduced the pilot savings and likely diminished the pilot's cost-effectiveness. Cadmus estimated that the pilot would have been cost-effective for 2014-2015 if savings in 2015 had been 15% higher. However, the pilot showed potential for operating cost-effectively. When estimating pilot cost-effectiveness for 2015, which excluded the pilot set-up costs and 2014 savings, the RCBS Pilot proved cost-effective (1.33).

Recommendation: **Re-evaluate the pilot cost-effectiveness at the end of 2016.** It is likely that the RCBS pilot was not cost-effective for 2014-2015 because of the suspension of report delivery. However, over a longer period, the pause in report delivery and the resulting loss of savings will have a diminishing impact on the pilot cost-effectiveness. The pilot may prove to be cost-effective when evaluated at the end of 2016.

Appendix A. Survey Instrument

Efficiency Vermont - Home Energy Report RCBS Pilot Customer Survey

December 2015

Research Area	Survey Items
Energy-Saving Improvements	B1-B6
Energy-Saving Behaviors	C1, C2
Awareness of Energy Efficiency Programs and EVT Satisfaction	D1-D6
Home Energy Report Recall, Readership, and Engagement	E1-E5
Report Content: Neighbor Comparison	F1-F3
General Reception of Home Energy Reports	G1-G2
Attitudes about and Barriers to Energy Efficiency	H1-H3
Demographics	I1-I9

Total Target Completes = 1200

- **Treatment Group Quota = 600**
  - **Usage Band Quotas = 200 high, 200 medium, 200 low**
- **Control Group Quota = 600 Control**
  - **Usage Band Quotas = 200 high, 200 medium, 200 low**

Interviewer instructions are in green

CATI programming instructions are in red

Answers that should not be read are in parentheses "( )"

Variables to be pulled into survey:

- **Group = Treatment Group or Control Group**
- **Usage Band = High, Medium, or Low**

Back-up information, not to be programmed:

- **If "No – Not a convenient time," ask if respondent would like to arrange a more convenient time for us to call them back or if you can leave a message for that person.**
- **If respondent asks how long, say, "Approximately 10 minutes."**
- **If questioned about survey's purpose: "This survey is for research purposes only and is not a marketing call. Your responses will remain confidential and are important to the Vermont Public Service Department."**
- **If asked for a Vermont Public Service Department contact to verify the survey's authenticity, offer PSD Consumer Affairs & Public Information (CAPI) at 800-622-4496.**

A. *Introduction and Screener*

[ASK SECTION A TO BOTH GROUPS]

Hello. I'm **[NAME]**, calling on behalf of the Vermont Public Service Department. We are talking to utility customers in Vermont about how energy is used in the home.

A1. Are you involved in managing or paying your home's utility bills?
- 1. (Yes)
- 2. (No) **[ASK TO SPEAK WITH THE PERSON WHO IS THE DECISIONMAKER AND START AGAIN. IF NO ONE, THEN THANK AND TERMINATE.]**
- 98. (Don't know) **[ASK TO SPEAK WITH THE PERSON WHO IS THE DECISIONMAKER AND START AGAIN. IF NO ONE, THEN THANK AND TERMINATE.]**
- 99. (Refused) **[THANK AND TERMINATE]**

A2. Do you or any member of your household work for Efficiency Vermont?
- 1. (Yes) **[THANK AND TERMINATE]**
- 2. (No)
- 98. (Don't know)

A3. We are conducting an important survey today about saving energy in your home. This survey will take approximately 10 minutes. Your answers will remain confidential. Do you have a few minutes to help us out?
- 1. (Yes)
- 2. (No) **[THANK AND TERMINATE]**

B. *Energy-Saving Improvements*

I would like to understand more about some of the things you might have done to save energy in your home.

[ASK BOTH GROUPS]

B1. I will read you a list of energy-saving home improvements. Tell me if you have done any of the following in the last 12 months. **[RECORD 1=YES, 2=NO, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT]**
- A. Purchased or received LEDs (light emitting diodes) or CFLs (compact fluorescent light bulbs)
- B. Installed a programmable or smart thermostat
- C. Purchased and installed ENERGY STAR or high-efficiency appliances
- D. Purchased and installed new heating or cooling equipment
- E. Changed the furnace filter
- F. Installed extra insulation to ceiling, ducts, walls, attic or basement
- G. Added caulking, spray foam, weather stripping, or plastic sheeting

H. Installed a water/energy-saving showerhead, faucet head or aerator
I. Installed higher-efficiency doors or windows
J. Added solar panels to home
K. Recycled a second refrigerator

[ASKI IF B1A=1]

B2. You mentioned that you purchased or received CFLs in the past 12 months. Did you purchase these CFLs or did you receive them for free?

1. (Purchased CFLs)
2. (Received free CFLs)
3. (Both purchased and received free CFLs)
4. (I purchased LEDs only) **[SKIP TO SECTION C]**

98. (Don't know) **[SKIP TO SECTION C]**
99. (Refused) **[SKIP TO SECTION C]**

[ASKI IF B2=1 OR 3]

B3. How many CFL bulbs did you purchase in the past 12 months? Please count the number of individual bulbs, not the number of boxes or packs.

1. **[RECORD NUMERIC ANSWER:___________________________]**

98. (Don't know)
99. (Refused)

[ASKI IF RESPONSE FROM B3>0]

B4. Of the **[INSERT RESPONSE FROM B3]** CFL bulbs you purchased, how many are currently installed in your home?

1. **[RECORD NUMERIC ANSWER:___________________________]**

98. (Don't know)
99. (Refused)

[ASKI IF B2=2 OR 3]

B5. How many CFL bulbs did you receive for free?

1. **[RECORD NUMERIC ANSWER:___________________________]**

98. (Don't know)
99. (Refused)

[ASKI IF RESPONSE FROM B5>0]

B6. Of the **[INSERT RESPONSE FROM B5]** CFL bulbs you received for free, how many are currently installed in your home?

1. **[RECORD NUMERIC ANSWER:___________________________]**

98. (Don't know)
99. (Refused)

C. Energy-Saving Behaviors

[ASK BOTH GROUPS]

C1. I will read through some energy-saving actions you may have heard or read about. Please let me know if you always, sometimes, or never have taken these actions in your home over the past 12 months. **[RECORD 1=ALWAYS, 2 =SOMETIMES, 3=NEVER, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT] [RANDOMIZE ORDER]**

A. Turn off lights in rooms that are unoccupied
B. Wash laundry in cold water
C. Unplug electronic equipment or appliances when not in use
D. Adjust thermostat setting on your air conditioner when leaving or sleeping
E. Take short showers
F. Turn down water heater temperature
G. Use energy-saving or "sleep" features of your computer **[IF RESPONDENT DOES NOT OWN A COMPUTER, MARK RESPONSE AS 99]**

[ASK BOTH GROUPS]

C2. Is there anything you use that helps remind you to take energy-saving actions?

1. (Yes **[SPECIFY:_______________]**)
2. (No)
98. (Don't know)
99. (Refused)

D. Awareness of Energy Efficiency Programs and Satisfaction with EVT

[ASK SECTION D TO BOTH GROUPS]

D1. Have you ever heard of Efficiency Vermont?

1. (Yes)
2. (No) **[SKIP TO SECTION E]**
98. (Don't know) **[SKIP TO SECTION E]**
99. (Refused) **[SKIP TO SECTION E]**

[ASK IF D1=1]

D2. Could you describe to the best of your ability what Efficiency Vermont does? **[CHECK ALL THAT APPLY]**

1. (Promotes energy efficiency)
2. (Saves energy)
3. (Improves the environment)
4. (Offers rebates for efficient appliances)
5. (Offers rebate for making homes more energy efficient)
6. (Provides information/education about energy efficiency)
7. (Reduces cost of light bulbs)
8. (Performs energy assessments or audits)
9. (Provides loans and financing)
10. (Other **[SPECIFY: ______________________]**)

98. (Don't know)
99. (Refused)

[ASK IF D1=1]

D3. Have you ever participated in an energy efficiency program from Efficiency Vermont?

1. (Yes)
2. (No)
98. (Don't know)
99. (Refused)

[ASK IF D3=1]

D4. What Efficiency Vermont programs have you participated in? **[MULTIPLE RESPONSE]**

1. (CFL bulb giveaway/discount)
2. (Refrigerator recycling)
3. (Energy assessment or audit)
4. (Clothes dryer rebate)
5. (Clothes washer rebate)
6. (Dehumidifier rebate)
7. (Freezer rebate)
8. (Furnace or boiler rebate)
9. (Heat pump rebate)
10. (Refrigerator rebate)
11. (Heat pump water heater rebate)
12. (Solar water heater rebate)
13. (Central air conditioning rebate)
14. (Room air conditioner rebate)
15. (Home Performance with ENERGY STAR)
16. (Comprehensive energy improvements – air sealing, insulation)
17. (Borrow home electric meter)
18. (Other **[SPECIFY: ______________________]**)
98. (Don't know)
99. (Refused)

[ASK IF D3=1]

D5. Would you say that you participated in the Efficiency Vermont programs before or after November of 2014?

1. (Before)
2. (After)
98. (Don't know)
99. (Refused)

[ASK IF D1=1]

D6. Overall, how likely would you be to recommend Efficiency Vermont to a friend or colleague? Please use a scale from 0 to 10 where 0 means "extremely unlikely" and 10 means "extremely likely."

1. **[RECORD AN ANSWER FROM 0-10:_________________________]**
98. (Don't know)
99. (Refused)

E. Home Energy Report Recall, Readership, and Engagement

[ASK SECTION E TO TREAMENT GROUP]

E1. Our records indicate that you should have received a document in the mail called a Home Energy Report. This report included some energy-savings tips and some charts that show how your home's energy consumption compares to that of neighbors. Do you recall seeing one of those reports or hearing someone in your household talking about that report?

1. (Yes)
2. (No) **[SKIP TO H1]**
98. (Don't know) **[SKIP TO H1]**
99. (Refused) **[SKIP TO H1]**

E2. Which of the following statements best describes what you did with the last report you received? **[READ LIST]**

1. I read the report thoroughly
2. I read some of the report
3. I skimmed the report
4. I did not read the report
98. (Don't know)
99. (Refused)

E3. I will read you some statements. Please tell me if you have done the following: **[RECORD 1=YES, 2=NO, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT] [RANDOMIZE ORDER]**

A. Look for changes in how you use energy since the previous Home Energy Report
B. Talk about the Home Energy Reports with others living in your home
C. Talk about the Home Energy Reports with other people outside your home
D. Call Efficiency Vermont for more information **[ASK IF D1=1]**
E. Visit the Efficiency Vermont website portal **[ASK IF D1=1]**

E4. On a scale from 0 to 10 where 0 means "not at all important" and 10 means "very important," how important would you say the Home Energy Reports were in prompting you to make any energy-saving improvements?

1. **[RECORD ANSWER FROM 0-10:_________________________]**
98. (Don't know)
99. (Refused)

E5. What energy-saving improvements that were suggested in the Home Energy Reports did you make? **[MULTIPLE RESPONSE]**

1. (Install LEDs or CFLs)
2. (Install a programmable or smart thermostat)

3. (Install ENERGY STAR or high-efficiency appliances)
4. (Install a new heating or cooling equipment)
5. (Change the furnace filter)
6. (Install extra insulation to ceiling, ducts, walls, attic or basement ceiling/attic)
7. (Add caulking, spray foam, weather stripping or plastic sheeting)
8. (Install extra insulation to ceiling/attic)
9. (Install a water/energy-saving showerhead, faucet head or aerator)
10. (Install solar panels)
11. (Install higher-efficiency doors or windows)
12. (Recycled a second refrigerator)
13. (Other **[SPECIFY:________________________]**)
14. (None; did not make any improvements suggested in the reports)
98. (Don't know)
99. (Refused)

F. *Neighbor Comparison*

[ASK SECTION F TO TREAMENT GROUP]

F1. Each report compares both your monthly and annual energy use to that of neighbors. Do you remember seeing this neighbor comparison?
1. (Yes)
2. (No) **[SKIP TO G1]**
98. (Don't know) **[SKIP TO G1]**
99. (Refused) **[SKIP TO G1]**

F2. I will read you some statements about the neighbor comparison. Please tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree. **[RECORD 1=STRONGLY AGREE, 2=SOMEWHAT AGREE, 3=NEITHER, 4=SOMEWHAT DISAGREE, 5=STRONGLY DISAGREE, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT] [RANDOMIZE ORDER]**
A. My household energy use was different than I expected compared to neighbors
B. I believe the neighbor comparison is generally accurate
C. The neighbor comparison helps me understand my household energy use

F3. On a scale from 0 to 10 where 0 means "not at all useful" and 10 means "very useful," how useful was the neighbor comparison in getting your household to save energy?
1. **[RECORD ANSWER FROM 0-10:__________________________]**
98. (Don't know)
99. (Refused)

G. *General Reception of Home Energy Reports*

[ASK SECTION G TO TREAMENT GROUP]

Now I'd like to ask you about your general thoughts about the Home Energy Reports.

G1. Overall, how satisfied are you with the Home Energy Reports? Please use a scale from 0 to 10 where 0 means "extremely dissatisfied" and 10 means "extremely satisfied."

1. **[RECORD AN ANSWER FROM 0-10:________________________]**
98. (Don't know)
99. (Refused)

[ASK IF D1=1]

G2. As a result of receiving the Home Energy Reports, would you say you feel more favorable, no differently, or less favorable toward Efficiency Vermont?

1. (More favorable)
2. (No different)
3. (Less favorable)
98. (Don't know)
99. (Refused)

H. *Attitudes and Barriers*

[ASK SECTION H TO BOTH GROUPS]

Now, I'd like to understand a little more about how you feel about using energy.

H1. For the following statements, please tell me whether you strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, or strongly disagree. **[RECORD 1=STRONGLY AGREE, 2=SOMEWHAT AGREE, 3=NEITHER, 4=SOMEWHAT DISAGREE, 5=STRONGLY DISAGREE, 98=DON'T KNOW, OR 99=REFUSED FOR EACH STATEMENT] [RANDOMIZE ORDER]**

A. It is important to conserve energy as much as possible
B. Using energy to keep the home comfortable is my top priority
C. I am committed to actions that help the environment
D. I would like to save more energy but do not know where to start
E. I have already done as much as possible to save energy in my home
F. Energy-efficient products are too expensive
G. I've tried a few things to save energy, but have not seen any real savings on my utility bills
H. I actively look for ways to reduce my carbon footprint

H2. Using a scale from 0 to 10 where 0 means "extremely difficult" and 10 means "extremely easy," how easy is it for you to save energy in your home?

1. [RECORD AN ANSWER FROM 0-10:_________________________]
98. (Don't know)
99. (Refused)

H3. What challenges, if any, do you face in saving energy in your home? [MULTIPLE RESPONSE]
1. (Have an older/leaky/non-efficient home)
2. (Can't control energy use by other household members)
3. (Don't know what to do/lack of information)
4. (Cost/Don't have money to invest in energy-efficient improvements)
5. (Have already done what we can and know to do)
6. (Health or comfort issues require higher energy use)
7. (Need energy for a home business or hobby)
8. (Hasn't been a priority/other home renovations a higher priority)
9. (Have energy-using equipment/appliances in need of repair)
10. I'm not willing to replace things that are working just fine.
11. (There are no challenges)
12. (Other [SPECIFY:_______________________])
98. (Don't know)
99. (Refused)

I. *Demographics*

[ASK SECTION I TO BOTH GROUPS]

Finally, I have a few questions about your home and household.

I1. What type of building is your home? Is it a… [READ LIST]
1. Detached single-family home
2. Two-family building or duplex
3. Three or four family building
4. Part of a building with 5 or more units
5. (Other [SPECIFY: ________________________])
98. (Don't know)
99. (Refused)

I2. Do you own or rent this home?
1. (Own/buying)
2. (Rent/lease)
3. (Other [SPECIFY: ________________________])
98. (Don't know)
99. (Refused)

I3. How many months out of the year do you usually occupy your home?

1. (12 months/year round)
2. (More than 6 but less than 12 months)
3. (Less than 6 months)
98. (Don't know)
99. (Refused)

I4. What is the approximate square footage of the finished living space of your home? Do <u>not</u> include unheated garages, attic, or basement space. Is it… **[READ LIST]**

1. Less than 800 square feet
2. 800 to 1,199 square feet
3. 1,200 – 1,599
4. 1,600 – 1,999
5. 2,000 – 2,499
6. 2,500 – 2,999
7. 3,000 – 3,999
8. 4,000 – 4,999
9. 5,000 or more square feet
98. (Don't know)
99. (Refused)

I5. Counting yourself, how many people live in your home for most of the year?

1. (1)
2. (2)
3. (3)
4. (4)
5. (5)
6. (6)
7. (7)
8. (8 or more)
9. (None/seasonally occupied)
98. (Don't know)
99. (Refused

I6. Does your household have an electric car?

1. (Yes)
2. (No)
98. (Don't know)
99. (Refused)

I7. Please stop me when I mention the range that contains your age. **[READ LIST]**

1. 18-24
2. 25-34
3. 35-44
4. 45-54
5. 55-64

6. 65-74
7. 75 and older
98. (Don't know)
99. (Refused)

I8. As our final question, please stop me when I read the range that contains the total combined income of all members of your household over the past 12 months. **[READ LIST]**

1. Less than $20,000
2. $20,000 to less than $50,000
3. $50,000 to less than $75,000
4. $75,000 to less than $100,000
5. $100,000 to less than $150,000
6. $150,000 to less than $200,000
7. $200,000 or more
98. (Don't know)
99. (Refused)

I9. Respondent's gender **[RECORD, BUT DO NOT ASK]**

1. Male
2. Female

J. Closing

That is the end of the survey. The Vermont Public Service Department appreciates you for taking time to respond. Thank you. Have a nice day!

Appendix B. Survey Results (Attached Separately)

Appendix C. AMI Data Model Specifications

Peak Savings

Using the following regression equation, Cadmus estimated the average savings per customer during ISO-New England peak hours:

$$kWh_{it} = \sum_{j=1}^{J} \beta_j \, Hour_{jt} + \sum_{j=1}^{J} \sum_{k=1}^{K} \theta_{jk} \, Hour_{jt} \, x \, PreTreatment \, kWh \, Hour_{ik} + \sum_{j=1}^{J} \delta_j \, Hour_{jt} \, x \, Treatment_{it} + \gamma DegreeHour_{it} + \varepsilon_{it}$$

Where:

kWh_{it} = Hourly electricity use for customer i during peak hour t, t=1, 2, …, T. During winter 2015-2016, there were 82 hours per customer that met the ISO-New England definition of peak. During summer 2015, there were 252 hours per customer that met the definition.

β_j = Coefficient indicating average demand for hour j, j=1, 2, …, J after controlling for weather and pre-treatment usage. For the winter, j=1 corresponds to the 5:00 to 6:00 p.m. hour, and j=2 corresponds to the 6:00 to 7:00 p.m. hour. Summer hours are defined analogously.

$Hour_{jt}$ = One if hour *t* was the jth hour of the non-holiday weekday.

θ_{jk} = Effect of pre-treatment energy use during hour k, k=1, 2, …, K, on energy use during treatment hour j. For winter, K=2, with k=1 corresponding to the 5:00 to 6:00 p.m. hour, and k=2 corresponds to the 6:00 to 7:00 p.m. hour. For summer hours, k is defined analogously.

Pre-Treatment kWh $Hour_{ik}$ = average kWh energy use for customer i during pre-treatment hour k, k=1, 2, …, K.

$Treatment_{it}$ = Indicator variable that customer i had previously received an energy report. This variable equals 1 in hour t if the customer was in the treatment group and previously received an energy report and equals 0 otherwise.

δ_j = Average savings per treated customer for peak hour j.

γ = Average effect of a heating degree hour (base temperature 65°F) for winter or cooling degree hour (base temperature 70°F) for summer on customer energy use.

$DegreeHour_{it}$ = Heating degree hour (base temperature 65°F) for winter or cooling degree hour (base temperature 70°F) for summer for customer i during hour t.

ε_{it} = Model error term.

Weekday and Weekend Hour of the Day Savings

Cadmus estimated the average savings per customer for each hour of the day. We conducted separate analyses for weekdays and weekends and for summer and winter. Using the following regression equation, Cadmus estimated the average savings per customer during weekday and weekend hours:

$$kWh_{it} = \sum_{j=0}^{23} \beta_j \, Hour_{jt} + \sum_{j=0}^{23} \sum_{k=1}^{4} \theta_{jk} \, Hour_{jt} \, x \, PreTreatment \; kWh \; Hour_{ik} + \sum_{j=0}^{23} \delta_j \, Hour_{jt} \; x \; Treatment_{it} + \gamma DegreeHour_{it} + \varepsilon_{it}$$

Where:

kWh_{it} = Hourly electricity use for customer i during hour t, t=1, 2, …, T of the period (summer or winter).

β_j = Coefficient indicating average demand for hour j, j=0, 2, …, 23 after controlling for weather and pre-treatment usage. j=0 corresponds to the 12:00 to 1:00 a.m. hour, and j=1 corresponds to the 1:00 to 2:00 a.m. hour.

$Hour_{jt}$ = One if hour *t* was the jth hour of the day.

θ_{jk} = Effect of pre-treatment energy use during hour k, k=1, 2, …, K, on energy use during treatment hour j. For winter, K=2, with k=1 corresponding to the 5:00 to 6:00 p.m. hour, and k=2 corresponds to the 6:00 to 7:00 p.m. hour. For summer hours, k is defined analogously.

Pre-Treatment kWh $Hour_{ik}$ = Customer average energy use per hour for period *k* of the day, k=1,2,…,4 (11 pm-5 a.m., 6:00 a.m.-9:00 a.m., 10:00-4:00 p.m., and 5:00 p.m.-10:00 p.m.) during the same season of the pre-treatment period.

$Treatment_{it}$ = Indicator variable that customer i had previously received an energy report. This variable equals 1 in hour t if the customer was in the treatment group and previously received an energy report and equals 0 otherwise.

δ_j = Average savings per treated customer for hour j.

γ = Average effect of a heating degree hour (base temperature 65°F) for winter or cooling degree hour (base temperature 70°F) for summer on customer energy use.

$DegreeHour_{it}$	=	Heating degree hour (base temperature 65°F) for winter or cooling degree hour (base temperature 70°F) for summer for customer i during hour t.
ε_{it}	=	Model error term.