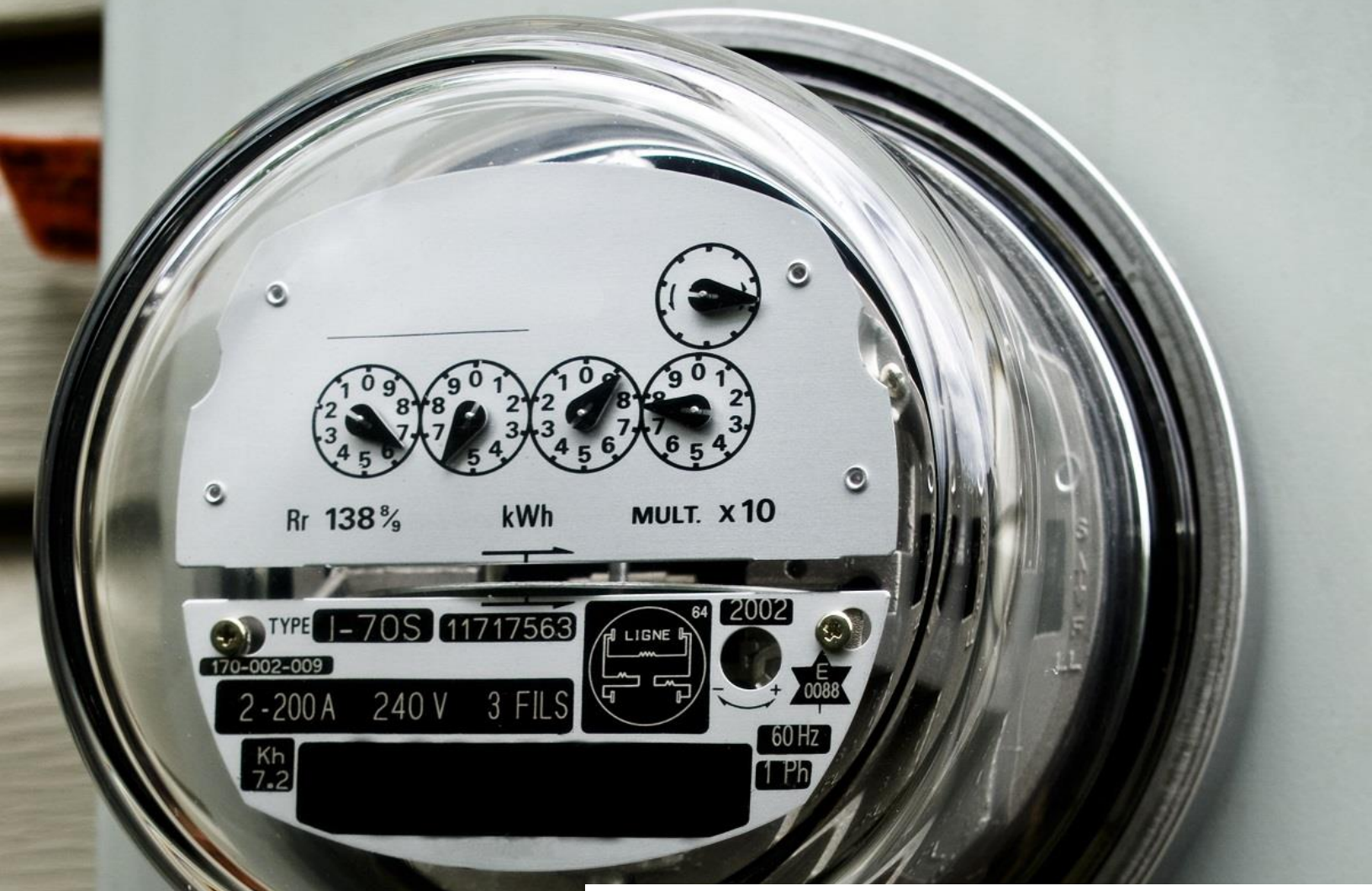

Evaluation of Persistence in the Eversource Customer Behavior Program (R32)

FINAL

March 2016

SUBMITTED TO:
Connecticut Energy Efficiency Board
Eversource

SUBMITTED BY:
NMR Group, Inc.

NMR Group, Inc.

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Abstract

This report updates findings from two prior evaluations of the Home Energy Reports (HERs) Pilot Program, implemented for Eversource by OPower.

The study had two main objectives:

- Explored the degree to which savings extend after the delivery of HER reports is discontinued – continuing a time series of persistence analyses for samples of HER participants conducted over the past few years. This is the third year of persistence work for at least one of the subpopulations.
- Examined whether the (awareness or other effects from) HER reports help increase participation in other Connecticut Energy Efficiency (EE) programs, or whether the HER reports have a side benefit of increasing investment in "deeper" measures, a desirable outcome of the HES and other programs.

The study found:

- Savings continued for the various discontinued groups – with somewhat different results depending on which group (frequency and duration of reports received initially). However, on an overall basis, the results indicated that savings degradation was between 21-34% (about 24% overall) for each year after the reports were stopped.
- Statistically-significant savings remained at least two and up to three years after HER reports were stopped (depending on the study group). This indicates that measure lifetimes for this behavioral program may exceed 3 years in life – although of course, the savings multiplier is affected by the degradation factor noted above.
- The program is cost-effective as it is currently delivered; however, these results imply that there may be more cost-effective ways to deliver this program other than repeating full-cost treatment continuously. Several scenarios in the report indicate that "cycling" customers off the program may lead to more total savings at a lower cost per kWh than the traditional program delivery. Examples and implications are provided in the report.
- The analysis of participation in other programs found that the HER program boosted participation in HES slightly, but the results were statistically significant (4.7% vs. 4.0%).
- The analysis also found that one of the HER sub-groups studied (high-use extension) installed insulation at a higher rate than the control group (8.9% vs. 7.1%, with a savings effect of about 0.03%). Changes in investment in other "deeper" measures was not found.

ES Executive Summary

This report updates findings from two prior evaluations of the Home Energy Reports (HERs) Pilot Program, implemented for Eversource by OPower.[1]

The objectives included the following:

- Update savings persistence for high-use households[2] that stopped receiving reports no later than April 2013
- Estimate the post-treatment measure life of savings for high-use households
- Explore program cost-effectiveness[3] (high level) and realization rates
- Examine the impact of HERs on participation in other CEEF programs and deeper measure adoption for both high-use and average-use households
- Assess whether Eversource is in danger of "double counting" savings in HERs and other CEEF programs for both high-use and average-use households

Note that data on savings persistence and the related concepts of measure life, retention rates, and persistence factors for behavioral programs in the literature is somewhat sparse—and because the behavioral programs differ in delivery and message—so the results cannot easily be transferred from other studies. This study provides specific information for the Eversource program.

PROGRAM DESCRIPTION

The HERs Pilot program is a behavior-based program that sends households a report reporting their energy use, providing comparisons to other households, and suggesting ways to save energy. The pilot program uses an experimental design to provide reports to a sample of households, and not provide reports to a specially-selected "control group", facilitating comparisons and impact measurements. Eversource and program implementer OPower administered a behavior pilot program for the purposes of achieving residential electricity savings and providing value to their customers through the delivery of two-page (printed on front and back) reports. Relying on a randomized control design, these reports present a treatment group with feedback on

[1] The Residential Area Consultant, NMR Group, Inc. (NMR), lead the prior two evaluations and the current one described in this report. Appendix C summarizes the most pertinent results from the two prior evaluations. NMR Group, Inc. and Tetra Tech. 2013. *Evaluation of the Year 1 CL&P Pilot Customer Behavior Program*. http://www.energizect.com/government-municipalities/final-clp-behavioral-year-1-program-report-030613
NMR Group, Inc. and Tetra Tech. 2014. *Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2)*. Available at http://www.energizect.com/government-municipalities/evaluation-year-2-clp-pilot-customer-behavior-pgm-r2-final-report-8-8-14

[2] The study refers to "households" rather than "participants" for two reasons: 1) strictly speaking, in an experiment design, members of both the treatment and the control groups are "participants"; and 2) it avoids confusion when speaking about participants in other programs (especially HES and HES-IE) addressed in the process evaluation.

[3] The analysis does not perform a full cost effectiveness assessment, but offers a simple calculation of the ratio of expenditures per kWh.

their electricity use and compare that use to a group of similar households referred to as "neighbors," which are defined as 100 occupied households similar in size and paying the same rate code as the participant home. They also provide lists of energy-saving tips that differ from month to month and year to year. The implementer then compares the energy savings of the treatment group to a control group that did not receive the HERs. The pilot program uses an "opt-out" design (prior research concluded that very few households actually do opt out), so the design does not suffer from the self-selection bias that often plagues other energy efficiency program evaluations. The Year 1 pilot program initially targeted high-use households (average monthly use of 1,600 kWh), but the Year 2 pilot program also included some average-use households (average monthly use of 700 kWh).

KEY DEFINITIONS

There are a number of definitions around the concept of "measure lifetimes" associated with energy savings. To add to the confusion, persistence, lifetime, and measure life are used casually to mean similar concepts even if the more technically have distinct meanings. Most of the definitions assume adoption of an efficiency measure rather than a behavior. Two critical concepts include the following:[4]

- **Effective Useful Life (EUL):** typically refers to the *median* lifetime for savings from measures, and is typically multiplied by first year savings to yield lifetime savings resulting from the investment in the measure.
- **Technical degradation factor (TDF):** represents how much the savings from a measure decrease over time due to mechanical (e.g., furnace does not operate as efficiently over time; duct insulation comes loose) or behavior degradation (e.g., being less diligent about washing full loads of laundry). There is very little data on TDF in the literature, so usually the concept is folded into measure lifetime, assuming full savings for each year of that EUL.

For behavioral measures, the TDF is an important component. One does not expect 100% savings each year due to behavioral variation for any number of reasons. Realistically, when examining behavior persistence, studies measure the TDF until savings no longer differ statistically from a control group.

Considering this, **for the purposes of this study**, the following definitions apply:

- **Measure life**: number of years the treatment households exhibit statistically significant savings compared to the control group.
- **Technical degradation factor (TDF):** the pattern of the percentage of savings achieved in (successive) years.

[4] Skumatz, Khawaja, and Colby, "Lessons Learned and Next Steps in Energy Efficiency Measurement and Attribution: Energy Savings, Net to Gross, Non-Energy Benefits, and Persistence of Energy Efficiency Behavior", CIEE, 11/2009; and Skumatz, "Behavioral Measure Lifetimes, Persistence, Retention, and EULs", 2/5/16.

- **Effective Useful Life (EUL):** combination of measure life and TDF—in years—to be applied to the savings in the benefit/cost equations, measured as the *mean* as opposed to the *median* due to the lack of information on the latter.

Other key concepts include the following:

- **Behavior savings persistence**: for behavior programs, this refers to the savings treatment households achieve after they stop receiving reports. The study also refers to this concept as "persistence of savings." This measure provides the numbers that factor into the TDF.
- **Retention rate**: ratio of annual post-treatment savings achieved relative to treatment savings; **technical retention rate** is the average of this ratio for years with statistically significant savings.
- **Savings degradation rate**: The percentage by which savings decline annually. This differs from the TDF in that the savings degradation rate is the *change* in the TDF.
- **Persistence factor**: Retention rate multiplied by the measure life; serves as a critical input to estimating total lifetime savings. This can be used as another term for the Behavior EUL.

The literature on behavioral programs sometimes uses these terms interchangeably or may even introduce new terms to capture the same concepts, as the nomenclature has not been codified. Likewise, the current study sometimes uses "savings persistence" to serve as an umbrella terms encompassing all of these concepts.

Another potential point of confusion in this study stems from the many different treatment and sub-treatment groups included in the HERs program between January 2011 and July 2013. Table 5 and Table 6 in the main body of the report provide additional details on these groups and their inclusion in various past and current evaluation analyses. Here, it is important to know the following:

- **High-use Discontinued group (n=16,000)**: Starting receiving reports in January 2011 and stopped receiving reports by April 2012; all had higher than average pre-program energy use
    - **Discontinued Monthly group (n=2,000)**: Received monthly reports through April 2012, for an average of 16 reports
    - **Discontinued Quarterly group (n=10,000)**: Received reports every three months through April 2012, for an average of five reports
    - **Discontinued Persistence group[2] (n=4,000)**: Received an average of eight monthly reports through August 2011 and this discontinued treatment
        - The "Persistence Group" was so named by OPower and Eversource. The study design sought to determine Year 1 program savings for a sub-treatment group that received reports for eight months (the Persistence group) versus those that received reports for a full year, therefore examining savings persistence for the first four months post-treatment given an abbreviated treatment.

- **High-use Extension group (n=8,000)**: Received reports starting in January 2011 and continued to receive them through at least July 2013, with a hiatus in April to June 2012. As the date treatment ended is not known, the study cannot provide an estimate of the total number of reports received.
- **Average-use Expansion group (n=10,000)**: Received reports July 2012 through at least July 2013. As the date treatment ended is not known, the study cannot provide an estimate of the total number of reports received.

Savings estimates presented in this report apply solely to High-use Discontinued households unless otherwise noted. As outlined more in Appendix C, the High-Use Discontinued Monthly Group exhibited greater savings rates than the High-Use Monthly Extension Group during the first year of treatment (3.62% vs. 1.96% respectively). Therefore, the results presented here for the High-use Discontinued Monthly group cannot safely be extrapolated to all high-use monthly report recipients. Likewise, the savings estimates presented here apply only to High-use Discontinued households and not to any average-use households.

STUDY METHODS

The study used billing analysis to examine persistence of savings for the High-use Discontinued group(s). This study conducted a billing analysis to estimate savings for the period through November 2014, which makes a continuous set of savings estimates for the *High –use Discontinued group* since they first began receiving reports in January 2011

The study *did not / could not* examine the persistence of the High-use Extension or Average-use Expansion groups. These two groups were still receiving reports when the work plan for this study was developed. An examination of their savings persistence will need to await discontinuation of reports to these households.[5]

The study provided information related to program cost effectiveness (measured in a simple way) and realization rates. Using program budgets and estimated savings, the study presents the ratio of program expenditures to savings and comments on the program realization rate.

The study explored participation in other programs and deeper measure uptake. The study presents statistical comparisons of rates of Home Energy Services (regular and income eligible) and rebate programs participation and deeper measure update for HERs treatment and control group households all three groups—discontinued, high-use extension, and average-use expansion.

[5] If the households are no longer receiving reports, the EEB would need to approve a new study to examine persistence for these groups.

FINDINGS

Persistence of Savings

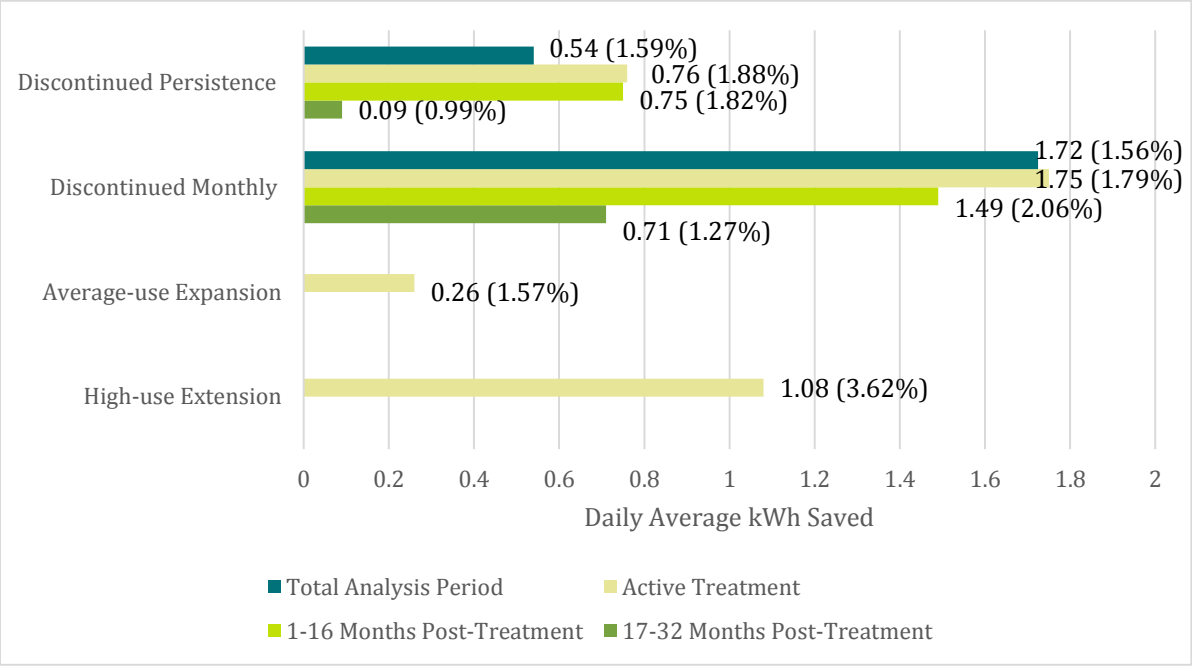
The HERs program leads to savings during treatment and well after the high-use households received reports. Figure 1[6] summarizes the estimated savings, and retained savings, for the various groups for treatment (actively receiving HER reports), and various lengths of post-treatment periods. The main findings are:

- **Over the entire analysis period:** The discontinued high use households saved an average of 0.78 kWh per day over the 47 months of their analysis period from treatment through post-treatment (January 2011- November 2014). The savings for the subgroups varied, ranging from 0.54 kWh per day for the high-use Persistence group, 0.76 kWh per day for the high-use Quarterly group, and 1.72 kWh for the high-use Discontinued monthly group.
- **Sub-Periods**: Examining individual periods shows that the Persistence and Monthly households stopped savings energy within 16 months post treatment, while the Quarterly group continued to achieve savings up to 32 months post treatment. The lower result for the monthly group is more a function of small sample size of discontinued household than to a lack of savings.[7] Figure 1 shows substantial retention of savings in the years after the HER reports are stopped.

[6] Figure 1 compare the savings achieved by the discontinued households in three different periods, coinciding with each of the three HERs program studies: January 2011 to March 2012, April 2012 to July 2013, and August 2013 to November 14 (see Section 2.1 of the main body for additional discussion and statistics). The figure present the results for the overall Discontinued Group and each of the sub-groups.

[7] The smaller sample size undermines estimates of statistical significance. There were only 1,670 households were in this group, yet their savings up to 32 months post treatment are 21% higher than those of the quarterly group. The main body of this report addresses this topic in more detail in the main report. Statistical tests also confirm that savings differ within each group across time periods.

Figure 1: High- use Discontinued Group Average Daily Savings Over Time[1,2,3]



[1] All discontinued households were considered "high users" of electricity prior to receiving home energy reports.
[2] The number of cases per subgroup are as follows: Monthly group (n=1,670), persistence group (n=3,979), quarterly group (n=9,856), control group (n=24,268).
[3] Value in the parenthesis represents the % reduction in usage.

Figure 2 recasts the savings from Figure 1 into annualized figures, and Figure 3 translates these persistence results (from Figure 2) into percentage of treatment year savings retained annually for each study group. The figures show:

Annualized retention rates for these behavioral savings are strong, declining less than 25% on average for each of the 3 years after discontinuation.

- The High-use Discontinued group realized 426 kWh savings during the first year, and (retained) savings declined to 119 kWh by the third year. The High-use Discontinued Monthly group saved the most energy during and post-treatment (but the small sample size undermines the statistical significance of the savings estimate). It is important to keep in mind that the High-use Discontinued Monthly group exhibited higher treatment savings than the High-use Monthly Extension group that continued to receive reports (3.6% vs. 2.0%, respectively), so results cannot safely be extrapolated across the two groups.

- As expected, savings decline in each year post-treatment for all three High-use Discontinued groups. However, savings did not degrade at a linear rate within groups and also varied across groups. Average annual degradation was most severe for the High-use Persistence group (34%), who received reports for only eight months—and their savings persisted for only two years. It was least severe for High-use Quarterly households at 21% annually for their three years of savings persistence. High-use Monthly households fell in between, with a 28% degradation across the two years they achieved statistically significant persistence savings.

Figure 2: Annualized Savings per Household, High-use Discontinued Treatment Groups

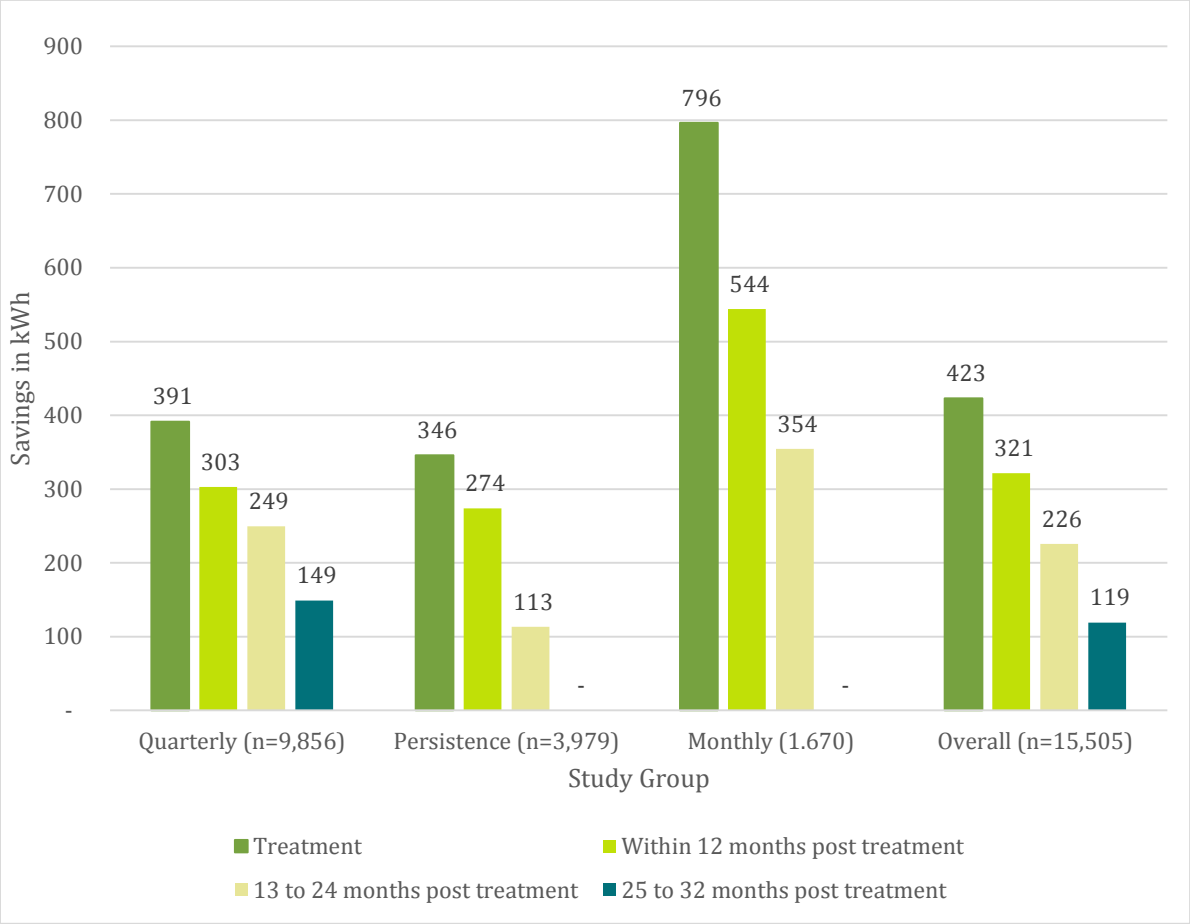
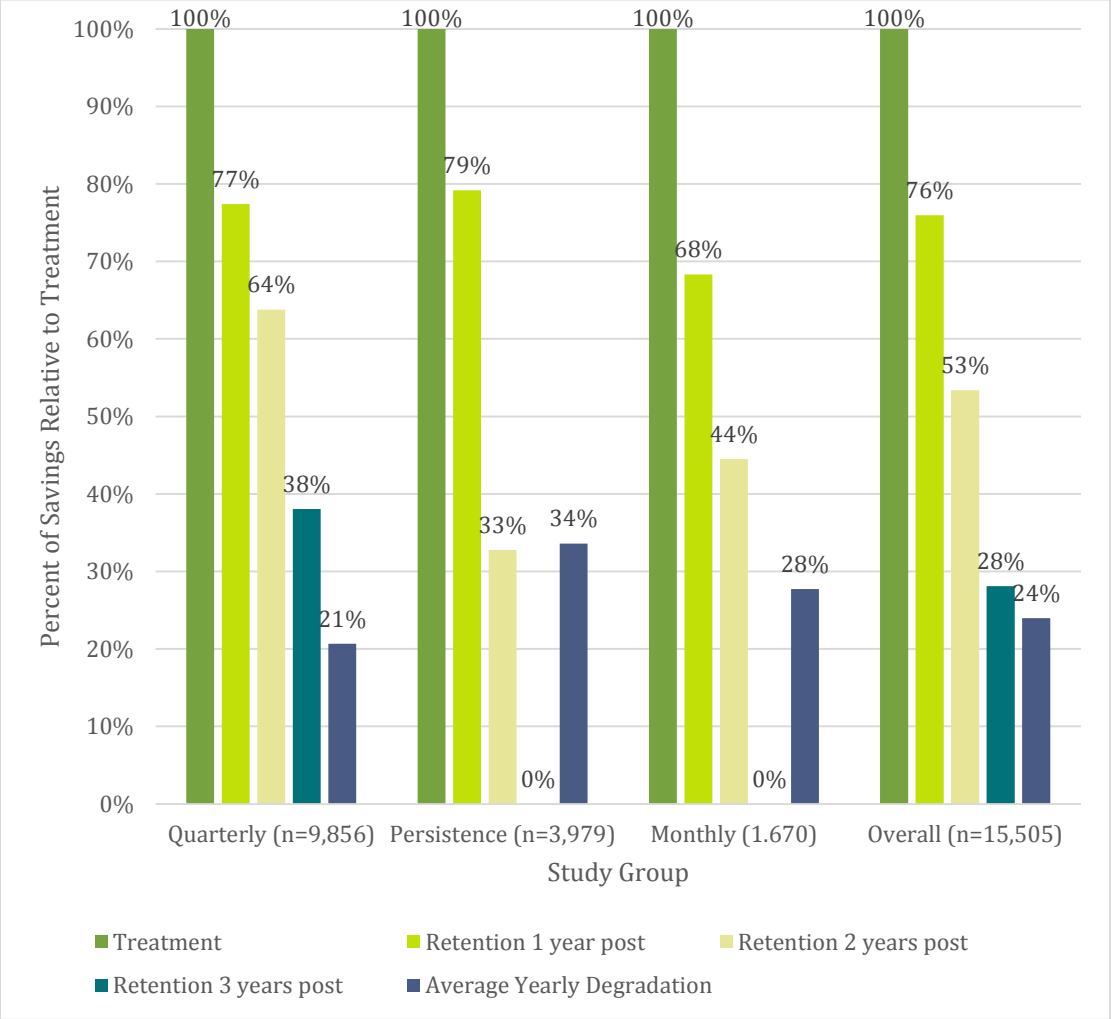


Figure 3: Percentage of Annual Savings Retained Relative to Treatment by High-use Discontinued Treatment Group*



* Statistically significant savings persist two years post treatment for the High-use Discontinued Persistence and Monthly treatment groups and three years for the Quarterly treatment group and all Discontinued households. As discussed in text, the analysis suggests that the Monthly savings would likely be significant if the sample size were larger.

What the Persistence Results Mean for Total Savings and Cost-Effectiveness

The persistence of behavior savings from the High-use Discontinued households in this program are quite strong. This has implications related to "revised" costs per kilowatt-hour savings that the program delivers for the pilot study groups—and for the program more widely.

The study used information on the treatment year savings and costs, post-treatment savings, and the "persistence factors" (which are analogous to EULs in this study) to compute the total cost per kWh under the programs as they existed (considering the actual years they delivered and did not deliver report), and by extension, the savings under "hypothetical" conditions of starting / stopping HER reports. Table 1 on the next page provides a summary from more detailed tables included later in the report (Table 12 through Table 15, which also include much more explanation). Table 1 summarizes both the total savings and the implied cost per kWh saved per household (the assessment of cost effectiveness) under alternative scenarios.[8]

[8] The analysis focuses on the hypothetical or projected scenarios rather than drawing on the experiences of High-use Extension and Average-use Expansion households due to lack of information on total program budgets and full treatment period for these households.

Table 1: Summary of Total Program Savings and Ratio of Expenditures to Savings, Three Discontinued High-Use Treatment Groups

		Quarterly Treatment Group	Persistence Treatment Group	Monthly Treatment Group[1]
Actual – 1 year treatment, no persistence	kWh savings including retention	391	346	796
	Amount spent / household	$11.94	$11.94	$11.94
	Cost per kWh	$0.031	$0.035	$0.015
Actual – 1 year treatment, 1 year persistence	kWh savings including retention	693	620	1,340
	Amount spent / household	$11.94	$11.94	$11.94
	Cost per kWh	$0.017	$0.019	$0.009
Actual: 1 year treatment, 2 years persistence	kWh savings including retention	944	733	1,694
	Amount spent / household	$11.94	$11.94	$11.94
	Cost per kWh	$0.013	$0.016	$0.007
Actual: 1 year treatment, 3 years persistence	kWh savings including retention	1,093	n/a	n/a
	Amount spent / household	$11.94	n/a	n/a
	Cost per kWh	$0.011	n/a	n/a
Scenario / Projected: 4 years continual treatment	kWh savings including retention	1,565	1,383	3,185
	Amount spent / household	$47.76	$47.76	$47.76
	Cost per kWh	$0.031	$0.035	$0.015
Scenario / Projected: 2 years treatment, 2 years persistence[1]	kWh savings including retention	1,887	1,467	3,393
	Amount spent / household	$23.88	$23.88	$23.88
	Cost per kWh	$0.018	$0.022	$0.010

[1] The results apply only to the High-use Monthly Discontinued Households and cannot be extrapolated to High-use Extension (Continued) Monthly households or Average-use Expansion Monthly households due to differences in savings rates and treatment duration. See Table 5 and Appendix C for more detail on these differences.

The amounts in Table 1 imply that lower cost per kWh is achieved if the program delivery design leverages off the fact that the program has strong savings persistence. As suggested by Rogers and Allcott (2012)[9], "cycling" customers may be more cost-effective than continual delivery of HERs. In fact, based on estimates presented in Table 16 of the main report and summarized in Table 2 below, a four-year cycling design in which HERs are sent to rotating groups of customers over a four year period could result in 68% greater energy savings—and for two-thirds of the cost—than sending one group HERs for a continual four years.

Table 2: Summary of Savings and Cost: Cycling vs. Continuous Program Designs

	Cycling Design	Continuous Design
Number of households	3,000 (1,000 / year)	1,000 (same each year)
Accumulated Four Year Savings (kWh)	2,879	1,715
Accumulated Four Year Costs	$48.00	$48.00
Cost per kWh	$0.017	$0.028
Percent Greater Savings from Cycling	68%	

The study could not estimate retention rates for High-use Extension households and Average-use Expansion households; given the number of customers in these groups, their persistence of savings should be documented in future studies and credited to the program in assessing cost-effectiveness. The PSD revisions for measure life/savings degradation cited should be applied solely to High-use Discontinued households that received reports for about a year. Additional treatment savings and persistence savings remain unknown for the High-use Extension and Average-use Expansion groups at this time. Future studies should examine persistence/degradation for these groups as they comprise 18,000 Eversource customers, so their full savings—treatment and persistence—should be documented and credited to the program. Eversource may also want to consider reactivating HERs to at least portions of these groups to see if it boosts savings above persistence rates.

[9] Allcott, H., T. Rogers, 2012. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation" National Bureau of Econ Research. Cambridge, MA. Link: http://scholar.harvard.edu/files/todd_rogers/files/the_short.pdf. See especially page 31 and Table 8 in the original report.

The study did not have access to savings as reported from OPower, which would be necessary to assess realization rates. Therefore, we have no option but to suggest Eversource maintain an assumed treatment period realization rate of 100%, as stated in the PSD. The PSD for 2015 assumes a treatment period realization rate of 100%[10] for Behavioral Change programs. Lacking access to the deemed savings provided by OPower, this analysis cannot confirm or reject the assumed realization rate of 100%, it is suggested that the Companies continue to assume a treatment period realization rate of 100%.[11] This recommendation applies to *all* treatment households regardless of study group, treatment year, or pre-program usage. To refine this estimate, Eversource should work with OPower to make certain they have the necessary information on reported savings and compare those to the estimates provided by the Evaluation Team.

Outside Program Participation and Deeper Measure Impact

HERs treatment households—High-use and Average-use—take part in HES at higher rate (4.69%) than the control households (3.96%). The analysis of uptake in the HES program demonstrated that treatment households participated in the program at a significantly higher rate than did the control households. No other program showed statistically greater participation among the treatment group compared to the control group.

Insulation is the only deeper measure adopted at a greater rate by treatment households (8.93% versus 7.09% for control households), and only by High-Use Extension households. Table 3: shows rates of deep measure adoption of all households in the HERs study group—High-use Discontinued, High-use Extension, and Average-use Expansion. Looking at the percentage of deep measure adoption between the groups (compared to a control group), only one measure was adopted a higher rate among treatment households—insulation for High-use Extension households; otherwise, no extra adoption of "deeper" measures is induced by HERs.

[10] Appendix 3, page 290: Realization Rates.
[11] In comparison, the Massachusetts Behavior Program assumes a realization rate of 105% and a measure life of one year. Source: 2011 Massachusetts Technical Reference Manual, Residential Energy Efficiency Measures.

Table 3: Deep Measure Adoption among HERs Study Group Households

		Sample Size	Insula-tion	Fur-nace / Boiler	HVAC	Fridge/ Freezer	Water Heater Heat Pump	Win-dow
High-Use Discon-tinued	Treatment	15,519	7.43%	0.08%	1.77%	2.51%	1.94%	0.26%
	Control	24,268	7.09%	0.08%	2.01%	2.37%	1.91%	0.21%
High-use Exten-sion	Treatment	8,047	8.93%*	0.09%	0.58%	0.23%	1.88%	0.26%
	Control	24,268	7.09%	0.08%	2.01%	2.37%	1.91%	0.21%
Average-use Expan-sion	Treatment	10,217	7.14%	0.14%	1.94%	2.26%	1.87%	0.32%
	Control	10,242	6.81%	0.13%	1.75%	2.23%	1.91%	0.35%

* Indicates that the treatment group measure adoption rate is significantly different than the control group measure adoption rate (X^2=30.62, p<0.001).

There is little danger of double counting of savings across HERs and other programs due to small rates of adoption of deeper measures by HERs treatment households. In order to assess the degree to which deeper measure adoption drives HERs program savings—and therefore may result in double counting of savings—the evaluators included controls for these measures in energy savings models. By including deeper measures in savings estimations, the study found that various measures were indeed associated with greater savings—as one would expect—but none of these measures reduced the estimated savings resulting directly from receipt of the HERs report.[12] Given that measures did not "absorb" the Behavior Program savings, we can conclude that the HERs program savings are largely due to behavior change and not deeper measure adoption. The reported estimates of HERs savings also do not lead to significant double counting of savings in HERs compared to HES and rebate programs.

CONCLUSIONS AND RECOMMENDATION

The study draws the following conclusions and related recommendations.

Persistence of Savings: The HERs program induces energy savings for High-use Discontinued households not only during the treatment period but for months and even years post-treatment.

[12] Statistically, the inclusion of these measures does not change the coefficient for HERs-induced savings enough (less than a hundredth of a percent), likely because so few HERs treatment households actually install deeper measures relative to the population size. Therefore, the claimed HERs savings do not include any measureable double-counting from HES.

Recommendation 1: Eversource should consider revising the PSD to reflect the findings from this study. The specific values are summarized in Table 4:. Note that this study does not provide estimated savings for High-use Extension or Average-Use Expansion Households as persistence savings have not been studied to date.

Table 4: Recommended Revisions to the Program Savings Document

	High-use Discontinued Quarterly	High-use Discontinued Persistence	High-use Discontinued Monthly[2]
Treatment Savings in kWh[1]	391	346	796
Persistent Factor[3] (use in place of EUL)	1.79	1.12	1.13

[1] Assumes a treatment period of about one-year. Longer treatment periods, such as those of the High-use Extension households, may yield different annual savings.
[2] Based on a treatment savings rate of 3.6%, which is significantly higher than the 2.0% of the High-use Extension Monthly group or the 1.2% of the Average-use Expansion Monthly group; therefore, results should not be extrapolated beyond the High-use Discontinued Monthly households.
[3] To be multiplied by Treatment Savings and the two values summed to yield total lifetime savings per household.

Recommendation 2: Until we have sufficient data to revise the estimate, Eversource should retain a realization rate of 100% for the treatment period. The evaluators did not have access to updated estimates of energy savings as provided by OPower, so the study could not provide realization rates. However, it is our experience that most OPower estimates of savings *during the treatment period* tend to align with those estimated from third-party evaluations. Thus, the study recommends a treatment period realization rate of 100%. To calculate realization rates for post-treatment periods, Eversource will need to compare the savings estimates presented in this report with those provided by OPower.

Cost-Effective Program Design: Due to the sheer number of people in the treatment group, the HERs program yields a great deal of savings relative to the program expenditures during the treatment period. Factoring in the persistence of savings only increases the already high program cost to savings ratio, suggesting that the most cost effective design may involve bursts of treatment activity followed by “down” periods when the program reaps persistence savings.

Recommendation 3: Eversource should *consider* the most appropriate length of treatment—and possible downtimes between treatment—given that savings persist for at least two years post treatment, yielding savings that rival continued treatment but at a lower cost to the program. The analyses suggest that program designs that involve cycling—that is, an “on/off” treatment design involving rotating groups of HERs recipients—likely yield greater savings at lower costs than sending reports repeatedly. Eversource, the EEB, and OPower would need to weigh various factors of costs, savings, and equity (e.g., inclusion or exclusion of average-use households) as part of this consideration.

Participation in other CEEF-funded programs and deeper measure adoption: The study concludes that the HERs program induces participation in the HES program across all treatment groups and greater uptake of insulation among High-use Extension households. However, due to the relatively small number of treatment households taking part in other CEEF programs or adopting deeper measures, the analysis finds little danger of double-counting of savings across programs.

> **Recommendation 4: Do not adjust the HERs program savings to avoid double counting with other CEEF programs.** Although a few HES-installed deeper measures do result in statistically significant savings in treatment households, their effect does not diminish the estimated savings from the HERs program. Therefore, Eversource should not make any adjustments to the savings calculations for HES or HERs in the Program Savings Document to correct for double counting. Though the study is not currently recommending abbreviating program savings to account for double counting, it is the current industry standard to do so. Therefore, Eversource should monitor savings in both the HERs program and the HES program. If savings increase substantially in either, then Eversource may need to take actions to avoid double-counting, although the nature of the adjustment may require future inquiry.

1 Introduction and Background

This report updates findings from two prior evaluations of the Home Energy Reports (HERs) Pilot Program, implemented for Eversource by OPower.[13] NMR Group, Inc. (NMR) conducted the analyses described in the current report.

1.1 Program Description

Using an experimental design, some households[14] receive a report describing their energy use relative to other households and suggesting ways to save energy. Eversource and program implementer OPower administered a behavior pilot program for the purposes of achieving residential electricity savings and providing value to their customers through the delivery of HERs. Home Energy Reports provide feedback on household electricity use and compare that use to a group of similar households referred to as "neighbors." The implementer uses a randomized control trial (RCT) approach, a true experimental design in which households eligible for the program are randomly assigned to either the treatment group that receives reports or the control group that does not. We urge readers to review our earlier reports, linked in prior footnotes, for a more detailed program description.

The study design changed over time to include various sub-treatment groups based on pre-program energy use and how frequently and for how long they received HERs. Table 5: summarizes the study designs for the Year 1 and Year 2 Pilot Program, provided as background information to understand program design and introduce the different study groups referred to in this report. Note that this table will serve as a useful resource to readers to refresh their memories on the different sub-treatment groups discussed in this report. The current analysis focuses on the long-term savings achieved by the High-use Discontinued treatment group, but it also explores the influence of HERs on other program participation and deeper measure adoption as well as cost effectiveness and realization rates for all treatment group households that were a part of the HERs program from January 2011 through July 2013. The most important point to keep in mind is that the pre-program energy use for participants differed over time in order to assess program impact on both high-use (1,600 kWh/month on average) and average-use (700/month kWh on average) customers and the length of time households received reports also varied. The

[13] Appendix C summarizes the most pertinent findings from these two prior evaluations. NMR Group, Inc. and Tetra Tech. 2013. *Evaluation of the Year 1 CL&P Pilot Customer Behavior Program*. http://www.energizect.com/government-municipalities/final-clp-behavioral-year-1-program-report-030613
NMR Group, Inc. and Tetra Tech. 2014. *Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2)*. Available at http://www.energizect.com/government-municipalities/evaluation-year-2-clp-pilot-customer-behavior-pgm-r2-final-report-8-8-14

[14] The report refers to "households" rather than "participants" for two reasons: 1) strictly speaking, in an experiment design, members of both the treatment and the control groups are "participants"; and 2) it avoids confusion when speaking about participants in other programs (especially HES and HES-IE) addressed in the process evaluation.

results cannot be safely extrapolated across groups for reasons discussed more in the report and in Appendix C.

Table 5: HERs Year 1 and Year 2 Program Designs and Study Groups

Program Component	Year 1	Year 2
Treatment Period	January 2011 to April 2012	July 2012 to June 2013
Study Group Size	48,000	68,500
Control Group Size	24,000	34,500
Active Treatment Group Size	24,000	18,000[a]
Discontinued Treatment Group Size[b]	0	16,000
Pre-program usage type	High users only (1,600 kWh)	High-use (1,600 kWh) Average-use (700 kWh)
Monthly Sub-treatment Group (received monthly reports for 16 months)	Yes (n=10,000; all high-users)	Yes (n=18,000; 8,000 high-users [Extension; continued], 10,000 average users [Expansion; new])
Quarterly Sub-treatment Group (received reports every three months for a year)	Yes (n=10,000)	No
Persistence Sub-treatment Group (received monthly reports, but only for eight months rather than 16)	Yes (n=4,000)	No

[a] Includes 8,000 households from the Year 1 Pilot that continued receiving reports in the Year 2 Pilot
[b] Comprising all recipients from the Year 1 Pilot who did not receive reports in the Year 2 Pilot.

1.2 Study Objectives

The study objectives focus on how long savings persist after households stop receiving reports and the impact of HERs on participation in other Connecticut Energy Efficiency Fund (CEEF) programs and measure adoption.

More specifically the objectives are as follows:

- Update savings persistence for high-use households that stopped receiving reports no later than April 2013
- Estimate the post-treatment measure life of savings for high-use households
- Explore (high level) program cost-effectiveness[15] and realization rates
- Examine the impact of HERs on participation in other CEEF programs and deeper measure adoption for both high-use and average-use households

[15] The analysis does not perform a full cost effectiveness assessment, but offers a simple calculation to explore the concept.

- Assess whether Eversource is in danger of "double counting" savings in HERs and other CEEF programs for both high-use and average-use households

1.3 METHODS

The evaluators used three different methods to inform the study objectives:

1. Billing analysis of discontinued households
2. Cross-tabulation and statistical testing for significant differences in other CEEF program participation and deeper measure adoption between the HERs treatment and control groups
3. Estimation of savings in the treatment group due to deeper measure adoption and program-induced savings

Table 6: summarizes the different study groups included in all three evaluations of the HERS program. As with Table 5:, Table 6: will serve as a useful resource for keeping track of the various sub-treatment groups addressed in the study.

Table 6: HERs Evaluation Activities Over Time and by Study Group

Evaluation Activity[1]	High-use Discontinued[2]	High-use Extension[3]	Average-use Expansion[4]
Study 1 Treatment Billing Analysis	Yes	Yes	No
Study 1 Persistence Analysis	8-month treatment group only	No	No
Study 1 Assessment of other CEEF Program Participation	Yes	Yes	No
Study 2 Treatment Billing Analysis	No	Yes	Yes
Study 2 Persistence Analysis	Yes	No	No
Study 3 Persistence Analysis	Yes	No	No
Study 3 Assessment of other CEEF Program Participation	Yes	Yes	Yes
Study 3 Assessment of Deeper Measure Uptake	Yes	Yes	Yes

[1] Study 1: NMR and Tetra Tech, 2013 as cited above; Study 2: NMR and Tetra Tech, 2014 as cited above; Study 3: Current Study.
[2] Discontinued households received reports from approximately January 2011 through either September 2011 or April 2012. All were considered "high users" prior to receiving reports.
[3] Extension households received reports from approximately January 2011 through at least June 2013. All were considered "high users" prior to receiving reports.
[4] Extension households received reports from approximately July 2012 through at least June 2013. All were considered "average users" prior to receiving reports.

1.3.1 Billing Analysis

The study relied on billing analyses to estimate post-treatment electricity savings and the persistence of these savings for High-use Discontinued households. The billing analysis relied on data obtained from three different sources: 1) Eversource, 2) OPower, and 3) the National Climate Data Center (NCDC) website, as outlined in Appendix A.[16] The data span from January 1, 2010 (one year pre-program) through November 30, 2014 (one month prior to the original data request).

The study subjected customer electricity bills to a billing analysis to determine if savings persisted and for how long. The billing analysis relied on a statistical technique known as ordinary least squares (OLS) robust regression. This technique ensures that the method does not over-estimate or underestimate treatment effects reflecting any imbalances in pre-program use between treatment and control groups and also to outliers. Inputs to the model included billing data, whether a household was in the treatment or control group, and weather data. The estimating equation is as follows:

> Estimated Average Electricity Savings=β_0(Avg. Post-Treatment Electricity Use)+ β_1(Dichotomous Treatment)+ β_2 (Avg. Pre-Treatment Electricity Use)+ β_3 (Dichotomous Electric Heat)+ β_4 (Heating Degree Days)+ β_5 (Cooling Degree Days)[17]

The analysis explored persistence by high-use sub-treatment groups that had stopped receiving reports no later than April 2013 and for various time periods, as follows:

- Study Groups
  - Monthly Discontinued: received reports every month from January 2011 through March 2012 (n=1,670)
  - Quarterly Discontinued: received reports every three months from January 2011 through March 2012 (n=9,856)
  - Persistence: as named during the Year 1 Pilot; received reports every month from January 2011 through August 2011 (n=3.979)
  - Discontinued control group who never received reports (n=24,268)
- Time Period
  - January 2011 to March 2012: Year 1 Pilot treatment period
  - April 2012 to July 2013: approximately one to 14 months post-treatment (coincides with Year 2 Pilot program)
  - August 2013 to November 2014: 15 to 32 months post-treatment

[16] Accessed at http://www7.ncdc.noaa.gov/CDO/cdoselect.cmd?datasetabbv=GSOD&countryabbv=&georegionabbv=

[17] All results have also been multiplied by negative one (-1.0) for ease of interpretation; this step converts a measure of decreased use—a negative number—to a measure of savings—a positive number.

1.3.2 Other Program Participation and Deeper Measure Uptake

The study also explored the impact of deep measure adoption on savings by comparing HERS treatment and control group participation in other CEEF programs. This analysis involved matching accounts numbers for CEEF program participants[18] from January 2010 through December 2014 to households in the HERs treatment and control group, including those who took part in both Year 1 and Year 1 of the pilot program (see Table 5 and Table 6). Statistical cross-tabulations and Chi-square tests assessed whether behavioral treatment and control households participated in CEEF programs at significantly different rates.

The study also explored the impact of the HERs program on deeper measure update. In order to define what deeper measures were impacting Behavior Program savings, the study ran a savings regression model with controls for whether the household had installed a deeper measure (e.g., insulation, HVAC equipment, and appliances).[19] The analysis included separate models for high-use discontinued, a high-use extension, and an average-use expansion households.

[18] These included Home Energy Solutions, Home Energy Solutions Income Eligible, and various rebate programs.

[19] The randomized nature of the study design coupled with the period considered (2012 through 2014) largely addresses any lag between having a core services visit and installing deeper measures through the program. Only those households having an HES audit late 2014 would not have had ample time to install add-on measures during the period under consideration in the analysis.

2 Key Findings

The study results point to three critical findings:

- Most High-use Discontinued treatment households saved energy at least 32 months after receiving their last report
- The program induced greater participation in HES
- Deeper measure adoption among treatment group households does not lead to double counting of savings for reasons described below.

This section expands on each of these findings and related issues of savings decay, cost effectiveness, and realization rates.

1.4 Persistence of Savings Two Years After Treatment Cessation

The HERs program design induces statistically significant savings during the treatment period and beyond. The study finds that the high-use discontinued treatment group achieved statistically significant savings of 1.6% over the control group from the beginning of the program (January 2011) through November 2014 (nearly three years after report cessation, Table 7). However, it is worth noting that the same analysis conducted through July 2013 showed the overall savings to be 2%, so savings do seem to be slipping over time.[20] An analysis by different time periods further suggests a degradation of savings over time. While discontinued households achieved savings of 1.9% during the treatment period and 1.8% for the 16 months immediately following treatment, they achieved savings of 1.0% in the next 16 months post-treatment—statistically lower than the other two periods.

Table 7: High-use Discontinued Household Program Savings through November 2014

(Savings relative to the control group's energy use)

	Entire Period (Jan. 2011 – Nov. 2014)	Jan. 2011 – Mar. 2012 (Treatment)	Apr. 2012 – Jul. 2013 (Post)	Aug. 2013 – Nov. 2014 (Post)[2]
Average Daily kWh saving[1]	0.78	0.91	0.88	0.48
Average Percent Savings	1.59%	1.88%	1.82%	0.99%
Sample Size	35,096	35,000	35,000	35,000
Explained Variance	75%	82%	66%	62%

[1] All results are statistically significant at 90% confidence, $p < 0.001$

[2] While the model demonstrates that the high-use discontinued group continued to save statistically more energy than the control group during this period, it is also the case that the savings were statistically lower than those from the two previous time periods. A Wald test ($X^2 = 14.46$, $p<.001$) concludes that the savings estimates in all three time periods differ significantly.

[20] NMR and Tetra Tech, 2014, as cited above.

The study also examines persistence of savings among high-use discontinued households by the duration and frequency at which households received HERs. While evaluations in other areas have documented that HERs-type program savings persist after treatment, the evaluation team for the current study is not aware of any other studies that have examined persistence by how long and how often households received reports. The two prior studies of the Eversource HERs program found that the persistence group—those households who received HERs for eight months only—saved a significant amount of electricity from September 2011 through March 2012 but their savings stopped achieving statistical significance five months after they stopped receiving reports.[21] The prior studies also suggested that savings amounts differed between the quarterly and monthly report recipients, with monthly housing savings more per household.

The analysis of savings by time period found mixed results for the persistence of savings for high-use discontinued households based on how long and how often they received reports, but different sample sizes muddy the results. The analysis suggests that all three high-use discontinued sub-treatment groups continued to achieve savings in the April 2012 through July 2013 time period (Table 8:). However, only the High-use Discontinued Quarterly group exhibited statistically significant savings over the control group (1.3%) in the August 2013 to November 2014 period. The findings, though, are somewhat perplexing because the High-use Discontinued Monthly treatment group achieved savings of 1.7% but the results in the same August 2013 to November 2014 time period, but the results were not statistically significant. Because Eversource and OPower continued to send reports to most monthly report households in the Year 2 Pilot (these are the High-use Extension households described in Table 5:) and due to data cleaning, the High-use Discontinued Monthly treatment group contains only 1,670 households. This small sample size lacks the statistical power to yield significant results. Yet, the fact that the quarterly group had smaller savings that nevertheless achieved significance due to a larger sample size strongly suggests that the monthly group most likely saved energy in the August 2013 to November 2014 period as well. In contrast, the persistence group's savings decrease to only 0.23%, pointing to an earlier end of the program effect for households that received report for only eight months. A Wald test for the monthly discontinued households (X^2 = 9.92, p<.01) and the persistence discontinued households (X^2 = 14.78, p<.001) concludes that the savings estimates in all three time periods differ significantly. The quarterly discontinued group shows significant savings in all time periods, but a Wald test does not allow us to conclude that we detect a significant amount of change in savings from one evaluation period to the next.

[21] Full Year 1 persistence group savings can be found in *Evaluation of Year1 of the CL&P Pilot Customer Behavior Program*" cited previously.

Table 8: Estimated Average Savings among the High-use Discontinued Sub-Groups during Evaluation Periods[1]

(Savings relative to the control group's energy use)

	Discontinued Treatment Sample Size	Jan. 2011 – Nov. 2014 (Treatment & Post Treatment)	Jan. 2011 – Mar. 2012 (Treatment)	Apr. 2012 – Jul. 2013 (Post-Treatment)	Aug. 2013 – Nov. 2014 (Post-Treatment)
Discontinued Monthly Treatment Effect[2]	1,670	1.72* (3.56%)	1.75* (3.62%)	1.49* (3.70%)	0.71 (1.66%)
Discontinued Persistence Treatment Effect	3,979	0.54* (1.11%)	0.76* (1.57%)	0.75* (1.86%)	0.09 (0.23%)
Discontinued Quarterly Treatment Effect	9,856	0.76* (1.56%)	0.86* (1.79%)	0.83* (2.06%)	0.61* (1.27%)
Sample Size Overall[2]	15.505	35,000	35,000	35,000	35,000
Explained Variance	n/a	75%	82%	69%	62%

[1] Daily savings in kWh and percentages. Recall that all discontinued households were "high users" of electricity prior to receiving reports.

[2] The High-use Discontinued Monthly treatment households exhibited far higher savings during treatment than any other treatment group, including High-use Extension Monthly treatment households (1.98%) and Average-use Expansion Monthly treatment households (1.17%). See Appendix C for more detail.

[3] The remaining 19,495 households in the overall sample size are the discontinued control group households.

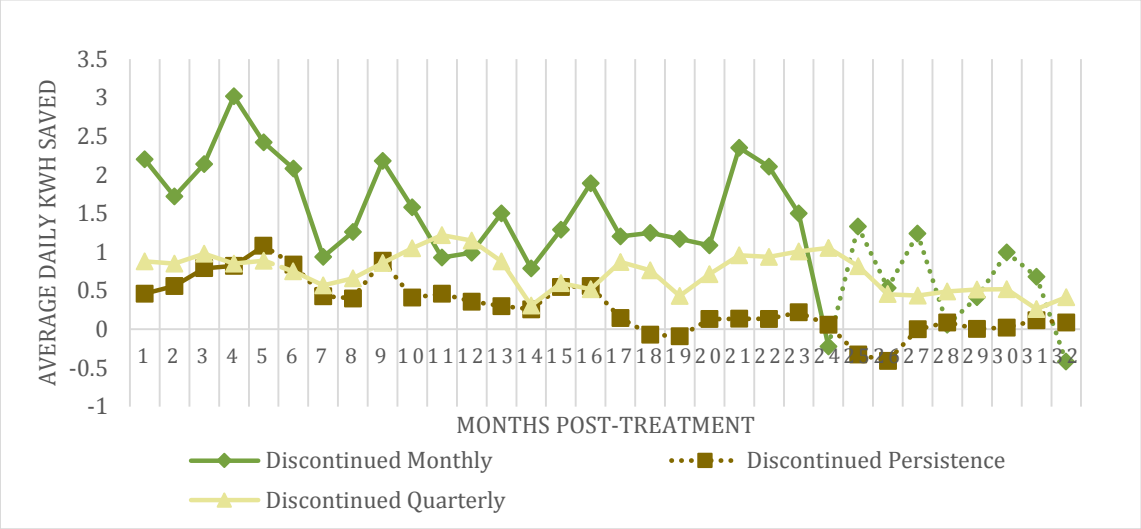
* Statistically significant at 90% confidence.

Analysis of savings by month allows the study to pinpoint when households in different high-use discontinued treatment groups stop savings energy. To delve into more detail about the duration of persistent savings for each of the discontinued treatment groups, the study examined persistence for each individual month from April 2012 through November 2014.[22] Figure 4 graphs the trend lines in savings for each of the discontinued treatment groups, with the dotted lines showing when the savings generally cease being statistically significant for each group. As the earlier analyses suggested, the graph confirms that discontinued households that received reports for a full year—whether monthly or quarterly—appear to exhibit greater savings and persistence of these savings when compared to the group that received reports for only eight months. For the Discontinued Monthly treatment group, these savings remain significant for about two years after receipt of the last report, while those for the Discontinued Quarterly group remain significant for nearly three years after receipt of the last report. Again, the variation in the number of cases likely explains why the Quarterly group exhibits significant results longer than the Monthly group. Thus, this study concludes that a full year of treatment—and not eight months—is sufficient to produce long-term persistence in savings for at least two years among the households in these two Discontinued treatment groups; the results are *indicative* of those savings persisting for nearly three years post-treatment, although the lack of statistical power means we cannot definitively conclude this is the case.

It is also the case that all of the trend lines show some seasonal and monthly variation and point to gradually diminishing savings over time. In other words, savings do not drop off precipitously at a given length of time after the program; instead, they seem to be slowly fading over time, likely because consumers return to their old habits as the energy-saving tips and neighbor comparison fade from their memories.

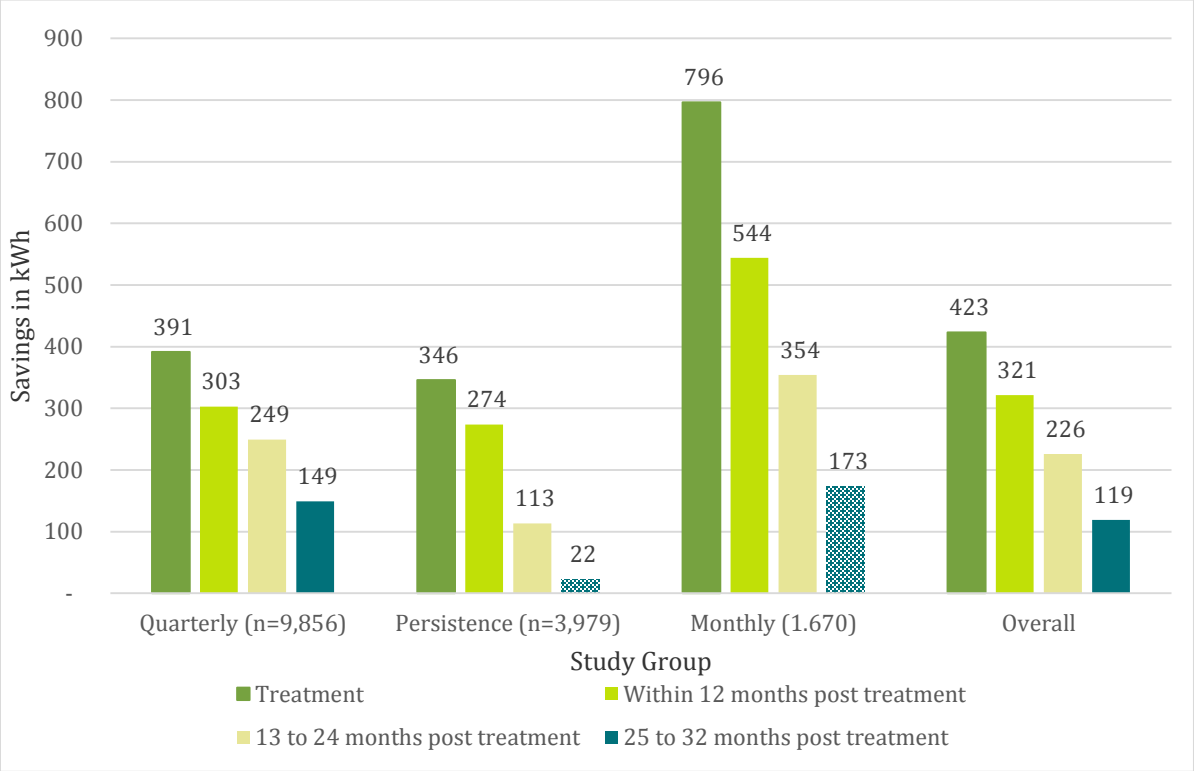
[22] Appendix B provides more detail on this monthly persistence analysis.

Figure 4: Persistent Savings by Month after Treatment Cessation for High-use Discontinued Households



Savings persist, but they decline each year after the High-use Discontinued household stops receiving reports. Figure 5 shows the per household annualized savings in kWh for each of the high-use discontinued treatment groups, coinciding with the treatment period and then 12 months, 12 to 24 months, and 25 to 32 months post-treatment. The figure demonstrates that households that received monthly reports for a year saved the most energy during and post-treatment, but the small sample size of 1,670 lacks the power to yield a statistically significant result. The figure also makes clear that savings for all three groups decline each year post-treatment.

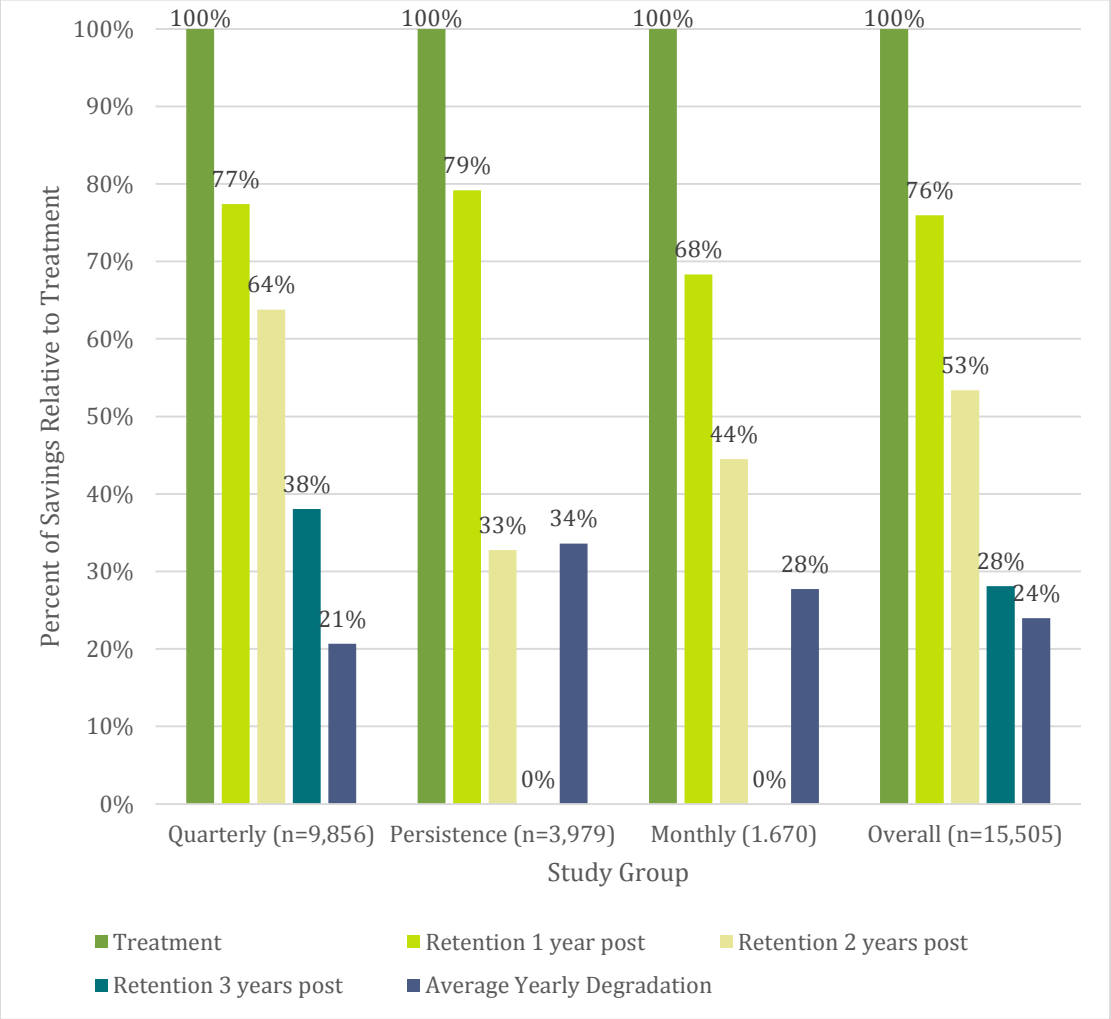
Figure 5: Annualized Savings per Household, High-use Discontinued Treatment Groups



[1] Shaded columns indicated that the savings for the sub-treatment groups were not statistically higher than those for the control group.

Savings persist, but they decline at about an average rate of 24% each year overall relative to treatment period savings. (Figure 6). Savings degradation rates were not linear within the high-use discontinued groups and also varied across groups. Average annual degradation was most severe for the Discontinued Persistence group (34%), who received reports for only eight months—and their savings persisted for only two years. It was least severe for Discontinued Quarterly households at 21% annually for their three years of savings persistence. Discontinued Monthly households fell in between, with a 28% degradation across the two years they achieved statistically significant persistence of savings.

Figure 6: Percentage of Annual Savings Retained Relative to Treatment by High-use Discontinued Treatment Group*



* Statistically significant savings persist two years post treatment for the High-use Discontinued Persistence and High-use Discontinued Monthly treatment groups and three years for the High-use Discontinued Quarterly treatment group and all High-use Discontinued households. As discussed in text, the analysis suggests that the High-use Monthly savings would be significant if the sample size were larger.

The savings decay of 24% in the Eversource HERs is in line with those reported for similar programs. The overall High-use Discontinued Group savings decayed an average of 24% per year for 32 months post treatment. This falls within the range of decay rates compiled by Khawaja and Stewart in their review of a number of OPower programs' long-run savings (Table 9).[23] Khawaja and Stewart were able to review five studies reporting persistent savings more than a year after behavioral treatment cessation and found a range of first year savings decay from 11% to 32%.

Table 9: Savings Decay among Discontinued Sub Groups in Various Studies[1]

(Ratio of Active Treatment Savings to Post-treatment Persistence Savings)

Original Author	Area	Number of treatment months	Number of Post Treatment Months	Annual Savings Decay
DNV GL (2014)	Puget Sound Energy	24	36	11%
Allcott and Rogers (2014)	West Coast	25 to 28	34	15%
Allcott and Rogers (2014)	West Coast	24	29	18%
Allcott and Rogers (2014)	Upper Midwest	24 to 25	26	21%
NMR Group (2015)	**Eversource**	**8 to 14**	**32**	**24%**
Integral Analytics (2012)	SMUD	27	12	32%

[1] Discontinued groups in other studies typically included both high- and average-use households, but the majority of savings came from high-use households.

The overall HERs ratio of program expenditures to program savings is about one cent per kWh save based on the first year budget and savings accumulated by the high-use discontinued households. By using the Year 1 Pilot program budget to estimate the ratio of program expenditures to program savings across the treatment and post-treatment period. Table 10 shows that the ratio of expenditures to savings was relatively low for all three high-use discontinued groups during the treatment period, ranging from one cent per kWh saved for the Discontinued Monthly Group and three cents for the Discontinued Quarterly and Discontinued Persistence Groups. Adding in statistically significant persistence savings only adds to the already high cost effectiveness of the program. The Persistence Group had the largest cost per savings at two cents; the Monthly Group expenditure to savings ratio was just over one-half a cent; while the largest group, the Quarterly Group, ratio was one cent per kWh saved. The ratio of expenditure to savings is not directly correlated to the number of reports issued, the Monthly group received the largest number of reports and had the smallest ratio, and the Persistence group received more reports than did the Quarterly group but had a higher ratio than did the Quarterly

[23] See the full report at http://www.cadmusgroup.com/wp-content/uploads/2014/11/Cadmus_Home_Energy_Reports_Winter2014.pdf

group. In short it is not number of reports driving the expenditure ratio but the magnitude of savings generated by the group that is driving the low expenditure to savings ratios.

Table 10: Dollar Expenditure per kWh Savings for the High-use Discontinued Group

(Calculations include the treatment and post-treatment period; cost= program expenditures/program savings)

Savings Period	Discontinued Quarterly Group	Discontinued Persistence Group	Discontinued Monthly Group[2]	Total Discontinued Group
Cost / savings: Treatment	$0.03	$0.03	$0.01	$0.03
Program Savings treatment only	3,856,653	1,375,938	1,329,738	6,562,329
Cost / savings: Treatment and one year post-treatment	$0.02	$0.02	$0.01	$0.02
Program savings treatment and one year post-treatment	6,842,528	2,465,189	2,237,967	11,545,684
Cost / savings Treatment and two years post-treatment	$0.01	$0.02	$0.007	$0.01
Program savings treatment and two years post-treatment	9,301,501	2,916,289	2,829,665	15,047,455
Cost / savings Treatment and three years post-treatment	$0.01	--	--	$0.01
Program savings treatment and three years post-treatment	10,768,468	3,003,668	3,118,976	16,891,112
Program Expenditure[1]	$113,527	$45,833	$19,926	$178,596
Sample Size	9,856	3,979	1,670	15,505

[1] Program expenditures allocated proportionately based on sample in the models.

[2] Keep in mind that the High-use Discontinued Monthly group exhibited a higher savings rate than any other study group, including both high-use and average-use households as well as discontinued and continued households.

Because of savings persistence, High-use Discontinued Group households exhibit a higher ratio of expenditures to savings (one cent) than High-use Extension (two cents) and Average-use Expansion households (five cents) as measured through November 2014. Through July 2013, the cost effectiveness of the High-use Extension Group rivaled that of the three High-use Discontinued groups (three cents per kWh), but, by November 2014, its ratio of expenditures to savings more closely resembled the Discontinued Persistence Group (two cents per kWh)

than the more Discontinued Quarterly or Monthly Groups (one cent and one-half cent per kWh, respectively).[24] Additionally, because their savings rate is lower than any of the high-use households, the Average-use Expansion achieved a ratio of expenditure to savings of 13 cents per kWh through July 2013 (one year of treatment), while this improved to five cents through November 2014. Importantly, the Extension and Expansion households were still receiving reports during planning for the current study. While they have requested the information, at the time of writing the evaluators were not aware of how long their treatment continued or the total budget spent on each group during the full treatment period. Therefore, the ratio of expenditures to savings through November 2014 *overstates* the cost-effectiveness of the program because additional money was spent during that time. Future evaluations will need to assess the persistence of savings for these two groups, which would provide a fuller understanding of the lifetime cost-effectiveness for the Extension and Expansion households.

Table 11: Dollar Expenditure per kWh Savings for the High-use Extension and Average-use Expansion Groups

Savings Period	High Use Extension Group	Average Use Expansion Group
Treatment through July 2013	$0.03	$0.13
Treatment/post-treatment through November 2014	$0.02	$0.05
Program Expenditures	$201,131	$128,319
Sample Size	3,979	9,856

[1] The Treatment period only savings come from the *Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2)*. Available at http://www.energizect.com/government-municipalities/evaluation-year-2-clp-pilot-customer-behavior-pgm-r2-final-report-8-8-14

[2] The date when these households stopped receiving reports is unknown at this time. If available before this report is finalized, the study will revise these estimates. The treatment / post treatment period for the average-use group includes July 2012 through November 2014 and for the high-use group is January 2011 through November 2014.

The three tables on the following pages summarize treatment and post-treatment savings for the three discontinued groups, **including presenting "persistence factors" that should be used in place of a measure life to estimate lifetime savings, with calculations described in the tables below.**[25] The tables also summarize the assessment of cost effectiveness—measure as expenditures per kWh saved per household—for different hypothetical program scenarios. Note that the expenditures per kWh in the tables below assume a constant value for all study groups and differ from those reported in Table

[24] Although, it must be remembered that the High-use Discontinued Monthly group exhibited greater savings than the High-Use Extension Monthly group.

[25] The persistence factors do not take discounting into effect. However, if one assumes a discount rate of 4% yields monthly-group savings estimates that are 97% of those without discounting. Even with a 10% discount rate, the monthly group savings are 93% of estimates without discounting.

10, which are based on actual achieved savings as modeled for the current study. The constant value makes comparisons easier across the hypothetical scenarios and should ease program planning but will likely overstate the expenditures per kWh for high-use monthly households. By way of comparison, the study also presents a fourth table that draws on results for the High-use Extension households from the prior two evaluations; given that the High-use Discontinued Monthly group exhibited higher savings compared to all other study groups (3.6% treatment for Discontinued Monthly [n=1,670] vs. 2.0% [n=8,047] treatment for Extension monthly). This fourth table **may** represent a more realistic expectation of costs and savings for various scenarios but further research will be needed to confirm this since the persistence of this group was not addressed in the study (they will still receiving reports when this study was planned).

The High-use Discontinued Quarterly Treatment Group exhibited statistically significant savings for three years after treatment, yielding a total lifetime savings of 1,093 per household at a little over one cent per kWh saved (Table 12**).** This total savings comprises both treatment savings and three years of persistence savings, with a retention rate of 0.6, or a persistence factor of 1.79, across the three years. If the program had sent reports to these households for four years *at the same cost and with the same savings achieved*, the total energy savings would have been 1,575 kWh at a cost of three cents per kWh saved.[26]

Table 12: Summary of Total Program Savings and Ratio of Expenditures to Savings, Quarterly Treatment Group

(n=9,856)

	Actual: One Year Treatment, no Persistence	Actual: One Year Treatment, One Year Persistence	Actual: One Year Treatment, Two Year Persistence	Actual: One Year Treatment, Three Year Persistence	Hypothetical: Four Years Continual Treatment	Hypothetical: Two Year Treatment, Two Year Persistence
1. Treatment Savings (kWh / HH)	391	391	391	391	1,565	783
2. Years Post-Treatment with Statistically Significant Savings	0	1	2	3	0	2
3. Technical Retention (Average by Years Persistent)	0	0.77	0.71	0.60	0	0.71
4. Persistence factor (Row 2 x Row 3)	0	0.77	1.41	1.79	0	1.41
5. Amount spent on group per HH[1]	$11.94	$11.94	$11.94	$11.94	$47.76	$23.88
6. Total Saved in kWh / HH (Row 1 + [Row 1 x Row 4])	391	693	944	1,093	1,565	1,887
7. Expenditures per kWh Saved (Row 5 / Row 6)	$0.031	$0.017	$0.013	$0.011	$0.031	$0.018

[1] Based on Year 1 program spending proportionately allocated to each discontinued group (and adjusting for amount spent in Year 1 of the program on the continued group); multiplied by assumed years of treatment in alternative scenarios.

[26] The experiences of the High-use Expansion group from the Year 2 Pilot Program (See Appendix C) as well as research by Rogers and Allcott suggests that savings increase with continued treatment. However, Rogers and Alcott also note that the impact of continued treatment wains sometime between two to four years, sometimes even degrading over time. Thus, while the hypothetical scenarios presented in Table 12 through Table 15 are conservative, they are likely in the ballpark of what could actually be expected. Allcott, H., T. Rogers, 2012. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation" National Bureau of Econ Research. Cambridge, MA. Link: http://scholar.harvard.edu/files/todd_rogers/files/the_short.pdf.

Although the High-use Discontinued Persistent Treatment Group received reports for only eight months, Table 13 converts their savings to a full year for ease of comparison across groups. **Because this group achieved statistically significant savings only two years post-treatment, the lifetime savings sums to 733 kWh per household at a cost of about 1.6 cents per kWh saved, representing the most spent among discontinued households relative to achieved savings. The persistence factor for this group is 1.12.**

Table 13: Summary of Total Program Savings and Ratio of Expenditures to Savings, Persistent Treatment Group

(n=3,979)

	Actual: One Year Treatment, no Persistence	Actual: One Year Treatment, One Year Persistence	Actual: One Year Treatment, Two Year Persistence	Hypothetical: Four Years Continual Treatment	Hypothetical: Two Year Treatment, Two Year Persistence
1. Treatment Savings (kWh / HH)	346	346	346	1,383	692
2. Years Post-Treatment with Statistically Significant Savings	0	1	2	0	2
3. Technical Retention (Average by Years Persistent)	0	0.79	0.56	0	0.56
4. Persistence factor (Row 2 x Row 3)	0	0.79	1.12	0	1.12
5. Amount spent on group per HH[1]	$11.94	$11.94	$11.94	$47.46	$23.88
6. Total Saved in kWh / HH (Row 1 + [Row 1 x Row 4])	346	620	733	1,383	1,467
7. Expenditures per kWh Saved (Row 5 / Row 6)	$0.035	$0.019	$0.016	$0.035	$0.022

[1] Based on Year 1 program spending proportionately allocated to each discontinued group (and adjusting for amount spent in Year 1 of the program on the continued group); multiplied by assumed years of treatment in alternative scenarios.

Even with just two years of statistically significant post-treatment savings, the Monthly treatment group exhibited the greatest amount of savings per household (1,694 kWh) at the lowest cost per kWh (just over one-half of a cent), although the treatment savings rate of 3.6% was greater than for all other study groups (range of 1.2% for Average-use Expansion households to 2.3% for High-use Extension households in their second year of treatment). The persistence factor for this group is 1.13. The monthly reminder of the HERs led the Discontinued Monthly treatment households to achieve the highest savings during treatment (Table 14). While their savings degraded at faster rate than the Quarterly group (0.56 in two years vs. 0.71 in two years, respectively), this still could not undo the high treatment savings. As mentioned earlier in this report, the fact that the Discontinued Quarterly treatment group (n=9,856) achieved statistically significant savings three years post treatment with smaller savings than the Discontinued Monthly group (n=1,670) strongly suggests that the Monthly group would also have shown persistence savings three year out with a larger sample size, which would only serve to increase its overall savings and cost effectiveness.

Table 14: Summary of Total Program Savings and Ratio of Expenditures to Savings, Monthly Treatment Group

(n=1,670)

	Actual: One Year Treatment, no Persistence	Actual: One Year Treatment, One Year Persistence	Actual: One Year Treatment, Two Year Persistence	Hypothetical: Four Years Continual Treatment	Hypothetical: Two Year Treatment, Two Year Persistence
1. Treatment Savings (kWh / HH)	796	796	796	3,185	1,593
2. Years Post-Treatment with Statistically Significant Savings	0	1	2	0	2
3. Technical Retention Rate (Average by Years Persistent)	0	0.68	0.56	0	0.56
4. Persistence factor (Row 2 x Row 3)	0	0.68	1.13	0	1.13
5. Amount spent on group per HH[1]	$11.94	$11.94	$11.94	$47.46	$23.88
6. Total Saved in kWh / HH (Row 1 + [Row 1 x Row 4])	796	1,340	1,694	3,185	3,393
7. Expenditures per kWh Saved (Row 5 / Row 6)	$0.015	$0.009	$0.007	$0.015	$0.010

[1] Based on Year 1 program spending proportionately allocated to each discontinued group (and adjusting for amount spent in Year 1 of the program on the continued group); multiplied by assumed years of treatment in alternative scenarios.

By way of comparison, High-use Extension households, who received reports monthly from January 2011 through at least July 2013 (with a brief hiatus from April to July 2012), exhibit an expenditures per savings ratio of about two cents for two years of actual treatment and assumed persistence of two years. Using savings and budget estimates from the Year 1 and Year 2 studies coupled with High-use Discontinued Monthly household savings retention results, Table 15 presents five different hypothetical scenarios of the total savings and expenditures to savings ratios for the High-use Extension group. As with the other examples presented above, savings appear to be maximized with continued treatment, but it costs the program more to earn each kWh of savings.

Table 15: Estimate of Total Program Savings and Ratio of Expenditures to Savings, High-use Extension Treatment Group[1]

(n=8,047)

	Hypothetical: One Year Treatment, no Persistence	Hypothetical: One Year Treatment, One Year Persistence	Hypothetical: One Year Treatment, Two Year Persistence	Hypothetical: Four Years Continual Treatment	Similar to Actual: Two Year Treatment, Two Year Persistence
1. Treatment Savings (kWh / HH)	416	**416**	**416**	**1,715**	849
2. Years Post-Treatment with Statistically Significant Savings	0	1	2	0	2
3. Technical Retention Rate (Average by Years Persistent)	0	0.68	0.56	0	0.56
4. Persistence factor (Row 2 x Row 3)	0	0.68	1.13	0	1.13
5. Amount spent on group per HH[2]	$11.94	$11.94	$11.94	$50.94	$24.94
6. Total Saved in kWh / HH (Row 1 + [Row 1 x Row 4])	416	700	885	1,715	1,808
7. Expenditures per kWh Saved (Row 5 / Row 6)	$0.029	$0.017	$0.013	$0.030	$0.019

[1] All of the scenarios are hypothetical because they differ from the actual treatment and persistence periods for the High-use Extension households, and the studies to date have not assessed persistence for this study group. However, the inputs are based on Year 1 and Year 2 program spending and savings rates for the High-use Extension Group (see Appendix C) but apply the retention and degradation rates of the High-use Discontinued Monthly group, due to lack of persistence information for the Extension Group. The scenario in the last column is the most similar to the actual treatment period for the High-use Extension group but the savings persistence are hypothetical.

[2] Based on first year savings of 416 kWh per household and subsequent year savings of 433 kWh per household (the amount saved per households in Year 2).

[3] Based on Year 1 and Year 2 program spending of $11.94 in Year 1 (same as other groups) and $13 for subsequent years based on Year 2 budget; multiplied by assumed years of treatment in alternative scenarios.

When examining the treatment and persistence savings and costs of continual versus discontinued treatment, prominent HERs scholars Rogers and Allcott (2012) have suggested that, *"The basic principle suggested by [the results] is to repeat an intervention to induce consumers to form new capital stock [efficient behavior], and reduce treatment intensity after this has happened."*[27] In other words, consumers should be sent repeated reports for a while but then the frequency of reports should be reduced or discontinued.

The current study explores one possible approach the cycling design advised by Rogers and Allcott. Table 16presents two competing designs that costs approximately the same amount of money to administer and reach the same number of households annually. However, the amount of savings achieved and the cost of achieving them diverge greatly. The first scenario has three treatment groups of 1,000 households each: Group A receives HERs in Year 1, Group B in Year 2, and Group C in Year 3, and then Group A again receives HERs in Year 4. The second scenario assumes constant treatment to a single group of 1,000 households who receive HERs for four years. The energy savings and cost inputs draw on the first and second year savings of the High-use Extension households, as they are more aligned with the savings of other study groups, but Appendix D presents a similar scenario using High-use Discontinued Monthly households and High-use Extension households, which is more closely resembles the actual study design as implemented (without cycling) in Connecticut.

A four year, three-group cycling design that touches 3,000 households could possibly save 68% more electricity than a continuous report design that touches only 1,000 households. The analysis in Table 16 suggests that cycling households in the manner described above leads to effective cumulative savings across four years of 2,879 kWh at a cost of 1.7 cents per kWh precisely because the program, while only touching 1,000 households a year at $12.00 per household (but 3,000 in all), reaps the treatment savings of the "on-cycle" group and the persistence savings of the "off-cycle" groups. In contrast, because savings tend to plateau with repeated treatment and they garner no persistence savings, sending the same group of 1,000 households HERs for four years results in 1,715 kWh of savings at a cost of 2.8 cents per kWh. The scenario is only one of various cycling designs, and the exact nature of such a design would need to be carefully considered and planned by Eversource, the EEB, and OPower. Yet, the analysis supports the conclusion that cycling can achieve greater savings at lower costs than continual treatment. Note also that some of the savings and cost estimates differ very slightly from those in Table 12 through Table 15 due to rounding error in Table 16.

[27] Rogers and Allcott. 2012. As cited above, page 31.

Table 16: Hypothetical Cycling vs. Continuous Program Design Comparison

Program Year	Savings and Costs	Cycling Design: Based on High-use Extension Group Findings				Four Year Continuous Treatment Design[1]
		Group A	Group B	Group C	Program Total[2]	
	Assumed Sample Size	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
Year 1	Treatment Savings (kWh)	416	0	0	416	416
	Persistence Savings (kWh)	0	0	0	0	0
	Total Savings (kWh)	416	0	0	416	416
	Annual Cost	$12.00	$0	$0	$12.00	$12.00
	Cost per kWh	$0.029	N/A	N/A	$0.029	$0.029
Year 2	Treatment Savings (kWh)*	0	416	0	416	433
	Persistence Savings (kWh)	283	0	0	283	0
	Accumulated Two-Year Savings (kWh)	699	416	0	1115	849
	Annual Cost**	$0.00	$12.00	$0.00	$12.00	$12.00
	Accumulated Two-Year Cost	$12.00	$12.00	$0.00	$24.00	$24.00
	Cost per kWh	$0.017	$0.029	N/A	$0.022	$0.028
Year 3	Treatment Savings (kWh)	0	0	416	416	433
	Persistence Savings (kWh)	183	283	0	466	0
	Accumulated Three-Year Savings (kWh)	882	699	416	1,997	1,282
	Annual Cost**	$0.00	$0.00	$12.00	$12.00	$12.00
	Accumulated Three-Year Costs	$12.00	$12.00	$12.00	$36.00	$36.00
	Cost per kWh	$0.014	$0.017	$0.029	$0.018	$0.028
Year 4	Treatment Savings (kWh)	416	0	0	416	433
	Persistence Savings (kWh)	0	183	283	466	0
	Accumulated Four-Year Savings (kWh)	1298	882	699	2879	1715
	Annual Cost**	$12.00	0	0	$12.00	$12.00
	Accumulated Four-Year Costs	$24.00	$12.00	$12.00	$48.00	$48.00
	Cost per kWh	$0.018	$0.014	$0.017	$0.017	$0.028
Program Total for Four Years[2]	**Accumulated Four Year Savings (kWh)**				**2,879**	**1,715**
	Accumulated Four Year Costs				**$48.00**	**$48.00**
	Cost per kWh				**$0.017**	**$0.028**
	Percent Greater Savings from Cycling				**68%**	

[1] Treatment savings Year 1 and Year 2 equal to evaluated results (see Appendix C); Year 3 and Year 4 use Year 2 savings.

[2] Program totals for cycling reflect effective achievements across all households. In other words, no individual home will save 2,879 over the four years, but the program effectively achieves this savings by paying for report for just 1,000 households but reaping persistence savings for 2,000 more (in some years).

The study did not have access to savings as reported from OPower, which would be necessary to assess realization rates. Therefore, the Eversource should maintain an assumed treatment period realization rate of 100%, as stated in the PSD. The PSD for 2015 assumes a treatment period realization rate of 100%[28] for Behavioral Change programs. Lacking access to the deemed savings provided by OPower, this analysis cannot confirm or reject the assumed realization rate of 100%, it is suggested that the Companies continue to assume a treatment period realization rate of 100%.[29] This recommendation applies to *all* treatment households regardless of study group, treatment year, or pre-program usage.

1.5 Rates of Outside Program Participation among Behavioral Program Participant and Non-participant Households

The HERs program induces participation in the HES program. While the persistence savings analysis focused only on discontinued households, the study included all treatment households from Year 1 and Year 2 Pilot programs in the analysis of the HERs program impact on participation in other CEEF programs. The results of the analysis of participation in other CEEF programs suggests that HERs treatment households inducing greater participation in the HES and between January 1, 2011, and December 31, 2014 (X^2=21.2 and p-value <0.001) (Table 17). The evidence for other programs is not statistically significant (and sometimes points to greater control group participation).

Table 17: Participation in other CEEF Programs

Program	Sample Size	HES-IE	HES	Resi Rebate	Res HVAC	Lighting Catalog	Lighting Coupon
# Treatment Group	32,974	294	1,558	280	390	15	278
# Control Groups	33,037	290	1,320	305	429	16	256
% of all Treatment	32,974	0.88%	4.69%*	0.84%	1.17%	0.05%	0.84%
% of all Control	33,037	0.88%	3.96%	0.91%	1.29%	0.05%	0.77%
Difference	n/a	0.00%	0.73%	-0.07%	-0.12%	0.00%	0.07%

* Indicates that the treatment group measure adoption rate is significantly different than the control group measure adoption rate (X^2=21.2 and p-value < 0.001).

While confirming greater HES participation among HERs households, this straightforward analysis does not allow us to conclude that these households were acting on specific tips from the HERs when choosing to take part in these other CEEF programs. Nor do we know

[28] Appendix 3, page 290: Realization Rates.
[29] In comparison, the Massachusetts Behavior Program assumes a realization rate of 105% and a measure life of one year. Source: 2011 Massachusetts Technical Reference Manual, Residential Energy Efficiency Measures.

if these households adopted deeper measures due to their HES participation—a topic to which we turn next.

1.6 DEEPER MEASURE ADOPTION IMPACT ON PROGRAM SAVINGS

High-use Extension households adopted insulation at a higher rate than the control group. To examine deeper measure adoption among HERs treatment households, the evaluation team linked measure adoption data in the HES, HES-IE, and rebate program tracking database (2010 to 2014) to HERs treatment and control group households. Looking at deep measure adoption by treatment group (discontinued, high-usage [Extension], and average-usage [Expansion]), HERs High-use Extension households adopted insulation at a greater rate than the control group (Table 18). The HERs households in all other groups failed to adopt any other measures at a greater rate than the control group.

Table 18: Deep Measure Adoption among Behavior Program Households

		n	Insula-tion	Furnace / Boiler	HVAC	Fridge / Freezer	Water Heater Heat Pump	Window
Discontinued all high-use	Treatment	15,519	7.43%	0.08%	1.77%	2.51%	1.94%	0.26%
	Control	24,268	7.09%	0.08%	2.01%	2.37%	1.91%	0.21%
High-use Extension	Treatment	8,047	8.93%*	0.09%	0.58%	0.23%	1.88%	0.26%
	Control	24,268	7.09%	0.08%	2.01%	2.37%	1.91%	0.21%
Average-use Expansion	Treatment	10,217	7.14%	0.14%	1.94%	2.26%	1.87%	0.32%
	Control	10,242	6.81%	0.13%	1.75%	2.23%	1.91%	0.35%

* Indicates that the treatment group measure adoption rate is significantly different than the control group measure adoption rate (X^2=30.62, p<0.001).

The study examines the possible double counting of savings between HERs and other programs. Because the HERs program includes energy-saving tips that encourage households to take part in HES and buy products that may have incentives applied to them, the question arises as to whether the HERs savings are being double counted in other programs—notably, HES, HES-IE, and rebate programs. In other words, are the HERs savings simply reflecting measures adopted in other programs? To explore this, the study included a series of regression models with flags for whether the treatment and control households had adopted deeper measures (the same named in Table 18 above). We ran separate models for discontinued households, high-use extension households, and average-use expansion households due to their different pre-program energy use and length of time they received reports. If the measures were in fact responsible for a portion of the HERs savings, then the model should capture it. Statistically, the coefficient for the impact of receiving HERs should decrease.

The models suggests little danger of double counting of savings in HERs due to deeper measure adoption. As one would expect, the regression models confirm that households in both the treatment and control groups that adopted deeper measures saved energy. However, the coefficient for HERs program-induced savings—the element of the model that tells us how much energy the average HERs treatment household saved—decreased no more than a hundredth of a percent when the deeper measure variable was included in the models (Table 19 to Table 21). In short, deeper measure adoption impacts savings, but not on a scale that would lead to any double counting between other programs. Why would this be the case? The number of HERs households adopting deeper measures is too small to matter in the average. Those households with insulation, for example, save more than other households, but another household ignore the HERs and does nothing. It all averages out in the end.

Table 19 to Table 21 present the results of these models for the discontinued, high-use, and average-use households.

Table 19: Estimated Discontinued Group Program Savings with Deeper Measures

(Savings relative to the control group's energy use)

	Discontinued High-Use Households	Discontinued Households with Deeper Measures included in Model
Average Daily kWh saving[1]	0.777	0.773
Average Percent Savings	1.59%	1.58%
Sample Size	35,000	35,000
Explained Variance	75%	75%

[1] All results are statistically significant at 90% confidence

Table 20: Estimated High Usage Household Program Savings with Deeper Measures

(Savings relative to the control group's energy use)

	High Usage Extension Households	High Usage Households with Deeper Measures included in Model
Average Daily kWh saving[1]	1.13	1.12
Average Percent Savings	2.37%	2.34%
Sample Size	31,000	31,000
Explained Variance	72%	72%

[1] All results are statistically significant at 90% confidence

Table 21: Estimated Average Usage Household Program Savings with Deeper Measures

(Savings relative to the control group's energy use)

	Average Usage Expansion Households	Average Usage Households with Deeper Measures included in Model
Average Daily kWh saving[1]	0.294	0.291
Average Percent Savings	1.33%	1.31%
Sample Size	20,000	20,000
Explained Variance	45%	45%

[1] All results are statistically significant at 90% confidence

3 Conclusions and Recommendations

This study was designed to determine whether the HERs program was continuing to induce persistent savings and, if not, when the savings stopped. These analyses allowed the study to also comment on realization rates, measure life, and cost effectiveness. The study additionally explored whether deeper measure adoption was responsible for a portion of the HERs savings, thereby leading to double counting of savings across programs.

Table 22 provides a summary of the findings on savings, persistence, and cost per kWh saved.

Table 22: Year 3 HERs Evaluation Findings Summary

	Average-use Expansion	High-use Extension	Discontinued[1]			
			Quarterly	Persis-tence	Monthly	Total
Sample Size	10,000	8,000	9,856	3,979	1,670	15,505
Percent of customers	0.90%	0.72%	0.89%	0.36%	0.15%	1.40%
Avg. annual pre-treatment usage (kWh)	8,496	19,848	19,968	19,920	20,028	19,956
Avg. monthly pre-treatment usage	708	1,654	1,664	1,660	1,669	1,663
HH Program savings: kWh/year	949,000	3,474,800	2,734,054	784,261	1,048426	4,414,800
HH Program savings: kWh/month	96	433	277	197	628	285
HH Program savings: kWh/day	0.26	1.19	0.76	0.54	1.72	0.78
Program savings: percent of annual consumption	1.17%	2.31%	1.56%	1.11%	3.56%	1.59%
Persistence factor	--	--	1.79	1.12	1.13	1.57
Savings degradation	--	--	21%	34%	28%	24%
Annual cost of HER[2]	--	--	$117,026	$47,638	$13.392	$178,596
Dollar cost per kWh saved[3]	$0.13	$0.03	$0.01	$0.02	$0.007	$0.01

[1] All Discontinued and Discontinued Sub-group values are based on significant savings. Average-use and High-use Expansion savings are based on values reported in the Year 2 evaluation

[2] Based on first year of participation (by group) expenditure as reported to the evaluator during the Year 2 evaluation.

[3] The evaluators are unsure of the time period the Average-use Expansion and High-use Extension groups received active treatment, therefore these values are based only on the active treatment period as reported in the Year 2 evaluation.

The study draws the following conclusions and related recommendations.

Persistence of Savings: The HERs program induces energy savings for high-use households not only during the treatment period but for months and even years post-treatment.

> **Recommendation 1:** Eversource should consider revising the PSD to reflect the findings from this study. The specific values are summarized in Table 23. Note that this study does not provide estimated savings for High-use Extension or Average-Use Expansion Households as persistence savings have not been studied to date.

Table 23: Recommended Revisions to the Program Savings Document

	High-use Discontinued Quarterly	High-use Discontinued Persistence	High-use Discontinued Monthly
Treatment Savings in kWh[1]	391	346	796
Persistent Factor[3] (use in place of EUL)	1.79	1.12	1.13

[1] Assumes a treatment period of about one-year. Longer treatment periods, such as those of the High-use Extension households, may yield different annual savings.
[2] Based on a treatment savings rate of 3.6%, which is significantly higher than the 2.0% of the High-use Extension Monthly group or the 1.2% of the Average-use Expansion Monthly group; therefore, results should not be extrapolated beyond the High-use Discontinued Monthly households.
[3] To be multiplied by Treatment Savings and the two values summed to yield total lifetime savings per household.

> **Recommendation 2: Until we have sufficient data to revise the estimate, Eversource should retain a realization rate of 100% for the treatment period.** The evaluators did not have access to updated estimates of energy savings as provided by OPower, so the study could not provide realization rates. However, it is our experience that most OPower estimates of savings *during the treatment period* tend to align with those estimated from third-party evaluations. Thus, the study recommends a treatment period realization rate of 100%. To calculate realization rates for post-treatment periods, Eversource will need to compare the savings estimates presented in this report with those provided by OPower.

Cost-Effective Program Design: Due to the sheer number of people in the treatment group, the HERs program yields a great deal of savings relative to the program expenditures during the treatment period. Factoring in the persistence of savings only increases the already high program cost to savings ratio, suggesting that the most cost effective design may involve bursts of treatment activity followed by "down" periods when the program reaps persistence savings.

> **Recommendation 3: Eversource should consider the most appropriate length of treatment—and possible downtimes between treatment—given that savings persist for at least two years post treatment, yielding savings that rival continued treatment but at a lower cost to the program.** The analyses suggest

that program designs that involve cycling—that is, an "on/off" treatment design involving rotating groups of HERs recipients—likely yield greater savings at lower costs than sending reports repeatedly. Eversource, the EEB, and OPower would need to weigh various factors of costs, savings, and equity (e.g., inclusion or exclusion of average-use households) as part of this consideration.

Participation in other CEEF-funded programs and deeper measure adoption: The study concludes that the HERs program induces participation in the HES program and greater uptake of insulation among high-use extension households. However, due to the relatively small number of treatment households taking part in other CEEF programs or adopting deeper measures, the analysis finds little danger of double-counting of savings across programs.

Recommendation 4: Do not adjust the HERs program savings to avoid double counting with other CEEF programs. Although a few HES-installed deeper measures do result in statistically significant savings in treatment households, their effect does not diminish the estimated savings from the HERs program. Therefore, Eversource should not make any adjustments to the savings calculations for HES or HERs in the Program Savings Document to correct for double counting. Though the study is not currently recommending abbreviating program savings to account for double counting it is the current industry standard to do so. Therefore, Eversource should monitor savings in both the HERs program and the HES program. If savings increase substantially in either, then Eversource may need to take actions to avoid double-counting, although the nature of the adjustment may require future inquiry.

Appendix A Expanded Methods

The evaluation team cleaned the data to exclude incomplete data, add weather data, and evaluate the usage patterns compared to average Eversource households.

Eversource provided flags for households who had contacted Eversource to opt out of the program. Eversource also included rate codes, so the evaluators could determine all-electric rate-paying households and flags for whether service had been disconnected.

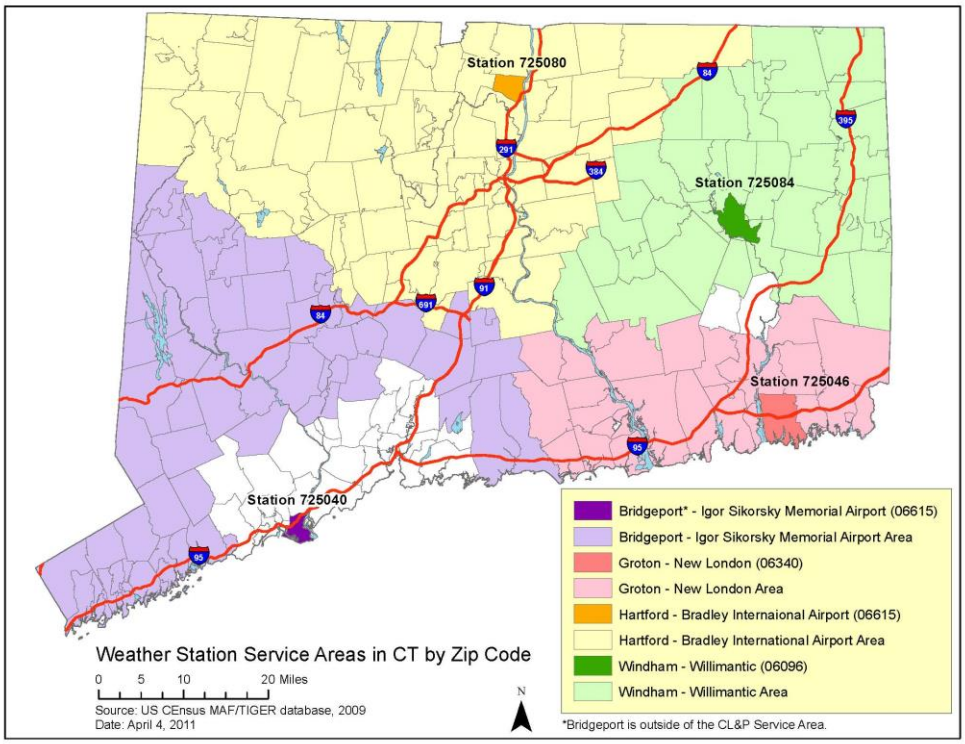
OPower provided the billing data used in this analysis, making certain to include electricity account numbers for matching to other data files (e.g., data from prior evaluations study years) and providing the data in formats requested by the evaluators. These data included monthly electricity use per service account for both the HERs treatment group and control group as well as the meter read dates from January 1, 2010, through November 30, 2014. OPower also sent data on treatment group, control group, and sub-treatment group assignments (i.e., average use, quarterly, monthly, and persistence samples). Data sent by OPower also showed the date that they mailed the first report to each treatment household. As with the billing data, OPower also provided the supporting data in the formats requested.

Weather data came from four regional stations in Connecticut, as agreed on during the initial evaluation. We have retained these same stations in each subsequent evaluation for the sake of comparability and consistency. This appendix includes a map that links zip codes to the nearest of the four weather stations. The areas in white are served by municipal utilities and the United Illuminating Company. Also, the Igor Sikorsky Memorial Airport is outside of the Eversource service territory, but it is the closest weather station to many of the Eversource towns located in the southwest corner of the state. For each region, the evaluation team calculated average monthly temperature, total monthly heating degree days, and total monthly cooling degree days from daily data available from the NCDC website for December 2009 through November 2014 and included the heating and cooling degree days as a control for the impact model.

Table 24: Billing Analysis Data Sources

Eversource	OPOWER	NCDC
Flag for treatment households who opted out of program[a]	Monthly billing data in kWh, presented as total usage and daily average usage	Average daily temperature for four major weather stations in Connecticut
Flag for service disconnection	Meter read date	Heating Degree Days (HDD), calculated from the average daily temperature data
Rate codes to identify all-electric rate customers	Date of first report	Cooling Degree Days (CDD), calculated from the average daily temperature data
	Assignment to treatment and control as well as any sub-treatment group	

Figure 7: Weather Station Assignment



Opt-out households have been retained in the analysis. The final database included household characteristics, monthly billing data, and monthly regional weather data. Table 25 summarizes the final sample sizes used in the analysis as well as the monthly pre-treatment electricity use for the households.

Table 25: Total Pre-Program Electricity Usage for Households Included in Analysis

	Households	Average Monthly Use (kWh)
Average-use Expansion Treatment Group	10,217	708
Average-use Expansion Control Group	10,242	709
High-use Extension Treatment Group	8,047	1,650
High-use Extension Control Group	24,268	1,654
Discontinued Treatment Group	15,519	1,663
Discontinued Monthly	1,670	1,669
Discontinued Persistence	3,979	1,660
Discontinued Quarterly	9,856	1,664
Discontinued Control Group[b]	24,268	1,654

[a] These data reflect the period from January 2010 through December 2010 for the high-use Extension and Discontinued groups and August 2011 through July 2012 for the average-use Expansion groups.
[b] Encompasses all control group households from the Year 1 Pilot including the high-use Extension control group. The high-use Extension control group households have never received a report and should be statistically similar to the other control group households from the Year 1 Pilot.

Turning first to the persistence group (i.e., those who stopped receiving monthly reports in August 2011), the Year 1 and Year 2 Pilot Program evaluations found that savings for this group diminished over time. The current evaluation shows that this group is no longer generating significant savings as of August 2013.

B Appendix B Expanded Monthly Results

The analysis involved running monthly regressions for the persistence group by sub-group to determine how long savings persist as well as if and when the savings stop.

The evaluators approach the savings for the individual month results with prudence, as any single month carries a great deal of statistical "noise." Using multiple months of data in a model has the benefit of reducing such noise because the results take more data into account, which serves to smooth what could be random monthly variations. Using a single month of data does not permit this smoothing and is the likely reason we see a good deal of variation in savings from month to month.

Table 26 reports that the persistence sub-group failed to achieve any significant savings after August 2013 and, looking back to the Year 2 Pilot Program evaluation, the sub-group had not achieved consistent significant savings as of January 2013. The monthly treatment sub-groups continues to have significant program-induced savings through March 2013, and the quarterly sub-group is still achieving significant program-induced savings.

Table 26: Estimated Average Electricity Savings among the Discontinued Group by Subgroup by Month during Two Years after Report Cessation

	Discontinued Monthly Treatment Effect-Daily kWh	Discontinued Persistence Treatment Effect-Daily kWh	Discontinued Quarterly Treatment Effect-Daily kWh	Sample Size	Explained Variance
August 2013	1.20	0.15*	0.87	31,224	73
	2.13%	0.26%	1.59%		
September 2013	1.25	-0.07*	0.77	31,256	70
	2.59%	-0.14%	1.58%		
October 2013	1.17	-0.09*	0.43	31,271	59
	3.12%	-0.24%	1.15%		
November 2013	1.09	0.13*	0.72	28,204	53
	2.61%	0.32%	1.72%		
December 2013	2.35	0.14*	0.96	31,165	63
	4.36%	0.26%	1.78%		
January 2014	2.11	0.13*	0.94	31,508	69
	3.34%	0.21%	1.48%		
February 2014	1.50	0.22*	1.01	28,741	71
	2.39%	0.35%	1.60%		
March 2014	-0.22*	0.06*	1.05	31,504	62
	-0.38%	0.10%	1.80%		
April 2014	1.33	-0.33*	0.82	30,128	48
	2.85%	-0.70%	1.76%		
May 2014	0.53*	-0.41*	0.45	29,988	43
	1.43%	-1.09%	1.21%		
June 2014	1.24*	0.00*	0.44	31,542	56
	3.10%	-0.01%	1.10%		
July 2014	0.06*	0.09*	0.49	31,530	61
	0.11%	0.17%	0.93%		
August 2014	0.41*	0.01*	0.51	31,655	62
	0.81%	0.01%	1.01%		

	Discontinued Monthly Treatment Effect-Daily kWh	Discontinued Persistence Treatment Effect-Daily kWh	Discontinued Quarterly Treatment Effect-Daily kWh	Sample Size	Explained Variance
September 2014	0.99*	0.02*	0.52	31,697	65
	2.10%	0.05%	1.09%		
October 2014	0.68*	0.12*	0.26	31,717	53
	1.86%	0.33%	0.72%		
November 2014	-0.42*	0.09*	0.42	30,095	41
	-1.06%	0.22%	1.05%		

*Indicates effect is not statistically significant.

C Appendix C Summary of Year 1 and Year 2 Evaluations

The Eversource Home Energy Reports Program has been subject to two prior evaluations in previous years. Both evaluations examined program processes, treatment group reactions to the program and reports, and energy savings (including savings persistence). The first evaluation addressed the Year 1 program, which operated from approximately January 2011 through March 2012. All Year 1 study group households—both treatment and control—exhibited high pre-program electricity use (mean of 1,600 kWh per month—double the average-use customer mean of ~800 kWh per month). The second evaluation examined the Year 2 program in which a subset of Year 1 participants continued receiving reports (the High-use Extension group) and a new group of Average-use treatment households (the average-use expansion groups with usage of 700 kWh pre-program usage) started to receive reports. The second evaluation also examined savings persistence for the subset of Year 1 households that no longer received reports after March 2012 (the High-use Discontinued group, subdivided into the Monthly, Quarterly, and Persistence groups as described in Table 5 in the main body of the report). The Year 2 program started in August 2012, and, as far the evaluators know, Extension and Expansion households were still receiving reports as of July 2013. The full evaluation reports for these studies are available on the Energize Connecticut website.[30]

The key findings from the studies include the following (see also Table 27):[31]

- High-use households saved a greater percentage of energy than Average-use households did in the first year of treatment (2.2% versus 1.2%). This translates into annual savings of about 415 kWh for each high-use household and 96 kWh for each average-use household, with expenditures per kWh saved of three cents versus 13 cents, respectively.
- The High-use Discontinued Monthly households saved more energy than another other high-use or average-use treatment group. High-use Discontinued Monthly households saved about 3.6% energy during treatment compared to about 1.5% to 2.0% for other high-use households and about 1% for average-use households. This suggests that the group differs systematically from other study households, but the evaluators could not ascertain the source of this difference.

[30] NMR Group, Inc. and Tetra Tech. 2013. *Evaluation of the Year 1 CL&P Pilot Customer Behavior Program*. http://www.energizect.com/government-municipalities/final-clp-behavioral-year-1-program-report-030613
NMR Group, Inc. and Tetra Tech. 2014. *Evaluation of the Year 2 CL&P Pilot Customer Behavior Program (R2)*. Available at http://www.energizect.com/government-municipalities/evaluation-year-2-clp-pilot-customer-behavior-pgm-r2-final-report-8-8-14.

[31] This summary addresses findings on energy savings and prior program participation only as they are most relevant to the current evaluation. For information on process evaluation findings, please see the original repots.

- The results indicated an increase in the percentage savings for High-use Extension households that received reports for two years, with first year savings of around 2.0% and second year savings of 2.3%.
- High-use Persistence households (received reports for only eight months) continued to exhibit statistically significant savings up to two years post-treatment, but savings appeared to be decreasing over time.
- The evaluation of the Year 1 program also demonstrated that High-use Treatment households took part in the Home Energy Solutions program at a higher rate *after first receiving home energy reports* than did the control group. The Year 2 evaluation did not repeat this analysis for average-use groups, which is why the current study again addresses this topic and deeper measure adoption.

Table 27: Summary of Energy Savings Results from Year 1 and Year 2 Eversource Behavior Pilot Program Evaluations

Treatment and Sub-treatment Groups			Average daily savings (kWh)	% savings	Average Savings / HH	Average expen-diture / kWh saved
High-use	Monthly	First Year Treatment[1]	1.07	2.17%	415 kWh	$0.03
		Second Year Treatment[2]	1.19	2.31%	433 kWh	$0.03
		First Year Post-Treatment[3]	1.49	3.70%	292 kWh	$0.02
	Quarterly	First Year Treatment	0.72	1.45%	429 kWh	$0.03
		First Year Post-Treatment	0.83	2.06%	303 kWh	$0.02
	Persistence	First Eight Months Treatment	0.8	1.58%	427 kWh	$0.03
		Seven Months Post-Treatment	0.52	1.06%	273 kWh	$0.02
		23 Months Post-Treatment	0.75	1.86%		
Average use	Monthly	First Year Treatment	0.26	1.17%	96 kWh	$0.13

[1] Entire high-use monthly treatment group in the Year 1 Pilot Program

[2] High-use extension group in the Year 2 Pilot Program, which is a subset of the high-use monthly treatment group from the Year 1 Pilot. Period covers just over a year, April 2012 to July 2013.

[3] Discontinued high-use monthly group, which saved 3.6% during the treatment period—substantially more than the ~2.0% for all other high-use monthly report recipients. Period covers just over a year, April 2012 to July 2013.

Appendix D Hypothetical Cycling vs. Continuous Program Design Using High-use Discontinued Monthly Group as the Base

Table 16 above presents what the evaluation results for that past three years suggests is a realistic scenario comparing the savings and costs of cycling versus continuous program designs. The analysis assumes that the treatment year savings of the High-use Extension household because they are in line with most of the other HERs high-use study groups. In contrast, evaluated results for High-use Discontinued Households exhibited much higher savings than the High-use Extension group (and other high-use groups) during treatment (3.6% vs. ~2.0%). For this reason, Table 28 on the next page presents the same hypothetical analysis as in Table 16 but uses the savings of the High-use Discontinued Households as the base for the cycling group, and the High-use Extension results for the continuous group. Thus, the savings presented in Table 28 align more closely with evaluated findings for Discontinued and Extended High-use households yet they most likely **overstate** the savings for the cycling group, as suggested by the broader body of results yielded from the multiple studies conducted on the Eversource HERs program.

Table 28: Hypothetical Cycling vs. Continuous Program Design Comparison

Program Year	Savings and Costs	Cycling Design: Based on Discontinued High-use Group Savings				Four Year Continuous Treatment Design[1]
		Group A	Group B	Group C	Program Total[2]	
	Assumed Sample Size	*1,000*	*1,000*	*1,000*	*1,000*	*1,000*
Year 1	Treatment Savings (kWh)	796	0	0	796	416
	Persistence Savings (kWh)	0	0	0	0	0
	Total Savings (kWh)	796	0	0	796	416
	Annual Cost	$12.00	$0	$0	$12.00	$12.00
	Cost per kWh	$0.015	N/A	N/A	$0.015	$0.029
Year 2	Treatment Savings (kWh)*	0	796	0	796	433
	Persistence Savings (kWh)	541	0	0	541	0
	Accumulated Two-Year Savings (kWh)	1,337	796	0	2,133	849
	Annual Cost**	$0.00	$12.00	$0.00	$12.00	$12.00
	Accumulated Two-Year Cost	$12.00	$12.00	$0.00	$24.00	$24.00
	Cost per kWh	$0.009	$0.015	N/A	$0.011	$0.028
Year 3	Treatment Savings (kWh)	0	0	796	796	433
	Persistence Savings (kWh)	350	541	0	892	0
	Accumulated Three-Year Savings (kWh)	1,6898	1,337	796	3,821	1,282
	Annual Cost**	$0.00	$0.00	$12.00	$12.00	$12.00
	Accumulated Three-Year Costs	$12.00	$12.00	$12.00	$36.00	$36.00
	Cost per kWh	$0.007	$0.009	$0.015	$0.009	$0.028
Year 4	Treatment Savings (kWh)	796	0	0	796	433
	Persistence Savings (kWh)	0	350	541	892	0
	Accumulated Four-Year Savings (kWh)	2,484	1,6898	1,337	5,508	1715
	Annual Cost**	$12.00	$0.00	$0.00	$12.00	$12.00
	Accumulated Four-Year Costs	$24.00	$12.00	$12.00	$48.00	$48.00
	Cost per kWh	$0.010	$0.007	$0.009	$0.009	$0.028
Program Total for Four Years[2]	**Accumulated Four Year Savings (kWh)**				**5,508**	**1,715**
	Accumulated Four Year Costs				**$48.00**	**$48.00**
	Cost per KWh				**$0.009**	**$0.028**
	Percent Greater Savings from Cycling				**221%**	

[1] Treatment savings Year 1 and Year 2 equal to evaluated results (see Appendix C); Year 3 and Year 4 use Year 2 savings.

[2] Program totals for cycling reflect effective achievements across all households. In other words, no individual home will save 5,508 over the four years, but the program effectively achieves this savings by paying for report for just 1,000 households but reaping persistence savings for 2,000 more (in some years).