Connecticut Light and Power Home Energy Reports Program: Spring and Summer Billing Analysis

DRAFT INTERIM REPORT

3/9/2012

Submitted to:

Connecticut Energy Efficiency Board

Connecticut Light and Power

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1 Introduction

This interim report summarizes the results of a billing analysis performed by NMR Group, Inc. (NMR) on households randomly selected to be a part of the Home Energy Reports (HERs) Program, implemented for Connecticut Light and Power (CL&P) by OPower. The billing analysis was funded by the Connecticut Energy Efficiency Fund (CEEF) in cooperation with CL&P. This report covers the program months of February 2011 through August 11, 2011.

The HERs program seeks to reduce electricity use through behavioral changes induced by information presented in a report that documents recipients' electricity use, rates their use compared to similar "neighbors", and offers them tips for ways their households can save electricity. While savings for each member of the treatment group are small, taken together, the program can produce substantial savings.

Throughout this report, NMR uses the following terms to refer to specific groups throughout the report:

- Treatment group: households actually receiving HERs reports; some of these households receive reports each month (monthly), while others receive them every three months (quarterly)
- Control group: households selected by the program implementer to serve as a comparison group to the treatment group
- Study group: all households included in both the treatment and control groups
- Participants: reserved to refer to households that have taken part in other CEEF programs - either in the study group or outside of the study group.

1.1 Key Findings

The NMR team ran a series of models, yielding the following key findings. These findings are based on different statistical models, each testing for a specific set of program influences. We urge the reader to refer to the main body of the report to learn more about the individual models and their interpretation.

- The program implementer estimated overall electricity savings of approximately 1.4% for the first three months of the program. NMR has confirmed these savings, with our models estimating savings of 1.5% through May and 1.8% through June (Table 3-5).
- Based on overall pre-program electricity use, mean program-induced savings across all treatment households for the period of February through August 2011 are approximately 4,638 MWh. While comprising 28% of the treatment and control groups, households that pay the all-electric rate code account for 4,200 MWh (91%) of total savings (Table 3-2).
- A billing analysis of electricity use for February through August 2011 indicates that all-electric customers who receive reports save the most of the electricity in the program.

Specifically, monthly treatment households that pay the all-electric rate[1] saved 5.9% more than do non-monthly, non-all-electric households (Table 3-3). Of these savings 5.3% is associated with being in the all-electric treatment group, while only an additional 0.6% is related to receiving monthly reports.

- Quarterly report recipients generated less electricity savings than monthly recipients, suggesting that savings are lower when reports are received less frequently than when they are received on a monthly basis.[2] This finding is consistent across all models summarized in the report.
- HERs treatment households participated in greater numbers than control households in the Home Energy Solutions program, though not in HES-IE.

1.2 Program Description

The HERs program seeks to reduce electricity use through behavioral changes induced by information presented in a report that documents recipients' electricity use, rates their use compared to similar "neighbors", and offers them tips for ways their households can save electricity. Reports are tailored to the individual household based on its electricity use and housing characteristics (*e.g.,* home size, heating fuel, presence of central air conditioning, *etc.*).

One of the vital characteristics of the CL&P pilot program is its experimental design. The program implementer (OPower) selected eligible households based on a number of criteria and then randomly assigned the eligible households to either a treatment group that receives the reports or a control group that does not receive the reports. Electricity savings are estimated by comparing the change in electricity use prior to the program to that after the program for both the treatment group and the control group. The criteria used by the implementer to select households for the HERs program included the following:

- Active account
- Sufficient billing history
- No gaps in the billing history
- High annual average electricity use

The HERs study population includes approximately 48,000 households selected from among all CL&P customers who met the study criteria cited above.[3] The study population was split evenly between the treatment and control groups. The large sample size is necessary because the expected program savings are relatively small per household, about 2% according to the

[1] CL&P labels this rate the "electric heating service" rate, but to qualify customers had to have all of their energy needs met by electricity, not just heat.

[2] Future analyses will address the issue of persistence of savings more directly by examining changes in electricity use before and after September 2011 for a sub-set of households formerly receiving monthly reports (the "persistence sample") that stopped receiving any mailed reports in September 2011.

[3] The actual number of households used in our analyses is 48,080. Data provided by OPower to the evaluators included a few extra records spread evenly across the treatment and control groups yielding a total study group size of 48,129. Our data cleaning efforts described in Section 2.1.1 reduced the size to 48,080.

implementer. Finding such a small per household effect—and concluding that the effect is statistically significant—requires ample statistical power, which the study achieves through a large sample size.[4]

In addition to the overall experimental design, CL&P and OPower structured the pilot to allow additional experiments on the frequency of reports on electricity savings and how long savings persist after households stop receiving the reports. For this reason, the approximately 24,000 treatment households were divided into three sub-treatment groups as follows[5]:

- 10,000 monthly customers receive monthly reports for an entire year
- 10,000 quarterly customers receive quarterly reports for an entire year
- 4,000 persistence customers receive monthly report for six months

All three sub-treatment groups have access to a HERs website (https://clp.opower.com/) for one full year. This report does not address website use but we expect to discuss patterns of website use in a process assessment report that will be completed later in the study period.

1.3 Purposes of the Study

This study had two main purposes, named below and described in the sections that follow:

1. Estimate program-induced electricity savings
2. Identify any impact of the HERs program on participation in other CEEF programs

1.3.1 Estimate Program-Induced Electricity Savings

The main purpose of this study was to estimate the electricity savings resulting from the HERs program and to explore how other factors, such as weather, time of year, household characteristics, and the actual tips recommended to individual treatment households also affect the savings achieved. We estimate these savings for the entirety of the HERs treatment group but also for each of the sub-treatment groups. We accomplish this through an analysis of electricity usage as billed to the residence based on actual or estimated meter reads, employing statistical controls for the sub-treatment groups and the additional factors that could also influence electricity savings as needed.

1.3.2 Identify HERs Impact on Participation in other CEEF Program

Although many of the HERs tips seek to induce the treatment group to change their everyday behaviors in an effort to save electricity, some of the tips also suggest that the treatment households take actions that will likely involve their participation in other CEEF-funded programs. For example, one tip suggests that households have an energy audit performed on their home, which would feed into the Home Energy Solutions programs (HES and HES-IE). Other

[4] In smaller sample sizes the program savings effect does not change, but the usual tests for statistical significance may suggest that savings are not statistically significant. This is known in statistical parlance as a Type II error, concluding that an effect does not exist, when, in fact, it does.

[5] NMR assigned the control group to sub-control groups for analysis purposes. See Section 5.1 for details.

tips promote the purchase of energy efficient appliances and lighting, which relate to HES and also to the ENERGY STAR® retail products programs. A second purpose of the impact evaluation, then, was to assess the degree to which the HERs program increased participation of the treatment group compared to the control group in other CEEF programs.

2 Methods Highlights

To fulfill these three purposes, NMR prepared a dataset containing billing, program, and weather data and then analyzed the data in STATA, a widely used statistical analysis software package. We highlight the methods used in this section. For the more technical reader, Section 5 provides a detailed discussion of the data preparation process, method, and modeling results.

2.1.1 Data Preparation

The billing analysis relied on data obtained from three different sources: 1) CL&P, 2) OPower, and 3) the National Climate Data Center (NCDC) website (Table 2-1).

Table 2-1: Data Sources

<table>
<tr><th>CL&P</th><th>OPOWER</th><th>NCDC</th></tr>
<tr><td>Monthly billing data in kWh, presented as total usage and daily average usage</td><td>Household and demographic characteristics</td><td>Heating Degree Days (HDD) for four major weather stations in Connecticut</td></tr>
<tr><td>Participation in other CEEF programs since January 1, 2011</td><td>Tips received by each treatment household and date(s) received</td><td>Cooling Degree Days (CDD)for four major weather stations in Connecticut</td></tr>
<tr><td>Flag for service disconnection</td><td>Date of first report</td><td rowspan="4"></td></tr>
<tr><td>Meter read date</td><td rowspan="2">Assignment to treatment and control</td></tr>
<tr><td rowspan="2">Rate codes to identify all-electric customers</td></tr>
<tr><td>Assignment to sub-treatment group (for treatment only)</td></tr>
</table>

[a] Data provided for all treatment and control group households unless otherwise noted.

The data preparation process involved a series of steps that culminated in a database that included the following characteristics:

- Monthly billing data for all treatment and control group households from January 1, 2010 through August 31, 2011, limited to those billing accounts still active as of January 1, 2011
- Household characteristics
- Service address information
- Monthly weather data including average temperature, total heating degree days, and total cooling degree days

- Participation in other CEEF programs since January 1, 2011
- Selection of the tips received by each treatment household and date(s) tips were received

The nature of the analysis necessitated that we remove households with the following criteria from the dataset:

- Lacked a full year of pre-program billing data
- Service disconnection prior to January 1, 2011
- Pre-program use of zero
- Records with duplicated billing account numbers
- Records not assigned to either the treatment or control group

The final number of households in the study group is 48,080 with 24,038 being in the treatment group and 24,042 being in the control group. Analyses of pre-program average electricity use as well as distribution of all-electric households and dwelling type confirmed random assignment across all of the treatment (monthly, quarterly and persistence) and control groups.

2.1.2 Billing Analysis Methods

We used a statistical modeling technique known as linear fixed-effects regression (LFER) to determine whether or not the program led to a statistically significant reduction of electricity use among the treatment group compared to the control group. We developed a series of models, each of them designed to test the impact of different factors (*e.g.,* weather, housing characteristics, sub-treatment group, time of year, *etc*) on electricity use and on the amount of savings attributable to the HERs program.

We first used LFER to model the effect of receiving HERs on use, resulting in what we call the base model. The base model tested for changes in electricity use by comparing the pre- and post-program periods for the entire report recipient treatment group as well as any unique effects associated with being in the quarterly report recipient sub-treatment group.[6] Because factors other than the reports also affect electricity use, we developed additional models that controlled for weather, month of the year, and household characteristics (*e.g.,* all-electric, age of home, *etc.*).[7]

When interpreting the models, it is important to keep in mind that they work like a simple math equation for the treatment variables. The "treatment effect" describes the savings associated with

[6] In other words, we ran the model on all treatment and control households, but also created a flag variable (see Section 5.2 for discussion of flag variables) to capture whether the quarterly treatment group differed in any way from the overall patterns of change in use for all households in the treatment group. The base model did not include a flag for the persistence group because the entire persistence sample was still receiving monthly reports during the time period included in this analysis. The planned Spring 2012 billing analysis will include months in which the persistence sample no longer receives reports, allowing for a direct assessment of the persistence of savings.

[7] We also tested the potential impact of selected tips (see Section 5.1 for the list of tips) received by the treatment households. However, the models were inconclusive. NMR will return to the tip-specific analysis in the Spring 2012 billing analysis when we will have the benefit of the follow-up survey and self-reported adoption of tips to help explain the relationship between tip receipt, tip adoption, and electricity savings.

being a member of the treatment group; it applies to every treatment household in the particular model. One adds or subtracts the conditional average treatment effects for other variables in the model from the treatment effect to calculate the impact of being in the quarterly treatment group or the treatment group paying the all-electric rate, for example. In the results section, we take care to show the calculations for the various effects examined in the models.

Tercile[8] Analysis. At CL&P's request, NMR performed an additional billing analysis in which the savings of the HERs treatment and control groups would be assessed after breaking them into sub-groups based on their pre-program period electricity use.[9] CL&P requested the tercile approach as a way to examine the possible impacts of the pilot on the typical residential customer, and to use an approach that mirrors one used in a recent study of a similar program in a neighboring state.[10]

To implement the analysis, we ranked the entire study group by pre-program usage, and then divided the resulting set into thirds, creating terciles based on average pre-program use (Table 2-2). Due to the randomization process that provided treatment and control groups with statistically-identical usage, roughly the same numbers of treatment and control households are in each of the terciles. We ran billing analysis models limited to each tercile. It is important to stress that, although average use differs across these terciles, the average customer in the lowest tercile in the HERs study still uses 18% more kWh per month than does the average residential customer of CL&P.

Table 2-2: Baseline Monthly Use by Tercile

Tercile (kWh use category)	# Households in Study Group (n = 48,080)	Average Use (kWh)	% Greater than Average Customer
Tercile 1 (highest users in study group)	16,027	2,573	226%
Tercile 2 (moderate users in study group)	16,026	1,414	79
Tercile 3 (lowest users in study group)	16,027	933	18
For comparison: average CL&P residential customer	~1,000,000[a]	789	0

[a] Approximate number of residential customers as estimated from 2010 Census data on number of households in Connecticut, adjusted for service territories of other electric utilities.

The use of terciles has one critical short-coming, however, that limits the usefulness of the analysis. Specifically, the terciles give a false impression of three very distinct groups, when, in reality, the average monthly usage of the households at the low end of Tercile 1 differs from the households at the high end of Tercile 2 by only 0.1 kWh, and likewise for the distinctions between Tercile 2 and Tercile 3. Therefore, rather than providing distinct groups, the division of the sample into terciles instead means that there is a great deal of similarity between the groups

[8] "Terciles" are the result of dividing any ordered group into three parts of equal number.
[9] In August 2011 NMR submitted a memorandum describing use by terciles.
[10] Opinion Dynamics Corporation and Navigant Consulting. 2011. *Massachusetts Cross-Cutting Behavioral Program Evaluation: Volume 1 and Volume 2*. Prepared for the Massachusetts Energy Efficiency Advisory Council. Delivered June 2011. Available at http://www.ma-eeac.org/EM&V%20Studies.htm.

at their margins, making it difficult to draw conclusions about differences in usage across terciles. Therefore, the requested modeling provided indeterminate results. The patterns within each tercile are consistent with each other, but the models cannot differentiate savings across the three terciles.

In order to provide more statistically rigorous results, the Final Report will provide a usage-based assessment that relies on a more statistically grounded approach to identifying sub-groups.

2.1.3 Methods to Assess Participation in other CEEF Programs

One of the objectives of the HERs program is to increase participation in other CEEF-funded programs. NMR assessed if this objective was being met by comparing participation rates in other CEEF programs between households in the HERs treatment and control groups. CL&P provided the team with data on participation by HERs study group households in additional CEEF residential programs since January 1, 2011. CL&P provided data on participation in the following programs:

- HES
- HES-IE
- Residential HVAC
- Lighting Coupons
- Lighting Catalog
- Insulation Rebate
- Appliance Retirement (ARP)

We performed two separate analyses to assess the impact of HERs on participation in these other programs. First, we compared the numbers and percentages of HERs treatment and control group households that took part in other programs, searching for patterns that would suggest greater participation among the HERs treatment group. Second, we performed a statistical test known as a *Chi-Square* (X^2) test that captures whether participation rates among the treatment and control groups differed from what could be expected based on chance. To prepare the data for this test, we scored each treatment and control group household in the entire study group with a "one" if they had participated in each individual program and a "zero" if they had not participated in that same program. We then used STATA to run the X^2 test for each of the seven other CEEF programs for which we had data. If the treatment group participated at a greater rate than the control group and if the X^2 test were found to be statistically significant at the 90% level of confidence (meaning that the results could be expected to be based on chance about 10% of the time), we concluded that the HERs program changed participation in the other CEEF program.

We then compared the rates of participation in HES for the HERs treatment group, the HERs study group, and all other households in Connecticut.

3 Results

The analyses yielded a number of important findings regarding the HERs program. In summary, the HERs program is having a statistically significant and positive impact on electricity savings and on participation in other CEEF programs. This section provides more detail on these overall findings. In each of the models below, we present both the number of treatment households and the number of control houses included in the model. It is necessary to enter data from both treatment and control households into the models in order to estimate program-induced savings relative to consumption changes made by control group households. Without the control group, the model would tell a misleading story about changes in electricity use among the treatment group.

3.1 Summary of Electricity Savings Rates and Amounts Attributable to the HERs Program[11]

Table 3-1 shows the average electricity savings rate for four example treatment households as suggested by the final model. Section 3.2 and Table 3-3: Model 3 describe this model more fully, but briefly, the model controls for report frequency and payment of the all-electric rate., Household 1 receives monthly reports but is not an all-electric household; the model suggests that this household would achieve a savings rate of 0.6% per month. Household 2 receives monthly reports and is an all-electric household, suggesting a monthly savings rate of 5.9%. Household 3 receives quarterly reports, thereby being scored as a "one" for being in the treatment group and also as "one" for being in the quarterly sub-treatment group; the model suggests that this household actually uses 0.2% more electricity per month than the control group. Finally, Household 4 is a quarterly treatment, all-electric household, with a savings rate of 5.1% per month.

Table 3-1: Example of Participant Electricity Savings Rates

Type of Effect	Effect Size	Household 1		Household 2		Household 3		Household 4	
		Score	Savings	Score	Savings	Score	Savings	Score	Savings
Treatment	0.6%	1	0.6%	1	0.6%	1	0.6%	1	0.6%
Quarterly Treatment	-0.8%	0	0	0	0	1	-0.8%	1	-0.8%
All-electric Treatment	5.3%	0	0	1	5.3	0	0	1	5.3%
Total Savings		**0.6%**		**5.9%**		**-0.2%**		**5.1%**	

[11] Section 5.3 reports more statistical information such as the margin of errors and explained variance for these models.

Table 3-2 reports the total electricity savings in MWh created by the pilot study between February and August 2011 for monthly and quarterly report recipients, further broken down by whether the recipients are all-electric households. These estimated savings are based on the savings rates resulting from the model presented above in Table 3-1 as well as in Table 3-3: Model 3. Compared to average pre-program electricity use, pilot-induced savings for all report recipients are 4,638 MWh. More than one-half of these savings are achieved by all-electric households receiving monthly reports (2,598 MWh), while all-electric, quarterly-report recipients saved 1,602 MWh. Put another way, 91% of the savings were achieved by the 28% of treatment households that pay based on the all-electric rate. Monthly report recipients who are not all-electric households collectively saved 576 MWh. Taken as a whole, quarterly report recipients who are not all-electric households had negative savings, meaning they actually used 138 MWh more electricity when compared to the control group and to monthly report recipients and all-electric households.

Table 3-2: Estimates of Program-induced Electricity Savings, February through August 2011

Group	Average Pre-program use (kWh)	Savings Rate	Number of Households	Monthly Savings (MWh)[a]	Overall Savings (MWh)[b]
Monthly Treatment, not All-electric Households	1,598	0.6%	10,046	96	576
Monthly Treatment, All-electric Households	1,835	5.9%	4,002	433	2,598
Quarterly Treatment, not All-electric Households	1,594	-0.2%	7,148	-23	-138
Quarterly Treatment, All-electric Households	1,845	5.1%	2,842	267	1,602
Total Savings	**1,665**		**24,038**	**774**	**4,638**

[a] Calculated as the product of pre-program use, percent savings, and number of households, divided by 1,000 to yield MWh instead of kWh.

[b] Calculated as Monthly Savings multiplied by six for each month in the analysis. Totals are influenced by rounding.

The remainder of the sub-sections in Section 3 describe the results of the model summarized above as well as other models and analyses performed in support of this impact evaluation of the HERs program.

3.2 Rates of Electricity Savings Attributable to the HERs Program[12]

Table 3-3 shows the modeling results for the entire study group, As mentioned above, these models include both treatment and control group households because inclusion of the control group is critical to determining the savings rate for treatment households. However, the estimated electricity savings, as reported above in Table 3-2, are based only on the treatment households, not the control households. The models in the table provide the average electricity savings rate for the group specified (*e.g.,* treatment, quarterly treatment, all-electric treatment) compared to all households that do *not* have the group characteristic, including the control group because none of the control households has the "treatment" characteristic. The treatment effects are considered average treatment effects that are conditionally related to the other treatment effect variables (*i.e.,* report receipt, quarterly report receipt, all-electric, and summer months). This means that if a household has more than one characteristic, the statistical model isolates the net (*i.e.,* individual) effect of each characteristic—the "conditional average treatment effect."[13] To estimate the per-household savings rate for treatment households, one sums the effects that apply to that household. The model achieves this through the use of flag variables. For each treatment household having a given characteristic (for example, quarterly reports) the flag variable is set to "one" and for those households not having the characteristic—including all control households and the remaining treatment households—the flag was set to "zero" (see Section 5.2 for more detail on the flag variables). As an example, the quarterly treatment effect shows the net savings rate associated with being a quarterly treatment household when compared to all other households—treatment and control—that do not receive quarterly reports. This amount is in addition to the savings rate the model also estimates for all treatment households.

[12] Section 5.3 reports more statistical information such as the margin of errors and explained variance for these models.

[13] Throughout this analysis "monthly treatment group" refers to the treatment households who received monthly reports between February and August, including the persistence treatment group since this latter group received monthly reports throughout the study period for this report, and stopped receiving reports in or soon after the month of August. The persistence group will be analyzed as a separate group in the follow-up billing analysis.

Table 3-3: Program Induced Savings Rate by Model Variations[ab]

Type of Effect	Average Treatment Effect		
	Model 1: Base	Model 2: Controls for weather and month	Model 3: Controls for household characteristics
Treatment	2.9%	2.2%	0.6%
Quarterly Treatment	-0.8%	-0.8%	-0.8%
All-electric Treatment	N/A	N/A	5.3%
Cooling Degree Days[c]	N/A	-0.1%	-0.1%
# Treatment of Households	24,038	24,038	24,038
# of Control Households	24,042	24,042	24,042

[a] The number in each cell is the percentage of savings in post-period electricity use. Thus, the quarterly treatment group did not decrease use by 0.8%, instead they saved 0.8% less than indicated by the treatment effect, which applies to all treatment households.

[b] All savings estimates reported are significant at the 90% level of confidence

[c] We also tested heating degree days but this variable failed to add any explanatory power or effect so we did not complicate the model with its inclusion. We expect that a later billing analysis that will include winter months will show larger and more stable effects associated with the heating season.

To read Table 3-3, consider Model 1, the base model in the first column of the table. This model shows that, on average, the treatment group used 2.9% less electricity than the control group. This 2.9% applies to every treatment household in the analysis, and the percentage also serves as the estimate of the savings rate achieved by monthly report recipients. The effects of the other characteristics in the model can be added or subtracted from this treatment effect. The model also includes a flag variable that isolates the quarterly treatment effect; the quarterly treatment effect suggests that this treatment group used 0.8% more electricity than did other households in the treatment group (that is the monthly report recipients for this particular model), yielding a savings rate of just 2.1% for the quarterly recipients (calculated as 2.9% [treatment effect] minus 0.8% [quarterly treatment effect). The other models in the table—as well as all other billing analysis models presented below—follow the same interpretation, albeit with a greater number of variables.

Note: although the difference of 0.8% between monthly and quarterly group customers seems small, in reality the degree of statistical power in the study design allows us to conclude with statistical certainty that the quarterly recipients did not save as much as the rest of the treatment group, pointing to a smaller savings rate in households that receive reports less frequently than in the households receiving monthly reports to remind them to save electricity. Future analyses will address the issue of persistence of savings more directly by examining changes in electricity use before and after September 2011 for a sub-set of households formerly receiving monthly reports (*i.e.,* the persistence sample) that stopped receiving any mailed reports in September 2011.

Next, we developed models that also controlled for weather and other monthly variations that influence electricity use; Model 2, presented in the second column of Table 3-3, estimates the program-induced savings rate to be a 2.2% post-period reduction for the treatment group (effectively monthly report recipients for this model) and 1.4% post-period reduction for the

quarterly treatment group (calculated as 2.2% [treatment effect] minus 0.8% [quarterly treatment effect].

Several models that included housing characteristics were examined. The best-performing model, which included flagging customers on CL&P's all-electric rate code (*i.e.,* all-electric) as a housing characteristic, is shown as Model 3 in the final column of Table 3-3.[14,15] The result of the inclusion of an all-electric treatment variable to the model[16] suggests that the majority of savings accrue to all-electric households receiving HERs. Specifically, once we add the all-electric variable to the model, the base treatment effect then reflects a savings rate of only 0.6% from the monthly report recipients who are not billed on the all-electric code, while the all-electric treatment households create an additional savings rate of 5.3%—for a total savings rate of 5.9% (calculated as 0.6% [treatment effect] plus 5.3% [all-electric treatment effect]). All-electric treatment homes who also receive quarterly reports would achieve an average savings rate of 5.1% (calculated as 0.6% [treatment effect] minus 0.8% [quarterly treatment effect] plus 5.3% [all-electric treatment effect]). It is possible that all-electric treatment households saved more electricity during this initial assessment period for a few reasons. First, February through June are still heating months in Connecticut, and the HERs program may have induced heating-related savings in these all-electric households during these months. Second, as all-electric households, this variable would also capture any savings related to clothes drying, water heating, and cooking. In other households, at least some of these savings would be captured by fuel-types not included in the current analysis (*e.g.,* oil, natural gas, propane, *etc*.).[17] Third, all-electric homes are also more likely to have air conditioning (*e.g.*, those relying on heat pumps) and can benefit from both summer and winter savings tips. Finally, because all-electric households were among the highest users, they had the greatest savings to achieve by adopting the suggested tips and other efficiency behaviors and measures. The full-year billing analysis will clarify the role that the all-electric rate code plays in producing electricity savings among HERs treatment households and help isolate any unidentified contributing variable.

[14] This is the model on which the results in Section 3.1 are based.

[15] See Section 5.2 more detail on an alternative to this model. Although we tested a number of housing characteristics in alternative models, the only variable that showed a stable, statistically significant relationship was the all-electric rate code. Other variables (*e.g.,* age of the home) performed inconsistently depending on the other specifications used in the model.

[16] This is also a "flag" variable similar to that used for quarterly treatment such that the variable captures the effect of both being in the treatment group and paying the all-electric rate.

[17] For example, an oil-heated home may have an electric dryer and range, but use oil to heat space and water.

The NMR team also ran a second set of models to address the issue of savings from the monthly sub-treatment group versus quarterly sub-treatment group using a slightly different technique. Instead of using a statistical flag variable, we developed individual models for each of these two sub-treatment groups, still controlling for the weather, but not including other housing characteristics (not shown in this summary table).[18] Table 3-4 shows the results of these models, which are statistically identical to the savings rates described above for Model 2 above in Table 3-3. The group receiving quarterly reports achieved a savings rate of 1.4%, on average, between the pre- and post-period compared to the quarterly control group. The monthly treatment group used 2.2% less electricity in the post-period than did the monthly control group. Again, the findings show that the monthly report recipients are better able to reduce their electricity usage than are the quarterly report recipients indicating that more frequent reports lead to greater electricity savings.

Table 3-4: Program Induced Savings Rate by Sub-treatment Group[ab]

Type of Effect	Average Treatment Effects	
	Quarterly	Monthly
Treatment (Net of Control Group)	1.4%	2.2%
# Treatment of Households	9,990	14,048
# of Control Households	9,996	14,046

[a] The number in each cell is the percentage of savings in post-period electricity use.

[b] All savings estimates reported are significant at the 90% level of confidence

[18] Although they had received monthly reports through the time period covered by this analysis, NMR also developed a model for the persistence sub-treatment group. We found that their post-period electricity savings were statistically identical to the monthly sub-treatment group.

The program implementer provided CL&P and the EEB with an estimate of the electricity savings rate resulting from the first three-months of the HERs program; they estimated that the program had induced a 1.4% reduction in electricity use. Because NMR was not certain on which three months the implementer based their estimated savings, we developed two models to verify the implementer's estimate: one model estimated savings through May 2011 and the second through June 2011. Table 3-5 shows that, when controlling for treatment groups, weather (this model uses heating degree days—as heating predominates through the spring months), and month, we find very similar results to those reported by the implementer. At 1.5% reduction in use through May and 1.8% reduction in use through June, our efforts suggest that the effect of treatment on usage during the first three months was somewhat higher than the 1.4% reported by the implementer. The quarterly treatment group also showed a reduction of electricity use but to a slightly smaller degree (1.4% through May and 1.3% through June). Compared to the entire period described in Table 3-3 and Table 3-4, these results also indicate that the treatment group continued to deepen their savings after June to achieve a savings rate of about 2.2%, while those of the quarterly sub-treatment group remained constant at about 1.4%. Again, this points to the importance of monthly reports in inducing deeper program savings.

Table 3-5: Program Induced Savings Rate for First Three Months[ab]

Type of Effect	Average Treatment Effect	
	Through May	Through June
Treatment	1.5%	1.8%
Quarterly Treatment	-0.1*	-0.5
# Treatment of Households	24,038	24,038
# of Control Households	24,042	24,042

[a] The number in each cell is the percentage of savings in post-period electricity use, with negative numbers indicating increased use for that variable after controlling for the others.

[b] All savings estimates reported are significant at the 90% level of confidence unless indicated by an asterisk.

In order to isolate the effect of the program on the summer season, we created a summer treatment variable. The summer treatment variable is an interaction variable composed of a dichotomous variable indicating whether or not the meter read date occurred in July or August 2011 and the treatment interaction variable described above. We ran this model both with and without the all-electric treatment variable described above (see Table 3-6). The first column in Table 3-6 shows that the program had the effect of reducing electricity usage by 1.8% when controlling for summer treatment but not all-electric treatment, but the additional reduction in the average summer treatment effect is not statistically significant, suggesting that the program did not experience a boost in savings in the summer months. The model summarized in the second column incorporates the all-electric treatment effect, and confirms the findings described for above that the program-induced savings are concentrated among all-electric treatment households; again, we will explore this question more in the full-year billing analysis to be performed in Spring 2012.

Table 3-6: Program Induced Summer Savings Rate Estimate[ab]

Type of Effect	Average Treatment Effect	
	Without All-electric	With All-electric
Treatment	1.8%	0.2%*
Summer Treatment	0.4*	0.4*
All-electric Treatment	N/A	5.3
# Treatment of Households	24,038	24,038
# of Control Households	24,042	24,042

[a] The number in each cell is the percent change in post-period electricity use.

[b] All savings estimates reported are significant at the 90% level of confidence unless indicated by an asterisk.

3.3 Participation in other CEEF Programs

The analysis of participation in other CEEF programs supports the conclusion that HERs increases participation in at least some of these programs, but especially in HES. Table 3-7 shows a comparison of the number and percentage of HERs treatment and control group households that took part in other CEEF programs between January 1, 2011 and August 31, 2011. A simple, non-statistical comparison of the participation rates suggest that, in five of the seven programs, HERs treatment households took part at a greater rate than did the control group households, but the sample sizes—and many of the differences in participation rates—are very small. Therefore, we tested the statistical significance of the differences. The statistical test suggests no differences in rates of participation in other programs between the HERs treatment and control groups, largely because neither the treatment nor control group took part in other programs in large numbers.

Table 3-7: Participation in other CEEF Programs

Program	HES-IE	HES	Insulation Rebate	Lighting Catalog	Lighting Coupon	Res HVAC	ARP
# Treatment Group	58	107	4	1	11	34	2
# Control Groups	47	71	2	2	6	31	2
# Study Group	**105**	**178**	**6**	**3**	**17**	**65**	**4**
% of all Treatment	0.241%	0.445%	0.017%	0.004%	0.046%	0.141%	0.008%
% of all Control	0.195%	0.295%	0.008%	0.008%	0.025%	0.129%	0.008%

Although very few of the 48,129 HERs study group households actually took part in any of these other CEEF programs, as mentioned previously (Section 1.2), the large sample size of the HERs study group provides ample statistical power for identifying small program effects.[19] Therefore, NMR expanded the analysis of participation in other programs to the entire study group and ran a X^2 test to see whether the participation pattern translated into statistically significant differential participation rates. We found that only the HES program (not HES-IE) demonstrated statistically different participation rates between the treatment and control groups (X^2=7.3 and p-value =0.007 or a confidence level of nearly 99%), supporting the conclusion that HERs increased participation in HES among the treatment group. Chi-square tests for the other programs were not statistically significant.

Table 3-8: Chi-Square Test of HES Participation

Statistics	Value	Degrees of Freedom	Significance Level
Pearson Chi-Square	7.321	1	0.007
Number of Households	48,129		

[19] We included all 48,129 study group households as, even if their billing data were not sufficient to be included in the billing analysis, the treatment households in this group still receive reports that may have induced participation in other CEEF programs.

These straightforward analyses do not allow us to conclude that these households were acting on specific tips when choosing to take part in these other CEEF programs. However, we can say with certainty that receiving the reports results in the treatment group turning to the HES program to help them reduce their electricity use.

In order to understand the degree to which the HERs experience may translate to the typical residential customer, NMR also compared the participation in HES among the HERs study group with HES participation among all households in Connecticut. The estimates we had available for HES participation included participants of UI and CL&P rather than CL&P alone. Moreover, although we subtracted the number of households in the HERs program from all residences in Connecticut, the overall population of "other residences" for the state still includes households served by municipal utilities. Yet, it remains that case that CL&P represents the vast majority of electric using households in the state; therefore, these shortcomings are rather minor in nature. The results make clear that the study group, among the highest users among CL&P's residential population, participate in HES less frequently than the general CL&P residential population (Table 3-9). Specifically, the results indicate that households in Connecticut that are *not* part of the HERs pilot participate in HES at a greater rate (0.8%) than do the households in the HERs study group (0.4% for the treatment group and 0.3% for the control group).[20] NMR believes that the correct interpretation of these results is that HERs increases HES participation among the study group, who are all higher users, but the study group still takes part in HES at a lower rate than the general CL&P residential population. These differential participation rates likely reflect underlying differences between the study group and the overall population.[21]

Table 3-9: HES Participation among HERs Households and Other Households

	HERs Treatment	HERs Control	Other Residences
Population	24,060	24,069	1,279,500[a]
# HES Participants	107	71	10,543[b]
% HES Participants	0.445%	0.295%	0.824%

[a] Includes customers of the United Illuminating Company and municipal utilities but subtracts out the 48,000 CL&P HERs households; rounded to the nearest 100.

[b] 10,721 minus the 178 households in the HERs program.

[20] Because these are population data, there was no need to perform tests of statistical significance.

[21] Some of the underlying differences include that the households in the HERs study group tend to be wealthier, own their homes at a greater rate, and are more likely to have amenities such as pools and spas than the average Connecticut household. Their responses to high electricity bills and home energy reports may be markedly different than the general residential population.

3.4 Tercile Billing Analysis

At CL&P's request, we ran three separate models, presented in Table 3-10 to Table 3-12, with the purpose of testing for any differences in savings based on pre-program electricity use: Tercile 1 alone (highest use in study group), Tercile 2 alone (mid-range use in the study group), and Tercile 3 alone (lowest use in the study group). CL&P initially anticipated that information on savings from typical customers would be available through the overall savings assessment process. Although CL&P knew that the HERs program would target high-use customers, usage among the study group was still higher than CL&P had anticipated. In fact, very few "typical" customers are included in the study group.

More specifically, the HERs program design selected the study group from among those CL&P residential customers with the highest electricity use. Highest users have the most electricity savings to gain, and the likely savings impact of a behavioral program will be greatest for these users. However, the focus on high users also means that the study group systematically differs from the population of CL&P's residential customers. The average CL&P residential customer uses about 800 kWh per month while the average customer in the study population uses about 1,700 kWh per month, more than twice that of the average residential customer. Furthermore, only approximately 300 of the 48,080 combined treatment and control households had pre-usage below 1,000 kWh per month (which is still 25% more than the average). Understanding that these usage characteristics preclude direct analysis of typical customers, CL&P requested that the evaluation assessment attempt to look more closely at the lower usage sample within the study population and requested that the assessment be done using a tercile analysis as had been done in Massachusetts.[22]

However, due to the shortcomings of the tercile approach for statistical modeling of between group differences, the analysis produced inconclusive results. On the one hand, the models, examined separately, are indicative of the pattern observed in Massachusetts[23]—the savings rate is highest in households that used the most electricity prior to the program, and lowest in households that used less electricity prior to the program. Specifically, the treatment effect for Tercile 1 suggests a savings rate of 1.4%; all-electric households in Tercile 1 saved an additional 4.4%. The treatment savings rate for Tercile 2, in contrast, was only 0.5% and Tercile 3 was 0.3%; the all-electric treatment variable was not statistically significant in the Tercile 2 and Tercile 3 models.

[22] Opinion Dynamics Corporation and Navigant Consulting. 2011. Cited above. *Massachusetts Cross-Cutting Behavioral Program Evaluation: Volume 1 and Volume 2*. Prepared for the Massachusetts Energy Efficiency Advisory Council. Delivered June 2011.

[23] Opinion Dynamics Corporation and Navigant Consulting. 2011. *Massachusetts Cross-Cutting Behavioral Program Evaluation: Volume 1 and Volume 2*. Prepared for the Massachusetts Energy Efficiency Advisory Council. Delivered June 2011.

On the other hand, statistical tests of the treatment effects across models are not strong enough to support the conclusion that Tercile 1 households actually achieved a higher savings rate than Tercile 2 or Tercile 3 households.[24]

The Final Report will provide a usage-based assessment that relies on a more statistically grounded approach to identifying sub-groups effects.

Table 3-10: Program-Induced Savings Rate for Tercile 1[ab]

Type of Effect	Average Treatment Effect
Treatment	1.4%
Quarterly Treatment	-1.0
All-electric Treatment	4.4
# Treatment of Households	8,004
# of Control Households	8,023

[a] The number in each cell is the percentage of savings in post-period electricity use, with negative numbers indicating increased use for that variable after controlling for the others.
[b] All savings estimates reported are significantly different from zero with 90% confidence.

Table 3-11: Program Induced Savings Rate for Tercile 2[ab]

Type of Effect	Average Treatment Effect
Treatment	0.5%
Quarterly Treatment	-0.2
All-electric Treatment	0.2*
# Treatment of Households	8,010
# of Control Households	8,016

[a] The number in each cell is the percentage of savings in post-period electricity use, with negative numbers indicating increased use for that variable after controlling for the others.
[b] All savings estimates reported are significantly different from zero with 90% confidence unless indicated by an asterisk

Table 3-12: Program Induced Savings Rate for Tercile 3[ab]

Type of Effect	Average Treatment Effect
Treatment	0.3%
Quarterly Treatment	-0.3
All-electric Treatment	0.2*
# Treatment of Households	8,024
# of Control Households	8,003

[a] The number in each cell is the percentage of savings in post-period electricity use, with negative numbers indicating increased use for that variable after controlling for the others.
[b] All savings estimates reported are significantly different from zero at the 90% level of confidence unless indicated by an asterisk

[24] See Section 5.3 for a more statistically oriented discussion of these results.

4 Conclusions

The key conclusions resulting from the work described in this report are as follows:

- The program implementer estimated overall electricity savings of approximately 1.4% for the first three months of the program. NMR has confirmed these savings, with our models estimating savings of 1.5% through May and 1.8% through June (Table 3-5).
- Based on overall pre-program electricity use, mean program-induced savings across all treatment households for the period of February through August 2011 are approximately 4,638 MWh. While comprising 28% of the treatment and control groups, households that pay the all-electric rate code account for 4,200 MWh (91%) of total savings (Table 3-2).
- A billing analysis of electricity use for February through August 2011 indicates that all-electric customers who receive reports save the most electricity in the program. Specifically, monthly treatment households that pay the all-electric rate saved 5.9% more compared with non-monthly, non-all-electric households (Table 3-3). Of these savings 5.3% is associated with being in the all-electric treatment group, while only an additional 0.6% is related to receiving monthly reports.
- Quarterly report recipients generated less electricity savings than monthly recipients, suggesting that savings are lower when reports are received less frequently than when they are received on a monthly basis. This finding is consistent across all models summarized in the report.
- HERs treatment households participated in greater numbers than control households in the Home Energy Solutions program (though not in HES-IE).

In the next few months, the NMR team will perform the following additional tasks:

- Follow-up surveys with samples of the study group to provide broad information exploring program satisfaction, adoption of recommended tips and other energy saving behavior as a result of the reports, and process-oriented questions, such as satisfaction with the reports
- Focus groups to provide in-depth information on customer experiences exploring program satisfaction, and process-oriented questions, such as satisfaction with the reports and actions reported
- Second billing analysis in the Spring 2012 covering the first full year of the program: objectives of the second billing analysis will include estimating winter and annual savings, monitoring the persistence of savings for all groups but especially the persistence sample, and attempting to isolate savings associated with particular tips. An alternate assignment technique will be used to assess savings by usage level.
- Continued tracking of HERs-induced increases in participation in other CEEF programs

5 Detailed Methods and Results

This section provides more information on the data preparation process as well as methods and results. It is provided for those readers who desire more detail on these aspects of the report.

5.1 Data Preparation Process

The billing analysis relied on data obtained from three different sources: 1) CL&P, 2) OPower, and 3) the National Climate Data Center (NCDC) website (Table 5-1).[25] This section describes the process of preparing these data for inclusion in the billing analysis.

Table 5-1: Data Sources[a]

CL&P	OPOWER	NCDC
Monthly billing data in kWh, presented as total usage and daily average usage	Household and demographic characteristics	Average daily temperature for four major weather stations in Connecticut
Flag for treatment households who opted out of program[b]	Tips received by each treatment household and date(s) received	Heating Degree Days (HDD), calculated from the average daily temperature data
Participation in other CEEF programs since January 1, 2011	Date of first report	Cooling Degree Days (CDD), calculated from the average daily temperature data
Flag for service disconnection	Data on web-based users[c]	
Meter read date	Electric heat as listed by third-party sources, not CL&P[c]	
Rate codes to identify all-electric customers	Assignment to treatment and control	
	Assignment to treatment and control	

[a] Data provided for all treatment and control group households unless otherwise noted.

[b] Opt-out household have been retained in the analysis.

[c] Signifies a variable received that has not been used in the present analysis but will be used in future process or impact analyses and reports. We do not discuss these data in the current report.

CL&P provided the billing data used in this analysis. These data included monthly electricity use (overall and average daily) per service account for both the HERs treatment group and control group as well as the meter read dates from January 1, 2010 through August 31, 2011. CL&P included rate codes, so we could determine all-electric households, and flags for whether service had been disconnected. Although they originated with OPower, CL&P also sent data on treatment and control group assignments, sub-treatment group assignments (*i.e.*, quarterly, monthly, and persistence samples) for the treatment group only, and if members of the HERs treatment had opted out of (*i.e.*, asked to be excluded from) the study.

The estimate of electricity use we used in the analysis had to be normalized so that we could interpret it as a percent change in use instead of the average reduction in use in terms of kWh.

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

We normalized use for both the treatment and control groups use by dividing their monthly use by the average post-period control group consumption and multiplying the result by 100.

We also assigned a meter read month for each meter read date from the billing data using the 15th of each month as a cutoff: if the reading was before the 15th of the month, the use was attributed to the previous month; if the reading was after the 15th, it was attributed to the read month. This means that the pre-program period actually extends back to December 2009, as the January 1 through January 14, 2010 read dates were assigned to that month. We also created a variable to designate the post-treatment time period (post-treatment). This is a dichotomous variable, meaning it is scored zero if pre-treatment and one if post-treatment. We assigned to the post-period any meter reading that occurred 40 days or more after the initial HERs report.[26] For the control group, the post-period was defined as any meter reading that occurred after March 6, 2011, 40 days after the first large mailing of the HERs. The actual variable that captures the effect of the HERs on use (treatment) is an interaction variable, developed by multiplying the treatment group variable and the post-treatment variable, to capture the relationship between being in the treatment group after the program had started.

To support the examination of whether the HERs program boosts participation in other CEEF programs, NMR examined data on whether households in the HERs treatment and control groups had taken part in additional CEEF residential programs since January 1, 2011.[27] NMR created dummy variables to indicate participation in each of these other programs.

OPower provided NMR with data they had obtained from third-party sources on household characteristics such as the dwelling type, number of occupants, age and size of the home, and the presence of air conditioning in the home. NMR cautions that these third-party data are not available for all households, and their quality and accuracy varies, but in ways that are equally true for both the treatment and control groups.[28] Data sent by OPower also showed the date that they mailed the first report to each treatment household, which we used to determine the post-treatment time period as described above.

OPower also provided data collected on the tips received by each treatment household and the date that tip was mailed to each household. As of August 31, 2011, a total of 58 different tips had been distributed to treatment group households. We could not explore all 58 in the analysis for the following reasons:

[26] This method and rationale follows the work of *Alcott, H., Social norms and energy conservation, J. Public Econ (2011)*

[27] Additional CEEF residential programs included in this study: Home Energy Solutions, Residential HVAC, Lighting Coupons, Lighting Catalog, Residential New Construction, Insulation Rebate, and Appliance Retirement.

[28] We only removed households lacking data on these characteristics in the models in which we tested for the impacts of these characteristics on electricity use and savings. This is because the information is actually "missing" for them, and the model excludes cases that are missing data on the variables being tested. Excluding households lacking the housing data may introduce bias into the analysis if the households for which we do and do not have housing data differ systematically from each other, which is possible. However, due to the random assignment process, the treatment and control groups are identical, and any bias that may be introduced by removing households lacking housing data will be in the same, although unknown, direction for the treatment and control groups.

- Some tips had been received by too many or too few recipients so that there was not sufficient variation in tip receipt for the model to capture differential impacts
- Some tips suggested broad behaviors not easily captured in an analysis of specific behaviors
- Some tips were too closely related to provide differential impacts

We prioritized the tips with ties to CL&P programs considering the following:

- The percentage of treatment households receiving the tips was between 20% and 70% so that the tip was not saturated among the treatment group but still prevalent enough to show an effect.
- The tips were not ubiquitous in larger society (for example: turn off lights when not in use, don't leave the refrigerator door open too long, etc.).

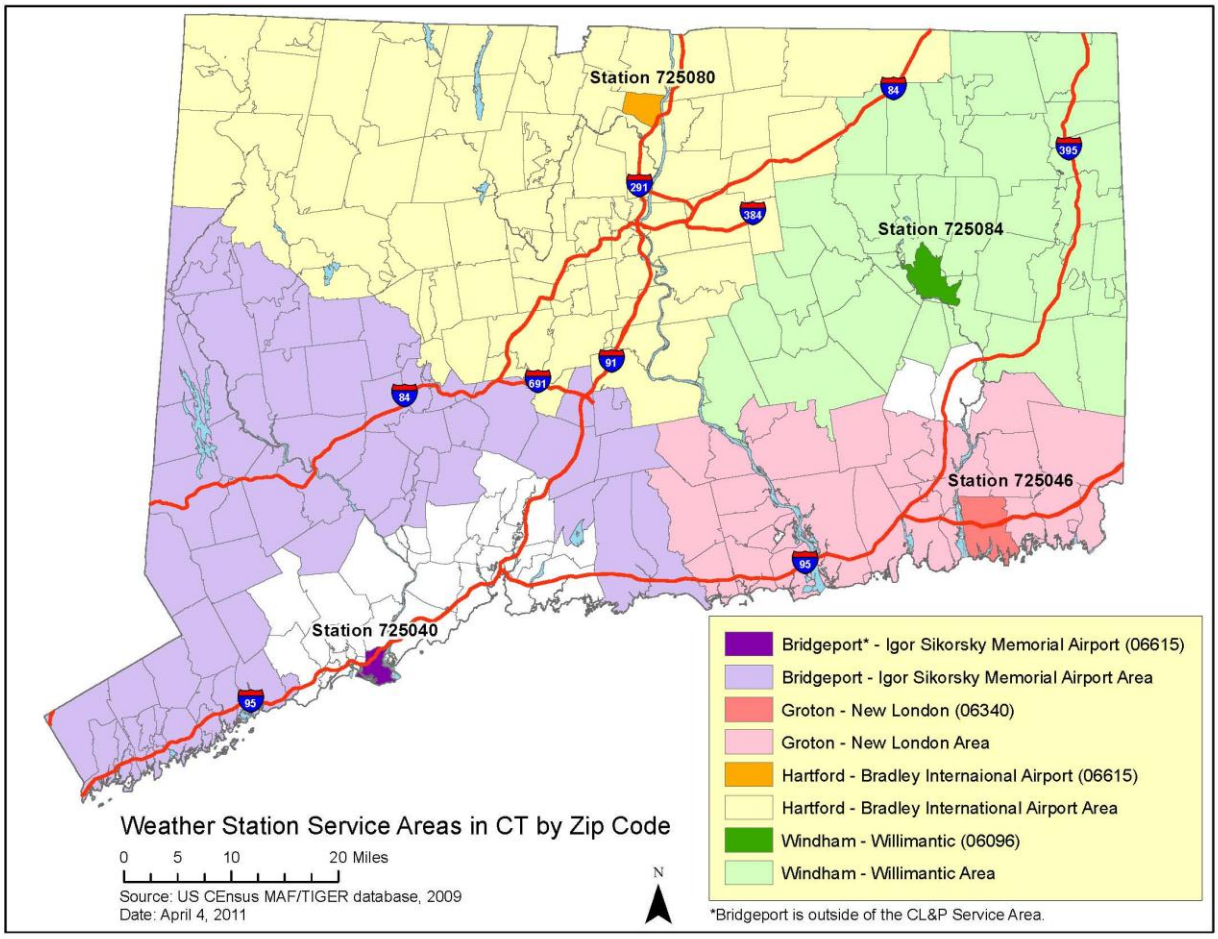
NMR included the following tips in the initial billing analysis:[29,30]

- Care for your refrigerator
- Choose efficient clothes washer
- Choose efficient freezer
- Choose efficient light fixtures
- Seal window air conditioner
- Upgrade central air conditioning
- Use fans for cooling
- Improve insulation
- Test ducts for leaks
- Set thermostat wisely in the summer
- Adjust television display setting
- Adopt a plug power meter

[29] For reasons discussed in Section 2.1.3, we do not report the models with tips, but will instead explore the impact of individual tips on savings in future billing analyses.
[30] The implementer provided us with summaries of tips and not specific tip language. Therefore, the actual tip may be more specific than indicated in our list.

Weather data came from four regional stations in Connecticut. Using GIS, we created a map and assigned service account zip codes to the nearest of the four weather stations (Figure 5-1). The areas in white are served by municipal utilities and the United Illuminating Company. Also, the Igor Sikorsky Memorial Airport is outside of the CL&P service territory, but it still is the closest weather station to many of the CL&P towns located in the southwest corner of the state.

Figure 5-1: Weather Station Assignment



For each region, the 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 August 2011.

OPower assigned each treatment household to a sub-treatment group based on frequency and duration of the reports: 1) monthly group receives a report reach month for 12 months; 2) quarterly group receives a report every three months for one year; and 3) persistent group receives a monthly report a certain duration but then ceases to receive the report.[31] However,

[31] This duration was originally planned to be six months, but NMR has learned that at least some—and perhaps all—of the persistence households received reports for eight months. This difference does not matter for the current analysis, as all persistence sample households received reports the entire period of analysis.

OPower did not assign the control group to corresponding sub-control groups that matched the sub-treatment groups. NMR needed such assignment among the control group for our analysis, so we randomly assigned each control household to a sub-control group to correspond with the sub-treatment groups. We tweaked these households within the sub-control groups until their total average use was similar the use of the corresponding sub-treatment group.

We needed to remove some households from the analysis. The greatest number of cases was excluded because they did not have billing data for the full pre-program time period (2010 calendar year). We also removed households that had their service disconnected prior to January 1, 2011, accounting for most of the remaining removals. We excluded households from the analysis because they lacked a unique billing account, and another six household had not been assigned to a treatment or control group. In total, this process reduced the number of records from 48,129 to 48,080, with 22 records removed from the treatment group and 27 from the control group.

The final database included household characteristics, monthly billing data, monthly regional weather data, CEEF program participation, and a selection of tips received through the program. Table 5-2 summarizes the final sample sizes used in the analysis.

Table 5-2: Participation and Use

	Households	Total Usage (kWh)	Average Usage (kWh)
Treatment Group	24,038	771,355,555	32,089
Control Group	24,042	770,480,392	32,047
Entire Study Group	48,080	1,541,835,947	32,068

5.2 Detailed Discussion of Billing Analysis

The results described in Section 3.1 highlight the key results from the numerous models NMR ran to estimate the impact of the HERs program on electricity savings. This section is meant to provide more detail on the inputs into the fully specified models and an example of an alternative model that includes household characteristics. We present this section for those readers who may be interested in some of the statistical details of the analyses. Note that the sample sizes presented include all households—treatment and control—included in the analysis.

The treatment variables throughout the analysis are all created so that each study household is scored with either a zero or a one. The benefit of the approach is that the effects we find in the models apply to only those households scored with a one. For example, in the overall treatment variable, those records (*i.e.,* an individual month's billing data for a household) scored one represent treatment household in the post-period; all remaining records—the control households no matter the time period and treatment households in the pre-period—get scored as zero. As we narrow the treatment variables in order to analyze separate effects, the treatment variable refers to a more limited set of records*;* for example, in the quarterly treatment variable, those scored as

one refers only to the records of treatment households in the post-period that have received quarterly reports. This allows us to control for specific treatment effects and identify the impact of each treatment on changes in electricity use. Therefore, in a model containing the overall treatment variable and other treatment variables, the overall treatment variable describes the typical effect across all cases, controlling for such things as quarterly treatment and all-electric treatment. The other treatment variables capture the additional effect of that factor among the treatment group during the post-period. This method is what allows us to isolate the treatment effect to a specific time, to a specific type of report reception as well as to specific demographic differences. The complete effect for any group is the sum of the various treatment effects that apply to them.

Table 5-3 is an example of the full model that NMR used to estimate electricity savings for the entire population. The model presented below is the same as that presented in the third column of Table 3-3. However, the information in Table 5-3 includes not only the treatment, sub-treatment, weather, and all-electric effects but also lists the effects associated with monthly controls and various lower level interactions. The lower level interactions are included in the models so that the treatment estimate will not be biased. The models include monthly controls to account for variability in use that was not due to weather or treatment. We excluded the month of January from the models to avoid introducing perfect collinearity into the models, making then unable to estimate coefficients for the inputs.

Table 5-3: Population Electricity Savings Rate Estimate—Full Model

Input	Coefficient
Treatment	0.63% (0.846)
Quarterly Treatment	-0.78 (1.004)
Post	1.42 (1.492)
CDD	-0.05 (0.004)
All-electric Treatment	5.28 (1.603)
All-electric * Post	21.46 (1.074)
February	7.17 (0.414)
March	24.91 (0.541)
April	49.06 (0.869)
May	58.41 (1.083)
June	51.80 (1.557)
July	25.78 (1.776)
August	18.68 (1.531)
September	32.48 (1.369)
October	50.02 (1.173)
November	45.83 (0.911)
December	23.17 (0.685)
2011	1.19 (0.541)
February 2011	-6.94 (0.499)
March 2011	-9.56 (1.154)
April 2011	-17.90 (1.586)
May 2011	-7.51 (1.580)
June 2011	-6.16 (1.571)
July 2011	4.82 (1.650)
August 2011	-4.12 (1.629)
Explained Variance (R^2)	0.21
# of Households	48,080

*Variables were multiplied by -1 in order to make them consistent with the reporting earlier in the report.

The next model is an example of one we rejected; this model includes the comprehensive set of household characteristics tested in the analysis (Table 5-4). At first glance it looks as though a number of household characteristics (*i.e.*, all-electric, single family residence and, home age) were significant predictors of electricity use. However, other inputs (*i.e.*, home size, number of occupants, and presence of central air conditioning) were not significant. When we reran the model and included only those variables originally found to be statistically significant, the variables for single family residence and home age ceased being significant predictors of electricity use. The all-electric rate code variable remained the only household variable that significantly predicted electricity use. Note also that, because we did not have household variables for all 48,080 households in the study group, inclusion of household variables caused the sample size to drop by nearly 20,000. It is likely that the homes for which we did not have households variables differed in systematic ways from those that did, although the bias was likely similar in the treatment and control groups.

Table 5-4: Example of Savings Estimate with Household Characteristics[a]

	Estimate
Treatment	0.55% (1.153)
Quarterly Treatment	-0.74 (1.234)
CDD	-0.05 (0.005)
All-electric Treatment	6.08 (2.446)
Single Family	-0.60 (1.112)
Home Age	-0.45 (0.875)
Home Size	0.11* (0.960)
Number of Occupants	-0.02* (0.864)
Central AC	0.18* (0.819)
Explained Variance (R^2)	0.22
# of Households	28,820

[a] The lower level interactions and month controls were excluded from the table for the sake of brevity.
[b] All savings estimates reported are significant at the 90% level of confidence unless indicated by an asterisk

5.3 Statistical Details for Final Models

The tables presented in this section represent the same models presented in Section 3. The tables below are an expanded version of the tables in Section 3, they include the margin of error and the explained variance (*i.e.*, R-squared values). The margin of error will give the 90% confidence interval by adding and subtracting the margin of error from the effect in the top row of each cell. The explained variance (given as a percent) can be thought of as the amount of variation in

electricity usage that is explained by the model and is not due to extraneous factors. The higher the R-square, the better the model is at explaining the factors that lead to changes in electricity use among the study group. Because we discuss the implications of these results in the full body of the report, we only present the more detailed tables here for those interested in assessing the models from a statistical perspective. The exception is for Table 5-10, which does include more explanation regarding the tercile analysis.

Table 5-5: Program Induced Savings Rate by Model Variations[ab]

Type of Effect	Model Variation		
	Base	Controls for weather and month	Controls for household characteristics
Treatment	2.9% (0.91) [c]	2.2% (0.908)	0.6% (0.846)
Quarterly Treatment	-0. 8 (1.18)	-0. 8 (1.182)	-0. 8 (1.004)
Cooling Degree Days[b]	N/A	-0.1 (0.004)	-0.1 (0.004)
All-electric Treatment	N/A	N/A	5.3 (1.603)
Explained Variance (R^2)	1%	20%	21%
# of Households	48,080	48,080	48,080

[a] The number in each cell is the percentage of savings in post-period electricity use. Thus, the quarterly treatment group did not decrease use by 0.8%, instead they saved 0.8% less than indicated by the overall treatment effect.
[b] All savings estimates reported are significant at the 90% level of confidence unless otherwise indicated
[c] Numbers in parentheses refer to the margin of error.

Table 5-6: Example of Participant Electricity Savings Rates

Type of Effect	Effect Size	Household 1		Household 2		Household 3		Household 4	
		Score	Savings	Score	Savings	Score	Savings	Score	Savings
Treatment	0.6%	1	0.6%	1	0.6%	1	0.6%	1	0.6%
Quarterly Treatment	-0.8%	0	0	0	0	1	-0.8%	1	-0.8%
All-electric Treatment	5.3%	0	0	1	5.3	0	0	1	5.3%
Total Savings		**0.6%**		**5.9%**		**-0.2%**		**5.1%**	

Table 5-7: Program Induced Savings Rate by Sub-treatment Group[a]

Type of Effect	Sub-treatment Group Model	
	Quarterly	Monthly
Treatment	1.4% (1.211)[b]	2.2% (1.00)
Cooling Degree Day	-0.1 (0.006)	-0.1 (0.005)
Explained Variance (R^2)	20%	20%
# of Households	19,986	28,094

[a] All savings estimates reported are significant at the 90% level of confidence unless otherwise indicated
[b] Numbers in parentheses refer to the margin of error.

Table 5-8: Program Induced Savings Rate for First Three Months[a]

Type of Effect	Model for First Three Month of the Program	
	Through May	Through June
Average Treatment Effect	1.5% (0.805)[b]	1.8% (0.657)
Conditional Average Quarterly Treatment Effect	-0.1* (0.981)	-0.5 (0.838)
Heating Degree Days	-5.95×10^3 (0.002)	-5.98×10^3 (0.002)
Explained Variance (R^2)	22%	21%
# of Households	48,080	48,080

[a] All savings estimates reported are significant at the 90% level of confidence unless indicated by an asterisk
[b] Numbers in parentheses refer to the margin of error.

Table 5-9: Program Induced Summer Savings Rate Estimate[a]

Type of Effect	Without All-electric	With All-electric
Treatment	1.8% (0.570)[b]	0.2%* (0.747)
Summer Treatment	0.4* (1.760)	0.4* (1.757)
CDD	-0.1 (0.004)	-0.1 (0.004)
All-electric Treatment	N/A	5.3 (1.603)
Explained Variance (R^2)	20%	21%
# of Households	48,080	48,080

[a] All savings estimates reported are significant at the 90% level of confidence unless indicated by an asterisk.
[b] Numbers in parentheses refer to the margin of error.

Table 5-10 repeats the information presented in Table 3-10 through Table 3-12 in Section 3.4, but also includes the margin of error. When one creates a confidence interval around the estimated average treatment effect using the margin of error, it is evident that the effect overlaps across all terciles. Means testing confirms that the treatment effects (which are significantly different from zero, with the exception of the all-electric treatment in the Tercile 2 and Tercile 3 models) are not significantly different across terciles. However, these terciles are not very distinct groups; the cut off between Terciles was artificially created by dividing the population into three equal parts based on pre-program usage. Thus, the lowest use household in Tercile 1 uses 0.1 kWh per month more than the highest user in Tercile 2, and we believe this fact underlies the overlap in the confidence intervals for the estimates.

Table 5-10: Program Induced Savings Rate by Baseline Electricity Use[a]

Type of Effect	Model Limited to Specified Terciles		
	Tercile 1 Model (highest use in study group)	**Tercile 2 Model (mid use in study group)**	**Tercile 3 Model (lowest use in study group)**
Treatment	1.4% (1.727) [b]	0.5% (0.412)	0.3% (0.451)
Quarterly Treatment	-1.0 (1.977)	-0.2 (0.465)	-0.3 (0.510)
CDD	-0.1 (0.008)	0.0 (0.002)	0.0* (0.002)
All-electric Treatment	4.4 (3.008)	0.2* (0.777)	0.2* (0.785)
Explained Variance (R^2)	32%	2%	0.8%
# of Households	16,027	16,006	16,027

[a] All savings estimates reported are significant at the 90% level of confidence unless otherwise indicated by an asterisk

[b] Numbers in parentheses refer to the margin of error.

Similar to Table 3-1 above, Table 5-11 presents the expected savings for example households in each tercile. Again, we caution that the tercile analysis is inconclusive, but we believe walking through the models in this manner is helpful to explain how we estimate savings from the statistical models. For Tercile 1, the model suggests a savings rate of 1.4% per household or more for most of the example households, which, when expanded to all households with these characteristics, would result in substantial savings. The one exception is quarterly report recipients who are not all-electric households; they saved only 0.4% per household. In contrast, none of the example treatment households in Tercile 2 or Tercile 3 would save more than 0.7%, based on these models.

Table 5-11: Example of Participant Electricity Saving Rates by Tercile

Average Treatment Effect	Effect	Household 1		Household 2		Household 3		Household 4	
		Score	Savings	Score	Savings	Score	Savings	Score	Savings
Tercile 1									
Treatment	1.4%	1	1.4%	1	1.4%	1	1.4%	1	1.4%
Quarterly Treatment	-1.0%	0	0.0%	0	0.0%	1	-1.0%	1	-1.0%
All-electric Treatment	4.4%	0	0.0%	1	4.4%	0	0	1	4.4%
Total Savings		**1.4%**		**5.8%**		**0.4%**		**4.8%**	
Tercile 2									
Treatment	0.5%	1	0.5%	1	0.5%	1	0.5%	1	0.5%
Quarterly Treatment	-0.2%	0	0.0%	0	0.0%	1	-0.2%	1	-0.2%
All-electric Treatment	0.2%	0	0.0%	1	0.2%	0	0.0%	1	0.2%
Total Savings		**0.5%**		**0.7%**		**0.3%**		**0.5%**	
Tercile 3									
Treatment	0.3%	1	0.3%	1	0.3%	1	0.3%	1	0.3%
Quarterly Treatment	-0.3%	0	0.0%	0	0.0%	1	-0.3%	1	-0.3%
All-electric Treatment	0.2%	0	0.0%	1	0.2%	0	0.0%	1	0.2%
Total Savings		**0.3%**		**0.5%**		**0%**		**0.2%**	