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Massachusetts Cross Cutting Evaluation Home Energy Report Savings Decay Analysis

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1. Executive Summary

This report presents findings from Opinion Dynamics' evaluation of the National Grid Home Energy Report reduced treatment experiment. Opinion Dynamics conducted this study for the Massachusetts program administrators (PAs) and Energy Efficiency Advisory Council (EEAC) under the Massachusetts Cross-Cutting Evaluation Contract. The goal of this study was to determine what effect reduced treatment had on program savings - measured as the difference in program savings between participants for whom treatment is reduced, compared to those who continued to receive standard treatment.

Overview of the Program and Reduced Treatment Experiment

This study focused on the Opower Home Energy Report (HER) program implemented in Massachusetts, and specifically two cohorts within the National Grid program. More generally, both National Grid and Northeast Utilities implement this program model. Through the program, Opower, the program implementer, randomly assigns qualifying customers to treatment and control groups. All members of the treatment group receive paper-based reports through the mail on an ongoing basis (bi-monthly or seasonally) and have access to an online portal. Some members of the treatment group (the majority of those with email addresses¹) also receive the reports electronically (via email). Control groups are retained for the purposes of evaluation.

Each PA administers fuel-specific reports (gas, electric, or both) to groups of treatment customers who are randomly assigned to start treatment at the same time (for example, October 2009). Customers then continue to be treated as a group indefinitely, or until the PAs decide to stop treating customers. Because customers "enter" as a group at the same time, we refer to each distinct group of treatment customers as a "cohort" throughout this report. National Grid administers an HER program serving both gas and electric customers. The program began in 2009 with two pilot cohorts (electric and gas), and continued to add additional cohorts of treatment customers into 2013. This report looks at two different treatment customer cohorts, one of which began in November 2010 (electric) and one of which began in November 2011 (gas). The cohorts that are the focus of this experiment specifically targeted high-usage households.

The HER program prompts energy savings through two primary paths: (1) educational reports (delivered as paper reports or electronically), and (2) the program's online platform. The HERs detail and benchmark customers' energy usage and compare it against their past usage and the usage of similar homes in the area. Customers have the option of opting-in to an online platform to gain greater feedback on their energy usage. All customers also have the option of opting out of the HER program at any time.

Reduced Treatment Experiment

The reduced treatment experiment refers to a reduction in paper reports after the electric and gas programs had been in the field for certain length of time. As part of the reduced treatment experiment, about 40% of customers in both treatment and control households within two cohorts—one electric and one gas—were randomly assigned to "reduced treatment," and received paper reports at a lower frequency than did customers in a "continued treatment" group. The timing, duration, and extent of reductions in paper report treatment was different for the electric and gas cohorts. The electric cohort had been receiving paper reports

¹ About 98% of electric cohort customers and 90% of gas cohort customers who had previously provided an email address to National Grid received electronic HERs (eHERs).

for about 26 months before the reduced treatment experiment, while the gas cohort had been receiving paper reports for about 15 months before the reduced treatment experiment.

Since the reduced treatment experiment affects only paper reports, the extent to which overall treatment was reduced differed for participants receiving both paper and electronic HERs (eHERs) compared with those who had only been receiving paper reports. Those in the reduced treatment group that previously received both types of reports saw a reduction in the paper HERs only, but no change in the eHERs. Those who did not provide an email address and therefore only received paper HERs saw the same reduction in paper HERs as customers with email addresses did (i.e., the reduction in paper reports was the same for customers with and without email addresses).

The duration and extent of the report reductions were generally more pronounced for the electric cohort. Customers in the reduced treatment group of the electric cohort experienced a 9-10 month gap in reports during their first reduction period, whereas customers in the reduced treatment group of the gas cohort experienced interruptions in winter season reports of no more than two months at a time.

Research Objectives and Activities

Based on the design of the treatment reduction experiment, the evaluation team sought to answer one central research question as part of this effort:

- What is the difference in program savings (expressed as percent savings) between customers receiving a reduction in treatment compared to those who continue to receive regular treatment? ²

While one original goal of the study was to establish the rate at which savings decay in the period following the reduction of treatment, we determined that this analysis was not appropriate, given that: (a) there was only one period of consecutive, multi-month reduction (for the electric cohort in 2013),³ and (b) during this period, the reduced treatment group did not see reduced savings relative to the continued treatment group. This means that further disaggregation of results in this period would not have resulted in a decay rate.

Instead of the decay rate analysis, we investigated differences in reduced treatment effects between customers who registered an email address with National Grid (the majority of whom received eHERs in addition to paper reports), and customers who did not have an email address on-file with National Grid (who received only paper reports throughout the program). Reduced and continued treatment customers who had been receiving eHERs continued to receive eHERs throughout the reduced treatment period, allowing us to investigate whether continued electronic reports could mitigate the effect of reduced treatment with paper HERs.

Based on these objectives, Opinion Dynamics conducted three main activities, as outlined in Table 1.

² For the electric cohort, “regular treatment” meant continued bi-monthly HERs. For the gas cohort, “regular treatment” meant near-monthly HERs in the winter and no reports in summer months.

³ When writing the scope of work, we were under the impression that there were multiple prolonged periods of report reduction. However, upon examination of HER delivery patterns, we learned that only one cohort experienced a prolonged reduction period, and for only one period.

Table 1. Decay Analysis Research Activities

Activity	Data Sources
Data Request and Review	Opower Tracking Data
Implementation Contractor Interviews	Opower Project Manager and Staff
Billing Analysis	Opower Tracking Data

Key Findings and Implications

The study resulted in five key findings related to the treatment reduction experiment:

- **Key Finding #1:** A reduction in treatment led to a decline in observed savings for both cohorts.
 - **Implication:** A reduction in treatment may reduce program savings. This finding is consistent with existing studies (Appendix C), but this study illustrates that the magnitude of the savings reduction likely depends on the reduced-treatment design, fuel type, and the duration of program intervention before the reduction.
- **Key Finding #2:** The electric and gas cohorts responded differently to the reduction in treatment. Compared to the electric cohort, reduced treatment customers in the gas cohort seem to show a much sharper reduction in savings in response to the reduction in reports they experienced.
 - **Implication:** The duration of time for which participants receive HERs prior to reduction may affect savings persistence. As shown above, receiving fewer reports over a shorter time period, as seen within the gas cohort, may not provide sufficient time for customers to habituate behaviors or install equipment.
 - **Implication:** Report fuel type may have an impact on savings persistence. Not only do electric and gas customers have different actions that they can take in the home, but there are also differences in the costs of each fuel, making it possible that feedback on one fuel is more valuable than feedback on another.
- **Key Finding #3:** The electric and gas cohorts experienced a decay in savings at different times relative to the reduction in treatment. For electric, the decline did not set in immediately, whereas for gas, the decline was more immediate and precipitous.
 - **Implication:** Consider multiple factors when designing a treatment reduction strategy. Many factors could affect the rate of savings decay, such as fuel type, seasonality, and duration.
- **Key Finding #4:** Additional research in this area could help inform the design of treatment reduction strategies. We recommend that future experiments plan the timing of treatment reductions to further test the potential impact of the following factors: treatment duration prior to the experiment, seasonality of the reduction, duration of the reduction, and fuel-specific differences.
 - **Implication:** Studies with larger cohort sizes (including control group sizes) could be used to test the hypotheses developed from this study.
 - **Implication:** If the PAs are not comfortable designing experiments that impact larger cohorts (or large portions of larger cohorts) due to potential negative impact on program savings, they could try more numerous and more focused experiments with smaller cohorts as an alternative (i.e., each experiment could aim to test one particular implementation strategy, as well as the four factors we listed above).

It is also important to note that given the differences in the experiment's design for electric and gas cohorts, and the specificity of this experiment in terms of timing and cohort targeting, we cannot definitely state that the patterns we observed would occur again in a different group, or with different timing or duration of reductions, or with a different duration of treatment before reductions began. Although we have reliable estimates for the overall change in savings associated with this specific experiment, readers should consider the specificity of this experiment (with respect to timing, duration, and the relative scale of treatment reduction within each fuel type, and the original cohort targeting) when drawing inferences from these results. This experiment tested intermittent reductions of varying duration and timing among a group of customers who matched specific targeting criteria set by the program implementer. As such, the National Grid experiment with reduction is unique, and the findings may provide only a directional indication of the potential impact of this type of program change.

2. Introduction

In early 2013, National Grid began a “reduced treatment” experiment within two Home Energy Report (HER) cohorts—one electric and one gas—who had been receiving reports for at least one year. The experiment consisted of a randomly selected subgroup of treatment customers in each cohort receiving HERs less frequently than other treatment customers. The timing and duration of the treatment gaps varied by fuel type.

Opinion Dynamics conducted the savings decay analysis to determine what the difference in program savings is between participants for whom treatment is reduced (“reduced treatment” group) compared to those who continue to receive standard treatment (“continued treatment” group). We also examined whether there was a noticeable difference in the effect of reduced treatment (when it is present) between participants with and without email addresses, to see whether electronic HERs (eHERs, which were not “reduced”) could stem the effect of reduced paper reports. We relied on statistical billing analysis to estimate these differences.

2.1 Overview of the Reduced Treatment Experiment

The reduced treatment experiment refers to a reduction in paper reports after the electric and gas programs had been in the field for certain length of time. As part of the reduced treatment experiment, about 40% of customers in both treatment and control⁴ households within both cohorts were randomly assigned to “reduced treatment,” and received paper reports at a lower frequency than customers in a “continued treatment” group. The timing, duration, and extent of reductions in paper report treatment was different for the electric and gas cohorts. The electric cohort had been receiving paper reports for about 26 months before the reduced treatment experiment, while the gas cohort had been receiving paper reports for about 15 months before the reduced treatment experiment.

The duration and extent of the report reductions were generally more pronounced for the electric cohort. Since the reduced treatment experiment affects only paper reports, the extent to which overall treatment was reduced differed for participants receiving both paper and electronic HERs (eHERs) compared with those who had only been receiving paper reports. Those who did not provide an email address and therefore only received paper HERs saw the same reduction in paper HERs as customers with email addresses did (i.e., the reduction in paper reports was the same for customers with and without email addresses). Additional detail regarding the timing and duration of the reduced treatment experiment is provided in Section 4.1.

Table 2 and Table 3 describe the various customer groups in this analysis, and the type of treatment each received.

⁴ While the control group did not receive an actual reduction in reports as they never received the reports in the first place, they were still randomly assigned to be controls specifically for the treatment group that experienced an actual reduction.

Table 2. Summary of Program Treatment Received by Each Electric Analysis Group

Group	Email Address	Electric Cohort	
		Treatment	Control
Continued Treatment	Has Email	100% of group received paper reports throughout the program. 98% of group received eHER reports starting about 10 months in the program.	Never received any reports. ⁵ Served as counterfactual to continued treatment with email. ⁶
	Paper Only	100% of group received paper reports throughout the program	Never received any reports. Served as counterfactual to continued treatment with paper-only reports.
Reduced Treatment	Has Email	100% of group received paper reports throughout the program, though paper report frequency was reduced after 26 months. 98% of group received eHER reports starting about 10 months in the program. eHERs were NOT reduced.	Never received any reports. Served as counterfactual to reduced treatment with email.
	Paper Only	100% of group received paper reports throughout the program, though paper report frequency was reduced after 26 months.	Never received any reports. Served as counterfactual to reduced treatment with paper-only reports.

Table 3. Summary of Program Treatment Received by Each Gas Analysis Group

Group	Email Address	Gas Cohort	
		Treatment	Control
Continued Treatment	Has Email	100% of group received paper reports throughout the program. 90% of group received eHER reports throughout the program.	Never received any reports. Served as counterfactual to continued treatment with email.
	Paper Only	100% of group received paper reports throughout the program	Never received any reports. Served as counterfactual to continued treatment with paper-only reports.
Reduced Treatment	Has Email	100% of group received paper reports throughout the program, though paper report frequency was reduced after 15 months. 90% of group received eHER reports throughout the program. eHERs were NOT reduced.	Never received any reports. Served as counterfactual to reduced treatment with email.
	Paper Only	100% of group received paper reports throughout the program, though paper report frequency was reduced after 15 months.	Never received any reports. Served as counterfactual to reduced treatment with paper-only reports.

Limitations of the Experimental Design

The nature of the experimental design described above posed a number of challenges for the PAs and evaluation team in terms of being able to explicate the factors involved in savings persistence. In particular, the fact that participants who had an e-mail address on file typically continued receiving program messaging by e-mail, while participants who did not have an e-mail address on file stopped receiving messaging altogether hindered efforts to draw reliable conclusions about persistence and decay. Not only would we expect these groups to have different results, but we also know that there are likely complex self-selection effects based on which customers provide or do not provide an email address to National Grid.

In addition, the fact that reductions in treatment were intermittent with only one period of extended reduction made it challenging to draw many conclusions about persistence and decay. This also makes it difficult to compare the results of this study to others that examine what occurs after a cessation of reports.

This experience illustrates the benefits of engaging evaluators early in the process of experimental design to ensure that studies can be conducted that will provide definitive results. Nonetheless, Section 2.2 outlines the contribution of this report to the PA planning process.

2.2 How to Use This Report

This report documents and provides results from a novel treatment reduction experiment that differs considerably from the persistence and decay studies typically performed for HER programs (where treatment is completely discontinued for some participants).⁷ The results highlight key factors to consider when designing future experiments, as well as important insights into understanding customer engagement with HERs. The findings presented here provide a springboard for conducting future experiments that isolate key drivers of savings and persistence of savings.

Factors identified through this research include:

- Duration of treatment prior to experiment – The amount of time during which a participant receives treatment prior to a reduction may influence the rate and level of decay
- Timing of reduction – There are likely seasonal drivers behind participants' responses to reduction in treatment
- Duration of the reduction – The amount of time that a participant experiences a gap in reports, or reduced report frequency, may affect savings
- Fuel type and its relative costs – The variability and cost of gas may have a bearing on participants' responsiveness to the intervention.

As a result, this study provides a key tool for the design of experiments that control for these factors.

⁷ See Appendix C for a list of other publically available persistence studies.

3. Methods

As part of the study, Opinion Dynamics conducted three main activities (Table 1).

3.1 Data Request and Review

The evaluation team conducted an extensive review of all program data provided by Opower. As part of the review process, the team also spoke with Opower as outlined under task 3.2 below.

3.2 Implementation Contractor Interviews

The evaluation team interviewed Opower in order to understand the reduced treatment experiment, as well as answer any questions about data files provided for this study.

3.3 Billing Analysis

Data Sources and Cleaning

We aggregated and cleaned two types of databases to perform this analysis:

1. **Historical billing data files:** Opower provided more than four years of billing data for each cohort's treatment and control group. These files contain monthly energy bill data, including billing dates, consumption, and number of days in the period. These files also contain information on when an account became "inactive" (customer closed the National Grid account), and if/when a participant opted-out of the Home Energy Report (HER) program. For analysis purposes, we assigned each billing period to a calendar month based on the month of the mid-point of the billing period.
2. **Report history files:** Opower also provided household-level data on HERs sent since the beginning of each cohort's program, including the first report date, dates of subsequent paper and electronic reports for the treatment group, and dates of proxy reports for the control group. Note that the control group proxy report dates did not specify whether the report was paper or electronic. This file also contained email addresses for the treatment and control groups, which we used to develop an indicator of having an email address on file with National Grid.

We examined these data to ensure that only customers with sufficient program information (e.g., report dates) and billing history were included in the final analysis. For inclusion in this analysis, we required customers to have sufficient data spanning the entire analysis period, from the baseline period through the reduction period (2013-2014). The data cleaning steps we performed are summarized in Appendix A.

For electric customers, we retained 81% of treatment customers and 77% of control customers, based on the original cohort. The most common reason for excluding electric customers (about 80% of all drops from each group) was account closure before the analysis period (i.e., the customer became inactive before 2014). For gas customers, we were able to retain 69% of treatment customers, and 70% of control customers. The most common reason for gas customers being excluded (65% and 69% of drops from each group, respectively) was account closure before the analysis period (i.e., the customer became inactive before 2014). Compared with the electric cohort, relatively more gas customers were dropped due to missing report date information (e.g., no report dates were found in the report date file).

Model Specification

We used linear fixed-effects regression analysis to examine the effect of reduced treatment within each cohort.⁸ These models rely on monthly billing data for all remaining treatment and control customers extending from one year prior to the start of the program (2008-2009) through March 2014. The models estimate treatment effects for both treatment groups (continued and reduced) compared to each cohort's control group in the three distinct treatment periods. The evaluation team developed these treatment periods for analysis purposes, to correspond with changes in report frequency and reduction. We did this to ensure that we were able to identify trends based on how the experiment was designed. These periods are defined below in the post-period dummy variable definition. For more details about the time periods, see Section 4.2.

We tested a number of models for each cohort, using different combinations of baseline consumption terms (winter, summer, and overall) and interactions with the “period” dummies. We selected final models based on model fit, drawing primarily on Akaike Information Criterion (AIC) values, taking into account multicollinearity and the plausibility of results. We explain each model in detail below.

Electric Model:

$$\begin{aligned} ADC_{it} = & B_0 + B_{1-3}P_{1-3} + B_{4-6}CT_iP_{1-3} + B_{7-9}RT_iP_{1-3} \\ & + B_{10-12}Email_iP_{1-3} + B_{13-15}PreADC_iP_{1-3} \\ & + B_{16-18}Email_iCT_iP_{1-3} + B_{19-21}Email_iRT_iP_{1-3} \\ & + B_{22-24}PreADC_iEmail_iP_{1-3} + \alpha_i + \varepsilon_{it} \end{aligned}$$

Where:

ADC_{it} = Average daily kWh consumption for participant i at time t

CT = Continued treatment throughout program (where 1=Continued Treatment, 0=Control or Reduced Treatment)

RT = Paper report treatment frequency reduced in 2013-2014 (where 1=Reduced Treatment, 0=Control or Continued Treatment)

P = Post-period dummy variable, where:

Period 0 = pre-program period (November 2009 – October 2010) (*Baseline period*)

Period 1 = post-period and November 2010 – December 2012 (*Before the reduced treatment experiment*)

Period 2 = post-period and January 2013 – October 2013 (*First reduction period*)

⁸ Opower is using a panel regression with household fixed effects to assess this experiment.

Period 3 = post-period and November 2013 – March 2014⁹ (*Second reduction period*)

Email = Dummy variable for having email address on file with National Grid

PreADC = Average daily consumption in the pre-program year

α_i = Customer-specific intercepts

ε = Error

Gas Model:

$$\begin{aligned} ADC_{it} = & B_0 + B_{1-3}P_{1-3} + B_{4-6}CT_iP_{1-3} + B_{7-9}RT_iP_{1-3} \\ & + B_{10-12}Email_iP_{1-3} + B_{13-15}PreADC_iP_{1-3} \\ & + B_{16-18}Email_iCT_iP_{1-3} + B_{19-21}Email_iRT_iP_{1-3} \\ & + B_{22-24}PreADC_iCT_iP_{1-3} + B_{25-27}PreADC_iRT_iP_{1-3} \\ & + \alpha_i + \varepsilon_{it} \end{aligned}$$

Where:

ADC_{it} = Average daily therm consumption for participant i at time t

CT = Continued treatment throughout program (where 1=Continued Treatment, 0=Control or Reduced Treatment)

RT = Paper report treatment frequency reduced in 2013-2014 (where 1=Reduced Treatment, 0=Control or Continued Treatment)

P = Post-period dummy variable, where:

Period 0 = pre-program period (November 2010 – October 2011) (*Baseline period*)

Period 1 = post-period and November 2011 – October 2012 (*Before the reduced treatment experiment*)

Period 2=post-period and November 2012 – August 2013 (*First reduction period*)

Period 3=post-period and September 2013 – March 2014 (*Second reduction period*)

Email = Dummy variable for having email address on file with National Grid

⁹ For the electric cohort, we also estimated a model with a combined post-period including all of Periods 2 and 3, to represent the duration of the reduced treatment experiment. Based on a comparison of these modeled results (which showed a limited reduced treatment effect overall) and the unadjusted consumption trends by month during the same period, we elected to break the reduction period into two periods to determine if there were differences in the reduced treatment effect toward the beginning or end of the period.

PreADC = Average daily consumption in the pre-program year

α_i = Customer-specific intercepts

ε = Error

The inclusion of dummy variables and interactions for all periods allows us to determine whether the reduced treatment and continued treatment groups had the same treatment effects (savings) in the first year of the program when they received reports at the same frequency. If there are differences in savings in this first period, it is important to account for these differences when assessing the impact of reduced treatment (discussed in the next section).

While not necessary for assessing overall impacts between continued and reduced treatment, the inclusion of a term for having an email address on-file with National Grid allows us to look for differences in savings trends between customers with email address (the majority of whom received eHERs) and those without (who only received print HERs).

It is also important to note that weather variables (heating and cooling degree-days) were not available in the existing program data, and therefore are not included in the models. However, the experimental design of this program allows estimation of unbiased estimates in the absence of weather variables. The absence of weather variables will lead to less precision in the estimates, but in the case of this analysis, which is at the population level, we are not concerned with this measure of sampling error.

As part of the experimental design, indicators for all relevant subgroups (i.e., continued and reduced; email address and paper reports) were available for the control group. As a result, we tested models where the various control groups provided points of comparison specific to each corresponding subgroup within the treatment group. We found that using the subgroup-specific control groups yielded unstable results, likely due to relatively small group sizes (see Table 4). Therefore, all models presented here are based on pooled control groups (i.e., control group overall, and report type within the control group—eHERs or paper report only).

Monthly Decay Analysis

A few HER programs in other jurisdictions have implemented persistence experiments wherein they have discontinued treatment for a portion of a cohort after two or three years of program treatment.¹⁰ In nearly all of these experiments, treatment is completely discontinued for the reduced treatment group, rather than continued at a lower frequency. In some of these experiments, researchers have calculated a decay rate to capture the rate at which savings decline following the cessation of treatment.

While one original goal of the study was to estimate a decay rate following a reduction in treatment, we discovered that this analysis was not appropriate for this experiment, given that: (a) there was only one period of consecutive, multi-month reduction (for the electric cohort in 2013)¹¹; and (b) during this period, the reduced treatment group did not see reduced savings relative to the continued treatment group (in fact,

¹⁰ SMUD and Puget Sound Energy conducted these experiments. The respective evaluation reports are cited in Appendix C.

¹¹ When writing the scope of work, we were under the impression that there were multiple prolonged periods of report reduction. However, upon examination of Home Energy Report delivery patterns, we learned that only one cohort experienced a prolonged reduction period, and for only one period.

savings appeared to increase, as shown in Figure 11). This means that further disaggregation of results in these periods would not have resulted in a decay rate. As a result, this evaluation does not include estimates of decay rates.

Assessment of Reduction Effects

Using each equation, we calculated a number of metrics that are inputs to the savings comparison. First, we estimated average daily consumption for each group (continued, reduced, and the counterfactual¹²) for each post-treatment period defined for analysis purposes as explained above (Periods 1, 2 and 3). The counterfactual consumption we estimate from the model represents the consumption the treatment group *would have experienced* in the absence of the program.¹³ Then, we calculated average daily savings for each treatment group (relative to the counterfactual) for each program period. Finally, we calculated percent savings for the continued and reduced groups in each period as modeled average daily savings divided by modeled average daily consumption for the counterfactual condition (i.e., consumption in that period, assuming average baseline consumption of the treatment group, but also assuming no program treatment in the period).

For example, for the gas cohort, the following linear equations estimate average daily savings in Period 2 for the continued and reduced treatment groups, respectively:

$$\text{Continued Treatment Consumption}_2 = B_5 + B_{17}PctEmail + B_{23}PreADC$$

$$\text{Reduced Treatment Consumption}_2 = B_8 + B_{20}PctEmail + B_{26}PreADC$$

Where:

PctEmail = Percentage of gas customers with email addresses

PreADC = Average daily therm consumption in the baseline period (1 year)

Average daily consumption for the “counterfactual” condition (i.e., no treatment) is the sum of the constant and all Period 2 terms that do not interact with one of the treatment terms (*CT_i* or *RT_i*).

After calculating percent savings for each group (continued, reduced) for each treatment period (1, 2 and 3), we examined the differences in percent savings between continued and reduced groups in each time period. In some cases, we observed a difference in savings in Period 1, where we would have expected to see identical savings for both the continued and reduced groups because this period occurred before the reduced treatment periods for both electric and gas.¹⁴ As a result, to calculate the overall impact of reduced treatment in each

¹² We use the term “counterfactual” here instead of “control group” because the usage number is not exactly the same as control group usage. The point of comparison (that we are calling the counterfactual) consists of a combination of the pre-program usage for treatment and control, as well as the program-period usage of the control group. In addition, when calculating the counterfactual usage and the treatment-related usage, the estimating equation is used, substituting the mean baseline usage of the treatment group. This process yields a slightly different number than what would be observed in a simple mean control group usage.

¹³ The control group’s consumption in each month and period is a guide for these values, and we use the terms in the model for average baseline consumption and percentage of customers with email addresses to more closely approximate what the treatment group would have consumed in the absence of the program, because these terms allow us to enter values specific to the treatment group.

¹⁴ We would expect identical savings for the continued and reduced treatment groups before the reduced treatment experiment began because the reduced treatment was randomly assigned, and therefore we assume the same distribution of customers in both groups.

reduction period, we subtracted the difference in savings between reduced and continued groups in Period 1 from the difference in savings in each of the two reduction periods (Periods 2 and 3). Thus, the reduction effects we estimate in Section 4 account for any pre-existing differences in savings between the continued and reduced groups in the pre-reduction treatment period.

Reporting Findings and Uncertainty

The customers in the cohorts chosen for this analysis represent a population rather than a sample. Opower defined the parameters for this population to identify an appropriate type of customer for the program, and scored all customers on these parameters based on a proprietary scoring algorithm. Opower then ordered all utility client customers on this score, going down that list as far as needed to meet the contracted number of customers and/or savings levels. As a result, there is no sampling error associated with this analysis, and standard measurements of sampling error (such as standard errors) do not have their usual meaning. Further, because the analysis included a population, the concept of relative precision (which is associated with a sample) does not apply. Therefore, the body of this report contains point estimates of savings and the reduction effects, but does not include confidence intervals. However, we chose to report standard errors with model coefficients in the Appendix to be consistent with conventional statistical reporting practices. Moreover, while sampling error does not apply here, these sampling statistics do provide some information about variability within a population for key variables.

4. Study Findings

This section of the report provides detailed documentation of the reduced treatment experiment conducted by National Grid, as well as the results of the savings decay analysis.

4.1 Reduced Treatment Experiment Design

Part of the evaluation team's charge was to document how the program implementer conducted the reduced treatment experiment. The following subsections detail the cohorts used in the experiment, as well as the timing and scale of the reduction in treatment. Overall, the team found that the nature of reduction in treatment varied widely within and between the cohorts chosen for the experiment, and differed significantly from the initial assumptions outlined in the Scope of Work.

Analysis Populations

The analysis populations consist of two National Grid Home Energy Report (HER) program cohorts: electric and gas. The program implementer, Opower, randomly assigned members of each cohort to a treatment or control group. However, it is important to note that both cohorts were originally selected to include relatively higher-usage customers within each fuel type. For the electric cohort, for example, the usage patterns suggest that many customers may use electric heat.

The electric cohort treatment group started with approximately 25,000 customers, who began receiving paper HERs in November 2010. The gas cohort treatment group started with approximately 26,000 customers, who began receiving paper HERs in November 2011. Within both cohorts, there were fewer control group households than treatment group households.¹⁵ However, the ratio of treatment to control need not be 1-to-1 to provide a valid comparison. The power of the design to detect treatment effects is reduced by having a smaller control than treatment group, but the result is not biased.

Table 4 presents a summary of the final sizes of the various treatment and control groups included in electric and gas analyses. Section 2.1 above describes the type of treatment that each analysis group received. Since the inception of the program, many program customers closed their accounts (about 16% of electric customers and 22% of gas customers). These customers and other customers with insufficient data for analysis were excluded from analysis. The team documents all of the data cleaning methods in the Methods section.

¹⁵ Note that for the control group, the program implementer generated proxy report dates corresponding to when reports were generated for treatment households. However, the reports were not actually mailed to control households.

Table 4. Analysis Group Sizes for Reduced Treatment Experiment

Experimental Group	Have Email Address ¹⁶	Electric Cohort		Gas Cohort	
		Treatment	Control	Treatment	Control
Continued Treatment	Has Email	4,792	1,382	5,892	3,839
	Paper Only	7,236	2,165	5,183	3,715
Reduced Treatment	Has Email	3,281	827	3,665	2,441
	Paper Only	4,834	1,391	3,288	2,268
Continued Overall		12,028	3,547	11,075	7,554
Reduced Overall		8,115	2,218	6,953	4,709
Recipient Status Overall		20,143	5,765	18,028	12,263

Timing and Magnitude of Report Reduction

These report patterns show that electric and gas participants experienced different treatment and report reduction patterns. The patterns are distinct in the following ways:

- The electric cohort began receiving reports one year earlier than the gas cohort did.
- The electric cohort had been receiving reports for about one year longer than the gas cohort prior to the reduction in treatment (the first report reduction occurred 26 months into the program for electric, compared to 15 months for gas).
- Electric reduced customers in Period 2 experienced a much sharper reduction in reports compared to gas reduced customers in Period 2.¹⁷
- Gas reduced customers in Period 3 experienced a much sharper reduction in reports compared to electric reduced customers in Period 3.

Given these differences, it is difficult to directly compare reduced savings impacts between the electric and gas cohorts. As a result, we must consider the differences in the natures of the reduction experiments when interpreting findings.

Electric Cohort

Electric participants received bi-monthly paper reports for more than two years before any reductions in treatment began. Throughout the report, we refer to the period before the reduction as Period 1.¹⁸ In Figure 1, the bi-monthly nature of the reports is visible in the seesaw pattern of the percentage of customers who receive reports in a given month – just over 60% of customers receive reports in one month, and just under 40% of

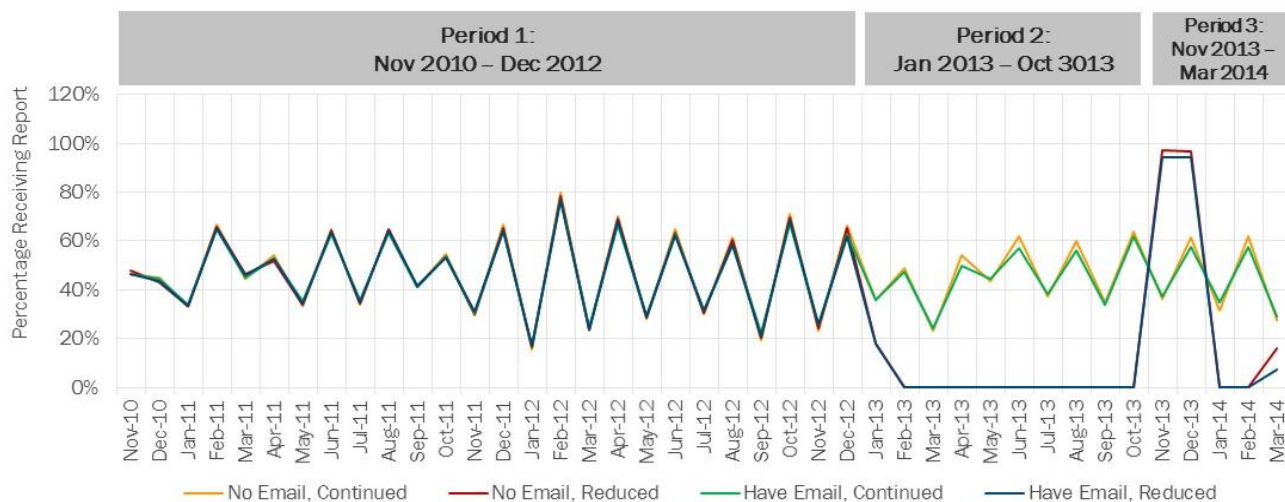
¹⁶ About 98% of the electric treatment group and 90% of the gas treatment group with email addresses received eHERs.

¹⁷ The evaluation team developed the analysis periods to reflect how the experiment was implemented.

¹⁸ All analysis periods are explained and defined in Section 3.3.

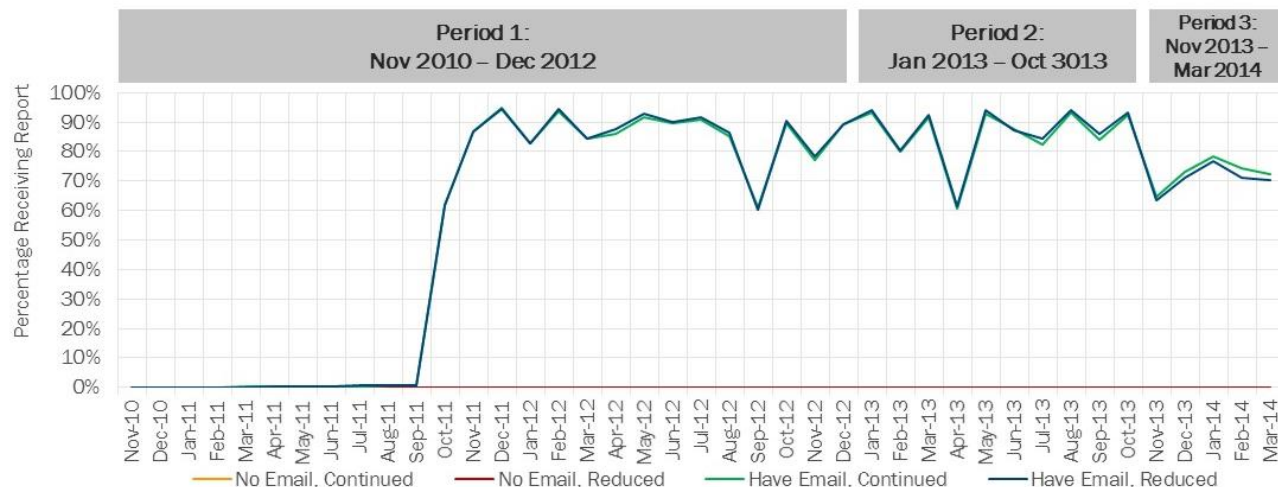
customers receive reports in the following month. In January 2013, the reduced treatment group (representing about 40% of the overall treatment group) stopped receiving paper reports and experienced a nine- to 10-month gap before receiving reports again in November 2013, while continued treatment customers continued to receive bi-monthly reports (again visible in the see-saw pattern). We refer to this gap in paper reports between January 2013 and October 2013 among the reduced treatment customers as Period 2. Reduced customers then received monthly reports in November and December of 2013, followed by a three-month gap in January through March of 2014. We refer to this period as Period 3. Figure 1 shows the program periods included in this study (note that we also include a baseline period—representing time before the start of the program—in the billing analysis).

Figure 1. Paper Report Receipt among Electric Treatment Customers



As mentioned above, in contrast to the paper report reduction, electronic reports continued at the same frequency for both the continued and reduced group customers with email addresses (Figure 2). Electronic reports began in October 2011, when about 98% of customers with email addresses began receiving eHERs. These reports have continued on a monthly or near-monthly basis since that point, as shown in the top lines of Figure 2. Customers without email addresses never received eHERs, as shown by the line for these customers at 0% in Figure 2.

Figure 2. Electronic Report Receipt among Electric Treatment Customers

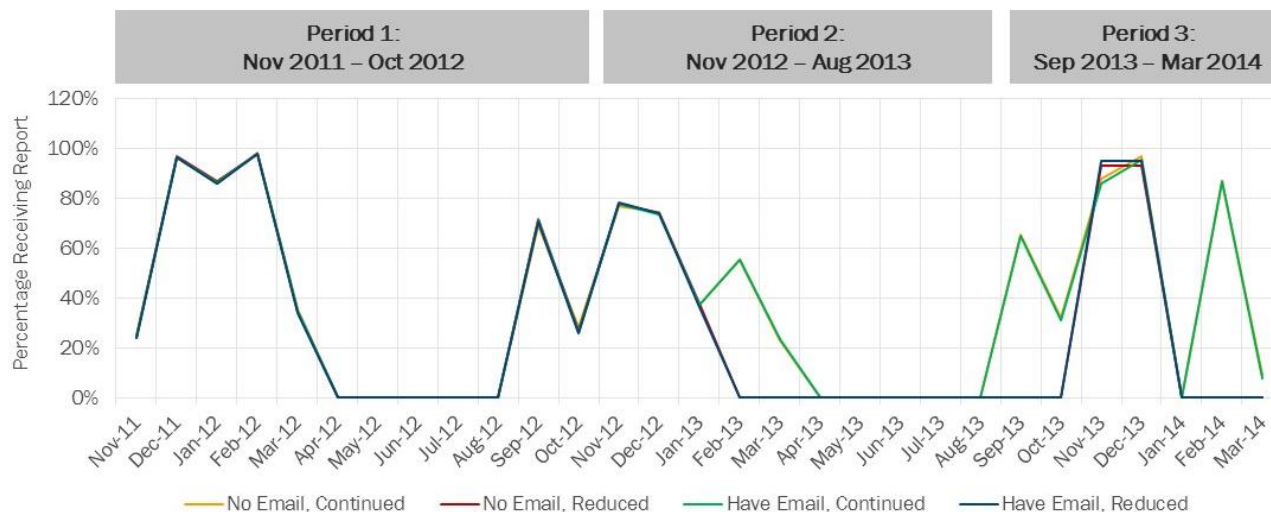


Gas Cohort

Gas participants in this and other Opower programs typically receive reports in fall and winter months only. For the first and most of the second winter, continued and reduced participants received paper reports at this frequency. Throughout the report, we refer to this period before the reduction as Period 1.¹⁹ However, about 15 months after the start of the program, the reduced treatment group (representing about 38% of the overall treatment group) experienced a gap in paper reports. More specifically, in February and March of 2013 the reduced group did not receive any paper reports, while about 55% of the continued group received paper reports in February, and 23% of the continued group received them in March. We refer to the winter, spring, and summer surrounding this brief reduction as Period 2. In the fall and winter of 2013-2014, treatment was reduced (compared to the continued group) in September, October, February, and March (to a more limited extent). We refer to this period as Period 3.

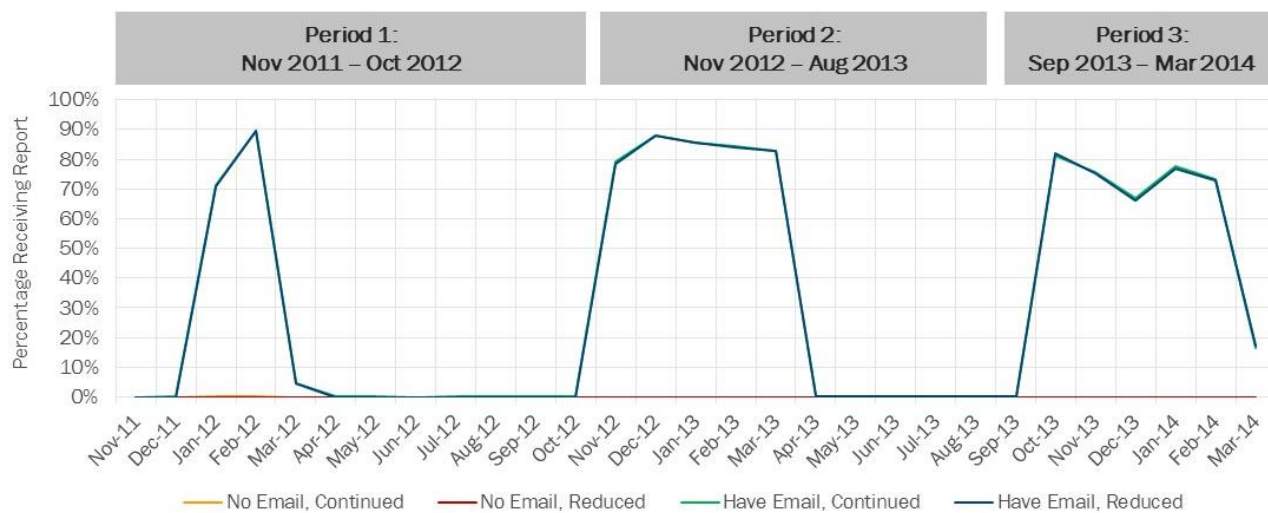
¹⁹ All analysis periods are explained and defined in Section 3.3.

Figure 3. Paper Report Receipt among Gas Treatment Customers



The program began sending electronic reports to those with email addresses during the first winter.²⁰ The eHERs continued in the subsequent winters, and similar to the electric cohort, customers with email addresses in the reduced group continued to receive eHERs at the same frequency as customers with email addresses in the continued group (Figure 4). Customers without email addresses never received eHERs, as shown by the line for these customers at 0% in Figure 4.

Figure 4. Electronic Report Receipt among Gas Treatment Customers



²⁰ About 90% of gas customers with email addresses began receiving eHERs at this time.

We also examined report reduction patterns by looking at the average number of reports received in each period for the continued and reduced groups. Table 5 shows the average number of paper reports received in each period. As shown, the most aggressive reduction occurred for the electric customers in Period 2, when continued customers received an average of 4.6 reports (bi-monthly over 10 months) and reduced customers received almost no reports (0.2, on average).

In contrast, in Period 3, reduced electric customers received close to the same number of reports as their continued counterparts because they received reports for two consecutive months (November and December) while the continued group continued to receive bi-monthly reports. The gas reduction periods were less extreme. In Period 2, reduced customers experienced a 29% reduction in paper reports compared with continued customers (an average of 1.9 reports for reduced treatment, compared with 2.7 for continued treatment). In Period 3, the reduction was greater; they received about half as many reports as the continued group (an average of 1.9 reports for reduced treatment, compared with 3.8 for continued treatment).

Table 5. Average Number of Paper Reports per Period for Electric and Gas Participants

HER Program		Electric			Gas		
		Continued	Reduced	% Difference	Continued	Reduced	% Difference
Period 1	Average # Paper Reports	12.3	12.2	-0.3%	4.4	4.4	-0.3%
	Average # Months in Period	26			12		
Period 2	Average # Paper Reports	4.6	0.2	-96%	2.7	1.9	-29%
	Average # Months in Period	10			10		
Period 3	Average # Paper Reports	2.2	2.0	-6%	3.8	1.9	-50%
	Average # Months in Period	5			7		

4.2 Decay Analysis Results

In this section, we compare baseline-period equivalency of treatment and control electric and natural gas consumption to validate the experimental design and support the selection of models. We then present savings results and discuss implications for future programs and research design.

Baseline Period Equivalency

Before performing billing analysis, we checked for equivalency of usage among each treatment group and the control group in the baseline period (i.e., one year before the start of HERs). Overall, we found some non-equivalency within the electric cohort, but equivalent usage within the gas cohort. More specifically, for the electric cohort, we found no significant differences in the baseline period between the continued group overall versus the control group overall, nor between the reduced group overall and the control group overall (see Table 6). However, we did find some differences between the treatment and control groups by report type (i.e., customers with email addresses versus print-only customers) (see Appendix B for more details). In particular, annual baseline consumption and winter baseline consumption are greater for continued treatment customers with email addresses, compared to control customers with email addresses. Further, winter baseline consumption is greater for reduced treatment customers with email addresses, compared with control customers with email addresses.

For these reasons, we included interaction terms with baseline consumption and email status in the electric model specification. Nevertheless, these differences may have implications for the interpretation of the model results for customers with and without email addresses, and given these differences and the relatively small group sizes, we advise interpreting results specific to email and non-email customers with caution.

Table 6. Baseline Period Consumption for Electric Treatment Groups, by Email Status (Has Email vs. Print Only)

Treatment Group	Has Email vs. No Email	Number of Customers	Baseline Overall ADC	Baseline Summer ADC	Baseline Winter ADC
Continued Treatment	Has Email	4,792	43.1 ⁺	47.5	46.6 ⁺
	No Email (Print Only)	7,236	42.2	46.2	46.0
Reduced Treatment	Has Email	3,281	42.8	47.0	46.4 ⁺⁺
	No Email (Print Only)	4,834	42.5	46.2	46.7
Control	Has Email	2,209	42.2	46.7	45.5
	No Email (Print Only)	3,556	42.6	46.4	46.8

⁺ Represents statistically significant difference between treatment group and control group within report type (email or print-only) at $\alpha < 0.05$.

⁺⁺ Represents statistically significant difference between treatment group and control group within report type (email or print-only) at $\alpha < 0.10$.

For the gas cohort, we found no significant differences in the baseline period between the continued group overall and the control group overall, nor between the reduced group overall and the control group overall (Table 7). We also found no differences between treatment and control within report type (i.e., customers with email addresses and print-only customers).

Table 7. Baseline Period Consumption for Gas Treatment Groups, by Email Status (Has Email vs. Print Only)

Treatment Group	Has Email vs. No Email	Number of Customers	Baseline Overall ADC	Baseline Summer ADC	Baseline Winter ADC
Continued Treatment	Has Email	5,892	2.31	0.63	4.94
	No Email (Print Only)	5,183	2.41	0.67	5.12
Reduced Treatment	Has Email	3,665	2.32	0.64	4.97
	No Email (Print Only)	3,288	2.39	0.64	5.11
Control	Has Email	6,280	2.35	0.65	5.03
	No Email (Print Only)	5,983	2.36	0.65	5.03

Monthly Consumption Trends (Not Modeled)

Before conducting statistical models, we examined consumption estimates for each treatment group (continued and (continued and reduced) in each of the three program periods (Periods 1, 2, and 3). Figure 5 and

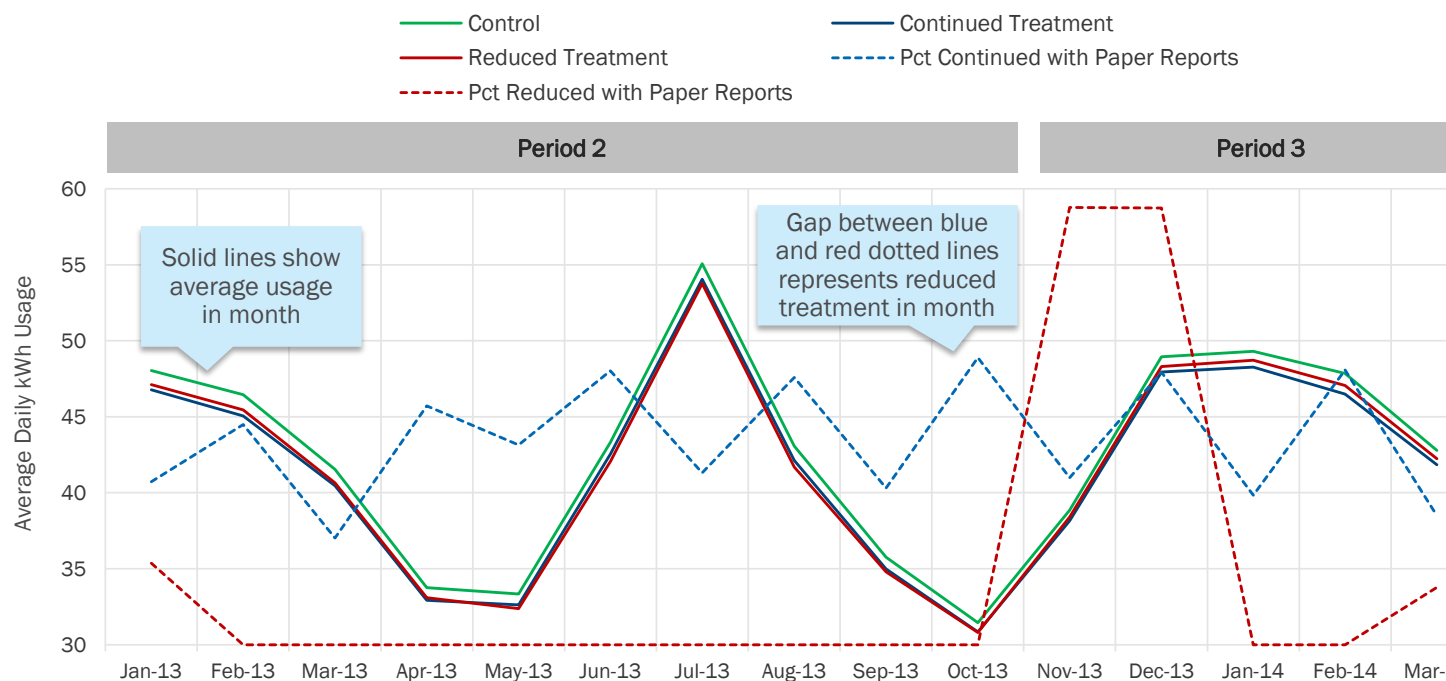


Figure 8 show average monthly consumption for the electric and gas cohorts. In addition to being equivalent in baseline consumption, we would expect no differences between the groups in Period 1, because all cohorts received the same treatment in that period.

For electric participants, we observe that:

- The continued and reduced groups have similar, but not exactly the same, levels of consumption throughout most of Period 1 (control group households use slightly more electricity in this period than treatment group households do, which reflects the treatment effect of that period).
- Between December 2012 and February 2013 (one month before and two months after the report reduction), the reduced group appears to use slightly more energy than the continued group does.
- However, for the remainder of Period 2 (the first reduction period), including the end of the period, electric usage appears nearly identical for the reduced and continued treatment groups. We outline our hypotheses around why savings did not decline for the electric reduced treatment customers (compared with the continued treatment customers) in Section 5.
- Around the time when reports resume for the reduced group (November 2013), we begin to see a difference in usage between the reduced and continued groups, suggesting lower savings for the reduced group in Period 3.

For gas participants, we observe that:

- The continued and reduced groups have relatively similar levels of consumption throughout most of Period 1.
- Between January and March 2013 (around the time of the first report reduction), the reduced group appears to use slightly more energy than the continued group does. It does not appear that this effect continues for the remainder of Period 2.
- In December of 2013 and February and March of 2014, we can see a difference in usage between the reduced and continued groups, suggesting lower savings for the reduced group in Period 3.

Figure 5. Average Daily kWh Consumption for Electric Customers

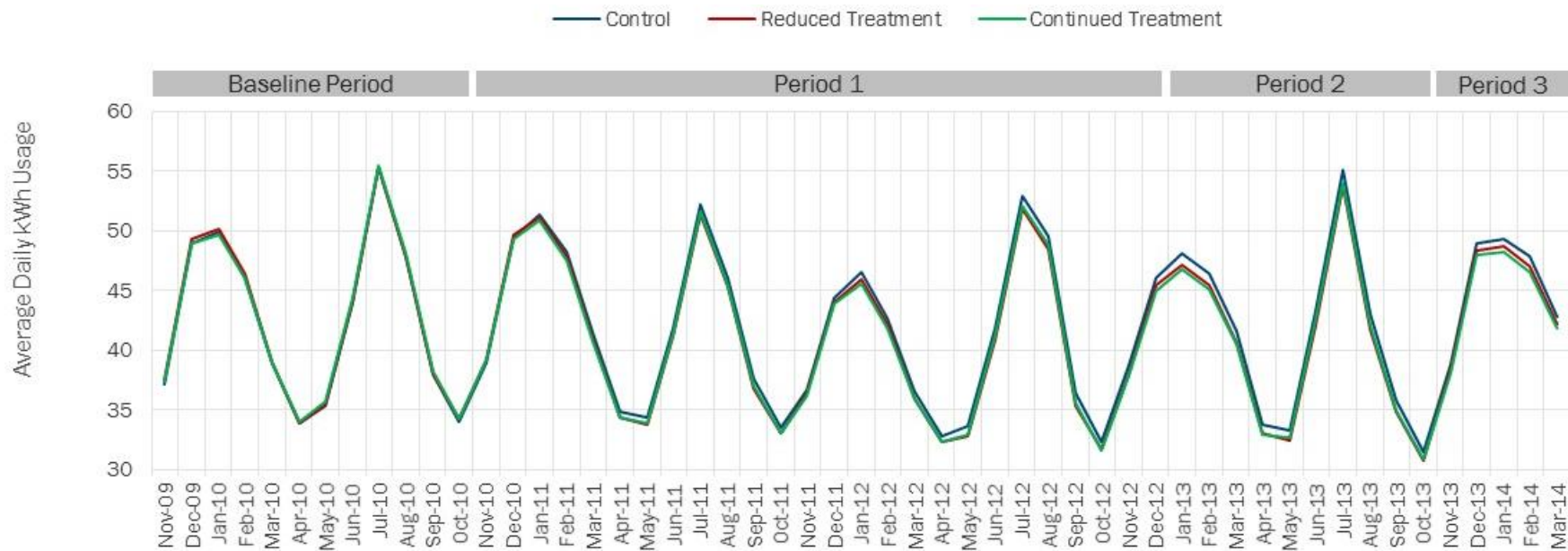


Figure 6. Average Daily kWh Consumption for Electric Customers – Period 2 and Period 3

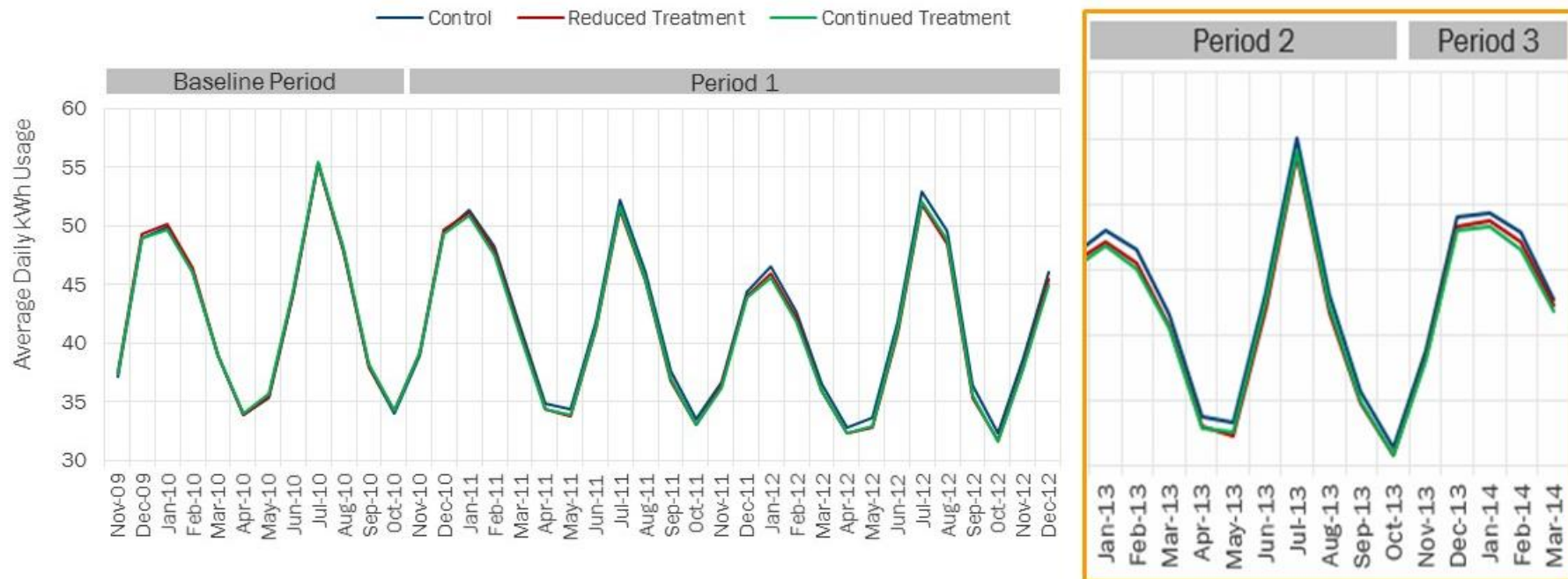


Figure 7. Average Daily kWh Consumption for Electric Customers with Report Dates (Periods 2 and 3)

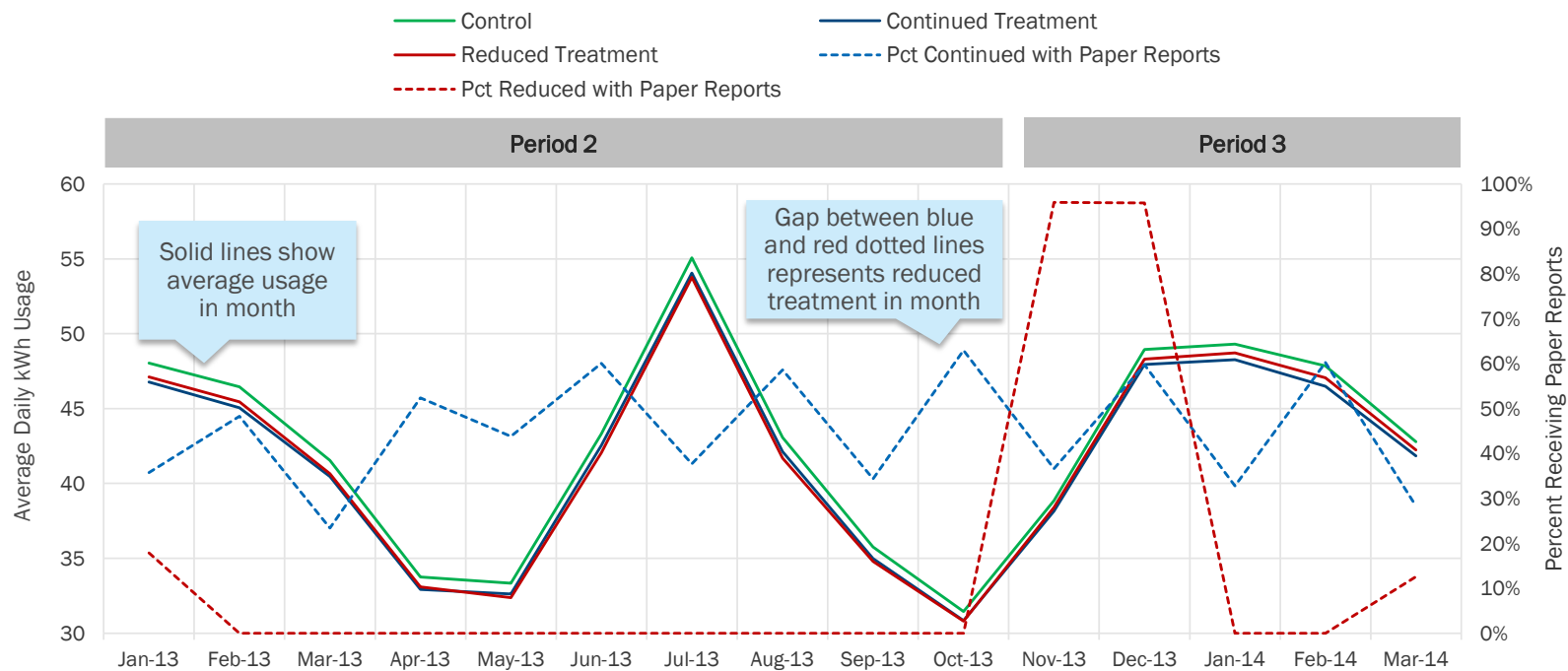


Figure 8. Average Daily Therm Consumption for Gas Customers

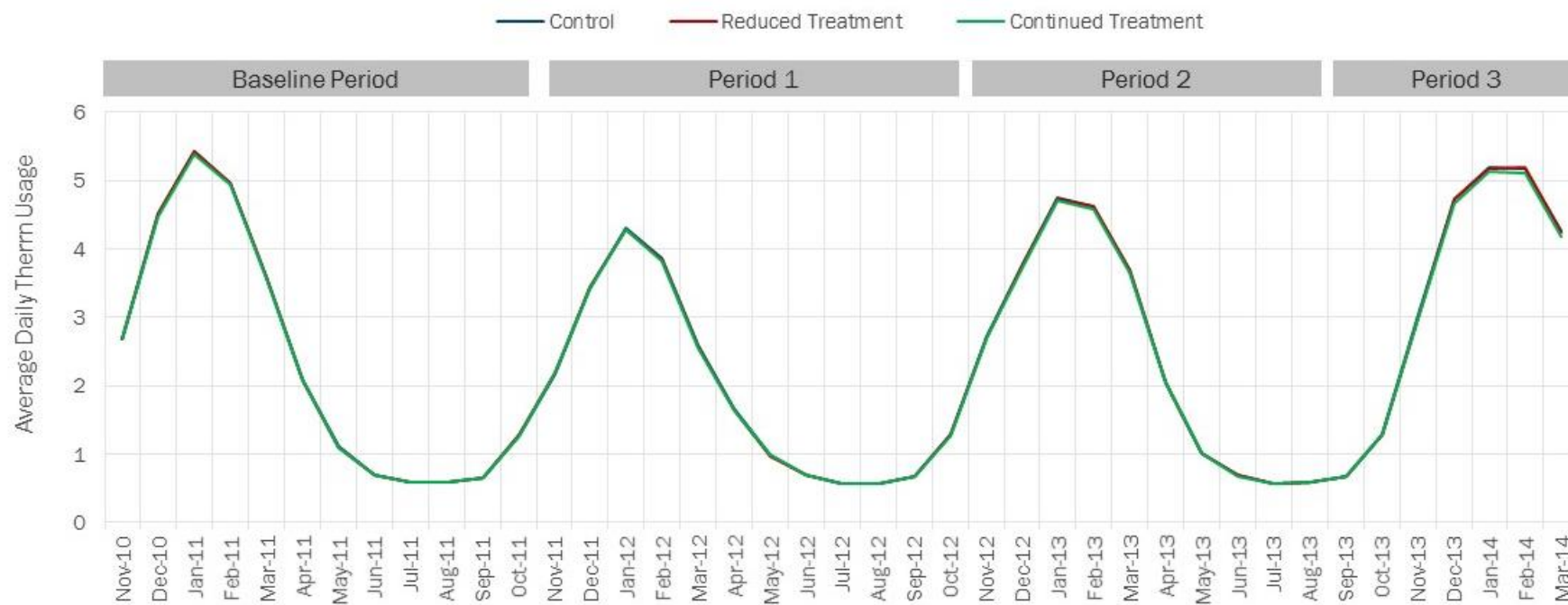


Figure 9. Average Daily Therm Consumption for Gas Customers – Period 3

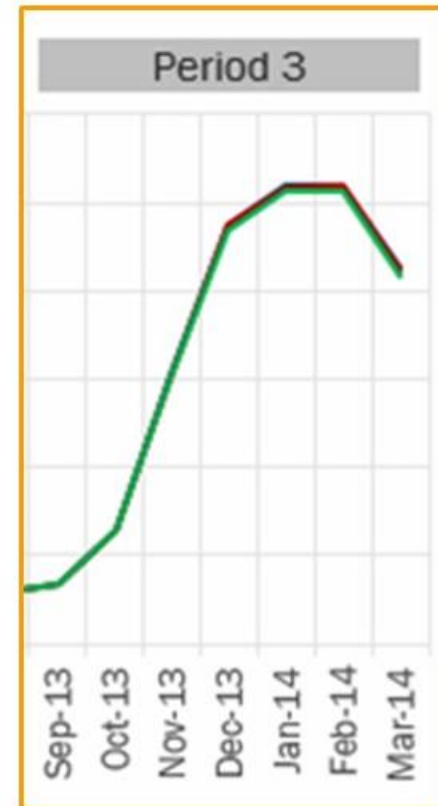
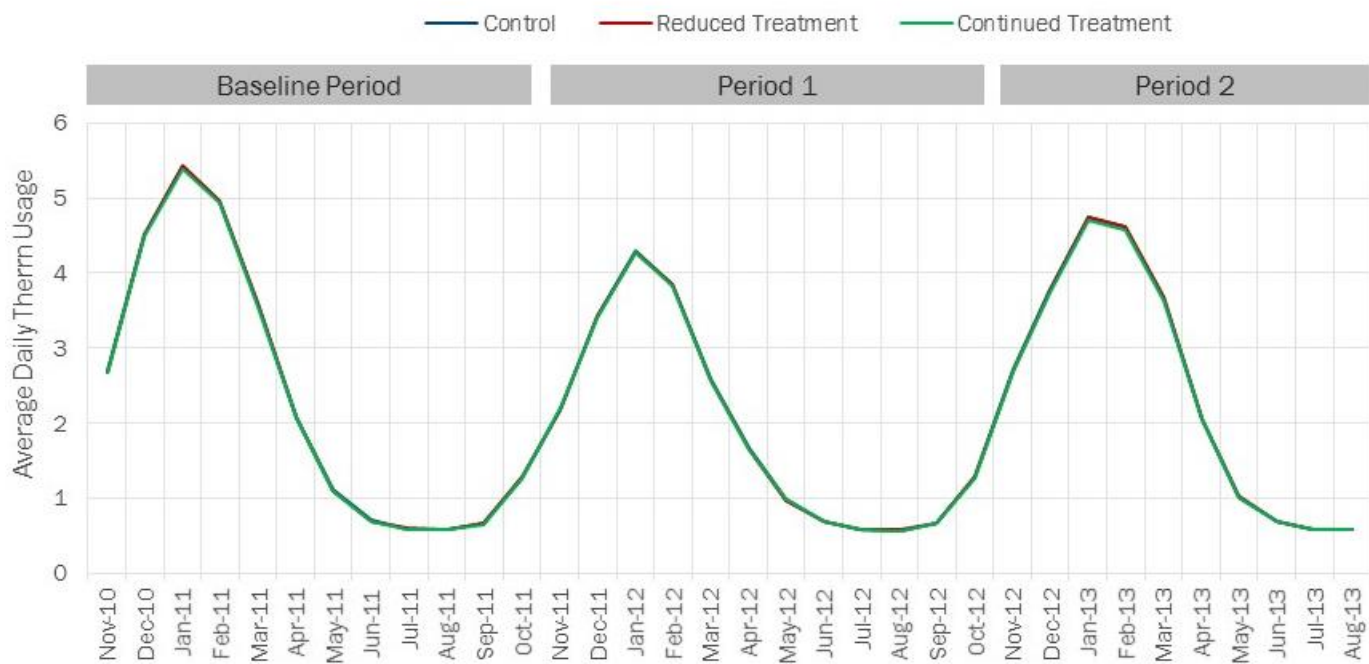
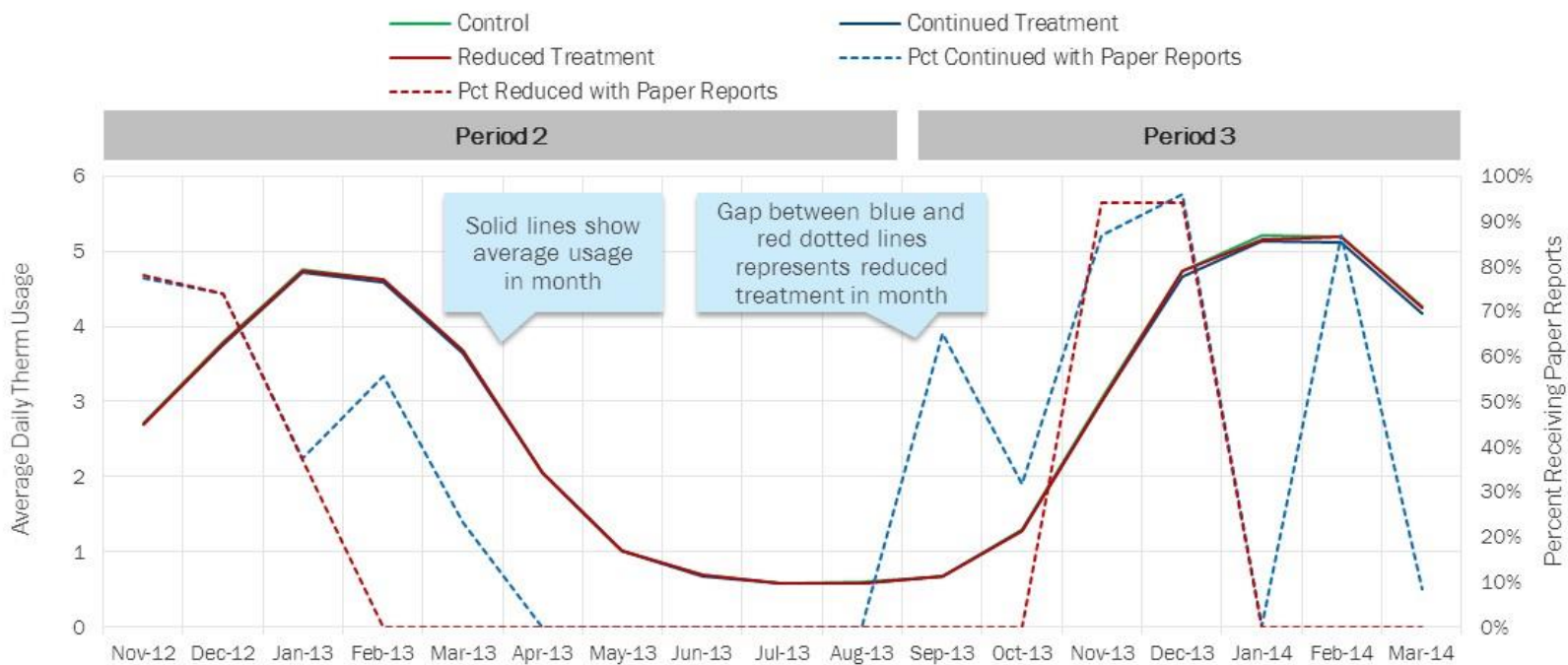


Figure 10. Average Daily Therm Consumption for Gas Customers with Report Dates (Periods 2 and 3)



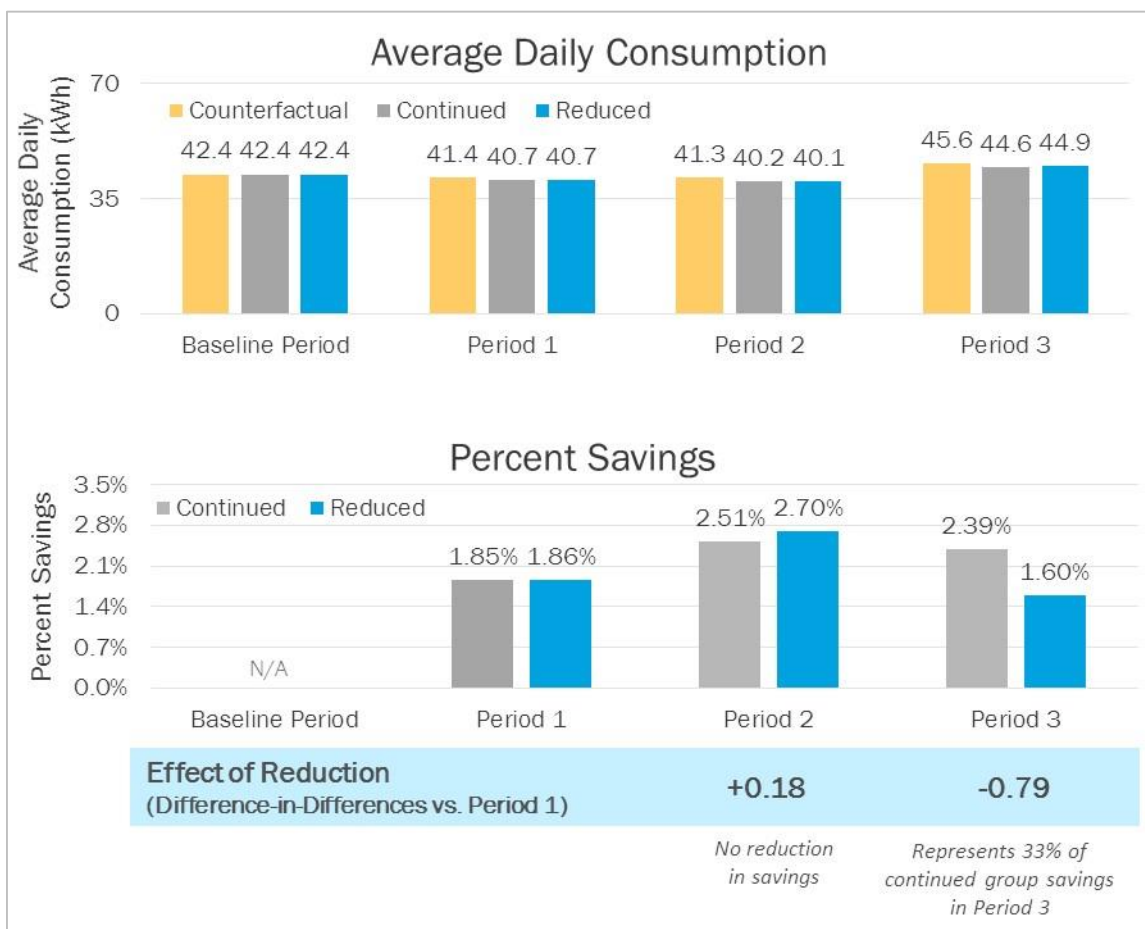
Modeled Results

The effects of reduced treatment vary between the electric and gas cohorts. Figure 11 and Figure 12 below show (1) modeled average daily consumption for the continued group, reduced group, and the “counterfactual” condition representing what consumption would have been without any treatment; and (2) percent savings of each treatment group relative to that counterfactual.

Within the electric cohort, the reduced treatment group did not exhibit a reduction in savings in Period 2, the 10-month period when paper reports were dramatically reduced. In fact, savings appear to increase in this period, relative to what the continued group achieved during the same period (2.70% savings for the reduced group, compared with 2.51% savings for the continued group). This increase of 0.18 percentage points represents 7% of the continued group’s savings in the same period.

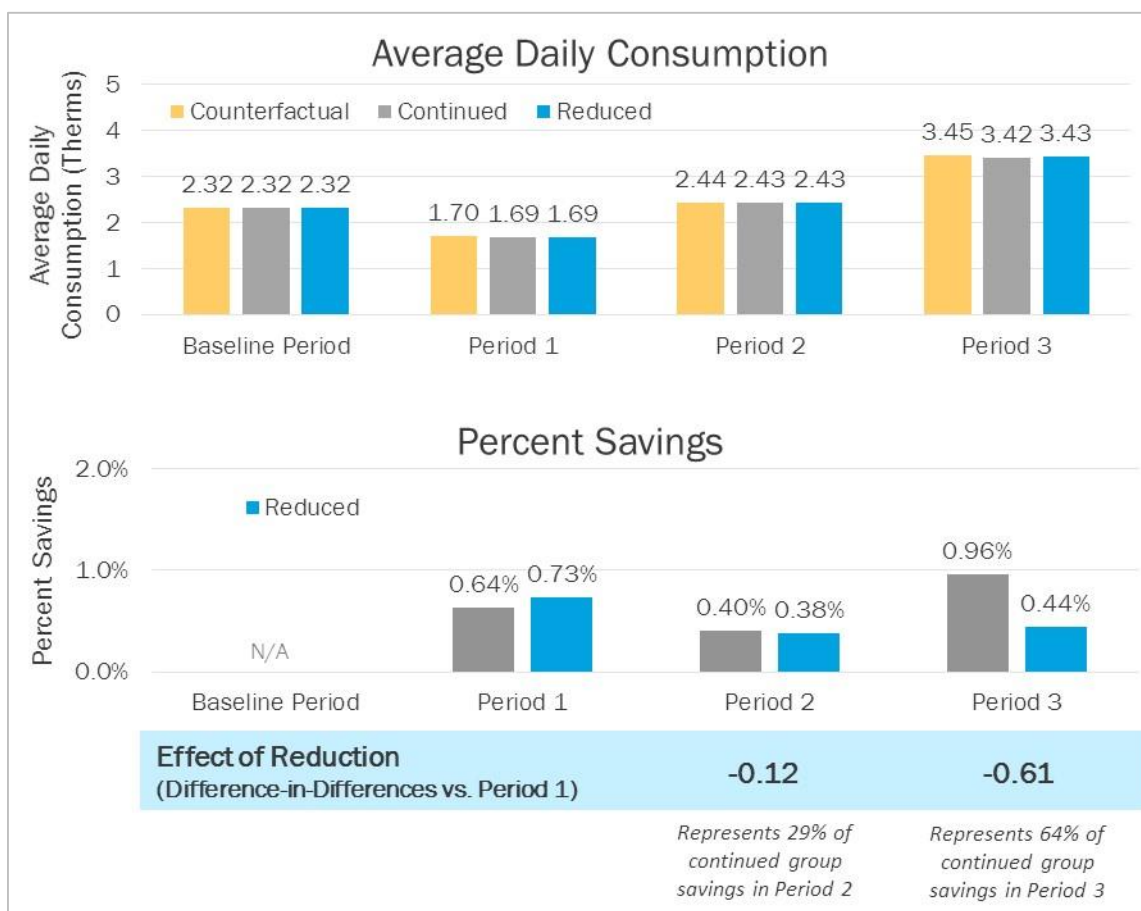
In Period 3, we observe a reduction in savings of 0.79 percentage points, which represents a 33% reduction in savings relative to the continued group’s savings in the same period. If we treat Periods 2 and 3 as one combined period, we observe a small net reduction in savings of 0.23 percentage points for the reduced group, representing about 9% of the continued group’s savings in the same period.

Figure 11. Electric Reduced Treatment Group Results (Average Daily Consumption & Percent Savings)



Within the gas cohort, the reduced treatment group exhibited a reduction in savings in both periods. In Period 2, we observe a reduction in savings of 0.12 percentage points,²¹ which represents a 29% reduction in savings relative to the continued group's savings in the same period. In Period 3, we observe a reduction in savings of 0.61 percentage points, which represents a 64% reduction in savings relative to the continued group's savings in the same period.

Figure 12. Gas Reduced Treatment Group Results (Average Daily Consumption and Percent Savings)



In sum, the savings decay analysis yields the expected result that a reduction in treatment leads to a decline in observed savings. However, while achieving the expected result overall, the gas and electric cohorts responded differently to the reduction in treatment. In the next section, we present key findings, as well as implications for program design and future research.

²¹ As described in the Methods section, we use the sum of difference in consumption between the continued and reduced in Period 2 as well as Period 1 to account for pre-existing differences in savings between groups. Although the difference in Period 2 appears small, the reduced group was saving more in Period 1; therefore, the overall effect of the reduction using a difference-in-difference approach is greater than the reduction in Period 2 alone. We performed the same calculations for the electric cohort, though the effect is less noticeable because the continued and reduced groups had fairly similar savings in the electric Period 1.

The Appendix contains a breakdown of these results for customers with and without email addresses.

5. Conclusions and Implications

This section presents findings specific to the cohorts included in this study, as well as implications of this research that the program administrators (PAs) should consider.

Key Finding #1: A reduction in treatment led to a decline in observed savings for both cohorts.

Overall, the reduced treatment customers in the electric cohort exhibited a small net reduction in savings (0.79 percentage points) compared to those receiving continued regular treatment. However, the electric reduced treatment group saw a reduction in savings only in Period 3, not in Period 2. For gas, there was a reduction in savings in both Period 2 and Period 3. The effect of the reduction in treatment in Period 3 was a decline in savings of 0.61 percentage points.

Implication:

- **A reduction in treatment may reduce program savings.** This finding is consistent with existing studies, which have also shown that a reduction in treatment may reduce program savings. In addition, this study illustrates that the magnitude of the savings reduction likely depends on the reduced-treatment design, the fuel type, and the duration of program intervention before the reduction.

Key Finding #2: The electric and gas cohorts responded differently to the reduction in treatment.

Compared with the electric cohort, reduced treatment customers in the gas cohort seem to show a much sharper reduction in savings in response to the reduction in reports they experienced. Not only did the reduced-treatment gas customers exhibit a noticeable decline in savings during the Period 1 treatment reduction, but the decline in savings in Period 3 was also relatively large compared to the savings achieved by the continued treatment group. One explanation for this relatively larger impact may be the shorter duration of program treatment prior to the reduction experiment. Gas customers received reports for only about 15 months prior to the treatment experiment (compared with 26 months among electric participants), and the reports they received were only sent in the fall and winter months.

The sharp reduction in savings for the gas cohort when reports were reduced for about two months in the second winter may suggest that participants had not habituated behaviors yet, or that they had not yet installed energy-saving measures due to the relatively short program period. The relatively larger impact of gas treatment reduction relative to electric treatment reduction may also be related to the fuel. For example, gas is more variable during the winter, and the customer sees a much higher monthly gas bill during the winter, which may make energy feedback information more meaningful and valuable. Combined with this particularly cold recent winter, the lack of feedback may have been more strongly felt for gas heating customers. Another reason persistence may be slightly greater for electric customers than for gas customers could be the mix of actions taken by customers who are provided with reports for one fuel rather than another. Electric customers may be able to take more easily habituated actions or install more low-cost measures than gas customers are able to (e.g., turning lights off or purchasing CFLs versus thermostat adjustment, which requires more comfort sacrifice, or air sealing, which may require more technical knowledge and investment).

Implications:

- **The duration of time that participants receive HERs prior to reduction may affect savings persistence.** As shown above, receiving fewer reports over a shorter time period (as seen within the gas cohort) may not provide sufficient time for customers to habituate behaviors or install equipment.
- **Report fuel type may have an impact on savings persistence.** Not only do electric and gas customers have different actions that they can take in the home, but there are also differences in the costs of each fuel, making it possible that feedback on one fuel is more valuable than feedback on another. However, the sensitivity to reduction we see from gas participants should not be confused with their overall savings compared to electric participants. Overall, participants save more electricity than gas.

Key Finding #3: The electric and gas cohorts experienced a decay in savings at different times relative to the reduction in treatment.

For the electric cohort, the decline did not set in immediately, whereas for the gas cohort, the decline was more immediate and precipitous. For the electric cohort, the timing of the decline in savings did not align directly with the period of the greatest reduction in treatment. Based on this experiment, it is unclear whether this is primarily due to a lag effect, or whether the seasonality of the experiment (the first reduction, as well as the timing of resumed reports) also affected results. In general, the appearance of a reduction effect (decline in savings) in Period 3 but not Period 2 seems to align with the theory that savings persist and slowly degrade. This suggests that participants in this cohort had partially habituated some behaviors (or installed measures) within the two-plus years prior to the paper report reduction.

However, the actual usage data patterns do not show such a gradual decline for the electric cohort, which we would expect from a habituation effect. In fact, they seem to show an immediate effect, then no effect, and a more meaningful drop in savings around the time that reports resumed in the winter. This precipitous decline in the last winter may be due to a combination of factors, including the built-up effect of not receiving reports for the preceding nine-to-10 months, and not receiving reports during critical winter months when energy information may be more important. Based on the seasonal usage patterns, we suspect that this cohort includes many electric heat customers, although we do not have any information about the exact proportion. Under this hypothesis, during the most recent winter, which was particularly cold, any electric heat customers in this cohort may have been more attuned to energy consumption information, making the reports more meaningful—and making the lack of feedback more strongly felt.

Implications:

- **Consider multiple factors when designing a treatment reduction strategy.** Many factors could affect the rate of savings decay, such as fuel type, seasonality, and duration. As shown in this study, there is also variation in the time that it takes for decay to kick-in.

Key Finding #4: Additional research in this area could help inform the design of treatment reduction strategies.

It is not possible to tease-out the reasons for differences in persistence with the evidence available from an experiment of this kind. Precisely explaining the reasons for the differences between the electric and gas cohorts when comparing only the two cohorts included in one study, given that they experienced different treatment reduction strategies, is not possible. As a result, we recommend that future experiments plan the timing of treatment reductions to further test the potential impact of the following:

- Treatment duration prior to the experiment: Within the same fuel, or even within a larger cohort, how does decay change when the first reduction occurs after one, two, or three years?
- Seasonality of reduction: How does a gap in the winter compare with a summer gap? Is there a way to optimize winter gaps to achieve greater persistence?
- Fuel-specific differences: Test similar reductions with participants at the same “program maturity” level between electric and gas.

Implications:

- **Studies with larger cohort sizes (including control group sizes) could be used to test the hypotheses developed from this study.** A larger cohort size might allow for multiple frequency tests within the same cohort, which would allow the PAs to “hold constant” some factors that may affect persistence (such as customer characteristics and program maturity), while testing other factors such as the length or timing of reduced treatment. For example, one reduced group could receive a reduction starting after one year, while a second reduced group could experience a reduction after two years. Alternatively, one reduced group could experience intermittent reductions, while another group could experience a longer reduction. A larger cohort size would also allow more “cuts” of the findings into smaller subgroups and time periods, resulting in greater confidence in differences observed in them.
- **If the PAs are not comfortable designing experiments that impact larger cohorts (or large portions of larger cohorts) due to potential negative impact on program savings, they could try more numerous and more focused experiments with smaller cohorts as an alternative.** Each experiment could aim to test one particular implementation strategy, among the four factors we listed above. With all of the factors at play (duration prior to reduction; timing/seasonality of reduction; unplanned extreme weather; cohort targeting), a single study may not be sufficient to answer questions about what the optimal treatment strategy may be for more mature cohorts. As a result, leveraging several smaller studies is one way to deal with the undesirability of using a large cohort for an experiment, which would put savings goals at risk. Under this scenario, it would be important to do more than one small study for each hypothesis, to judge the stability of the findings across jurisdictions or customer groups.

It is also important to note that given the differences in the experiment’s design for electric and gas, and the specificity of this experiment in terms of timing and cohort targeting, we cannot definitely state that the patterns we observed would occur again in a different group, or with different timing or duration of reductions, or with a different duration of treatment before reductions began. The declines we observed in this study suggest that HER savings will likely decline if reports are reduced (a) for an extended period of time, or (b) at critical times of the year. However, given the intricacies of the experiment’s design and the cohorts included here, we cannot definitely state that the patterns we observed (i.e., persistence for nine-to-10 months followed by decay within electric; sharp decline for gas) would occur again in a different group, or with different timing or duration of reductions. This study is somewhat idiosyncratic in terms of the differences in the nature of the reduction across electric and gas cohorts, as well as the relatively small cohort sizes.

Although we have reliable estimates for the overall change in savings associated with this specific experiment, readers should consider the specificity of this experiment (with respect to timing, duration, and the relative scale of treatment reduction within each fuel type, as well as the original cohort targeting) when drawing inferences from these results. To date, persistence research has focused on the result of a complete stop in treatment among treatment group participants. This experiment tested intermittent reductions of varying duration and timing among a group of customers who matched specific targeting criteria set by the program

implementer. As such, the National Grid experiment with reduction is unique, and the findings may provide only a directional indication of the potential impact of this type of program change.

Appendix A. Data Cleaning Steps and Detailed Results

Table 8 describes data cleaning steps for the Electric and Gas cohorts.

Table 8. Reasons for Excluding Customers from Decay Analysis

Reason for Exclusion		Electric Cohort		Gas Cohort	
		Treatment	Control	Treatment	Control
Initial N in billing file		25,000	7,440	26,000	17,530
No report dates for duration of program					
	n dropped	290	110	1,383	913
	n remaining	24,710	7,330	24,617	16,617
First report date after first year of program					
	n dropped	16	4	103	60
	n remaining	24,694	7,326	24,514	16,557
Inactive on/before Dec 31, 2013					
	n dropped	3,790	1,350	5,203	3,641
	n remaining	20,904	5,976	19,311	12,916
Opted out on/before Dec 31, 2013					
	n dropped	422	n/a	307	n/a
	n remaining	20,482	5,976	19,004	12,916
Sufficient data in pre period (at least 9 observations before first report date)					
	n dropped	10	2	161	99
	n remaining	20,472	5,974	18,843	12,817
Sufficient data in pre period winter (at least 3 bills in 5-month period Nov 2010-March 2011)					
	n dropped	n/a	n/a	459	300
	n remaining	n/a	n/a	18,384	12,517
Sufficient data in post period summer (at least 3 bills in the 5-month period May-Sept 2013)					
	n dropped	160	70	n/a	n/a
	n remaining	20,312	5,904	n/a	n/a
Sufficient data in post period winter (at least 3 bills in the 5-month period Nov 2013-March 2014)					
	n dropped	148	44	320	238
	n remaining	20,164	5,860	18,064	12,279
Sufficient data in post period (at least 9 bills in respective post-period)					
	n dropped	0	0	12	6
	n remaining	20,164	5,860	18,052	12,273
No Flag for Continued or Reduced					
	n dropped	0	85	0	0
	n remaining	20,164	5,775	18,052	12,273
No Flag for Having Email Address					
	n dropped	21	10	24	10
	n remaining	20,143	5,765	18,028	12,263
Percentage of Original Cohort Retained		81%	77%	69%	70%

The tables below present the linear fixed-effect regression model results for electric and gas. Note that since the analysis included a population of participants, the concept of relative precision (which is associated with a sample) does not apply. However, we chose to report these measures of uncertainty to be consistent with conventional statistical reporting practices. Moreover, while sampling error does not apply here, these sampling statistics (standard errors, t-statistics and p-values) do provide some information about variability within a population for key variables.

Table 9. Electric Model Results (Dependent Variable Is Average Daily kWh Consumption)

Independent Variable	Coefficient	Robust Standard Error	t-statistic	p-value
Period1	1.932	0.304	6.35	0.000
Period2	2.723	0.408	6.67	0.000
Period3	2.790	0.788	3.54	0.000
Period1Xctreat	-0.665	0.130	-5.10	0.000
Period2Xctreat	-0.787	0.188	-4.18	0.000
Period3Xctreat	-0.941	0.398	-2.36	0.018
Period1Xrtreat	-0.799	0.141	-5.67	0.000
Period2Xrtreat	-0.995	0.201	-4.94	0.000
Period3Xrtreat	-0.681	0.436	-1.56	0.118
Period1Xemail	0.524	0.448	1.17	0.243
Period2Xemail	1.116	0.620	1.80	0.072
Period3Xemail	-0.278	1.239	-0.22	0.822
Period1Xbaseline_adc ²²	-0.070	0.007	-9.99	0.000
Period2Xbaseline_adc	-0.098	0.009	-10.45	0.000
Period3Xbaseline_adc	0.010	0.018	0.52	0.604
Period1Xbaseline_adcXemail	-0.007	0.010	-0.67	0.504
Period2Xbaseline_adcXemail	-0.009	0.014	-0.65	0.513
Period3Xbaseline_adcXemail	0.009	0.029	0.30	0.763
Period1XctreatXemail	-0.260	0.209	-1.24	0.215
Period2XctreatXemail	-0.629	0.307	-2.05	0.040
Period3XctreatXemail	-0.372	0.634	-0.59	0.557
Period1XrtreatXemail	0.072	0.225	0.32	0.749
Period2XrtreatXemail	-0.294	0.326	-0.90	0.367
Period3XrtreatXemail	-0.125	0.681	-0.18	0.854
Constant	42.407	0.034	1253.20	0.000

²² Baseline consumption is represented as “baseline_adc” in model output (average daily consumption in the baseline period)

Table 10. Gas Model Results (Dependent Variable Is Average Daily Therm Consumption)

Independent Variable	Coefficient	Robust Standard Error	t-statistic	p-value
Period1	0.041	0.024	1.72	0.085
Period2	0.104	0.030	3.47	0.001
Period3	0.226	0.049	4.63	0.000
Period1Xctreat	0.001	0.032	0.04	0.966
Period2Xctreat	-0.068	0.037	-1.84	0.066
Period3Xctreat	-0.024	0.088	-0.27	0.789
Period1Xrtreat	0.017	0.030	0.55	0.580
Period2Xrtreat	-0.043	0.041	-1.06	0.289
Period3Xrtreat	-0.071	0.072	-0.99	0.324
Period1Xemail	0.012	0.007	1.61	0.108
Period2Xemail	0.029	0.011	2.68	0.007
Period3Xemail	0.023	0.018	1.28	0.202
Period1Xbaseline_adc	-0.287	0.011	-25.64	0.000
Period2Xbaseline_adc	0.000	0.014	-0.03	0.975
Period3Xbaseline_adc	0.381	0.023	16.58	0.000
Period1XctreatXemail	-0.006	0.011	-0.60	0.547
Period2XctreatXemail	-0.020	0.016	-1.28	0.199
Period3XctreatXemail	0.020	0.027	0.73	0.464
Period1XrtreatXemail	-0.010	0.012	-0.81	0.419
Period2XrtreatXemail	-0.012	0.017	-0.71	0.481
Period3XrtreatXemail	0.028	0.029	0.99	0.322
Period1Xbaseline_adcXctreat	-0.004	0.015	-0.25	0.800
Period2Xbaseline_adcXctreat	0.030	0.017	1.73	0.084
Period3Xbaseline_adcXctreat	-0.009	0.041	-0.21	0.835
Period1Xbaseline_adcXrtreat	-0.010	0.014	-0.74	0.458
Period2Xbaseline_adcXrtreat	0.017	0.019	0.93	0.355
Period3Xbaseline_adcXrtreat	0.018	0.033	0.54	0.591
_cons	2.324	0.002	1177.75	0.000

Appendix B. Findings by Report Type

In this section, we present findings for participants with email addresses, the vast majority of whom received electronic Home Energy Reports (eHERs), compared to customers without email addresses, who received paper reports only. These subgroups—by treatment type (continued, reduced, and control) and report type (email address and paper-only)—are fairly small relative to the very small differences in effects we are looking for, and in some cases (see Table 6 above) show non-equivalent consumption between treatment and control groups of a report type in the baseline period. Additionally, the savings patterns we observed are not entirely consistent between periods and cohorts, and some are not in the expected direction. For these reasons, we caution that these results may be highly specific to the particular customers in each group, and suggest limiting any generalizations that may be drawn from these findings.

Monthly Consumption Trends for Email and Print-Only Participants (Not Modeled)

As discussed in the Methods section, electric treatment group participants with email addresses do not exhibit the same baseline consumption patterns as electric control group customers with email addresses. This is evident in the first baseline usage pattern chart below (Figure 13), where we see the treatment groups' consumption above the control. Further, we see some slight differences between continued and reduced treatment customers during the baseline period. Among electric customers without email addresses, we see that the control group's baseline consumption is equivalent to that of the reduced group, while the continued group's baseline consumption is slightly lower. Within each report type (paper or electronic), we also see slight differences between continued and reduced group consumption in Period 1, where we expect consumption and savings to be equivalent. The electric models control for baseline consumption as well as the interaction between baseline consumption and having an email address, and therefore the modeled savings results may lead to slightly different findings and implications than examining the unadjusted usage data would.

For gas customers, we also see a difference in baseline consumption patterns between treatment group participants with email addresses and control group customers with email addresses, though in this case the control group's consumption is higher. Among participants with email addresses, we also see some differences in usage patterns between continued and reduced in Period 1, where we expect equivalent savings. Among gas customers without email addresses (they receive only paper reports), usage levels of the treatment groups are above the control group in the baseline period, and stay consistently above the control group throughout the treatment period.²³ With these trends, it is difficult to detect savings differences, and therefore we suggest relying on the modeled savings results. Still, we acknowledge that even though the models control for baseline consumption differences, there may be pre-existing differences between groups that could affect savings.

²³ For both the electric and gas cohorts, we tested a different method of classifying customers as eHER and print-only. Because eHER status is known for recipients (i.e., available in the databases) but not known for control customers, we first classified customers as eHER if (a) they were participants who received eHER reports, or (b) they were control group members with email addresses (as a proxy for eHER status). When customers are classified in this manner, baseline consumption is even less equivalent between treatment and control within report type than when we classify all customers based on having an email address (the results shown here).

Figure 13. Average Daily kWh Consumption for Electric Customers with Email Addresses (98% Received eHERs)

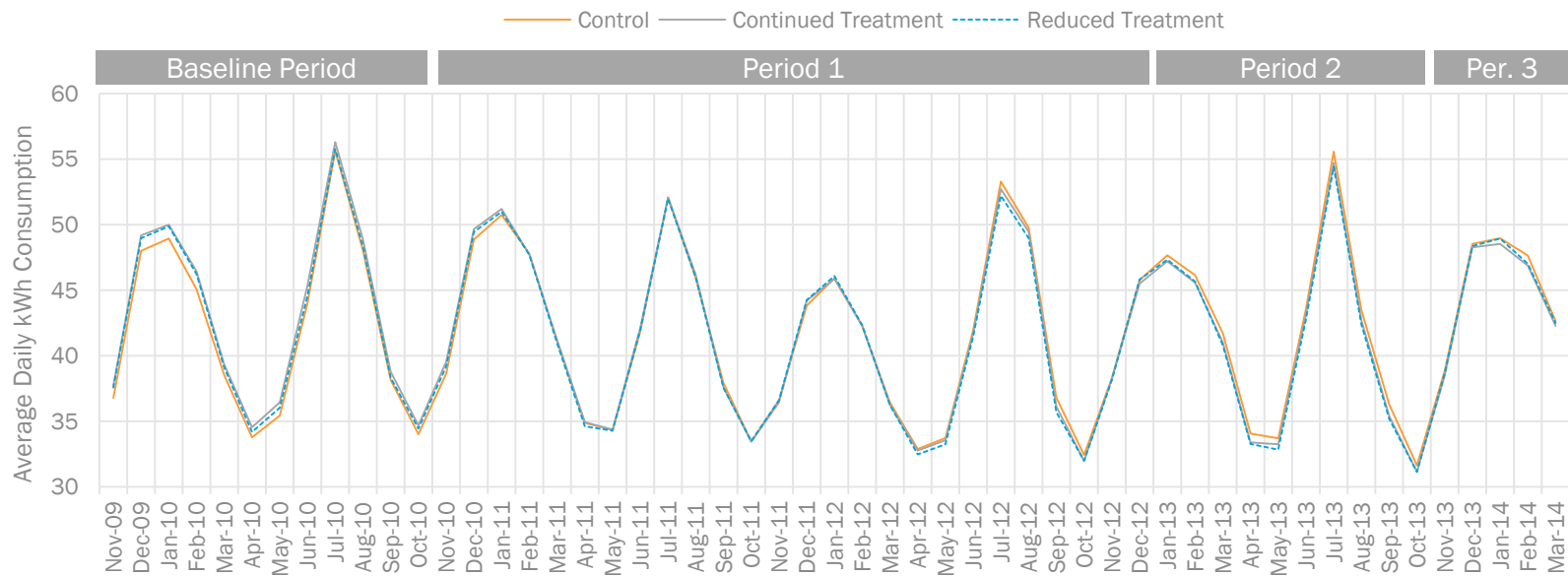


Figure 14. Average Daily kWh Consumption for Electric Customers without Email Addresses (Print Only)

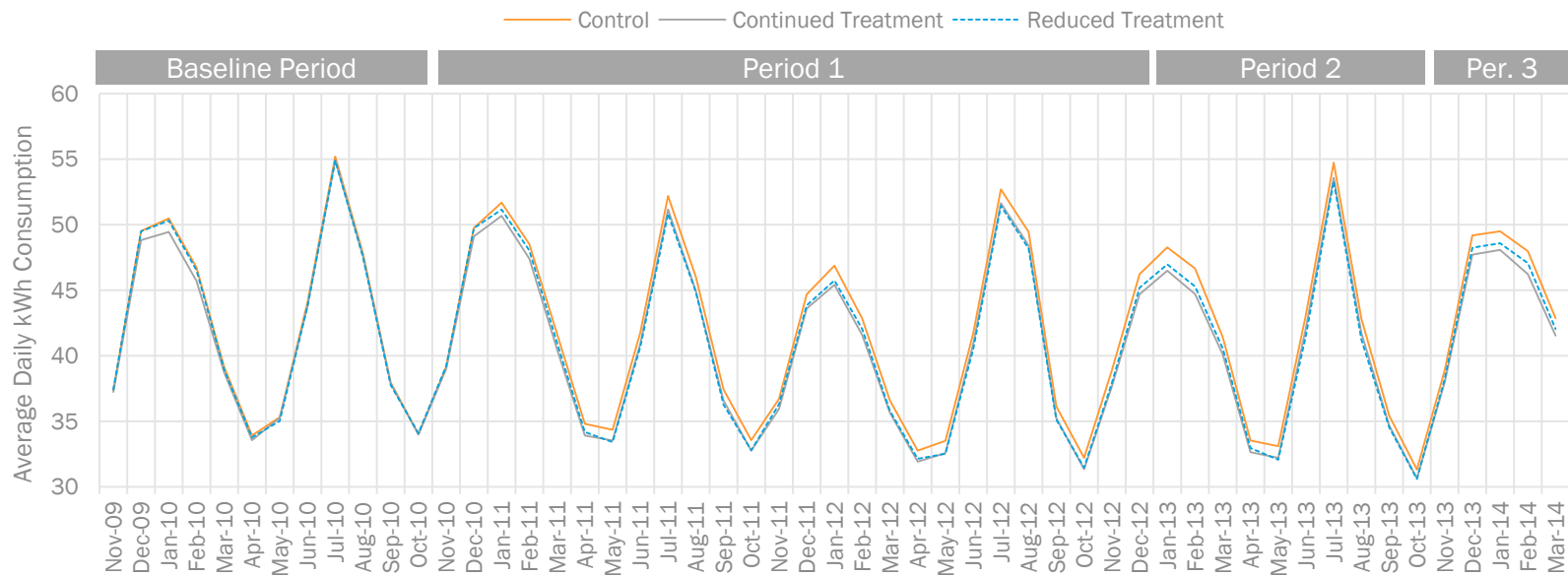


Figure 15. Average Daily Therm Consumption for Gas Customers with Email Addresses (90% Received eHERs)

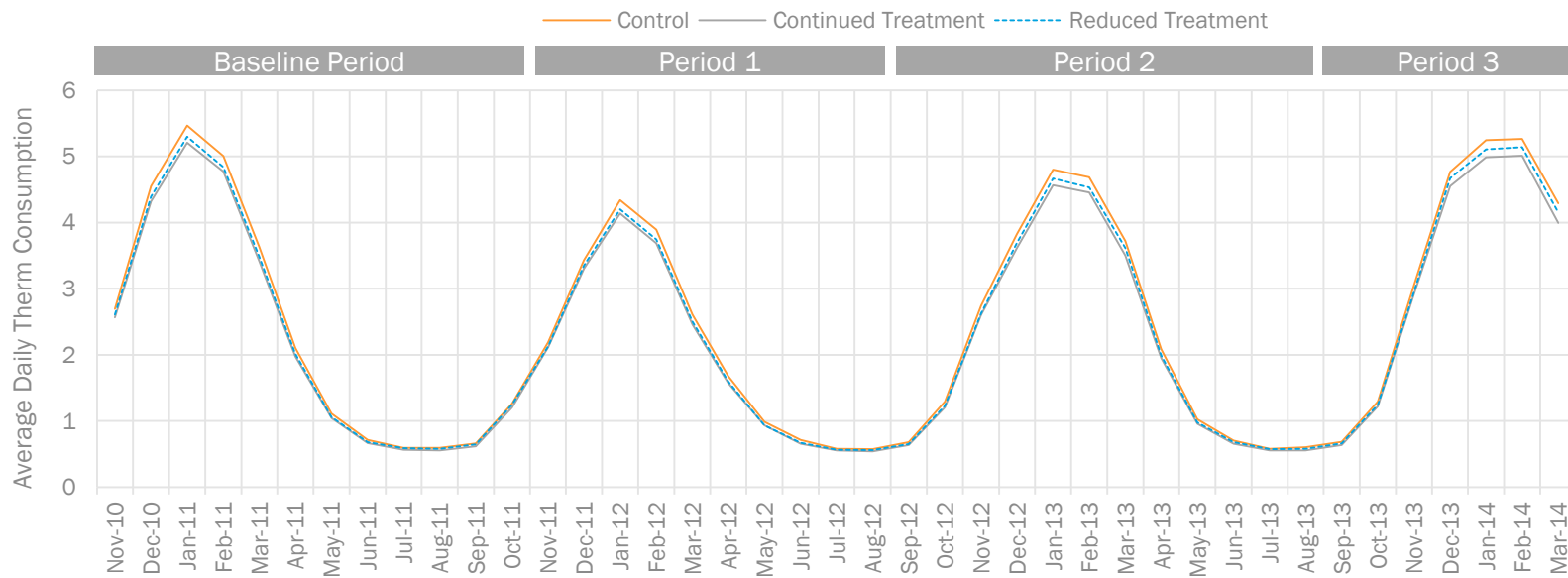
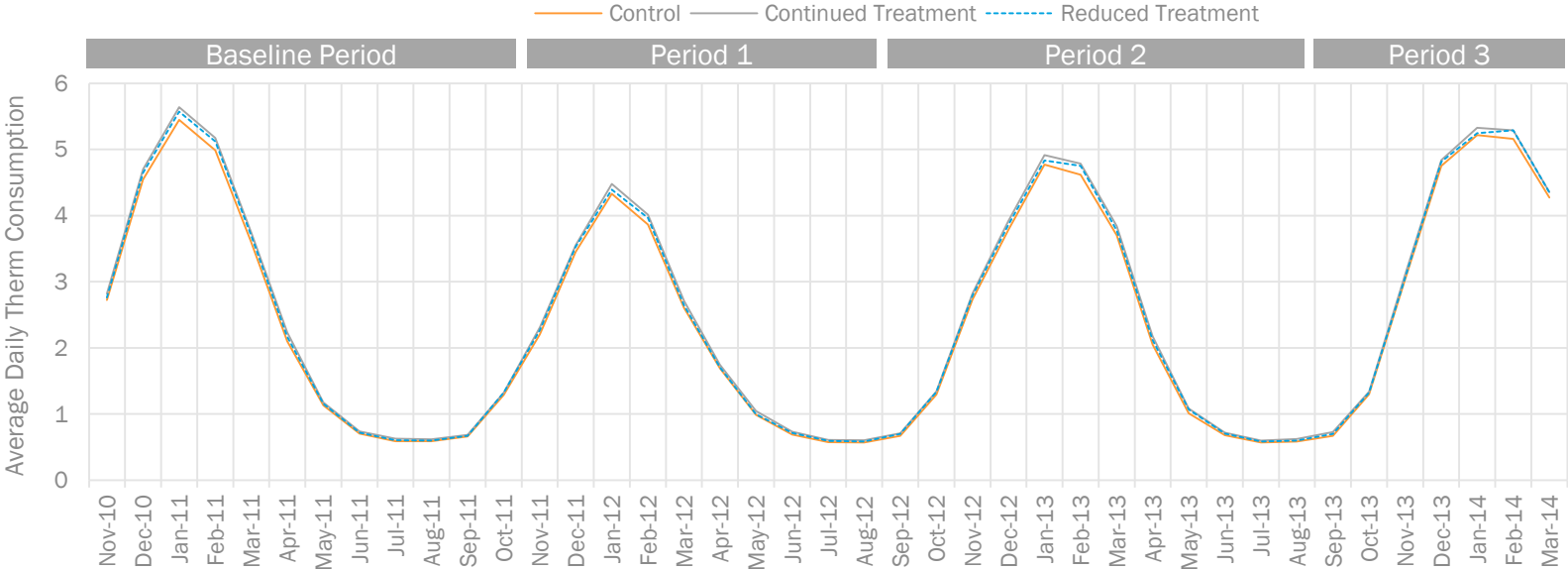


Figure 16. Average Daily Therm Consumption for Gas Customers without Email Addresses (Print Only)



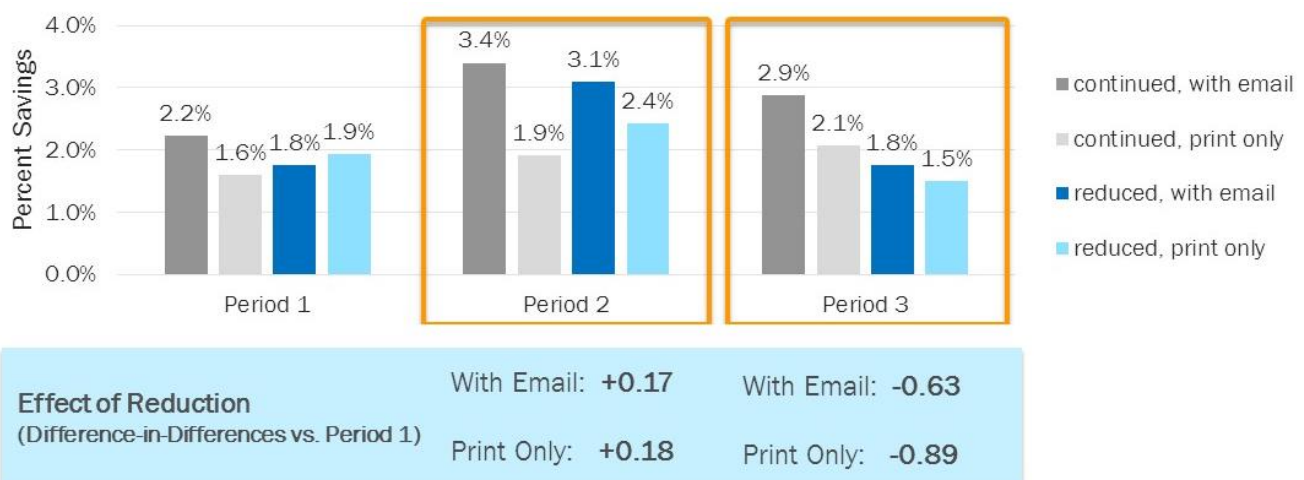
Modeled Results for Email and Print-Only Participants

One hypothesis for savings trends of customers with and without email addresses may be that savings decay less (i.e., there is more persistence) for reduced treatment customers with email addresses, because they continue to receive eHERs at the same frequency as the continued group. When examining results for customers with and without email addresses, we evaluated whether the results were in the expected direction based on this hypothesis; do participants who receive both paper-only and eHERs show greater persistence of savings than paper-only participants do?

To answer this question, we evaluated the models described above for the four treatment subgroups: continued, with email; continued, print-only; reduced, with email; and reduced, print-only. We evaluated the reduced treatment effect for customers with and without email addresses using the same method that we use to evaluate overall reduced treatment effects. First, we calculated percent savings for each group in each period. Then, for the reduced treatment groups, we calculated difference-in-differences savings as (a) the difference in savings for the reduced treatment subgroup and its respective control group's savings in Period 2 or 3, compared with (b) the difference in savings for the reduced treatment subgroup and its respective control group's savings in Period 1. Figure 17 and Figure 18 present modeled percent savings in each period, and below each period, we show the difference-in-differences effect of reduced treatment (in percentage points).

Within the electric experiment, we see that savings increased for both reduced treatment groups in Period 2 (relative to the continued treatment groups). Further, we see that both reduced groups saw an increase in savings of a similar magnitude. This finding does not support our initial hypothesis that the effect of reduction may be smaller among customers for whom email reports continue, because savings do not decay in this period for either group. During Period 3, we see that print-only reduced participants experienced a greater reduction in savings than did the reduced group with email addresses. This finding does align with the initial hypothesis, and in fact, this is the only one of the four periods we investigated where savings decay more for the print-only group compared with the email group.

Figure 17. Modeled Percent Savings for Electric Cohort Subgroups

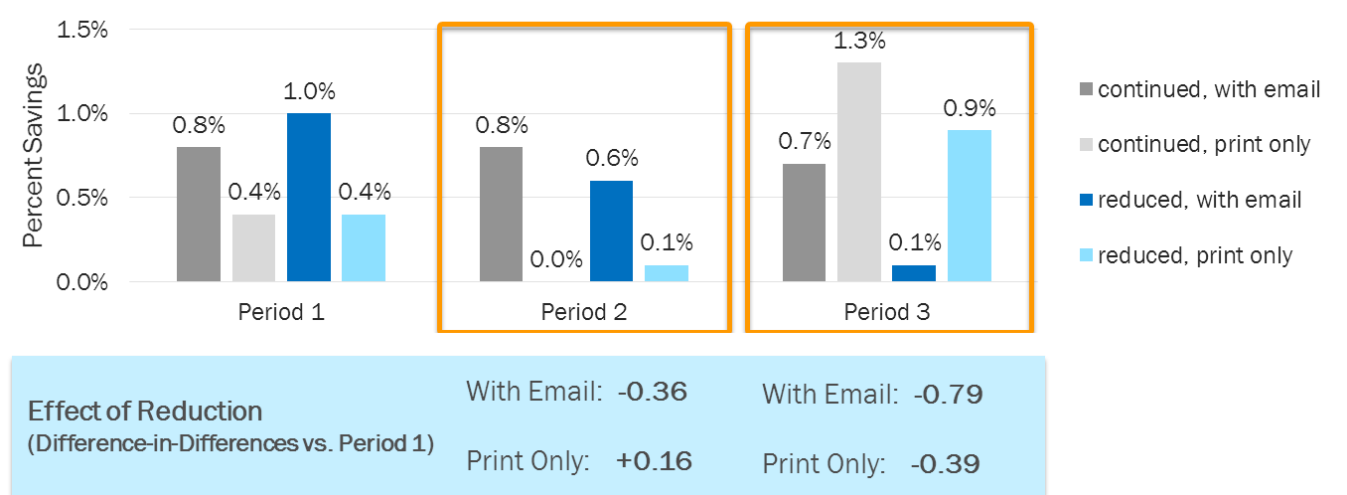


Within the gas experiment, savings decayed more among reduced treatment customers with email addresses than reduced treatment customers who received only paper reports. In Period 2, reduced treatment customers with email addresses showed a decline in savings, while reduced print-only customers did not experience a

decline in savings (relative to continued print-only customers) (see Figure 18). In Period 3, we see a larger decay for reduced treatment customers with email addresses compared with reduced print-only. Neither of these findings align with the initial hypothesis.

However, the gas results may suggest an alternative hypothesis: Having an email address could be a proxy for general engagement with the HER material (content) rather than engagement with the emails themselves. If customers with email addresses were generally more engaged with the paper reports, then a reduction in paper reports may have more of an impact for them. In Period 1, we see that gas customers with email addresses (both continued and reduced) had savings levels at least twice as high as those without email addresses (who were print-only). Without knowing email open rates (which were not available for this evaluation), we can't determine whether this difference was due to higher engagement with the paper or email reports, though this trend does suggest that gas customers with email addresses may be more receptive to messaging, regardless of channel. Email open rates could bring additional insights to these results.

Figure 18. Modeled Percent Savings for Gas Cohort Subgroups



Discussion and Implications

The savings patterns we observed in the email and print-only analysis are not consistent between periods and cohorts, and in some cases, the patterns are not in the expected direction. When interpreting these findings, there are a few considerations to keep in mind: (1) the cohort sizes are fairly small, and therefore the observed patterns could be subject to random fluctuations; (2) the persistence test was likely not designed to support findings at the delivery-channel level; and (3) differences in baseline consumption within each delivery channel (e.g., treatment vs. control within electric customers with email addresses) can make results more volatile.

With these considerations in mind, there are a few things we can say about the results. In general, these results cannot be used to support the hypothesis that participants who continued to receive email reports but experience reduced paper reports, will exhibit higher savings persistence than those who experience a reduction in paper reports and do not receive email reports. More research is needed to determine whether ongoing email reports could be a cost-saving strategy to improve persistence. In particular, an examination of email open rates could illuminate whether engagement with email reports is high enough to suggest that information provided in these reports could supplement or replace the role of the paper reports among more mature cohorts. Additionally, we suggest further research to understand whether having an email address with

the utility or program administrator is a proxy for higher potential engagement with the HER program in general (including engagement with email reports). This alternative hypothesis could explain some of the trends observed here.

Appendix C. Relevant Literature

Allcott, Hunt, and Todd Rogers (2012). "How Long Do Treatment Effects Last? The Persistence and Durability of a Descriptive Norms Intervention in Energy Conservation." Working Paper, Harvard University.

Allcott, Hunt, and Todd Rogers (2013). "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." National Bureau of Economic Research.

Ferraro, P.J., J.J. Miranda, M.K. Price. 2011. The Persistence of Treatment Effects with Norm-Based Policy Instruments: Evidence from a Randomized Environmental Policy Experiment. *American Economic Review: Papers and Proceedings* 101(3) 318-322.

Publically Available Persistence Studies

KEMA (2012). "Puget Sound Energy's Home Energy Reports Program: Three Year Impact, Behavioral and Process Evaluation." Madison, Wisconsin: DNV KEMA Energy and Sustainability.

Integral Analytics (2012). Impact & Persistence Evaluation Report: Sacramento Municipal Utility District Home Energy Report Program. Cincinnati, Ohio: Integral Analytics.

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