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Behavioral Energy Savings Programs: Home Energy Reports Persistence Study Part 2 – April 2015 to September 2015

Final

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Nicor Gas

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E EXECUTIVE SUMMARY

E.1. STUDY DESCRIPTION

The Nicor Gas Behavioral Energy Savings Programs (BESP) included a Home Energy Report (HER) program during GPY3.[1] This report presents the findings associated with the persistence of savings for the Nicor Gas HER program beyond the initial year of the program in GPY3. Specifically, this report addresses Part 2 of the persistence study, which is associated with the second 6-month period (April 2015 – September 2015) after GPY3 operations. Over the past several years there has been a growing interest in the persistence of savings from HER programs after reports have been stopped. If savings persist after the cessation of reports, it has important implications for the lifetime measure savings and cost-effectiveness of HER programs. This is an important study for Nicor Gas because little evidence exists on the persistence of savings for gas HER programs.

In the GPY3 evaluation report, Navigant estimated savings from the HER program during the first year that it was run, covering the period from October 2013 to September 2014.[2] Navigant found savings of 4.1 million therms in the GPY3 evaluation. For the purposes of assessing the persistence of savings beyond GPY3, Navigant broke the year after the original program was offered into two six-month parts. During Part 1, covering the period from October 2014 to March 2015, Navigant found that the program generated 1.9 million therms of savings in the first six months after it was discontinued (in September 2014).[3] Part 2 of this study looks at savings for the remainder of the first year after the initial program year, from April 2015 to September 2015. Additionally, this study will estimate an annual decay rate and effective useful life for the program based on the savings found.

The HER program was an opt-out program designed to generate natural gas savings by providing residential customers with information about their specific gas use and related conservation suggestions and tips. The information was provided in the form of reports that illustrate: a) how customers' recent gas consumption compares to their gas consumption in the past; b) tips on how the customers can reduce gas consumption, some of which are tailored to each customer's unique circumstances; and c) information on how the customers' gas consumption compares to that of neighbors with similar homes. In other studies, this type of information has stimulated customers to reduce their gas consumption, creating average savings of around 1%, depending on local gas consumption patterns.

The GPY3 evaluation covered savings during the initial program year, through September 2014. Although the evaluation covered one year, the last reports were sent in March 2014 as reports were sent only during the heating season.[4] The current study looks at persistence savings from this program that accrued in the second half of the year after the program ended, April 2015 to September 2015. Because reports were ended in March, this study may represent a conservative estimate of persistence savings since the year the program ran included seven months when reports were sent and five months when reports were not sent. However, it is typical for a gas only Opower program to only send reports during

[1] GPY3 began June 1, 2013, and ended May 31, 2014.

[2] Navigant Consulting Inc. 2015. "Behavioral Energy Savings Program GPY3 Evaluation Report." Presented to Nicor Gas.

[3] Navigant Consulting Inc. 2015. "Behavioral Energy Savings Programs: Home Energy Reports Persistence Study Part 1 – October 2014 to March 2015" Presented to Nicor Gas.

[4] The program was defined as running for one year from October 2013 to September 2014 so that a full year of savings would be estimated. During the year that the program ran, reports were only sent during the heating season as is typical for a gas only Opower program.

the heating season, thus the GPY3 evaluation captured a typical gas only program year and this study covers a typical year after ending a gas only program.

E.2. SUMMARY OF GPY3 FINDINGS – OCTOBER 2013 TO SEPTEMBER 2014

In GPY3 Navigant evaluated savings from the first year of the HER program covering the period from October 2013 to September 2014. Table E-1 summarizes Navigant's finding from the GPY3 report.

Table E-1. HER Total Program Gas Savings during its First Year

Savings Category	Savings (Therms)
Net Savings Goal	3,327,435
Ex Ante Net Savings*	4,140,321
Percentage Savings, Before Uplift Adjustment	0.78%
Verified Net Savings, Before Uplift Adjustment	4,264,371
Verified Net Savings, After Uplift Adjustment	4,111,100

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis

* Savings results reported by Opower through October 31, 2014.

E.3. PART 1 PERSISTENCE STUDY SAVINGS – OCTOBER 2014 TO MARCH 2015

Table E-2 summarizes the gas savings from the HER program for the first six months after the initial program year. The HER program ended in September 2014 after running for one year, and the Part 1 study evaluated savings in the period from October 1, 2014 to March 31, 2015 (i.e. the heating season). Navigant was unable to consider double-counted savings due to uplift in this study because other energy efficiency program tracking data was unavailable.[5]

Table E-2. HER Total Gas Savings from October 2014 – March 2015

Savings Category	Savings (Therms)
Percentage Savings, Before Uplift Adjustment	0.41%
Verified Net Savings, Before Uplift Adjustment	1,924,321

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis

[5] In GPY3 Navigant found that savings from uplift were 3.6% of total program savings.

E.4. PART 2 PERSISTENCE STUDY SAVINGS – APRIL 2015 TO SEPTEMBER 2015

Table E-3 summarizes the gas savings from the HER program for the latter half of the year after the initial program year. The initial program year ended in September 2014, and this Part 2 study evaluates savings in the period from April 1, 2015 to September 30, 2015. Navigant was again unable to consider double-counted savings due to uplift in this draft because other energy efficiency program tracking data was unavailable.[6] Therefore this report compares savings before the uplift adjustment in order to calculate savings decay.

Table E-3. HER Total Gas Savings from April 2015 – September 2015

Savings Category	Savings (Therms)
Percentage Savings, Before Uplift Adjustment	0.43%
Verified Net Savings, Before Uplift Adjustment	509,559

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis

E.5. ANNUAL SAVINGS DECAY RATE

Table E-4 presents the annual decay rate, the lifetime savings, and the effective useful life for the HER program in the first year after the initial program year, October 2014 to September 2015. These savings are before the uplift adjustment.[7]

Table E-4. HER Total Gas Savings from October 2014 – September 2015

Type of Statistic	Annual October 2014 – September 2015
Annual Decay Rate	46%
Annual Persistence Factor*	54%
Lifetime Savings, Therms	8,861,472
HER Effective Useful Life	2.08 years

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis

*The persistence factor is equal to one minus the decay rate.

E.6. KEY FINDINGS AND RECOMMENDATIONS

This section summarizes the key impact findings and recommendations.

Finding 1. The utility-specific annual decay rate for the Nicor Gas HER program is 46% one year after the initial program year. This implies a persistence factor of 54% for the first year after the initial program year, meaning that 54% of the program savings persist after one year.

[6] See Footnote **Error! Bookmark not defined.**.

[7] These estimates assume a constant annual decay rate and an annual attrition rate due to residence changes of 3.17% which was calculated based on the attrition during the year for which the HER program ran.

Finding 2. The estimated effective useful life of the Nicor Gas HER program in first year equivalents is two years. This means that if reports are sent for one year (meaning one heating season), treatment customers will achieve lifetime savings that are approximately double those achieved in the initial year.

Recommendation 1. The decay rate of 46% should be considered in determining persistence factors and measure life for the Illinois Technical Reference Manual (IL TRM).[8] This study represents one data point in a broader literature, and any values created for the IL TRM should also take the broader literature into account. Combining the results of this research and the GPY3 evaluation shows that lifetime savings from the GPY3 program were almost nine million therms or a bit more than double the therm savings achieved in GPY3.

Recommendation 2. Nicor Gas should continue this study for another year and look at savings in the second year after the initial program year, from October 2015 to September 2016. The continued study would estimate the decay rate in the second year after reports are stopped. This would add to research on whether decay rates remain constant, increase, or decrease in the second year after the initial program year and the results could be used to inform second year persistence factors in the IL TRM.

Recommendation 3. The absolute therm savings in this study are not weather normalized, however, the decay and persistence factors are weather normalized (at least in part), since they are calculated from percentage savings rather than absolute savings.

There has been discussion around the idea that absolute savings should also be weather normalized to accurately compare savings across different years and to accurately calculate savings using the IL TRM algorithms since the algorithms apply persistence factors to absolute savings. However, the question of how to most accurately weather normalize has not been resolved, and we recommend that this be a topic of discussion among interested stakeholders when updating the relevant measure in the IL TRM.

[8] The relevant measure is "Adjustments to Behavior Savings to Account for Persistence" which is measure 6.1.1 in Volume 4 of Version 5 of the IL TRM. < http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_4_X-Cutting_Measures_and_Attach._021116_Final.pdf>

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1. INTRODUCTION

1.1 STUDY DESCRIPTION

1.1.1 Home Energy Report Persistence Study Description

The Nicor Gas Behavioral Energy Savings Programs (BESP) included a Home Energy Report (HER) program during GPY3[9]. This report presents the findings associated with the persistence of savings for the Nicor Gas HER program beyond the initial year of the program in GPY3. In the GPY3 evaluation report, Navigant estimated savings from the HER program during the first year that it was run, covering the period from October 2013 to September 2014.[10] Navigant found savings of 4.1 million therms in the GPY3 evaluation. Having already established savings of 1.9 million therms during the first six months after the initial program year, the purpose of this current study is to look at whether the HER program continued to generate savings in the second six months after the initial program year, covering the period from April 2015 to September 2015. Additionally, this study estimates an annual decay rate and effective useful life for the program based on the savings found.

The Home Energy Report (HER) program was designed to generate gas savings by providing residential customers with sets of information about their specific gas consumption and related conservation suggestions and tips. The information was provided in the form of reports that give customers various types of information, including: a) how their recent gas consumption compares to their use in the past; b) tips on how to reduce consumption, some of which are tailored to the customer's circumstances; and c) information on how their gas consumption compares to that of neighbors with similar homes. This set of information has been shown in other studies to stimulate customers to reduce their gas consumption, creating average savings around 1%, depending on local gas consumption patterns.

An important feature of the program is that it was a randomized controlled trial (RCT). Customers in the program were randomly assigned to a treatment (participant) group and a control (non-participant) group, for the purpose of estimating changes in gas consumption due to the program.

The GPY3 evaluation covered savings during the initial program year, through September 2014. Although the evaluation covered one year, the last reports were sent in March 2014 as reports were sent only during the heating season.[11] The current study looks at persistence savings from this program that accrued in the second half of the year after the program ended, April 2015 to September 2015. Because reports were ended in March, this study may represent a conservative estimate of persistence savings since the year the program ran included seven months when reports were sent and five months when reports were not sent. However, it is typical for a gas only Opower program to send reports only during the heating season. Thus the GPY3 evaluation captured a typical gas only program year and this study covers a typical year after ending a gas only program.

[9] GPY3 began June 1, 2013, and ended May 31, 2014.

[10] Navigant Consulting Inc. 2015. "Behavioral Energy Savings Program GPY3 Evaluation Report." Presented to Nicor Gas.

[11] The program was defined as running for one year from October 2013 to September 2014 so that a full year of savings would be estimated. During the year that the program ran, reports were only sent during the heating season as is typical for a gas only Opower program.

1.2 SUMMARY OF GPY3 FINDINGS

In GPY3 Navigant evaluated savings from the first year of the HER program covering the period from October 2013 to September 2014. **Error! Reference source not found.** summarizes Navigant's finding from the GPY3 report.

Table 1-1. HER Total Program Gas Savings during its First Year

Savings Category	Savings (Therms)
Net Savings Goal	3,327,435
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Percentage Savings, Before Uplift Adjustment	0.78%
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Verified Net Savings, After Uplift Adjustment	4,111,100

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis.

* Savings results reported by Opower through October 31, 2014.

1.3 PART 1 PERSISTENCE STUDY SAVINGS – OCTOBER 2014 TO MARCH 2015

Error! Reference source not found. summarizes the gas savings from the HER program for the first six months after the initial program year. The GPY3 evaluation report covered the period through September 2014, and the Part 1 study evaluated savings in the period from October 1, 2014 to March 31, 2015. Navigant was unable to consider double-counted savings due to uplift in this part of the study because other energy efficiency program tracking data was unavailable.[12]

Table 1-2. HER Total Gas Savings from October 2014 – March 2015

Savings Category	Savings (Therms)
Percentage Savings, Before Uplift Adjustment	0.41%
Verified Net Savings, Before Uplift Adjustment	1,924,321

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis.

1.4 STUDY OBJECTIVES

The primary objective of this study is to determine the extent to which participants in the HER program reduced their gas consumption in the year after the program's cessation due to their participation in the HER program during GPY3. As a secondary objective, Navigant estimated the annual savings decay rate for the HER program and the associated program effective useful life. In this evaluation, the savings decay is defined as the reduction is savings post-suspension of the HER program and thus answers the

[12] In GPY3 Navigant found that savings from uplift were 3.6% of total program savings.

question “how much do savings persist following termination of the program as a percentage of final year savings?” Notably, this definition of savings decay does not include the opportunity cost of missed incremental savings from continuing the program.[13]

[13] Gas only Opower programs typically have incremental savings in the second year due to ramp-up. Other gas only programs in Illinois have seen savings increase by approximately 40% in year two as compared to year one.

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2. STUDY APPROACH

2.1 HOME ENERGY REPORT PERSISTENCE STUDY APPROACH

The study approach for the persistence savings from the HER program relies on statistical analysis appropriate for a RCT. Navigant's approach is identical to the GPY3 evaluation report except that we added a model to estimate savings by month to examine monthly decay as described in Section 2.1.2. In this section, Navigant presents the study approach for the following:

1. **Validation of Randomization** identifies the approach used to confirm the program was implemented as a RCT,
2. **Statistical Models used in the Impact Findings** identifies the model specifications used to estimate persistence impacts,
3. **Accounting for Uplift** identifies the method used to estimate savings that may be double-counted due to increased participation in other energy efficiency programs as a result of the HER program,
4. **Estimating Decay** explains how Navigant estimated the annual savings decay rate and the associated program effective useful life, and
5. **Data** describes the data used in the study. This section walks through the data we received from Nicor Gas, the verified number of participants and controls, and how we created the cleaned sample from these verified customers that is used in the impact analysis described in Section 2.1.2.

2.1.1 Validation of Randomization

The HER program was implemented by the program implementer, Opower, as a RCT. The study group for the HER program was selected from Nicor Gas's residential customer base by Opower using their proprietary algorithm to determine customers with the highest potential to save, the primary driver being high usage. The customers in this study group were then randomly assigned to a treatment (participant) group and a control (non-participant) group. If the allocation of the households across the treatment and control groups is truly random, the two groups should have the same distribution of energy usage for each of the 12 months before the start of the program. For this analysis Navigant compared mean energy usage for the treatment and control groups for each of the 12 months before the start of the program (September 2012 through August 2013). Navigant conducted this analysis before the start of the HER program, and the results, showing that the assignment of customers was consistent with an RCT, were delivered to Nicor Gas via memo on September 20th, 2013. For reference, this memo is provided in Section 5.1.

2.1.2 Statistical Models used in the Impact Findings

Navigant estimates persistence impacts using two approaches applied to monthly billing data: a linear fixed effects regression (LFER) analysis and a simple post-program regression (PPR) analysis with lagged controls. We run both models as a robustness check. Although the two models are structurally very different, both generate unbiased estimates of persistence savings in a RCT, and assuming the RCT is well balanced with respect to the drivers of energy use, in a single sample the models generate very similar estimates of persistence savings.

2.1.2.1 LFER model

The simplest version of an LFER model convenient for exposition is one in which average daily consumption of therms by household *k* in bill period t, denoted by ADC_{kt}, is a function of the binary

variable $Post_t$, taking a value of zero if month *t* is in the pre-treatment period, and one if in the post-treatment period and the interaction of $Post_t$ with the binary variable $Treatment_k$, taking a value of zero if household *k* is assigned to the control group, and one if assigned to the treatment group. The interaction $Post_t \cdot Treatment_k$ takes a value of one when both $Post_t$ and $Treatment_k$ equal one, and zero otherwise. Formally, the LFER model is shown in **Error! Reference source not found.**.

Equation 2-1. LFER Model

$$ADC_{kt} = a_{0k} + a_1 Post_t + a_2 Treatment_k \times Post_t + e_{kt}.$$

Three observations about this specification deserve comment. First, the coefficient α_{0k} captures all household-specific effects on energy use that do not change over time, including those that are unobservable. Examples include the square footage of a residence, the presence of a pool, and the shell characteristics. Second, α_1 captures the average effect across all households of being in the post-treatment period. Third, the effect of being both in the treatment group and in the post period –the effect directly attributable to the program—is captured by the coefficient α_2. In other words, whereas the coefficient α_1 captures the change in average daily therms use across the pre- and post-treatment for the *control* group, the sum $\alpha_1+\alpha_2$ captures this change for the treatment group, and so α_2 is the estimate of average daily therms savings due to the program from April 2015 to September 2015.

2.1.2.2 PPR Model

Whereas the LFER model controls for non-treatment differences in energy use between treatment and control customers using the customer-specific fixed effect, the PPR model controls for these differences using lagged energy use as an explanatory variable. In particular, energy use in calendar month *m* of the post-program period is framed as a function of the treatment variable, a set of monthly fixed effects, and the monthly fixed effects interacted with energy use in the same calendar month of the pre-program period. The underlying logic is that systematic differences between control and treatment customers will be reflected in differences in their past energy use, which is highly correlated with their current energy use. Formally, the model is shown in Equation 2-2.

Equation 2-2. PPR Model

$$ADC_{kt} = \sum_j \beta_{1j} Month_{jt} + \sum_j \beta_{2j} Month_{jt} \cdot ADClag_{kt} + \beta_3 Treatment_k + \varepsilon_{kt}$$

In this specification $Month_{jt}$ is a binary variable taking a value of one when $j=t$ and zero otherwise[14] and $ADClag_{kt}$ is customer *k*'s energy use in the same calendar month of the pre-program year as the calendar month of month *t*. In this model, β_3 is the estimate of average daily therms savings due to the program from April 2015 to September 2015.

2.1.2.3 Monthly Savings Model

Navigant also estimated persistence savings by month using a variation on the PPR model. In this variant, the treatment indicator is interacted with the monthly dummies to get an estimate of savings in each month. Formally, the model is shown in **Error! Reference source not found.**.

Equation 2-3. Monthly PPR Model

$$ADC_{kt} = \sum_j \beta_{1j} Month_{jt} + \sum_j \beta_{2j} Month_{jt} \cdot ADClag_{kt} + \sum_j \beta_{3j} Month_{jt} \cdot Treatment_k + \varepsilon_{kt}$$

[14] In other words, if there are *T* post-program months, there are *T* monthly dummy variables in the model, with the dummy variable $Month_{tt}$ the only one to take a value of 1 at time t. Simply put, these are monthly fixed effects.

All variables are as defined above. The set of β_{3j} coefficients give the estimate of average daily therms savings due to the program in each month *j*.

2.1.3 Accounting for Uplift

The HERs include energy saving tips, some of which encourage participants to enroll in other Nicor Gas energy efficiency programs. Uplift occurs when the HER program causes participants to enroll in other energy efficiency (EE) programs at a higher rate than they otherwise would have. If participation rates in other EE programs are the same for HER participants and controls, the savings estimates from the regression analysis are not attributable to other programs and there is no uplift, as this indicates the HER program had no effect on participation in the other EE programs. However, uplift occurs if the HER program affects participation rates in other energy efficiency programs, then savings across all programs are lower than indicated by the simple summation of savings in the HER and EE programs. For instance, if the HER program increases participation in other EE programs, the increase in savings may be allocated to either the HER program or the EE program, but cannot be allocated to both programs simultaneously.

Navigant was again unable to consider double-counted savings due to uplift in this draft because other energy efficiency program tracking data was unavailable.[15] Therefore this report compares savings before the uplift adjustment in order to calculate savings decay.

2.1.4 Estimating Decay

Navigant combined the savings estimates from Part 1 and 2 of the persistence study to estimate the annual saving decay rate for the first year after reports were discontinued, which covers the period from October 2014 – September 2015. The decay rate is equal to one minus the ratio of the percentage savings in the first year after the reports were discontinued to percentage savings in the last year before the reports were discontinued. Equation 2-4 shows this calculation where δ is the decay rate.

Equation 2-4. Decay Rate

$$\delta = 1 - \frac{\%\ Savings\ in\ first\ year\ after\ reports\ stop}{\%\ Savings\ in\ last\ year\ reports\ are\ sent}.$$

The decay rate can be used to measure the lifetime savings. Assuming a constant decay rate of δ and annual attrition due to residence changes of α, the lifetime savings are calculated via an infinite series which converges to **Error! Reference source not found.**.[16,17] This estimate of lifetime savings may be conservative if attrition due to residence changes is overestimated, which might occur if customers changing residences remain within the Nicor service territory and still generate savings even after they move to a new residence and no longer receive the home energy reports.

Equation 2-5. Lifetime Savings Convergence

$$\begin{aligned} Lifetime\ Savings &= First\ Year\ of\ Program\ Savings \\ &+ \sum_{t=2}^{\infty} First\ Year\ of\ Program\ Savings * (1-\delta)^{t-1} * (1-\alpha)^{t-1} \\ &= \frac{First\ Year\ of\ Program\ Savings}{\delta + \alpha - (\delta * \alpha)} \end{aligned}$$

[15] In GPY3 Navigant found that savings from uplift were 3.6% of total program savings.

[16] The convergence assumes that savings decay infinitely at a constant annual rate of *(1-δ)(1-α)*.

[17] The Cadmus Group, Inc. 2014. "Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs." Prepared by M. Sami Khawaja, PhD. And James Stewart, PhD.

Where the final year of program savings are the savings from the last year that the program was run. In this case the final year of program savings are the estimated savings from the GPY3 evaluation report. The lifetime savings is then used to estimate the effective useful life of the HER program in first year equivalents contingent on having received reports for one year, as shown in Equation 2-6.

Equation 2-6. Effective Useful Life

$$HER\ Effective\ Useful\ Life = \frac{Lifetime\ Savings}{First\ Year\ of\ Program\ Savings}.$$

2.1.5 Data

For the GPY3 study, Navigant received program tracking data from Opower, the program implementer, and monthly billing data from Nicor Gas, covering the period of September 2012 to September 2014. In particular, Navigant received data for 351,845 participants and 30,000 controls. For the persistence study, Navigant received additional monthly billing data on the same participants and controls for the period of October 2014 to September 2015. Some Nicor Gas customers have their meters read every other month, with estimated reads between meter readings. For this reason, Navigant combined the estimated read with the following actual read to create an extended bill that represents actual usage for the impact analysis. This means that the average bill length for some customers is 60 days and about half of the customers have a bill ending in any given month.

To find the number of verified participants and controls, Navigant removed the following customers from the data received:

- Customers marked for exclusion by the program implementer[18]
- Customers with no first report generation date
- Customers with no bills in the analysis period[19]

This results in 290,512 verified participants and 24,611 verified controls.

To create a cleaned sample for the impact analysis, Navigant removed the following customers and data points from the analysis:

- Customers with a delayed first report generation date[20]
- Observations of bi-monthly bills with less than 50 or more than 70 days in the billing cycle
- Observations of monthly bills with less than 20 or more than 40 days in the billing cycle
- Observations missing billing usage data
- Observations outside the twelve month pre-program period or the study period
- Outliers, defined as observations with average daily consumption more than one order of magnitude above the median usage in the heating season[21]

[18] The program implementer marks for exclusion any "VIP" treatment customers who receive the reports for any reason other than random assignment, for example utility executives who request reports to get the "report experience".

[19] Customers with no bills in the analysis period had presumably changed residences.

[20] Just under 99% of participants receive their first report on or before October 9th, 2013. After that customers' first reports are delayed from a few weeks up to several months.

[21] The median usage from September through April was 4.843 therms per day. Observations with usage values greater than 48.43 therms per day were excluded from the analysis.

- For the PPR model, observations in the study period which did not have a corresponding value for the *ADClag* variable, described in Section 2.1.2.2.

This results in a cleaned sample for the impact analysis containing 287,718 treatment and 24,393 controls; all together the cleaned sample includes 99% of the verified participants and controls. The cleaned sample includes participants who opt-out and customers whose accounts become inactive up until the point of inactivation (meaning that if a customer's account closed in June, their billing data are included up until June). Including these two groups of participants in the analysis is in line with behavior-based program evaluation protocol. For opt-outs, the State and Local Energy Efficiency Action Network report explains that, "if the households that opt out are excluded from the treatment group…then the results will suffer from selection bias: the households in the control group are no longer the same types of households as those in the treatment group."[22] For accounts that become inactive, "it is unlikely that households move or close their accounts because of an efficiency program; thus, we can safely assume that account closures are random and occur at the same rate for both the control and treatment group."[23] We include customers whose accounts go inactive up until the inactive date to ensure that the results are not biased if certain types of customers are more likely to move than others (for example, if the younger population is more mobile).

The service territory for Nicor Gas overlaps with the Commonwealth Edison (ComEd) electric service territory. ComEd also runs a HER program for their electric customers. The service territory overlap means that some customers in the Nicor Gas HER program control and treatment groups receive electric HERs from ComEd, and vice versa. It is possible that the ComEd electric HERs create cross-fuel effects that lower gas usage for those who receive them. However, this does not affect the estimate of the effect of the gas HER program conditional on the state of the world, which happens to include the electric program. This is because, due to random assignment, the treatment group in the gas program is exposed to the electric program at the same rate as the control group for the gas program. Given that our study objective is to estimate gas savings due to the Nicor Gas HER program, we do not need to remove customers receiving ComEd electric HERs, because the "all else equal" condition imposed by the RCT includes the fact that gas treatment and control customers are being exposed at equal rates to the electric treatment (and attendant spillovers to gas consumption) run by ComEd. Navigant verified this assumption in the GPY3 report by matching Nicor Gas and ComEd customers by name and address; we found that 8.7% of the Nicor Gas treatment group and 8.5% of the control group receives an electric HER from ComEd. Nicor Gas and ComEd are currently considering a study that would estimate cross-fuel savings across their two programs

A summary of the data and data sources used in the study are provided in Table 2-1.

[22] State and Local Energy Efficiency Action Network. 2012. *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. http://behavioranalytics.lbl.gov. Page 13.

[23] Ibid. Page 30.

Table 2-1. Data Sources

Data	Source	Time Period Covered	Description
Billing Data	Nicor Gas	September 2012 – September 2015	HER program participants and controls during the pre- and post-period.
Tracking Data	Opower	September 2012 – September 2015	HER program participants and controls during the pre- and post-period.

Source: Nicor Gas billing data and Opower implementation data

3. GROSS IMPACT FINDINGS

3.1 HOME ENERGY REPORT IMPACT FINDINGS

As detailed below, the LFER and PPR models generate very similar results for persistence savings. We use PPR results for reporting total persistence savings, given that gas usage is highly seasonal. Overall verified net savings were 581,174 therms for the period of April 2015 to September 2015, prior to adjusting for savings uplift. Adding this to the 1,924,321 therms for the period of October 2014 to March 2015, gives total therm savings for the year from October 2014 to September 2015 of 2,505,494 therms.[24] Total therm savings after accounting for uplift are unavailable at this time; in GPY3 the savings due to uplift were 3.6% of total program savings.

3.1.1 Validation of Randomization

Prior to the start of the HER program, Navigant conducted a statistical analysis to determine whether the assignment of customers to the treatment and control group was statistically consistent with an RCT design. These results were delivered to Nicor Gas via memo on September 20th, 2013, see Section 5.1. The results of the analysis indicated that the differences in energy usage between the treatment and control groups in the pre-program period were not statistically significant. As a result, Navigant concluded that the HER program was implemented in a manner consistent with a RCT.

3.1.2 Savings Estimates

As discussed in Section 2.1.2, Navigant estimates persistence savings from the HER program using both the LFER and PPR models. The savings estimates are based on data from the cleaned sample described in Section 2.1.5. Table 3-1 presents these results for the April 2015 – September 2015 period. The PPR model estimates a reduction in usage of 0.43%, while the LFER model estimates 0.38%. The PPR estimate is statistically significant at the 90% confidence level, while the LFER estimate is not.

Table 3-1. Savings Estimates, April 2015 – September 2015

	HER Savings Estimates	
	LFER	PPR
Percent Savings *(Standard Error)*	0.38% *(0.34%)*	0.43% *(0.19%)*
Average Daily Therms Savings per Participant *(Standard Error)*	0.0085 *(0.007)*	0.0096 *(0.004)*

Source: Navigant analysis

[24] The one therm discrepancy in this summation is due to rounding error.

Table 3-2 shows the savings estimates from Part 1 of this persistence study.

Table 3-2. Savings Estimates, October 2014 – March 2015

	HER Savings Estimates	
	LFER	PPR
Percent Savings *(Standard Error)*	0.50% *(0.14%)*	0.41% *(0.09%)*
Average Daily Therms Savings per Participant *(Standard Error)*	0.0386 *(0.011)*	0.0320 *(0.007)*

Source: Navigant analysis

Detailed results from both models from Part 1 and Part 2 of the study are included in Section 5.2. Navigant reports savings from the PPR model; because gas usage is highly seasonal, the PPR model likely does a better job of accounting for unobserved factors that cause slight average differences in gas usage between treatment and control customers over the course of a year because it accounts for usage in the pre-program period by month rather than as a whole like the LFER model.

Navigant runs both of these models as a robustness check on our estimate and our expectation is that the two models do not give statistically different estimates of the program savings, not that the point estimates are exactly the same. The estimates in this study are not statistically different in either Part 1 or Part 2. The LFER model for Part 2 from April 2015 – September 2015 has an estimate of 0.38% with a 90% confidence interval from -0.17% to 0.94% and the PPR model has an estimate of 0.43% with a 90% confidence interval from 0.12% to 0.75%. The LFER model for Part 1 from October 2014 – March 2015 has an estimate of 0.50% with a 90% confidence interval from 0.27% to 0.73% and the PPR model has an estimate of 0.41% with a 90% confidence interval from 0.26% to 0.56%.

As we go further out from the program termination, the point estimates of these models are slightly farther apart than the PY3 estimates because these studies use less data and more variable data than the PY3 report making our estimates less precise; the estimates for April 2015 – September 2015 are less precise than the estimates for October 2014 – March 2015 which are less precise than the estimates for PY3. This effect can be seen in the relative precision of the PY3 estimates versus the estimates in this study. In PY3 the relative precision at 90% (equal to the standard error times 1.645 divided by the point estimate) was 0.23 for the LFER model and 0.15 for the PPR model. In the October 2014 – March 2015 study the relative precision was 0.46 for the LFER model and 0.36 for the PPR model. In this study the relative precision was 1.44 for the LFER model and 0.73 for the PPR model.

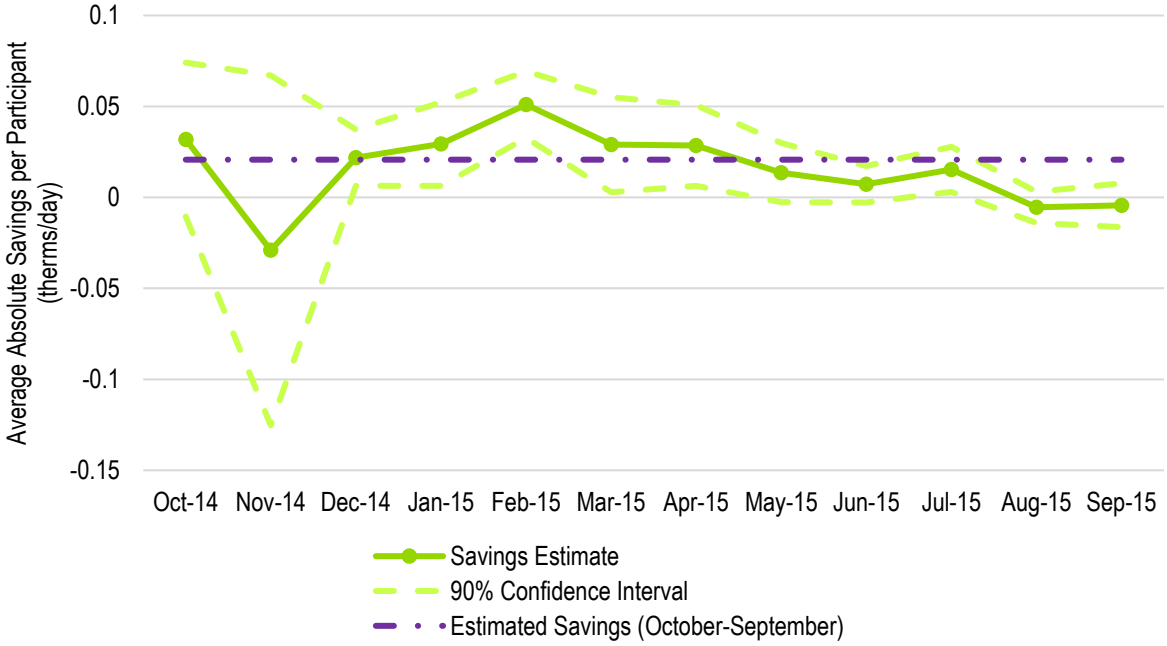
3.1.3 Monthly Savings Estimates

Navigant additionally estimated savings by month for the period from October 2014 to September 2015 in order to look at the decay in savings over time. Figure 3-1 and Figure 3-2 show the absolute and percentage savings estimates, respectively, with 90% confidence intervals. Detailed results from this model are included in Section 5.2. The savings are statistically significant at the 90% confidence level in six of the twelve months considered. The confidence intervals vary considerably due to the number of observations in each month which varies because of the bimonthly billing cycle on which Nicor Gas operates.[25] The monthly savings do not increase or decrease by a statistically significant amount throughout the time period; that is savings, especially percentage savings, remain relatively constant

[25] Specifically, November 2014 had considerably fewer observations than the other months.

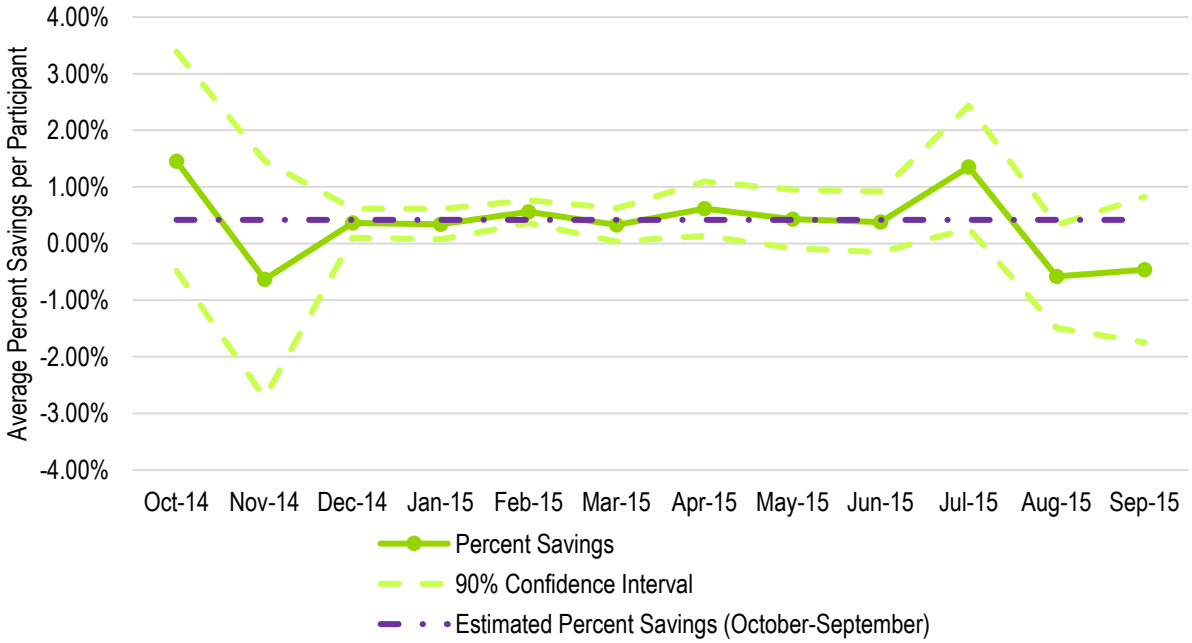
from October 2014 to September 2015. Although the absolute savings do show a slight downward trend after February 2015.

Figure 3-1. Monthly Absolute HER Persistence Savings, October 2014 – September 2015



Source: Navigant analysis

Figure 3-2. Monthly Percentage HER Persistence Savings, October 2014 – September 2015



Source: Navigant analysis

3.1.4 Verified Net Persistence Impact Results

Table 3-3 presents verified net therms savings in Part 1 and Part 2 of this study and the annual savings for the full first year after the initial program year. The annual percentage and average daily savings are weighted averages of Parts 1 and 2 of the study, while the total savings is the sum of Parts 1 and 2.[26] These savings are before the uplift adjustment.

Table 3-3. HER Net Persistence Savings

Type of Statistic	Part 1 October 2014 – March 2015	Part 2 April 2015 – September 2015	Annual October 2014 – September 2015
Number of Verified Participants	341,308	290,512	-
Sample Size, Treatment	316,185	287,718	-
Sample Size, Control	26,884	24,393	-
Percent Savings	0.41%	0.43%	0.42%
Average Daily Savings per Participant, Therms	0.032	0.010	0.021
Total Verified Net Savings, Before Uplift Adjustment, Therms*	1,924,321	509,559	2,433,879

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis

* Total savings are pro-rated for participants that close their accounts during the study period.

3.1.5 Estimating Decay

Error! Reference source not found. presents the annual decay rate, the lifetime savings, and the effective useful life for the HER program. These savings are before the uplift adjustment.[27]

Table 3-4. HER Decay Estimations

Type of Statistic	Annual October 2014 – September 2015
Annual Decay Rate	46%
Annual Persistence Factor*	54%
Lifetime Savings, Therms	8,861,472
HER Effective Useful Life	2.08 years

Source: Nicor Gas billing data, Opower implementation data, and Navigant analysis

*The persistence factor is equal to one minus the decay rate.

[26] Total verified net savings in each part of this study are calculated using the number of verified participants in each evaluation period. Total savings are calculated as (verified participants)*(savings per day)*(days as an active customer in the evaluation period). For example, if all customers had been active for the entire post period for Part 1 this calculation would work out to be 341,308*0.032*182=1,987,778. The difference between our estimated savings and this number is due to people moving out partway through the evaluation period.

[27] These estimates assume an annual attrition rate due to residence changes of 3.17% which was calculated based on the attrition during the year for which the HER program ran.

These results suggest that the average annual decay rate for the Nicor Gas HER program is 46%, meaning that the persistence factor[28] after one year is 54%. Based on this decay rate, the effective useful life for this HER program is two years. This means that if reports are sent for one year (meaning one heating season), treatment customers will achieve lifetime savings that are approximately double those achieved in the initial year.

[28] The persistence factor is defined as one minus the decay rate, 1-δ.

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4. FINDINGS AND RECOMMENDATIONS

This section summarizes the key impact findings and recommendations.

Finding 1. The utility-specific annual decay rate for the Nicor Gas HER program is 46% one year after the initial program year. This implies a persistence factor of 54% for the first year after the initial program year, meaning that 54% of the program savings persist after one year.

Finding 2. The estimated effective useful life of the Nicor Gas HER program in first year equivalents is two years. This means that if reports are sent for one year (meaning one heating season), treatment customers will achieve lifetime savings that are approximately two times those achieved in the initial year.

Recommendation 1. The decay rate of 46% should be considered in determining persistence factors and measure life for the Illinois Technical Reference Manual (IL TRM).[29] This study represents one data point in a broader literature, and any values created for the IL TRM should also take the broader literature into account. Combining the results of this research and the GPY3 evaluation shows that lifetime savings from the GPY3 program were almost nine million therms or a bit more than double the therm savings achieved in GPY3.

Recommendation 2. Nicor Gas should continue this study for another year and look at savings in the second year after the initial program year, from October 2015 to September 2016. The continued study would estimate the decay rate in the second year after reports are stopped. This would add to research on whether decay rates remain constant, increase, or decrease in the second year after the initial program year and the results could be used to inform second year persistence factors in the IL TRM.

Recommendation 3. The absolute therm savings in this study are not weather normalized, however, the decay and persistence factors are weather normalized (at least in part), since they are calculated from percentage savings rather than absolute savings.

There has been discussion around the idea that absolute savings should also be weather normalized to accurately compare savings across different years and to accurately calculate savings using the IL TRM algorithms since the algorithms apply persistence factors to absolute savings. However, the question of how to most accurately weather normalize has not been resolved, and we recommend that this be a topic of discussion among interested stakeholders when updating the relevant measure in the IL TRM.

[29] The relevant measure is "Adjustments to Behavior Savings to Account for Persistence" which is measure 6.1.1 in Volume 4 of Version 5 of the IL TRM. < http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_5/Final/IL-TRM_Effective_060116_v5.0_Vol_4_X-Cutting_Measures_and_Attach._021116_Final.pdf>

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5. APPENDIX

5.1 RCT MEMO

The following is a copy of the memo Navigant provided to Nicor Gas in September 2013 with the results of the RCT consistency check.

To: **Steve Grzenia; Nicor**
Gina Valo; Opower

From: **Bethany Glinsmann; Navigant**

Date: **September 20, 2013**

Re: **Validation of Control Group for Nicor Gas HER Program**

This memorandum addresses Navigant's validation of the random allocation of households to the treatment and control groups for the Nicor Gas Home Energy Report (HER) program.

Methodology

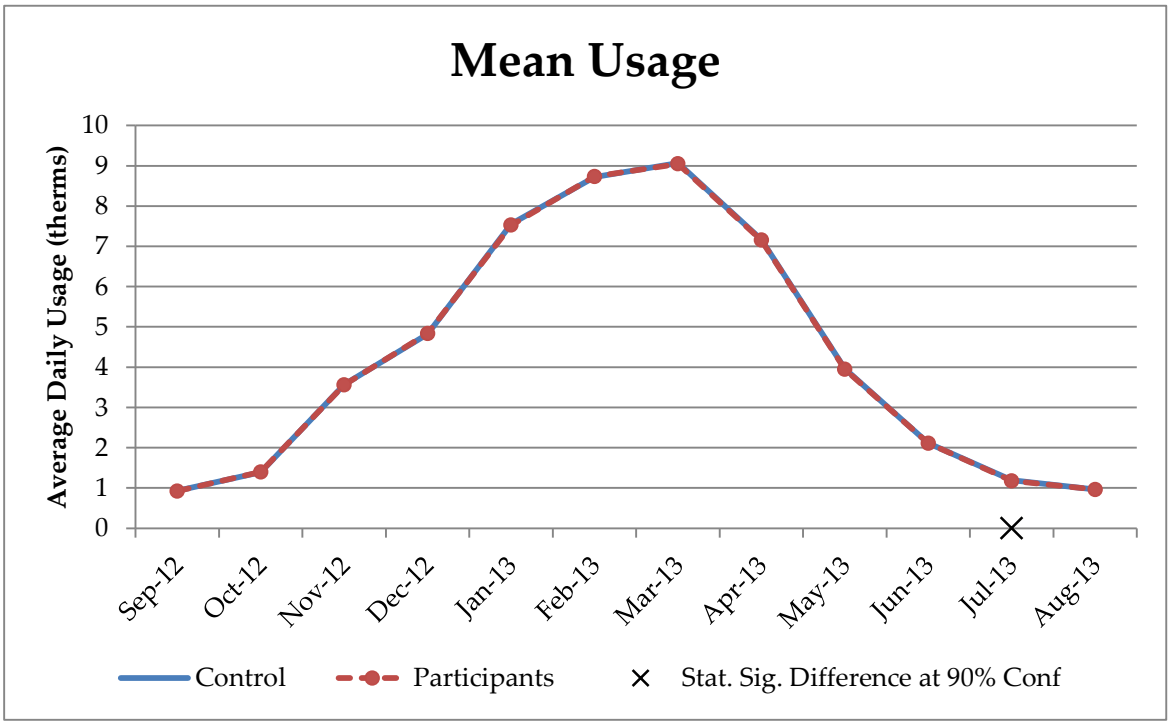
The HER program consists of 351,843 participants and 30,000 control households designated by the program implementer, Opower. Navigant compared the monthly energy usage of the treatment and control groups during the 12 month period prior to the start of the program (September 2012 through August 2013). If the allocation of the households across the treatment and control groups is truly random, the two groups should have the same distribution of energy usage for each of the 12 months before the start of the program. For this analysis, Navigant compared the mean usage for the two groups for each of the 12 months before the start of the program.

Note that Nicor Gas has bi-monthly meter readings. For this analysis Navigant combined estimated reads with the following actual read, creating a long bill with actual usage. Approximately half of the treatment customers and half of the control customers have a bill that ends in any given month.

Results

The results of the analysis validate that program households were randomly allocated across the treatment and control groups. Figure 5-1 below depicts the average energy usage for treatment and control households for the 12 months prior to the start of the HER program. The blue line indicates the average energy usage for the control group and the red dashed line indicates the average energy usage for the treatment group. The two lines are essentially identical, indicating no difference in average usage patterns for the treatment and control groups. Navigant conducted a statistical test on the difference in the mean energy usage for the two groups in each of the twelve months. In general Navigant found the difference to be statistically insignificant at the 90% confidence level, with the exception of one month.[30] The difference was statistically significantly at the 90% confidence level for July 2013. All differences were less than 0.03 therms in magnitude.

Figure 5-1. Mean Energy Usage for Treatment and Control Households, by Month



Source: Navigant analysis

Conclusion

Given that the differences in average energy usage for the treatment and control groups were not statistically significant, Navigant concludes that HER program households were randomly allocated to the treatment and control groups.

[30] Note that using a 90% confidence interval we would expect on average one out of every ten months to have a statistically significant difference in average consumption, due to random chance. Here we found that one month had a statistically significant difference, but had we found that zero, two, or even three months had a statistically significant difference, we would still conclude that the treatment and control groups were determined via random assignment.

5.2 MODEL RESULTS

Error! Reference source not found. shows the detailed model output for the PPR model for October 2014 to March 2015.

Table 5-1. PPR Detailed Model Output: October 2014 – March 2015

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
treatment	-0.03196	0.006735	-4.74486	2.09E-06	***
yrmo201410	0.752567	0.05012	15.01521	5.94E-51	***
yrmo201411	0.703396	0.110692	6.354504	2.09E-10	***
yrmo201412	1.009671	0.020715	48.74195	0	***
yrmo201501	0.7202	0.023897	30.1377	2.1E-199	***
yrmo201502	0.442595	0.020163	21.95071	9.2E-107	***
yrmo201503	0.572474	0.026094	21.93858	1.2E-106	***
pre.therms:yrmo201410	0.680094	0.024836	27.38314	5.3E-165	***
pre.therms:yrmo201411	0.988298	0.028796	34.32034	6.3E-258	***
yrmo201411	0.703396	0.110692	6.354504	2.09E-10	***
yrmo201412	1.009671	0.020715	48.74195	0	***
yrmo201501	0.7202	0.023897	30.1377	2.1E-199	***
yrmo201502	0.442595	0.020163	21.95071	9.2E-107	***
yrmo201503	0.572474	0.026094	21.93858	1.2E-106	***
pre.therms:yrmo201410	0.680094	0.024836	27.38314	5.3E-165	***
pre.therms:yrmo201411	0.988298	0.028796	34.32034	6.3E-258	***
pre.therms:yrmo201412	0.998081	0.004093	243.8611	0	***
pre.therms:yrmo201501	1.028013	0.003193	321.9967	0	***
pre.therms:yrmo201502	0.978699	0.002295	426.5012	0	***
pre.therms:yrmo201503	0.934783	0.002993	312.2852	0	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.355 on 723411 degrees of freedom
Multiple R-squared: 0.9735, Adjusted R-squared: 0.9735
F-statistic: 2.044e+06 on 13 and 723411 DF, p-value: < 2.2e-16

Source: Navigant analysis

Table 5-2 shows the detailed model output for the LFER model for October 2014 to March 2015.

Table 5-2. LFER Detailed Model Output: October 2014 – March 2015

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
post	3.576963	0.01031	346.9481	0	***
post.trt	-0.03863	0.010733	-3.59881	0.00032	***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Total Sum of Squares: 39525000

Residual Sum of Squares: 30755000

R-Squared: 0.22189, Adj. R-Squared: 0.19785

F-statistic: 434517 on 2 and 3047466 DF, p-value: < 2.22e-16

Source: Navigant analysis

Error! Reference source not found. shows the detailed model output for the monthly PPR model for October 2014 to March 2015.

Table 5-3. Monthly PPR Detailed Model Output: October 2014 – March 2015

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
yrmo201410	0.752431	0.055756	13.49515	1.69E-41	***
yrmo201411	0.647023	0.121054	5.344932	9.05E-08	***
yrmo201412	1.000339	0.021579	46.35606	0	***
yrmo201501	0.71777	0.026492	27.09336	1.4E-161	***
yrmo201502	0.46015	0.021668	21.23615	4.8E-100	***
yrmo201503	0.569787	0.029195	19.51642	8.37E-85	***
treatment:yrmo201410	-0.03181	0.025727	-1.23638	0.216318	
treatment:yrmo201411	0.02907	0.058487	0.497037	0.619163	
treatment:yrmo201412	-0.02182	0.009387	-2.32507	0.020069	*
treatment:yrmo201501	-0.02933	0.013967	-2.10028	0.035704	*
treatment:yrmo201502	-0.05103	0.011107	-4.59437	4.34E-06	***
treatment:yrmo201503	-0.02905	0.015878	-1.82977	0.067285	.
yrmo201410:pre.therms	0.680094	0.024836	27.38326	5.3E-165	***
yrmo201411:pre.therms	0.988325	0.028774	34.34754	2.5E-258	***
yrmo201412:pre.therms	0.99808	0.004093	243.8643	0	***
yrmo201501:pre.therms	1.028015	0.003193	321.9918	0	***
yrmo201502:pre.therms	0.978701	0.002295	426.5013	0	***
yrmo201503:pre.therms	0.934784	0.002993	312.2881	0	***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Residual standard error: 1.355 on 723406 degrees of freedom

Multiple R-squared: 0.9735, Adjusted R-squared: 0.9735

F-statistic: 1.476e+06 on 18 and 723406 DF, p-value: < 2.2e-16

Source: Navigant analysis

Table 5-4 shows the detailed model output for the PPR model for April 2015 to September 2015.

Table 5-4. PPR Detailed Model Output: April 2015 – September 2015

	Estimate	Std. Error	t-value	Pr(>|t|)	Signif.
treatment	-0.009598	0.004255	-2.255892	0.024077	.
yrmo201504	0.5104526	0.021415	23.835787	1.5E-125	***
yrmo201505	0.4708511	0.019796	23.785007	5.2E-125	***
yrmo201506	0.4166791	0.0118506	35.160850	1.2E-270	***
yrmo201507	0.1605291	0.0110367	14.544975	6.3E-48	***
yrmo201508	0.2243528	0.0091654	24.478140	2.7E-132	***
yrmo201509	0.3272082	0.0103334	31.664831	6.2E-220	***
pre.therms:yrmo201504	0.5797928	0.0031387	184.723189	0	***
pre.therms:yrmo201505	0.7053623	0.0053413	132.057311	0	***
pre.therms:yrmo201506	0.7205351	0.0057758	124.748961	0	***
pre.therms:yrmo201507	0.8666876	0.0101158	85.676606	0	***
pre.therms:yrmo201508	0.7725700	0.0094735	81.549934	0	***
pre.therms:yrmo201509	0.6314063	0.0106505	59.284147	0	***
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					
Residual standard error: 0.9888 on 899634 degrees of freedom					
Multiple R-squared: 0.8876, Adjusted R-squared: 0.8876					
F-statistic: 5.465e+05 on 13 and 899634 DF, p-value: < 2.2e-16					

Source: Navigant analysis

Table 5-5 shows the detailed model output for the LFER model for April 2015 to September 2015.

Table 5-5. LFER Detailed Model Output: April 2015 – September 2015

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
post	-2.038371	0.007139	-285.52415	0	
post.trt	-0.008517	0.007432	-1.1461086	0.251750	***
*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*					
Total Sum of Squares: 30490000					
Residual Sum of Squares: 27748000					
R-Squared0.089934, Adj. R-Squared: 0.080026					
F-statistic: 147789 on 2 and 2991057 DF, p-value: < 2.22e-16					

Source: Navigant analysis

Table 5-6 shows the detailed model output for the monthly PPR model for April 2015 to September 2015.

Table 5-6. Monthly PPR Detailed Model Output: April 2015 – September 2015

	Estimate	Std. Error	t value	Pr(>|t|)	Signif.
yrmo201504	0.527872	0.0245189	21.529161	8.8E-103	***
yrmo201505	0.474581	0.0216131	21.958035	7.7E-107	***
yrmo201506	0.414513	0.012558	33.007204	8.9E-239	***
yrmo201507	0.165872	0.012268	13.520431	1.2E-41	***
yrmo201508	0.210464	0.009595	21.934112	1.3E-106	***
yrmo201509	0.314404	0.011941	26.329557	1.0E-152	***
treatment:yrmo201504	-0.0285119	0.013514	-2.109683	0.034885	
treatment:yrmo201505	-0.01364029	0.009914	-1.375805	0.168882	
treatment:yrmo201506	-0.00724571	0.006121	-1.183674	0.236542	*
treatment:yrmo201507	-0.01539520	0.007527	-2.045247	0.040830	*
treatment:yrmo201508	0.005484	0.005213	1.051798	0.292892	***
treatment:yrmo201509	0.004286	0.007306	0.586731	0.557384	.
yrmo201504:pre.therms	0.579794	0.003138	184.725564	0	***
yrmo201505:pre.therms	0.705361	0.005341	132.058498	0	***
yrmo201506:pre.therms	0.720534	0.005775	124.748651	0	***
yrmo201507:pre.therms	0.866688	0.010115	85.677899	0	***
yrmo201508:pre.therms	0.772558	0.009473	81.550687	0	***
yrmo201509:pre.therms	0.631411	0.010650	59.284948	0	***

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Residual standard error: 0.9888 on 899629 degrees of freedom

Multiple R-squared: 0.8876, Adjusted R-squared: 0.8876

F-statistic: 3.947e+05 on 18 and 899629 DF, p-value:< 2.2e-16

Source: Navigant analysis