NAVIGANT

Residential Education and Outreach Program Evaluation Report

Home Energy Reports Program

FINAL

Energy Efficiency Plan:
Gas Plan Year 5
(6/1/2015-5/31/2016)

Presented to
Peoples Gas and North Shore Gas

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E. EXECUTIVE SUMMARY

This report summarizes Navigant Consulting, Inc.'s (Navigant's) findings and results from the impact and process evaluation of the fifth program year (GPY5)[1] of the Peoples Gas (PGL) and North Shore Gas (NSG) Home Energy Reports (HER) programs. Initially launched in 2013[2], these programs are designed to generate energy savings by providing residential customers with information about their energy use and energy conservation suggestions and tips. Program participants receive information in the form of home energy reports that give customers various types of information, including the following:

- Assessment of how their recent energy use compares to their own energy use in the past
- Tips on how to reduce energy consumption, some of which are tailored to their own circumstances
- Information on how their energy use compares to that of neighbors with similar homes

Recipient customers receive several reports per year by mail and also have the option to log onto a dedicated program website to learn more ways to save energy and to report conservation steps they have taken. Other studies have shown that receiving reports containing this information can stimulate customers to reduce their energy use, creating average energy savings in the one percent to three percent range, depending on local energy use patterns.

An important feature of the PGL and NSG HER programs is that both are designed as randomized controlled trials (RCTs).[3] Customers in the target group of residential customers from each utility are randomly assigned to either the recipient group or the control (non-recipient) group for the purpose of estimating changes in energy use due to the program. Customers may opt *out* of the program at any time, but cannot opt *in* due to the RCT design. An implication of the RCT design is that the savings estimates are intrinsically net of free-ridership and most spillover bias. Unless otherwise noted, reported "savings" in this report refer to *net savings*.[4]

E.1 Program Savings

Table E-1 summarizes the GPY5 natural gas savings from the PGL and NSG HER Programs. In its evaluation of GPY5 PGL and NSG HER programs, Navigant verified net savings of 2,520,299 and 1,021,659 therms prior to the uplift adjustment, resulting in verified gross realization rates for the two programs of 0.98 and 1.01. The verified net therms savings for the PGL and NSG programs after uplift adjustment[5] were 2,447,961 and 992,342, respectively.

[1] GPY5 began June 1, 2015 and ended May 31, 2016.

[2] The HER programs were initially rolled out to targeted samples of 151,200 PGL customers and 91,350 NSG customers beginning in October 2013. Control groups of approximately 21,000 were also selected for each program.

[3] The program implementer, Opower, randomly allocated targeted PGL and NSG residential customers between participant and control groups. As part of its GPY3 impact evaluation, Navigant confirmed that the usage data was consistent with an RCT design.

[4] In some instances, the word "net" appears in column headings and summary sentences for added clarity.

[5] Uplift refers to the impact of the HER program on enrollment in *other* PGL and NSG EE programs. To avoid double-counting the savings from this indirect effect, Navigant subtracts the estimated uplift savings from the total HER program savings, including legacy uplift from prior years (cf. Section 6.5 for details). The fact that uplift savings is subtracted from the HER programs' total energy savings does not indicate that the uplift savings was not *caused by* the HER programs, or that the HER programs shouldn't be credited for its occurrence. It is an accounting adjustment to avoid double-counting when aggregating savings over multiple EE programs. Indeed, the existence of uplift is an indicator of successful cross-marketing by the HER programs, and thus should be seen as an added program benefit.

Table E-1. GPY5 Peoples Gas and North Shore Gas HER Program Savings

Utility	*Ex-ante* Savings[6] (Therms)	Verified Savings Prior to Uplift Adjustment (Therms)	Verified Realization Rate[7]	Total Uplift Adjustment* (Therms)	Verified Net Savings After Uplift Adjustment (Therms)
PGL	2,583,885	2,520,299	0.98	72,338	2,447,961
NSG	1,008,829	1,021,659	1.01	29,317	992,342

Source: Navigant analysis of PGL and NSG customer billing data.
* The total uplift adjustment includes both the uplift calculated for GPY5 and the legacy uplift from GPY3 and GPY4. See Section 6.5 for details.

By way of comparison, Table E-2 summarizes the GPY4 natural gas savings from the PGL and NSG HER Programs. In Navigant's evaluation of GPY4 PGL and NSG HER programs, it verified net savings of 3,318,421 and 1,094,406 therms, respectively, resulting in realization rates of 1.10 and 1.25 percent. Verified net savings after uplift adjustment was 3,280,440 and 1,108,565, respectively.

Table E-2. GPY4 Peoples Gas and North Shore Gas HER Program Savings

Utility	*Ex-ante* Savings[5] (Therms)	Verified Savings Prior to Uplift Adjustment (Therms)	Verified Realization Rate	Total Uplift Adjustment (Therms)	Verified Net Savings After Uplift Adjustment (Therms)
PGL	3,009,588	3,318,421	1.10	37,981	3,280,440
NSG	874,691	1,094,406	1.25	-14,159	1,108,565

Source: Navigant analysis of PGL and NSG customer billing data.

E.2. Program Volumetric Detail

Table E-3 presents participation details for the GPY5 PGL and NSG HER programs. The PGL program achieved an average savings rate of 1.17 percent in GPY5, while the two NSG waves[8] had average savings rates of 1.03 and 0.19 percent, respectively. In GPY4, the programs had savings rates of 1.19 percent and 0.88 percent, respectively.

Table E-3. GPY5 Peoples Gas and North Shore Gas HER Program Participation Detail

Utility	Number of Participants	Number of Controls	Average Participant Savings (therms)	Average Savings Rate	Average Savings Rate Standard Error
PGL	151,200	18,766	17.65	1.17%	0.15%
NSG (Wave 1)	91,349	18,684	11.80	1.03%	0.16%
NSG (Wave 2)	10,526	2,465	2.18	0.19%	0.46%

Source: Navigant analysis of PGL and NSG customer billing data.

[6] The term *ex-ante* refers to the forecasted savings reported by the Program Administrator that have not been independently verified through evaluation. Savings that have been independently verified by Navigant are referred to as "Verified".
[7] Verified Gross Realization Rate (RR) = Verified Gross Savings/*ex-ante* Gross Savings.
Verified Gross Savings = RR * *ex-ante* Gross Savings
[8] NSG Wave 1 started in October 2013, and NSG Wave 2 started in September 2015.

E.3 Findings and Recommendations

For PGL, the total verified energy savings for GPY5 was 2,520,299 therms prior to the uplift adjustment, and 2,447,961 after the adjustment. For NSG, the corresponding figures were 1,021,659 and 992,342 respectively. The aggregate therms saved for both programs declined compared to GPY4. However, the programs generally met expectations, with realization rates of 0.98 and 1.01, respectively. The new Wave 2 cohort for NSG had low, statistically non-significant savings due to its relatively small size and recent rollout. Navigant has no recommendations for GPY5.

Finding 1. Relative to GPY4, the aggregate HER energy savings decreased in GPY5 for both programs, particularly the PGL program (cf. Table E-1 and Table E-2). However, the average savings *rate* for the PGL HER program in GPY5 (1.17 percent) was virtually unchanged from GPY4 (when it was 1.19 percent), while the savings rate for the NSG Wave 1 participants – which represents the customers that participated in both program years – increased from 0.88 percent in GPY4 to 1.03 percent in GPY5.

Finding 2. The savings estimate for the NSG Wave 2 cohort was not statistically significant at the 90 percent level. Its point estimate (absolute savings value) provides the best indication of savings and is reported in this evaluation. The wave's lower savings rate (0.19 percent) is consistent with the experience of other HER programs during their first few months. Savings rates are generally expected to ramp up over time. The GPY6 evaluation should provide a better indication of this wave's savings rate going forward.

Finding 3. The verified savings rates of both programs were more closely aligned with *ex-ante* estimates in GPY5 than they were in GPY4. The PGL program's realization rates moved from ten percentage points above target (1.10) in GPY4 to two percentage points below target (0.98) in GPY5. For NSG, the realization rate went from 25 percentage points above target (1.25) in GPY4 to one percentage point above target (1.01) in GPY5.

1. INTRODUCTION

1.1 Program Description

This report presents a summary of the findings and results from the impact and process evaluation of the GPY5 Peoples Gas (PGL) and North Shore Gas (NSG) Home Energy Reports (HER) programs. These programs are designed to generate energy savings by providing residential customers with information about their energy use and energy conservation suggestions and tips. Program participants receive information in the form of home energy reports that give customers various types of information, including the following:

- Assessment of how their recent energy use compares to their own energy use in the past
- Tips on how to reduce energy consumption, some of which are tailored to their own circumstances
- Information on how their energy use compares to that of neighbors with similar homes

In GPY5, recipient customers received five reports by mail. They were also invited to log onto a dedicated program website that offers suggestions of additional opportunities to save energy, and allows participants to fine-tune their profiles and report conservation steps that they have taken. Other studies have shown that receiving reports containing this type of information can stimulate customers to reduce their energy use, creating average energy savings in the one percent to three percent range, depending on local energy use patterns.

An important feature of the PGL and NSG HER programs is that both are designed as randomized controlled trials (RCTs). Customers in the target group of residential customers from each utility were randomly assigned to either the recipient group or the control (non-recipient) group for the purpose of estimating changes in energy use due to the program. This approach makes the process of verifying energy savings much simpler and more robust: among other things it effectively eliminates free-ridership bias and thus the need for net-to-gross research. Customers may opt *out* of the program at any time, but they cannot opt *in* due to the RCT design.

For the GPY5 evaluation, the PGL HER program had 151,200 participants and 20,999 controls. For NSG Wave 1, these figures were 91,349 and 21,000, respectively. The newly introduced NSG Wave 2 had 10,526 participants and 2,465 controls (see Table 1-1).

Table 1-1. Synopsis of PGL and NSG Programs

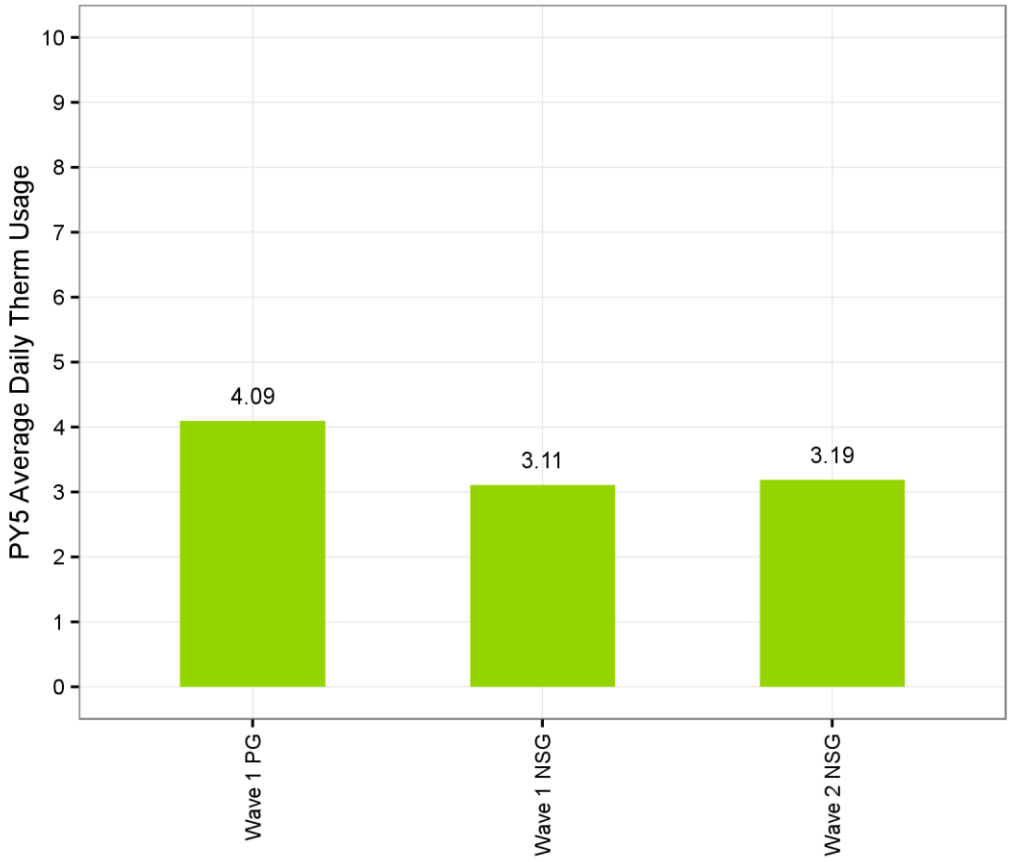
Utility/Wave	Month of First Report	Month of Last GPY5 Report	Number of Participants	Number of Controls	Average Daily Usage in Post Period (Therms)
PGL	October 2013	May 2016	151,200	20,999	4.09
NSG (W1)	October 2013	May 2016	91,349	21,000	3.11
NSG (W2)	September 2015	May 2016	10,526	2,465	3.19

Source: Navigant analysis of PGL and NSG customer billing data.

In its GPY3 evaluation report, Navigant confirmed the RCT design of both programs by comparing the distributions of monthly energy usage of each treatment group-control group pair and verifying that they

were consistent with randomized allocation.[9] Navigant performed a similar exercise for the second NSG wave, which is detailed in the Appendix. Figure 1-1 provides a graphical depiction of average daily usage levels by wave.

Figure 1-1. GPY5 Average Daily Usage by Wave



Source: Navigant analysis of PGL and NSG customer billing data.

1.2 Evaluation Objectives

The primary objective of this report is to determine the extent to which the HER program caused PGL and NSG participants to reduce their energy consumption in GPY5, and to assess how program savings changed from the previous program year. A secondary objective is identifying uplift in other PGL and NSG energy efficiency (EE) programs due to the Opower programs to avoid double-counting energy savings. The only process research Navigant pursued for either program in GPY5 consisted of interviewing the program managers, which limits the evaluation's ability to address questions such as why realization and savings rates differed between PGL and NSG programs.

[9] See PGL-NSG Home Energy Reports GPY3 Evaluation Report,

2. EVALUATION APPROACH

The evaluation approach used to produce the results presented in this report is consistent with that of the evaluation in the previous program year, and with evaluations of similar programs in other utilities' territories, relying on statistical analysis appropriate for measuring the impacts of RCTs.

2.1 Overview of Data Collection Activities

Navigant received tracking and monthly billing data for all program participants and control customers for the June 2015 to May 2016 period from the program implementer, as shown in Table 2-1.

Table 2-1. Primary Data Collection Activities

Collection Method	Subject Data	Quantity	Net Impact	Process
Customer Billing Data	Program Participants and Controls	All	X	N/A
Program Tracking Data	Program Participants and Controls	All	X	N/A
Tracking Data for Other Programs	Participants in Other Programs	All	X	N/A

Source: Navigant analysis.

For purposes of estimating the GPY5 program impacts, Navigant also used pre-program billing data. For the PGL wave and NSG Wave 1, this period included November 2012 through October 2013. For NSG Wave 2, the pre-program period was September 2014 through August 2015.

2.2 Sampling Plan

The PGL and NSG HER programs were implemented by the program implementer as an RCT, in which individual customers from each utility's target customer group were randomly assigned to either a treatment (participant) or control group for the purpose of measuring program energy savings. Data for all participants and controls are included in the impact evaluation.

2.3 Data Used in Impact Analysis

In preparation for the impact evaluation, Navigant combined and cleaned the data provided by the implementer. The dataset included 292,990 customers: 253,075 participants and 39,915 controls. Navigant performed the following data cleaning steps:

- Exclude data from outside of the period of examination (June 2015 to May 2016);
- Remove customers with more than 14 or fewer than 10 bills[10];
- In instances where there are two bills for the same month, average the usage;
- Exclude bills with negative usage;
- Exclude observations where number of days in bill period is > 40 or < 20;
- Exclude outlier observations, defined as observations with average daily usage greater than one order of magnitude from the median usage.[11]

Detailed accounts of the customers and observations removed by wave are included in Section 6.1 of the appendix.

[10] For the NSG Wave 2, these figures were 12 and 7.

[11] Median average daily usage was 3.308 therms for PGL and 2.257 therms for NSG Wave 1 and 2.1 for NSG Wave 2. Navigant removed observations with usage greater than 10 times the median therms per day for each utility wave.

2.4 Statistical Models Used in the Impact Evaluation

Navigant estimated program impacts using two approaches: a simple post-program regression (PPR) analysis with lagged individual controls and a linear fixed-effects regression (LFER) analysis, both applied to monthly billing data. Both approaches should, in principal, produce unbiased estimates of program savings under a wide range of conditions, but Navigant prefers the PPR results for two reasons. First, savings estimates produced by the PPR model tend to be more accurate and more precisely estimated than those from the LFER model[12] based on past experience analyzing similar HER programs' impacts and recent findings from the academic literature.[13] Second, the implementer also uses a post-only model for their evaluation. Although the two models are structurally very different, they should generate similar program savings estimates, assuming the RCT is well balanced with respect to the drivers of energy use. Navigant used the PPR results for reporting total program savings for GPY5, while the LFER provided a robustness check.

The LFER model combines cross-sectional and time-series data in a single panel dataset. The regression essentially compares pre- and post-program billing data for participants and controls to identify the effect of the program on usage. The customer-specific fixed effect is a key feature of the LFER analysis and captures all customer-specific factors affecting natural gas usage that do not change over time, including those that are unobservable. Examples of the latter include the construction and square footage of the premise, the number of occupants, the amount of seasonal sun exposure, and the thermostat settings. The fixed effect represents an attempt to control for any small, systematic differences between the treatment and control customers that might occur due to chance.

Like the LFER model, the PPR model also combines cross-sectional and time-series data in a panel dataset. Unlike the LFER model, however, it uses only the post-program data for estimation and includes the customer's lagged energy usage for the same calendar month of the pre-program period to serve as the control for any small, systematic differences between the treatment and control customers, in that sense serving the same purpose as the customer fixed effect included in the LFER model. Section 6.3 of the Appendix presents the details of the PPR and LFER models used in the analysis.

2.5 Accounting for Uplift in Other Energy Efficiency Programs

The home energy reports sent to participating households included energy-saving tips, some of which encouraged participants to enroll in other PGL-NSG EE programs. If participation rates in other EE programs were the same for HER participant and control groups, the savings estimates from the regression analysis are already "net" of savings from the other programs, as this indicates the HER Program had no net effect on participation in the other EE programs. However, if the receipt of HERs increased participation rates of recipients relative to controls in other EE programs, then the combined savings across all programs would be lower than indicated by the simple summation of savings in the HER and the other EE programs. For instance, if the HER Program increases participation in another EE program, the resulting increase ("uplift") in savings may be allocated to either the HER Program or the EE program, but cannot be allocated to both programs simultaneously.[14]

[12] One likely reason for this is that the PPR model embodies more flexibility than the LFER model, in that the former allows the individual customer control variable to vary seasonally while the latter does not – a particularly attractive feature given the highly seasonal nature of natural gas usage. The LFER model treats all unobserved inter-household heterogeneity affecting households' energy usage as time-invariant, while the PPR model uses lagged individual controls that can vary over time. This is discussed in more detail in section 6.2.1 of the Appendix.

[13] Allcott, Hunt and Todd Rogers, 2014. "The Short-Run and Long-Run Effects of Behavioral Intervention: Experimental Evidence from Energy Conservation. *American Economic Review*, 104(10): 3003-37.

[14] It is not possible to avoid double-counting of the savings generated by programs for which tracking data are not available, such as upstream lighting programs.

As data permitted, Navigant used a difference-in-difference (DID) statistic to estimate uplift in other EE programs. To calculate the DID statistic, Navigant subtracted the change in the participation rate in another EE program between GPY5 and the pre-program period for the control group from the same change for the treatment group. For instance, if the rate of participation in an EE program during GPY5 is five percent for the treatment group and three percent for the control group, and the rate of participation during the year before the start of the HER Program is two percent for the treatment group and one percent for the control group, then the rate of uplift due to the HER Program is one percent, as reflected the following calculation:

(GPY5 treatment group participation – pre-PY treatment group participation) – (GPY5 control group participation – pre-PY control group participation) = DID statistic

(5% – 2%) – (3% – 1%) = 1%

The DID statistic generates an unbiased estimate of uplift when the baseline average rate of participation is the same for the treatment and control groups, or when they are different due only to differences between the two groups in time-invariant factors, such as the square footage of the residence.

An alternative statistic that generates an unbiased estimate of uplift when the baseline average rate of participation in the EE program is the same for the treatment and control groups is a simple difference in participation rates during GPY5. Navigant uses this alternative statistic –the "post-only difference" (POD) statistic –in cases where the EE program did not exist for the entire pre-program year.

Navigant examined the uplift associated with three other PGL-NSG EE programs: Home Energy Jumpstart, Home Energy Rebate, and Multifamily Energy Savings. For each EE program, uplift savings were calculated separately for each utility. In addition, legacy uplift (uplift from GPY4 and GPY3) was also calculated. These calculations are described in greater detail in Section 6.5.

2.6 Process Evaluation

Navigant's GPY5 PGL and NSG HER process evaluations were limited to interviews with the program implementer to update our information about the program, including plans for an additional wave of participants in GPY5. No participant surveys or interviews were pursued.

3. GROSS IMPACT EVALUATION

Total program savings are summarized in Table 3-1 below. The reported savings from the implementation contractor was 2,583,885 therms for PGL and 1,008,829 therms for NSG. Verified savings, prior to uplift, was 2,520,299 therms for PGL and 1,021,658 therms for NSG. PGL caused 38,661 therms of uplift savings in other EE programs while NSG caused 12,001 therms of uplift, resulting in final GPY5 verified savings of 2,481,638 therms for PGL and 1,009,658 for NSG. PGL had a gross realization rate of 0.98, and NSG's gross realization rate was 1.01. The uplift adjustment resulted in a one percent decrease in the net savings for NSG, and two percent decrease for PGL which the implementer did not accounted for in their savings estimate. The remaining difference in the realization rate for PGL was likely due to small differences in the regression models used by Navigant and the implementer.

Table 3-1. GPY5 PGL and NSG HER Program Gas Savings

Savings Category	PGL Savings (therms)	NSG Savings (therms)
Implementer Estimated Savings*	2,583,885	1,008,829
Verified Savings Prior to Uplift Adjustment	2,520,299	1,021,659
Verified Net Savings after Uplift Adjustment	2,447,961	992,342
Verified Gross Realization Rate†	0.98	1.01

Source: Navigant analysis of NSG program tracking and customer billing data.

* This estimate comes from the implementation contractor's ex-post analysis of the program.

† Calculated as the ratio of verified savings prior to uplift adjustment to implementer estimated savings.

3.1 PPR and LFER Model Parameter Estimates

The PPR and LFER models generated very similar results for program savings estimates. Navigant used the PPR results for reporting GPY5 total program savings. Across the two models, the parameter estimates are not statistically different; that is, the estimates for each model are within the 90 percent confidence bounds for the other model. Furthermore, the pattern across the different program waves between the two models is very similar. Section 6 includes detailed estimate information for each wave and model.

3.2 Uplift Analysis Results

The PPR estimates of program savings include savings that resulted from the uplift in participation in other EE programs caused by the HER programs. To avoid double-counting, program savings due to this uplift must be counted towards either the HER Program or the other EE programs, but not both programs. Legacy uplift captures energy savings from previous program years for measures that have multi-year measure lives. GPY5 uplift captures savings from other EE programs that occurred in GPY5, while legacy uplift reflects uplift remaining from prior program years (GPY3 and GPY4). For PGL, the GPY5 uplift was 38,661 therms and legacy uplift was 33,677. For NSG, these figures were 12,001 and 17,316 respectively. Table 3-2 shows how the uplift adjustment affects total savings.

Table 3-2. GPY5 PGL and NSG Uplift Results

	PGL Savings (therms)	NSG Savings (therms)
Verified Net Savings, Prior to Uplift Adjustment	2,520,299	1,021,659
GPY5 Uplift Adjustment	38,661	12,001
Legacy Uplift Adjustment	33,677	17,316
Final Verified Net Savings	2,447,961	992,342

Source: Navigant analysis of NSG program tracking and customer billing data.

Section 6.5 in the appendix presents the detailed calculations of GPY5 and legacy uplift for each of the three EE programs considered in the analysis: the HEJ, HER (Home Energy Rebate), and MF programs.

3.3 Verified Program Impact Results

Table 3-3 summarizes estimated program savings by participant wave, including GPY5 and legacy uplift adjustments. The table also included the number of participants, controls, and average savings rates. Both Verified savings prior to uplift and average savings rates include standard error figures. After adjusting for uplift, verified savings were 2,447,961 therms for PGL, 998,495 therms for NSG Wave 1 and 10,583 therms for NSG Wave 2.[15]

Table 3-3. PGL and NSG GPY5 HER Program Savings

Savings Category	PGL	NSG W1	NSG W2
Number of Participants	151,200	91,349	10,526
Number of Controls	20,999	21,000	2,465
Verified Savings Prior to Uplift Adjustment, therms	2,520,299	1,004,922	16,736
(Standard Error)	*(331,337)*	*(157,805)*	*(41,026)*
Average Savings Rate	1.17%	1.03%	0.19%
(Standard Error)	*(0.15%)*	*(0.16%)*	*(0.46%)*
GPY5 Uplift Adjustment, therms	38,661	5,848	6,153
Legacy Uplift, therms	33,677	17,316	-
Total Uplift Adjustment, therms	72,338	23,164	6,153
Verified Net Savings After Uplift Adjustment, therms	2,447,961	981,759	10,583

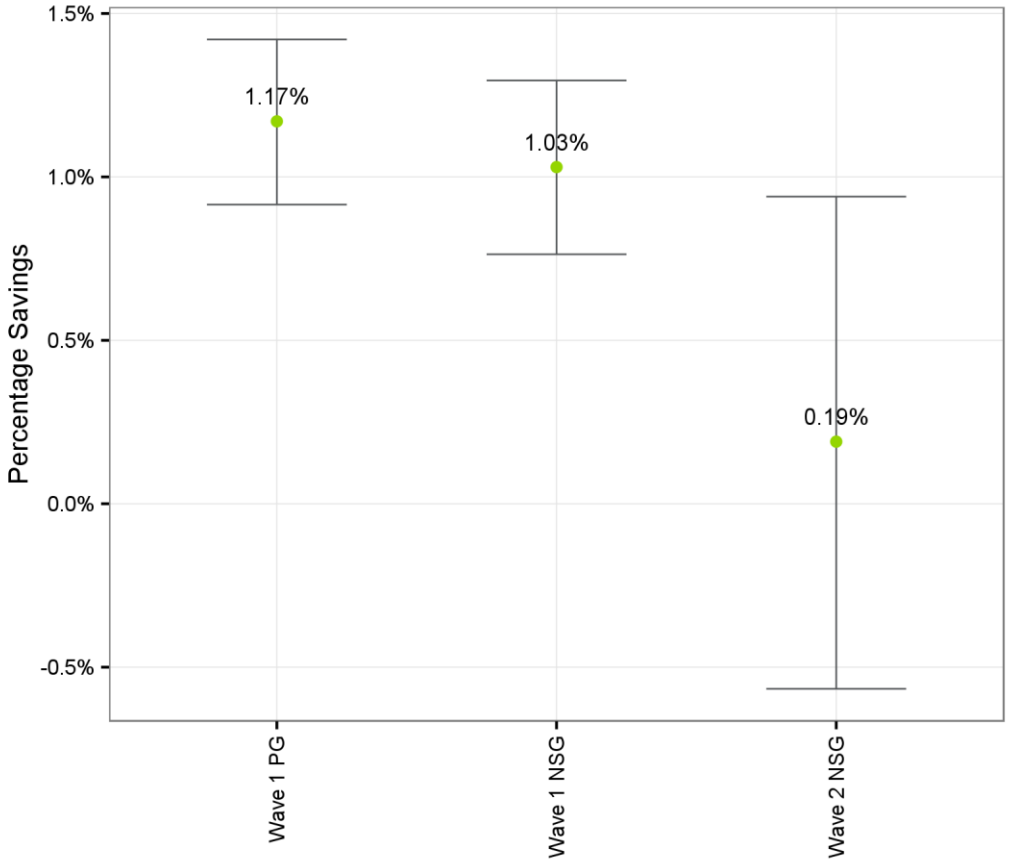
Source: Navigant analysis of NSG program tracking and customer billing data.

Figure 3-1 shows energy savings for each wave with 90 percent confidence intervals. The low savings rate and wide confidence interval for NSG Wave 2 savings likely result from the cohort being relatively

[15] The savings estimate for NSG Wave 2 was not statistically significant at the 90 percent level. However, its point estimate provides the best indication of savings, and is reported here.

small and having only a relatively short period of exposure to the program since it was rolled out late in the program year. Because the confidence interval crosses the zero percent savings border, it cannot be considered statistically meaningful on its own.

Figure 3-1. GPY5 Percent Savings and 90 Percent Confidence Interval, by Wave



Source: Navigant analysis of NSG customer billing data.

4. NET IMPACT EVALUATION

A key feature of the RCT design of the HER program is that the analysis inherently estimates net savings because there are no participants who would have received the individualized reports in the absence of the program. While some customers receiving reports may have taken energy-conserving actions or purchased high-efficiency equipment anyway, the random selection of program participants (as opposed to voluntary participation) implies that the control group of customers not receiving reports would be expected to exhibit the same degree of energy-conserving behavior and purchases. Therefore, this method estimates net savings and no further NTG adjustment is necessary.

5. FINDINGS AND RECOMMENDATIONS

For PGL, the total verified savings for the HER program in GPY5 was 2,520,299 therms prior to the uplift adjustment, and 2,447,961 therms after the adjustment. For NSG, the corresponding figures were 1,021,659 therms and 992,342 therms, respectively. The aggregate therms saved for both programs declined compared to GPY4. However, the programs generally met expectations, with realization rates of 0.98 and 1.01, respectively. The new Wave 2 cohort for NSG had low, statistically non-significant savings due to its relatively small size and recent rollout. Navigant has no recommendations for GPY5.

Finding 1. Relative to GPY4, the aggregate HER energy savings decreased in GPY5 for both programs, particularly the PGL program (cf. Table E-1 and Table E-2). However, the average savings *rate* for the PGL HER program in GPY5 (1.17 percent) was virtually unchanged from GPY4 (when it was 1.19 percent), while the savings rate for the NSG Wave 1 participants – which represents the customers that participated in both program years – increased from 0.88 percent in GPY4 to 1.03 percent in GPY5.

Finding 2. The savings estimate for the NSG Wave 2 cohort was not statistically significant at the 90 percent level. Its point estimate (absolute savings value) provides the best indication of savings and is reported in this evaluation, but cannot be taken as a statistically meaningful savings estimate on its own. The wave's lower savings rate (0.19 percent) is consistent with the experience of other HER programs during their first few months. Savings rates are generally expected to ramp up over time as HER recipients gain experience in the program and begin responding to the messages contained in the reports. The GPY6 evaluation should provide a better indication of this wave's savings rate going forward.

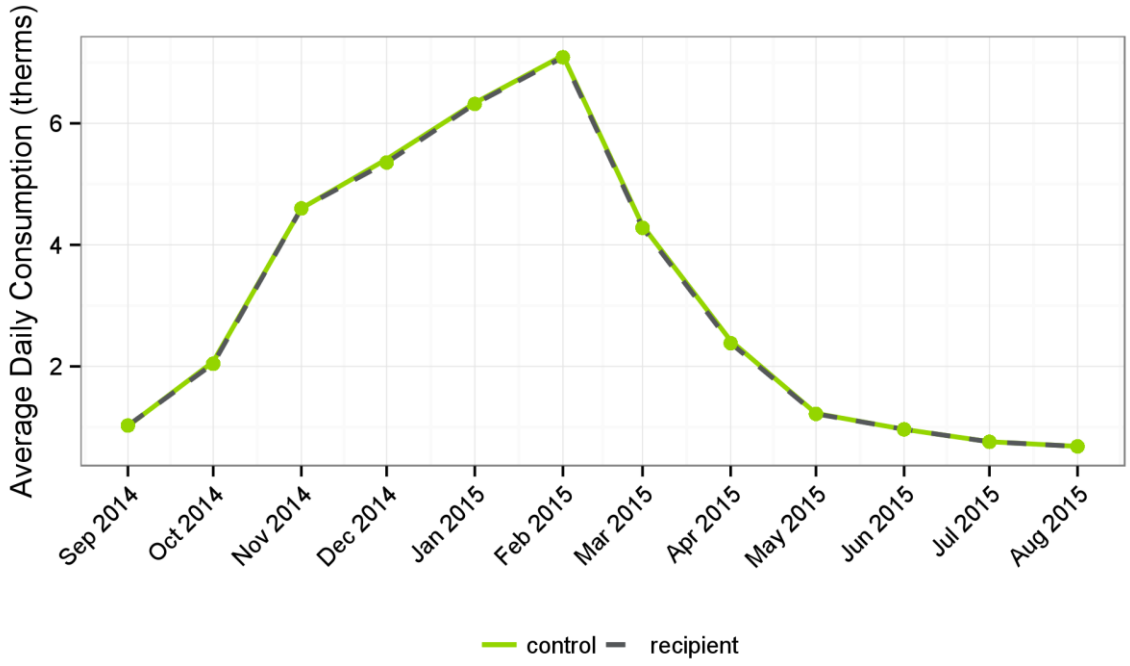
Finding 3. The verified savings rates of both programs were more closely aligned with *ex-ante* estimates in GPY5 than they were in GPY4. The PGL program's realization rates moved from ten percentage points above target (1.10) in GPY4 to two percentage points below target (0.98) in GPY5. For NSG, the realization rate went from 25 percentage points above target (1.25) in GPY4 to one percentage point above target (1.01) in GPY5.

6. APPENDIX

6.1 Graphs for NSG Wave 2 RCT Check

Figure 6-1 shows participant and control usage for NSG Wave 2 during the nine-month pre-period. This graph shows that the assignment of customers into treatment and control groups was consistent with randomization.

Figure 6-1. RCT Usage Comparison for NSG Wave 2



Source: Navigant analysis of PGL and NSG customer billing data.

6.2 Detailed Data Cleaning

Navigant performed the following data cleaning steps:

- Exclude data from outside of the period of examination (June 2015 to May 2016)
- Remove customers with more than 14 or less than 10 bills in a month[16]
- In instances where there are two bills for the same month, average the usage
- Exclude bills with negative usage
- Exclude observations where number of days in bill period is > 40 or < 20
- Exclude outlier observations, defined as observations with average daily usage greater than one order of magnitude from the median usage[17]

[16] For the NSG Wave 2, these figures were 7 and 12.

[17] Median average daily usage was 3.308 therms for PGL and 2.257 therms for NSG Wave 1 and 2.1 for NSG Wave 2. Navigant removed observations with usage greater than 10 times the median therms per day for each utility wave.

Table 6-1 through Table 6-3 give counts of customers and observations removed for the data cleaning steps identified above. Each data cleaning step removed a similar percentage of treatment and control customers for each wave. This suggests that non-random biases were not introduced into the data by the cleaning steps.

Table 6-1. Peoples Gas GPY5 Data Cleaning Results

Cleaning Step	Customers		Observations	
	Treatment	Control	Treatment	Control
Raw Data	151,200	20,999	6,795,820	945,115
Subset to pre/post periods	151,199	20,999	3,452,083	479,976
Remove customers with too many or too few bills	141,778	19,718	3,296,303	458,653
Bill Flattening	141,778	19,718	3,232,231	449,631
Remove observations with negative usage	141,778	19,718	3,232,231	449,631
Exclude bills with long or short durations	141,778	19,718	3,166,152	440,297
Exclude outliers	141,778	19,718	3,165,831	440,246

Source: Navigant analysis of PGL and NSG customer billing data.

Table 6-2. North Shore Gas Wave 1 GPY5 Data Cleaning Results

Cleaning Step	Customers		Observations	
	Treatment	Control	Treatment	Control
Raw Data	91,349	21,000	4,123,230	946,482
Subset to pre/post periods	91,349	21,000	2,085,512	478,736
Remove customers with too many or too few bills	86,140	19,816	1,997,810	459,071
Bill Flattening	86,140	19,816	1,952,233	448,446
Remove observations with negative usage	86,140	19,816	1,952,233	448,446
Exclude bills with long or short durations	86,140	19,816	1,906,076	437,666
Exclude outliers	86,140	19,816	1,899,956	436,241

Source: Navigant analysis of PGL and NSG customer billing data.

Table 6-3. North Shore Gas Wave 2 GPY5 Data Cleaning Results

Cleaning Step	Customers		Observations	
	Treatment	Control	Treatment	Control
Raw Data	10,526	2,465	242,275	56,655
Subset to pre/post periods	10,516	2,464	213,102	49,803
Remove customers with too many or too few bills	9,497	2,209	197,419	45,934
Bill Flattening	9,497	2,209	191,484	44,520
Remove observations with negative usage	9,497	2,209	191,484	44,520
Exclude bills with long or short durations	9,497	2,209	185,158	43,006
Exclude outliers	9,497	2,209	184,603	42,835

Source: Navigant analysis of PGL and NSG customer billing data.

6.3 Detailed Impact Methodology

Navigant used two regression models to estimate impacts: a PPR model and an LFER model. The following sections present each model.

6.3.1 PPR Model

The PPR model controls for non-program differences in energy use between the treatment and control groups using each customer's lagged energy usage as an explanatory variable. In particular, the model frames energy use in calendar month *t* of the post-program period as a function of both the treatment variable and 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 6-1.

Equation 6-1. Post Program Regression Model

$$ADU_{kt} = \beta_1 Treatment_k + \sum_J \beta_{2j} Month_{jt} + \sum_J \beta_{4j} Month_{jt} \cdot ADUlag_{kt} + \varepsilon_{kt}$$

where:

ADU_{kt}	is average daily consumption of kWh by household k in bill period t
$Treatment_k$	is a binary variable taking a value of 0 if household k is assigned to the control group, and 1 if assigned to the treatment group
$ADUlag_{kt}$	is household k's energy use in the same calendar month of the pre-program year as the calendar month of month t
$Month_{jt}$	is a binary variable taking a value of 1 when $j = t$ and 0 otherwise[18]
ε_{kt}	is the cluster-robust error term for household k during billing cycle t; cluster-robust errors account for heteroscedasticity and autocorrelation at the household level.[19]

The coefficient β_1 is the estimate of the average daily kWh energy savings due to the program.

6.3.2 LFER Model

The LFER model used by Navigant is one in which average daily consumption of kWh by household k in bill period t, denoted by ADU_{kt}, is a function of the following three terms:

1. The binary variable $Treatment_k$
2. The binary variable $Post_t$, taking a value of 0 if month t is in the pre-treatment period, and 1 if in the post-treatment period.
3. The interaction between these variables, $Treatment_k \cdot Post_t$

Formally, the LFER model is shown in Equation 6-2.

Equation 6-2. Linear Fixed Effects Regression Model

$$ADU_{kt} = \alpha_{0k} + \alpha_1 Post_t + \alpha_2 Treatment_k \cdot Post_t + \varepsilon_{kt}$$

In this model, the coefficient α_{0k} captures all household-specific effects on energy use that do not change over time, including those that are unobservable, the coefficient α_2 captures the average effect *across all households* of being in the post-treatment period, and the effect of being both in the treatment group and in the post period (i.e., the effect directly attributable to the program) is captured by the coefficient α_2. In other words, while the coefficient α_1 captures the change in average daily kWh use across the pre- and post-treatment for the *control* group, the sum α_1 + α_2 captures this change for the treatment group, and so α_2 is the estimate of average daily kWh energy savings due to the program.

6.4 Detailed Impact Results: Parameter Estimates

Table 6-4 through Table 6-9 show PPR and LFER model results for each wave. Across the two models, parameter estimates are not statistically different. That is, model estimates are within 90 confidence bounds of each other. Furthermore, the pattern across the different program waves between the two models is similar.

[18] 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. These are, in other words, monthly fixed effects.

[19] Ordinary Least Squares (OLS) regression models assume that the data are homoscedastic and not autocorrelated. If either of these assumptions is violated, the resulting standard errors of the parameter estimates are incorrect (usually underestimated). A random variable is heteroskedastic when the variance is not constant. A random variable is autocorrelated when the error term in one period is correlated with the error terms in at least some of the previous periods.

Table 6-4. PPR Model Estimates, GPY5 PGL HER Program

	Estimate	Std. Error	T Value	P Value
treatment	-0.05	0.00	-16.20	0.00
yrmo201506	0.49	0.01	60.33	0.00
yrmo201507	0.36	0.01	54.01	0.00
yrmo201508	0.29	0.01	42.99	0.00
yrmo201509	0.31	0.01	45.30	0.00
yrmo201510	0.61	0.01	90.85	0.00
yrmo201511	0.26	0.01	26.70	0.00
yrmo201512	0.90	0.01	83.06	0.00
yrmo201601	0.43	0.01	38.31	0.00
yrmo201602	0.86	0.01	74.06	0.00
yrmo201603	0.52	0.01	45.77	0.00
yrmo201604	0.93	0.01	90.28	0.00
yrmo201605	1.20	0.01	136.45	0.00
yrmo201506:pre_use	0.63	0.00	149.02	0.00
yrmo201507:pre_use	0.61	0.01	116.41	0.00
yrmo201508:pre_use	0.65	0.01	106.42	0.00
yrmo201509:pre_use	0.68	0.01	112.05	0.00
yrmo201510:pre_use	0.64	0.00	188.01	0.00
yrmo201511:pre_use	0.66	0.00	366.88	0.00
yrmo201512:pre_use	0.81	0.00	527.86	0.00
yrmo201601:pre_use	0.90	0.00	827.23	0.00
yrmo201602:pre_use	0.83	0.00	822.26	0.00
yrmo201603:pre_use	0.69	0.00	629.28	0.00
yrmo201604:pre_use	0.62	0.00	448.52	0.00
yrmo201605:pre_use	0.59	0.00	253.49	0.00
Residual standard error: 1.274 with 1,699,246 degrees of freedom				
Multiple R-squared: 0.94, Adjusted R-squared: 0.95				
F-statistic: 1,208,037 with 25 and 1,699,246 DF, p-value: 0				

Source: Navigant analysis of PGL data.

Table 6-5. LFER Model Estimates, GPY5 PGL HER Program

	Estimate	Std. Error	T Value	P Value
post	-0.65	0.01	-56.64	0.00
post_trt	-0.05	0.01	-3.96	0.00
R-Squared: 0.01; Adj. R-Squared: 0.01				
F-statistic: 14,918 with 2 and 3,444,579 DF, p-value: 0.00				

Source: Navigant analysis of PGL data.

Table 6-6. PPR Model Estimates, GPY5 NSG HER Program, Wave 1

	Estimate	Std. Error	T Value	P Value
treatment	-0.03	0.00	-9.45	0.00
yrmo201506	0.47	0.01	68.38	0.00
yrmo201507	0.21	0.01	29.67	0.00
yrmo201508	0.30	0.01	48.26	0.00
yrmo201509	0.23	0.01	35.90	0.00
yrmo201510	0.48	0.01	68.67	0.00
yrmo201511	0.21	0.01	24.32	0.00
yrmo201512	0.83	0.01	83.32	0.00
yrmo201601	0.37	0.01	36.14	0.00
yrmo201602	1.14	0.01	104.20	0.00
yrmo201603	1.43	0.01	132.01	0.00
yrmo201604	1.26	0.01	130.11	0.00
yrmo201605	1.17	0.01	132.66	0.00
yrmo201506:pre_use	0.49	0.00	157.34	0.00
yrmo201507:pre_use	0.79	0.00	195.86	0.00
yrmo201508:pre_use	0.67	0.00	181.01	0.00
yrmo201509:pre_use	0.76	0.00	173.44	0.00
yrmo201510:pre_use	0.67	0.00	215.56	0.00
yrmo201511:pre_use	0.72	0.00	383.82	0.00
yrmo201512:pre_use	0.77	0.00	437.07	0.00
yrmo201601:pre_use	0.92	0.00	682.81	0.00
yrmo201602:pre_use	0.78	0.00	617.18	0.00
yrmo201603:pre_use	0.58	0.00	419.28	0.00
yrmo201604:pre_use	0.56	0.00	339.57	0.00
yrmo201605:pre_use	0.58	0.00	213.01	0.00
Residual standard error: 1.395 with 1,094,311 degrees of freedom				
Multiple R-squared: 0.90, Adjusted R-squared: 0.90				
F-statistic: 390,248 with 25 and 1,094,311 DF, p-value: 0				

Source: Navigant analysis of PGL/NSG data.

Table 6-7. LFER Model Estimates, GPY5 NSG Her Program, Wave 1

	Estimate	Std. Error	T Value	P Value
post	-0.35	0.01	-39.24	0.00
post_trt	-0.03	0.01	-2.89	0.00
R-Squared: 0.00; Adj. R-Squared: 0.00				
F-statistic: 4697 with 2 and 2,230,239 DF, p-value: 0.00				

Source: Navigant analysis of PGL/NSG data.

Table 6-8. PPR Model Estimates, GPY5 NSG Her Program, Wave 2

	Estimate	Std. Error	T Value	P Value
treatment	-0.01	0.01	-0.49	0.62
yrmo201509	0.21	0.02	9.51	0.00
yrmo201510	0.24	0.02	10.24	0.00
yrmo201511	0.36	0.02	14.70	0.00
yrmo201512	0.53	0.03	18.13	0.00
yrmo201601	0.46	0.03	15.82	0.00
yrmo201602	1.15	0.03	38.24	0.00
yrmo201603	1.14	0.03	38.58	0.00
yrmo201604	1.18	0.03	43.34	0.00
yrmo201605	1.06	0.02	42.85	0.00
yrmo201509:pre_use	0.70	0.02	38.66	0.00
yrmo201510:pre_use	0.65	0.01	57.28	0.00
yrmo201511:pre_use	0.60	0.01	98.88	0.00
yrmo201512:pre_use	0.60	0.00	126.07	0.00
yrmo201601:pre_use	0.77	0.00	188.97	0.00
yrmo201602:pre_use	0.73	0.00	188.36	0.00
yrmo201603:pre_use	0.57	0.00	148.75	0.00
yrmo201604:pre_use	0.63	0.01	102.75	0.00
yrmo201605:pre_use	0.63	0.01	71.45	0.00
Residual standard error: 1.4 on 91,835 degrees of freedom				
Multiple R-squared: 0.88, Adjusted R-squared: 0.88				
F-statistic: 37,149 with 19 and 91,835 DF, p-value: 0				

Source: Navigant analysis of PGL/NSG data.

Table 6-9. LFER Model Estimates, GPY5 NSG Her Program, Wave 2

	Estimate	Std. Error	T Value	P Value
post	0.17	0.03	6.41	0.00
post_trt	-0.01	0.03	-0.26	0.80
R-Squared: 0.00; Adj. R-Squared: 0.00				
F-statistic: 101 on 2 and 215,730 DF, p-value: 0.00				

Source: Navigant analysis of PGL/NSG data.

6.5 Detailed Uplift Analysis Results

6.5.1 GPY5 Uplift

Table 6-10 through Table 6-12 present program savings due to participation in other EE programs in GPY5. Each table provides the uplift for a single program group in each of four EE Programs for which estimates for deemed savings are available: HEJ, HER, and MF. While these tables show estimates of both positive and negative uplift, only positive values were used to adjust program savings for double-counting. For all cases where the EE program did not exist in the pre-program year, the estimate is based on a POD statistic, otherwise it is based on a DID statistic.

The tables also include the percentage change in EE program participation rate for HER participants. This differs from the change in EE program participation rate for the entire EE program, which is not reported here. These rates should be interpreted with caution because they likely have very wide error bounds, many of which likely include zero. The calculation of standard errors on these rates is not straightforward and therefore Navigant does not report them here.

Table 6-10. GPY5 PGL HER Uplift Adjustment Details

	HEJ	HER	MF
Median program savings (annual therms per participant)	59.22	246.20	53.35
Number of treatment customers	151,200	151,200	151,200
Treatment rate of participation, GPY5 (%)	2.06%	0.47%	0.02%
Change in rate of treatment participation from pre-program year (%)	0.82%	-0.45%	0.00%
Number of control customer	20,999	20,999	20,999
Control rate of participation, GPY5 (%)	2.09%	0.44%	0.02%
Change in rate of control participation from pre-program year (%)	0.91%	-0.55%	0.00%
DID or POD statistic	-0.09%	0.10%	0.01%
Participant uplift	(131)	155	9
Statistically significant at the 90% confidence level?	No	Yes	Yes
Savings attributable to other programs (therms)	-7,773.54	38,170.34	490.84
Percentage change in EE program participation rate for HER participants	-97.94%	-99.53%	-99.98%

Source: Navigant analysis of PGL program tracking and customer billing data.

* Median program savings are the median therms impacts of HER recipients in each program.

Table 6-11. GPY5 NSG Wave 1 HER Uplift Adjustment Details

	HEJ	HER	MF
Median* program savings (annual therms per participant)	58.62	267.74	32.68
Number of treatment customers	91,349	91,349	91,349
Treatment rate of participation, GPY5 (%)	0.83%	1.56%	0.05%
Change in rate of treatment participation from pre-program year (%)	0.58%	0.25%	-0.13%
Number of control customer	21,000	21,000	21,000
Control rate of participation, GPY5 (%)	0.71%	1.39%	0.05%
Change in rate of control participation from pre-program year (%)	0.48%	0.26%	-0.14%
DID or POD statistic	0.11%	-0.01%	0.00%
Participant uplift	98	-10	3
Statistically significant at the 90% confidence level?	Yes	No	No
Savings attributable to other programs (therms)	5745.14	-2649.97	102.90
Percentage change in EE program participation rate for HER participants	-99.17%	-98.44%	-99.95%

Source: Navigant analysis of PGL program tracking and customer billing data.
* Median program savings are the median therms impacts of HER recipients in each program.

Table 6-12. GPY5 NSG Wave 2 HER Uplift Adjustment Details

	HEJ	HER	MF
Median program savings (annual therms per participant)	58.62	243.00	32.68
Number of treatment customers	10,526	10,526	10,526
Treatment rate of participation, GPY5 (%)	0.67%	1.21%	0.15%
Change in rate of treatment participation from pre-program year (%)	0.60%	0.82%	0.04%
Number of control customer	2,465	2,465	2,465
Control rate of participation, GPY5 (%)	0.61%	1.05%	0.16%
Change in rate of control participation from pre-program year (%)	0.49%	0.61%	0.00%
DID or POD statistic	0.11%	0.21%	0.04%
Participant uplift	12	22	4
Statistically significant at the 90% confidence level?	No	No	No
Savings attributable to other programs (therms)	689.25	5333.18	130.72
Percentage change in EE program participation rate for HER participants	-99.33%	-98.79%	-99.85%

Source: Navigant analysis of PGL program tracking and customer billing data.
* Median program savings are the median therms impacts of HER recipients in each program.

6.5.2 Legacy Uplift

To calculate legacy uplift from GPY3 and GPY4, Navigant considered double-counted savings for the following programs: HEJ, HER (Home Energy Rebate), and MF. The measure lives for GPY3 and GPY4 programs were taken from the total resource cost report.[20] The measure lives these programs MF programs are the simple average of the measures included in that program. Table 6-13 and Table 6-14 show double counted savings (kWh) from each program for GPY3 and GPY4 respectively. These tables show estimates of both positive and negative uplift, however, only positive uplift was used to adjust program savings for double-counting.[21]

Table 6-13. Doubled Counted Savings (kWh) from GPY3

	HEJ	HER	MF
Measure Life	10	15	12
PGL	17,076	2,145	-
NSG Wave 1	9,547	6,926	-
Total	**26,623**	**9,071**	**-**

Source: Navigant analysis of PGL program tracking and customer billing data.

Table 6-14. Doubled Counted Savings (kWh) from GPY4

	HEJ	HER	MF
Measure Life	10	15	12
PGL	4,046	11,898	1,815
NSG Wave 1	2,207	-33,568	729
Total	6,253	-21,670	2,544

Source: Navigant analysis of PGL program tracking and customer billing data.

[20] Navigant Consulting, 2016. *Plan Year 1 through 3 Total Resource Cost Test Results and Impact Summary Evaluation Report.* Presented to Peoples Gas

[21] To calculate legacy uplift values, the uplift savings from each previous program year must be multiplied by a move-out adjustment factor, which is 0.8836 for GPY3 and 0.94 for GPY4.