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ComEd Great Energy Stewards Program Evaluation Report

FINAL

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ComEd Great Energy Stewards Program Evaluation Report

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E. EXECUTIVE SUMMARY

This report presents a summary of the findings and results from the impact evaluation of the PY9[1] Great Energy Stewards (GES) program. The GES program is a third-party behavioral energy efficiency program being implemented under the Illinois Power Agency (IPA) funding mechanism.[2] It was designed and implemented by Shelton Solutions, Inc. (Shelton) starting in PY6. The GES program is designed to generate energy savings by providing ComEd residential customers with information on their energy usage and energy-saving tips through periodic postcards mailed to their homes and via electronic mail. The program also offers small financial incentive payments for energy savings.[3] This program was ended on May 31, 2017.

For the purposes of this report, Navigant characterized GES participants as comprising three waves that used rolling enrollment to acquire customers. The earliest wave, Wave 1, began enrollment at the beginning of PY6 in June 2013 and the latest wave, Wave 3, began enrollment at the beginning of PY8 in June 2015.[4] No new customers were added to the program in PY9.

E.1. Program Savings

Table E-1 summarizes the PY9 electric savings from the GES program. Navigant's analysis estimated total savings of 597 MWh prior to the uplift adjustment. After adjusting for uplift from other energy efficiency programs (see Section 2.4), estimated savings were 556 MWh. However, Wave 3's 26 MWh savings were not statistically significant, and therefore cannot be causally attributed to the program. Thus, final verified program savings were 530 MWh. The evaluation team calculated savings using regression analysis of monthly billing data comparing participants to a matched set of nonparticipants. As discussed in Section 4, this type of analysis estimates net savings and no further net-to-gross (NTG) adjustment is necessary.

Table E-1. PY9 Total Program Electric Savings

Savings Category	Energy Savings (MWh)
Implementer Estimated Savings †	NA
Net Savings, Prior to Uplift Adjustment	597
Net Savings, After Uplift Adjustment	556
Not Statistically Significant Savings ‡	26
Final Verified Savings	530
Realization Rate †	-

Source: ComEd tracking data and Navigant team analysis.

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[1] For GES, PY9 began June 1, 2016 and ended May 31, 2017.

[2] Created by Illinois Public Acts 97-0616 ("PA 97-0616") and 97-0824 ("PA 97-0824").

[3] Originally, the program offered customers 5 cents per kWh saved up to $50. Starting in PY7, the implementer instead offered small ($5) gift cards as an enrollment incentive, redeemable at local fast food outlets (Dunkin Donuts or Subway) and held raffles or drawings with similar small ($5-$25) prizes to reward participation.

[4] Waves 1 and 2 were called the PY6 Wave and the PY7 Wave respectively in the PY8 report for this program.

† Navigant did not receive implementer estimated savings for this program and as such was not able to calculate a realization rate.
‡ The savings for Wave 3 were not statistically significant, which means they cannot be causally attributed to the program.

E.2. Program Savings by Wave

Table E-2 summarizes estimated program savings by wave.[5] In this table, Number of PY9 participants, in the first row, represents the number of customers in each wave who were still active at the start of PY9, while sample sizes, in the second and third rows, indicate the number of participants and controls with sufficient data for inclusion in the regression analysis. Navigant estimated separate savings for each wave using regression analysis as described in Section 2.3. The weighted average per customer savings estimate was 5.4 percent (438 kWh).

Table E-2. PY9 GES Program Results by Wave

Type of Statistic	Wave 1	Wave 2	Wave 3	Total
Number of PY9 Participants	429	579	377	1,385
Sample Size - Treatment	429	579	377	1,385
Sample Size – Matched Control	414	601	402	1,417
Percentage Savings	10.1%	4.1%	2.1%	5.4% §
Standard Error	*2.9%*	*2.1%*	*2.2%*	*-*
Annualized Savings Per Customer, kWh	882	293	155	438 §
Standard Error	*250*	*152*	*165*	*-*
Net Savings, Prior to Uplift Adjustment, MWh †	373	167	57	597
Standard Error	*106*	*87*	*61*	*-*
PY9 Uplift Adjustment, MWh	6	3	9	18
Legacy Uplift Adjustment, MWh	1	0	22	23
Net Savings, MWh ‡	366	164	26	556
Not Statistically Significant Savings, MWh	-	-	26	26
Final Verified Savings, MWh	366	164	-	530

Source: ComEd tracking data and Navigant team analysis.
† Total savings are pro-rated for participants that closed their accounts during PY9.
‡ Net Savings are equal to Net Savings, Prior to Uplift Adjustment less the uplift of savings in other EE programs.
§ Number displayed is the weighted average, not a total.

As shown in Figure E-1, energy savings for individual waves in the GES program have trended upward over time. However, of these results, only Wave 1 and Wave 2 active customers in PY9 were statistically significant. The GES savings levels in PY9 were considerably higher than those found in other behavioral programs (e.g., Home Energy Reports), which typically have savings in the one to three percent range.

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[5] Discrepancies in totals or net savings are due to rounding.

Figure E-1. GES Energy Savings Trends
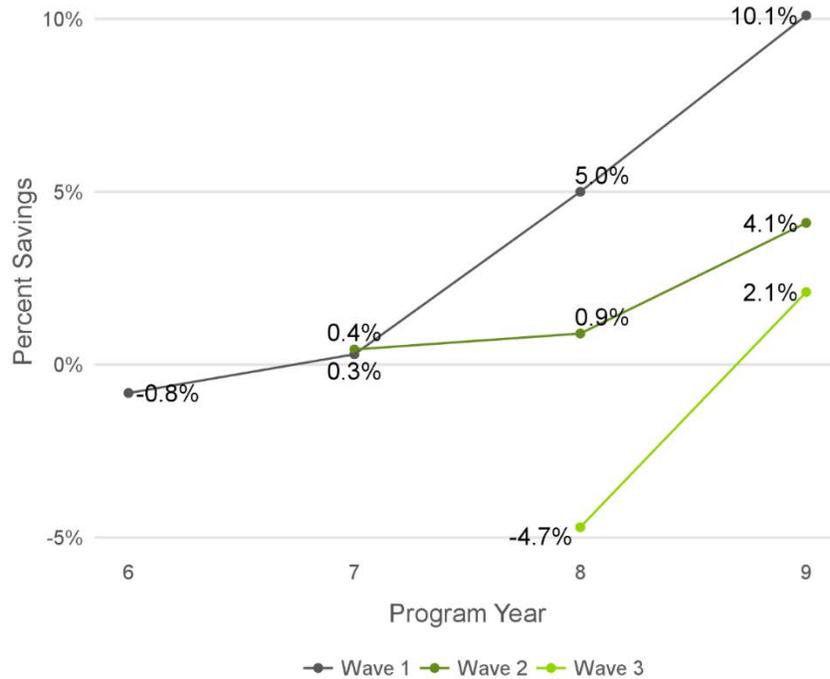
Source: ComEd billing data and Navigant team analysis.

E.3. Findings and Recommendations

Finding 1. The GES program had weighted average savings of 5.4 percent in PY9, which resulted in 597 MWh of savings. Uplift adjustment revised this figure down to 556 MWh. After subtracting Wave 3's savings (26 MWh) because they were not statistically significant, the program had final verified savings of 530 MWh.

Finding 2. Savings after uplift (including results that were not statistically significant) increased from 197 MWh in PY8 to 597 MWh in PY9. Possible explanations for this increase include GES participants saving more energy in PY9, or low-saving customers exiting the program (i.e., by moving[6]). Additionally, GES did not add any new participants in PY9 and historically we have seen very low (or negative) savings for participants in the first year of this program, thus the lack of new participants may have raised the savings average. While PY9 savings do constitute a large increase from PY8 results, the small number of GES participants (1,385) means the PY9 results are not very generalizable. Thus, it is uncertain how effective this program would be in the future.

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[6] The average PY9 move-out rate for GES participants across all waves was 13%.

1. INTRODUCTION

1.1 Program Description

The Great Energy Stewards (GES) program is a third-party behavioral energy efficiency program being implemented under the Illinois Power Agency (IPA) funding mechanism.[7] It was designed and implemented by Shelton Solutions, Inc. (Shelton) based on the hypothesis that local church congregations comprise a receptive audience for behavioral EE programs. Program participants received periodic postcards containing information on their energy consumption relative to the previous year and energy saving tips, and were offered small monetary incentives[8] to reward energy savings. As the program evolved, the energy saving tips were distributed via an electronic system. Participants received their tips via email.

Restrictions on use of participants' confidential information prevented the implementation contractor from monitoring participants' energy usage which was a key feature of the program's initial design strategy for tracking energy savings through behavior change.[9] As a partial solution, ComEd provided the implementer with quarterly reports since the start of the program in PY6 that show the unadjusted change in each participant's monthly kWh consumption compared to the same period in the last year. Since these do not compare the changes to those of a matched control group or after adjustment for weather and other differences, there is no way for the program implementer to know whether this unadjusted year-over-year change would be more, or less than equal to the verified savings. Also, the implementer's inability to get timely insight into the participants' monthly usage levels limits its ability to track participants' progress in a timely fashion, which has limited insights into participants' energy consumption patterns that could be helpful in tailoring the energy-saving tips to individual participants.

GES used rolling enrollment to acquire customers. For the purposes of this report, Navigant characterized GES participants as comprising three waves. The earliest wave, Wave 1, began enrollment in June 2013, Wave 2 began enrollment in June 2014, and Wave 3, began enrollment in June 2015.

1.2 Evaluation Objectives

The objective of this evaluation was to determine energy savings generated by the GES program during PY9.

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[7] Created by Illinois Public Acts 97-0616 ("PA 97-0616") and 97-0824 ("PA 97-0824")

[8] Originally, the program offered customers 5 cents per kWh saved up to $50. Starting in PY7, the implementer instead offered small ($5) gift cards as an enrollment incentive, redeemable at local fast food outlets (Dunkin Donuts or Subway) and held raffles or drawings with similar small ($5-$25) prizes to reward participation.

[9] 2013 Great Energy Stewards SCOPE OF WORK DOCUMENT

2. STUDY APPROACH

The evaluation approach in PY9 is consistent with that of the evaluations in previous years, relying on statistical analysis appropriate for opt-in behavioral programs. Navigant used matching methods to create a matched control group and then estimated program impacts using a regression with pre-program matching (RPPM) analysis with lagged controls for pre-period energy usage.

2.1 Overview of Data Collection Activities

The core data collection activities included receiving billing and tracking data for the GES program, and receiving tracking data for the other programs used in the uplift analysis. The full set of data collection activities is shown in Table 2-1.

Table 2-1. Primary Data Collection Activities

What	Who	When
GES Program Tracking Database	Participants and Potential Controls	May 2017
GES Program Billing Database	Participants and Potential Controls	January 2012 – May 2017
Other Programs Tracking Database	Participants and Potential Controls	June 2009 – May 2017

Source: Navigant analysis

2.2 Data Used in Impact Analysis

In preparation for the impact analysis, Navigant combined and cleaned data provided by the program implementer and ComEd. The dataset included 1,618 participants in the GES program and 1,417 controls. Billing data used in the analysis extended from January 2012 (17 months before the start of the program) to May 2017. Data during the twelve-month pre-period for each participant and during PY9 were used in the regression analysis described in Section 2.3.

Navigant removed customers and data points from the analysis in the following steps:

- Participants who did not have an active account on the first day of PY9
- Observations with a bill duration of zero
- Bill Flattening - Aggregating records that ended in the same month[10]
- Duplicate bills
- Observations with missing or negative usage
- Observations with less than 20 or more than 40 days in a billing cycle
- Observations that were outliers, defined as having average daily usage more than one order of magnitude from the median usage[11]

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

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[10] This does not remove any records but rather redistributes records for analysis purposes.
[11] The pre-cleaning median kWh usage per day for Waves PY6 through PY8 were 18.2, 15.3, and 16.2, respectively.

2.3 Statistical Models Used in the Impact Evaluation

To estimate energy savings, Navigant used the regression with pre-program matching (RPPM) approach described in Ho, Imai, King, and Stuart (2007).[12] Using the RPPM method, Navigant has successfully evaluated many opt-in behavioral programs. Additional detail about the statistical approach used in this evaluation is described in Section 6.2.1.

2.3.1 Matching Algorithm

Matching methods rely on a set of matched comparison households to estimate program savings. The pool of non-participant households available for matching consisted of approximately 275,000 ComEd residential customers. Additional detail about the matching methods used for this evaluation is included in Section 6.2.2

For each program participant, energy consumption in the period spanning 14 months to three months before program enrollment (a 12-month period)[13] was compared to that of all customers in the available non-participant pool with billing data over the same 12 months. For matching, program enrollment occurred when a participant signed up for the GES program, (i.e., when they created an account on the GES website). The potential control with energy use most similar to a participant's during the 12-month matching period was used as the match.

Since no new participants joined the program in PY9, Navigant did not draw any new matches for the PY9 evaluation. Discussion of the quality of the matches can be found in the PY8 report.[14]

2.4 Accounting for Uplift in Other Energy Efficiency Programs

2.4.1 Accounting for Uplift in PY9

If participation rates in other energy efficiency (EE) programs are the same for GES participants and their matched controls, the savings estimates from the regression analyses are already net of savings from other programs, as this indicates the GES program does not increase or decrease participation in other EE programs. However, if the GES program affects participation rates in other EE programs, then savings across all programs are lower than indicated by the simple summation of savings in the GES and EE programs. For instance, if the GES program increases participation in other EE programs, the increase in savings may be allocated to either the GES program or the EE program, but cannot be allocated to both programs simultaneously.[15] Note that when the GES program decreases participation in other programs there is no issue of double-counting and thus no adjustment to the savings total is made.

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[12] Ho, Daniel E., Kosuke Imai, Gary King, and Elizabeth Stuart. 2007. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis* 15(3): 199-236.

[13] In order to draw a match, a GES participant had to have data in at least eight of the twelve months in the matching period.

[14] Navigant, 2016. *ComEd Great Energy Stewards Program Evaluation Report.* Presented to Commonweath Edison Company. < http://ilsagfiles.org/SAG_files/Evaluation_Documents/Draft%20Reports%20for%20Comment/ComEd_EPY8_Draft_R eports/ComEd_EPY8_Great_Energy_Stewards_Eval_Report_Draft_2016-11-11.pdf >

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

Data permitting, Navigant uses a difference-in-difference (DID) statistic to estimate uplift in other EE programs. To calculate the DID statistic, the change in the participation rate in another EE program between PY9 and the pre-program year for the matched control group is subtracted from the same change for the treatment group. For instance, if the rate of participation in an EE program during PY9 is five percent for the treatment group and three percent for the matched control group, and the rate of participation during the year before the start of the program is two percent for the treatment group and one percent for the matched control group, then the rate of uplift due to the GES program is one percent, as reflected in Equation 2-1.

Equation 2-1. DID Statistic Calculation

$$(PY9\ treatment\ group\ participation - prePY\ treatment\ group\ participation)$$
$$- (PY9\ control\ group\ participation - prePY\ control\ group\ participation)$$
$$= DID\ statistic$$
$$(5\% - 2\%) - (3\% - 1\%) = 1\%$$

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 residence's square footage.

An alternative to the DID statistic is the post-only difference (POD) statistic, which is the simple difference in participation rates between the treatment and matched control groups during PY9. The POD statistic generates an unbiased estimate of uplift when the baseline average rate of participation in the EE program is the same for the two groups. Navigant uses this alternative statistic in cases where the EE program did not exist for the entire pre-program year.

Navigant examined the uplift associated with four EE programs: the Fridge and Freezer Recycling (FFR) program, the Home Energy Assessment (HEA) program, the Home Energy Rebates (Rebate) program, and the Multi-Family Energy Savings Program (MESP). The FFR program achieves energy savings through retirement and recycling of older, inefficient refrigerators, freezers, and room air conditioners. The HEA program is offered jointly with the local gas utilities and achieves savings by providing direct installation of low-cost efficiency measures for single family homes, such as CFLs and low-flow showerheads. The Rebate program offers weatherization and incentives to residential customers to encourage customer purchases of higher efficiency heating, ventilating, and air-conditioning (HVAC) equipment. MESP offers direct installation of low-cost efficiency measures, such as water efficiency measures and CFLs at eligible multifamily residences.

For each EE program, double-counted savings were calculated separately for each program year wave of the GES program.

2.4.2 Accounting for Legacy Uplift

The uplift adjustment methodology described in 2.4.1 only accounts for uplift which occurs in the current program year because EE program tracking files in any given program year only capture the new measures installed in that year, regardless of the expected measure life.[16] However, for other EE programs

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[16] Tracking data files are set-up this way because, in conformity the Illinois Technical Reference Manual Section 3.2, savings are first-year savings, not lifetime savings.

with multi-year measure lives, GES program savings capture the portion of their savings due to uplift in each year of that program's measure life. For instance, a measure with a ten-year measure life that was installed in PY2 would generate savings captured in the GES program savings not just in PY2, but in PY3 through PY11 as well.

Consider the following example. A household in the GES program enrolls in the FFR program in PY6. The uplift adjustment subtracts FFR PY6 program savings to avoid double counting. In PY7 this household still receives savings from the FFR program because it has an eight-year measure life.

However, the PY7 GES uplift adjustment does not remove these savings because the PY7 adjustment only accounts for a measure installed in PY7, the initial year that the household entered a program. Thus, when only relying on the uplift adjustment described in Section 2.4.2, FFR second year savings would be included in the PY7 GES program's savings, which is inconsistent with Illinois's practice of only crediting utilities with first-year EE program savings. Legacy uplift removes double counted energy saving from programs with a multiple-year measure life.

Navigant accounts for legacy uplift by subtracting the double counted savings from previous years, adjusted for the average annual move-out rate, from PY9 GES savings through the measure lives of other EE programs.[17] The legacy uplift adjustment is shown in Equation 2-2 .

Equation 2-2. Legacy Uplift Calculation

$$\text{HER Savings}_{\text{PY}}^{\text{Adjusted}} = \text{HER Savings}_{\text{PY}}^{\text{Unadjusted}} - \text{Uplift Savings}_{\text{PY}} - \sum_{i=1}^{\text{PY-1}} \text{"Live" Legacy Uplift Savings}_i \cdot (1 - \text{MOR})^{\text{PY - i}}$$

Where, "'Live' Legacy Uplift Savings" refers to uplift savings where the other EE programs' measure lives have not yet run out (i.e., where measure life exceeds the difference between *PY* and *i*) and MOR refers to the move out rate.

The legacy uplift adjustment goes back to PY6 when Navigant first evaluated the GES program. In PY6, Navigant considered double-counted savings for the Fridge Freezer Recycle Rewards (FFR), the Complete System Replacement (CSR), the Multi-Family Home Energy Savings (MF), and the Single-Family Home Energy Savings (SFHES) programs. In PY7 Navigant considered double-counted savings for the same four programs as PY8: the FFR program, the HEA program, the Rebate program, and MESP.

2.5 Process Evaluation

The PY9 GES program evaluation did not include a process evaluation.

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[17] Since GES program participants are dropped from that program when they move, other EE programs' savings are no longer captured in the GES program savings from that point forward.

3. GROSS IMPACT EVALUATION

Total program savings are summarized in Table 3-1 below. Navigant's analysis estimated total savings of 597 MWh prior to the uplift adjustment. After adjusting for uplift from other energy efficiency programs (see Section 2.4), estimated savings were 556 MWh. However, Wave 3's 26 MWh savings were not statistically significant, and therefore cannot be causally attributed to the program. Thus, final verified savings were 530 MWh.

Table 3-1. PY9 Total Program Electric Savings

Savings Category	Energy Savings (MWh)
Implementer Estimated Savings †	NA
Net Savings, Prior to Uplift Adjustment	597
Net Savings, After Uplift Adjustment	556
Not Statistically Significant Savings ‡	26
Final Verified Savings	530
Realization Rate †	-

Source: ComEd tracking data and Navigant team analysis.
† Navigant did not receive implementer estimated savings for this program and as such was not able to calculate a realization rate.
‡ The savings for Wave 3 were not statistically significant, which means they cannot be causally attributed to the program.

3.1 Uplift of Savings in Other EE Programs

RPPM program savings estimates include savings resulting from the uplift in participation in other EE programs caused by the GES program. To avoid double-counting savings, program savings due to uplift must be counted towards either the GES program or the other EE programs, but not both. Uplift in other EE programs was 41 MWh, or 6.9 percent, which can be broken into PY9 and legacy uplift. PY9 uplift was 18 MWh or 3.0 percent of total program savings. Legacy uplift was 23 MWh or 3.9 percent of total program savings. Table 3-2 shows how the uplift adjustment affects total savings.

Table 3-2. PY9 Uplift Adjustment

Savings Category	Energy Savings (MWh)
Net Savings, Prior to Uplift Adjustment	597
PY9 Uplift Adjustment	18
Legacy Uplift Adjustment	23
Net Savings, After Uplift Adjustment	556

Source: ComEd data and Navigant team analysis.

Subtracting the savings uplift from total savings (597 MWh) generates a net savings estimate of 556 MWh. To put this in perspective, across the three waves, the weighted average percentage savings for PY9 due

to the GES program was 5.4 percent, and removing the savings uplift in other EE programs reduces this value to 5.0 percent.[18]

Table 3-2 presents a summary of the double-counted savings due to PY9 and legacy uplift in other EE programs and the estimated savings for the GES program obtained by removing these savings from the estimate of verified program savings prior to uplift adjustment, by program wave. Section 6.4 in the appendix presents the details of the calculation of the PY9 and Legacy uplift for each of the four ComEd EE programs considered in the analysis. As previously mentioned, the programs included in the uplift analysis in PY9 were the FFR program, the HEA program, the Rebate program and the MESP.[19]

The estimate of double-counted savings is most likely an *overestimate* because it presumes participation in the other EE programs occurs at the very start of PY9. Under the more reasonable assumption that participation occurs at a uniform rate throughout the year, the estimate of double-counted savings would be approximately 11.5 MWh, half the estimated value of 23 MWh. Overall, double counting of savings with other ComEd EE programs is larger for this program than for some of ComEd's other behavioral programs, but still does not have a large impact on per customer savings.

3.2 Verified Program Impact Results

Table 3-3 summarizes estimated program savings by wave.[20] In this table, the number of PY9 participants, in the first row, represents the number of customers in each wave who were still active at the start of PY9, while the sample sizes, in the second and third rows, indicate the number of customers with sufficient data for inclusion in the regression analysis. Navigant estimated separate savings for each wave using regression analysis as described in Section 2.3. The weighted average per customer savings estimate was 5.4 percent (438 kWh).

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[18] Multiplying 5.4 percent (the percentage of total energy use saved) by 6.9 percent (the percentage of total savings uplift in other EE programs) generates the value 0.4 percent. Formally, as shown in the following calculation: .054 × .069 =.0037. Subtracting this value from .054 gives .0503, or 5.0 percent.

[19] ComEd has other residential programs that were not included in the analysis. The Residential Lighting and Elementary Education programs do not track participation at the customer level, and so do not have the data necessary for the uplift analysis. Double counting between the Residential New Construction and GES program is not possible due to the requirement in our evaluation that GES participants have sufficient historical usage data.

[20] Discrepancies in totals or net savings are due to rounding

Table 3-3. PY9 GES Program Results by Wave

Type of Statistic	Wave 1	Wave 2	Wave 3	Total
Number of PY9 Participants	429	579	377	1,385
Sample Size - Treatment	429	579	377	1,385
Sample Size – Matched Control	414	601	402	1,417
Percentage Savings	10.1%	4.1%	2.1%	5.4% §
Standard Error	*2.9%*	*2.1%*	*2.2%*	*-*
Annualized Savings Per Customer, kWh	882	293	155	438 §
Standard Error	*250*	*152*	*165*	*-*
Net Savings, Prior to Uplift Adjustment, MWh †	373	167	57	597
Standard Error	*106*	*87*	*61*	*-*
PY9 Uplift Adjustment, MWh	6	3	9	18
Legacy Uplift Adjustment, MWh	1	0	22	23
Net Savings, MWh ‡	366	164	26	556
Not Statistically Significant Savings, MWh	-	-	26	26
Final Verified Savings, MWh	366	164	-	530

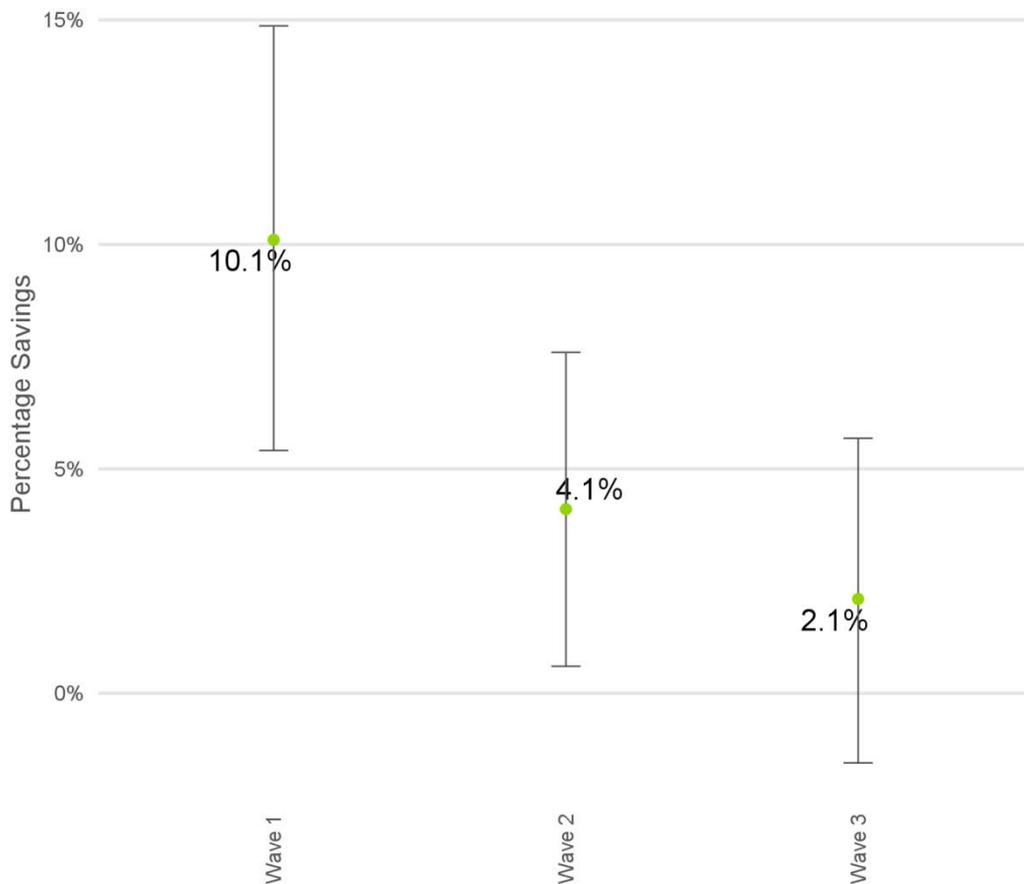*Source: ComEd tracking data and Navigant team analysis.*
† Total savings are pro-rated for participants that closed their accounts during PY9.
‡ Net Savings are equal to Net Savings, Prior to Uplift Adjustment less the uplift of savings in other EE programs.
§ Number displayed is the weighted average, not a total

Figure 3-1 shows the energy savings for each wave with the 90 percent confidence interval. Savings from Wave 3 were not statistically significant because the wave's confidence bounds include zero. Waves 1 and 2 had statistically significant results.

Figure 3-1. PY9 Percent Savings and 90 Percent Confidence Interval, by Wave

Source: ComEd billing data and Navigant team analysis.

As shown in Figure 3-2, energy savings for individual waves in the GES program have trended upward over time. However, of these results, only those from Wave 1 and Wave 2 from PY9 have been statistically significant. The GES savings levels in PY9 were considerably higher than those found in other behavioral programs (e.g., Home Energy Reports), which typically have savings in the one to three percent range.

Figure 3-2. Historical GES Energy Savings
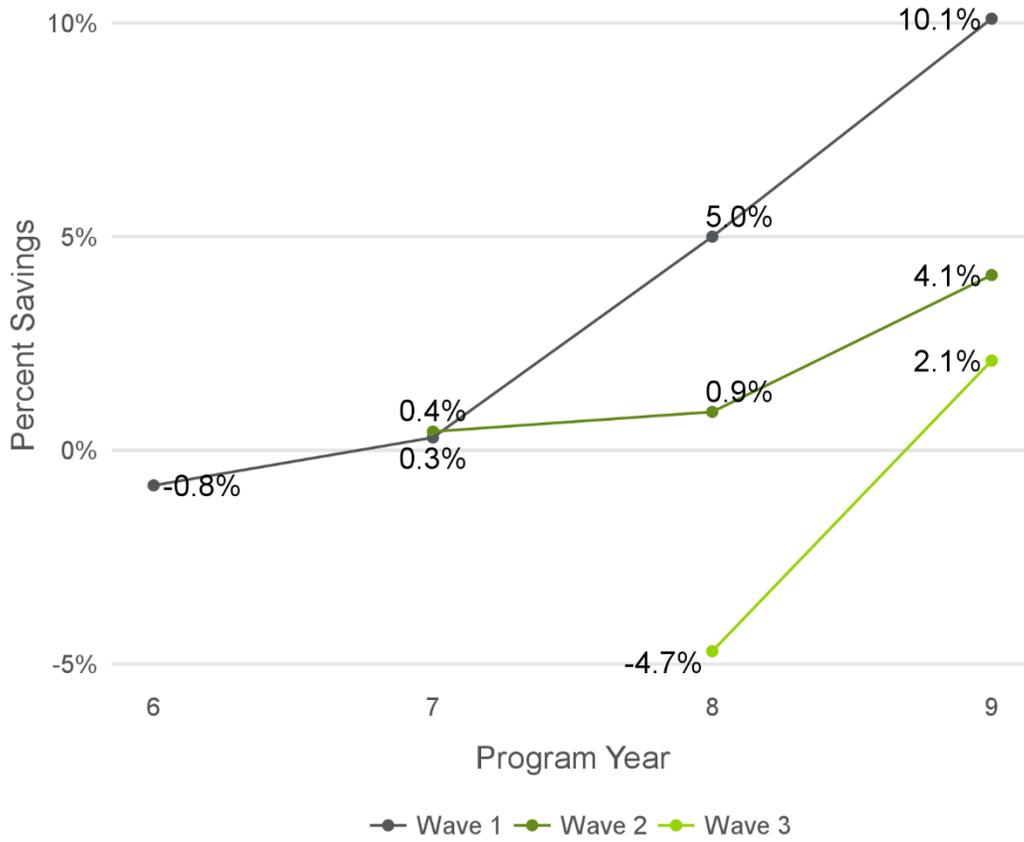
Source: ComEd billing data and Navigant team analysis.

4. NET IMPACT EVALUATION

A key feature of the matched control group method used to estimate savings for the GES program is that the analysis assumes that with respect to unobserved variables that may affect program savings, on average program enrollees are no different than customers matched to them. In other words, in the absence of the program the expectation is that participants in the GES program and their matched controls would have exhibited the same energy usage. In particular, in the absence of the program the expectation is that participants and matched controls would 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

Finding 1. The GES program had weighted average savings of 5.4 percent in PY9, which resulted in 597 MWh of savings. Uplift adjustment revised this figure down to 556 MWh. After subtracting Wave 3's savings (26 MWh) because they were not statistically significant, the program had final verified savings of 530 MWh.

Finding 2. Savings after uplift (including results that were not statistically significant) increased from 197 MWh in PY8 to 597 MWh in PY9. Possible explanations for this increase include GES participants saving more energy in PY9, or low-saving customers exiting the program (i.e., by moving[21]). Additionally, GES did not add any new participants in PY9 and historically we have seen very low (or negative) savings for participants in the first year of this program, thus the lack of new participants may have raised the savings average. While PY9 savings do constitute a large increase from PY8 results, the small number of GES participants (1,385) means the PY9 results are not very generalizable. Thus, it is uncertain how effective this program would be in the future.

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[21] The average PY9 move-out rate for GES participants across all waves was 13%.

6. APPENDIX

6.1 Detailed Data Cleaning

Navigant removed customers and data points from the analysis in the following steps:

- Participants who did not have an active account on the first day of PY9
- Observations with a bill duration of zero
- Bill Flattening - Aggregating records that ended in the same month[22]
- Duplicate bills
- Observations with missing or negative usage
- Observations with less than 20 or more than 40 days in a billing cycle
- Observations that were outliers, defined as having average daily usage more than one order of magnitude from the median usage[23]

Table 6-1, Table 6-2, and Table 6-3 give counts and percentages of data points removed for the data cleaning steps identified above.

Table 6-1. Treatment Customers/Observations Removed by Data Cleaning Step, Wave 1

Data Cleaning Step	Customers		Observations		Customer % Change		Observation % Change	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Subset to pre/post periods	429	414	9,898	9,647	-	-	-	-
Bill duration ≠ 0	429	414	9,898	9,647	0%	0%	0%	0%
Bill Flattening	429	414	9,626	9,647	0%	3%	0%	0%
Remove duplicate bills	429	414	9,626	9,647	0%	0%	0%	0%
Exclude observations missing usage	429	414	9,626	9,647	0%	0%	0%	0%
Remove observations with negative usage	429	414	9,626	9,647	0%	0%	0%	0%
Exclude bills with long or short durations	429	414	9,602	9,543	0%	0%	0%	0%
Exclude outliers	429	414	9,512	9,491	0%	1%	0%	0%

Source: ComEd data and Navigant team analysis.

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[22] This does not remove any records but rather redistributes records for analysis purposes.
[23] The pre-cleaning median kWh usage per day for Waves PY6 through PY8 were 18.2, 15.3, and 16.2, respectively.

Table 6-2. Treatment Customers/Observations Removed by Data Cleaning Step, Wave 2

Data Cleaning Step	Customers		Observations		Customer % Change		Observation % Change	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Subset to pre/post periods	579	601	13,223	14,016	-	-	-	-
Bill duration ≠ 0	579	601	13,223	14,016	0%	0%	0%	0%
Bill Flattening	579	601	12,894	14,016	0%	0%	2%	0%
Remove duplicate bills	579	601	12,894	14,016	0%	0%	0%	0%
Exclude observations missing usage	579	601	12,894	14,016	0%	0%	0%	0%
Remove observations with negative usage	579	601	12,894	14,016	0%	0%	0%	0%
Exclude bills with long or short durations	579	601	12,863	13,882	0%	0%	0%	1%
Exclude outliers	579	601	12,781	13,804	0%	0%	1%	1%

Source: ComEd data and Navigant team analysis.

Table 6-3. Treatment Customers/Observations Removed by Data Cleaning Step, Wave 3

Data Cleaning Step	Customers		Observations		Customer % Change		Observation % Change	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Subset to pre/post periods	377	402	8,546	9,443	11%	0%	76%	61%
Bill duration ≠ 0	377	402	8,546	9,443	0%	0%	0%	0%
Bill Flattening	377	402	8,442	9,443	0%	0%	1%	0%
Remove duplicate bills	377	402	8,442	9,443	0%	0%	0%	0%
Exclude observations missing usage	377	402	8,442	9,443	0%	0%	0%	0%
Remove observations with negative usage	377	402	8,442	9,443	0%	0%	0%	0%
Exclude bills with long or short durations	377	402	8,416	9,371	0%	0%	0%	1%
Exclude outliers	377	402	8,362	9,326	0%	0%	1%	0%

Source: ComEd data and Navigant team analysis.

6.2 Detailed Impact Methodology

6.2.1 Regression with Pre-Program Matching Model (RPPM)

As discussed in Section 2.3, the basic logic of regression with a matching model is to balance the participant and non-participant samples by matching on the exogenous covariates known to have a high

correlation with the outcome variable. Doing so increases the efficiency of the estimate and reduces the potential for model specification bias. Formally, the argument is that if the outcome variable Y is independently distributed conditional on X and D (conditional independence assumption), where X is a set of exogenous variables and D is the program variable, then the analyst can gain some power in the estimate of savings and reduce potential model specification bias by assuring that the distribution of X is the same for treatment and matched control observations.

In this evaluation, the outcome variable is average daily use in post-program period months, and the available exogenous covariate with by far the greatest correlation with this outcome variable is energy use in the same month of the pre-program period, $PREkWh_{kt}$, where k indexes the customer and t indexes the month; this is why the matching takes the form described in Section 2.3.1. The RPPM approach can be interpreted as using regression analysis to further control for any remaining imbalance in the matching on this variable. If, for instance, after matching the participants use slightly more energy on average in the pre-program period than their matches – in other words, they are higher baseline energy users – then including $PREkWh_{kt}$ as an explanatory variable in a regression model predicting monthly energy use during the post-program period prevents this remaining slight difference in baseline energy use from being attributed to the program.

In the RPPM approach the development of a matched comparison group is viewed as a useful pre-processing step in a regression analysis to assure that the distributions of the covariates (i.e., the explanatory variables on which the output variable depends) for the treatment group are the same as those for the comparison group that provides the baseline measure of the output variable.[24] This minimizes the possibility of model specification bias. The regression model only uses the post-treatment period data in the dependent variable, and the matching focuses on those variables expected to have the greatest impact on the output variable.

6.2.2 Matching Algorithm and Matching Results

As described in Section 2.3.1 participants and potential controls were matched on energy use during the pre-treatment period, and then estimated a model for all post-program observations in which energy use in month *t* is a function of a monthly fixed effect, energy use in the same calendar month in the one-year period before program enrollment, and whether the customer is a program participant. Formally, the model is shown in Equation 6-1.

Equation 6-1. RPPM Model

$$ADU_{kt} = \beta_1 Treatment_k + \sum_J \beta_{2j} Month_{jt} + \sum_J \beta_{3j} Month_{jt} \cdot PREkWh_{kt} + \varepsilon_{kt}$$

Where,

ADU_{kt} = Average daily energy use by household *k* in month *t*.

$Treatment_k$ = A binary variable taking a value of 1 if customer *k* is a GES participant and 0 otherwise.

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[24] Ho, Daniel E., Kosuke Imai, Gary King, and Elizabeth Stuart. 2007. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference. *Political Analysis* 15(3): 199-236.

$Month_{jt}$ = A binary variable taking a value of 1 when $j = t$ and 0 otherwise.[25]

$PREkWh_{kt}$ = The average daily electricity use by household k during the most recent month before household k (or its match) enrolled in the GES program that is also the same calendar month as month t. For instance, if household k enrolled in August 2011, the value of $PREkWh_{kt}$ for June 2012 is June 2011.

ε_{kt} = Model error term.

In this model β_1 is the treatment effect. The monthly fixed effect is included to account for unobserved time-related factors, such as weather, that affect all customers. The monthly dummy variable is interacted with $PREkWh_{kt}$ to account for the fact that the relationship between energy use in the year before enrollment and energy use in the program year might vary by calendar month.

For the sake of expositional clarity below, let t_k denote the month t in which customer k enrolled in the program, with t_k -1 denoting the month before enrollment, t_k +1 denoting the month after enrollment, and so on. Customers with more than four missing bills during the designated matching period [t_k -14, t_k -3] were not matched.

The basis of the comparison is the difference in monthly energy use between a participant and a potential match, D_{PM} (**D**ifference between **P**articipant and potential **M**atch). The quality of a match is denoted by the Euclidean distance to the participant over the twelve values of monthly D_{PM} used for matching; that is, denoting by SSD the sum of squared D_{PM} over the matching period, it is denoted by $SSD^{1/2}$. The non-participant customer with the shortest Euclidean distance to a participant was chosen as the matched comparison for the participant. Matching was done with replacement.

6.3 Savings Due to Participation Uplift in Other EE Programs

6.3.1 Uplift in PY9

Table 6-4, Table 6-5, and Table 6-6 present program savings due to participation uplift in other EE programs for each wave. For waves without treatment or control customers in a specific ComEd EE program, those programs are not included in the below tables. Overall, the empirical evidence indicates that the HER program caused an increase in other EE program participation of 18 MWh.

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[25] 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.

Table 6-4. Estimates of Double Counted Savings in PY9, Wave 1

	FFR	MESP	Rebate
Median program savings (annual kWh per participant)	592	304	151
Number of treatment customers	489	489	489
Treatment rate of participation, PY9 (%)	2%	0%	0%
Change in rate of treatment participation from pre-program year (%)	0%	-1%	0%
Number of control customers	414	414	414
Control rate of participation, PY9 (%)	1%	0%	0%
Change in rate of control participation from pre-program year (%)	2%	0%	0%
DID or POD statistic	2%	-1%	0%
Participant uplift	10	-3	-1
Statistically significant at the 90% confidence level?	Yes	No	No
Savings attributable to other programs (kWh)	5,825	-913	-187
Percentage change in EE program participation rate for GES participants	-946%	-100%	-100%

Source: ComEd tracking data and Navigant team analysis.

Table 6-5. Estimates of Double Counted Savings in PY9, Wave 2

	FFR	MESP
Median program savings (annual kWh per participant)	592	271
Number of treatment customers	705	705
Treatment rate of participation, PY9 (%)	1%	0%
Change in rate of treatment participation from pre-program year (%)	0%	0%
Number of control customers	601	601
Control rate of participation, PY9 (%)	1%	0%
Change in rate of control participation from pre-program year (%)	0%	0%
DID or POD statistic	1%	-1%
Participant uplift	5	-4
Statistically significant at the 90% confidence level?	Yes	Yes
Savings attributable to other programs (kWh)	3,044	-1,146
Percentage change in EE program participation rate for GES participants	1,437%	-76%

Source: ComEd tracking data and Navigant team analysis.

Table 6-6. Estimates of Double Counted Savings in PY9, Wave 3

	FFR	MESP
Median program savings (annual kWh per participant)	674	96
Number of treatment customers	424	424
Treatment rate of participation, PY9 (%)	2%	0%
Change in rate of treatment participation from pre-program year (%)	1%	-1%
Number of control customers	402	402
Control rate of participation, PY9 (%)	0%	0%
Change in rate of control participation from pre-program year (%)	-2%	-1%
DID or POD statistic	3%	0%
Participant uplift	14	-1
Statistically significant at the 90% confidence level?	Yes	No
Savings attributable to other programs (kWh)	9,499	-80
Percentage change in EE program participation rate for GES participants	-221%	-100%

Source: ComEd tracking data and Navigant team analysis.

6.3.2 Legacy Uplift

Table 6-7, Table 6-8, and Table 6-9 show double counted savings from each program for PY6 – PY8 respectively. The measure lives for PY6 programs were taken from the EPY6 total resource cost report.[26] Measure lives for SFHES and MESP programs are the simple average of the measures included in that program. The PY7 and PY8 total resource cost reports were not yet available at the time this report was written, so related program measure lives were not included. For the PY9 legacy uplift adjustment Navigant assumed each of these programs had a measure life of at least two years and should be deducted in PY9. Although these tables show estimates of both positive and negative uplift, only positive uplift was used to adjust program savings for double-counting.

Table 6-7. Double Counted Savings (kWh) from PY6

	SFHES	CSR	FFR	MF
Measure Life	8.4	18	8	4.67
Wave 1	1,800	0	0	-155
Double Counted Savings (kWh)	1,800	0	0	0

Source: ComEd tracking data and Navigant team analysis.

Table 6-8. Double Counted Savings (kWh) from PY7

	FFR	HEA	MESP	Rebate
Measure Life	-	-	-	-
Wave 1	-139	78	-35	-9
Wave 2	118	53	24	-†
Double Counted Savings (kWh)	118	131	24	0

Source: ComEd tracking data and Navigant team analysis.
† None of the households in Wave 2 treatment or control groups were in the Rebate program

Table 6-9. Double Counted Savings (kWh) from PY8

	FFR	HEA	MESP	Rebate
Measure Life	-	-	-	-
Wave 1	3,788	1,150	913	839
Wave 2	5,977	1,990	-2,798	984
Wave 3	6,698	7,805	-1,523	-62
Double Counted Savings (kWh)	16,463	10,945	0	0

Source: ComEd tracking data and Navigant team analysis.

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[26] Navigant Consulting, Inc. 2016. *Review of EPY6 Total Resource Cost Test Assumptions.* Presented to Commonwealth Edison Company.