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ComEd
Agentis Business Energy Analyzer Pilot Program Evaluation Report

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Prepared by:

Paul Higgins
Navigant

Anusha Jagannathan
Navigant

William Sierzchula
Navigant

www.navigant.com

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Submitted to:

ComEd
Three Lincoln Centre
Oakbrook Terrace, IL 60181

Submitted by:

Navigant
30 S. Wacker Drive, Suite 3100
Chicago, IL 60606

Contact:

Randy Gunn, Managing Director
312.583.5714
Randy.Gunn@Navigant.com

Jeff Erickson, Director
608.497.2322
Jeff.Erickson@Navigant.com

Patricia Plympton, Associate Director
202.253.9356
Patricia.Plympton@Navigant.com

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E. EXECUTIVE SUMMARY

This report presents a summary of the findings and results from the impact evaluation of Commonwealth Edison's (ComEd's) Business Energy Analyzer (BEA) pilot program. BEA is a free, opt-in program that enables ComEd commercial and industrial (C&I) customers to leverage the energy usage information collected by their recording interval (AMI or AMR[1]) meters via an individualized, cloud-based web platform to gain greater insight and control over their electricity use, improve their energy efficiency, and reduce their utility bills.[2] Agentis Energy (Agentis) is the implementer for BEA in ComEd's service territory.

BEA grew out of a previous C&I behavioral pilot, also administered by Agentis and launched in Program Year 5 (PY5)[3], in which the assignment of customers to treatment and control groups was randomized. In the previous program the treatment customers received mailed reports and were also encouraged to log onto a web platform similar to BEA. ComEd discontinued this program after PY5 because it failed to achieve meaningful energy savings.[4] ComEd began offering BEA to most of its C&I customers in late PY6 and continued through PY7 and PY8. For reporting purposes, Navigant divided BEA participants into three waves based on when they first logged onto the BEA web site and registered their account information. Waves 1-3 comprise the customers who enrolled during PY6, PY7 and PY8, respectively.

This report presents results from all three program years. Navigant focused particular attention on the savings that accrued during PY8, including performing an uplift adjustment to eliminate possible double-counting of savings from that year[5], to enable the inclusion of BEA PY8 program savings in the PY8 portfolio savings report. The PY8 savings are presented in the remainder of this Executive Summary.

E.1. Program Savings

As shown in Table E-1, the BEA pilot program achieved net energy savings of 66,056 MWh in PY8 prior to the uplift adjustment. After the uplift adjustment, the total PY8 net energy savings was 59,217 MWh.

[1] Advanced metering infrastructure (AMI) comprises the integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. Automated meter reading (AMR) refers to technologies that automatically collect consumption, diagnostic, and status data from electric meters and transfer that data to a central database. Both AMI and AMR permit the collection and storage of short-term interval energy usage data.
[2] See the short video clip describing the BEA program available on ComEd's Smart Ideas For Your Business® website (http://www.comed.com/WaysToSave/ForYourBusiness/Pages/BusinessEnergyAnalyzer.aspx) for more information.
[3] PY5 began June 1, 2012 and ended May 31, 2013. PY6 began June 1, 2013 and ended May 31, 2014. PY7 began June 1, 2014 and ended May 31, 2015. PY8 began June 1, 2015 and ended May 31, 2016.
[4] Navigant performed the impact evaluation for the previous program. See "ComEd Commercial & Industrial Behavioral Program PY5 Evaluation Report," presented by Navigant to ComEd on March 11, 2014.
[5] See sections 2.4, 2.43.4, and 6.4 below for discussion of the uplift adjustment.

Table E-1 Total PY8 BEA Energy Savings – All Waves

Savings Category	Energy Savings (MWh)
Ex Ante Gross Savings	NR*
Net Savings Prior to Uplift Adjustment	66,056
Standard Error	*22,418*
Uplift Adjustment	6,839
Net Savings After Uplift Adjustment	59,217
Realization Rate*	-

Source: ComEd data and Navigant analysis.
* NR = Not Reported. Navigant did not receive ex ante savings for this program, and thus did not calculate a realization rate.

E.2. Key Findings and Recommendations

The following section includes some of the program findings and recommendations.[6] The complete set is in section 6.

Finding 1. The BEA program achieved 66,056 MWh of net energy savings in PY8 (59,217 MWh after an adjustment to avoid double-counting of savings resulting from the uplift in participation in other ComEd EE programs induced by participation in BEA).[7] It achieved a total of 78,200 MWh of net energy savings, or 1.5 percent, over the PY6-PY8 period.

Finding 2. Navigant's finding of BEA participants' average daily energy savings over the PY6-PY8 period (126 ± 87 kWh/day)[8], while statistically significant[9], is lower than what was reported by the implementer (222 ± 152 kWh/day).[10] This variance is mainly due to differences in how Navigant and Agentis cleaned the customer energy consumption data used to estimate the savings. In particular, Navigant applied a different screen for high-end outliers, and also used QQ plots to identify and remove poor-quality matches that were clustered at the extreme upper tail of the usage distribution.

Finding 3. Navigant found mixed evidence of savings ramp-up across multiple years in the BEA program impacts. Wave 1 experienced ramp-up between year 1 (PY6) and year 3 (PY8), but Wave 1 savings in year 2 (PY7) was not significantly different from zero. Wave 2 showed ramp-up from year 1 (PY7) to year 2 (PY8). With only one year of experience, Wave 3 cannot yet be evaluated for ramp-up.

Finding 5. The rate of new BEA registrations initially surged in PY6-PY7 following the re-launch of the program in October 2013, but declined steadily in PY8, suggesting that the effect of the launch may be nearing its natural saturation point.

[6] Numbered findings and recommendations in this section are the same as those found in the Findings and Recommendations section of the evaluation report for ease of reference between these sections.
[7] The net savings estimate of 66,056 MWh is significant (p value < 0.01) in a 2-tailed test.
[8] The uncertainty bands about the Navigant and Agentis savings estimates represent 90 percent confidence intervals.
[9] The net savings estimate of 126 kWh per customer per day is significant (p value < 0.02) in a 2-tailed test.
[10] Agentis Energy, "Agentis/ComEd C&I Business Energy Analyzer Report: PY8 Q4."

Recommendation 1. ComEd and Agentis should consider undertaking additional marketing strategies to boost enrollment in BEA.

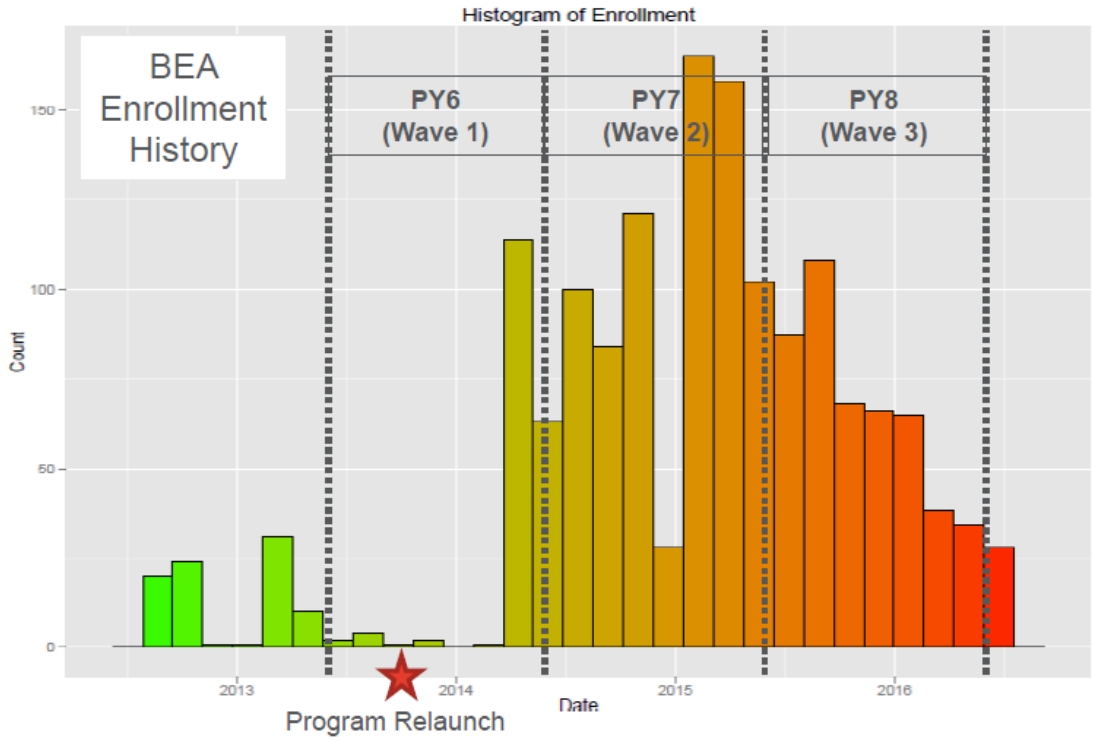
1. INTRODUCTION

1.1 Program Description

The ComEd Business Energy Analyzer (BEA) program is a free, opt-in pilot program designed for ComEd by Agentis Energy (Agentis) that enables ComEd commercial and industrial (C&I) customers to leverage the energy usage data collected by their AMI/AMR meters to gain greater insight and control over their electricity use, improve their energy efficiency, and reduce their utility bills. BEA consists of a suite of self-serve tools that show participating customers how their current energy use compares to what it was in the previous year, as well as to that of other businesses of the same type as their own company. BEA also suggests possible energy efficiency projects to improve their energy efficiency and save money, and identifies ComEd Smart Ideas for Your Business® incentive programs customers may qualify for. Participating customers can use the BEA web platform at any time, and as frequently as they wish. All they need to do in order to participate in the program is go to the BEA page on the ComEd website and provide their ComEd account ID, a valid email address, and the zip code for their business premise. No further actions are required.

Navigant received data for a total of 1,526 customers who participated in BEA. Figure 1-1 shows pattern of enrollment history for BEA customers. For its evaluation, Navigant chose to include only the customers whose enrollment dates fell within the PY6-PY8 period. For the purposes of its analysis, Navigant divided participants in the BEA pilot program into three waves corresponding to the program year in which they signed up.

Figure 1-1. Enrollment History of customers in BEA pilot*



Source: ComEd data and Navigant analysis

* Navigant received data from customers with enroll dates as early as 2012, but restricted analysis to participants who initially logged onto BEA and linked their ComEd account information to the program within the PY6-PY8 timeframe.

Figure 1-1 shows an uneven pattern of enrollment, with a strong surge of customer sign-ups beginning several months after the initial roll-out on October 1, 2013 in late PY6 (denoted by the red star). Enrollments peaked in early 2015 (late PY7), and steadily tapered off throughout PY8. This suggests that the effect of the initial program launch may be nearing its natural saturation point.

1.2 Evaluation Objective

The objectives of this evaluation were to determine the energy savings generated by the BEA pilot program for Wave 1, Wave 2 and Wave 3 during PY6, PY7 and PY8, and to estimate the program's energy savings net of uplift for PY8.

2. EVALUATION APPROACH

For evaluating the impact of a behavior-based energy efficiency program, having a program that is designed as a randomized controlled trial (RCT) is considered optimal, since it results in estimates of program savings that are unbiased and robust. When a randomized design is not feasible or cost-effective, a quasi-experimental approach offers the best available option. Given the design of the revamped BEA program, participants were intrinsically self-selected: BEA was marketed to all eligible ComEd customers equally, and any eligible customer was able to sign up and begin using the BEA tools at any time. Neither ComEd nor Agentis screened applicants or controlled the timing of either their enrollment or their use of the tools available on the BEA site. Thus, an RCT approach was not feasible.

For this reason, Navigant used a quasi-experimental approach to measure BEA program savings. The approach compared the energy consumption of program participants to that of a set of carefully matched non-participants using regression analysis. This method, known as regression with pre-program matching (RPPM), is described in Ho, Imai, King, and Stuart.[11]

2.1 Matching Algorithm

The matching method relied on energy usage data obtained from the meters of program participants, as well as from a set of non-participating customers, to estimate program savings. The pool of non-participants from which the matches were drawn consisted of a large (n=23,755) sample of eligible non-participant ComEd C&I customers. For each BEA participant, Navigant compared the average daily energy consumption in each month during the pre-enrollment year to that of all customers in the pool of potential matches over the same period. For each comparison, Navigant calculated the difference in average daily energy use in the given month, D_{PM} (**D**ifference between **P**articipant and potential **M**atch). The quality of the potential match was indicated by the Euclidean distance between their usage and that of the participant calculated over the matching period. Denoting the sum of squared D_{PM} over the matching period by SSD, the match quality was defined as $\sqrt{SSD}$. The non-participant whose energy usage minimized this distance during the pre-enrollment year was chosen as the match for that participant. Matching was done with replacement.

2.2 Data Used in Impact Analysis

In preparation for the impact analysis, Navigant combined and cleaned the data provided by the implementer. The dataset contained daily interval energy usage data for 1,526 treatment customers and 23,761 potential matched controls. Data covering each enrollment wave's time in the program, along with corresponding usage data from the year prior to each wave's enrollment year for matching purposes, was used in the PPR analysis as described in Section 2.3. Navigant rolled the one-day interval data up to calendar months for each customer for purposes of matching.

[11] Daniel Ho, Kosuke Imai, Gary King, Elizabeth A. Stuart, "Matching as Nonparametric Preprocessing for Reducing Model Dependence in Parametric Causal Inference," *Political Analysis* (2007) 15: 199-236. Downloadable at: http://gking.harvard.edu/files/matchp.pdf. See also Guido W. Imbens and Donald B. Rubin, *Causal Inference for Statistics, Social and Biomedical Sciences: An Introduction,* Cambridge University Press 2015; Paul J. Gertler et al., *Impact Evaluation in Practice,* International Bank for Reconstruction and Development 2011; and Joshua D. Angrist and Jörn-Steffen Pischke, *Mostly Harmless Econometrics: An Empiricist's Companion,* Princeton University Press 2009.

Prior to matching, Navigant removed customers and data points from the participant dataset for the following reasons:

- Customers who lacked usage data during their initial enrollment month
- Observations outside the relevant pre- or post-program period
- Customers with fewer than nine months of pre-enrollment usage data
- Observations with negative usage
- Outlier observations, defined as observations with average daily usage more than one order of magnitude from the median usage[12]
- Observations with missing usage.

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

2.3 Statistical Model Used in the Impact Evaluation

Navigant estimated program impacts using daily energy usage data and a post-program regression (PPR) model with lagged controls.[13] Separate runs of the PPR were used to obtain results for reporting total program savings by enrollment wave and program year, total savings by wave over multiple years, and multiple waves for a given year.

Once the matches were selected, Navigant applied the regression model below to the *post-enrollment* usage values of participants and their matched controls[14] from the date of each participant's program entry (as early as October 1, 2013) through the end of PY8 (May 31, 2016):

$$DailykWh_{kt} = \beta_1 Treatment_k + \sum_j \beta_{2j} Month_{jt} + \sum_j \beta_{3j} Month_{jt} \cdot DailykWh\_lag_{kt} + \varepsilon_{kt}$$

where:

$DailykWh_{kt}$ is daily kWh used by customer k on day t of the post-enrollment period

[12] Median energy usage for BEA participants during the pre-program year was 4,554 kWh per day.
[13] The lagged usage terms interacted with month dummies serves a purpose in the PPR model that is conceptually similar to that of the customer fixed effect in a fixed-effects model: namely, controlling for innate inter-customer heterogeneity in energy consumption. The advantage of the PPR model over the fixed effects model is that in the PPR case the customer-specific control can vary seasonally, whereas in the fixed effects model it can't.
[14] While only post-enrollment observations are used to estimate the parameter values of the PPR model, pre-enrollment energy usage enters the model via the lagged usage variable. Navigant assumed that program exposure began for each participant on their start date, when they logged onto the BEA site and registered their account.

$Treatment_k$	denotes whether customer k is a participant (=1) or a matched control (=0)
$DailykWh\_lag_{kt}$	is customer k's mean daily energy use in the same month of the pre-program year as that of the current observation
$Month_j$	comprises a set of binary variables indicating which month the current observation (indexed by t) falls into
ε_{kt}	is a cluster-robust disturbance term for customer k

In the above model, β_1, the regression coefficient on the $Treatment_k$ variable, estimates the average difference in *daily* energy use between the treatment and control groups in the post-enrollment period. To obtain the total program energy savings over the period of evaluation, Navigant multiplied this mean daily program effect by the total number of *post-enrollment customer-days* for all BEA program participants.[15]

2.4 Accounting for Uplift in Other Energy Efficiency Programs

If participation rates in other EE programs were the same for BEA treatment and control groups before and after enrollment, there would be no need to make an uplift adjustment, since this would indicate that, on balance, the BEA pilot program neither increased nor decreased participation in other EE programs. However, if the BEA pilot program affected participation rates in other EE programs, the savings across all programs would be lower (or higher) than indicated by the simple summation of the savings identified in the evaluations of BEA and the other EE programs. For instance, if the BEA pilot program caused BEA participants to increase their participation in another EE program relative to that of the matched control group, the resulting increase in savings from that uplift may be allocated to either the BEA pilot program or the other EE program, but not to both programs simultaneously. Note that in cases when the BEA pilot program led to a decrease in participation in other EE programs there was no question of double-counting and thus no adjustment to the savings total was made.

Data permitting, Navigant used a difference-in-difference (DID) statistic to estimate the induced uplift in other EE programs. To calculate the DID statistic, the change in the participation rate in another EE program between PY8 and the pre-program year for the control group was subtracted from the same change for the treatment group. For instance, if the rate of participation in an EE program during PY8 was 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 BEA pilot program was two percent for the treatment group and one percent for the control group, then the rate of uplift due to the BEA pilot program was one percent, as reflected in Equation 2-1.

Equation 2-1. DID Statistic Calculation

$$\begin{aligned}&(PY8\ treatment\ group\ participation - prePY\ treatment\ group\ participation)\\&\quad - (PY8\ control\ group\ participation - prePY\ control\ group\ participation)\\&\quad = (5\% - 2\%) - (3\% - 1\%) = 1\%\end{aligned}$$

The DID statistic generates an unbiased estimate of the uplift in participation in the other EE programs that was induced by BEA when the baseline average rate of participation is the same for the treatment and control groups, or when they differ due only to differences between the two groups in time-invariant factors, such as the residence's square footage.

[15] Thus, the aggregate savings estimate is pro-rated based on the date each customer first logged onto the BEA website and registered.

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 control groups during PY6 to PY8. 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 treatment and control groups. Navigant used this alternative statistic in cases where the EE program did not exist for the entire pre-program year.

Navigant examined the uplift associated with five EE programs: the Prescriptive program, the Custom program, the Data Centers program, the Retro-commissioning program (RCx) and the New Construction program.

For each EE program, double-counted savings were calculated separately for each wave of the BEA pilot program.[16]

2.5 Process Evaluation

The BEA pilot evaluation did not include a process evaluation.

[16] See Section 6.4 for a complete description of the uplift adjustment calculations.

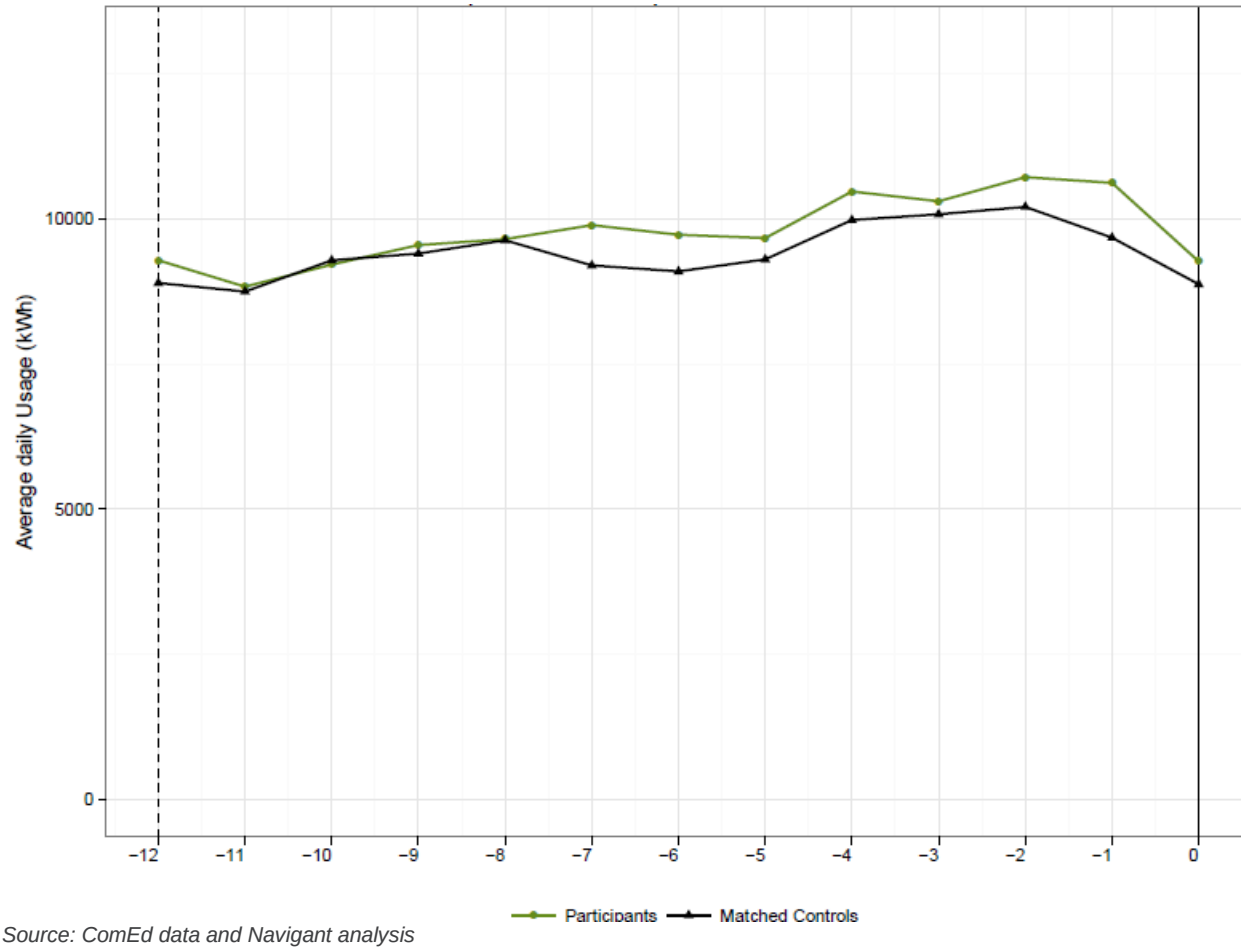
3. GROSS IMPACT EVALUATION

3.1 Matching Results

In the RPPM approach, the development of a matched comparison group is a useful pre-processing step in the regression analysis to assure that the distributions of the covariates (i.e., the explanatory variables on which the outcome variable, energy consumption, depends) are the same in the treatment group and the comparison group. This minimizes the risk of selection bias.

Figure 3-1 through Figure 3-3 show the quality of the matching results for each enrollment wave by comparing the mean daily energy use of the treatment and matched control samples in each month of the matching period (the 12 months prior to each participant's enrollment date).

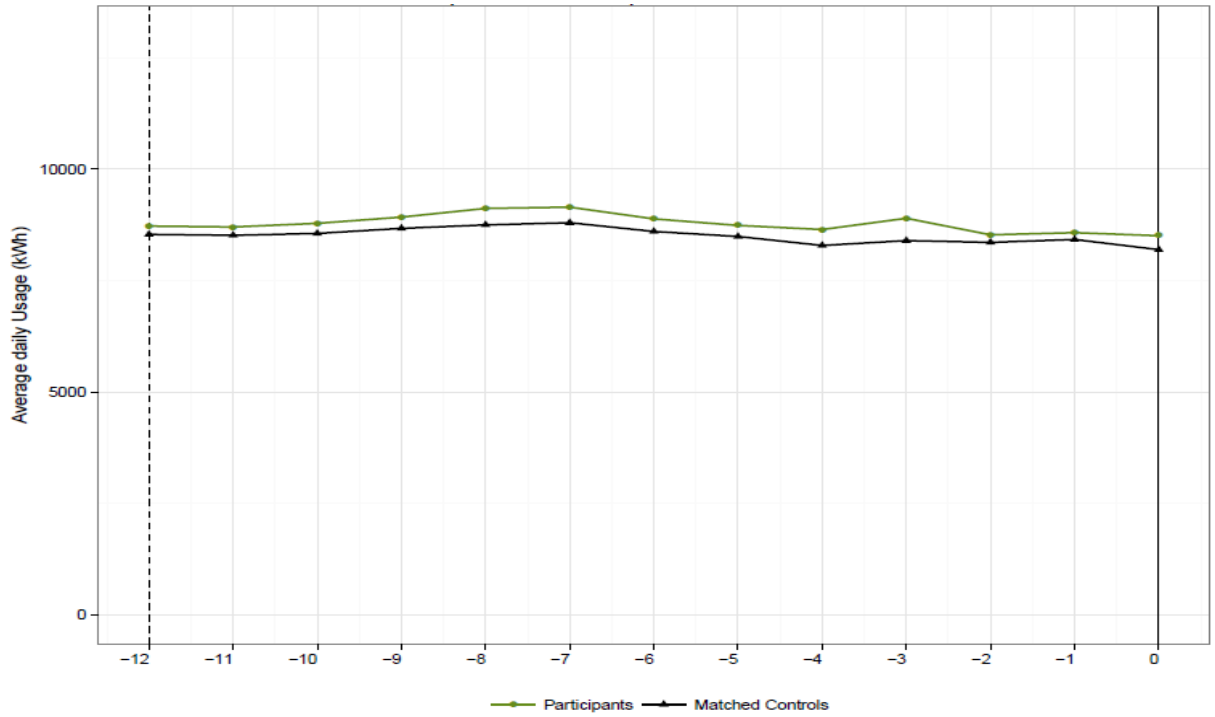
Figure 3-1. Mean Energy Use of Wave 1 Participants and Matches during Pre-Program Year (June 2012- May 2013)*



Source: ComEd data and Navigant analysis

* Plotted points show mean daily energy use per customer for participants and matched controls in each month of the pre-enrollment matching period.

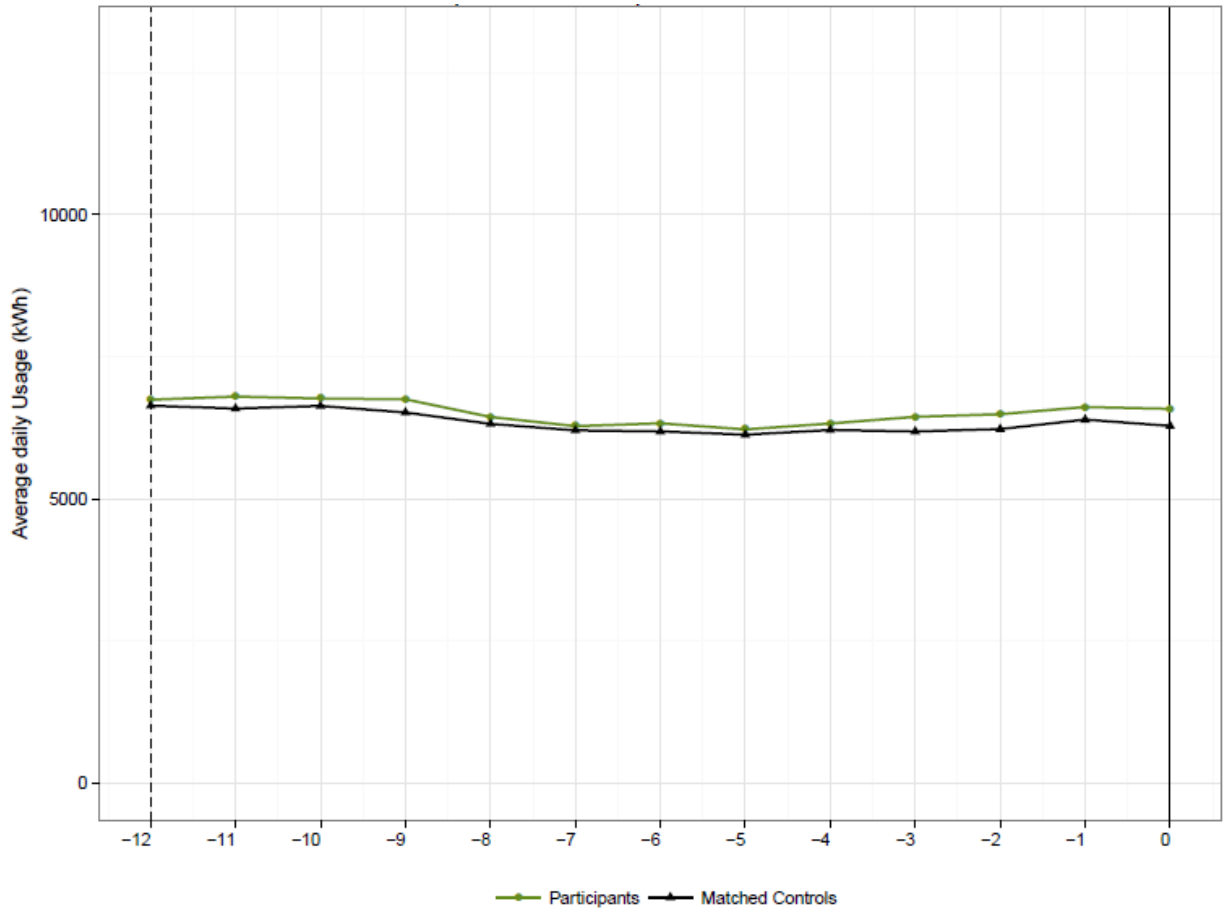
Figure 3-2. Mean Energy Use of Wave 2 Participants and Matches during Pre-Program Year (June 2013- May 2014)*



Source: ComEd data and Navigant analysis

* Plotted points show mean daily energy use per customer for participants and matched controls in each month of the pre-enrollment matching period.

Figure 3-3. Mean Energy Use of Wave 3 Participants and Matches during Pre-Program Year (June 2014- May 2015)*



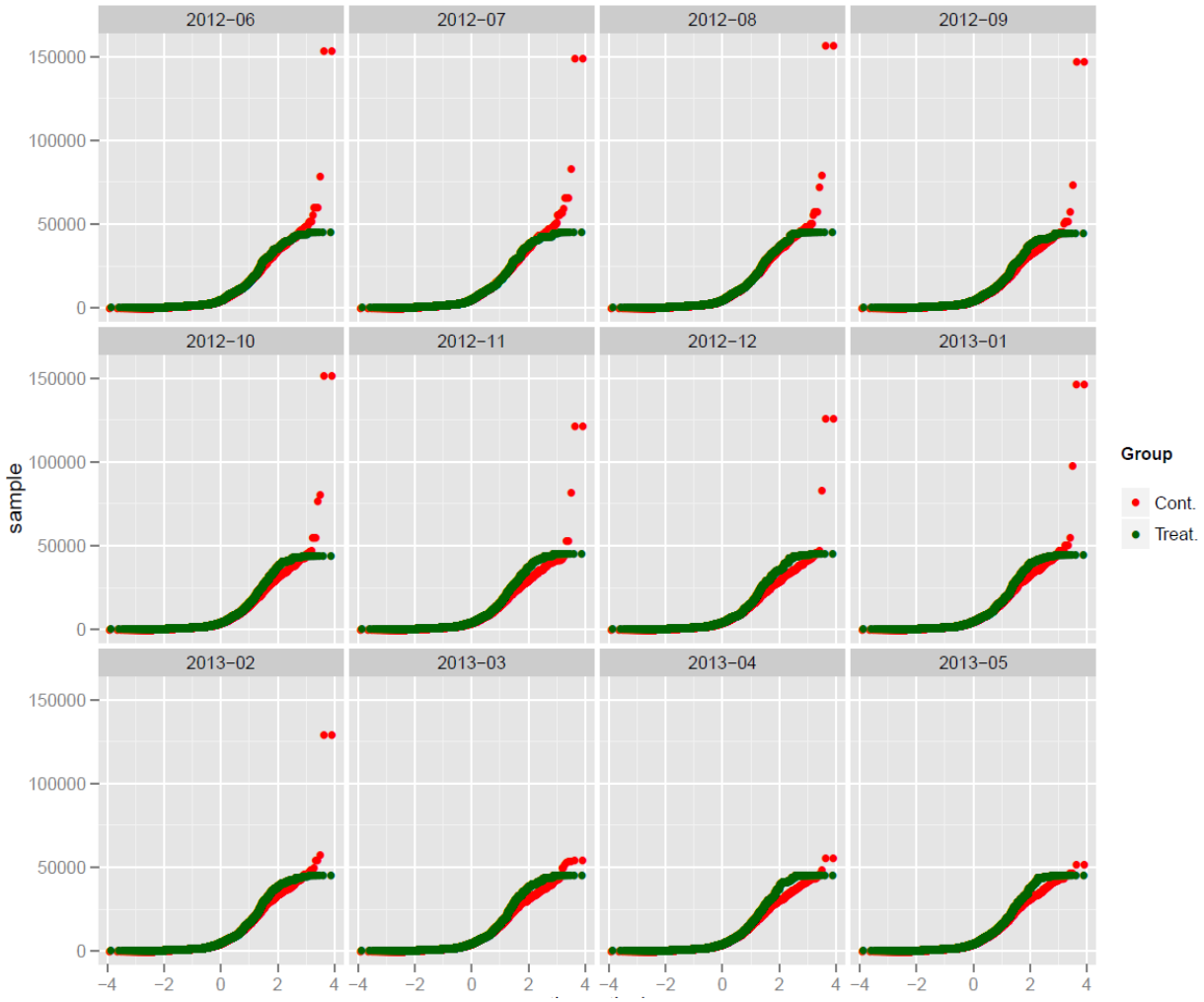
Source: ComEd data and Navigant analysis
* Plotted points show mean daily energy use per customer for participants and matched controls in each month of the pre-enrollment matching period.

Note that the match quality was relatively poor for Wave 1, as indicated by the gaps between the treatment and control group usage means in several of the months of the pre-enrollment year. This was largely a function of the relatively small sample size for Wave 1. The monthly treatment and control means tracked one another more closely in Waves 2 and 3, where the samples were substantially larger.

To further assess match quality prior to performing the regression analysis, Navigant used quantile-quantile (QQ) plots to compare the distributions of energy usage of the participant and matched control groups in each enrollment wave across the full range of usage values in each month of the pre-enrollment year, rather than just comparing the means of the two groups. QQ plots can be particularly useful when monthly usage is skewed or asymmetrically distributed, as is the case here. Figure 3-4 through Figure 3-6

show the monthly QQ plots for the participant and matched control customers for Wave 1, Wave 2 and Wave 3, respectively.[17]

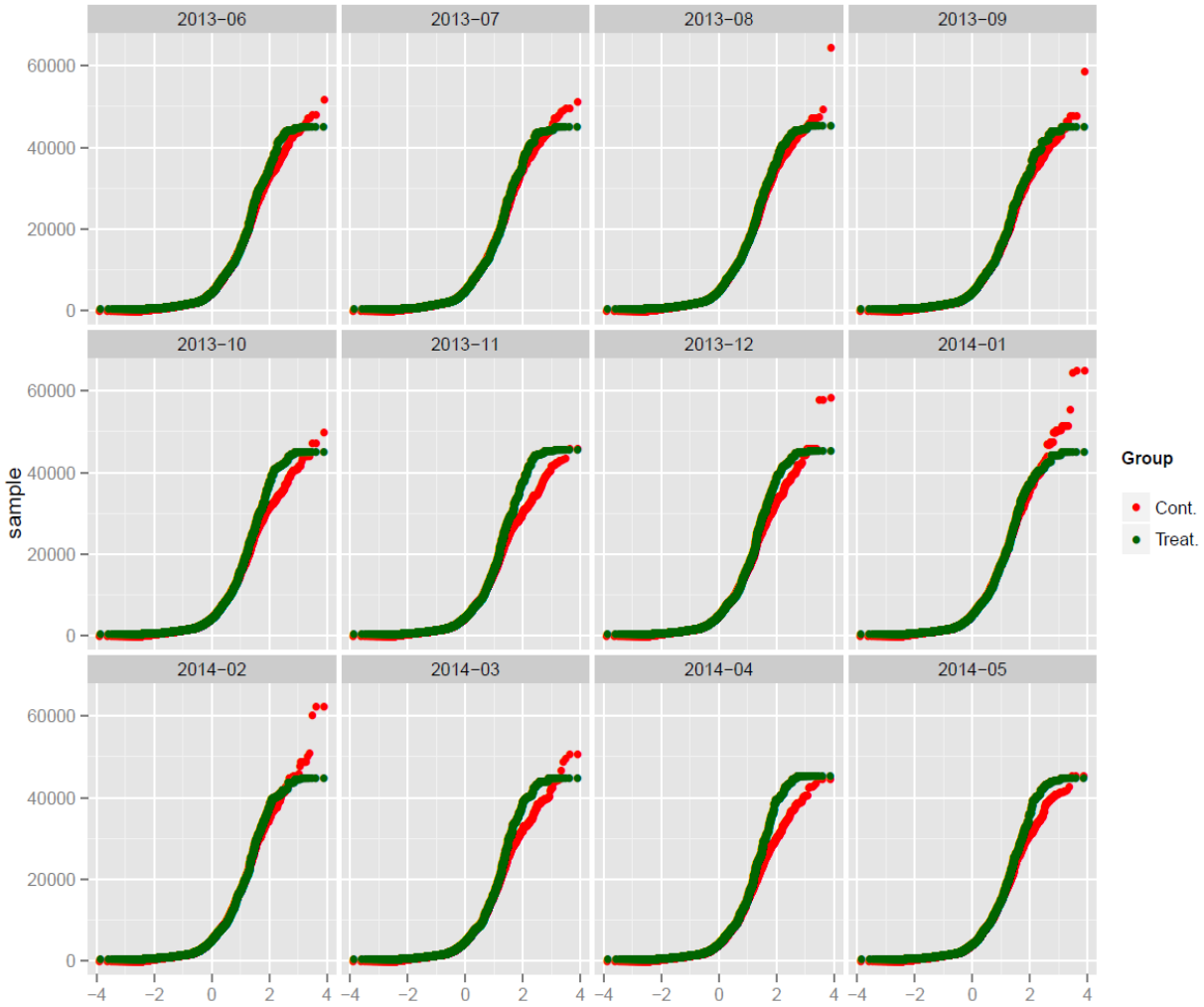
Figure 3-4. Plots of Participant and Match Group Usage Quantiles by Month – Wave 1



Source: ComEd data and Navigant analysis

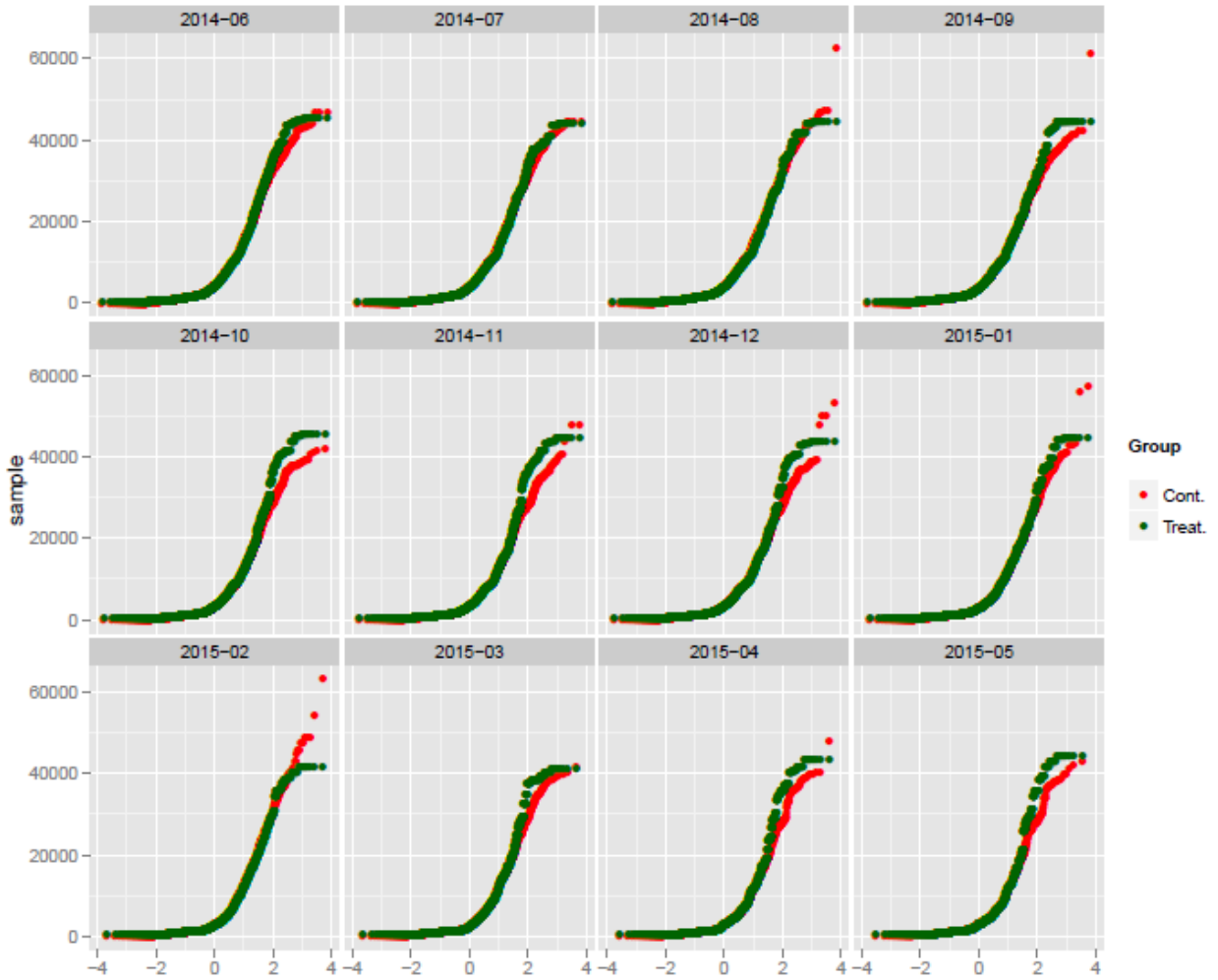
[17] Each QQ plot contains one pane per month of the relevant pre-enrollment year. The green and red curves consist of the percentile values of usage per day in kWh (measured on the vertical axis) plotted against the number of standard deviations from the mean (horizontal axis). As in Figure 3-1 through **Error! Reference source not found.**, match quality is indicated by the size of the gap (or lack thereof) between the treatment and control groups – but in this case by percentile rather than just at the means. A perfect match at every percentile would cause the green and red curves to perfectly coincide.

Figure 3-5. Plots of Participant and Match Group Usage Quantiles by Month – Wave 2



Source: ComEd data and Navigant analysis.

Figure 3-6. Plots of Participant and Match Group Usage Quantiles by Month – Wave 3



Source: ComEd data and Navigant analysis.

Sizeable gaps are evident in a number of months during the matching periods in all three waves, but especially in the first three quarters of Wave 1 and the third quarter of Wave 2. In all cases, poor match quality occurred at the extreme upper tail of the usage distribution. In every case, the deviations resulted from upside outliers in the set of matched controls. After examining the individual usage values of the matched controls, Navigant chose to add an additional data screen before proceeding to the regression analysis: we dropped matched control customers whose usage exceeded 50,000 kWh per day.[18]

3.2 Gross Savings

Table 3-1 summarizes the key results by participation wave for the BEA pilot. In this table, the first row shows the number of BEA participants in each wave, while the values in the second and third rows indicate the number of participant and matched control customers with sufficient data for inclusion in the regression analysis. The weighted average per customer savings estimate was 1.48 percent (126 kWh annually) for all waves for PY6 - PY8.

[18] When a matched control was dropped for this reason, the corresponding participant was also dropped from the regression analysis. See Section 6.1 for more information.

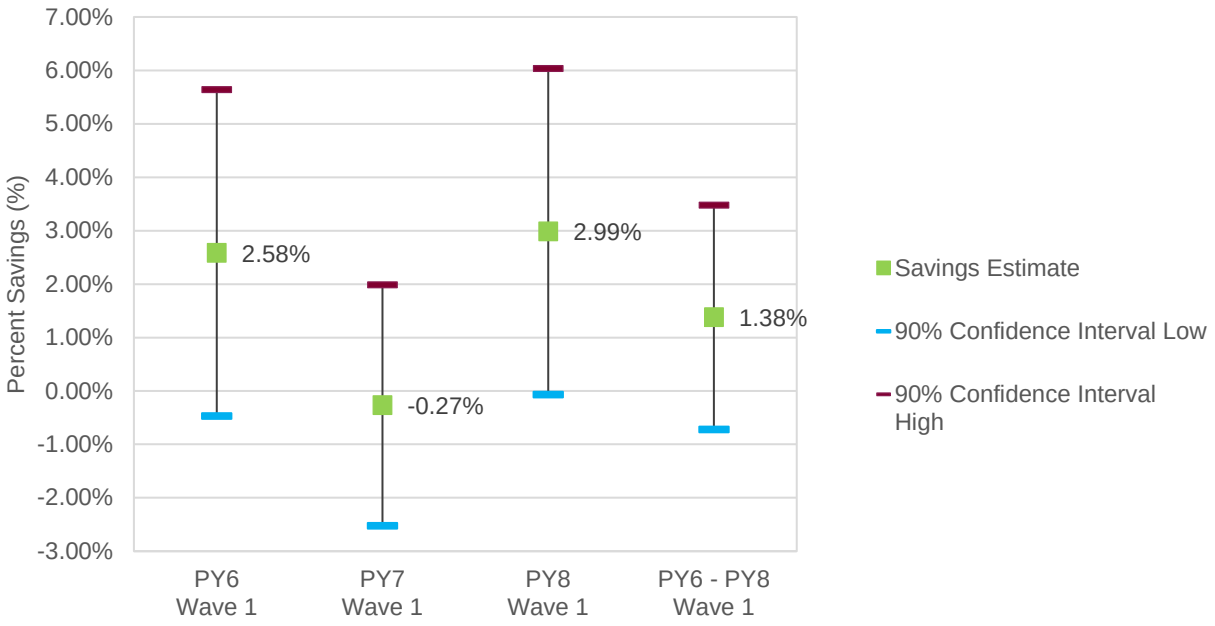
Table 3-1. Total BEA Pilot Program Results by Enrollment Wave

Type of Statistic	Wave 1	Wave 2	Wave 3	All Waves Combined
Number of Participants w/ usable data*	138	748	488	1,374
Sample Sized used in Regression – Participants†	123	663	244	1,030
Sample Size used in Regression – Controls†	119	610	234	963
Percentage Gross Savings	1.38%	1.44%	1.81%	1.48%
Standard Error	*1.28%*	*0.74%*	*1.46%*	*0.62%*
Average Savings Per Customer Per Day, kWh	126	127	113	126
Standard Error	*117*	*65*	*91*	*53*
Total Gross Savings MWh‡	13,560	50,504	13,085	78,200
Standard Error	*12,564*	*25,873*	*10,586*	*32,748*

Source: ComEd data and Navigant analysis.
* I.e., participants with sufficient data falling within the PY6-PY8 analysis period.
† Count reductions reflect the results of data cleaning prior to the regression analysis. Control counts reflect the number of *unique* controls; matching was done with replacement, so some controls were matched to multiple participants.
‡ Total savings are pro-rated to account for participants' actual enrollment dates, as well as account closures and opt-outs. Wave totals don't sum to "All Waves Combined" total because a separate regression was applied to data of all three waves combined to obtain the aggregate result.

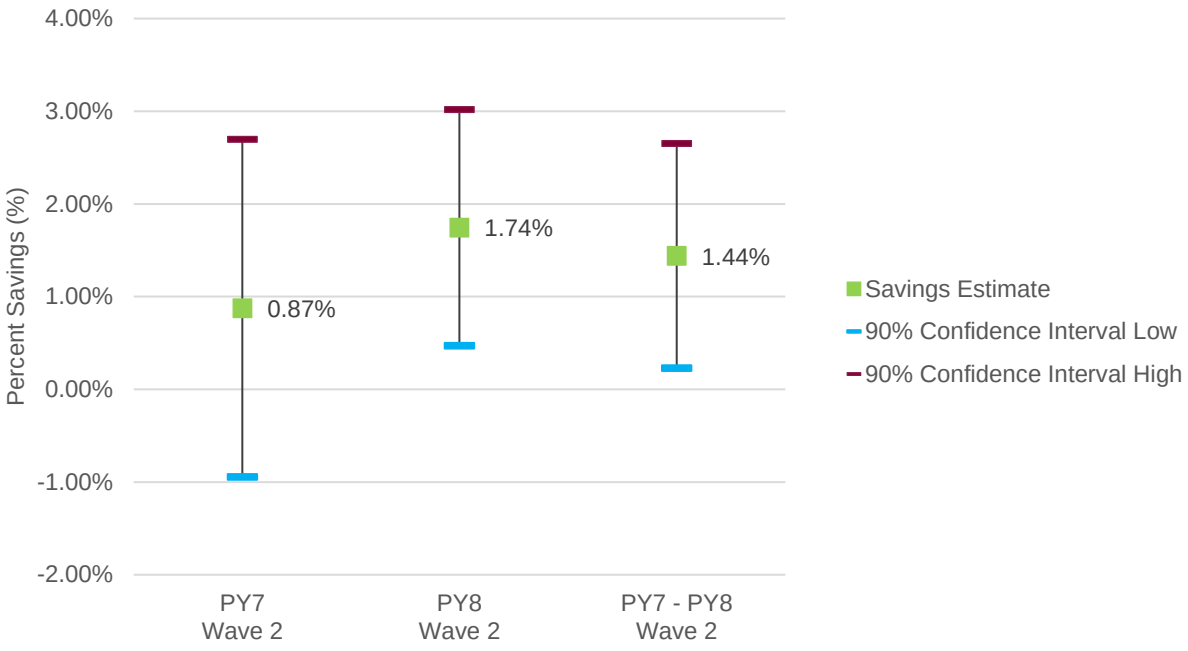
Navigant also analyzed each enrollment wave separately by program year. Figure 3-7 through Figure 3-9 show percentage energy savings for each wave in each program year, as well as by wave pooling across years, with the associated 90 percent confidence intervals. Results with larger confidence bounds should be viewed as being less precise than those with tighter bounds.

Figure 3-7. Percent Savings by Year for Wave 1



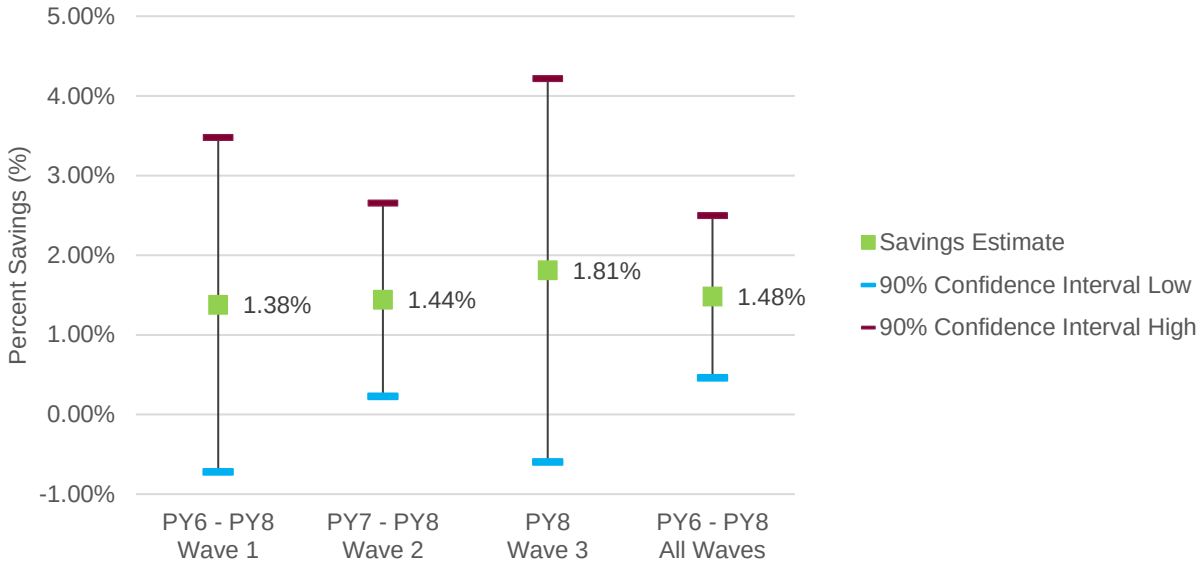
Source: ComEd data and Navigant analysis.

Figure 3-8. Percent Savings by Year for Wave 2



Source: ComEd data and Navigant analysis.

Figure 3-9. Percent Savings by Year for Wave 3, and All Years for Waves 1 and 2



Source: ComEd data and Navigant analysis.

3.3 Reconciling Navigant and Agentis Savings Estimates

Agentis reported aggregate energy savings of 222 ± 152 kWh/day for all BEA participants, pooling all enrollment waves and program years PY6 through PY8. In contrast, Navigant found savings of 126 ± 87 kWh/day pooling waves and program years. To reconcile these divergent results, Navigant identified three key areas where differences in analytical approach might lead to different findings, in order to identify which of them are driving the variance. These include differences in:

- Data cleaning and matching
- Level of data aggregation used in the regression analysis
- The regression model used

In discussions with Agentis, Navigant confirmed that the matching algorithms used to select matched controls were the same for the two analyses. However, Navigant's data cleaning methodology differed in key respects from that used by Agentis: whereas both Agentis and Navigant screened out customers with insufficient data[19], Agentis performed a uniform screen that excluded participants at or above the top 5th percentile of annual usage from their regression analysis. Navigant performed a different outlier screen, excluding observations with average daily usage more than one order of magnitude from the median, as described in Section 6.1. In addition, as described in Section 3.1, Navigant scrutinized the post-matching quality of individual matches using QQ plots, which resulted in the exclusion of a number of additional extreme high-end users from the regression analysis.

Another key difference had to do with the level of data aggregation used in Agentis's and Navigant's regression analyses. While Agentis chose to fit its PPR regression model to customer data that had been aggregated to the average daily energy usage in monthly observations, Navigant's regression analysis relied on actual daily usage values. Finally, Agentis's and Navigant's regression models are similar, but Navigant's model contained additional terms as explanatory variables – the lagged average daily usage term was interacted with each month-year dummy variable.[20]

To test whether the level of data aggregation or the specific regression model used were responsible for the divergence between Agentis's and Navigant's main impact findings, Navigant reran its regression using the Agentis model and a data set that had been cleaned in the manner described in this report, but which had been aggregated up to monthly average daily usage values. The model results did not change Navigant's key finding significantly.[21]

This exercise confirmed that the key factor driving the difference in savings estimates between Agentis and Navigant is the different approaches each took to data cleaning and screening.

3.4 Uplift of Savings in Other EE Programs

The program savings estimates shown above include savings resulting from the uplift in participation in other EE programs induced by participation in the BEA pilot program. To avoid double-counting savings, program savings due to this uplift must be counted towards either the BEA pilot program or the other EE

[19] For a description of Navigant's data cleaning screens, see Sections 2.2 and 6.1 of this report. For a description of Agentis's data cleaning approach, see Agentis Energy, "Agentis/ComEd C&I Business Energy Analyzer Report: PY8 Q4," p. 4.
[20] For Navigant's modeling approach, see Section 2.3 of this report. For Agentis's approach, see Agentis, ibid. p. 4.
[21] Employing Agentis's model and level of data aggregation but Navigant's method of data cleaning and post-match validation caused Navigant's average customer savings estimate to change from 126 ± 87 kWh/day to 127 ± 89 kWh/day – a completely non-significant change.

programs, but not both.[22] At ComEd's request, Navigant assessed the uplift induced by BEA for five programs in PY8: the Prescriptive, Custom, Data Centers, Retro-Commissioning, and New Construction programs. The results of the uplift adjustment are shown in Table 3-2.

Table 3-2. Uplift Adjustment for PY8 BEA Savings – All Waves

Savings Category	Energy Savings (MWh)
Net Savings, Prior to Uplift Adjustment	66,056
*Standard Error**	*22,418*
Uplift Adjustment	6,839
Final Verified Net Savings	59,217

Source: ComEd data and Navigant analysis.

* The net savings estimate of 66,056 MWh is significant (p value < 0.01) in a 2-tailed test.

The uplift of savings in other EE programs was a relatively large proportion of the total BEA energy savings: 6,839 MWh, or 10.4 percent of total savings prior to the adjustment. This is a larger percentage than Navigant typically finds when evaluating behavioral EE programs.[23]

Details of the uplift calculation for each of the five ComEd EE programs considered in the analysis are shown in Section 6.4.

[22] This is purely an accounting adjustment to avoid double-counting savings when summing savings across programs for the purposes of the portfolio-level cost-effectiveness analysis. It does not imply that the BEA program did not *cause* the uplift savings, nor that the uplift savings from these other EE programs don't "belong" to BEA in a causal sense. On the contrary, in Navigant's view *uplift savings should be understood as an additional benefit of the BEA program*, since it represents the fruits of successful cross-marketing by BEA. By raising participants' awareness of their energy consumption, and providing them with specific recommendations for Smart Ideas® incentive programs that they qualify for, BEA drove additional participation in several other EE programs. The implication is that the uplift savings would not have occurred were it not for BEA.

[23] It should be noted that most of these other behavioral programs on which Navigant bases its comment target residential customers. It is possible that a larger uplift may be more typical of programs targeting C&I customers.

4. NET IMPACT EVALUATION

Program savings calculated using the RPPM approach are inherently net savings, due to the use of a matched control group. As long as the participant and control groups are similar with respect to the distribution of factors driving spillover and free-ridership, the nature of the savings calculation ensures that the effects will be differenced out. Therefore, no further net-to-gross (NTG) adjustment is necessary.

5. FINDINGS AND RECOMMENDATIONS

This section includes program findings and recommendations.

Finding 1. The BEA program achieved 66,056 MWh of net energy savings in PY8 (59,217 MWh after an adjustment to avoid double-counting of savings resulting from the uplift in participation in other ComEd EE programs induced by participation in BEA).[24] It achieved a total of 78,200 MWh of net energy savings, or 1.5 percent, over the PY6-PY8 period.

Finding 2. Navigant's finding of BEA participants' average daily energy savings over the PY6-PY8 period (126 ± 87 kWh/day)[25], while statistically significant[26], is lower than what was reported by the implementer (222 ± 152 kWh/day).[27] This variance is mainly due to differences in how Navigant and Agentis cleaned the customer energy consumption data used to estimate the savings. In particular, Navigant applied a different screen for high-end outliers, and also used QQ plots to identify and remove poor-quality matches that were clustered at the extreme upper tail of the usage distribution.

Finding 3. Navigant found mixed evidence of savings ramp-up across multiple years in the BEA program impacts.[28] Wave 1 showed ramp-up between year 1 (PY6) and year 3 (PY8), but the savings for Wave 1 in year 2 (PY7) was not significantly different from zero. Wave 2 showed ramp-up from year 1 (PY7) to year 2 (PY8). With only one year of experience, Wave 3 cannot yet be evaluated for ramp-up.

Finding 4. Navigant determined that Wave 1 had zero savings in PY7, which is anomalous relative to the other findings. Discussions with the implementer suggested that the small size of Wave 1, coupled with the fact that Wave 1 contained holdovers from Agentis's previous C&I behavioral program, which meant their experience with the program differed from those of the other waves, are likely the reason for this unusual pattern.

Finding 5. The rate of new BEA registrations initially surged starting several months after the re-launch of the program in October 2013 and continued through PY7. However, it declined steadily throughout PY8, suggesting that the effect of the launch may be nearing its natural saturation point.

Recommendation 1. ComEd and Agentis should consider undertaking additional marketing strategies to boost enrollment in BEA.

[24] The net savings estimate of 66,056 MWh is significant (p value < 0.01) in a 2-tailed test.
[25] The uncertainty bands about the Navigant and Agentis savings estimates represent 90 percent confidence intervals.
[26] The net savings estimate of 126 kWh per customer per day is significant (p value < 0.02) in a 2-tailed test.
[27] Agentis Energy, "Agentis/ComEd C&I Business Energy Analyzer Report: PY8 Q4."
[28] Ramp-up refers to the phenomenon of average savings per customer tending to rise over time as participants gain greater experience with the program. The expectation of seeing ramp-up in behavioral EE programs is based solely on experience with programs aimed at residential customers. Navigant believes there are reasons to expect behavioral programs targeting C&I customers to exhibit different responses over time.

6. APPENDIX

6.1 Detailed Data Cleaning

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

- Customers who lack usage data for their initial enrollment month
- Customers with fewer than nine months of pre-enrollment usage data
- Observations with negative usage;
- Outliers, defined as observations with average daily usage more than one order of magnitude from the median usage[29]
- Observations with missing usage;
- Observations outside the relevant pre- or post-program period
- Outliers identified after examination of post-match QQ plot.

Table 6-1 gives counts of customers and observations removed for each data cleaning step. The table also provides the percentage of customers or observations removed by each step.

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

Data Cleaning Step	Observations	# Observations Removed	Customers	# Customers Removed	% Customers Removed
Raw Data	81,706	n.a.	1,526	n.a.	n.a.
Remove customers lacking usage data in the initial enrollment month	79,841	1,865	1,466	60	4%
Remove observations w/ fewer than nine months of pre-enrollment usage data	65,159	14,682	1,166	300	20%
Remove observations w/ negative usage	65,159	0	1,166	0	0%
Remove outlier observations	58,350	6,809	1,156	10	1%
Exclude observations w/ missing usage	58,350	0	1,156	0	0%
Exclude observations outside of analysis period	54,974	3,376	1,093	63	4%

Source: ComEd data and Navigant analysis.

[29] Median usage for BEA participants in the pre-enrollment year was 4,554 kWh per day.

6.2 Detailed Impact Methodology

Navigant estimated BEA program impacts by applying the following post-program regression (PPR) model with lagged controls to the post-enrollment daily interval usage data of BEA participants and matched controls that survived the data cleaning process. Separate runs of the PPR were used to obtain results for reporting total program savings by enrollment wave and program year, total savings by wave over multiple years, and multiple waves for a given year.

Once the matches were selected, Navigant applied the regression model below to the *post-enrollment* usage values of participants and their matched controls[30] from the date of each participant's program entry (as early as October 1, 2013) through the end of PY8 (May 31, 2016):

$$DailykWh_{kt} = \beta_1 Treatment_k + \sum_j \beta_{2_j} Month_{jt} + \sum_j \beta_{3_j} Month_{jt} \cdot DailykWh\_lag_{kt} + \varepsilon_{kt}$$

where:

$DailykWh_{kt}$	is daily kWh used by customer k on day t of the post-enrollment period
$Treatment_k$	denotes whether customer k is a participant (=1) or a matched control (=0)
$DailykWh\_lag_{kt}$	is customer k's mean daily energy use in the same month of the pre-program year as that of the current observation
$Month_j$	comprises a set of binary variables indicating which month the current observation (indexed by t) falls into
ε_{kt}	is a cluster-robust disturbance term for customer k

In the above model, β_1, the regression coefficient on the $Treatment_k$ variable, estimates the average difference in *daily* energy use between the treatment and control groups in the post-enrollment period. To obtain the energy savings over the period of evaluation, Navigant multiplied this mean daily program effect by the total number of *post-enrollment customer-days* for all BEA program participants.

6.3 Detailed Savings by Program Year and Enrollment Wave

Detailed results for each program year and wave are shown in Table 6-2 through Table 6-4.

[30] While only post-enrollment observations are used to estimate the parameter values of the PPR model, pre-enrollment energy usage enters the model via the lagged usage variable. Navigant assumed that program exposure began for each participant on their start date, when they logged onto the BEA site and registered their account.

Table 6-2. BEA Agentis Pilot Program Results for Wave 1

Wave 1	Time Period	Savings
Participants	Wave 1	147
Participants used in analysis	Wave 1	138
Matched controls used in analysis	Wave 1	120
Average savings per customer per day	PY6	195
Cluster robust standard error	PY6	140
Percent savings	PY6	2.58%
Average savings per customer per day	PY7	-25
Cluster robust standard error	PY7	128
Percent savings	PY7	-0.27%
Average savings per customer per day	PY8	273
Cluster robust standard error	PY8	170
Percent savings	PY8	2.99%
Average savings per customer per day	PY6-PY8	126
Cluster robust standard error	PY6-PY8	117
Percent savings	PY6-PY8	1.38%

Source: ComEd data and Navigant analysis.

Table 6-3. BEA Agentis Pilot Program Results for Wave 2

Wave2	Time Period	Customers
Participants	Wave 2	761
Participants used in analysis	Wave 2	663
Matched controls used in analysis	Wave 2	613
Average savings per customer per day	PY7	89
Cluster robust standard error	PY7	113
Percent savings	PY7	0.87%
Average savings per customer per day	PY8	127
Cluster robust standard error	PY8	65
Percent savings	PY8	1.74%
Average savings per customer per day	PY7-PY8	127
Cluster robust standard error	PY7-PY8	65
Percent savings	PY7-PY8	1.44%

Source: ComEd data and Navigant analysis.

Table 6-4. BEA Agentis Pilot Program Results for Wave 3

Wave 3	Time Period	Customers
Participants	Wave 3	503
Participants used in Analysis	Wave 3	244
Matched Controls used in Analysis	Wave 3	238
Average savings per customer per day	PY8	113
Cluster robust standard error	PY8	91
Percent savings	PY8	1.81%

Source: ComEd data and Navigant analysis.

6.4 Savings Due to Participation Uplift in Other EE Programs

Table 6-5 through Table 6-7 show the calculation of program savings for each wave due to participation uplift in other EE programs in PY8. Each table provides the uplift for a single program enrollment wave in

each of five EE programs for which estimates of deemed savings are available: Prescriptive, Custom, Data Centers, Retro-commissioning (RCx), and New Construction.

In all of the tables, a dash (-) in a row concerning the change in rate of participation from the pre-program year indicates the EE program did not exist for the entire pre-program year, or that none of the treatment or control customers participated. For all cases where neither the treatment or controls customers participated 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 BEA 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 6-5. Estimates of Double-Counted Savings: Wave 1[31]

	Program		
	Custom	Prescriptive	RCx
Median program savings (annual kWh per participant)	244,176	436,346	1,606,603
Number of treatment customers	123	123	123
Treatment rate of participation, PY8	0%	0%	1%
Change in rate of treatment participation from pre-program year	-2%	-2%	-
Number of control customer	120	120	120
Control rate of participation, PY8	0%	0%	0%
Change in rate of control participation from pre-program year	-3%	-1%	-
DID statistic	1%	-1%	1%
Participant uplift	1	-1	1
Statistically significant at the 90% confidence level?	No	No	No
Savings attributable to other programs (kWh)	262,489	-425,438	1,606,603
Percentage change in EE program participation rate for BEA participants	-100%	-100%	Inf

Source: ComEd data and Navigant analysis.

[31] -100% or Inf in percentage change in EE program participation indicates if there were no participants or controls in either pre or program periods.

Table 6-6. Estimates of Double-Counted Savings: Wave 2

	Program			
	Custom	Data Center	Prescriptive	RCx
Median program savings (annual kWh per participant)	481,918	398,277	230,493	335,868
Number of treatment customers	663	663	663	663
Treatment rate of participation, PY8	0%	0%	1%	0%
Change in rate of treatment participation from pre-program year	0%	-	-	0%
Number of control customer	619	619	619	619
Control rate of participation, PY8	0	0	0	0
Change in rate of control participation from pre-program year	0%	-	-	0%
DID statistic	0%	0%	1%	0%
Participant uplift	-1	1	8	1
Statistically significant at the 90% confidence level?	No	No	Yes	No
Savings attributable to other programs (kWh)	-481,918	398,277	1,843,945	383,617
Percentage change in EE program participation rate for BEA participants	-100%	Inf	Inf	-100%

Source: ComEd data and Navigant analysis.

Table 6-7. Estimates of Double-Counted Savings: Wave 3

	Program		
	Custom	New Construction	Prescriptive
Median program savings (annual kWh per participant)	172,723	113,584	157,683
Number of treatment customers	244	244	244
Treatment rate of participation, PY8	0%	0%	6%
Change in rate of treatment participation from pre-program year	-	-	5%
Number of control customer	238	238	238
Control rate of participation, PY8	0%	0%	0%
Change in rate of control participation from pre-program year	-	-	-1%
DID statistic	0%	0%	5%
Participant uplift	1	1	13
Statistically significant at the 90% confidence level?	No	No	Yes
Savings attributable to other programs (kWh)	172,723	113,584	2,057,827
Percentage change in EE program participation rate for BEA participants	Inf	Inf	669%

Source: ComEd data and Navigant analysis.