NAVIGANT

ComEd Energy Advisor Monitoring-Based Commissioning Program Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Plan Year 9 (PY9)

Presented to Commonwealth Edison Company

FINAL

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's PY9 Energy Advisor Monitoring-Based Commissioning (Energy Advisor) Program. The energy impacts of the program are summarized in the main body of the report, and details of the impact analysis methodology are presented in the appendix. PY9 covers June 1, 2016 through December 31, 2017.

2. PROGRAM DESCRIPTION

The Energy Advisor Program is an energy efficiency program designed and operated for ComEd by Power TakeOff (PTO) that provides qualified ComEd business customers[1] with energy management and information system (EMIS) services to better manage their energy usage, identify energy savings opportunities, and achieve energy savings through low- or no-cost energy-saving measures. The Energy Advisor Program follows a step-by-step process to identify customers with significant potential for low- or no-cost energy savings, work with them to understand their energy usage and identify savings opportunities, enroll them in the Energy Advisor Program, and monitor their progress throughout the program. All energy savings actions taken by each participant are documented as part of the program, and PTO estimates energy savings throughout the year for each action using a regression analysis of the participant's pre- and post-enrollment energy usage data.

Unlike behavioral energy efficiency programs that provide participating customers with generic energy savings recommendations, where little or nothing is known about the specific actions taken by individual participants, the Energy Advisor Program collects a substantial amount of information about each participant, including a detailed log of each contact PTO had with the customer, the actions each participant agreed to take, and the date each action was undertaken.[2] Additionally, the program collects at least one year of pre-enrollment and three to six months of post-enrollment interval usage data from each meter.

The program had 75 participants in PY9 and 79 energy management projects, as shown in the following table.

Table 2-1. PY9 Volumetric Findings Detail

Participation	
Participants	75
Installed Projects*	79

* 3 customers had multiple projects
Source: ComEd tracking data and Navigant team analysis.

[1] To qualify, a participant must be a ComEd business customer with at least one year of 30-minute interval AMI energy usage data available.
[2] Recommended actions may include, but are not limited to, adjusting HVAC schedules to match occupancy, installing smart timers to turn off unneeded equipment during off hours, managing equipment start-up and shut-down schedules, and delamping.

3. Program Savings

Table 3-1 summarizes the energy savings the Energy Advisor Program achieved in PY9. The program net-to-gross ratio (NTGR) is deemed at 1.0 for PY9.[3]

Table 3-1. PY9 Total Annual Incremental Savings

Participation	Energy Savings (kWh)	Demand Savings (kW)†	Peak Demand Savings (kW)†
Ex Ante Gross Savings	1,684,291*	NA	NA
Program Realization Rate	120%	NA	NA
Verified Gross Savings	2,020,622	NA	NA
Program Net-to-Gross Ratio (NTGR)	1.0	NA	NA
Verified Net Savings	2,020,622	NA	NA

* These are ex post savings estimated by the implementer, PTO.
† The program did not estimate demand savings and Navigant's impact methodology does not produce demand savings.
Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

The Energy Advisor Program does not track savings by measure.

5. Impact Analysis Findings and Recommendations

The Energy Advisor Program does not have relevant impact parameters. Total PY9 verified savings were 2,020,622 kWh. Further detail on site-level Energy Advisor changes and realization rates can be found in Section 7.

Finding 1: The regression models PTO used to estimate energy savings for sites with HVAC-related energy saving actions differed in one material way from Navigant's model. PTO's HVAC-related change variable(s) were interacted with heating (HDD) and cooling (CDD) degree-days. This has the effect of forcing the coefficients associated with the change variables – which form the basis of the energy savings calculation – to reflect only energy impacts which are correlated with the weather variables. Navigant's model takes a more agnostic approach, including just one pair of degree-day variables, not interacted with the change dummy variable(s). This difference affected the site-level realization rates. Specifically, in the case of HVAC changes, PTO's models typically resulted in somewhat lower savings values than the verified savings obtained by Navigant.

Recommendation 1: Specify models with one pair of degree-day variables and post-change dummy variables, as in Equation 1 in the appendix.

Finding 2: In some cases, PTO chose to remove month variables from a regression model if they were found to be statistically insignificant. In a forecasting or simulation context this is not a

[3] The Illinois Stakeholders Advisory Group (SAG) consensus process agreed to a NTGR of 1.0 for this program for PY9. See http://ilsagfiles.org/SAG_files/NTG/2016_NTG_Meetings/Final_Documents/ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx.

good practice. Navigant found that the month variables were nearly always statistically significant, and included them in all models.[4]

Recommendation 2: Include monthly variables in all models used to estimate energy savings.

Finding 3: Some of PTO's models included endogenous variables to control for unexpected or unusual energy consumption in the baseline period which were unverified by the program participant.[5] Navigant did not include these variables in its models unless they had been verified by the program participant as having resulted from an exogenous cause[6], as stated in the notes provided in each of the implementer models. This discrepancy impacted site-level realization rates for the following PTO site IDs: 25729, 93057, 180453, 113935, 94758, 213680, 111022, 102750, and 107135.

Recommendation 3: Only periods of unexpected or unusual consumption that are verified as having been the result of an exogenous cause should be modeled and controlled for.

Finding 4: Navigant found a few cases where PTO did not handle exogenous variables correctly when estimating savings. These cases arose when an exogenous event affecting energy usage occurred for a short period. In such cases PTO appropriately included a binary indicator to account for the atypical energy consumption during these periods (failing to do this could cause the estimates of the other model parameters to be biased.) For example, if a site had atypical energy consumption due to a period of overnight construction during the baseline period, the appropriate response would be to include a dummy variable that equals one during the construction period and equals zero elsewhere during the initial model estimation phase. This allows the model to capture the additional energy usage during the atypical construction period without adversely affecting the values of the other parameter estimates. However, such dummy variables should be set to zero during the simulation phase to avoid including the atypical effects in the savings estimates. Navigant adjusted how these variables were applied for the following PTO site IDs: 23014, 239090, 101679, 224211, 224441, and 224663.

Recommendation 4: Dummy variables included in models to account for atypical, exogenous events should be included when estimating the model parameters, but not included when estimating the savings.

6. Appendix 1. Impact Analysis Methodology

Navigant measured the Energy Advisor Program's CY2018 annualized energy savings by developing baseline daily energy usage models for each PY9 program participant, calibrated to their year of pre-enrollment daily usage data using regression analysis, of the form shown in Equation 1, and using the models, together with degree-day data derived from local weather data, to estimate each participant's gross energy savings attributable to the program. PY9 gross program savings comprise the sum of the individual participants' gross annualized savings.

Equation 1. Energy Advisor Load Model

$$kWh_t = \beta_0 + \beta_1 Weekday_t + \sum_{i=1}^{12} \beta_{2i} Month_{ti} + \beta_3 CDD_t + \beta_4 HDD_t + \sum_{j=1}^{J} \beta_{5j} Change_{tj} + \varepsilon_t$$

where:

[4] Even when individual month dummies are non-significant, a full set of such variables should be included if there are a priori reasons for believing that usage is time-varying.
[5] I.e., dummy variables whose non-zero values matched the period(s) of unexpected or unusual energy consumption observed in the usage data where the anomalous consumption values weren't shown to have been caused by an exogenous event unrelated to the Energy Advisor Program.
[6] For example, an on-site construction project or power outage unrelated to the Energy Advisor Program.

kWh_t	is energy usage during day t
$Weekday$	equals 1 when t is a weekday and 0 otherwise
$Month_{ti}$	equals 1 when t falls within month i and 0 otherwise
CDD_t	is the average number of degrees above the base cooling temperature per day t[7]
HDD_t	is the average number of degrees below the base heating temperature per day t[4]
$Change_{tj}$	is a binary indicator that equals 1 when day t falls after agreed-upon behavior change j and 0 otherwise
the $\beta_k s$	are unknown parameters to be estimated
ε_t	is a white-noise disturbance or error term

Navigant applied a net-to-gross (NTG) value of 1.0 to the adjusted gross savings to estimate the verified net savings in PY9.

Base temperatures used to calculate HDD and CDD values were selected through an optimization process on a site-specific basis. See Section 7 for more information on this process. Both Navigant and PTO chose to optimize base temperatures for each site as this information was not provided by the program participants. Illinois TRM v5.0 Volume 1[8] states that while the default base temperature for C&I settings is 55 degrees for cooling and heating, developing custom degree-days with building-specific base temperatures is recommended.

Participant site-specific parameter values were obtained by fitting Navigant's regression model (Equation 1) to each participant's daily usage data and weather data using all available (pre- and post-enrollment) data. Participant usage data consisted of daily roll-ups of 30-minute interval meter data provided by PTO. Prior to conducting the impact analysis, Navigant verified that the interval data were aggregated correctly by PTO; Navigant requested 30-min interval meter data from ComEd for a sample of participant sites, aggregated them to daily usage levels, and compared the values with PTO's daily usage values for the same customers. No material discrepancies were found.

When calculating the cooling and heating degree-day variables from the weather data, Navigant identified site-specific optimal base temperatures for each participant using a grid-search process. We fitted models to each participant site's data for all combinations of (integer) cooling and heating base temperatures on the [50° F, 75° F] grid, and selected the pair of base temperatures that yielded the highest model R^2 value in each case.

[7] When fitting the model to obtain estimates of the parameter values in each participant's energy usage model, Navigant used the actual weather data recorded during PY9 to calculate the daily degree-day variable values. We used a grid search process to solve for the optimal degree-day base temperatures at each site. When estimating the participant's annualized energy savings attributable to the program, we substituted the local TMY3 temperature data series. See http://rredc.nrel.gov/solar/old _data/nsrdb/1991-2005/tmy3/ for more information.

[8] Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0, available at: http://www.ilsag.info/technical-reference-manual.html.

Once the final model parameter values were estimated for a given participant site, Navigant then used these, together with normal (TMY3) weather data[9], to forecast annualized usage for the pre- and post-install period for all participating customers. Annualized savings were calculated by simulating each participant's usage in this fashion twice: once with the change variable(s) set to zero (to simulate their baseline usage) and once with the change variable(s) set to one (to simulate their usage with the changes in place), and subtracting the post-change profile from the baseline profile.

7. Appendix 2. Impact Analysis Detail

Table 7-1 presents program savings by participant site. The "Nature of Energy Saving Action" column provides insight on the nature of the energy saving recommendations made by PTO to each participant.

Table 7-1. PY9 Verified Savings by Site

Site ID	Ex Ante Savings (kWh)	Realization Rate	Verified Gross Savings (kWh)	Nature of Energy Saving Action
94758	5,922	2,371%	140,421	HVAC
14952	3,097	813%	25,182	HVAC
93057	1,906	536%	10,219	HVAC
184009	11,663	467%	54,494	HVAC
107135	19,722	418%	82,525	Lighting
75753	4,534	377%	17,109	HVAC
113935	11,301	313%	35,359	HVAC
102750	9,814	301%	29,569	HVAC
79811	9,237	280%	25,889	HVAC
75760	275	279%	767	HVAC
11024	9,071	271%	24,558	HVAC
111022	24,713	255%	63,091	Lighting
216957	37,505	234%	87,686	HVAC
236095	11,483	231%	26,468	HVAC
213680	20,576	209%	42,982	HVAC
136511	2,802	195%	5,476	HVAC
165904	5,406	186%	10,065	HVAC
239090	33,959	181%	61,610	HVAC
224070	10,754	179%	19,246	HVAC
6216	7,613	154%	11,738	HVAC
111025	9,248	152%	14,076	HVAC
15480	10,306	152%	15,647	HVAC
23002	7,094	149%	10,553	HVAC
26891	12,236	141%	17,307	HVAC
162577	39,606	133%	52,801	HVAC
70959	14,360	131%	18,756	HVAC
256570	10,120	128%	12,924	HVAC

[9] See http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/ for more information.

Site ID	Ex Ante Savings (kWh)	Realization Rate	Verified Gross Savings (kWh)	Nature of Energy Saving Action
25729	44,331	127%	56,406	Lighting
95470	17,708	122%	21,564	HVAC
125936	9,971	121%	12,105	HVAC
23490	2,470	120%	2,960	HVAC
200121	23,140	120%	27,666	HVAC
242336	8,693	119%	10,341	HVAC
180453	26,112	119%	31,045	HVAC
162803	8,457	117%	9,920	HVAC
111014	23,519	116%	27,316	HVAC
189696	9,190	108%	9,920	HVAC
285067	22,023	107%	23,458	Lighting
87230	25,906	106%	27,335	HVAC
108819	24,127	104%	25,148	HVAC, Lighting
200536	75,310	103%	77,550	Equipment Scheduling
26203	10,621	103%	10,911	HVAC
89597	31,095	103%	31,921	HVAC
190483	82,431	102%	83,738	Equipment Scheduling
83958	14,698	102%	15,013	Equipment Scheduling
371789	20,157	102%	20,574	Lighting
88652	9,642	102%	9,817	HVAC
23500	62,153	101%	62,692	Lighting
293615	25,662	101%	25,861	Lighting
11769	30,540	101%	30,711	Lighting
205464	55,190	100%	55,266	Lighting
225574	13,605	100%	13,615	Lighting
288308	25,757	100%	25,774	Lighting
107298	16,043	100%	16,042	Lighting
21161	15,564	100%	15,560	Lighting
14594	81,171	99%	80,565	Equipment Scheduling
278374	54,456	98%	53,553	Lighting
223702	26,731	98%	26,092	Lighting
311895	25,242	94%	23,801	Equipment Scheduling
133182	23,196	93%	21,575	Lighting
284331	21,237	87%	18,516	Equipment Scheduling
203400	24,709	86%	21,188	HVAC
68575	23,912	84%	19,968	HVAC
95516	58,292	80%	46,868	HVAC, Lighting
224211	19,967	38%	7,580	Lighting
6104	14,452	32%	4,668	HVAC

Site ID	Ex Ante Savings (kWh)	Realization Rate	Verified Gross Savings (kWh)	Nature of Energy Saving Action
197666	43,200	29%	12,629	HVAC, Lighting, Equipment Scheduling
112891	16,732	29%	4,843	HVAC
101679	12,649	29%	3,624	Lighting
224441	11,199	19%	2,074	Lighting
224663	41,646	10%	4,313	HVAC, Lighting
189639	3,912	7%	277	HVAC
22409	11,124	5%	515	HVAC
92536	8,849	-7%	-591	HVAC
198376	4,816	-12%	-578	HVAC
105602	6,406	-19%	-1,244	HVAC
23014	65,287	-32%	-20,867	Equipment Scheduling
233597	3,309	-69%	-2,277	HVAC
259709	3,361	-96%	-3,220	HVAC

Source: ComEd tracking data and Navigant team analysis.

8. Appendix 3. TRC Detail

Table 8-1, the Total Resource Cost (TRC) variable table, only includes cost-effectiveness analysis inputs available at the time of finalizing this PY9 impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to evaluation at a later date. Detail in this table (e.g., EUL), other than final PY9 savings and program data, are subject to change and are not final.

Table 8-1. TRC Detail

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Ex Ante Gross Savings (kWh)	Ex Ante Gross Peak Demand Reduction (kW)*	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)*
MBCx Savings	MBCx Savings	Project	79	5†	NA	NA	2,020,622	NA

* This program does not produce demand or peak demand savings.
† Navigant agrees that a 5-year EUL is reasonable and in line with previous evaluations of similar programs; this value may change in the future if warranted by further research. See "Review of EPY6 Total Resource Cost Test Assumptions," Navigant, May 23, 2016, §3.17.1, p. 42.
Source: ComEd tracking data and Navigant team analysis.