ComEd Residential Behavior Impact Evaluation Report

**Energy Efficiency / Demand Response Plan:
Program Year 2019 (CY2019)
(1/1/2019-12/31/2019)**

**Presented to
ComEd**

FINAL

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ComEd Residential Behavior Impact Evaluation Report

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1. INTRODUCTION

This report presents the results of the impact evaluation of ComEd's CY2019 Residential Behavior Program.[1] It includes a summary of the energy impacts for the total program broken out by relevant measure and program structure details. The appendix provides the impact analysis methodology and details of the Total Resource Cost inputs. CY2019 covers January 1, 2019 through December 31, 2019.

2. PROGRAM DESCRIPTION

The Residential Behavior Program is designed to generate energy savings by providing residential customers with information about energy use and conservation strategies. Program participants receive information in the form of regularly mailed and emailed home energy reports[2] that give customers information, including:

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

The program had 1,519,734 participants in CY2019 and 224,057 controls across 12 waves (Wave 7 has two components) as shown in Table 2-1. Participants and controls in the table represent active accounts at the beginning of CY2019. Oracle stopped treatment of Wave 3 through the program at the end of CY2018 and as such the evaluation team did not evaluate Wave 3 in CY2019.

Table 2-1. CY2019 Volumetric Findings Detail (in thousands)

Wave	Participants	Controls
Wave 1	22.6	26.3
Wave 2	1.8	1.8
Wave 4	13.6	13.7
Wave 5	4.3	5.5
Wave 6	62.2	18.8
Wave 7 Low	384.8	32.0
Wave 7 High	421.0	35.1
Wave 8	44.5	6.0
Wave 9	222.8	14.1
Wave 10	107.7	13.4
Wave 11	63.1	15.0
Wave 12	70.7	16.9
New Mover	100.8	25.2

Source: ComEd tracking data and evaluation team analysis.

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[1] Note that in previous years, the evaluation team referred to this as the Home Energy Report (HER) Program.
[2] The frequency of reports sent through direct mail varied across the waves, where customers identified by the program implementer as having a greater propensity to save received more frequent reports. Additionally, the implementer sent monthly electronic reports to treatment customers with email addresses on file.

3. PROGRAM SAVINGS DETAIL

Table 3-1 summarizes the incremental savings the Residential Behavior Program achieved in CY2019. These savings reflect adjustments for uplift and CY2018 persisting savings under the CPAS framework. This program evaluation specifically focused on energy savings, and demand savings were not estimated. Additionally, since the randomized control trial (RCT) design inherently estimates net savings, neither the evaluation team nor the implementer estimated gross savings and there is no gross realization rate and no net-to-gross (NTG) ratio. The net realization rate, along with modeled savings, savings after uplift adjustment,[3] savings attributed to persistence from CY2018 participation, and final verified net savings, are shown in Table 3-2.

Table 3-1. CY2019 Total Annual Incremental Electric Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Summer Peak Demand Savings (kW)*
Electricity			
Ex Ante Gross Savings	NA	NA	NA
Program Gross Realization Rate	NA	NA	NA
Verified Gross Savings	NA	NA	NA
Program Net-to-Gross Ratio (NTG)	NA	NA	NA
Verified Net Savings	55,129,576	NR	NR
Converted from Gas†			
Ex Ante Gross Savings	NA	NA	NA
Program Gross Realization Rate	NA	NA	NA
Verified Gross Savings	NA	NA	NA
Program Net-to-Gross Ratio (NTG)	NA	NA	NA
Verified Net Savings	NR	NR	NR
Total Electric Plus Gas			
Ex Ante Gross Savings	NA	NA	NA
Program Gross Realization Rate	NA	NA	NA
Verified Gross Savings	NA	NA	NA
Program Net-to-Gross Ratio (NTG)	NA	NA	NA
Verified Net Savings	55,129,576	NR	NR

NR = Not reported (refers to a piece of data that was not reported, i.e., non-coincident demand savings)
NA = Not applicable (refers to a piece of data that cannot be produced or does not apply)
* The evaluation did not estimate coincident summer peak demand savings for this program.
† The evaluation did not estimate gas savings for this program.
Source: ComEd tracking data and evaluation team analysis.

Table 3-2 provides detailed adjustments made to arrive at the final verified net savings for CY2019 and compares them to ex ante net savings provided by the implementer.

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[3] The uplift adjustment is made to account for participation in other ComEd energy efficiency programs. See Section 7.5 for a detailed explanation.

Program interventions in CY2019 resulted in over 227,072,180 kWh of energy savings across all treated waves. Modeled savings of 227,072,180 kWh are in line with the previous year's results,[4] indicating steady impacts from the program's continued treatment of participants. Adjustments for current year and legacy uplift resulted in energy savings of 218,080,379 kWh, which represents a 4% downward adjustment from the modeled savings. Of those, 162,950,803 kWh, or 75% of adjusted modeled savings, were claimed in CY2018 for CY2019 as part of the CPAS and decay framework, resulting in final verified net savings of 55,129,576 kWh for CY2019.

The evaluation team calculated a 93% program realization rate compared to the savings estimated by the implementer. The uplift adjustment, which is unaccounted for in the implementer's savings estimate, along with small differences in regression models used by the evaluation team and the implementer are the key drivers of the realization rate.

Table 3-2. CY2019 Total Program Net Electric Savings

Savings Category	Energy Savings (kWh)
Ex Ante Net Savings	59,292,000
Modeled Savings	227,072,180
Current Year Uplift Adjustment	3,971,096
Legacy Uplift Adjustment	5,020,706
Persistence Adjustment	162,950,803
Final Verified Net Savings	55,129,576
Program Net Realization Rate*	93%

* This value is after the uplift adjustment.
Source: ComEd tracking data and evaluation team analysis.

4. CUMULATIVE PERSISTING ANNUAL SAVINGS

Table 4-1 and Figure 4-1 show the wave-specific and total verified net savings for the Residential Behavior Program and the cumulative persisting annual savings (CPAS) for the home energy reports sent to treatment customers in CY2019.

The electric CPAS across all reports sent to treatment customers in 2019 is 55,129,576 kWh (Table 4-1). The "historic" rows in the table are the CPAS contribution back to CY2018. The "Program Total Electric CPAS" is the sum of the CY2019 contribution and the historic contribution. Historic program total contribution to CPAS in CY2019 is 200,821,372 kWh. As a result, program interventions resulted in total CPAS of 255,950,948 kWh for the program in CY2019.

There are several items worth noting related to CPAS:

- Historic program total electric contribution to CPAS is inclusive of Wave 3, which ComEd dropped from the program in CY2019. The historic contribution excluding that wave would be 161,729,514 kWh.
- Coming from the CY2018 evaluation, the historic program total electric contribution to CPAS for CY2019 was adjusted using a prospective retention rate of 90%. When calculating the

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[4] ComEd stopped treating Wave 3 in CY2019, and so total modeled savings in CY2019 are smaller compared to CY2018. When comparing CY2019 modeled results to CY2018 without the inclusion of CY2018, the results are similar (227 GWh in CY2019 versus 231 GWh in CY2018).

persistence adjustment for CY2019, we relied on the retrospective retention rate[5] as opposed to the prospective retention rate to develop an estimate of savings attributed to prior years, as prescribed in Version 7.0 of the Illinois Technical Reference Manual (TRM). This switch from the prospective retention rate to the retrospective one resulted in 1,221,289 kWh of savings unclaimed either as part of the historic program total electric contribution to CPAS or CY2019 verified net savings (i.e., the persisting savings attributed to CY2018 in the CY2019 evaluation is 1,221,289 kWh higher than the CPAS claimed for CY2019 from the CY2018 evaluation). This difference occurred even though the weighted average retrospective retention rate across all waves was also 90% (the same as the prospective rate) because the savings rate differs by wave.

- The statistical nature of the custom savings calculations for the Residential Behavior Program presents uncertainty in terms of savings variation year-over-year within the CPAS framework. Such variation can stem from factors such as customer attrition, uplift, as well as variation around the savings estimates due to modeling. The latter is especially true for waves with few participants, such as Wave 2 and Wave 5, where error bounds around the modeled savings estimates are larger than for waves with larger participant counts and therefore cause fluctuation in savings year-over-year. A lower modeled savings rate in CY2019 compared to CY2018 for a given wave results in a savings shortage from what was claimed in persisting savings for CY2019 in CY2018. Higher than expected attrition (i.e., a lower retrospective than prospective retention rate) can have the same effect. In CY2019, savings for Wave 5 were negative due to a decrease in the savings rate from 2.19% in CY2018 to 1.75% in CY2019.[6]

The evaluation team did not evaluate gas savings for this program and as such electric CPAS is equivalent to total CPAS. In addition, this type of analysis estimates net savings and no further NTG adjustment is necessary. Because of this, there is no NTG ratio and no gross savings estimate.

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[5] We calculated retrospective retention rate for each wave and applied it to each wave's savings as part of the analysis. The retrospective retention rate ranges from 76% to 95% across the waves. These percentages are included in Table 8-1.

[6] Notably, this decrease is not statistically significant.

Table 4-1. CPAS - Electric

End Use Type	Research Category	EUL	CY2019 Verified Gross Savings (kWh)	NTG*	Lifetime Net Savings (kWh)†	2018	2019	2020	2021	2022	2023	2024	2025	2026
Behavioral	Wave 1 CR	5.0	NA	NA	456,665		184,005	132,484	80,484	41,583	18,109	-	-	-
Behavioral	Wave 1 LR	5.0	NA	NA	160,585		64,705	46,588	28,302	14,623	6,368	-	-	-
Behavioral	Wave 2	5.0	NA	NA	297,405		119,834	86,281	52,415	27,081	11,793	-	-	-
Behavioral	Wave 4	5.0	NA	NA	384,207		154,810	111,463	67,714	34,985	15,236	-	-	-
Behavioral	Wave 5	5.0	NA	NA	(225,669)		(90,929)	(65,469)	(39,772)	(20,549)	(8,949)	-	-	-
Behavioral	Wave 6	5.0	NA	NA	10,731,460		4,324,054	3,113,319	1,891,341	977,193	425,552	-	-	-
Behavioral	Wave 7 Low	5.0	NA	NA	6,247,591		2,517,358	1,812,498	1,101,092	568,898	247,746	-	-	-
Behavioral	Wave 7 High	5.0	NA	NA	56,230,854		22,657,241	16,313,213	9,910,277	5,120,310	2,229,812	-	-	-
Behavioral	Wave 8	5.0	NA	NA	1,042,148		419,915	302,339	183,671	94,897	41,326	-	-	-
Behavioral	Wave 9	5.0	NA	NA	18,852,502		7,596,286	5,469,326	3,322,616	1,716,685	747,589	-	-	-
Behavioral	Wave 10	5.0	NA	NA	10,457,193		4,213,543	3,033,751	1,843,004	952,219	414,676	-	-	-
Behavioral	Wave 11	5.0	NA	NA	10,912,264		4,396,906	3,165,773	1,923,207	993,657	432,722	-	-	-
Behavioral	Wave 12	5.0	NA	NA	10,356,560		4,172,995	3,004,556	1,825,268	943,055	410,685	-	-	-
Behavioral	New Mover	5.0	NA	NA	10,917,092		4,398,852	3,167,173	1,924,058	994,096	432,913	-	-	-
CY2019 Program Total Electric Contribution to CPAS		-			136,820,857		55,129,576	39,693,295	24,113,676	12,458,733	5,425,577	-	-	-
Historic Program Total Electric Contribution to CPAS‡						279,539,772	200,821,372	121,727,875	62,752,974	27,267,179	-	-	-	-
Program Total Electric CPAS						279,539,772	255,950,948	161,421,169	86,866,650	39,725,912	5,425,577	-	-	-
CY2019 Program Incremental Expiring Electric Savings§							15,436,281	15,579,618	11,654,944	7,033,156	5,425,577	-	-	-
Historic Program Incremental Expiring Electric Savings‡§							78,718,400	79,093,497	58,974,901	35,485,794	27,267,179	-	-	-
Program Total Incremental Expiring Electric Savings§							78,718,400	94,529,779	74,554,519	47,140,738	34,300,335	5,425,577	-	-

Note: The green highlighted cell shows program total first year electric savings. The gray cells are blank, indicating values irrelevant to the CY2019 contribution to CPAS.

NA = Not applicable

* The randomized controlled trial used for this evaluation produces net savings and as such the NTG ratio is not applicable. Source: is to be found on the Illinois SAG web site here: https://www.ilsag.info/ntg_2019.

† Lifetime savings are the sum of CPAS savings through the EUL.

‡ Historical savings go back to CY2018.

§ Incremental expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n.

Source: Evaluation team analysis.

Figure 4-1. Cumulative Persisting Annual Savings
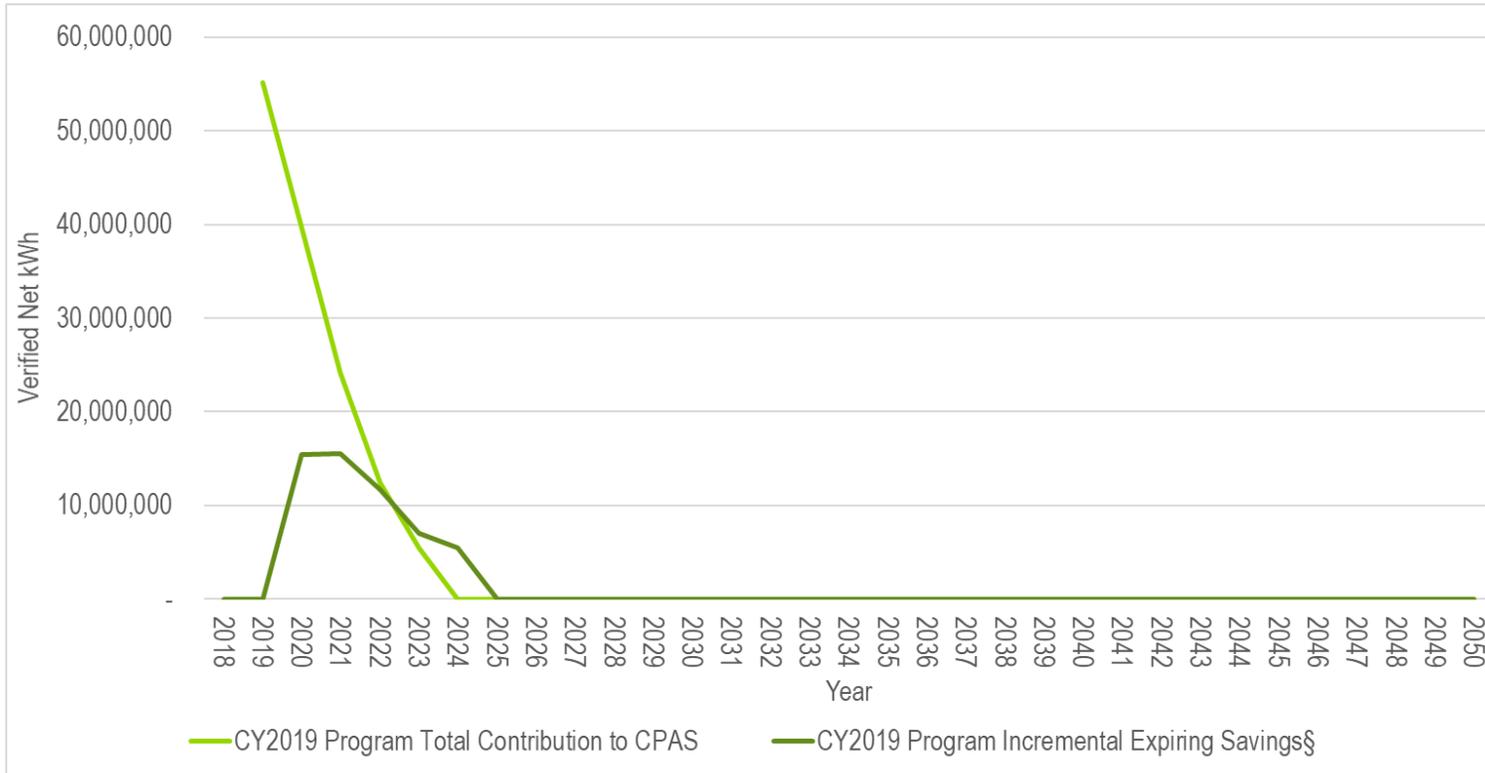
§ Expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n.
Source: Evaluation team analysis.

5. PROGRAM SAVINGS BY MEASURE

The Residential Behavior Program includes only one measure, behavioral savings, and so the program savings and measure savings are the same. Detailed savings by wave are presented in Section 8.

6. IMPACT ANALYSIS FINDINGS AND RECOMMENDATIONS

6.1 Impact Parameter Estimates

The Residential Behavior Program does not have relevant impact parameters.

6.2 Other Impact Findings and Recommendations

The evaluation team developed one recommendation based on findings from the CY2019 evaluation.

Finding 1. From CY2018 to CY2019, the average program savings rate increased slightly (from 1.52 to 1.65%), indicating steady and strong year-over-year program performance. Consistent with increased program impacts over an initial ramp-up period, savings for recently enrolled waves (Waves 11 and 12) increased from 1.20% to 1.53% and 0.52% to 1.18%, respectively. Savings for those two waves, however, remained below the program average of 1.65%. Past trends suggest flattening of the savings in the future years for these waves.

Finding 2. The CPAS framework took effect in CY2018 and at the same time the program measure life was revised from one to five years with savings decay in the TRM associated with each year. Under this framework, the persistence adjustment to CY2019 modeled savings reduced the CY2019 modeled savings by 72%. To optimize program performance under the framework, ComEd stopped treating Wave 3 in CY2019.

Finding 3. The statistical nature of the custom savings calculations for the Residential Behavior Program presents uncertainty in terms of savings variation year-over-year within the CPAS framework and can result in negative savings and even unclaimed savings, with attrition, uplift, and modeling uncertainty acting as possible contributing factors.
Recommendation 1. ComEd, the implementer, and the evaluation team should continue to review the retrospective retention rates each year. If the retention rates by wave are stable for several years, we should consider changes to the prospective retention rate to make it wave specific.

Finding 4. With over 1.5 million customers enrolled, ComEd's program has a broad reach and currently captures over half of ComEd's eligible customer base. The remaining customer base, however, is likely comprised of a disproportionate percentage of customers with lower usage. Historically, customers with lower usage tend to deliver lower savings, both in absolute and relative percent terms.
Recommendation 2. ComEd and the implementer should continue balancing continued treatment of existing customers to deliver incremental savings under the CPAS framework, while pairing that with enrollment of new waves, focusing on high usage customers, and further program optimization in terms of treatment frequency and optimization of high usage alerts. Enrollment of new customer waves should consider higher attrition in the first year

following enrollment than the average prospective attrition rate; high attrition may result in a savings shortage following the persistence adjustment.

7. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

7.1 Graphs for New Wave RCT Checks

Since no new waves were added to the Residential Behavior Program in CY2019, equivalency analysis was not necessary in CY2019.

7.2 Detailed Data Cleaning

The evaluation team removed customers and data points from the analysis in several steps:

- Observations outside CY2019 and each wave's relevant pre-program year
- Observations with a bill duration of zero days
- Observations missing usage
- Outliers, defined as observations with average daily usage more than one order of magnitude from the median usage

After selecting program and pre-program year data for each wave, these cleaning steps removed 0.01% of customers and 3.2% of observations,[7] evenly distributed across participants and controls. This suggests that non-random biases were not introduced into the data by the evaluation team's cleaning steps.

7.3 Imputation of Pre-Period Data

The evaluation team found that a large share of treatment and control customers in Waves 10, 11, and 12 had less than a full year of pre-period data. On average, customers in these waves had less than 10 months of pre-period billing data and only 27% of customers in Waves 10, 11, and 12 had a full year of pre-period billing data.

Incomplete (less than 12 months) pre-period data can introduce bias when modeling savings. In addition, due to the nature of the lagged dependent variable (LDV) model, participants with incomplete pre-period data are dropped from the modeling process.[8]

To account for the large number of missing pre-period observations for Waves 10, 11, and 12, we replaced the missing data with substituted values (i.e., imputed data) representing average daily consumption for customers that have pre-period data. We performed imputations independently for each wave, pre-period month, and customer group (treatment vs. control). As part of the modeling process, we checked the results for sensitivity by modeling savings with and without the imputations. The imputation resulted in a 0.01% or smaller difference in savings.

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[7] The New Mover Wave dropped more observations than the other waves (8.5%) because they were more frequently missing pre-period usage.

[8] Since this model includes pre-period information as explanatory variables, if a customer is missing billing data for a certain pre-period month, then the model will drop this calendar month in the analysis period for the customer.

7.4 Detailed Impact Methodology

The evaluation team used LDV and linear fixed effects regression (LFER) models to estimate program savings. The evaluation team used the LDV results for reporting CY2019 total program savings.[9] The following sections present the specifications for each model.

7.4.1 Lagged Dependent Variable Model

The LDV model controls for non-treatment differences in energy use between treatment and control customers using lagged energy use as an explanatory variable. The model frames energy use in calendar month t of the post-program period as a function of both the treatment variable and energy use in the same calendar month of the pre-program period. The underlying logic is that systematic differences between control and treatment customers will be reflected in differences in their past energy use, which is highly correlated with their current energy use. Formally, the model is shown in Equation 7-1.

Equation 7-1. Lagged Dependent Variable Regression Model

$$ADU_{kt} = \beta_1 Treatment_k + \sum_J \beta_2 Month_{jt} + \sum_J \beta_3 Month_{jt} \cdot ADUlag_{kt} + \varepsilon_{kt}$$

Where:

ADU_{kt}	is average daily consumption of kWh by household k in bill period t
$Treatment_k$	is a binary variable taking a value of 0 if household k is assigned to the control group, and 1 if assigned to the treatment group
$Month_{jt}$	is a binary variable taking a value of 1 when j = t and 0 otherwise[10]
$ADUlag_{kt}$	is household k's energy use in the same calendar month of the pre-program year as the calendar month of month t[11]
ε_{kt}	is the cluster-robust error term for household k during billing cycle t; cluster-robust errors account for heteroskedasticity and autocorrelation at the household level.

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

7.4.2 Linear Fixed Effects Regression Model

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

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

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[9] Across the two models, the parameter estimates were not statistically different; that is, the estimates for each model are within the 90% confidence bounds for the other model. Furthermore, the pattern across the different program waves between the two models is very similar. This supports the methodological approach, and indicates the results are robust.

[10] 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.

[11] Note that the evaluation team imputed these values for some observations of Waves 10, 11, and 12 as discussed in Section 7.3.

Formally, the LFER model is shown in Equation 7-2.

Equation 7-2. Linear Fixed Effects Regression Model

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

Three observations about this specification deserve comment. First, the coefficient α_{0k} captures all household-specific effects on energy use that do not change over time, including those that are unobservable. Second, α_1 captures the average effect across all households of being in the post-treatment period. Third, the effect of being both in the treatment group and in the post period, i.e., the effect directly attributable to the program, is captured by the coefficient α_2. In other words, whereas the coefficient α_1 captures the change in average daily kWh use across the pre- and post-treatment for the control group, the sum $\alpha_1 + \alpha_2$ captures this change for the treatment group, and so α_2 is the estimate of average daily kWh energy savings due to the program.

7.4.3 Weather Normalization

Version 7.0 of the TRM recommends that evaluators consider normalizing energy savings by weather to achieve "typical year savings", or average savings for a standard weather year, as part of their custom savings calculation. Such normalization can be important when estimating CPAS savings for the program, as it controls for the confounding effects of differences in weather in future years. The evaluation team gave careful consideration to using weather normalization and chose not to weather normalize savings in CY2019. The key reason behind the decision is the appropriateness of the most recent weather collection (Typical Meteorological Year 3 or TMY3). TMY3 data uses weather data from 1,020 weather stations collected from 1991 to 2005. The variation in weather during that time frame is likely different than the future expectations, given the effects of climate change. As such, weather normalization may produce a biased estimate, likely toward lower savings. Additionally, the evaluation team conducted a weather normalization assessment in 2018 that found limited model sensitivity to weather terms, which suggests a limited impact of applying weather normals when estimating the energy impacts from the program.

7.5 Account for Uplift in Other Energy Efficiency Programs

7.5.1 Accounting for Uplift in CY2019

The home energy reports sent to participating households include energy-savings tips, some of which encourage participants to enroll in other ComEd energy efficiency (EE) programs. If participation rates in other EE programs are the same for Residential Behavior treatment and control groups, the savings estimates from the regression analyses are already "net" of savings from other programs as this indicates the Residential Behavior Program does not increase or decrease participation in other EE programs. However, if the Residential Behavior 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 Residential Behavior and EE programs. For instance, if the Residential Behavior Program increases participation in other EE programs, the increase in savings may be allocated to either the Residential Behavior Program or the EE program, but cannot be allocated to both programs simultaneously.[12] Note that when the Residential Behavior 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] It is not possible to estimate and remove double counted savings generated by programs for which tracking data are not available, such as upstream lighting programs.

Data permitting, the evaluation team 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 CY2019 and the pre-program year for the control group is subtracted from the same change for the treatment group. For instance, if the rate of participation in an EE program during CY2019 is 5% for the treatment group and 3% for the control group, and the rate of participation during the year before the start of the Residential Behavior Program is 2% for the treatment group and 1% for the control group, then the rate of uplift due to the Residential Behavior Program is 1%, as reflected in Equation 7-3.

Equation 7-3. DID Statistic Calculation

$$(CY2019\ treatment\ group\ participation - prePY\ treatment\ group\ participation)$$
$$- (CY2019\ control\ group\ participation - prePY\ control\ group\ participation)$$
$$= DID\ statistic$$
$$(5\% - 2\%) - (3\% - 1\%) = 1\%$$

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 control groups during CY2019. 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. The evaluation team uses this alternative statistic in cases where the EE program did not exist in the pre-program year.

In CY2019 the evaluation team examined the uplift associated with the following EE programs:[13]

- Fridge & Freezer Recycling (FFR) Program. This program achieves energy savings through retirement and recycling of older, inefficient refrigerators, freezers, and room air conditioners.
- Single-Family Assessments Program.[14] This 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 LEDs, low-flow showerheads, faucet aerators, programmable thermostats and smart thermostats.
- Multi-Family Assessments Program. This program is offered jointly with the local gas utilities and installed various energy-saving measures, which included LEDs in tenant units, water-saving devices, programmable thermostats, pipe insulation, and LEDs in common area.
- Single-Family Retrofits – Income Eligible (IE) Program. This program achieves energy savings through offering a range of weatherization improvements, including window and door weatherization, heating system replacements, and electric baseload reduction. The program is offered through two components, one implemented by Franklin Energy Services with the Chicago Bungalow Association (CBA) and one implemented by Resource Innovations leveraging the Illinois Home Weatherization Assistance Program (IHWAP).
- Multi-Family Retrofits - IE Program. This program includes free home energy upgrades and weatherization improvements for qualifying multi-family properties. The program is offered through two components, one implemented by Elevate Energy and one implemented by Resource Innovations leveraging IHWAP.

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[13] ComEd has other residential programs that were not included in the analysis. The Appliance Rebates, Elementary Education, Lighting Discount, Food Bank-LED Distribution, and UIC-ERC IE Kits 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 Affordable Housing New Construction Programs and Residential Behavior is not possible due to the requirement that Residential Behavior participants have sufficient historical usage data.

[14] In past reports, the evaluation team referred to this program as Home Energy Assessments.

- Weatherization (Wx) Program. This program is offered jointly with the local gas utilities and achieves savings by providing incentives for insulation and air sealing improvements for non-income-qualified customers.
- Residential HVAC Program. This program offers incentives to residential customers to encourage customer purchases of higher efficiency heating, ventilating, and air conditioning (HVAC) equipment.
- Manufactured Housing Retrofits Program. This program achieves energy savings by providing direct installation of low-cost efficiency measures for manufactured homes, such as LEDs, smart thermostats, faucet aerators, and advanced power strips. The program also offers air and duct sealing to improve performance of HVAC equipment.

For each EE program, the evaluation team calculated double counted savings separately for each wave of the Residential Behavior Program and for the lapsed report (LR) subgroup in Wave 1. Because of pre-period data not being available for Single Family Retrofit, Multi-family Retrofit, Wx, and HVAC programs, we relied on the POD statistic to determine uplift. For all other programs, we used the DID statistic.

7.5.2 Accounting for Legacy Uplift

The uplift adjustment methodology described in Section 7.5.1 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.[15] However, for other EE programs that include measures with multi-year measure lives, Residential Behavior 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 Residential Behavior Program savings not just in PY2, but in PY3 through CY2019 as well.

Consider the following example. A household receiving home energy reports through the Residential Behavior 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 Residential Behavior Uplift adjustment does not remove these savings because the PY7 adjustment only accounts for measures installed in PY7, the initial year that the household entered a program. Thus, when only relying on the uplift adjustment described in Section 7.5.1 FFR second year savings would be included in the PY7 Residential Behavior Program's savings, which is inconsistent with Illinois's practices of only crediting utilities with first year EE program savings. Legacy uplift removes double counted energy savings from programs that include measures with multiple-year measure life.

The evaluation team accounts for legacy uplift by subtracting the double counted savings from previous years, adjusted for the average annual move out rate,[16] from CY2019 Residential Behavior savings through the measure lives of measures from other EE programs. The legacy uplift adjustment is shown in Equation 7-4.

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[15] Tracking data files are set-up this way because, in conformity with the TRM Section 3.2, savings are first-year savings, not lifetime savings.

[16] Since Residential Behavior Program participations are dropped from that program when they move, other EE programs' savings are no longer captured in the Residential Behavior Program savings from that point forward.

Equation 7-4. Legacy Uplift Calculation

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

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. Notably, to streamline the analysis, instead of using individual measure lives in developing legacy uplift savings, and subsequently removing measures one-by-one once they reach the end of their effective useful lives, the evaluation team calculated effective useful lives at the program level by weighting measure-specific effective useful lives by savings. Once the program reaches its weighted average measure life, it is removed from the legacy uplift calculation.

The legacy uplift adjustment goes back to PY4 when the evaluation team first considered uplift for the Residential Behavior Program. In PY4, the evaluation team considered double counted savings from the Fridge Freezer Recycle Rewards (FFRR), the Central Air Conditioning Efficiency Services (CACES), and the Single Family Home Performance (SFHP) Programs. In PY5, the evaluation team considered double counted savings for the FFRR, the Complete System Replacement (CSR), Clothes Washer Rebate (CW), Multi-Family Home Energy Savings (MF), and Single Family Home Energy Savings (SFHES) programs. The same programs were considered in PY6, except for the CW Program which was discontinued. In PY7, PY8, and PY9 the evaluation team considered legacy uplift savings for the Multi-family Energy Savings Program (MESP), and the HEA, HVAC and Weatherization, and FFR programs.[17]

7.6 Account for Savings Persistence and Participant Retention

Continued implementation of Residential Behavior programs in Illinois and across the country has demonstrated persistence of savings beyond the first year leading Illinois to adopt a measure decay framework in Version 7.0 of the TRM. This framework assumes that savings persist over five years but the persistence decays in each year. The TRM recommends using the persistence factors presented in Table 7-1 over the five-year life to estimate lifetime electric energy savings for the program.

Table 7-1. Residential Behavior Electric Savings Persistence Factors

Year	Electric Persistence Factor
Year 1	100%
Year 2 (program year under evaluation for all waves)	80%
Year 3	54%
Year 4	31%
Year 5	15%

Source: TRM, Measure 6.1.1, Volume 4, Version 7.0

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[17] Due to expiring weighted average measure life, legacy savings from the PY4 CACES Program, and the PY5 and PY6 MF Programs are no longer considered in the CY2019 legacy uplift.

In addition to applying persistence rate factors, lifetime savings need to account for customer attrition over time due to move-outs and account closures.[18] In CY2018, the evaluation team calculated a prospective annual retention rate of 89.8% which is also being applied in CY2019.[19]. This is a weighted average rate across all program waves, except for the New Mover Wave,[20] from 2014 through 2018. Using customers across all program waves allowed us to capture the various customer segments (e.g., high users, low users, etc.) that can have differing attrition due to move out or other reasons in the estimate. Using a five-year period allowed for a balance between capturing the general decrease in attrition over time, which is important to consider for existing participants, and possible economic changes affecting customer transiency, which is important from a forward-looking perspective. The details of this approach are available in the CY2018 report.

8. APPENDIX 2. IMPACT ANALYSIS DETAIL

This appendix presents savings by wave and aggregated uplift analysis results. Tables with the regression outputs and detailed uplift results by wave are available upon request.

8.1 Savings by Wave

This section disaggregates program savings according to individual waves and wave subgroups. To examine the persistence of savings, Oracle terminated reports in October 2012 for 10,000 customers in Wave 1, but accidentally restarted treatment in August 2013. This report refers to these customers as the Wave 1 LR subgroup. Customers in Wave 1 who continued to receive reports are referred to as the continued report (CR) subgroup. Wave 7 was divided into low and high users due to its size. Table 8-1 summarizes estimated program savings by participant wave. In CY2019, the evaluation attributed savings to 1,519,734 treatment customers. The evaluation team estimated separate savings for each wave and wave subgroup using regression analysis as described in Section 7.4.

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[18] It is possible that some savings resulting from Residential Behavior program interventions persist after customers move out as either (a) energy efficient improvements to the residence that continue to deliver savings or (b) habituated energy conservation behaviors that customers continue to exercise at their new residence (as long as that residence is within a utility's service territory). As of this time, no definitive data exists to estimate the extent to which either of these two scenarios occurs. Version 7.0 of the TRM therefore assumes no persisting savings upon customer move-out, though it encourages additional research on the matter.

[19] The evaluation team will update this prospective retention rate for the next plan cycle.

[20] We excluded the New Mover Wave participants because the continuous enrollment of customers into that wave over time could result in year-over-year retention rate exceeding 100%.

Table 8-1. CY2019 Residential Behavior Program Results by Wave

Wave	Treatment Customer Count*	Control Customer Count*	Percent Savings	Percent Savings Std. Err.	Annualized Customer Savings, kWh†	Annualized Customer Savings Std. Err.	Net Savings, Prior to Uplift, kWh	Net Savings Std. Err.	2019 Uplift, kWh‡	Legacy Uplift, kWh‡	CY2019 Custom Savings Calculation	Retrospective Retention Rate (2019 to 2018)§	Savings Attributed to Prior Years||	Verified Net Savings, kWh#
Wave 1 CR	17,247	26,273	2.45%	0.32%	326	42	5,469,705	707,491	394,963	193,378	4,881,364	0.95	4,697,359	184,005
Wave 1 LR	5,324		2.15%	0.32%	286	42	1,478,416	218,696	91,208	145,879	1,241,329	0.95	1,176,624	64,705
Wave 2	1,788	1,809	2.19%	1.17%	277	148	486,548	258,879	5,540	20,137	460,871	0.95	341,037	119,834
Wave 4	13,642	13,732	2.52%	0.36%	279	40	3,722,937	530,354	76,817	37,209	3,608,911	0.95	3,454,101	154,810
Wave 5	4,264	5,544	1.75%	0.69%	353	140	1,454,079	574,102	16,120	60,747	1,377,212	0.93	1,468,141	-90,929
Wave 6	62,212	18,830	2.22%	0.26%	327	39	19,796,605	2,331,954	166,610	344,090	19,285,905	0.94	14,961,851	4,324,054
Wave 7 Low	384,752	32,041	1.26%	0.19%	79	12	29,360,762	4,433,281	449,738	1,390,652	27,520,373	0.92	25,003,015	2,517,358
Wave 7 High	420,950	35,116	2.31%	0.12%	225	12	91,720,544	4,874,261	1,262,799	898,615	89,559,131	0.94	66,901,890	22,657,241
Wave 8	44,542	6,006	1.13%	0.47%	133	55	5,644,109	2,334,645	154,279	286,292	5,203,539	0.89	4,783,623	419,915
Wave 9	222,807	14,120	1.23%	0.27%	103	23	21,929,316	4,827,423	577,630	810,523	20,541,163	0.87	12,944,877	7,596,286
Wave 10	107,679	13,400	1.24%	0.33%	101	27	10,129,729	2,690,541	84,786	353,229	9,691,713	0.81	5,478,170	4,213,543
Wave 11	63,058	15,019	1.53%	0.26%	200	34	11,494,355	1,973,096	259,490	63,478	11,171,387	0.76	6,774,481	4,396,906
Wave 12	70,659	16,937	1.18%	0.28%	111	26	7,131,688	1,667,978	168,183	159,907	6,803,598	0.85	2,630,603	4,172,995
New Mover	100,810	25,230	1.73%	0.35%	183	37	17,253,387	3,491,964	262,934	256,570	16,733,883	0.83	12,335,031	4,398,852
Total	1,519,734	224,057	1.65%	-	156	-	227,072,180	30,914,665	3,971,096	5,020,706	218,080,379	0.90	162,950,803	55,129,576

* These counts are for active customers at the beginning of CY2019.

† Total savings are pro-rated for participants that closed their accounts during CY2019.

‡ No adjustment was made to total savings for negative uplift, (i.e. cases where the Residential Behavior Program decreased participation in other programs).

§ The retrospective retention rate reflects actual program retention for each wave from one year to the next.

|| Savings attributed to prior years are those deducted for persistence from CY2018 within the CPAS framework. This value is calculated by multiplying the CY2018 customer savings calculation per wave by the retrospective retention rate per wave by the savings decay rate for the second year of receiving reports (80%).

Verified Net Savings are equal to Net Savings, Prior to Uplift less CY2019 Uplift, Legacy Uplift, and Savings Attributed to Prior Years.

Source: ComEd data and evaluation team analysis.

Figure 8-1 shows energy savings for each wave with 90% confidence intervals overlaid on average pre-period daily electricity usage for each wave. Waves with larger confidence bounds generally had smaller sample sizes, which reduced the level of certainty in the savings results. For example, Wave 2 has a small sample size of 1,788 participants and 1,809 controls and large confidence bounds compared to the other waves, while Wave 7 Low had 384,752 participants and 32,041 controls and small confidence bounds compared to the other waves. Notably, all of the waves had statistically significant savings at the 90% confidence level.

Average pre-period daily electricity usage varied widely across waves. Wave 7 Low had the lowest average pre-period usage at 18 kWh per day, while Wave 5 had the highest at 58 kWh per day. Previous evaluations[21] identified that higher usage is often associated with greater Residential Behavior Program savings. Overlaying average pre-period daily usage with savings for each wave confirms that association. There is a positive correlation between pre-period usage and savings (0.557) indicating that energy savings increase with energy usage.

Figure 8-1. Savings and Pre-Period Usage by Wave
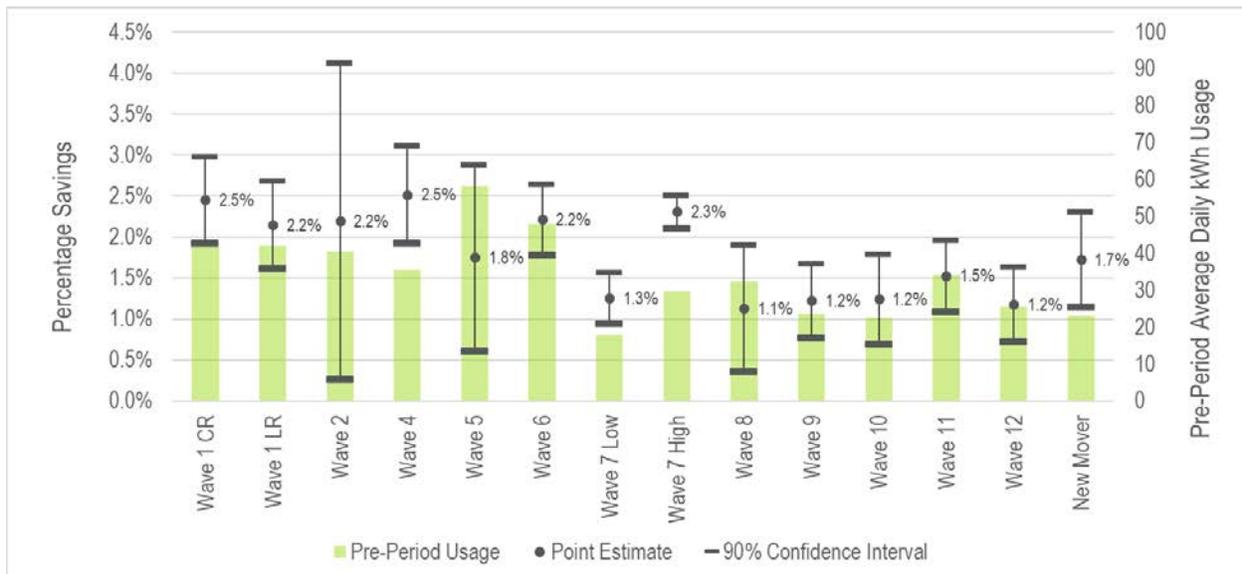
Source: ComEd data and evaluation team analysis.

Figure 8-2 combines CY2019 results with those from previous evaluations to show how the estimated percentage savings have changed over program years for each wave. In general, wave-specific savings show a consistent ramp-up in the first few years post-enrollment. After that savings tend to either plateau, though there can be considerable fluctuation from year to year.

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[21] Navigant. 2016. *ComEd Home Energy Report Program Evaluation Report.* Presented to Commonwealth Edison Company.

Figure 8-2. Residential Behavior Program Savings over Time by Wave
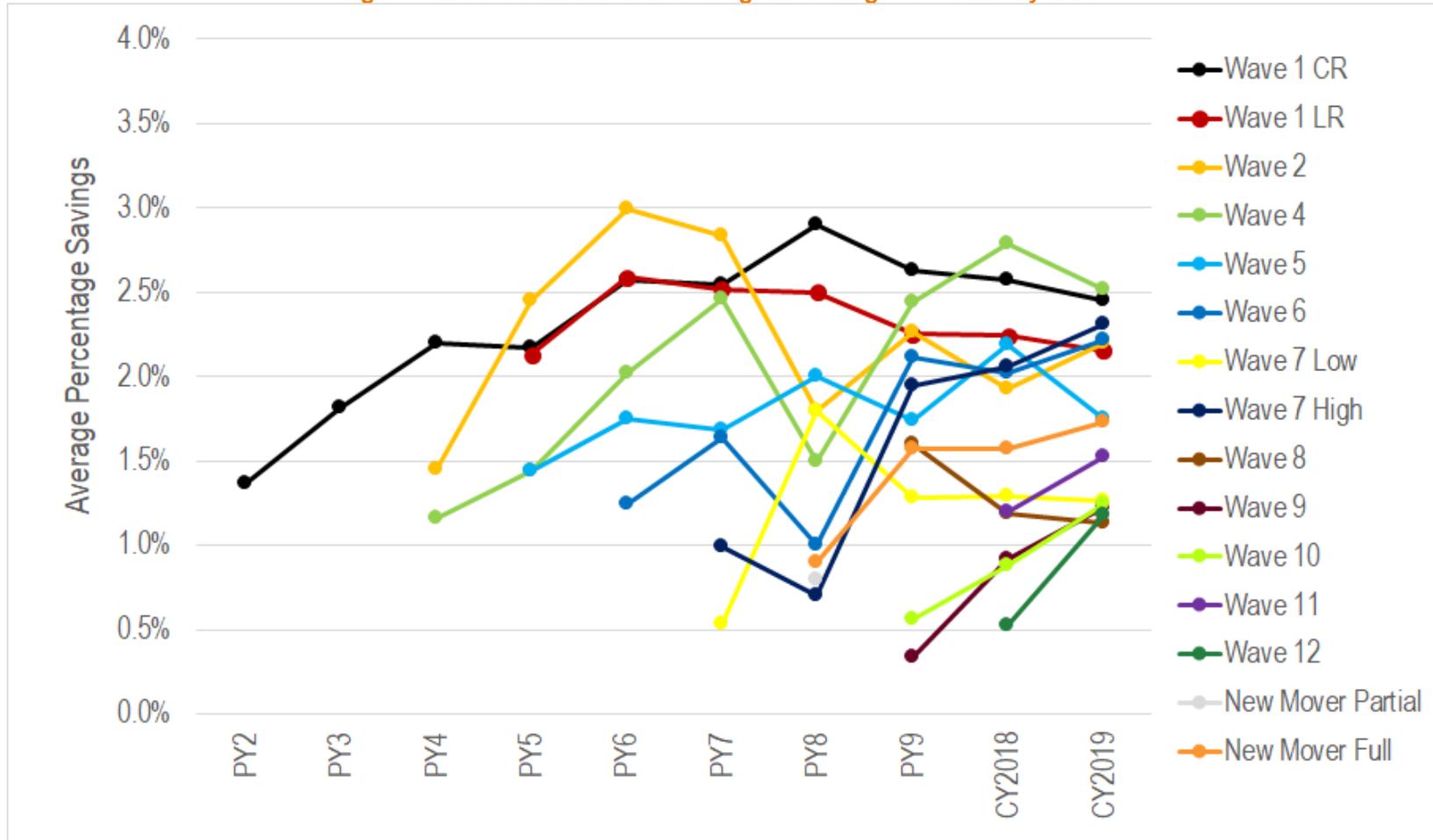
Note: In PY8, the evaluation team separated the New Mover Wave separated according to customers who received reports for a full or partial year (New Mover Full and New Mover Partial, respectively). In subsequent evaluations, the evaluation team combined these two subgroups under the "New Mover Full" heading. As a result, New Mover Partial does not have a savings value after PY8.
Source: ComEd data and evaluation team analysis.

8.2 Uplift Analysis Results

The uplift of savings in other EE programs was a small proportion of the total savings: 8,991,801 kWh, or approximately 4%. The uplift can be broken down into uplift in CY2019 and legacy uplift from previous program years. The CY2019 Uplift was 3,971,096 kWh or 1.7% of total program savings and the legacy uplift was 5,020,706 kWh or 2.2% of total program savings.[22] The upshot is that double counting of savings with other ComEd EE programs does not appear to be a significant issue for the Residential Behavior Program.

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[22] 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 the program year. It is more likely that participation varies across the year and not all of the first year program savings are captured by the Residential Behavior analysis. This overestimate likely offsets some underestimation due to the inability to account for double counting with upstream programs not tracked at the customer level.

9. APPENDIX 3. TOTAL RESOURCE COST DETAIL

Table 9-1 shows the Total Resource Cost (TRC) cost-effectiveness analysis inputs available at the time of finalizing this 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 the evaluation team later.

Table 9-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)	Verified Gross Savings Therms	Gross Heating Penalty (kWh)	Gross Heating Penalty (Therms)	NTG Ratio (kWh)	NTG Ratio (kW)	NTG Ratio (Therms)	Verified Net Savings (kWh)	Verified Net Peak Demand Reduction (kW)	Verified Net Savings Therms	Net Heating Penalty (kWh)	Net Heating Penalty (Therms)
Behavioral	All Waves	Household	1,519,734	5	NA	NA	NA	NA	NA	NA	NA	NA	55,129,576	NA	NA	NA	NA

NA = Not applicable
Note: The savings for this measure varies over time. See the CPAS tables in Section 4
Source: ComEd tracking data and evaluation team analysis.