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ComEd Residential Behavior Impact Evaluation Report

Energy Efficiency/Demand Response Plan:
Program Year 2021 (CY2021)
(1/1/2021-12/31/2021)

Prepared for:

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1. Introduction

This report presents the results of the impact evaluation of the CY2021 Residential Behavior Program.[1] It summarizes the total energy and demand impacts for the program broken out by relevant measure and program structure details. The appendices provide the impact analysis methodology and details of the total resource cost (TRC) analysis inputs. CY2021 covers January 1, 2021 through December 31, 2021.

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[1] This program is also referred to as the Home Energy Report (HER) Program and is so labeled in the NTG deemed spreadsheet.

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 from regularly mailed and emailed home energy reports,[2] including the following:

- 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 1,920,154 participants and 251,577 controls across 14 waves (Wave 7 has two components) in CY2021. Table 2-1 shows active participant and control accounts at the beginning of CY2021 rounded to the nearest thousand.[3] Wave 14 was new in CY2021.

Table 2-1. Number of Participants (In Thousands)

Participation	Participants	Controls	Total
Wave 1	20.3	23.6	43.9
Wave 2	1.6	1.6	3.2
Wave 4	12.4	12.5	24.9
Wave 5	3.7	4.8	8.5
Wave 6	55.4	16.8	72.1
Wave 7 Low	333.8	27.8	361.5
Wave 7 High	373.2	31.0	404.2
Wave 8	36.8	5.0	41.8
Wave 9	182.2	11.5	193.8
Wave 10	82.0	10.3	92.3
Wave 11	44.5	10.6	55.1
Wave 12	49.8	11.9	61.7
Wave 13	440.2	40.4	480.5
Wave 14	207.7	24.7	232.5
New Mover*	76.6	19.2	95.9
Total Participants	**1,920.2**	**251.6**	**2,171.7**

* Chronologically, the New Mover Wave came after Wave 8.
Source: ComEd tracking data and evaluation team analysis

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[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] The implementer stopped treatment of Wave 3 at the end of CY2018 and did not resume its treatment in CY2021. As such, the evaluation team did not evaluate Wave 3 in CY2021.

3. Program Savings Detail

Table 3-1 summarizes the incremental energy and demand savings the Residential Behavior Program achieved in CY2021. These savings reflect actual savings adjusted for uplift and CY2018, CY2019, and CY2020 persisting savings under the cumulative persisting annual savings (CPAS) framework.[4] 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.

Table 3-1. Total Annual Incremental Electric Savings

Savings Category	Units	Ex Ante Gross Savings	Program Gross Realization Rate	Verified Gross Savings	Program Net-to-Gross Ratio (NTG)	CY2019 Net Carryover Savings	CY2020 Net Carryover Savings	Verified Net Savings
Electric Energy Savings - Direct	kWh	N/A	N/A	N/A	N/A	0	0	105,968,421
Electric Energy Savings - Converted from Gas	kWh	N/A	N/A	N/A	N/A	0	0	-
Total Electric Energy Savings	kWh	N/A	N/A	N/A	N/A	0	0	105,968,421
Summer Peak§ Demand Savings	kW	N/A	N/A	N/A	N/A	0	0	18,290

N/A = not applicable (refers to a piece of data that cannot be produced or does not apply).
§ The coincident summer peak period is defined as 1:00-5:00 p.m. Central Prevailing Time on non-holiday weekdays, June through August.
Source: ComEd tracking data and evaluation team analysis

Table 3-2 provides the detailed adjustments made to arrive at the final verified net savings for CY2021 and compares them to ex ante net savings. Of the modeled savings, 5% are from uplift into other ComEd energy efficiency programs and just over half (54%) are attributable to prior program years. After the uplift and persistence adjustments, the evaluation team calculated a program net realization rate of 0.94. The bulk of this difference is driven by the uplift adjustment, which is unaccounted for in the ex ante savings estimate.

Table 3-2. Total Program Net Electric Savings

Savings Category	Energy Savings (kWh)
Ex Ante Net Savings	112,795,000
Modeled Savings	253,128,022
Current Year Uplift Adjustment	-2,435,301
Legacy Uplift Adjustment	-9,041,812
Verified Unadjusted Net Savings	241,650,908
Persistence Adjustment	-135,682,487
Final Verified Net Savings	105,968,421
Program Net Realization Rate	0.94

Source: ComEd tracking data and evaluation team analysis

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[4] For more information on uplift and persistence see Appendix A.1.5 and A.1.6, respectively. The retrospective persisting savings adjustments may not always match prospective claimed savings from prior years due to the difference between prospective and retrospective retention rates.

4. Cumulative Persisting Annual Savings

Table 4-1 and Figure 4-1 show the wave-specific and total verified gross savings for the Residential Behavior Program and the CPAS for the home energy reports sent to treatment customers in CY2021. The evaluation team did not evaluate gas savings for this program, so electric CPAS is equivalent to total CPAS. The historic rows in the table are the CPAS contributions back to CY2018. The Program Total Electric CPAS is the sum of the CY2021 contribution and the historic contribution. Figure 4-1 shows the savings across the effective useful life (EUL) of the program.

Coming from the CY2018, CY2019, and CY2020 evaluations, the evaluation team adjusted the historic program total electric contribution to CPAS for CY2021 using a prospective retention rate of 90%. When calculating the persistence adjustment for CY2021, the team relied on the retrospective retention rate as opposed to the prospective retention rate as applied to claimed first-year savings to develop an estimate of savings attributed to prior years, as the Illinois Technical Reference Manual v9.0 (IL-TRM)[5] prescribes.[6] This switch from the prospective retention rate to the retrospective retention rate resulted in 4,140,782 kWh of savings removed from the CY2021 verified net savings due to the historic program total electric contribution to CPAS (i.e., the persisting savings attributed to CY2018, CY2019, and CY2020 in the CY2021 evaluation is 4,140,782 kWh higher than the CPAS claimed for CY2021 from the CY2018, CY2019, and CY2020 evaluations).

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[5] In this report, unless stated otherwise, IL-TRM and IL-TRM Errata refers to version 9.0 (v9.0).

[6] The evaluation team calculated the retrospective retention rate for each wave and applied it to each wave's savings as part of the analysis. The retrospective retention rates range from 53% to 95% across the waves for the cumulative 2018-2021 period. Table B-1 includes 2020 to 2021 retention rates.

Table 4-1. Cumulative Persisting Annual Savings – Electric

End Use Type	Research Category	EUL	CY2021 Verified Gross Savings (kWh)	NTG*	Lifetime Net Savings (kWh)†	Verified Net kWh Savings								
						2018	2019	2020	2021	2022	2023	2024	2025	2026
Behavioral	Wave 1 CR	5.0	N/A	N/A	2,641,727				1,066,982	766,520	464,626	239,523	104,077	-
Behavioral	Wave 1 LR	5.0	N/A	N/A	940,726				379,955	272,960	165,455	85,295	37,062	-
Behavioral	Wave 2	5.0	N/A	N/A	(69,793)				(28,189)	(20,251)	(12,275)	(6,328)	(2,750)	-
Behavioral	Wave 4	5.0	N/A	N/A	1,311,319				529,636	380,490	230,634	118,896	51,662	-
Behavioral	Wave 5	5.0	N/A	N/A	479,569				193,696	139,151	84,346	43,482	18,894	-
Behavioral	Wave 6	5.0	N/A	N/A	5,389,822				2,176,925	1,563,903	947,960	488,691	212,344	-
Behavioral	Wave 7 Low	5.0	N/A	N/A	29,222,098				11,802,674	8,479,041	5,139,571	2,649,544	1,151,270	-
Behavioral	Wave 7 High	5.0	N/A	N/A	66,208,355				26,741,256	19,210,918	11,644,698	6,003,058	2,608,425	-
Behavioral	Wave 8	5.0	N/A	N/A	(1,628,882)				(657,898)	(472,634)	(286,487)	(147,689)	(64,173)	-
Behavioral	Wave 9	5.0	N/A	N/A	16,242,273				6,560,181	4,712,834	2,856,684	1,472,674	639,900	-
Behavioral	Wave 10	5.0	N/A	N/A	16,019,031				6,470,015	4,648,058	2,817,421	1,452,433	631,105	-
Behavioral	Wave 11	5.0	N/A	N/A	11,641,516				4,701,956	3,377,885	2,047,505	1,055,527	458,643	-
Behavioral	Wave 12	5.0	N/A	N/A	15,402,659				6,221,064	4,469,213	2,709,013	1,396,547	606,822	-
Behavioral	Wave 13	5.0	N/A	N/A	56,820,556				22,949,566	16,486,968	9,993,576	5,151,873	2,238,572	-
Behavioral	Wave 14	5.0	N/A	N/A	25,178,319				10,169,409	7,305,704	4,428,352	2,282,898	991,956	-
Behavioral	New Mover	5.0	N/A	N/A	16,566,646				6,691,194	4,806,954	2,913,735	1,502,084	652,680	-
CY2021 Program Total Electric Contribution to CPAS			-		262,365,944				**105,968,421**	76,127,714	46,144,814	23,788,506	10,336,490	-
Historic Program Total Electric Contribution to CPAS‡						279,539,772	255,950,948	240,435,808	143,757,190	74,286,915	23,282,095	7,776,226		-
Program Total Electric CPAS						279,539,772	255,950,948	240,435,808	249,725,611	150,414,629	69,426,909	31,564,732	10,336,490	-
CY2021 Program Incremental Expiring Electric Savings§										29,840,707	29,982,900	22,356,308	13,452,016	-
Historic Program Incremental Expiring Electric Savings									96,678,618	69,470,275	51,004,820	15,505,870	7,776,226	-
Program Total Incremental Expiring Electric Savings									96,678,618	99,310,982	80,987,720	37,862,177	21,228,242	-

Note: The green highlighted cell shows program total first-year electric savings. The gray cells are blank, indicating values irrelevant to the CY2021 contribution to CPAS.

N/A = not applicable (refers to a piece of data that cannot be produced or does not apply).

* A deemed value. Source: Illinois Stakeholder Advisory Group (SAG) website: **https://www.ilsag.info/evaluator-ntg-recommendations-for-2021**.

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

‡ Historic 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
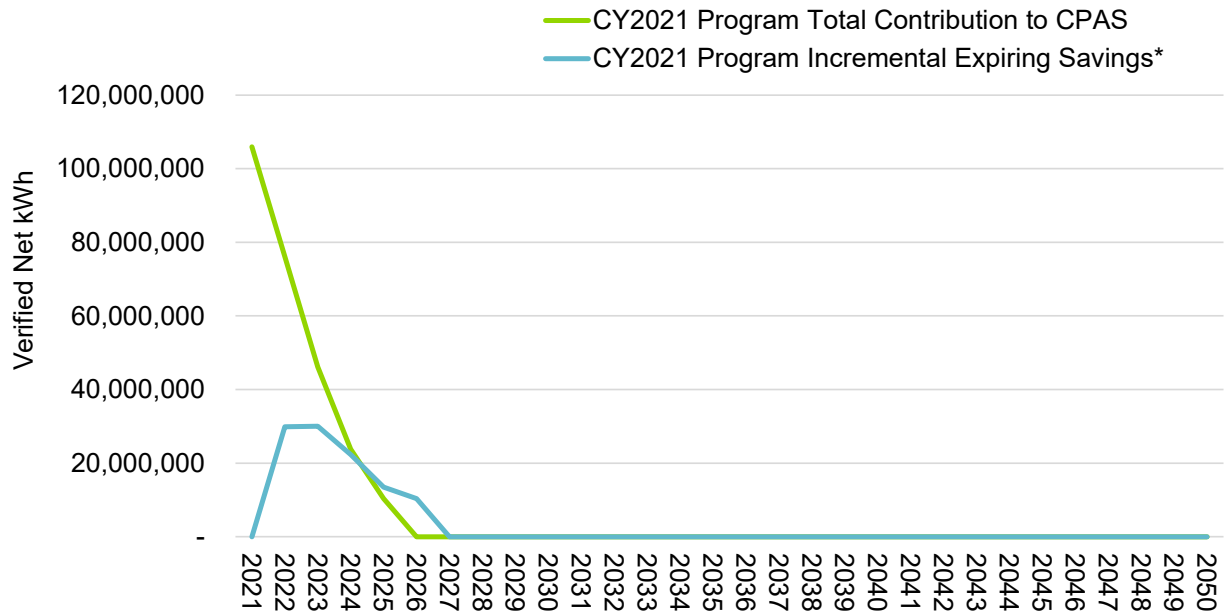
* Expiring savings are equal to CPAS Y_{n-1} - CPAS Y_n.
Source: Evaluation team analysis

5. Program Savings by Measure

This program has only one measure, so measure-level results are the same as the program-level results discussed in the previous section.

6. Impact Analysis Findings and Recommendations

One factor that affected adjusting ex ante savings was the uplift adjustment, which is unaccounted for in the implementer's savings estimate. The realization rate was 0.94 and uplift accounted for a 5% decrease in the verified savings, driving the bulk of the difference.

The evaluation team developed several recommendations for ComEd and the implementation team based on findings from the CY2021 evaluation.

Finding 1. In CY2021, the Residential Behavior Program achieved average per-participant savings of 1.49%, compared to 1.28% in CY2020 and 1.65% in CY2019. At the wave level, CY2021 per-participant savings ranged from 0.63% for Wave 14 to 2.53% for Wave 1.

Finding 2. Overall, the program saw a 34% increase in CY2021 verified net savings compared to final CY2020 verified net savings (from 79,014,639 kWh to 105,968,421 kWh). This performance was driven primarily by Wave 13's higher than expected growth and large size, growth in savings for Wave 12, and the addition of Wave 14. Overall, wave-level performance varied, with some waves experiencing higher and some waves experiencing lower CY2021 verified net savings than CY2020. Table B-1 provides more information on savings by wave.

Finding 3. The program-treated population was expanded in CY2021 by adding a new wave (Wave 14) of 207,734 treatment customers. With over 2 million customers enrolled, the program represents over two-thirds of ComEd's residential customer base. As expected for new waves given the magnitude of the population already in the program, average energy consumption of the newly enrolled Wave 14 customers is lower than that of many other waves at 24.4 kWh per day. Lower energy consumption is correlated with lower energy savings, both in absolute and relative terms, which is evidenced by Wave 14 having much lower per-participant savings than most other waves (58 kWh per year versus 77 for the next lowest wave). Savings for Wave 14 are expected to increase with ramp up over the next few years.

> **Recommendation 1.** Continue to balance the ongoing treatment of existing customers to deliver incremental savings under the CPAS framework, enrollment of new waves that focus on the highest usage customers available, and further optimization of treatment frequency and high usage alerts. This balance should take into account that the evaluation team has seen relatively high attrition from move outs in the first year for recent waves, which may result in a shorter lifespan of savings for those newer waves.

Finding 4. Continued treatment generally leads to an increase in savings over time, which occurred this year with Wave 13. With CY2021 marking the second year of treatment, average annual savings more than doubled from 31 kWh to 84 kWh per year, a 171% increase year-over-year. This ramp-up was larger than the evaluation team expected given what has occurred in other waves in past years.

> **Recommendation 2.** Given the large size of Wave 13, closely monitor performance among Wave 13 participants to anticipate any savings plateau.

Finding 5. The evaluation team relied on custom savings calculations to derive CY2021 program savings. Though the COVID-19 pandemic continued to impact customer lives and routines throughout 2021, normalization for COVID-19 was not explicitly performed in CY2021 (said another way, actual savings were assumed to be normal). This decision was primarily

driven by the CY2020 analysis where the team found that the custom analysis produced very similar savings to the normalization method used to claim savings in CY2020.

> **Recommendation 3.** Continue to monitor the pandemic and plan to leverage custom savings calculations for the program moving forward unless agreed otherwise.

Finding 6. The statistical nature of the savings calculations for the Residential Behavior Program introduces uncertainty in savings variation year-over-year within the CPAS framework and can result in negative savings and savings removed due to the differential between prospective and retrospective retention rates (as explained in Table 4-1), with attrition, uplift, and modeling uncertainty acting as possible contributing factors. CY2021 is the third year in a row where retrospective adjustments to the retention rates resulted in unclaimed savings. In addition, two CY2021 waves experienced negative savings after adjusting for savings attributed to prior years. The evaluation team is exploring an IL-TRM update to mitigate this difference between prospective and retrospective retention rates.

> **Recommendation 4.** Continue to review the retrospective retention rates each year. If the retention rates by wave are stable for several years, the evaluation team recommends changing the prospective retention rate to make it wave-specific.

# Appendix A. Impact Analysis Methodology

A.1 Savings Methodology

This section details the methodology employed for developing custom savings estimates for CY2021.

A.1.1 New Wave Consumption Equivalency

To test that the new CY2021 wave (Wave 14) is consistent with a randomized controlled trial (RCT), the evaluation team compared treatment and control usage for each month during the pre-program period. If the allocation of households across participants and controls is truly random, the two groups should have the same distribution of energy usage during the 12 months prior to receiving program intervention. The team conducted variance tests and t-tests comparing participant and control usage for each month of the pre-period and found that mean usage was not statistically different. As an additional check, the evaluation team performed a regression analysis in which average daily usage in the pre-program period was a function of monthly binary variables and a binary participation variable, which showed participation did not impact usage.

Figure A-1 illustrates the control group and treatment group usage during the 12-month pre-period for Wave 14. The graph indicates what the evaluation team's statistical analysis confirmed, namely that the assignment of customers into the treatment and control groups was consistent with randomization.

Figure A-1. RCT Usage Comparison for Wave 14
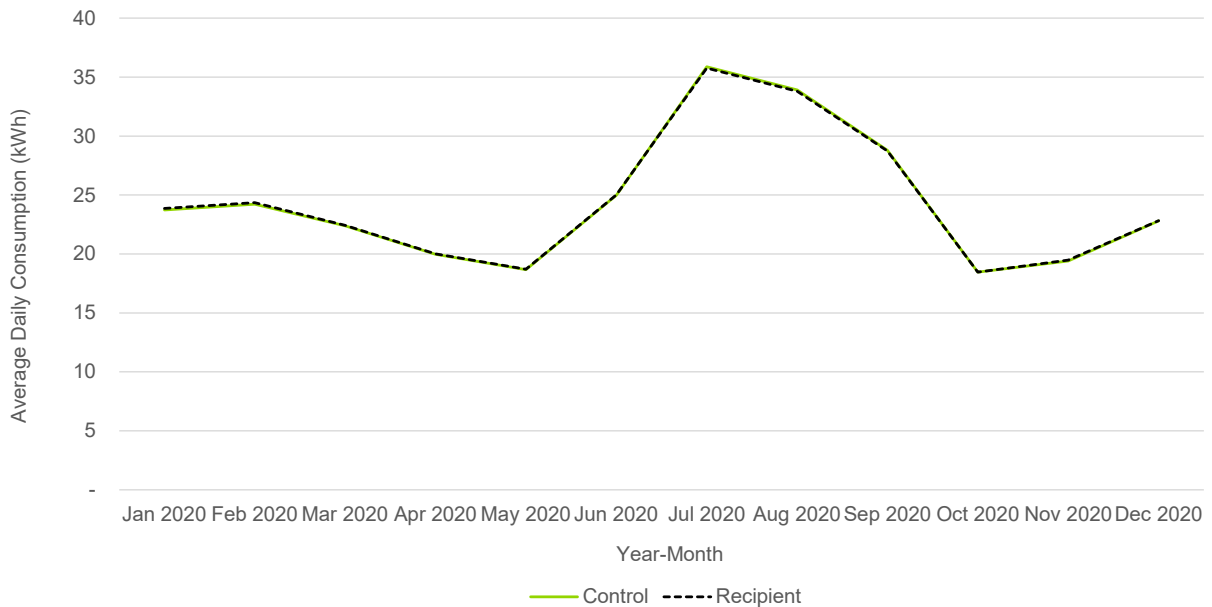
Source: Evaluation team analysis

A.1.2 Data Cleaning

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

- Observations outside CY2021 and each wave's relevant pre-program year

- Customers that no longer had active ComEd accounts in CY2021

- Persistence study customers[7]

- Observations with a bill duration of zero days

- Outliers, defined as observations with average daily usage more than one order of magnitude from the median wave usage

After selecting program and pre-program year data for each wave for active (non-persistence study) participants, the remaining cleaning steps removed 0.003% of customers and 0.04% of observations, evenly distributed across participants and controls. This suggests that the evaluation team's cleaning steps did not introduce non-random biases into the data.

A.1.3 Imputation of Pre-Period Data

The evaluation team found that a large share of treatment and control customers in Waves 10, 11, 12, and 14 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.

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, 12, and 14, the team replaced the missing data with substituted values (i.e., imputed data) representing average daily consumption for customers that have pre-period data. The evaluation team performed imputations independently for each wave, pre-period month, and customer group (treatment vs. control).

A.1.4 Modeling Methodology

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

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[7] These customers were dropped from the program several years ago to study how savings persist after reports stopped.

[8] Because 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.

[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 similar. This supports the methodological approach and indicates the results are robust.

LDV 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 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 A-1.

Equation A-1. LDV 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.

LFER 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·Post_t.*

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

Equation A-2. LFER Model

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

Coefficient α_{0k} captures all household-specific effects on energy use that do not change over time, including those that are unobservable. Coefficient α_1 captures the average effect across all

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[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. That is, these are monthly fixed effects.

[11] The evaluation team imputed these values for some observations of Waves 10, 11, 12, and 14, as discussed in Section A.1.3.

households of being in the post-treatment period. 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.

Weather Normalization

The IL-TRM recommends 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 is important when estimating CPAS savings for the program because it controls for the confounding effects of differences in weather in future years. The evaluation team considered using weather normalization and chose not to weather normalize CY2021 savings. The key reason 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 timeframe is likely different than the future expectations given the effects of climate change. 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.

A.1.5 Account for Uplift in Other Energy Efficiency Programs

Accounting for Uplift in CY2021

The home energy reports sent to participating households include energy-savings tips, some of which encourage participants to enroll in other ComEd energy efficiency programs. If participation rates in other energy efficiency 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 energy efficiency programs. If the Residential Behavior Program affects participation rates in other energy efficiency programs, then savings across all programs are lower than indicated by the simple summation of savings in the Residential Behavior and energy efficiency programs. For instance, if the Residential Behavior Program increases participation in other energy efficiency programs, the increase in savings may be allocated to either the Residential Behavior Program or the energy efficiency program but cannot be allocated to both programs simultaneously.[12] When the Residential Behavior Program decreases participation in other programs, there is no issue of double counting, and no adjustment to the savings total is made.

Data permitting, the evaluation team uses a difference-in-difference (DID) statistic to estimate uplift in other energy efficiency programs. To calculate the DID statistic, the change in the participation rate in another energy efficiency program between CY2021 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 energy efficiency program during CY2021 is 5% for the treatment group and 3% for the control group, and the rate of participation during the year

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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.

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 A-3.

Equation A-3. DID Statistic Calculation

$$(CY2021\ treatment\ group\ participation - prePY\ treatment\ group\ participation)$$
$$- (CY2021\ control\ group\ participation - prePY\ control\ group\ participation)$$
$$= DID\ statistic$$
$$(5\% - 2\%) - (3\% - 1\%) = 1\%$$

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 CY2021. The POD statistic generates an unbiased estimate of uplift when the baseline average rate of participation in the energy efficiency program is the same for the treatment and control groups. The evaluation team uses this alternative statistic in cases where the energy efficiency program did not exist in the pre-program year.

In CY2021 the evaluation team examined the uplift associated with the following energy efficiency programs:[13]

- **Single-Family Illinois Home Weatherization Assistance (SF-IHWAP) Program:** This program helps low income customers residing in single-family homes conserve fuel and reduce energy costs by making their homes and apartments more energy efficient. SF-IHWAP also provides many health and safety upgrades ensuring safe and healthy homes. Weatherization services included as part of the program include insulation and air sealing, heating, ventilation, and air conditioning (HVAC) and water heating equipment upgrades, and ventilation and moisture control measures.

- **Multi-Family Illinois Home Weatherization Assistance (MF-IHWAP) Program:** This program caters to building owners who provide housing to income-eligible residents in multifamily properties. Improvements include a range of weatherization services.

- **Residential HVAC Program:** This program offers incentives to residential customers to encourage customer purchases of higher efficiency HVAC equipment. In CY2020, this program also began offering rebates for the installation of ground source heat pumps.

- **Multi-Family Assessments:** This program provides qualifying property owners and managers with a no-cost energy assessment, incentives for energy-saving building upgrades, and incentives for energy-saving products installed throughout their building, including resident's homes.

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

- **Single Family Assessments:** 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 light-emitting diodes (LEDs), low flow showerheads, faucet aerators, programmable thermostats, and smart thermostats.

- **Public Housing Retrofits:** This program is offered jointly with the local gas utilities and works with public housing authorities (PHAs) to achieve electric and gas savings. Improvements benefit the PHA and public housing residents, including direct install measures and in-unit and common area space heating and cooling, refrigeration, lighting, and envelope upgrades.

For each energy efficiency 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. If pre-period data was not available for certain programs for certain waves, the team relied on the POD statistic to determine uplift. For all other programs, the team used the DID statistic.

Accounting for Legacy Uplift

The uplift adjustment methodology only accounts for uplift, which occurs in the current program year because energy efficiency program tracking files in any given program year only capture the new measures installed in that year, regardless of the expected measure life.[14] For other energy efficiency programs that include measures with multiyear measure lives; however, 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 10-year measure life that was installed in Program Year 5 (PY5)[15] would generate savings captured in the Residential Behavior Program savings not just in PY5, but in PY6 through CY2021 as well.

Consider the following example. A household receiving home energy reports through the Residential Behavior Program enrolls in the SF-IHWAP Program in CY2020. The uplift adjustment subtracts SF-IHWAP CY2020 Program savings to avoid double counting. In CY2021 this household still receives savings from the SF-IHWAP Program because it has a 16-year measure life. However, the CY2021 Residential Behavior uplift adjustment does not remove these savings because the CY2021 adjustment only accounts for measures installed in CY2021, the initial year the household entered a program. When only relying on the uplift adjustment, SF-IHWAP second-year savings would be included in the CY2021 Residential Behavior Program's savings, which is inconsistent with Illinois' practices of only crediting utilities with first-year energy efficiency 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 CY2021 Residential

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

[15] Illinois used PY to designate evaluation years until the end of 2017 (PY9) when the evaluation timeline was shifted to the calendar year and the CY convention took over.

[16] Because Residential Behavior Program participants are dropped from that program when they move, other energy efficiency programs' savings are no longer captured in the Residential Behavior Program savings from that point forward.

Behavior savings through the measure lives of measures from other energy efficiency programs. The legacy uplift adjustment is shown in Equation A-4.

<div align="center">**Equation A-4. Legacy Uplift Calculation**</div>

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

Where, "Live" Legacy Uplift Savings refers to uplift savings where the other energy efficiency 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. 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 EULs, the evaluation team calculated EULs at the program level by weighting measure-specific EULs by savings. Once the program reaches its weighted average measure life (WAML), 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 team considered double counted savings for the Multi-Family Energy Savings Program (MESP), and the HEA, HVAC and Weatherization, and Fridge Freezer Recycling (FFR) Programs. In CY2018, the evaluation team considered double counted savings for the FFR, HEA, Single Family Programs (CBA and IHWAP), Multi-Family Programs (MESP, Retrofits and IHWAP), HVAC, and Weatherization Programs. In CY2019, the program considered double counted savings from FFR, HEA, Multi-Family Programs (Multi-Family Retrofits IE, Multi-Family Energy Savings Program, IWHAP), Single Family Programs (Single Family Retrofits IE, IHWAP), HVAC, Weatherization, and Manufactured Housing Retrofits. In CY2020, the program considered double counted savings from FFR, HEA, Multi-Family Programs (Multi-Family Retrofits IE, Multi-Family Energy Savings Program, IWHAP), Single Family Programs (Single Family Retrofits IE, IHWAP), HVAC, and Manufactured Housing Retrofits.

Due to expired program-level EULs, the evaluation team removed all legacy PY4 uplift in CY2021, and also removed FFRR uplift from PY5, MF Program uplift from PY5 and PY6, and HEA and MESP uplift from PY7.

A.1.6 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 the IL-TRM. IL-TRM v9.0 shifts the measure EUL from 5 to 10 years and implements new persistence factors, but it explicitly states that those values are for Plan 6 planning and CY2021 evaluations should continue to use the 5-year life and persistence

factors from IL-TRM v8.0. IL-TRM v8.0 recommends using the persistence factors presented in Table A-1 over the 5-year life to estimate lifetime electric energy savings for the program.

Table A-1. Residential Behavior Electric Savings Persistence Factors

Year	Electric Persistence Factor
Year 1	100%
Year 2	80%
Year 3	54%
Year 4	31%
Year 5	15%

Source: IL-TRM v8.0, Measure 6.1.1, Volume 4

In addition to applying persistence rate factors, lifetime savings need to account for customer attrition over time due to move outs and account closures.[17] In CY2018, the evaluation team calculated a prospective annual retention rate of 89.8%, which is also applied in CY2021.[18] This is a weighted average rate across all program waves, except for the New Mover Wave[19] from 2014 through 2018. Using customers across all program waves allowed the evaluation team to capture the various customer segments (e.g., high users, low users) that can have differing attrition due to move out or other reasons in the estimate. Using a 5-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 CY2018 report includes details for this approach.

A.2 Peak Demand Savings Estimation

The evaluation team calculated peak demand savings using the approach outlined in the IL-TRM for cases where peak demand is not measured directly by the custom savings analysis.

Equation A-5. Peak Demand Savings Formula

$$\Delta kW_{T\ Adjusted} = \left(\frac{\Delta kWh_{T\ Adjusted\ Summer}}{Summer\ Hours} \right) * Peak\ Adjustment\ Factor$$

Where:

$\Delta kW_{T\ Adjusted\ Summer}$ = average adjusted electric energy savings (calculated above) for peak summer months

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[17] 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 (if 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. The IL-TRM assumes no persisting savings upon customer move out, though it encourages additional research on the matter.

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

[19] The team 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%.

$$= \Delta kWh_{T\ Adjusted} * 0.42 * (3/5)$$
$$= \Delta kW_{hT\ Adjusted} * 0.25$$

Where:

0.42 = summer load shape percentage for May through September

3/5 = proportion of May through September hours that fall in June, July, and August

summer hours = hours in June, July, and August

= 8,760 / 4

Where:

8,760 = Hours per year

peak adjustment factor = adjustment for peak kW over average kW for these hours

= 1.5

Appendix B. Impact Findings Detailed Results

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.

B.1 Savings by Wave

This section disaggregates program savings according to individual waves and wave subgroups. Table B-1 summarizes estimated program savings by participant wave. To examine the persistence of savings, the implementer 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. In CY2021, the evaluation attributed savings to 1,920,154 treatment customers. The evaluation team estimated separate savings for each wave and wave subgroup using regression analysis as described in Appendix A.1.

Table B-1. CY2021 Residential Behavior Program – Savings 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.	CY2021 Uplift, kWh‡	Legacy Uplift, kWh‡	CY2021 Custom Savings Calculation	Retrospective Retention Rate (2021 to 2020)§	Savings Attributed to Prior Years||	Verified Net Savings, kWh#
Wave 1 CR	15,499	23,584	2.53%	0.37%	345	50	5,198,103	749,454	108,919	438,251	4,650,933	0.95	3,583,951	1,066,982
Wave 1 LR	4,806		2.33%	0.37%	317	50	1,483,777	233,375	10,008	189,148	1,284,621	0.95	904,666	379,955
Wave 2	1,598	1,620	1.60%	1.33%	203	170	314,913	262,907	31,221	20,730	262,963	0.94	291,152	-28,189
Wave 4	12,396	12,463	2.30%	0.42%	259	47	3,123,942	565,387	1,917	99,010	3,023,015	0.95	2,493,379	529,636
Wave 5	3,700	4,813	1.64%	0.85%	339	177	1,216,154	633,115	11,562	79,323	1,125,269	0.94	931,573	193,696
Wave 6	55,372	16,763	1.80%	0.32%	274	49	14,711,489	2,647,698	195,350	473,627	14,042,512	0.94	11,865,587	2,176,925
Wave 7 Low	333,750	27,766	1.44%	0.23%	95	15	30,525,365	4,827,290	33,624	736,660	29,755,081	0.93	17,952,407	11,802,674
Wave 7 High	373,179	31,042	2.27%	0.15%	227	15	82,098,641	5,420,923	402,429	3,404,330	78,291,881	0.94	51,550,625	26,741,256
Wave 8	36,788	4,971	0.64%	0.60%	77	72	2,723,708	2,546,436	263,048	270,908	2,189,753	0.91	2,847,651	-657,898
Wave 9	182,222	11,529	1.28%	0.34%	113	30	19,718,506	5,226,631	428,021	1,506,698	17,783,787	0.91	11,223,607	6,560,181
Wave 10	81,981	10,270	1.72%	0.45%	154	41	11,992,557	3,154,582	113,947	524,105	11,354,505	0.89	4,884,491	6,470,015
Wave 11	44,519	10,565	1.82%	0.42%	243	56	10,185,538	2,362,160	84,536	360,863	9,740,139	0.87	5,038,183	4,701,956
Wave 12	49,803	11,903	2.01%	0.42%	209	44	9,792,132	2,068,435	9,079	203,406	9,579,647	0.87	3,358,583	6,221,064
Wave 13	440,158	40,355	1.14%	0.17%	84	12	33,999,139	4,974,255	89,163	133,419	33,776,557	0.81	10,826,990	22,949,566
Wave 14	207,734	24,729	0.63%	0.23%	58	22	10,769,552	3,995,262	600,143	0	10,169,409	1.00	0	10,169,409
New Mover	76,649	19,204	1.84%	0.41%	211	47	15,274,505	3,388,895	52,334	601,336	14,620,835	0.88	7,929,641	6,691,194
Total	**1,920,154**	**251,577**	**1.49%**	**-**	**138**	**-**	**253,128,022**	**43,056,806**	**2,435,301**	**9,041,812**	**241,650,908**	**0.91**	**135,682,487**	**105,968,421**

* These counts are for active customers at the beginning of CY2021.

† Total savings are prorated for participants that closed their accounts during CY2021.

‡ 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, CY2019, and CY2020 within the CPAS framework. This value is calculated by multiplying the CY2018, CY2019, and CY2020 customer savings calculation per wave by the retrospective retention rate per wave by the savings decay rate.

Verified net savings are equal to net savings, prior to uplift less CY2021 uplift, legacy uplift, and savings attributed to prior years.
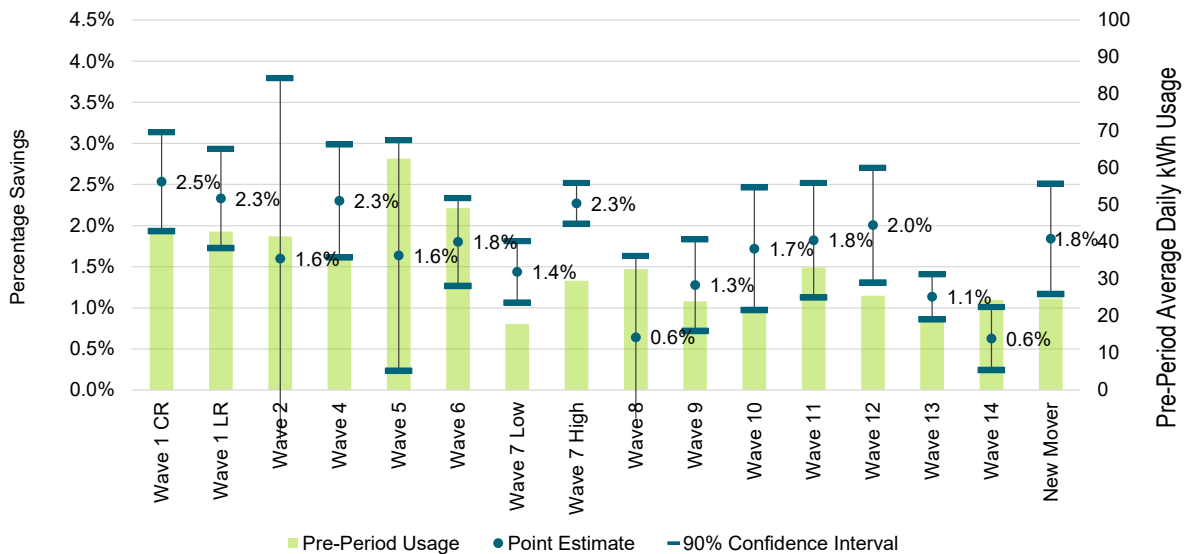
Source: ComEd data and evaluation team analysis

Figure B-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 1,598 participants and 1,620 controls and large confidence bounds compared to the other waves, while Wave 13 had 440,158 participants and 40,355 controls and small confidence bounds compared to the other waves. Notably, all 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 63 kWh per day. Previous evaluations identified that higher usage is often associated with greater Residential Behavior Program savings.[20] 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 (0.336) indicating that energy savings increase with energy usage.

Figure B-1. Actual Savings and Pre-Period Usage by Wave

Source: ComEd data and evaluation team analysis

Figure B-2 combines CY2021 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 plateau, though there can be considerable fluctuation from year to year.

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

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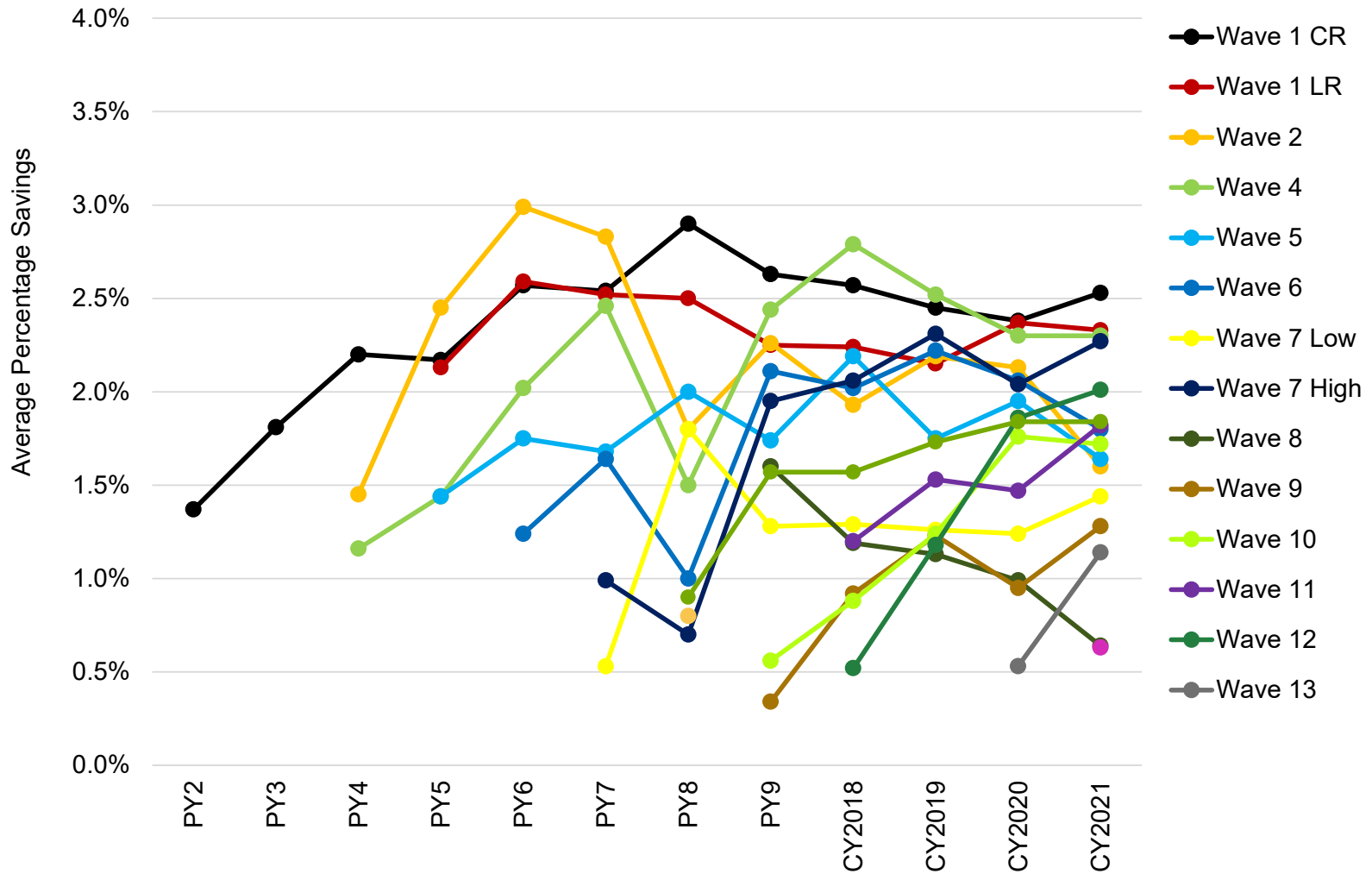
Note: In PY8, the evaluation team separated the New Mover Wave according to customers who received reports for a full or partial year (New Mover Full and New Mover Partial, respectively). In subsequent evaluations, the team combined these two subgroups under the "New Mover Full" heading. As a result,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

Source: ComEd data and evaluation team analysis

B.2 Uplift Analysis Results

This section summarizes CY2021 uplift results. The uplift of savings in other energy efficiency programs was a small proportion of the total savings: 11,477,114 kWh, or approximately 4.5%. The uplift can be broken down into uplift in CY2021 and legacy uplift from previous program years. The CY2021 uplift was 2,435,301 kWh or 1% of total program savings, and the legacy uplift was 9,041,812 kWh or 3.6% of total program savings.[21] Double counting of savings with other ComEd energy efficiency programs does not appear to be a significant issue for the Residential Behavior Program.

Table B-2 details the CY2021 uplift associated with each program and wave.

Table B-2. CY2021 Uplift by Program and Wave

	SF-IHWAP	MF-IHWAP	Residential HVAC	Single Family Assessments	Multi-Family Assessments	Public Housing Retrofits	Total
Wave 1 CR	11,368	0	0	97,551	0	0	**108,919**
Wave 1 LR	0	0	9,594	0	415	0	**10,008**
Wave 2	30,885	0	333	3	0	0	**31,221**
Wave 4	12	0	17	1,887	0	0	**1,917**
Wave 5	8,576	0	0	2,986	0	0	**11,562**
Wave 6	110,408	53,752	26,023	5,167	0	0	**195,350**
Wave 7 Low	0	2,467	0	27,247	3,911	0	**33,624**
Wave 7 High	264,924	0	137,505	0	0	0	**402,429**
Wave 8	230,187	25,834	6,353	0	675	0	**263,048**
Wave 9	233,738	15,328	0	172,196	6,758	0	**428,021**
Wave 10	0	3,280	7,852	102,815	0	0	**113,947**
Wave 11	7,545	2,125	34,497	40,368	0	0	**84,536**
Wave 12	0	0	7,534	0	0	1,546	**9,079**
Wave 13	0	0	24,861	0	45,906	18,396	**89,163**
Wave 14	72,814	0	91,190	427,545	8,594	0	**600,143**
New Mover	21,841	0	21,054	9,440		0	**52,334**
Total	**992,298**	**102,787**	**366,812**	**887,204**	**66,259**	**19,942**	**2,435,301**

Source: ComEd data and evaluation team analysis

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[21] The estimate of double counted savings is most likely an overestimate because it presumes participation in the other energy efficiency programs occurs at the very start of the program year. It is more likely that participation varies across the year and not all 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.

Table B-3 contains the legacy uplift attributed to each program and wave.

Table B-3. CY2021 Legacy Uplift by Program and Wave

	FFRR	FFR	CSR	CW	Residential HVAC	Weatherization (Wx)	SFHES	Single Family Assessments	CBA	SF-IE	SF-IHWAP	Multi-Family Assess.	MF-IE	MF-IHWAP	Manufactured Housing Retrofits	Total
Wave 1 CR	461	19,796	16,542	1,696	13,855	2,135	0	356,624	3,740	8,465	12,038	2,899	0	0	0	**438,251**
Wave 1 LR	1,099	96,680	1,214	291	45,182	597	2,246	32,159	1,357	8,154	0	167	0	0	0	**189,148**
Wave 2	0	0	3	0	5,587	295	235	13,053	0	1,556	0	0	0	0	0	**20,730**
Wave 4	0	3,775	0	0	24,567	0	713	48,641	0	4,062	16,778	0	473	0	0	**99,010**
Wave 5	6,943	39,243	6,253	400	10,912	0	1,283	0	0	3,271	11,019	0	0	0	0	**79,323**
Wave 6	7,976	16,177	28,137	0	201,379	3,387	7,057	193,506	2,506	7,972	0	0	0	0	5,530	**473,627**
Wave 7 Low	0	230,474	0	0	33,386	0	0	209,897	32,772	165,503	2,147	21,843	2,995	6,501	31,141	**736,660**
Wave 7 High	0	1,395,271	0	0	559,784	42,757	0	1,131,190	0	74,850	126,099	0	54,023	7,092	13,263	**3,404,330**
Wave 8	0	136,405	0	0	47,394	3,854	0	51,200	0	0	21,462	5,722	4,872	0	0	**270,908**
Wave 9	0	658,051	0	0	43,969	5,367	0	471,300	0	170,242	66,893	47,370	18,852	21,602	3,052	**1,506,698**
Wave 10	0	108,981	0	0	26,402	3,112	0	275,378	54,744	0	32,134	7,640	7,261	7,883	569	**524,105**
Wave 11	0	60,939	0	0	54,333	0	0	226,992	12,133	0	0	0	0	2,020	4,446	**360,863**
Wave 12	0	70,331	0	0	39,997	2,172	0	70,989	2,493	11,548	0	0	1,607	0	4,269	**203,406**
Wave 13	0	0	0	0	21,209	0	0	0	0	17,321	0	50,442	0	44,447	0	**133,419**
New Mover	0	185,075	0	0	97,777	7,582	0	156,829	30,157	58,606	56,691	2,770	0	5,849	0	**601,336**
Total	**16,478**	**3,021,198**	**52,149**	**2,388**	**1,225,733**	**71,259**	**11,536**	**3,237,759**	**139,901**	**531,550**	**345,262**	**138,852**	**90,084**	**95,394**	**62,270**	**9,041,812**

Source: ComEd data and evaluation team analysis

Appendix C. Total Resource Cost Detail

Table C-1 shows the TRC cost-effectiveness analysis inputs available at the time of finalizing this impact evaluation report. This table does not include additional required cost data (e.g., measure costs, program-level incentives, and non-incentive costs). ComEd will provide this data to the evaluation team later.

Table C-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	EUL (years)*	ER Flag†	Gross Electric Energy Savings (kWh)	Gross Peak Demand Reduction (kW)	Gross Gas Savings (Therms)	Gross Secondary Savings due to Water Reduction (kWh)	Gross Heating Penalty (kWh)	Gross Heating Penalty (Therms)	NTG (kWh)	NTG (kW)	NTG (Therms)	Net Electric Energy Savings (kWh)	Net Peak Demand Reduction (kW)	Net Gas Savings (Therms)	Net Secondary Savings due to Water Reduction (kWh)	Net Heating Penalty (kWh)	Net Heating Penalty (Therms)
Behavioral	All Waves	Household	1,920,154	5.0‡	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	105,968,421	18,290	0	0	0	0

N/A = not applicable (refers to a piece of data that cannot be produced or does not apply).

* The total of the EUL column is the WAML and is calculated as the sum product of EUL and measure savings divided by total program savings.

† Early replacement (ER) measures are flagged as YES, otherwise a NO is indicated in the column.

‡ The EUL for this measure varies over time See Table A-1 for persistence factors.

Source: ComEd tracking data and evaluation team analysis