Guidehouse

ComEd Residential Lighting Discounts Program Impact Evaluation Report

Energy Efficiency / Demand Response Plan:
Program Year 2020 (CY2020)
(1/1/2020-12/31/2020)

Prepared for:

ComEd

FINAL

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1. Introduction

This report presents results from the CY2020 impact evaluation of ComEd's Residential Lighting Discounts Program. The report summarizes the total energy and demand impacts for the program broken out by relevant measure and program structure details. Program sales in CY2020 come from the in-store retail sales channel and an online web sales channel (Marketplace 2.0). The results presented in this report cover sales from both the retailer and online channels. The appendices provide the impact analysis methodology and details of the total resource cost (TRC) inputs. CY2020 covers January 1, 2020 through December 31, 2020.

2. Program Description

The primary goal of the Residential Lighting Discounts Program is to increase the market penetration of energy efficient lighting by providing incentives for these products through various delivery channels. The program also seeks to increase customer awareness and acceptance of energy efficient lighting technologies by distributing educational materials. In CY2020, the program offered incentives for the purchase of directional and specialty LED lamps, LED fixtures and retrofit kits, connected LEDs, and LED nightlights.

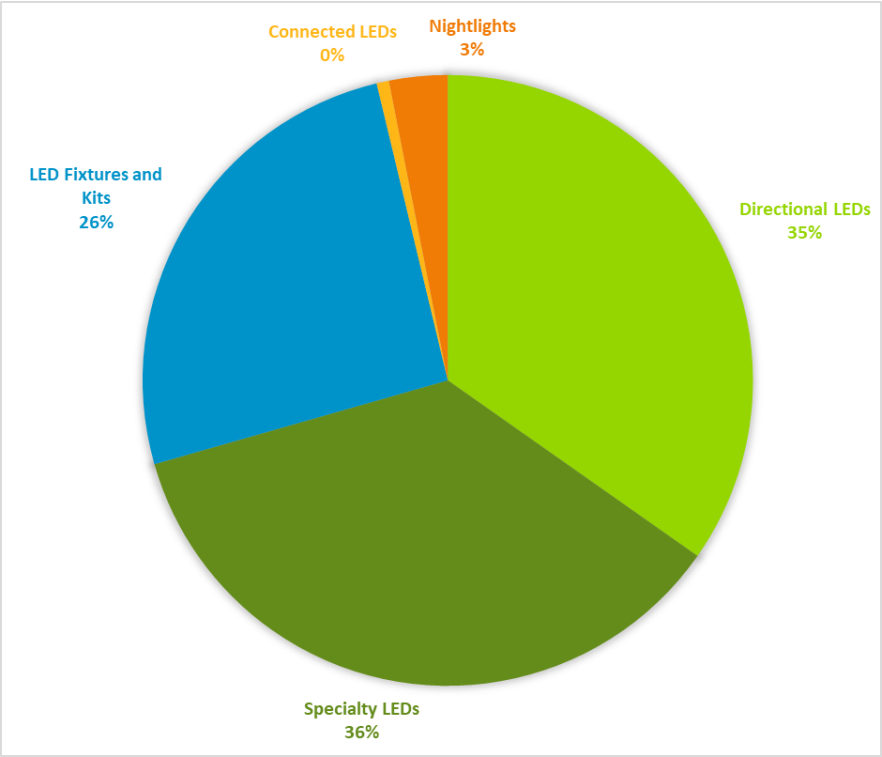
The CY2020 Residential Lighting Discounts Program incentivized over 5.6 million high efficiency lighting measures. This total included 1,955,620 directional LEDs, 2,016,013 specialty LEDs, 1,445,157 LED fixtures and retrofit kits, 36,617 connected LEDs, and 174,279 LED nightlights. An additional 621,304 lamps and fixtures (292,672 from CY2019 and 328,632 from CY2018) are expected to be installed in CY2020 from carryover lamps purchased in CY2018 and CY2019 as Table 2-1 and Figure 2-1 show. Starting in CY2019, the program no longer incentivizes omni-directional LEDs.

Table 2-1. CY2020 Volumetric Findings Detail

Participation	Total	Omni-Directional LEDs	Directional LEDs	Specialty LEDs	LED Fixtures and Kits	Connected LEDs	Nightlights
CY2020 Incentivized Bulbs	5,627,686	0	1,955,620	2,016,013	1,445,157	36,617	174,279
CY2020 1st Year Installed Bulbs	4,810,305	0	1,577,390	1,625,993	1,427,513	35,604	143,805
CY2019 Carryover – CY2020 Installs	292,672	59,688	133,381	97,088	2,514	0	0
CY2018 Carryover – CY2020 Installs	328,632	272,634	38,241	17,391	366	0	0
Total Installed Bulbs in CY2020	**5,431,608**	**332,322**	**1,749,012**	**1,740,473**	**1,430,392**	**35,604**	**143,805**

Source: ComEd tracking data and evaluation team analysis

Figure 2-1. Share of Measures Incentivized in CY2020 by Type



Source: ComEd tracking data and evaluation team analysis

3. Program Savings Detail

Table 3-1 summarizes the incremental energy and demand savings the Residential Lighting Discounts Program achieved in CY2020 from CY2020 first-year savings and carryover from CY2018 and CY2019 purchases installed in CY2020. The Residential Lighting Discounts Program did not claim any gas savings in CY2020. The program's verified gross kilowatt-hour (kWh) savings are approximately 4% higher than ex ante gross kWh savings.

Table 3-1. CY2020 Total Annual Incremental Electric Savings – with Carryover

Savings Category	Energy Savings (kWh)	Summer Peak* Demand Savings (kW)
Electricity		
Ex Ante Gross Savings‡	284,196,237	NR
Program Gross Realization Rate	1.04	NA
Verified Gross Savings‡	295,061,629	39,546
Program Net-to-Gross Ratio (NTG)	Varies	Varies
CY2018 Net Carryover Savings	9,205,745	1,171
CY2019 Net Carryover Savings	10,615,898	1,476
Verified Net Savings§	180,736,660	24,031
Converted from Gas†		
Ex Ante Gross Savings	NA	NA
Program Gross Realization Rate	NA	NA
Verified Gross Savings	NA	NA
Program Net-to-Gross Ratio (NTG)	NA	NA
Verified Net Savings	NA	NA
Total Electric Plus Gas		
Ex Ante Gross Savings‡	284,196,237	NR
Program Gross Realization Rate	1.04	NA
Verified Gross Savings‡	295,061,629	39,546
Program Net-to-Gross Ratio (NTG)	Varies	Varies
CY2018 Net Carryover Savings	9,205,745	1,171
CY2019 Net Carryover Savings	10,615,898	1,476
Verified Net Savings§	180,736,660	24,031

NR = Not reported (refers to a piece of data that was not reported)
NA = 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 p.m.-5:00 p.m. Central Prevailing Time on non-holiday weekdays, June through August.
‡Ex ante and verified gross savings exclude gross carryover savings from CY2018 and CY2019 bulb sales.
§Verified net savings includes net carryover savings from CY2018 and CY2019.
† Gas savings converted to kWh by multiplying therms by 29.31 (which is based on 100,000 Btu/therm and 3,412 Btu/kWh). The evaluation determines which gas savings are converted to kWh and counted toward ComEd's electric savings goal while producing the portfolio-wide summary report. According to Section 8-103B(b-25) of the Illinois Public Utilities Act, "In no event shall more than 10% of each year's applicable annual incremental goal as defined in paragraph (7) of subsection (g) of this Section be met through savings of fuels other than electricity."
Source: ComEd tracking data and evaluation team analysis

4. Cumulative Persisting Annual Savings

Table 4-1 show the measure-specific and total verified gross savings for the Residential Lighting Discounts Program and the cumulative persisting annual savings (CPAS) for the measures installed in CY2020. Figure 4-1 shows the savings across the useful life of the measures. The electric CPAS across all measures installed in 2020 is 180,736,660 kWh (Table 4-1). The evaluation team did not evaluate gas savings for this program; as such, electric CPAS is equivalent to total CPAS.

Table 4-1. Cumulative Persisting Annual Savings (CPAS) – Electric

End Use Type	Research Category	EUL	CY2020	NTG*	Lifetime Net	Verified Net kWh Savings 2018	2019	2020	2021	2022	2023	2024	2025	2026
Lighting	Directional LED (Residential)	10.0	94,908,067	0.52	357,309,889			49,352,195	49,352,195	49,352,195	49,352,195	26,650,185	26,650,185	26,650,185
Lighting	Directional LED (Nonresidential)	5.5	14,555,242	0.52	36,482,474			7,568,726	7,568,726	7,568,726	7,568,726	4,087,112	2,120,458	-
Lighting	Specialty LED (Residential)	10.0	69,439,714	0.59	301,535,016			40,969,431	40,969,431	40,969,431	40,969,431	22,942,882	22,942,882	22,942,882
Lighting	Specialty LED (Nonresidential)	4.5	10,667,398	0.59	27,022,227			6,293,765	6,293,765	6,293,765	6,293,765	1,847,167		
Lighting	LED Fixtures and Kits (Residential)	15.0	90,307,536	0.52	466,781,594			46,959,919	46,959,919	46,959,919	46,959,919	25,358,356	25,358,356	25,358,356
Lighting	LED Fixtures and Kits (Nonresidential)	13.8	8,485,557	0.52	41,014,234			4,412,490	4,412,490	4,412,490	4,412,490	2,382,744	2,382,744	2,382,744
Lighting	Connected LEDs (Residential)	10.0	2,276,059	0.80	13,187,085			1,820,847	1,820,847	1,820,847	1,820,847	983,949	983,949	983,949
Lighting	LED Nightlights (Residential)	8.0	4,422,054	0.80	28,301,148			3,537,644	3,537,644	3,537,644	3,537,644	3,537,644	3,537,644	3,537,644
Lighting	Carryover (Residential)	10.0	29,291,708	0.59	125,567,260			17,258,765	17,258,765	17,258,765	17,258,765	9,422,034	9,422,034	9,422,034
Lighting	Carryover (Nonresidential)	6.3	4,318,326	0.59	13,386,509			2,562,879	2,562,879	2,562,879	2,562,879	1,352,021	1,352,021	430,953
CY2020 Program Total Electric Contribution to CPAS			**328,671,663**		**1,410,587,438**			**180,736,660**	**180,736,660**	**180,736,660**	**180,736,660**	**98,564,094**	**94,750,273**	**91,708,747**
Historic Program Total Electric Contribution to CPAS‡						**301,534,004**	**474,908,010**	**474,908,010**	**289,217,183**	**281,827,374**	**266,545,351**	**185,777,255**	**182,958,720**	**182,958,720**
Program Total Electric CPAS						**301,534,004**	**474,908,010**	**655,644,669**	**469,953,843**	**462,564,034**	**447,282,011**	**284,341,349**	**277,708,992**	**274,667,467**
CY2020 Program Incremental Expiring Electric Savings§								**-**	**-**	**-**	**-**	**82,172,566**	**3,813,821**	**3,041,526**
Historic Program Incremental Expiring Electric Savings‡§								**-**	**185,690,827**	**7,389,809**	**15,282,023**	**80,768,096**	**2,818,536**	**-**
Program Total Incremental Expiring Electric Savings§								**-**	**185,690,827**	**7,389,809**	**15,282,023**	**162,940,661**	**6,632,357**	**3,041,526**

End Use Type	Research Category	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Lighting	Directional LED (Residential)	26,650,185	26,650,185	26,650,185	-	-	-	-	-	-	-	-	-
Lighting	Directional LED (Nonresidential)	-	-	-	-	-	-	-	-	-	-	-	-
Lighting	Specialty LED (Residential)	22,942,882	22,942,882	22,942,882	-	-	-	-	-	-	-	-	-
Lighting	Specialty LED (Nonresidential)	-	-	-	-	-	-	-	-	-	-	-	-
Lighting	LED Fixtures and Kits (Residential)	25,358,356	25,358,356	25,358,356	25,358,356	25,358,356	25,358,356	25,358,356	25,358,356	-	-	-	-
Lighting	LED Fixtures and Kits (Nonresidential)	2,382,744	2,382,744	2,382,744	2,382,744	2,382,744	2,382,744	1,919,575	-	-	-	-	-
Lighting	Connected LEDs (Residential)	983,949	983,949	983,949						-	-	-	-
Lighting	LED Nightlights (Residential)	3,537,644	-	-	-	-	-	-	-	-	-	-	-
Lighting	Carryover (Residential)	9,422,034	9,422,034	9,422,034	-	-	-	-	-	-	-	-	-
Lighting	Carryover (Nonresidential)	-	-	-	-	-	-	-	-	-	-	-	-
CY2020 Program Total Electric Contribution to CPAS		**91,277,794**	**87,740,150**	**87,740,150**	**27,741,101**	**27,741,101**	**27,741,101**	**27,277,931**	**25,358,356**	**-**	**-**	**-**	**-**
Historic Program Total Electric Contribution to CPAS‡		**176,043,054**	**62,688,315**	**42,888,775**	**42,888,775**	**41,752,806**	**37,577,025**	**8,232,351**	**-**	**-**	**-**	**-**	**-**
Program Total Electric CPAS		**267,320,847**	**150,428,466**	**130,628,926**	**70,629,876**	**69,493,907**	**65,318,126**	**35,510,283**	**25,358,356**	**-**	**-**	**-**	**-**
CY2020 Program Incremental Expiring Electric Savings§		**430,953**	**3,537,644**	**-**	**59,999,050**	**-**	**-**	**463,169**	**1,919,575**	**25,358,356**	**-**	**-**	**-**
Historic Program Incremental Expiring Electric Savings‡§		**6,915,666**	**113,354,738**	**19,799,540**	**-**	**1,135,969**	**4,175,781**	**29,344,674**	**8,232,351**	**-**	**-**	**-**	**-**
Program Total Incremental Expiring Electric Savings§		**7,346,619**	**116,892,382**	**19,799,540**	**59,999,050**	**1,135,969**	**4,175,781**	**29,807,843**	**10,151,927**	**25,358,356**	**-**	**-**	**-**

Note: The green highlighted cell shows program total first-year electric savings. The gray cells are blank, indicating values irrelevant to the CY2020 contribution to CPAS.

* A deemed value. Source found on the Illinois Stakeholder Advisory Group (SAG) website: https://www.ilsag.info/ntg_2020.

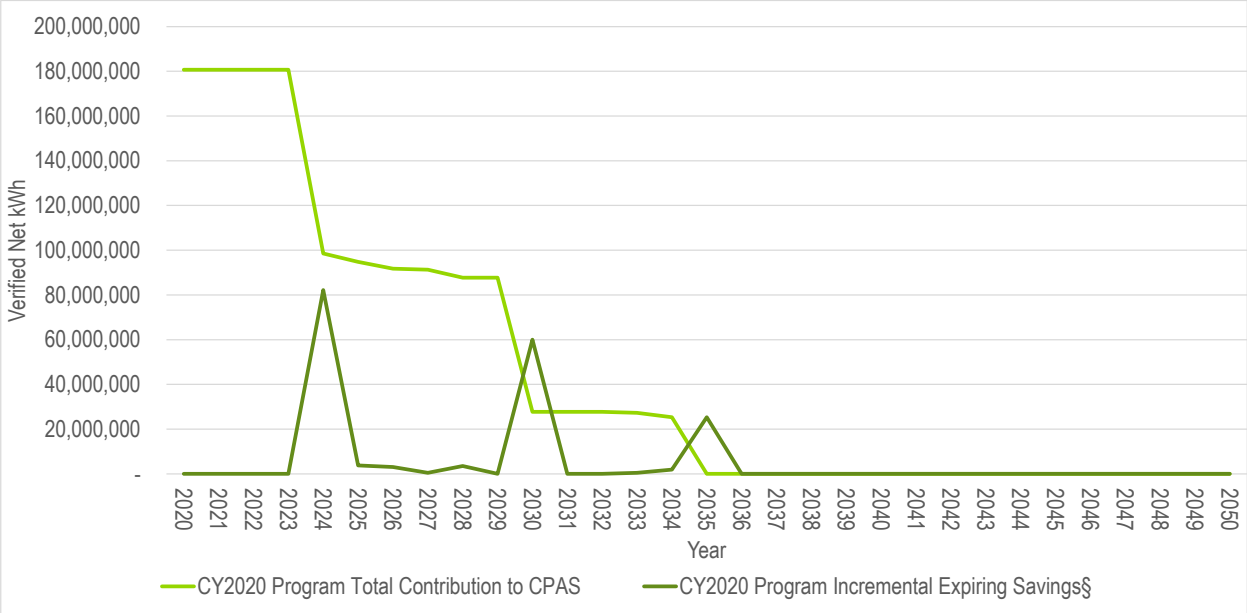
† Lifetime savings are the sum of CPAS savings through the effective useful life (EUL).

‡ 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 + Expiring Savings Y_{n-1}.

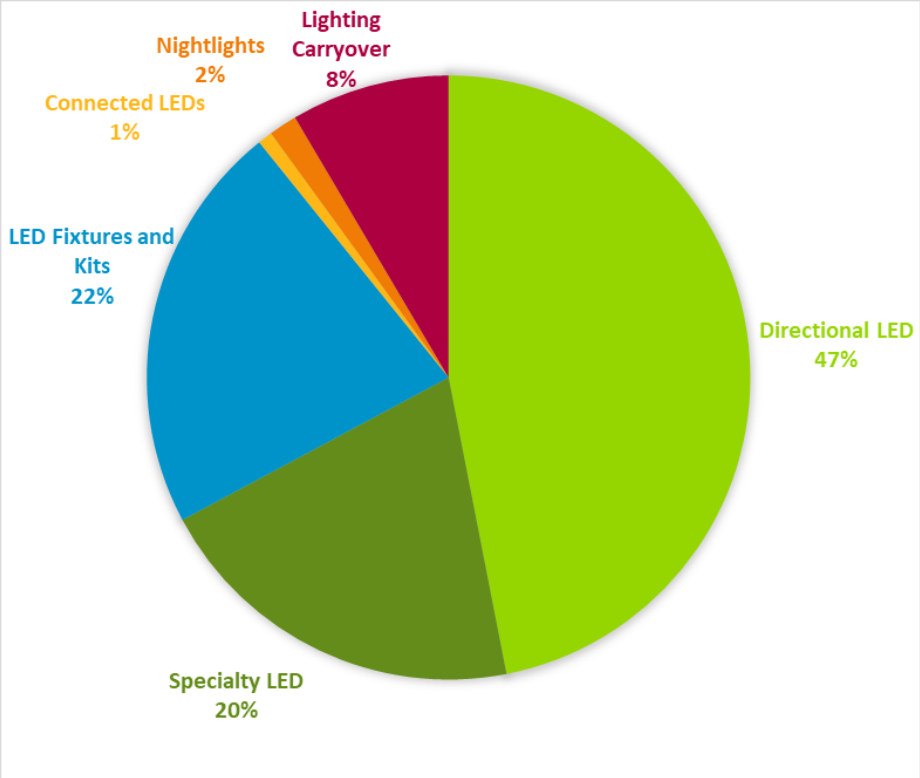
Source: Evaluation team analysis

5. Program Savings by Measure

The Residential Lighting Discounts Program includes six distinct lighting measure groups, as the following tables show. These groups include directional LEDs (BR, R, MR, and PAR lamps), specialty LEDs (globe, candelabra, and 3-way lamps), LED fixtures and retrofit kits, connected LEDs, LED nightlights, and carryover lamps from purchases in CY2018 and CY2019 that the Illinois Statewide Technical Reference Manual v8.0 (TRM v8.0) projects participants will install in CY2020. The first-year installations of directional and specialty LEDs and LED fixtures and retrofit kits contributed the majority of net savings in CY2020 (see Figure 5-1).

Table 5-1 and Table 5-2 present energy and summer peak demand savings by measure group for the Residential Lighting Discounts Program. The evaluation team split all measure groups into residential and nonresidential savings to highlight where savings are realized.

Figure 5-1. Verified Net Savings by Measure – Electric



Source: Evaluation team analysis

Table 5-1. CY2020 Energy Savings by Measure – Electric and Total

End Use Type	Research Category	Ex Ante Gross Savings (kWh)	Verified Gross Realization Rate	Verified Gross Savings (kWh)	NTG*	Verified Net Savings (kWh)	EUL (years)
Lighting	Directional LED (Residential)	87,246,075	1.09	94,908,067	0.52	49,352,195	10.0
Lighting	Directional LED (Nonresidential)	13,386,436	1.09	14,555,242	0.52	7,568,726	5.5
Lighting	Specialty LED (Residential)	69,705,917	1.00	69,439,714	0.59	40,969,431	10.0
Lighting	Specialty LED (Nonresidential)	10,700,997	1.00	10,667,398	0.59	6,293,765	4.5
Lighting	LED Fixtures and Kits (Residential)	87,697,453	1.03	90,307,536	0.52	46,959,919	15.0
Lighting	LED Fixtures and Kits (Nonresidential)	8,260,348	1.03	8,485,557	0.52	4,412,490	13.8
Lighting	Connected LEDs (Residential)	2,776,979	0.82	2,276,059	0.80	1,820,847	10.0
Lighting	LED Nightlights (Residential)	4,422,032	1.00	4,422,054	0.80	3,537,644	8.0
Lighting	Carryover (Residential)	NR	NA	29,291,708	0.59	17,258,765	10.0
Lighting	Carryover (Nonresidential)	NR	NA	4,318,326	0.59	2,562,879	6.3
	Total	**284,196,237**	**1.16§**	**328,671,663**	**0.55**	**180,736,660**	**NA**

Note: The savings in this table include secondary electric energy (kWh) savings from water supply and wastewater treatment plants for measures claimed by ComEd. The savings account for electric heating penalties, where applicable.

NR = Not reported (refers to a piece of data that was not reported)

NA = Not applicable (refers to a piece of data that cannot be produced or does not apply)

* A deemed value. Source found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.

§ The overall program realization rate includes verified gross carryover savings in the program savings totals. The overall program realization rate excluding verified carryover savings is 1.04.

Source: ComEd tracking data and evaluation team analysis

Table 5-2. CY2020 Summer Peak Demand Savings by Measure

End Use Type	Research Category	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Peak Demand Reduction (kW)	NTG*	Verified Net Peak Demand Reduction (kW)
Lighting	Directional LED (Residential)	NR	NA	11,272	0.52	5,861
Lighting	Directional LED (Nonresidential)	NR	NA	3,250	0.52	1,690
Lighting	Specialty LED (Residential)	NR	NA	8,247	0.59	4,866
Lighting	Specialty LED (Nonresidential)	NR	NA	2,382	0.59	1,405
Lighting	LED Fixtures and Kits (Residential)	NR	NA	12,114	0.52	6,299
Lighting	LED Fixtures and Kits (Nonresidential)	NR	NA	2,008	0.52	1,044
Lighting	Connected LEDs (Residential)	NR	NA	273	0.80	219
Lighting	LED Nightlights (Residential)	NR	NA	0	NA	0
Lighting	Carryover (Residential)	NR	NA	3,513	0.59	2,070
Lighting	Carryover (Nonresidential)	NR	NA	971	0.59	576
	Total	**NR**	**NA**	**44,030**	**0.55**	**24,031**

* A deemed value. Source found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.

Source: ComEd tracking data and evaluation team analysis

6. Impact Analysis Findings and Recommendations

6.1 Lighting Impact Parameter Estimates

Equation 6-1 is used to estimate energy and demand savings for LED lamps and fixtures sold through the program, as specified in the TRM 8.0.

Equation 6-1. Gross Annual Energy and Demand Savings

Verified Gross Annual ΔkWh = ResSplit * Res ΔkWh + NonResSplit * NonRes ΔkWh

Where:

- **Res ΔkWh =** Bulbs * DeltaWatts/1,000 * ISR_r * (1-Leakage) * HOU_r * $WHFe_r$
- **NonRes ΔkWh =** Bulbs * DeltaWatts/1,000 * ISR_{nr} * (1-Leakage) * HOU_{nr}* $WHFe_{nr}$

Verified Gross Annual Summer Peak ΔkW = Gross Annual ΔkW * Summer Peak CF * WHFd

Where:

- **Res/NonRes Split** = Percentage of program bulbs installed in residential and nonresidential locations, deemed within TRM v8.0.
- **Bulbs** = Quantity of bulbs sold through the CY2020 program based on program tracking data.
- **DeltaWatts** = Difference in wattage between the baseline bulb (WattsBase) and the efficient program bulb (WattsEE):
  - WattsBase = Baseline bulb wattage, mapping deemed in TRM v8.0.
  - WattsEE = Wattage of efficient program bulb based on program tracking data.
- **$ISR_{r(nr)}$** = First-year installation rate (residential or nonresidential), deemed in TRM v8.0.

- **Leakage** = Percentage of program bulbs installed outside of ComEd service territory, deemed in TRM v8.0.
- **$HOU_{r(nr)}$** = Annual hours of use (residential/nonresidential), deemed in TRM v8.0.
- **$WHFe_{r(nr)}$** = Waste heat factor – Energy (residential/nonresidential), deemed in TRM v8.0.
- **$WHFd_{r(nr)}$** = Waste heat factor – Demand (residential/nonresidential), deemed in TRM v8.0.
- **Summer Peak CF** = Peak load coincidence factor, the average runtime percentage of program bulbs during summer peak hours (weekdays from 1 p.m. to 5 p.m.), deemed in TRM v8.0.

Connected LEDs generate savings through both the measures control capabilities and the LED wattage efficiency savings over a baseline wattage lamp. Equation 6-2 is used to estimate the savings for connected LEDs. The first part of the equation, the lighting control savings, is specified in the TRM v8.0 for connected LEDs. The second portion of the equation, the LED efficiency savings, is the same as shown above in Equation 6-1 for LED lamps and fixtures. The TRM v10 will be updated to reflect these two savings components.

Equation 6-2. Gross Savings Equation (kWh) Connected LED Control Savings

Annual ΔkWh = Lighting Control Savings + LED Efficiency Savings

Where:

Lighting Control Savings = ((WattsEE/1,000 * HOU * SVGe * WHFe) - StandbykWh) * ISR * (1 – Leakage) * Lamps

LED Efficiency Savings = ((WattsBase-WattsEE)/1,000) * ISR * (1-Leakage) * HOU* WHFe

Where:

- **WattsEE** = Wattage of the connected LED based on program tracking data.
- **Lamps** = Quantity of lamps sold through the CY2020 program based on program tracking data.
- **HOU** = Annual hours of use, deemed in TRM v8.0.
- **SVGe** = Percentage of annual lighting energy saved by the lighting control, deemed in TRM v8.0.
- **WHFe** = Water heat factor – energy, deemed in TRM v8.0.
- **StandbykWh** = Standby power draw of the controlled lamp, deemed in TRM v8.0.
- **ISR** = First-year in-service rate, deemed in TRM v8.0.
- **Leakage** = Percentage of program lamps installed outside of ComEd service territory, deemed in TRM v8.0.

Table 6-1 provides the source of the verified first-year gross and net savings parameters. Appendix A.3 presents the sources of the parameters used to calculate the second- and third-year carryover savings. The lifetime energy and demand savings are estimated by multiplying the verified savings by the EUL for each measure.

Table 6-1. Savings Parameters

Gross Savings Input Parameters	Deemed or Evaluated?	Source*
Program Bulbs	Evaluated	Program Tracking Data
Delta Watts	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Installation Rate (ISR)	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Leakage	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Res/NonRes Split	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Hours of Use (HOU)**	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Summer Peak Coincidence Factor (CF)§	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Waste Heat Factor (Energy)§	Deemed	TRM v8.0, TRM v8.0 Errata –Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
Waste Heat Factor (Demand)§	Deemed	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12
NTG	Deemed	SAG Consensus
EUL	Mixture	TRM v8.0, TRM v8.0 Errata – Sections 5.5.6, 5.5.8, 5.5.9, 5.5.12

* TRM is the Illinois Statewide Technical Reference Manual version 8.0 from http://www.ilsag.info/technical-reference-manual.html. The NTG values can be found on the Illinois SAG website: https://www.ilsag.info/ntg_2020.
§ HOU, CF, and Waste Heat Factor values for connected LEDs are bulb- and fixture type-specific and do not come directly from Section 5.5.12; rather they come from their respective bulb or fixture type sections of the TRM v8.0. For example, HOU for BR30 connected LEDs comes from Section 5.5.6.

6.2 Other Impact Findings and Recommendations

The evaluation team developed one recommendation based on findings from the CY2020 evaluation.

Finding 1. The overall program gross realization rate for the Residential Lighting Discounts Program is 1.04 (exclusive of carryover savings, 1.16 with carryover). Realization rates that differ from 1.0 are due to the following issues:

- The evaluation team found discrepancies between ex ante and verified baseline wattages in 181,031 records in the final tracking data. These discrepancies primarily occurred with directional lamps, hardwire fixtures, and retrofit kits.
- The evaluation team identified several items that are causing discrepancies between the ex ante and verified savings methodology for connected LED measures (which represent slightly less than 1% of verified gross program savings), that led to a realization rate of 0.82 for this measure. These discrepancies included the following:
    - To calculate the savings attributed to the control capabilities of connected LEDs, the ex ante savings appear to use delta wattage values rather than the efficient measure wattages, as outlined in the savings equation of Section 5.5.12 of the TRM v8.0. ComEd and the implementation team are aware of this issue and plan to correct it for CY2021.

- The ex ante savings claimed zero savings (0 kWh) for Marketplace 2.0 omni-directional connected LEDs lamps. The tracking data included 36 of these lamps. The tracking data noted these lamps were not intended to be rebated and thus no ex ante savings were claimed. The evaluation team included approximately 1,500 kWh in savings from these lamps because they received program incentives.
- Guidehouse received two datasets of program tracking data: one for the retail channel and another for the Marketplace 2.0 channel.
  - In the retail channel tracking data, HOU and WHFe values for ex ante connected LED fixture savings applied directional HOU and WHFe values (1,020 HOU and 1.046 WHFe) rather than the fixture HOU and WHFe values (926 HOU and 1.06 WHFe) applied by the evaluation team.
  - Ex ante savings for Marketplace 2.0 BR30 connected LEDs were generated using HOU and WHFe values that represent omni-directional LEDs (1,159 HOU and 1.051 WHFe). While this is consistent with Section 5.5.12 of the TRM v8.0, these values represent the omni-directional LED HOU and WHFe presented in Section 5.5.8 of the TRM v8.0. The methodology the evaluation team used and implemented in the retail channel tracking dataset calls for using bulb type-specific HOU and WHFe from respective sections of the TRM v8.0. As a result, the team applied HOU and WHFe values from Section 5.5.6 of the TRM v8.0 (1,020 HOU and 1.046 WHFe).

Recommendation 1. Guidehouse recommends ComEd ensure all parameters used to estimate ex ante program savings align with the TRM and approved TRM exemptions be included in the agreed-upon program year calculators.

Appendix A. Impact Analysis Methodology

A.1 Verified Gross Program Savings Analysis Approach Estimates

The evaluation team calculated verified gross savings for all measures with available data. For CY2020, this included directional LEDs, specialty LEDs, LED fixtures and kits, connected LEDs, LED nightlights, and carryover lamps and fixtures sold in CY2018 and CY2019 that are estimated to have been installed in CY2020. The data used to estimate the verified gross program savings for the measures sold in CY2020 came from the CY2020 program tracking data,[1] the TRM v8.0, and the TRM v8.0 Errata. The carryover savings relied upon a mixture of parameter estimates deemed either in the year of purchase (CY2018 or CY2019) or the year of program install (CY2020) depending upon the parameter.

A.2 Verified Net Program Savings Analysis Approach

Verified net energy and peak demand savings are calculated by multiplying the verified gross savings estimates by a net-to-gross (NTG) ratio. For the CY2020 Residential Lighting Discounts Program, the NTG ratio estimates are 0.52 for omni-directional LEDs (although no omni-directional LEDs were sold through the program in CY2020), directional LEDs, and LED fixtures and kits; 0.59 for specialty LEDs; and 0.80 for connected LEDs and LED nightlights. These NTG ratios are approved through the Illinois SAG consensus process.

A.3 Carryover Savings Estimation

A.3.1 CY2020 Carryover Savings

The evaluation team calculated the CY2020 carryover savings estimates using the TRM (v6.0, v7.0, and v8.0) and the CY2018 and CY2019 impact evaluation reports. The energy and demand savings from second-year CY2019 and third-year CY2018 installations are calculated based on the following parameters:

- **DeltaWatts:** Verified deltawatts for bulbs installed in CY2020 based on the baseline wattage values associated with the installation year (source: TRM v8.0)
- **Res/Nonres split:** Verified res/nonres split from the year the bulbs were purchased (source: TRM v6.0 and 7.0)
- **HOU and summer peak CF:** Verified hours-of-use and summer peak coincidence factor from the installation year (source: TRM v8.0)
- **Energy and demand waste heat factors:** Verified WHFs from the year the bulbs are installed (source: TRM v8.0)
- **ISR:** Verified installation rate from the year the bulbs were purchased (source: TRM v6.0 and v7.0)
- **NTG:** Deemed NTG based on evaluation research from the year the bulbs were purchased (source: SAG consensus)

[1] The evaluation team received the final CY2020 tracking data for measures sold through in-store retailers on January 21, 2021 (RLD_CY2020_EOY_Data_Rev1_01152021.xlsx) and for measures sold online (Marketplace 2.0) on January 19, 2021 (MP2RLD_CY2020_EOY_Data_Rev3_01152021.xlsx).

Table A-1 shows that 328,632 lighting measures purchased in CY2018 and 292,672 measures purchased in CY2019 are expected to be installed within ComEd's service territory in CY2020. The table provides the gross and net energy and summer peak demand savings from these carryover bulbs that will be counted in CY2020. Total CY2020 net carryover savings are estimated to be 19,821,643 kWh and 2,646 summer peak kW.

Table A-1. CY2020 Carryover Savings from CY2018 and CY2019 Program Sales

Claimed CY2020 Carryover Savings	Second-Year Installation CY2019 Bulbs	Third-Year Installation CY2018 Bulbs	Total Carryover CY2020
Carryover Bulbs Installed During CY2020	292,672	328,632	621,304
Gross kWh Impact Per Unit	60.7	48.2	54.1
Gross Peak kW Impact Per Unit	0.008	0.006	0.007
Carryover Gross Energy Savings (kWh)	17,761,113	15,848,921	33,610,034
Carryover Gross Summer Peak Demand Savings (kW)	2,470	2,013	4,484
Net-to-Gross Ratio	0.60	0.58	0.59
Carryover Net Energy Savings (kWh)	10,615,898	9,205,745	19,821,643
Carryover Net Summer Peak Demand Savings (kW)	1,476	1,171	2,646
EUL Res	10.0	10.0	10.0
EUL NonRes	6.9	5.8	6.3

Source: ComEd tracking data and evaluation team analysis

A.3.2 CY2021 Preliminary Carryover Savings

The evaluation team calculated a preliminary CY2021 carryover savings estimate using the TRM (v7.0, v8.0, and v9.0) and the CY2019 and CY2020 impact evaluation reports. The energy and demand savings from these CY2019 third-year and CY2020 second-year installations are calculated based on the following parameters:

- **Deltawatts:** Verified deltawatts for bulbs installed in CY2021 based on the baseline wattage values associated with the installation year (source: TRM v9.0)
- **Res/Nonres split:** Verified res/nonres split from the year the bulbs were purchased (source: TRM v7.0 and v8.0)
- **HOU and summer peak CF:** Verified hours-of-use and summer peak coincidence factor from the installation year (source: TRM v9.0)
- **Energy and demand waste heat factors:** Verified WHFs from the year the bulbs are installed (source: TRM v9.0)
- **ISR:** Verified installation rate from the year the bulbs were purchased (source: TRM v7.0 and v8.0)
- **NTG:** Deemed NTG based on evaluation research from the year the bulbs were purchased (source: SAG consensus)

Table A-2 shows that 612,315 bulbs purchased in CY2019 or CY2020 are expected to be installed within ComEd's service territory in CY2021 (carryover). The table provides the gross and net energy and demand savings from these carryover bulbs. Total **preliminary** net carryover savings is estimated to be 21,005,859 kWh and 2,839 summer peak kW.

Table A-2. CY2021 Preliminary Carryover Savings Estimates from CY2019 and CY2020 Bulb Sales

Preliminary CY2021 Carryover Savings	CY2019 Bulbs	CY2020 Bulbs	Total Preliminary CY2021 Carryover
Carryover Bulbs Installed During CY2021	246,917	365,398	612,315
Gross Energy Savings (kWh)	14,984,751	21,786,837	36,771,587
Gross Peak Summer Peak Demand Savings (kW)	2,085	2,912	4,996
Net-to-Gross Ratio	0.60	0.55	0.57
Net Energy Savings (kWh)	8,957,681	12,048,178	21,005,859
Net Summer Peak Demand Savings (kW)	1,245	1,594	2,839
EUL Res	10.0	10.0	10.0
EUL NonRes	6.9	7.3	7.1

Source: Evaluation team analysis

A.3.3 CY2022 Preliminary Partial Carryover Savings from CY2020

The evaluation team calculated a preliminary partial CY2022 carryover savings estimate based on the bulbs sold during CY2020 (CY2021 sales are not known at this time) that are estimated to be installed in CY2022. This estimate is preliminary because several of the parameters used to estimate these CY2022 carryover savings are based on deemed parameters from the year of install (delta watts, HOU and peak CF, and waste heat factors of energy and demand), which would be based on TRM v10.0 for CY2022. Because TRM v10.0 is not yet finalized, the team used v9.0 of the TRM to estimate these parameters. The **preliminary** parameters for the partial CY2022 carryover savings are based on the following:

- **Delta watts:** Verified savings estimate from the installation year (source: TRM v9.0); this value is subject to change and will ultimately use the values from TRM v10.0.
- **Residential/nonresidential split:** Verified savings from the purchase year (source: TRM v8.0); this value is not subject to change.
- **HOU and peak CF:** Verified savings estimate from the installation year (source: TRM v9.0); this value is subject to change and will ultimately use the values from TRM v10.0.
- **Energy and demand IE:** Verified savings estimate from the installation year (source: TRM v9.0); this value is subject to change and will ultimately use the values from TRM v10.0.
- **Installation rate:** Verified savings estimate from the purchase year (source: TRM v8.0); this value is not subject to change.
- **NTG:** Deemed net-to-gross values from the purchase year; this value is not subject to change.

Table A-3 shows that 311,726 bulbs purchased in CY2020 are expected to be installed within ComEd's service territory in CY2022. The table provides the gross and net energy and demand savings from these carryover bulbs. Total preliminary CY2022 partial net carryover energy savings is estimated to be 10,268,312 kWh and 2,479 summer peak kW.

Table A-3. CY2022 Preliminary Carryover Savings Estimates from CY2020 Bulb Sales

Preliminary Partial CY2022 Carryover Savings	CY2020 Bulbs
Carryover Bulbs Installed During CY2022	311,726
Gross Energy Savings (kWh)	18,569,815
Gross Peak Summer Peak Demand Savings (kW)	2,479
Net-to-Gross Ratio	0.55
Net Energy Savings (kWh)	10,268,312
Net Summer Peak Demand Savings (kW)	1,358
EUL Res	10.0
EUL NonRes	7.3

Source: Evaluation team analysis

Appendix B. Impact Analysis Detail

B.1 Program Volumetric Detail

During CY2020, 5,627,686 lamps and fixtures were sold through the Residential Lighting Discounts Program, which is a 21% increase from the bulbs and fixtures sold during the eleventh program year (CY2019). Starting in CY2019, LED omni-directional lamps were phased out of the program and connected LEDs and LED nightlights were added to the program in CY2020. CY2020 is also the first program year bulbs sold through the Marketplace 2.0 online retail site hosted by ComEd were attributed to the Residential Lighting Discounts Program.

Table B-1 shows the volume of bulbs by bulb type incentivized through the Residential Lighting Discounts Program in PY3 through CY2020 (PY9 numbers represent sales over a 19-month period).

Table B-1. PY3 – CY2020 Volumetric Findings Detail

Program Year	Standard CFLs	Specialty CFLs	CFL Fixtures	LED Omni-Dir	LED Dir	LED Specialty	LED Fixtures	Connected LEDs	LED Nightlights	Coupons	Total
CY2020 Sales	0	0	0	0	1,955,620	2,016,013	1,445,157	36,617	174,279	0	5,627,686
CY2019 Sales	0	0	0	570,619	1,781,459	1,296,725	1,004,484	0	0	0	4,653,287
CY2018 Sales	0	0	0	7,800,621	1,905,419	866,560	679,049	0	0	0	11,251,649
PY9 Sales†	2,625,479	0	0	11,905,275	3,309,608	1,388,782	831,268	0	0	0	20,060,412
PY8 Sales	7,205,656	0	0	3,896,077	1,578,687	*	302,241	0	0	0	12,982,661
PY7 Sales	10,347,580	989,999	0	471,710	427,824	*	0	0	0	0	12,237,113
PY6 Sales	8,965,546	2,125,179	0	0	0	*	0	0	0	0	11,090,725
PY5 Sales	9,633,227	1,197,896	8,767	9,472	18,758	*	24,268	0	0	5,506	10,897,894
PY4 Sales	11,419,752	1,097,670	84,539	2,592	22,327	*	16,551	0	0	5,599	12,649,030
PY3 Sales	9,893,196	1,217,723	86,943	0	0	*	0	0	0	0	11,197,862

* Prior to PY9 LED specialty bulbs were included in the LED directional category. PY7 was the first program year to included specialty LED bulbs.
† PY9 consisted of a 19-month program year; all prior program years consisted of 12 months.
Source: ComEd tracking data and evaluation team analysis

B.2 Differences in Gross Parameter Estimates

This section discusses the differences the evaluation team observed between the ex ante and evaluation verified gross parameter estimates.

B.2.1 Baseline Wattages

The evaluation team calculated the baseline wattage for each program model[2] in the tracking data according to the deemed methods provided in the TRM v8.0. The TRM v8.0 specifies that baseline wattage for all lamp types except PAR lamps is determined based on mapping the lumen output of the program lamp to a baseline wattage based on tables included in the TRM. For PAR lamps, baseline wattage is calculated using the characteristics of the PAR lamp entered into Equation B-1 and then rounded down to the nearest wattage established by ENERGY STAR.

[2] The evaluation team did not calculate baseline wattage values for connected LEDs because the savings equation specified in Equation 6-2 does not call for a baseline wattage; rather, it applies the SVGe value to calculate the portion of savings attributed to the efficient measure.

Equation B-1. PAR Lamp Baseline Wattage ENERGY STAR Center Beam Candle Power Equation

$$\mathbf{Wattsbase} = 375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Lamp diameter (e.g., for PAR20, D = 20)
BA = Beam angle
CBCP = Center beam candle power

Overall, the team found 181,031 records where the ex ante baseline wattages did not align with the verified baseline wattages it calculated using the lumen mapping provided in the TRM v8.0. The majority of these discrepancies occurred with directional LEDs, hardwire fixtures, and retrofit kit measures. The evaluation team found baseline wattage discrepancies for 57,093 directional LEDs, 78,916 hardwire fixtures, and 41,195 retrofit kit records. Starting with TRM v8.0, LED fixtures were introduced as their own category in Section 5.5.9. Prior to CY2020, LED fixtures and retrofit kits were assigned baseline wattages using the lumen mapping for BR directional lamps. Starting in CY2020, Section 5.5.9 of the TRM v8.0 specified baseline wattages for LED fixtures based on the fixture classification (indoor, task and under cabinet, outdoor, and downlight) rather than on lumens. The team applied the downlight classification to all LED retrofit kits, the indoor classification to all indoor hardwire fixtures, and the outdoor classification to all outdoor hardwire fixtures. The evaluation team could not determine the method used to derive ex ante baseline wattages for hardwire fixtures and retrofit kits. ComEd and the implementation team are aware of this change to the TRM and will update in CY2021.

For R-shaped directional LEDs, the evaluation team found differences between the ex ante and verified baseline wattages for 12,189 records. These differences appeared to result from the lumen mappings that were applied. The TRM v 8.0 specifies two distinct lumen mappings for R-shaped medium-screw based directional lamps: for those with a diameter less than or equal to 2.25 inches and for those with a diameter greater than 2.25 inches. All R-shaped directional lamps sold through the program in CY2020 had a diameter of 2.5 inches or greater[3] and should have been mapped to lamps greater than 2.25 inches. However, it appears that a number of R-shaped directional lamps were incorrectly mapped with the mapping for lamps less than 2.25 inches.[4] R20 lamps with less than 720 lumens should be mapped with the R, ER, and BR exceptions provided in TRM v8.0.

The evaluation team found discrepancies with 44,872 PAR directional lamp records in the tracking data. The implementation team stated they apply the manufacturer's reported replacement wattage as the baseline instead of using the PAR lamp-specific center beam candlepower formula shown in Equation B-1.[5] Applying the PAR lamp formula from the TRM

[3] The diameter of a directional lamp can be calculated based on the numeric portion of the measure type. The number is a measurement in eighths of an inch—i.e., an R20 is 20/8 = 2.5''.

[4] The category variable was assigned correctly for these lamps and did correctly identify them as diameter less than 2.25''.

[5] The category assigned was LED (R, ER, BR and PAR with medium screw bases w/diameter >2.25").

v8.0 to calculate the verified baseline wattage for these records yielded baseline wattage differences ranging from 5 W to 85 W from ex ante baseline wattages included in eTRACK.

The team found baseline wattage discrepancies for 3,818 specialty LEDs. These bulbs included candelabra and globe lamp types with both candelabra and medium bases. The majority of these discrepancies were the result of the incorrectly applying the base category.

B.2.2 Application of Connected LED Savings Equation

Connected LED ex ante gross kWh savings estimates differed from the verified gross kWh savings estimates, resulting in an overall gross realization rate 0.82 for connected LEDs. The evaluation team identified four issues causing discrepancies between the ex ante and verified savings methodology for connected LED measures.

- The ex ante savings calculation appears to use delta wattage values rather than the efficient measure wattages attributed to the control capabilities of connected LEDs as outlined in the savings equation of Section 5.5.12 of the TRM v8.0. ComEd and the implementation team are aware of this issue and will correct it for CY2021.
- The ex ante savings claimed no savings for Marketplace 2.0 omni-directional connected LEDs lamps (approximately 1,500 kWh in savings and 36 lamps). The tracking data noted these lamps were not intended to be rebated and were not claimed for ex ante savings. Conversely, the evaluation team included savings from these lamps because they received program incentives.
- In the retail channel tracking data, HOU and WHFe values for ex ante connected LED fixture savings applied directional HOU and WHFe values (1,020 HOU and 1.046 WHFe) rather than the fixture HOU and WHFe values (926 HOU and 1.06 WHFe) applied by the evaluation team.
- Ex ante savings for Marketplace 2.0 BR30 connected LEDs were generated using HOU and WHFe values that represent omni-directional LEDs (1,159 HOU and 1.051 WHFe). While this is consistent with Section 5.5.12 of the TRM v8.0, these values represent the omni-directional LED HOU and WHFe presented Section 5.5.8 of the TRM v8.0. The methodology the evaluation team used and implemented in the retail channel tracking dataset calls for using bulb type-specific HOU and WHFe from respective sections of the TRM v8.0. As a result, the team applied HOU and WHFe values from Section 5.5.6 of the TRM v8.0 (1,020 HOU and 1.046 WHFe), which represent directional LED HOU and WHFe values.

Appendix C. Total Resource Cost Detail

Table C-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) is not included in this table and will be provided 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)
Lighting	Directional LED (Residential)	Lamp	1,877,395	10.0	No	94,908,067	11,272	NA	NA	NA	-1,857,512	0.52	0.52	NA	49,352,195	5,861	NA	NA	NA	-965,906
Lighting	Directional LED (Nonresidential)	Lamp	78,225	5.5	No	14,555,242	3,250	NA	NA	NA	-445,879	0.52	0.52	NA	7,568,726	1,690	NA	NA	NA	-231,857
Lighting	Specialty LED (Residential)	Lamp	1,935,372	10.0	No	69,439,714	8,247	NA	NA	NA	-1,359,053	0.59	0.59	NA	40,969,431	4,866	NA	NA	NA	-801,841
Lighting	Specialty LED (Nonresidential)	Lamp	80,641	4.5	No	10,667,398	2,382	NA	NA	NA	-373,707	0.59	0.59	NA	6,293,765	1,405	NA	NA	NA	-220,487
Lighting	LED Fixtures and Kits (Residential)	Lamp	1,401,802	15.0	No	90,307,536	12,114	NA	NA	NA	-1,998,912	0.52	0.52	NA	46,959,919	6,299	NA	NA	NA	-1,039,434
Lighting	LED Fixtures and Kits (Nonresidential)	Lamp	43,355	13.8	No	8,485,557	2,008	NA	NA	NA	-374,199	0.52	0.52	NA	4,412,490	1,044	NA	NA	NA	-194,583
Lighting	Connected LEDs (Residential)	Fixture	36,617	10.0	No	2,276,059	273	NA	NA	NA	-43,284	0.80	0.80	NA	1,820,847	219	NA	NA	NA	-34,627
Lighting	LED Nightlights (Residential)	Fixture	174,279	8.0	No	4,422,054	0	NA	NA	NA	0	0.80	0.80	NA	3,537,644	0	NA	NA	NA	0
Lighting	Carryover (Residential)	Unit	598,634	10.0	No	29,291,708	3,513	NA	NA	NA	-336,985	0.59	0.59	NA	17,258,765	2,070	NA	NA	NA	-198,552
Lighting	Carryover (Nonresidential)	Unit	22,670	6.3	No	4,318,326	971	NA	NA	NA	-59,566	0.59	0.59	NA	2,562,879	576	NA	NA	NA	-35,352
	Total		**6,248,990**	**11.0**		**328,671,663**	**44,030**	**NA**	**NA**	**NA**	**-6,849,097**	**NA**	**NA**	**NA**	**180,736,660**	**24,031**	**NA**	**NA**	**NA**	**-3,722,641**

* The total of the EUL column is the weighted average measure life (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.

Source: ComEd tracking data and evaluation team analysis