ComEd Residential Lighting Discounts Combined Evaluation Report

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

Presented to ComEd

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1. Introduction

This report combines the key deliverables from the evaluation of the Residential Lighting Discounts Program for PY9. Each of these deliverables were drafted, reviewed and finalized during the course of the PY9 evaluation.

APPENDIX A. ComEd In-Home Lighting Study and Statewide LED HOU Study Results 2017-12-22

Commonwealth Edison Residential Lighting Study and Illinois Statewide LED Hours of Use Study Results

To: Commonwealth Edison
From: Opinion Dynamics Evaluation Team
Date: December 22, 2017
Re: Residential Lighting Study and Illinois Statewide LED Hours of Use Study Results

1. Introduction

Commonwealth Edison (ComEd) has operated its Residential Lighting Program for nine years. From PY1 through PY9, the program discounted more than 92 million energy efficient (EE) light bulbs and fixtures, which is approximately 26 bulbs per residential customer.[1] To better understand program impacts, the state of the lighting market, and provide recommendations for future program direction, the evaluation team conducted an in-home study of customer lighting use. We conducted in-home lighting inventories in late 2016 and early 2017 as part of a larger statewide residential lighting study, which also included Ameren Illinois Company (AIC) customers. The study covered ComEd and AIC's service territories and consisted of the following components:

- **In-home lighting inventory.** The evaluation team collected data on all lighting products installed and in storage in customers' homes;
- **LED hours of use (HOU) metering study.** The evaluation team installed lighting loggers on a representative sample of residential customer light fixtures with LEDs. The goal of this effort is to develop LED-specific hours of use and coincidence factor estimates to update the Statewide TRM; and
- **Customer lighting preference study.** The evaluation team conducted a discrete choice survey with residential customers to assess customer preferences for standard and reflector light bulbs.

In this memo, we provide the results of the ComEd in-home lighting inventory, LED HOU study, and customer preference study.

2. Methodology

Overview of Approach

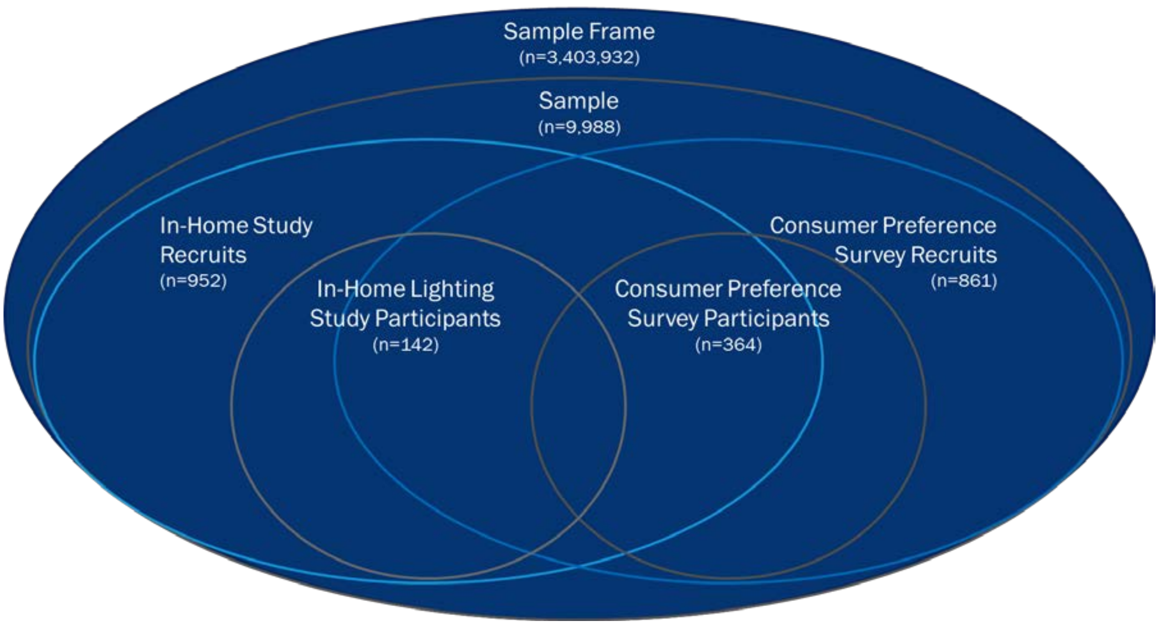
Opinion Dynamics completed a statewide in-home study aimed at developing estimates of HOU and coincidence factors for LEDs. As part of this statewide LED HOU study, we also completed lighting inventories

[1] Through in-store customer intercept interviews with ComEd customers, the evaluation team has found that commercial customers purchase approximately 5% of program-discounted bulbs. This estimate takes into account those commercial purchases.

at a representative sample of ComEd homes. The ComEd-specific lighting inventory allowed for analysis of penetration and saturation rates of the various lighting technologies and for exploring lighting storage and installation patterns. In addition, we administered a consumer preferences survey with ComEd customers, some of whom also participated in the in-home study.

Figure 1 illustrates ComEd-specific sample sizes of the different data collection efforts and the relationship between them. From ComEd's 3,403,932 residential electric customers, we drew a simple random sample of just under 10,000 customers to whom we mailed invitations to complete a study recruitment survey. Just over 950 customers completed the recruitment survey *and* agreed to participate in the study. From this group, we scheduled and completed in-home lighting inventories with 142 ComEd customers.[2] During the in-home study recruitment, we recruited slightly more than 850 customers to participate in the lighting preference study. In spring of 2017, we provided the survey link to these recruits, and 364 of them subsequently completed the consumer preference survey.

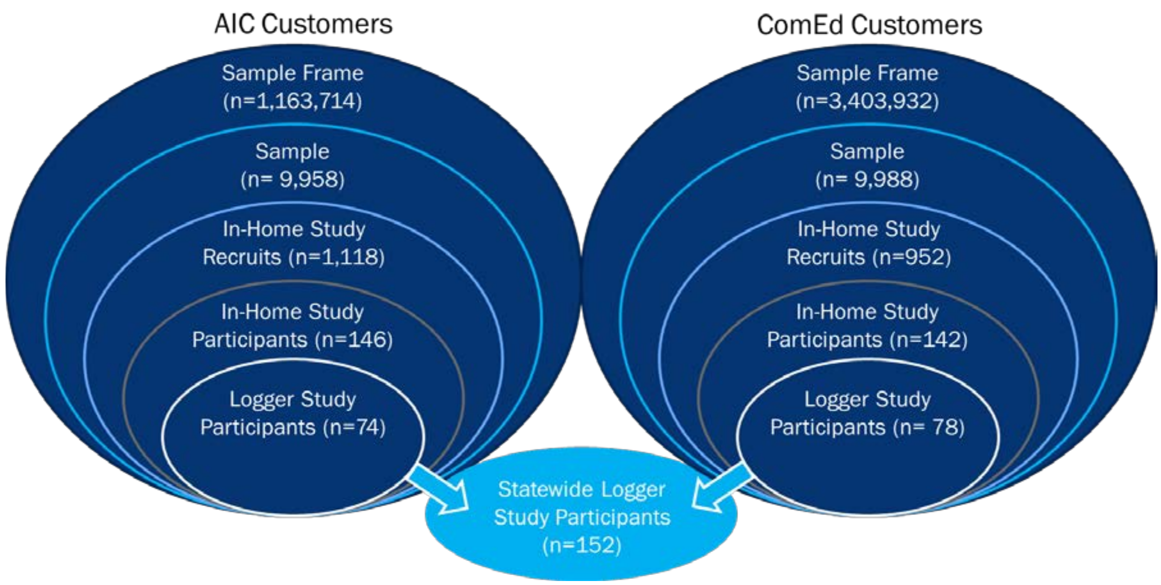
Figure 1. Sample Design for ComEd In-Home Lighting and Consumer Preference Studies



[2] We overrecruited participants because customers can change their minds when we call to schedule the in-home visit. It also may not be logistically possible to schedule visits with customers during the time the field team is in their area. Though we had intended to recruit more customers than we would include in the study, we had a higher response rate to the recruitment survey than we expected and ended up with a greater number of recruits. We compared the observable characteristics of those that received an in-home audit to those that were recruited but ultimately did not participate in the study. We found no statistically significant differences between these two groups across a number of observable characteristics, including household type, house size, the total number of rooms, the total number of household members, the proportion of retirees, education levels, and household income.

For the larger Illinois Statewide Residential LED Hours of Use study, we installed 415 light loggers on LEDs in the homes of 78 ComEd and 74 AIC customers for a total of 152 homes throughout the state of Illinois.[3]

Figure 2: Sample Structure for the Statewide Lighting Logger Study



Fielding Process and Timelines

We recruited customers to participate in the study by mailing them a letter that explained the study and encouraged them to complete a short recruitment survey. The letters provided a URL for customers to take the survey online, but those without internet could call our survey center to complete the survey with an interviewer. The recruitment survey allowed us to identify, pre-qualify, and recruit customers into the in-home lighting study, consumer preference study, or both studies. All customers were eligible for the in-home lighting inventory and consumer preference survey. Only customers with LEDs installed in their homes were eligible for the HOU study. Customers who participated in the HOU study had light loggers installed on their LEDs, which remained in place for approximately 8 months. Table 1 displays the dates of key study tasks.

Table 1. Table 1. Study Timeline

Study Task	Dates
Recruitment Survey Fielded	November 2016 – January 2017
In-Home Lighting Inventories and Light Loggers Installed	December 2016 – February 2017
Consumer Preference Survey Fielded	April 2017 – May 2017
Light Loggers Removed	August 2017 – September 2017

[3] The HOU analysis makes use of logger data from 137 homes. Loggers could not be retrieved from some homes. In addition, data cleaning identified some faulty loggers that had to be dropped from analysis. We provide additional details on the retrieval process and cleaning steps below.

To encourage study participation, we provided incentives for the different phases of the project. Customers who participated in the in-home study and had lighting audit conducted received a $75 Visa gift card. Customers who participated in the lighting logger study received an additional $75 gift card when the loggers were removed. Customers who completed the online lighting preference study each received a $10 Amazon eGift Card.

Data Collection Procedures

During each home visit, the auditor recorded the quantity and type of lighting installed in the interior and exterior of each home. For each light socket, the auditor recorded the socket type (e.g. screw, pin, etc.), light switch control type (e.g. on/off, dimmer, etc.), bulb technology (e.g. CFL, LED), shape (e.g. A-lamp, reflector, globe, etc.), fixture type (e.g. table lamp, recessed ceiling fixture, etc.), and room type (e.g. bedroom, kitchen, etc.). The auditor also recorded information about all lighting found in storage but not in use. We collected information on all bulbs installed inside and outside of ComEd homes.

During the audits, technicians installed loggers on interior and exterior switches that control sockets with LEDs. For logger deployment purposes, during the site visits, technicians classified rooms into nine following distinct room types[4]:

- Kitchen
- Living room
- Bedroom
- Bathroom
- Dining room
- Basement
- Closet
- Outdoor
- Other

As part of the audit, technicians collected the information on the total number of switches, switch controls, total number of light sockets controlled by each switch, lighting technology (CFL, LED, incandescent, halogen, empty socket), and bulb shape (twist, reflector, globe) in each socket. Technicians entered this information in electronic tables. Upon completion of the audits, the tablet produced a list of eligible switches that controlled at least one LED for logging. We deployed up to ten loggers per home, with at least one in each of the distinct room types described above. For homes with fewer than nine rooms, we deployed more than one logger per room (but no more than three loggers per room) to increase the overall precision as well as to act as a backup logger(s). If a room had more than one eligible switch, we randomly selected the light switch to log. For each logger, we recorded the switch it was placed on and the count of light bulbs, by technology, it controlled. We

[4] Note that the list of room types for lighting inventory is more detailed and includes 16 unique room types.

also recorded a detailed description of the logger placement to aid in subsequent retrieval visits (e.g., light above master bathroom mirror).

In order to accurately capture lighting usage, we placed lighting loggers as close to the light source as possible, without compromising the aesthetics of the lighting. We recorded any instances when lighting loggers cannot be placed on the desired fixture and detail reasons (accessibility, homeowner objections). We embedded processes for selecting alternative light fixtures for logger placement.

As part of the logger deployment process, we calibrated each logger's sensitivity setting to make sure it only captures lighting from the dedicated fixture and does not accidentally capture ambient sources of lighting, such as daylight.

Upon completion of the study, we removed the loggers using standard procedures for logger testing prior to removal. We also conducted a closing interview with the homeowner about any changes in lighting usage over the course of the logging period.

Appendix C contains details on the data preparation, cleaning, and analysis steps that we undertook to develop the HOU and CFs.

Data Weighting

We compared the demographics and home characteristics of the 142 ComEd customers who participated in the in-home inventory study with the overall ComEd residential customer population and found slight differences. Our study participants have slightly higher incomes, are somewhat better educated, are somewhat more likely to own their own homes, and live in single family homes. Because many of these characteristics are correlated with one another, we found that applying a single weight based on home ownership corrected most of the other differences as well. Table 2 summarizes the post-stratification weights we applied to in-home study participants.

Table 2. Weighting Summary for ComEd In-Home Lighting Audits

Ownership	Population	Inventory Sample	Inventory Weights
Own	71%	77%	0.85
Rent	29%	23%	1.48
Unknown	*N/A*	*1%*	*1.00*

For the LED HOU study, the target population is Illinois customers with LEDs installed in their homes. We do not have data on the demographics and household characteristics of AIC and ComEd customers with LEDs. Because this study included site visits with a broader sample, we were able to assess the potential for non-response bias through a two-stage approach:

- **Compare in-home study participants to the population of AIC and ComEd customers.** We compared the composition of the in-home study participants to the population of AIC and ComEd customers. We used the U.S. Census Bureau's 2010–2015 American Community Survey (ACS) data to obtain information on each utility's customer base. The sample of home study participants had more homeowners, single-family residents, and slightly more customers with higher income levels.
- **Compare logger study participants to eligible customers that filled out the recruitment survey.** We compared the demographic and household characteristics of the households that participated in the logger study with those of all customers eligible for the study, as determined through the recruitment

survey. This comparison allowed us to assess whether customers who agreed to participate in the logger study were different from those who qualified but chose not to participate. We found that our site visit sample was well aligned across key demographic and household characteristics.

Based on this analysis, we developed and applied survey weights based on homeownership to align the sample with the population. We applied the weights to the in-home study participant sample. We did not weight the data by home type or income because home type and income are highly correlated with homeownership, and weighting the data by the latter aligns the sample by the former. In addition to applying home ownership weights, we weighted the data by utility to account for the oversampling of AIC customers. We weighted the results in proportion to the share of each utility's customers in the population. Table 3 summarizes the weights that we applied.

Table 3. Weighting Summary for Statewide LED HOU Study

Utility	Home Ownership Status	Population	% Population	Site Visits	% Site Visits	Weight
ComEd	Own	2,221,313	49%	108	38%	1.30
	Rent	1,182,619	26%	34	12%	2.19
Ameren	Own	822,209	18%	107	37%	0.48
	Rent	341,505	7%	39	14%	0.55

We also had to weight the data to account for the fact that some loggers logged a LED that was on a switch that controlled more than one LED. Therefore, the logged LED represents all LEDs on the same switch. We aggregated individual logger data in stages. First, we aggregated individual loggers to room-level HOU and CF estimates. We then further weighted room-level HOU and CF estimates by the share of LEDs in each room type.

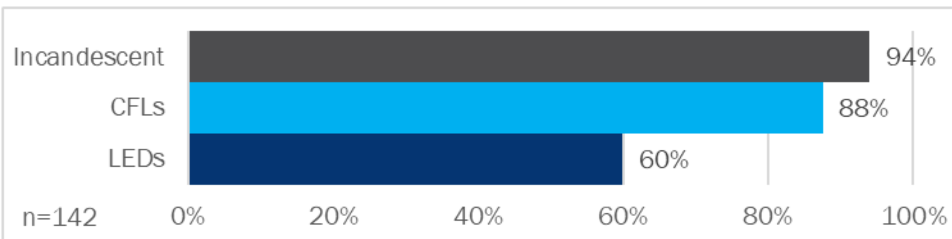
3. In-Home Lighting Inventory Results

The results of the ComEd customer lighting inventory study provide detailed information about how ComEd customers are using lighting in their homes and long-term program effects. Overall, the results of the in-home lighting inventory show that ComEd customers are adopting energy efficient (EE) light bulbs. LEDs have become the preferred product across all bulb types.

Lighting Penetration

Over half of ComEd customers have at least one LED installed in their home (60%) and a large majority have at least one CFL (88%). Despite relatively high rates of EE bulb usage, nearly all customers (94%) still have at least one incandescent bulb in use (see Figure 3).[5] Given that most customers tend to replace bulbs when they burn out, it is not surprising that we found incandescent bulbs in most homes. Less efficient bulbs will likely remain in sockets that are not used frequently as they are less likely to burn out and customers may feel that it does not make financial sense to replace working bulbs that are rarely used. While incandescent bulbs may not disappear entirely for some time, the market and customer preferences are quickly shifting towards LED options.

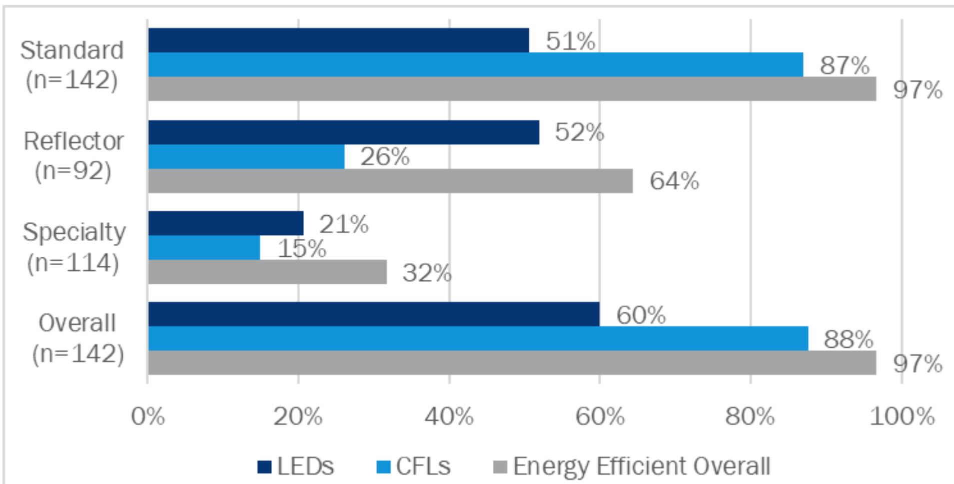
Figure 1. Figure 3. Bulb Penetration by Technology



[5] For this analysis, we combined traditional incandescent bulbs with EISA-compliant halogens. The bulbs look nearly identical so it is difficult to distinguish between the two technologies without removing many bulbs from their sockets during the audit, which we did not do in the interest of safety and due to time limitations. Therefore, separate results for incandescents and halogens would not be reliable. We refer to both bulb types as incandescents throughout this memo.

EE bulb penetration varies by bulb type. All customers have light sockets that require a standard light bulb and nearly all have at least one standard EE bulb. Penetration of EE bulbs in reflector and specialty sockets lag behind that of standard sockets (see Figure 4).[6] This is especially true for specialty bulbs; only 32% of homes with specialty bulbs in use have at least one specialty LED or CFL, compared to 64% for reflector bulbs and 97% for standard bulbs. CFLs are the primary driver of high EE bulb penetration for standard bulbs, and are installed in 87% of homes. LEDs play a larger role in driving EE penetration for reflector and specialty bulbs. This is especially true for reflector bulbs, where twice as many homes are using LEDs compared to CFLs (52% compared to 26%).

Figure 2. Figure 4. Efficient Bulb Penetration by Bulb Type



Lighting Saturation

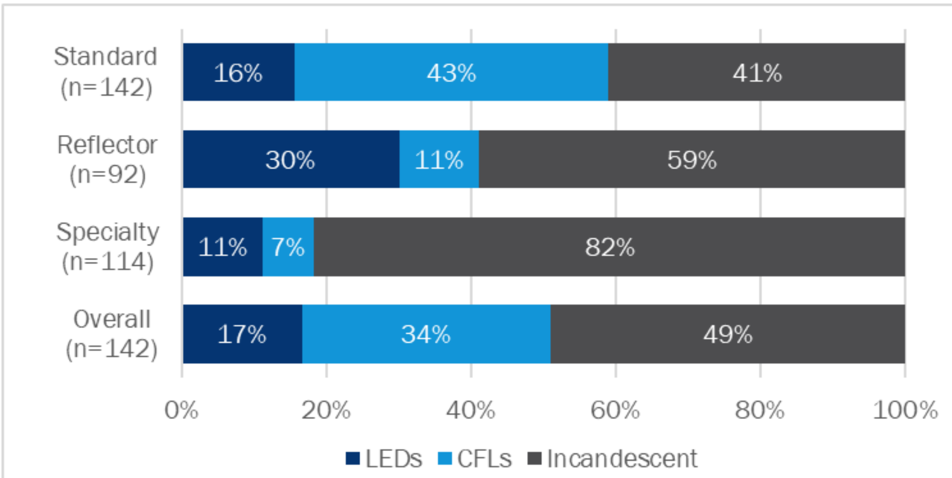
Over its nine years, the residential lighting program has provided incentives for standard, specialty and reflector CFLs and LEDs, though the large majority of program-discounted bulbs have been standard bulbs (85%). This program emphasis is appropriate since a majority of light sockets in the typical ComEd home use standard bulbs (60% in 2016). However, having discounted more than 70 million standard bulbs in its first eight years, the program shifted its focus slightly towards reflector and specialty products in the past year, with standard bulbs making up 73% of total sales in PY9.

Not surprisingly, EE bulb saturation for standard bulbs is considerably higher than that of reflector or specialty bulbs (see Figure 5). The average home has an EE bulb installed in over half (59%) of its standard light sockets, compared to 41% of reflector sockets and just 18% for other specialty sockets. CFLs are the most common bulb installed in 43% of standard sockets. Among reflector and specialty sockets, CFLs are far less common, making up just 11% of reflector sockets and only 7% of specialty ones, driving down EE bulb saturation for reflector and specialty sockets.

[6] Standard bulbs equate to A-lamps for most bulb technologies and spirals if the bulb is a CFL. We report the results for reflectors separately from other specialty bulbs for this analysis because reflectors are the specialty bulb most frequently discounted through the residential lighting program. Standard, specialty, and reflector sockets can all have bulbs of any technology installed. Although a resident could, in the future, install a standard bulb in a specialty socket or vice versa, our analysis assumes the resident has chosen the most appropriate bulb for the socket and will continue to use that same type of bulb.

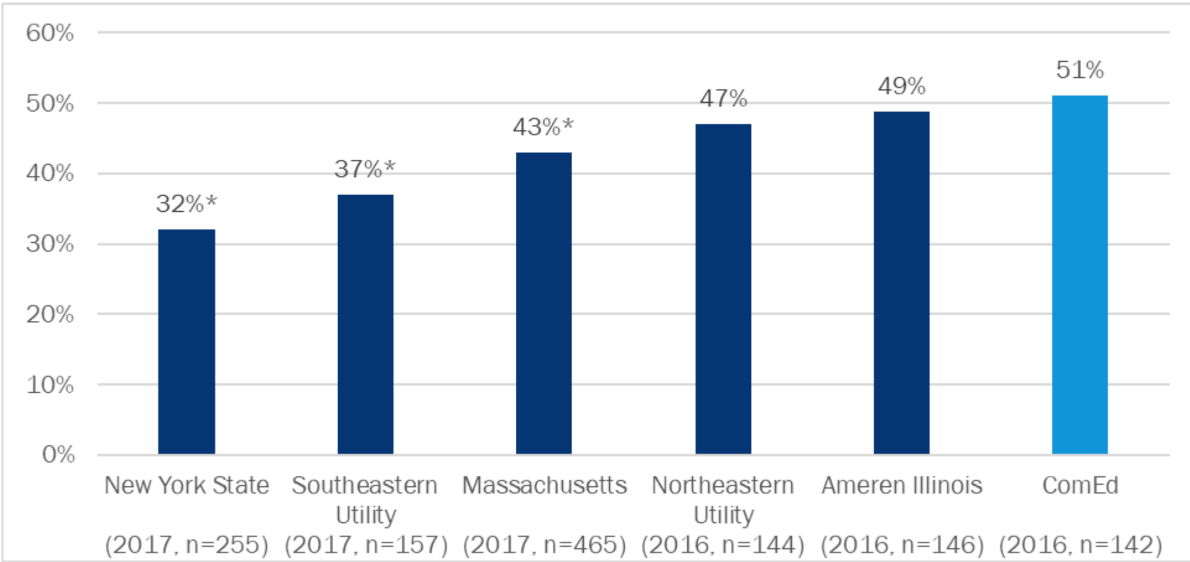
Although EE bulb saturation is lower for reflector sockets than standard ones, LEDs fill nearly twice the share of reflector sockets than standard sockets (30% compared to 16%). LEDs also make up a much larger portion of the EE bulbs installed in reflector or specialty sockets than they do in standard sockets.

Figure 5. Lighting Saturation Rates



We compared EE bulb saturation rates in ComEd territory to other jurisdictions and found ComEd to have the highest at 51% (see Figure 6). We included four other territories from across the country for which home audits were conducted in the past year. ComEd's EE bulb saturation rate is significantly higher than half of the findings we compared against, and trends higher than the other half of the jurisdictions included in the comparison.

Figure 6. Energy Efficient Bulb Saturation in Different Areas of the United States



Source: Home audits conducted by Opinion Dynamics and publicly available reports[7]

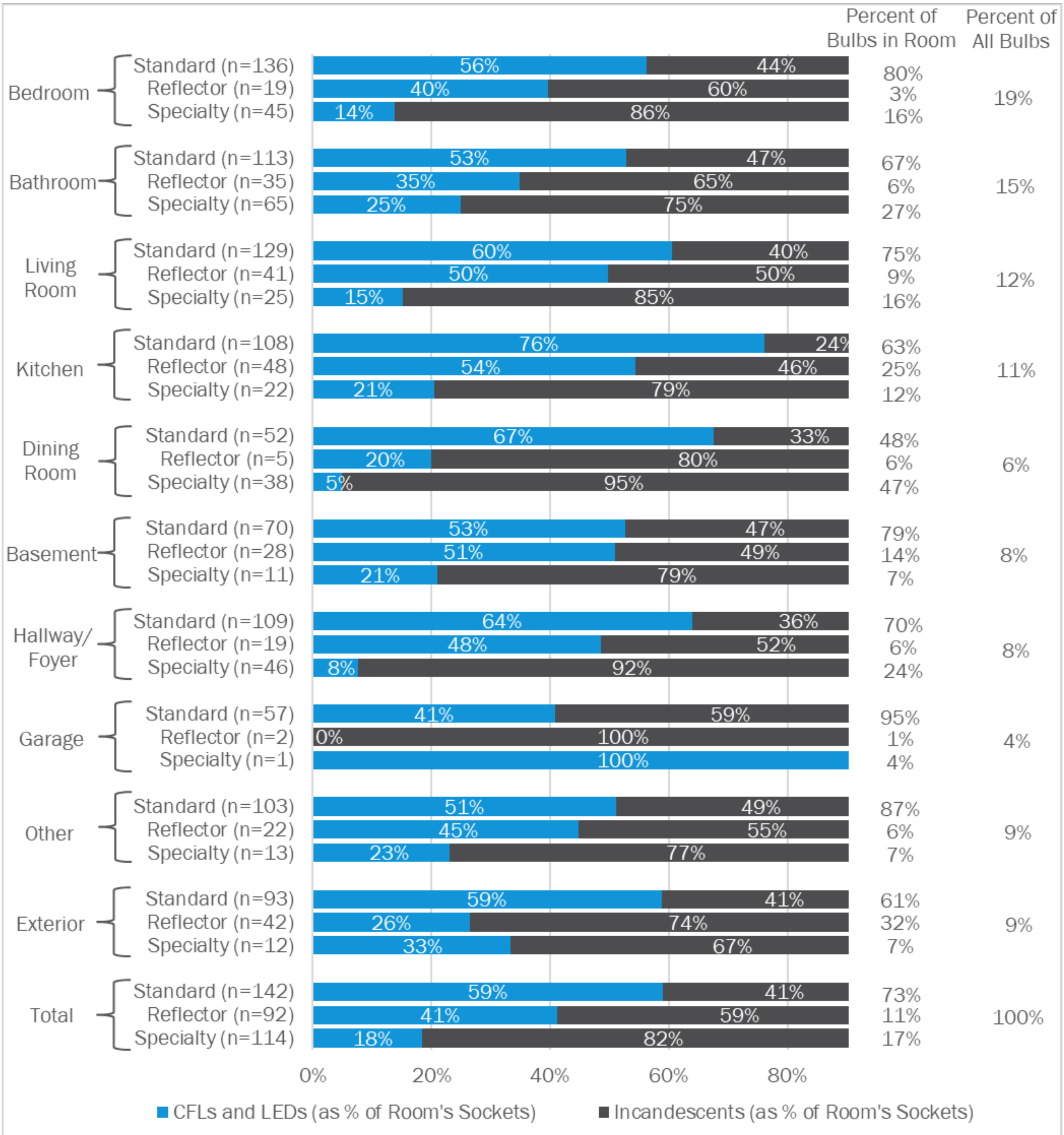
*Difference between AIC and utility is significant at the 0.1 alpha level.

Saturation by Room Type

ComEd customers use different types of bulbs and technologies depending on the room type (see Figure 7). For example, kitchens are the most advanced room in terms of the lighting in use. Kitchens have a higher percentage of reflector bulbs compared to any interior room and the highest EE reflector saturation rate. Customers also make use of more reflectors for their exterior lighting, but the EE saturation rate of these bulbs lags behind kitchens. Dining rooms and bathrooms have the highest percentage of specialty bulbs in use, but only a small percentage of these bulbs are EE. Customers are more likely to use standard bulbs in their bedrooms, living rooms, garages, and basements. Living rooms have the highest EE saturation rate followed closely by bedrooms. Most customers have yet to upgrade the standard bulbs in their basements and garages to EE bulbs. Exterior lighting, dining rooms, and bathrooms represent some the remaining opportunities for the residential lighting program. Garages and basements may provide some opportunities as well

[7] Massachusetts and New York numbers are drawn from 2015-2016 Lighting Market Assessment, Consumer Survey, and On-Site Saturation Study. Submitted to the Electric and Gas Program Administrators of Massachusetts, August 8, 2016 by NMR Group.

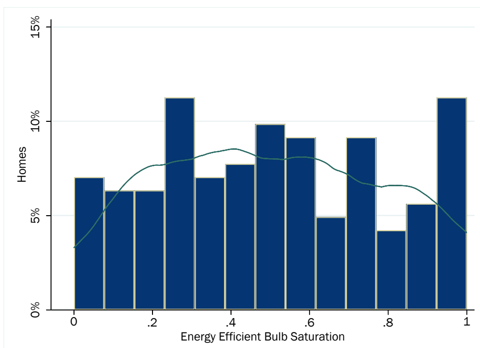
Figure 7. Energy Efficient Bulb Saturation by Socket and Room Type, 2012 - 2016



Saturation by Customer Segment

The evaluation team examined the distribution of EE bulb saturation to better understand the range of efficient bulb usage among ComEd customers and how it has changed. EE usage remains highly varied across AIC households though over time, we see the distribution shift from being skewed to the right to a uniform distribution (see Figure 8). The distribution is nearly uniform meaning that a ComEd household was equally likely to have few, some, or a lot of EE bulbs. With this EE bulb usage pattern, it is more challenging for the residential lighting program to continue to impact the market with an upstream program design. In the past, the typical customer who was purchasing lighting at a retailer most likely had just a few or some EE bulbs. Today, the typical customer is equally likely for most of their bulbs to be EE as they are to be non-EE. With an upstream delivery model, the program will end up discounting the lighting purchases of many customers who already have high EE bulb saturation and would likely purchase them without a discount. The challenge going forward will be to identify and target customers who have lower EE bulb saturation and who need the discount to encourage more EE bulb purchases.

Figure 8. Distribution of Energy Efficient Bulb Saturation



We compared EE bulb penetration and saturation across different demographic groups to help identify the types of customers that the program should target. We found few statistically significant differences due in part to the smaller sample sizes of some subgroups. However, consistent with our previous research in other jurisdictions, it appears that homeowners, customers living in single family homes, and older customers have somewhat lower EE bulb saturation rates than their counterparts. We suspected that some of these differences might result from differences in home size or bulbs types used by different demographic groups. For example, owned homes tend to be larger than rented, multi-family homes and tend to have more reflector and specialty sockets. As shown in Table 3, homes with more light sockets and homes with a greater proportion of reflector or specialty sockets have lower EE bulb saturation.

To examine these differences even further, we ran a multivariate regression predicting EE bulb saturation by respondent demographics, the total number of light sockets in the household, and the percentage of light sockets that use a reflector or specialty bulb. The model results show that most demographic variables are not significantly related to EE bulb saturation. The two demographic variables that are significant is age, which has a negative association with EE bulb saturation rates, and education, which has a positive association with EE saturation. In addition, the number of light sockets is not significantly related to EE bulb saturation, but the percentage of reflector or specialty sockets is (i.e., the type of sockets in a home matters more for EE bulb saturation than the number of sockets). In summary, households headed by older adults and that have a higher percentage of specialty light sockets have lower EE bulb saturation rates than other households while better educated households have higher EE saturation.

Table 4 Energy Efficient Penetration and Saturation Rates by Select Demographic Categories

Demographic Characteristic	n	CFL/LED Penetration	CFL/LED Saturation
Home Type			
Single-family (A)	99	96%	49%
Multifamily (B)	6	100%	53%
Other/mobile (C)	37	97%	54%
Home Ownership			
Own (A)	108	98%	49%
Rent (B)	33	94%	55%
Annual Household Income			
Less than $50,000 (A)	49	96%	54%
$50,000 – less than $75,000 (B)	20	92%[C]	44%
$75,000 or more (C)	68	99%	49%
Education			
High school or less (A)	21	96%	54%
Some college/technical/trade (B)	46	92%[C]	44%
College grad (or more) (C)	75	99%	49%
Age of Respondent			
18 – 34 years old (A)	24	94%	57%
35 – 54 years old (B)	55	97%	50%
55+ years old (C)	62	97%	48%
Employment			
Employed (A)	92	100%[B,C]	54%
Unemployed (B)	13	90%	43%
Retired/not looking (C)	36	91%	47%
Square Footage			
Less than 1,000 square feet (A)	28	92%[B]	57%
1,001 - 2,000 square feet (B)	67	99%	50%
Greater than 2,000 square feet (C)	47	98%	49%
Number of Light Sockets			
First Quartile (7 – 25 bulbs) (A)	37	94%	44%[D]
Second Quartile (26 - 43 bulbs) (B)	34	100%	40%[D]
Third Quartile (44 - 69 bulbs) (C)	40	98%	27%
Fourth Quartile (73 - 238 bulbs) (D)	31	97%	20%
Number of Specialty Bulbs			
First Quartile (0 - 5 bulbs) (A)	39	100%[B]	52%[C,D]
Second Quartile (6 - 15 bulbs) (B)	34	89%[C]	34%
Third Quartile (16 - 31 bulbs) (C)	34	100%	22%
Fourth Quartile (33 - 128 bulbs) (D)	35	97%	18%

Note: Letter codes denote significant difference between subgroups at the 0.1 alpha level.

Lighting Controls

Although the residential lighting program has only discounted light bulbs, lighting controls are another potential source of energy savings. We recorded the control type of each lighting switch inside ComEd customer homes and found, unsurprisingly, that simple “on/off” switches are the most common type of switch (91%) and that these switches control a large majority of bulbs (85%). Dimmable switches are the next most common type of switch, followed closely by 3-way switches. Only 1% or less of switches were timers, 4-way switches, or occupancy or motion sensors.[8] These results suggest that lighting controls could be a source of savings in the future.

Table 5 Distribution of Control Types in 2016

Control Type	n	Percent of Homes	Percent of Switches	Percent of Bulbs
On-off	141	99%	91%	85%
Dimmable	46	29%	4%	8%
3-way	34	21%	4%	6%
Timer	21	13%	1%	1%
4-way	4	2%	<1%	<1%
Motion/occupancy sensor	2	1%	<1%	<1%
Other	2	1%	<1%	<1%
Total	**142**	**100%**	**100%**	**100%**

LED Purchase and Installation Behavior

During the in-home audit, field technicians asked customers with LEDs installed several questions about their purchase and installation of the bulbs. LEDs are a new bulb technology for many customers. More than half of customers installed their first LEDs within the past year (54%).[9] Table 5 provides the number of survey participants who reported installing their first LED in each year.

Table 6 Distribution of Customers’ First LED Installations

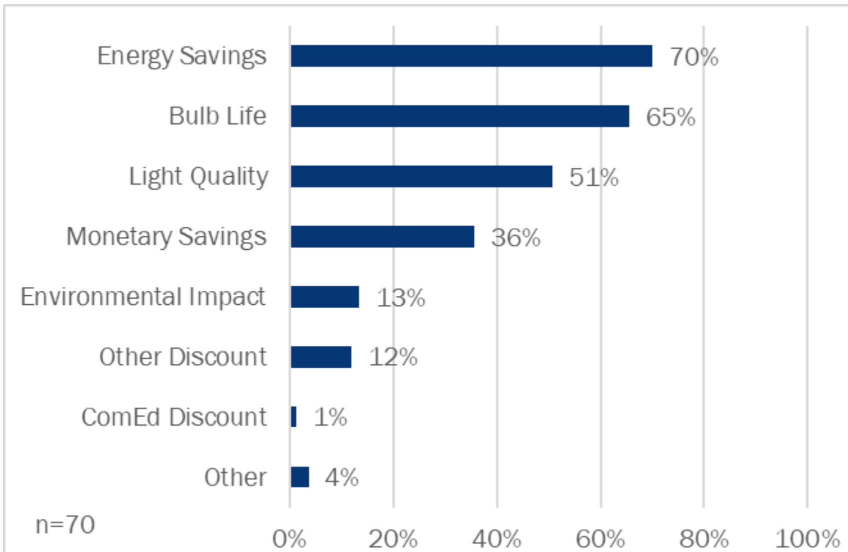
First LED Installed	n	%
2014 or earlier	12	19%
2015	15	27%
2016-17	30	54%
Total	**57**	**100%**

[8] We did not record switch types for bulbs installed outside the homes so it is possible that a greater percentage of exterior bulbs are on switches with motion sensors.

[9] The audits were conducted between December 2016 and February 2017 so any response of 2016 or 2017 is roughly the past year.

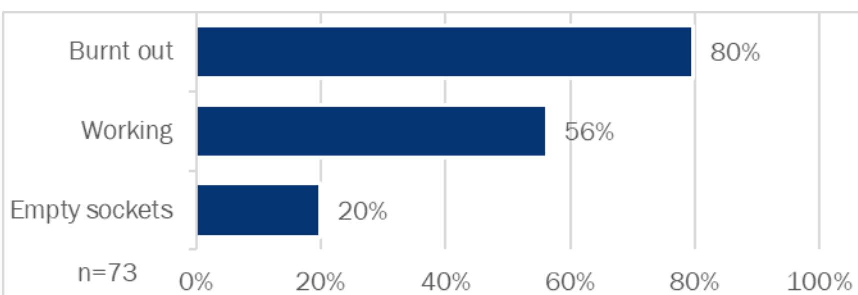
We asked customers why they purchased LEDs over another bulb technology. The top three reasons customers gave for purchasing LEDs over another bulb technology is the energy savings (70%), followed by longer bulb life (65%), and light quality (51%). Some customers also pointed to monetary savings (36%), and a smaller number of customers suggested they were motivated by environmental benefits (13%) or product discounts (13%).

Figure 9. Reasons for Purchasing LEDs Over Another Bulb Technology



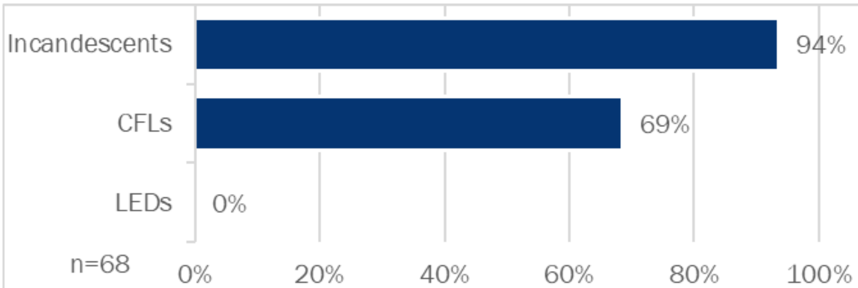
We asked customers about the status of the sockets in which they most recently installed LEDs prior to the LEDs' installation (See Figure 10). Most LEDs were installed to replace burnt out light bulbs (80%), but more than half replaced working bulbs (56%). A smaller number of respondents installed LEDs in previously empty sockets (20%).

Figure 10. Socket Status Prior to Most Recent LED Installation



We also asked customers about the types of bulbs they most recently replaced with LEDs (see Figure 11). A large majority said that they replaced incandescents (94%) while just over two-thirds replaced CFLs (69%). None of the 68 respondents replaced any LEDs in their most recent LED installation.

Figure 11. Type of Bulb Replaced by Most Recent LED Installation



As part of the in-home lighting inventory, we included bulbs in storage in the scope of our data collection. The quantity of bulbs in storage relative to the total number of bulbs found in the home provide an estimate of first-year ISR. Table 6 contains first-year ISR derived as part of this study as well as the ISR trajectory for standard LEDs and specialty LEDs. We developed the ISR trajectory based on the carryover method outlined in IL-TRM V5.0, which assumes that 98% of all bulbs will be installed within 3 years of purchase with 55% of bulbs remaining after the first year installed in year two and 45% installed in year three. As can be seen in the table, the overall first-year ISR for LEDs is 88%. First-year ISR for specialty LEDs is higher than for standard LEDs (95% vs. 84%).

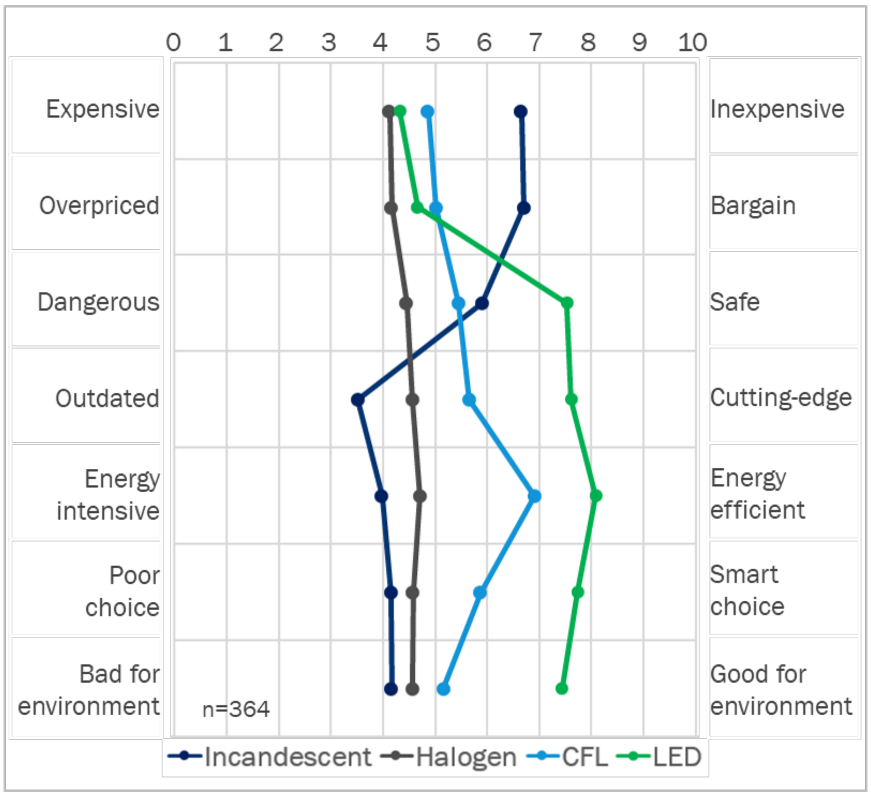
Table 2. Table 7. LED Residential In-Service Rates

Bulb Type	n	First Year ISR	Second Year ISR	Third Year ISR	Cumulative ISR
Standard LEDs	79	84%	8%	6%	98%
Specialty LEDs	62	95%	2%	2%	98%
Overall LEDs	**93**	**88%**	**5%**	**4%**	**98%**

Product Perception

As part of the consumer preferences survey, we asked respondents to rate each lighting technology on seven different attributes, including cost, safety, and energy use. The responses indicate that, on average, customers have a firm understanding of the different bulb types (see Figure 12). For example, customers understand that LEDs are the most energy efficient, best for the environment, and newest or most cutting-edge technology and that CFLs are the next best option in these areas. They also know that LEDs are among the most expensive products available and correctly identify incandescents as the oldest, cheapest, and least energy efficient option. The only signs of misunderstanding are with halogens, which customers on average perceive to be as expensive as LEDs.

Figure 3. Figure 12. Customer Perceptions of Available Lighting Technologies

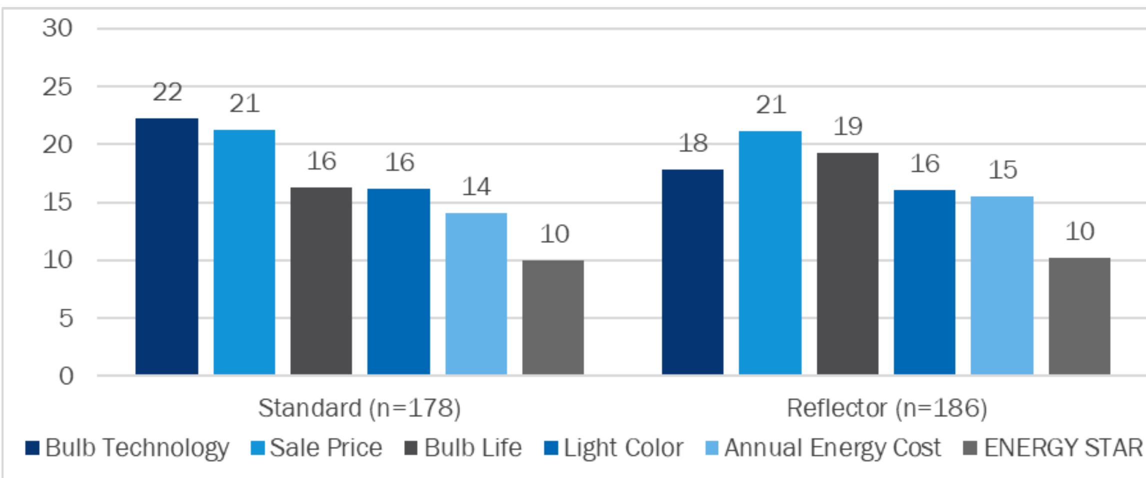


4. Customer Preference Study Results

As part of the customer preference study, we administered a discrete choice survey to examine the relative importance of different product attributes and to assess customers' price sensitivity towards energy efficient lighting products. Because of the notable differences in product application and pricing, we modeled results separately for standard bulbs and reflector bulbs.

Figure 13 provides relative importance scores for key product attributes. As can be seen in the figure, bulb technology and price are the top two attributes for standard and reflector products alike, followed by bulb life, light color, and annual energy cost. ENERGY STAR® (ES) certification is the least important attribute. Bulb technology and price are of greatest relative importance to customers when shopping for standard products, while price is of greatest importance when shopping for reflector products. This difference in attribute importance may be due to the higher cost of reflector bulbs and therefore higher sensitivity to price when shopping for reflectors.[10]

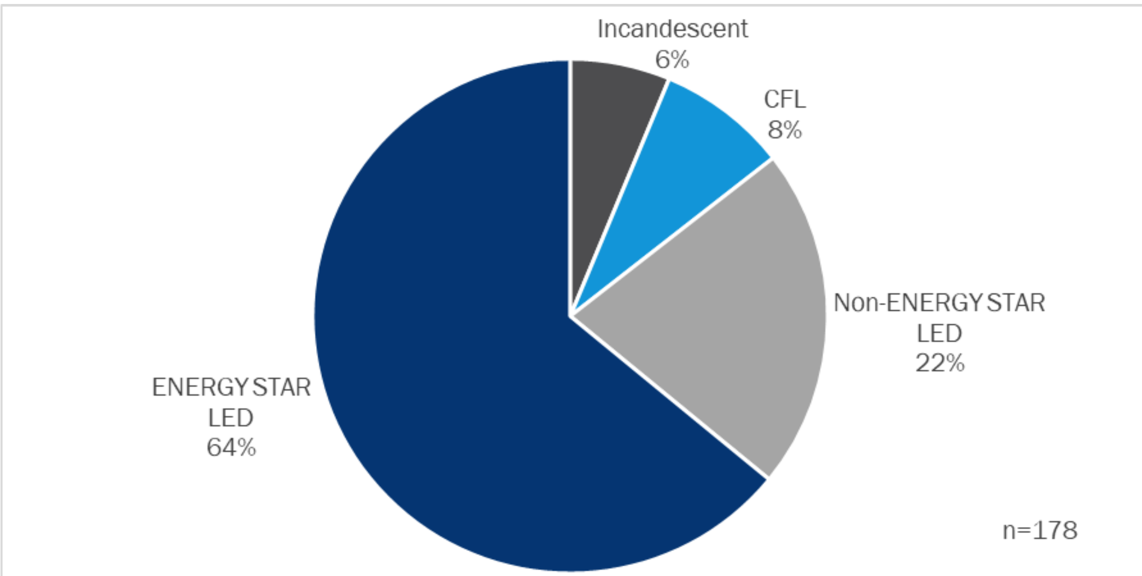
Figure 4. Figure 13. Relative Importance of Attributes by Bulb Type



[10] Please note that the importance score of each attribute for a product type is expressed in relative terms to the other attributes for that product and should not be compared across product types.

In addition to modeling the relative importance of the different bulb attributes, the discrete choice survey allowed us to simulate market shares for the different bulb technologies within the standard and reflector product categories. Figure 14 shows the market shares for standard products. The results suggest that customers prefer LEDs over other technologies at current market prices and with typical bulb attributes for each technology, such as bulb life, light color, and annual energy cost. ES LEDs would capture 64% of standard bulb sales, and non-ES LEDs would account for another 22%. Together, ES and non-ES LEDs account for a massive 86% of sales. CFLs make up less than one tenth of sales (8%), and incandescents account for the remaining 6% of lighting sales.

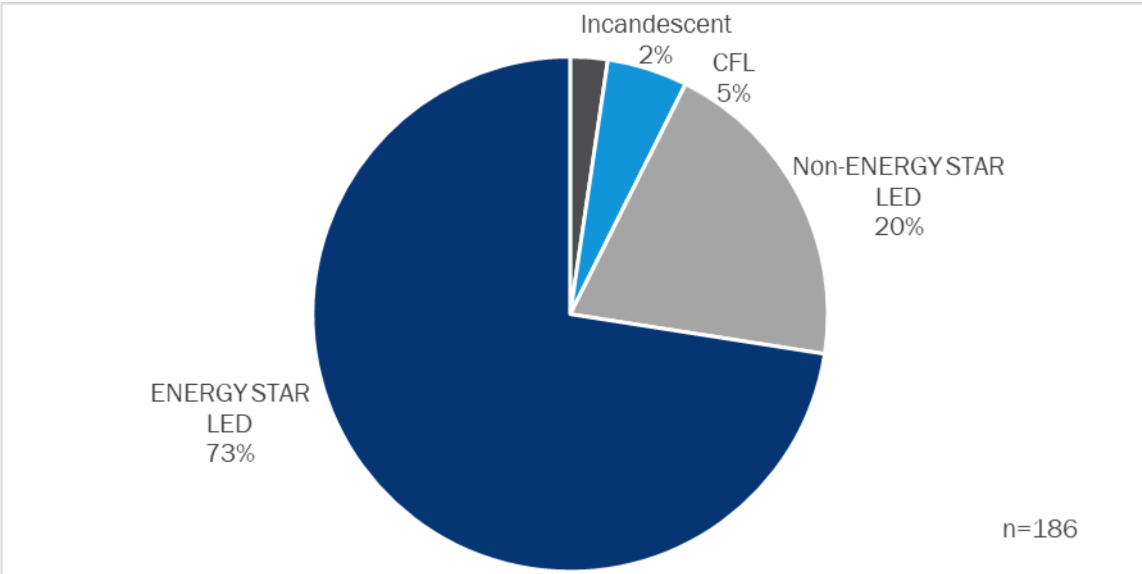
Figure 5. Figure 14. Standard Lighting Product Market Shares at Current Market Conditions



Simulator Inputs	Product 1	Product 2	Product 3	Product 4
Technology	Incandescent	CFL	Non-ES LED	ES LED
Sale price	$1.98	$3.17	$2.96	$4.90
Bulb life	1	5	10	15
Annual energy cost	$7.25	$1.75	$1.00	$1.00
Light color	Warm	Warm	Warm	Warm
ENERGY STAR	No	No	No	Yes

Figure 15 shows the modeled market shares for the reflector products. The results show that ES LEDs dominate reflector sales at current market prices and with typical product attributes. As can be seen in the figure, ES LEDs account for 73% of sales, and non-ES account for another fifth of sales (20%). The cumulative LED market share in the reflector category is over 90%. CFLs account for 5% of bulb sales and incandescent account for the remaining 2%.

Figure 6. Figure 15. Reflector Lighting Product Market Shares at Current Market Conditions



Simulator Inputs	Product 1	Product 2	Product 3	Product 4
Technology	Incandescent	CFL	Non-ES LED	ES LED
Sale price	$4.39	$5.96	$5.54	$6.36
Bulb life	1	5	10	15
Annual energy cost	$7.75	$2.00	$1.25	$1.25
Light color	Warm	Warm	Warm	Warm
ENERGY STAR	No	No	No	Yes

In addition to understanding the relative importance of the attributes and modeling lighting market shares at current market conditions, we examined how changes in the price of ES LEDs, holding all other attributes constant, impacted ES LED market share. We estimated price elasticity curves for different lighting product configurations across standard and reflector products. We define price elasticity as:

$$\frac{\%\Delta\ Quantiy}{\%\Delta\ Price}$$

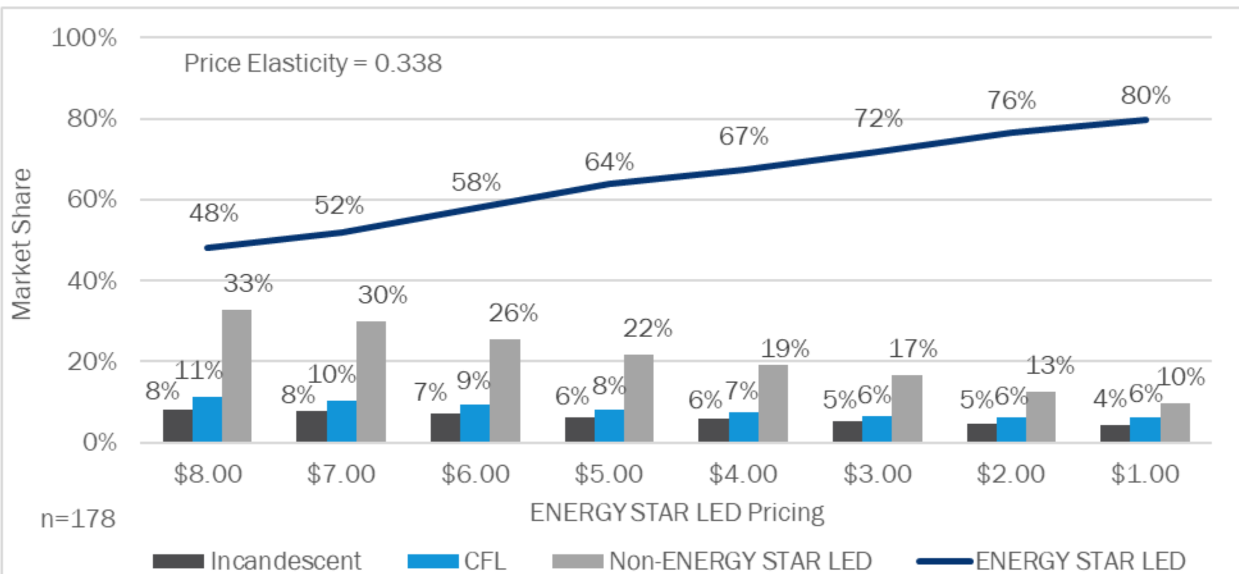
We show price elasticity as a number. For example, a price elasticity equal to 0.50 means that for every 10% drop in price, there will be 5% increase in market share.[11] We ran multiple price sensitivity scenarios.

[11] An elasticity (in absolute value) closer to 0 is considered low or relatively inelastic, while an elasticity closer to or greater than 1 is considered high or relatively elastic (Simon and Blume, 1994).

Figure 16 shows the results of the price sensitivity analysis for standard ES LEDs. The upward-sloping line reflects the change in ES LED market share as the price decreases. The bars below the line represent the market shares for an average-priced non-ES LED, CFL, and incandescent bulb at each ES LED price point.

The results show price that sensitivity for standard ES LEDs is relatively low at 0.338, which indicates that for every 10% decrease in bulb price, the market share of ES LEDs will increase only by 3.4%. ES LEDs have the greatest market share at all price points. At $8 per bulb, ES LEDs lead all bulb technologies with 48% of the market. For this analysis, we held the price of non-ES LEDs constant at $2.96 per bulb. When ES LEDs are $8 per bulb, 33% of customers will purchase a non-ES LED instead. The greater market share for ES LEDs suggests that some customers see value in the ES certification and in the longer expected bulb life. As the price of ES LEDs drops from $8 to $1 per bulb, their market share increases to 80% with most of the increase in market share coming at the expense of non-ES LEDs. The market share for non-ES LEDs drops from 33% to 10%. We also hold CFLs and incandescents constant at their current market prices, $3.17 and $1.98 respectively. Even with ES LEDs at $1 per bulb, a few customers will pay more to purchase CFLs (6%) or incandescents (4%), suggesting that some people may be more comfortable sticking with a technology they know.

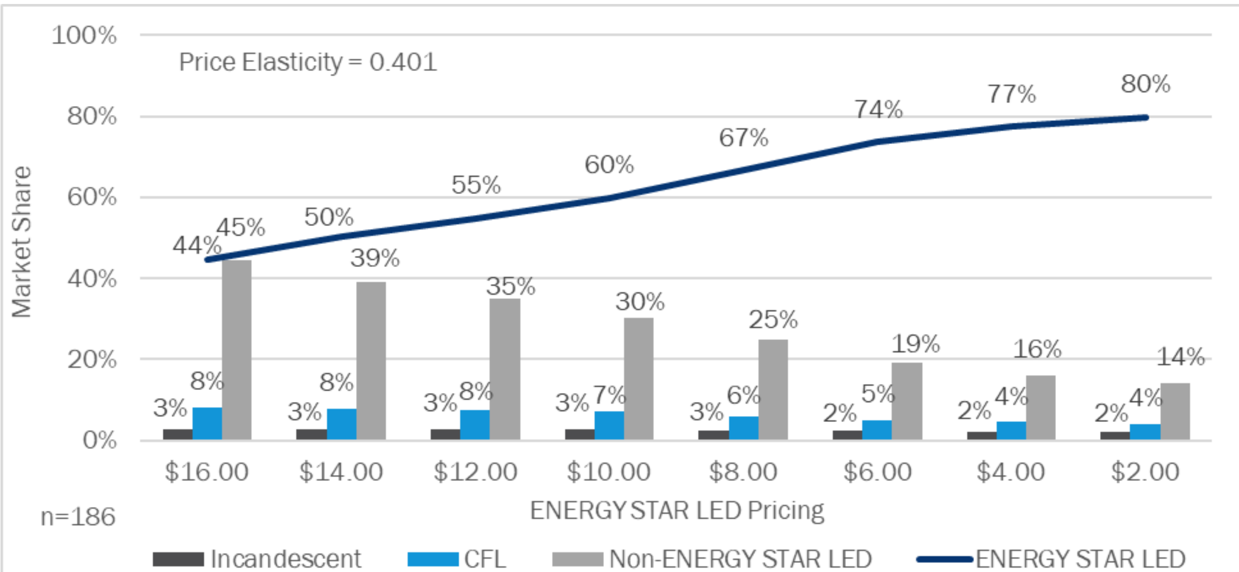
Figure 7. Figure 16. Price Sensitivity and Average Price Elasticity for Standard ENERGY STAR LEDs



Simulator Inputs	Product 1	Product 2	Product 3	Product 4
Technology	Incandescent	CFL	Non-ES LED	ES LED
Sale price	$1.98	$3.17	$2.96	**Varied**
Bulb life	1	5	10	15
Annual energy cost	$7.25	$1.75	$1.00	$1.00
Light color	Warm	Warm	Warm	Warm
ENERGY STAR	No	No	No	Yes

Compared to the standard ES LEDs, reflector ES LEDs are slightly more price elastic. The price elasticity for reflector ES LEDs is 0.401, which indicates that for every 10% decrease in bulb price, LED market share will increase by 4.0% (see Figure 17). At the highest price point of $16 for an ES LED, more customers would purchase a non-ES LED at $5.54 per bulb than an ES LED. However, as we saw with ES standard bulbs, there is value in the ES label and extended bulb life. As the price of reflector ES LEDs declines, market share increases so that at $14 per bulb, reflector ES LEDs have largest market share compared to all other technologies. As reflector ES LED market share increases, it pulls disproportionately from non-ES LEDs, though the market share of CFLs and incandescents drops as well to very low levels.

Figure 8. Figure 17. Price Sensitivity and Average Price Elasticity for Reflector ENERGY STAR LEDs



Simulator Inputs	Product 1	Product 2	Product 3	Product 4
Technology	Incandescent	CFL	Non-ES LED	ES LED
Sale price	$4.39	$5.96	$5.54	**Varied**
Bulb life	1	5	10	15
Annual energy cost	$7.75	$2.00	$1.25	$1.25
Light color	Warm	Warm	Warm	Warm
ENERGY STAR	No	No	No	Yes

These results suggest that customers are willing to pay more for LEDs, both ES and non-ES. The discrete choice survey was a hypothetical shopping experience so that it is possible that customers in an actual store setting might make different choices and simply purchase the least expensive product. However, combined with the in-home study results that indicate growing customer interest in LEDs and the survey results showing strong customer knowledge of the benefits of LED bulbs, the residential lighting market appears to be nearing transformation.

5. LED Light Logger Study Results

Hours of Use

The overall statewide average daily HOU for LEDs is 2.68 hours. Relative precision around the overall HOU estimate is 7% at 90% confidence. HOU by bulb type vary, with standard bulbs resulting in the highest HOU of 2.98, followed by specialty bulbs with an HOU estimate of 2.68. Reflectors have the lowest HOU of 1.71 hours.

Table 8. HOU Estimates by Bulb Type

Bulb Type	Number of Loggers	Number of Homes	HOU	Relative Precision
Standard	282	113	2.98	9%
Reflector	36	24	1.71	19%
Specialty	35	26	2.68	20%
Overall	**350**	**137**	**2.68**	**7%**

Table 8 provides HOU and CF estimates, and the associated relative precision, by utility. As can be seen in the table, AIC's daily average HOU is higher than ComEd's by about half an hour (3.13 vs. 2.58). The difference in the HOU could be explained by lower HOU in multifamily (MF) properties for ComEd than AIC[12], and a higher share of MF properties in ComEd territory as compared to AIC's (37% vs. 16%).

Table 9. HOU Estimates by Utility

Bulb Type	Number of Loggers	Number of Homes	HOU	Relative Precision
ComEd	200	70	2.58	10%
AIC	150	67	3.13	11%
Overall	**350**	**137**	**2.68**	**7%**

HOU and CFs vary by room type, with kitchens, living rooms, and dining rooms having the highest HOU, while bedrooms, basements, bathrooms, and other room types having the lowest HOU. Table 9 provides HOU and CF estimates by room, relative precision associated with each room-level HOU estimates, LED saturation in each room, as well as the share of all LEDs in each room type. Note the large relative precision values around the room-level estimates, which is indicative of a higher level of uncertainty.

[12] Average daily HOU in MF properties in is 2.25 in ComEd's service territory and 5.04 in AIC's service territory. These results, however, are based on small sample sizes (20 and 10 sites and 51 and 26 loggers, respectively).

Table 10. HOU Estimates by Room

Room Type	Number of Loggers	Number of Homes	HOU	Relative Precision	% of Sockets with LEDs in Each Room	% of All LEDs Across Rooms
Kitchen	48	43	4.24	14%	39%	18%
Living room	91	67	3.93	12%	35%	17%
Dining room	16	15	3.06	25%	22%	5%
Bedroom	61	43	2.37	23%	22%	13%
Basement	27	20	1.66	25%	22%	12%
Bathroom	51	40	1.10	14%	25%	18%
Other	56	43	2.66	22%	15%	17%
Overall	**350**	**137**	**2.68**	**7%**	**24%**	**100%**

Analysis of HOU values by key customer segments shows slightly higher HOU for single-family homes, owner-occupied homes, as well as homes occupied by customers with higher incomes and higher levels of education. HOU are also higher in homes occupied by customers under 55 years of age. None of these differences, however, are statistically significant.

Table 11. HOU Estimates by Key Customer Characteristics

Room Type	Number of Loggers	Number of Homes	HOU	Relative Precision
Home type				
Single-family	273	107	2.74	8%
Multi-family	77	30	2.50	15%
Home Ownership				
Own	293	116	2.75	8%
Rent	57	21	2.18	25%
Income				
<$50,000	123	49	2.66	14%
$50,000–$100,000	115	43	2.05	14%
$100,000+	99	40	3.54	12%
Education				
Less than college degree	162	66	2.57	10%
College degree+	188	71	2.75	11%
Age				
Under 55 years old	198	71	2.72	10%
55 years or older	146	65	2.55	11%

To place the HOU estimates derived through this study in perspective, we compared the results from this study to the HOU values recommended for use for LEDs in the IL-TRM Version 5.0 (V5.0). The TRM-recommended HOU values are based on a lighting logger study of CFLs conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. As can be seen in Table 11, the HOU are considerably higher for standard LEDs, somewhat higher for specialty LEDs, and considerably lower for reflector LEDs.

Table 12. Comparison of HOU Estimates to IL-TRM V5.0

Bulb Type	Average Daily HOU	
	This Study	IL-TRM V5.0
Standard	2.98	2.07[a]
Reflector	1.71	2.36[b]
Specialty	2.68	2.32[c]

[a]HOU is for residential and in-unit multifamily
[b]HOU for interior reflectors
[c]HOU for specialty generic light bulbs

We also compared the results of this study with other HOU studies conducted across the country. As can be seen in Table 12 below, the HOU estimates from this study are within the range of the other studies' estimates.

Table 13. Comparison of HOU Estimates across Studies

Study Name	Study Timing	n	HOU Result	Notes
New England HOU Study	2013	848	3.0	Efficient bulbs
Pennsylvania Statewide Residential Light Metering Study	2014	206	3.0	Efficient bulbs
DEP 2012 CFL HOU Study	2012	100	2.92	CFLs only
Southern Utility Residential Lighting Logger Study	2016	107	2.88	LEDs only
Illinois Residential Lighting Logger Study	**2017**	**101**	**2.68**	**LEDs only**
Midwestern Residential Lighting Logger Study	2017	101	2.66	LEDs only
Indiana Statewide CFL HOU Study	2012-2013	67	2.47	CFLs
EmPOWER Maryland HOU Metering Study	2014	111	2.46	Efficient bulbs
ComEd PY5/PY6 Lighting Logger Study	2014	85	2.32	Standard CFLs

Coincidence Factors

Table 13 summarizes summer and winter peak CF estimates, and associated relative precision, overall as well as by bulb type. As can be seen in the table, the overall summer peak CF is 0.122 and the overall winter peak CF is 0.127. Summer and winter peak CFs are higher for standard and specialty LEDs than for reflector LEDs.

Table 14. Summer and Winter Peak CF Estimates by Bulb Type

Bulb Type	# of Loggers	# of Homes	Result	Relative Precision
Summer Peak CF				
Standard	282	113	0.128	13%
Reflector	36	24	0.108	29%
Specialty	35	26	0.112	26%
Overall	350	137	0.122	11%
Winter Peak CF				
Standard	282	113	0.144	10%
Reflector	36	24	0.060	21%
Specialty	35	26	0.150	19%
Overall	350	137	0.127	8%

Summer peak CFs are virtually the same between ComEd and AIC (0.120 vs. 0.128), while winter peak CFs are lower for ComEd (0.123 vs. 0.148). Table 14 summarizes winter and summer peak CFs by utility.

Table 15. Summer and Winter Peak CF Estimates by Utility

Bulb Type	# of Loggers	# of Homes	Result	Relative Precision
Summer Peak CF				
ComEd	200	70	0.120	14%
AIC	150	67	0.128	15%
Overall	350	137	0.122	11%
Winter Peak CF				
ComEd	200	70	0.123	11%
AIC	150	67	0.148	11%
Overall	350	137	0.127	8%

Table 15 compared summer peak CFs to the values recommended in IL-TRM V5.0. As can be seen in the table, this study resulted in higher CF values across all product types. IL-TRM V5.0 does not provide winter peak CFs, therefore we are unable to draw comparisons.

Table 16. Comparison of Summer Peak CF Estimates to IL-TRM V5.0

Bulb Type	Summer Peak CF	
	This Study	IL-TRM V5.0
Standard	0.13	0.07[a]
Reflector	0.11	0.09[b]
Specialty	0.12	0.08[c]

[a]CF for interior single family or unknown location or multifamily in unit
[b]CF for interior reflectors
[c]CF for specialty generic light bulbs

Appendix A. Consumer Preferences Study Design

Standard Design

Design Summary

- 60 wattage assumption
- 4 options + "none" per choice set
- 12 total choice sets (including two fixed for quality assurance)

Table 17. Standard Design Attributes and Possible Values

Attributes	Levels	
Price	$0.60, $2.90, $5.20, $7.50, $9.80	None
Technology	Incandescent, CFL, or LED	
Bulb life	1, 3, 5, 10, 15, or 25 years	
Annual energy cost	$1.00, $1.75, $5.25, $7.25	
Light color	Warm/Soft, Cool/Bright, or Natural/Daylight	
ENERGY STAR rating	"ENERGY STAR rated" (LEDs only) or "Not ENERGY STAR rated"	

Survey Introduction

We'd like you to imagine that you need to purchase a standard light bulb for a frequently used light fixture. The fixture may look something like this.

For the next series of questions, we will show you 4 light bulb options on each page and ask you to choose which you would purchase. If you would not purchase any of the four, please select "none".

Each set of choices will look something like this:

Price	$5.20	$0.60	$2.90	$7.50	NONE
Bulb Type	Incandescent	LED	Incandescent	CFL	I would not choose any of these options
Bulb Life	10 years	3 years	5 years	25 years	
Yearly Energy Cost	$7.25	$1.00	$5.00	$1.75	
Light Color	Cool/Bright White	Cool/Bright White	Warm/Soft White	Natural/ Daylight	
ENERGY STAR Rating	Not ENERGY STAR rated	ENERGY STAR rated	Not ENERGY STAR rated	Not ENERGY STAR rated	

Assume that all bulbs shown are standard, screw-in, 60-watt equivalent bulbs. We will ask you to make 12 separate purchase decisions.

When making your selections, please:

- Do not compare products between screens. Only choose between products shown on the same screen.
- If you would not realistically purchase any of the products shown, select “NONE”.
- Respond as though you are spending your own money, even though no real money is involved.
- Imagine that all products you see are available for purchase, even though some options may be unrealistic.

Finally, remember, there are no right or wrong answers. We are looking to best understand how **you** purchase light bulbs.

Reflector Design

Design Summary

- 65 wattage assumption
- 4 options + "none" per choice set
- 12 total choice sets (including two fixed for quality assurance)

Table 18. Reflector Design Attributes and Possible Values

<table>
<tr><th>Attributes</th><th colspan="2">Levels</th></tr>
<tr><td>Price</td><td>$2.00, $6.00, $10.00, $14.00, or $18.00</td><td rowspan="6">None</td></tr>
<tr><td>Technology</td><td>Incandescent, CFL, or LED</td></tr>
<tr><td>Bulb life</td><td>1, 3, 5, 10, 15, or 25 years</td></tr>
<tr><td>Annual energy cost</td><td>$1.25, $2.00, $5.25, $7.75</td></tr>
<tr><td>Light color</td><td>Warm/Soft, Cool/Bright, or Natural/Daylight</td></tr>
<tr><td>ENERGY STAR rating</td><td>"ENERGY STAR rated" (LEDs only) or "Not ENERGY STAR rated"</td></tr>
</table>

Survey Introduction

We'd like you to imagine that you need to purchase a standard light bulb for a frequently used light fixture. The fixture may look something like this.

For the next series of questions, we will show you 4 light bulb options on each page and ask you to choose which you would purchase. If you would not purchase any of the four, please select "none".

Each set of choices will look something like this:

Price	$2.90	$0.60	$9.80	$7.50	NONE: I wouldn't choose any of these.
Bulb Type	LED	CFL	CFL	Incandescent	
Bulb Life	25 years	1 year	3 years	15 years	
Yearly Energy Cost	$7.25	$5.00	$1.75	$1.00	
Light Color	Cool/Bright White	Warm/Soft White	Warm/Soft White	Natural/ Daylight	
ENERGY STAR Rating	ENERGY STAR rated	Not ENERGY STAR rated	Not ENERGY STAR rated	Not ENERGY STAR rated	
	○	○	○	○	○

Assume that all bulbs shown are reflector, screw-in, 65-watt equivalent bulbs. We will ask you to make 12 separate purchase decisions.

When making your selections, please:

- Do not compare products between screens. Only choose between products shown on the same screen.
- If you would not realistically purchase any of the products shown, select "NONE".
- Respond as though you are spending your own money, even though no real money is involved.
- Imagine that all products you see are available for purchase, even though some options may be unrealistic.

Finally, remember, there are no right or wrong answers. We are looking to best understand how **you** purchase light bulbs.

Appendix B. Data Collection Instruments

In-Home Study
Recruiter Instrumen

In-Home Study
Deployment Instrum

In-Home Study
Retrieval Instrument

Consumer
Preferences Survey I

Appendix C. Detailed Lighting Logger Study Methodology

Logger Data Preparation and Cleaning

As part of the LED Hours of Use metering study, we deployed a total of 415 loggers across 152 homes. We were unable to retrieve a total of 43 loggers. One logger was mistakenly placed on a switch with no LEDs. Four additional loggers were missing deployment detail. We dropped all of those loggers from the analysis.

To prepare the logger data for analysis, we performed a series of data-cleaning steps to ensure that only loggers with proper and reasonable data are included in our analysis. Those steps included:

- **Identification and removal of corrupted/failed loggers:** Initial review of the logger files identified loggers that were corrupted or failed to log the data properly. Corrupted/failed loggers consisted of those that: (1) did not contain any logs falling within the valid logging time frame (indicative of issues with logger clock calibration); (2) did not collect any data (indicative of the loggers not working properly); (3) contained logged data in stark contrast to self-reported socket usage (namely, loggers with no "on" time or very sporadically low "on" periods, while the homeowner reported the fixtures being always on or on most of the time). We identified six loggers that were corrupted/failed and therefore needed to be removed from further analysis.

- **Logger date "trimming":** This step was necessary to ensure that extraneous observations (i.e., logs) associated with logger placement, testing, and calibration were not a part of the analysis. Logger data were "trimmed" to remove all logs recorded "on" before the logger installation date, as well as on or after the logger retrieval day. To determine and validate deployment and retrieval dates, we used data recorded by the field staff as part of the deployment and retrieval process. For each logger, we trimmed the start date to be the first full day of logging and the end date to be the last full day of logging. For loggers received in the mail and therefore missing a clear indicator of the logging end period,[13] we carefully reviewed each individual logger's log patterns to determine an appropriate end date. Comparing the selected end date to the ship date of the package validated this assumption. We did not drop any loggers as a result of this step.

- **Identification of loggers with short logging periods**: Once "trimmed," we calculated logging periods for each logger. Some loggers may have failed or been removed by the residents during the early part of the logging period and therefore only contained logging data for a small fraction of the period. To increase the reliability of the HOU estimates, loggers logging for less than one month were excluded from the analysis. We identified five loggers with a short logging period that needed to be removed from the analysis.

- **Analysis of unexpected/suspicious usage patterns:** To ensure proper operation of the loggers throughout the logging period, we performed an extensive analysis of logger usage patterns and flagged loggers with unusual or unexpected patterns for further review and validation. We explored a variety of patterns, including long "on" periods, long "off" periods and usage gaps, no "on" periods, and high variance in usage and usage changes over time. We did not drop any loggers as a result of this step.

[13] Those loggers were removed and mailed to us by residents; thus, the retrieval process did not follow standard retrieval procedures.

- **Analysis of logger flickering:** We thoroughly explored logger flickering and its impact on the HOU estimates. Logger flickering is caused by an external stimulus, such as sunlight or moisture interference. Flickering commonly manifests itself in short "flicks" or "on" and "off" periods. Flickering is generally difficult to identify and correct for because it is hard to determine whether the short-interval "on/off" periods are false positives or false negatives. We explored the impact logger flickering could have on average daily HOU by calculating, for each logger, the total number of logs that each logger recorded and normalizing the total number of logs to the days that the logger was in the field, thus arriving at an average number of logs per day. A high count of logs per day is usually indicative of loggers flickering. We then estimated the impact that potential logger flickering could have on the HOU estimates by summing for each logger every 1–10 second "on/off" period[14] and dividing them by the total number of days that the logger was deployed. The resulting number presents an upper bound of the impact that flickering has on the HOU estimates. The results of the analysis revealed that the impacts of the flickering issue on the estimation of the average daily HOU are negligible. As such, we did not make any adjustments to the logger data.

During the logger data cleaning process, we paid special attention to the loggers placed on exterior fixtures. Logging exterior lighting usage is particularly challenging for the following reasons:

- **Difficulty of logger placement:** the nature of the lighting fixtures and their positioning makes it more challenging to place the loggers, thus leading to exclusion of certain fixtures and the resulting biases in the HOU.

- **Exposure to daylight:** by the virtue of being outside, loggers placed on exterior fixtures have more exposure to daylight and may mistake daylight for the light being on, thus leading to higher than actual HOU. Even the most careful logger calibration and placement often does not mitigate the erroneous logging of daylight.

- **Exposure to the elements:** loggers placed outside are exposed to temperature fluctuations (subzero temperatures in the winter and hot days in the summer) and inclement weather conditions (rain, snow, wind, etc.) and are therefore prone to premature failure and data corruption.

As part of this study, we placed a total of six loggers on exterior fixtures. We conducted a careful analysis of those loggers' log patterns. Our analysis pointed to possible daylight exposure and presence of corrupted data. As the result of the analysis, we decided to exclude exterior loggers from the estimation of the HOU and CFs.

In the end, we used 350 of the 415 deployed loggers for analysis (84%). This is a typical logger attrition rate for a study of this duration. Table 18 provides a summary of logger attrition.

Table 19. Logger Attrition Summary

Cut or Drop Decision	Loggers Affected		Sites Affected	
	#	%	#	%
Total deployed	415	100%	152	100%
Unusable loggers	**65**	**16%**	**31**	**20%**
Unable to retrieve	43	10%	17	11%

[14] 1–10 second "on" and "off" periods were determined as the most common "flicker" periods. This is a very conservative range because the 10-second "on/off" pattern is a very conceivable usage pattern for people to exhibit.

Cut or Drop Decision	Loggers Affected		Sites Affected	
	#	%	#	%
Missing deployment data	4	1%	3	2%
Corrupted/failed loggers	6	1%	4	3%
Short logging period	5	1%	4	3%
Logged Incandescent	1	<1%	1	1%
Exterior Loggers	6	1%	6	4%
Total used in analysis	**350**	**84%**	**137**	**90%**

Hours of Use Annualization Process

It is well-known that the number of daylight hours affect hours of lighting use. Lighting logger studies that do not log usage during the entire year must annualize their results so they apply to the entire year and not simply the logged period. While this study did not cover the whole year, loggers were in place for most of the year, capturing data on usage during the spring, summer, and part of the fall. A fielding period of this length is likely to result in observed HOU estimates that are similar to annual values for a large share of loggers. Using observed estimates is preferable for those loggers given the modeling uncertainty that the annualization process might introduce. By reviewing the annualization modeling results, we can determine the loggers for which it is appropriate to use observed values and the loggers for which it is better to use the modeled values.

We annualized the lighting usage data using an individual ordinary least squares (OLS) regression model. The model specification is provided in the equation below.

Equation 1. Hours of Use Model Specification

$$Hd = \alpha + \beta sin(\theta d) + \varepsilon d$$

Where:

Hd = HOU on day d, starting with d=1 on January 1.

α = The intercept representing HOU when sin(θd)=0. Since average sin(θd) for the year is equal to zero by design, evaluating the model at the average declination angle leaves only the constant to estimate HOU; therefore, the intercept term is equal to average annualized HOU for each bulb.

β = Sine coefficient, or the difference between the HOU on the solstice and days with the average annual declination angle.

$Sin(\theta d)$ = Sine of the solar declination angle or day d converted to follow the change in the HOU and adjusted to fit the −1 to +1 interval with an average of zero for the year (for ease of analysis). The solar declination angle represents the latitude at which the sun is directly overhead at midday. We used the following formula to calculate the sine of the solar declination angle for each day of the year:

$$\sin(-\pi*2*(284+d)/365)$$

εd = Residual error

We fit sinusoid regression models separately for weekends and weekdays for each individual logger and then combined the results in proportion to the percent of weekends versus weekdays in a year. We analyzed each regression model for goodness of fit to determine if the individual bulb was sufficiently daylight-sensitive to justify regression-based annualization and to determine if the sinusoid model could provide a reliable estimate (i.e., the sinusoid model accurately represented trends in lighting use over time). Specifically, we looked at:

- **Significance of the sine coefficient t-statistic.** Loggers with a t-statistic lower than 1.282 or higher than −1.282 were flagged as "poor fit" (meaning that the solar declination angle is not significantly different from 0 at a 90% confidence level).
- **Magnitude of the sine coefficient.** Models that resulted in extremely high sine coefficients (absolute magnitude of five or more) were flagged as "poor fit."[15]
- **The value of the intercept.** Models with the negative intercept were flagged as "poor fit."
- **The direction of the coefficient.** Models with a negative regression coefficient (indicating positive relationship with daylight hours) were flagged as "poor fit." This accounts for the regression model predicting increased HOU as the daylight hours increase.

If any of the parameters described above were true, we replaced the modeled HOU with non-annualized observed daily average HOU. As part of this exercise, we replaced most of the modeled results (71%) with observed HOU estimates. This is not unusual given the duration of the metering effort.

Coincidence Factor Estimation

CFs represent the fraction of time during the peak period that the light is on. We used the following definitions of peak periods in the CF calculations:

- **Summer peak period:** non-holiday weekday, between June 1 and August 31, between the hours of 1pm and 5pm Central Time
- **Winter peak period:** non-holiday weekday, between January 1 and February 28, between the hours of 6am and 8am, and 5pm and 7pm Central Time

Loggers were in the field for most of the summer and winter seasons, thus covering both summer and winter peak periods and minimizing the need for annualization.

Summer Peak Coincidence Factor Estimation

Of the 350 loggers used in the analysis, only 12 logged lighting usage for less than a month of the summer peak period, while the remaining 338 logged two months or more (two-thirds or more). For the 12 loggers that logged lighting usage for less than a month of the summer peak period, we annualized usage during the peak hours of the day using the same regression model specification as for the HOU and performed a similar goodness of fit assessment. The models for all 12 loggers were a poor fit. For those loggers, we estimated lighting usage during peak hours based on the observed lighting usage for the entire logged period as opposed to just the summer period. We calculated the summer peak CF by summing, for each logger, the time the light was on during the summer peak hours and dividing the result by the number of hours within the peak period.

[15] In many of those cases, use changed dramatically during different periods of the study and it was not possible to determine typical use. For example, lights may have stayed continuously on for a portion of the study and then were used intermittently.

Winter Peak Coincidence Factor Estimation

Of the 350 loggers used in the analysis, only six logged lighting usage for less than a month of the winter peak period. The remaining 344 logged more than a month, of which half logged lighting usage for the entire duration of the winter peak period. For the six loggers that logged lighting usage for less than a month of the winter peak period, we annualized usage during the peak hours of the day using the same regression model specification as for the HOU and performed a similar goodness of fit assessment. We used modeled results for one of the six loggers. The modeled results for the remaining five loggers were a poor fit. For those loggers, we estimated lighting usage during peak hours based on the observed lighting usage for the entire logged period as opposed to just the winter period.

APPENDIX B. ComEd PY9 Residential Lighting Discounts Program Impact Evaluation Report 2018-05-08 Final

ComEd Residential Lighting Discounts Impact Evaluation Report

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

Presented to
ComEd

FINAL

May 8, 2018

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NAVIGANT

ComEd Residential Lighting Discounts Impact Evaluation Report

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1. Introduction

This report presents the results of the impact evaluation of ComEd's PY9 Residential Lighting Discounts Program. It presents a summary of the energy and demand impacts for the total program and broken out by relevant measure and program structure details. PY9 covers June 1, 2016 through December 31, 2017.

2. Program Description

The primary goal of this program is to increase the market penetration of energy-efficient lighting within ComEd's service territory by providing incentives for bulbs purchased through various retail channels. The program also seeks to increase customer awareness and acceptance of energy-efficient lighting technologies through the distribution of educational materials. In PY9, the Residential Lighting Discounts Program offered incentives for the purchase of standard compact fluorescent lamps (CFLs), standard, reflector and specialty LEDs, and LED fixtures.

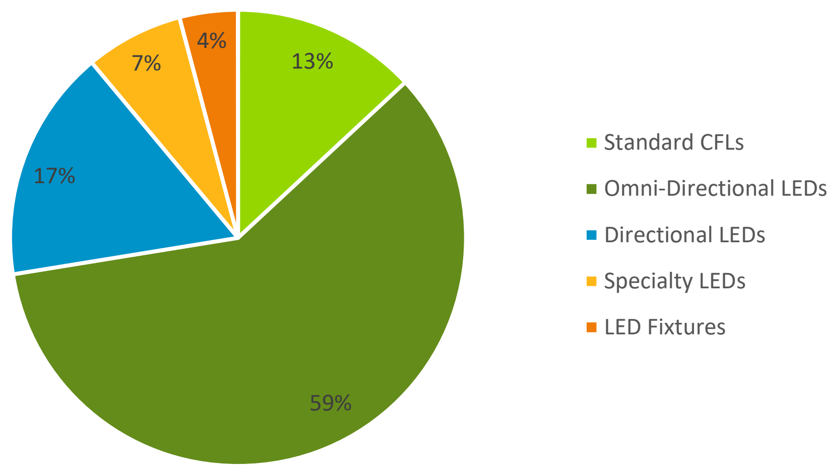
The PY9 program incentivized just over 20 million high efficiency lamps and fixtures. This included 2,625,479 standard CFLs, 11,905,275 omni-directional LEDs, 3,309,608 directional LEDs, 1,388,782 specialty LEDs, and 831,268 LED fixtures as shown in the following table and figure. While not all these bulbs were installed in PY9 (the TRM deems installation rates for years one, two and three), the overall quantity of bulbs installed in PY9 (20,901,070) exceeded the number of bulbs sold in PY9 due to the addition of carryover installations from bulbs sold in PY7 and PY8. The table below also provides the known volume of carryover bulbs that will be installed in CY2018 from program sales in PY8 and PY9 and the carryover in CY2019 from PY9 sales. Estimates of CY2018 carryover savings are provided in Section 7.3.

Table 2-1. PY9 Volumetric Findings Detail

Participation	Total	Standard CFLs	Omni-Directional LEDs	Directional LEDs	Specialty LEDs	LED Fixtures
PY9 Incentivized Bulbs	20,060,412	2,625,479	11,905,275	3,309,608	1,388,782	831,268
PY9 1st Year Installed Bulbs	18,527,719	1,919,750	11,313,345	3,145,054	1,319,732	829,838
PY7 Carryover – PY9 Installs	1,317,793	1,298,595*	13,208	5,990	0	0
PY8 Carryover – PY9 Installs	1,055,558	968,728	61,792	25,038	†	0
Total Installed Bulbs in PY9	20,901,070	4,187,073	11,388,345	3,176,082	1,319,732	829,838
PY8 Carryover - CY2018 Installs	899,919	824,039	54,000	21,881	†	0
PY9 Carryover - CY2018 Installs	616,370	352,969	188,580	52,424	21,998	399
PY9 Carryover - CY2019 Installs	531,074	300,250	165,245	45,937	19,276	366

*PY7 carryover - The standard CFL quantity includes specialty CFLs sold in PY7.
† PY8 carryover – The directional LED category includes specialty LEDs sold in PY8 as they were not broken out in previous years.
Source: ComEd tracking data and Navigant team analysis.

Figure 2-1. Distribution of PY9 Measures Sold by Type*



* Excluding PY9 carryover
Source: Evaluation Analysis

3. Program Savings

Table 3-1 summarizes the incremental energy and demand savings the Residential Lighting Discounts Program achieved in PY9.

Table 3-1. PY9 Total Annual Incremental Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings	832,334,739	NR	NR
Program Gross Realization Rate†	98.6%	N/A	N/A
Verified Gross Savings	821,034,429	788,919	96,222
Program Net-to-Gross Ratio (NTGR)	Varies	Varies	Varies
Verified Net Savings	489,975,212	470,557	57,469

† The gross realization rate for bulbs sold and installed in PY9 (excluding PY9 carryover) is 99.5%.
Source: ComEd tracking data and Navigant team analysis.

Table 3-2. PY9 Total Annual Incremental EEPS Savings[1]

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings	48,888,400	NR	NR
Program Gross Realization Rate	85%	N/A	N/A
Verified Gross Savings	41,574,846	42,420	4,624
Program Net-to-Gross Ratio (NTGR)	Varies	Varies	Varies
Verified Net Savings	26,095,320	26,651	2,900

Source: ComEd tracking data and Navigant team analysis.

Table 3-3. PY9 Total Annual Incremental IPA Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings	783,446,339	NR	NR
Program Gross Realization Rate	99%	N/A	N/A
Verified Gross Savings	779,459,583	746,499	91,598
Program Net-to-Gross Ratio (NTGR)	Varies	Varies	Varies
Verified Net Savings	463,879,892	443,906	54,569

Source: ComEd tracking data and Navigant team analysis.

Table 3-4. PY9 Total Annual Incremental Savings Excluding Carryover

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Peak Demand Savings (kW)
Ex Ante Gross Savings	749,049,139	NR	NR
Program Gross Realization Rate	99.5%	N/A	N/A
Verified Gross Savings	745,030,467	713,031	87,584
Program Net-to-Gross Ratio (NTGR)	Varies	Varies	Varies
Verified Net Savings	443,104,671	423,710	52,147

Source: ComEd tracking data and Navigant team analysis.

[1] All EEPS savings in PY9 are the result of 3rd year carryover savings from bulbs sold through the program in PY7. The Program Gross Realization Rate for EEPS is 85% due to an error in estimating the preliminary EEPS savings in the PY8 report. This preliminary carryover estimate from the PY8 report was used by ComEd as their ex ante EEPS savings value. Deemed NTG values vary by measure type.

Table 3-5. PY9 Total Annual Incremental Savings, Carryover Broken Out

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Summer Peak Demand Savings (kW)	Winter Peak Demand Savings (kW)
Ex Ante Gross Savings w/ ISR and WHF	749,049,139	NR	NR	NR
Ex Ante Gross Carryover - PY7 EEPS	48,888,400	NR	NR	NR
Ex Ante Gross Carryover - PY8 IPA	34,397,200	NR	NR	NR
Ex Ante Total Gross	832,334,739	NR	NR	NR
Program Gross Realization Rate	98.6%	NR	NR	NR
Verified Gross Program Savings - PY9 Sales	745,030,467	713,031	87,584	115,332
Verified Gross Carryover Savings - PY7 EEPS	41,574,846	42,420	4,624	5,338
Verified Gross Carryover Savings - PY8 IPA	34,429,116	33,468	4,014	4,422
Verified Gross Savings - Total	821,034,429	788,919	96,222	125,092
Program Net-to-Gross Ratio (NTGR)	Varies	Varies	Varies	Varies
Verified Net Program Savings - PY9 Sales	443,104,671	423,710	52,147	68,666
Verified Net Carryover Savings - PY7 EEPS	26,095,320	26,651	2,900	3,351
Verified Net Carryover Savings - PY8 IPA	20,775,221	20,196	2,422	2,670
Verified Net Savings - Total	489,975,212	470,557	57,469	74,687

Source: ComEd tracking data and Navigant team analysis.

4. Program Savings by Measure

The program includes five lighting measures as shown in the following table. The standard LED and directional LED measures contributed the most savings. This table also shows carryover savings resulting from bulbs purchased in PY7 and PY8 but installed in PY9.

Table 4-1. PY9 Energy Savings by Measure

End Use Type	Research Category	Ex Ante Gross Savings (kWh)*	Verified Gross Realization Rate*	Verified Gross Savings (kWh)	NTGR**	Verified Net Savings (kWh)	Technical Measure Life	Persistence	EUL†
Lighting	Standard CFL (Res)	60,151,637	98%	50,089,293	0.57	28,550,897	N/A	N/A	4
Lighting	Standard CFL (Non-Res)			8,901,999	0.57	5,074,139	N/A	N/A	3
Lighting	Standard LED (Res)	405,204,405	99%	340,443,332	0.58	197,457,132	N/A	N/A	10
Lighting	Standard LED (Non-Res)			62,662,380	0.58	36,344,180	N/A	N/A	5
Lighting	Directional LED (Res)	176,419,238	101%	151,238,548	0.60	90,743,129	N/A	N/A	10
Lighting	Directional LED (Non-Res)			26,462,463	0.60	15,877,478	N/A	N/A	7
Lighting	Specialty LED (Res)	59,924,908	100%	51,707,066	0.60	31,024,239	N/A	N/A	10
Lighting	Specialty LED (Non-Res)			8,000,431	0.60	4,800,259	N/A	N/A	6
Lighting	LED Fixtures (Res)	47,348,951	96%	39,518,520	0.73	28,848,520	N/A	N/A	10
Lighting	LED Fixtures (Non-Res)			6,006,436	0.73	4,384,698	N/A	N/A	14
Lighting	Carryover (Res)	83,285,600	91%	65,930,878	0.62	40,731,132	N/A	N/A	4
Lighting	Carryover (Non-Res)			10,073,084	0.61	6,139,409	N/A	N/A	3
Lighting	Total (Residential)	832,334,739	99%	698,927,636	0.60	417,355,049	N/A	N/A	N/A
Lighting	Total (Non-Residential)			122,106,793		72,620,163	N/A	N/A	N/A

* Residential and non-residential values are combined. Tracking data does not contain separate residential and non-residential savings.
** A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† EUL is a combination of technical measure life and persistence.
Source: ComEd tracking data and Navigant team analysis.

Table 4-2. PY9 Demand Savings by Measure

End Use Type	Research Category	Ex Ante Gross Demand Reduction (kW)	Verified Gross Realization Rate	Verified Gross Demand Reduction (kW)	NTGR*	Verified Net Demand Reduction (kW)
Lighting	Standard CFL	NR†	N/A	58,051	0.57	33,089
Lighting	Standard LED	NR	N/A	395,105	0.58	229,161
Lighting	Directional LED	NR	N/A	166,854	0.60	100,112
Lighting	Specialty LED	NR	N/A	50,445	0.60	30,267
Lighting	LED Fixtures	NR	N/A	42,576	0.73	31,081
Lighting	Carryover	NR	N/A	75,888	0.62	46,847
	Total	NR	N/A	788,919		470,557

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† NR = "Not Reported", as only ex ante savings are reported in the Lighting Discounts tracking data.
Source: ComEd tracking data and Navigant team analysis.

Table 4-3. PY9 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)	NTGR*	Verified Peak Net Demand Reduction (kW)
Lighting	Standard CFL	NR†	N/A	6,180	0.57	3,523
Lighting	Standard LED	NR	N/A	46,647	0.58	27,055
Lighting	Directional LED	NR	N/A	22,010	0.60	13,206
Lighting	Specialty LED	NR	N/A	7,245	0.60	4,347
Lighting	LED Fixtures	NR	N/A	5,501	0.73	4,016
Lighting	Carryover	NR	N/A	8,638	0.62	5,321
	Total	NR	N/A	96,222		57,469

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† NR = "Not Reported", as only ex ante savings are reported in the Lighting Discounts tracking data.
Source: ComEd tracking data and Navigant team analysis.

Table 4-4. PY9 Winter 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)	NTGR*	Verified Peak Net Demand Reduction (kW)
Lighting	Standard CFL	NR†	N/A	8,875	0.57	5,059
Lighting	Standard LED	NR	N/A	60,729	0.58	35,223
Lighting	Directional LED	NR	N/A	28,846	0.60	17,307
Lighting	Specialty LED	NR	N/A	9,596	0.60	5,758
Lighting	LED Fixtures	NR	N/A	7,286	0.73	5,319
Lighting	Carryover	NR	N/A	9,760	0.62	6,021
	Total	NR	N/A	125,092		74,687

* A deemed value. Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, which is to be found on the IL SAG web site here: http://ilsag.info/net-to-gross-framework.html.
† NR = "Not Reported", as only ex ante savings are reported in the Lighting Discounts tracking data.
Source: ComEd tracking data and Navigant team analysis.

5. Impact Analysis Findings and Recommendations

5.1 Impact Parameter Estimates

Energy and demand savings are estimated using the following formula as specified in the TRM:

Verified Gross Annual ∆kWh = Delta Watts/1000 * ISR * (1-Leakage) * HOU * IEe
Verified Gross Annual ∆kW = Delta Watts/1000 * ISR * (1-Leakage)
Verified Gross Annual Summer Peak ∆kW = Gross Annual ∆kW * Summer Peak CF * IEd
Verified Gross Annual Winter Peak ∆kW = Gross Annual ∆kW * Winter Peak CF * IEd

Where:

- Delta Watts = Difference between Baseline Wattage (incandescent wattage) and CFL Wattage
- HOU = Annual Hours of Use
- IEe = Energy Interactive Effects
- Leakage = % of Program Bulbs installed outside of ComEd Service Territory
- Summer Peak CF = Peak load coincidence factor, the percentage of Program Bulbs turned on during summer peak hours (weekdays from 1 to 5 p.m.)
- Winter Peak CF = Peak load coincidence factor, the percentage of Program Bulbs turned on during the PJM Winter Peak hours[2]
- IEd = Demand Interactive Effects (applied to summer Peak kW estimates only[3])

. The source of the verified first-year gross and net savings parameters are shown in the table below. The sources of the parameters used to calculate 2nd and 3rd year carryover are presented in the carryover section (Section 7.3).

[2] The Winter Peak Period is defined by PJM as the period from 6-8 am and 5-7 pm, Central Time Zone, between January 1 and February 28.
[3] Summer interactive effects represent the increased energy savings due to the cooler operating temperatures at which CFLs and LEDs operate and thus a reduction in cooling electric loads. In the winter the cooler operating temperature of efficient bulbs results in an increase in gas heating loads (often referred to as “heating penalties”). Since ComEd is an electric utility these heating penalties have not included in the winter peak kW savings estimates.

Table 5-1. Verified First-year Gross and Net Savings Parameter Source

Verified Savings Parameters	Deemed* or Evaluated?
Program Bulbs	Evaluated
Delta Watts	Deemed
Installation Rate	Deemed
Leakage	Evaluated
Res / Non-Res Split	Deemed
Hours of Use (HOU)	Deemed
Summer Peak Coincidence Factor (CF)	Deemed
Winter Peak Coincidence Factor (CF)	Evaluated
Energy Interactive Effects	Deemed
Demand Interactive Effects	Deemed
NTGR†	Deemed

* State of Illinois Technical Reference Manual version 5.0 from http://www.ilsag.info/technical-reference-manual.html.
† NTGR Source: ComEd_NTG_History_and_PY9_Recommendations_2016-02-26_Final.xlsx, found on the IL SAG web site.

The evaluation team determined the overall PY9 gross energy (kWh) realization rate of 98.6%. The small difference between the ex ante claimed savings and the verified savings resulted from a few minor discrepancies between the ex ante parameters that were applied and the parameters the evaluation team believes should have been applied in accordance with the IL TRM v5 (these discrepancies are listed in Table 7-2 below) and an error in the preliminary estimate of PY9 carryover savings (from lamps purchased in PY7, 3rd year carryover) that was estimated in PY8 . As the 98.6% realization rate indicates, the magnitude of these discrepancies was extremely small (less than one percent).

5.2 Other Impact Findings and Recommendations

The evaluation research findings and recommendations (based on the PY9 primary data collection activities) are provided in separate memos.

6. Appendix 1. Impact Analysis Methodology

6.1 Verified Gross Program Savings Analysis Approach Estimates

The evaluation team calculated verified savings by measure for measures with available data. For PY9, the evaluation team calculated verified savings for standard CFLs, omni-directional LEDs, directional LEDs, specialty LEDs, and LED fixtures. The data used to estimate the verified gross program savings came from the PY9 program tracking data[4], the Illinois Statewide Technical Reference Manual for Energy Efficiency Version 5.0 (Illinois TRM v5), and PY9 in-store intercept surveys.

6.2 Verified Net Program Savings Analysis Approach

Verified net energy and demand (coincident peak and overall) savings were calculated by multiplying the verified gross savings estimates by a net-to-gross ratio (NTGR). For PY9, the NTGR estimates were 0.57 for standard CFLs, 0.58 for Standard LEDs, 0.60 for specialty and directional LEDs, and 0.73 for LED

[4] The Evaluation Team received the final PY9 tracking data on February 14, 2018: Res_Lighting_PY9_EOY_Evaluation_Data_Rev3_02142018.xlsx.

fixtures. These NTGR estimates were based on past evaluation research and approved through the Illinois Stakeholder Advisory Group (IL SAG) consensus process.

7. Appendix 2. Impact Analysis Detail

7.1 Program Volumetric Detail

During the PY9 Residential Lighting Discounts Program a total of 20,060,412 lamps and fixtures were sold through the program, which is a 55 percent increase from the bulbs and fixtures sold during the eighth program year (PY8). It is important to note that PY9 was a 19-month program year and with normalization, the total sales in PY9 actually fell by two percent. In PY9, the shift in sales to LEDs from CFLs was completed, with CFLs being discontinued from the program in March of 2017. A comparison of the PY9 12-month "normalized" sales numbers to the PY8 sales numbers yields the following:

- 13% of the measures sold in PY9 were standard CFLs compared to 56% in PY8
- 59% of the measures sold in PY9 were omni-directional LEDs compared to 30% in PY8
- 23% of the measures sold in PY9 were directional/specialty LEDs compared to 12% in PY8
- 4% of the measures sold in PY9 were LED fixtures compared to 2% in PY8.

Table 7-1 shows the volume of bulbs, by bulb type, incentivized through the Residential Lighting Discounts program in PY3 through PY9 (non-normalized).

Table 7-1. PY3 – PY9 Volumetric Findings Detail[5]

Program Year	Standard CFLs	Specialty CFLs	CFL Fixtures	LED Omni-Dir	LED Dir	LED Specialty	LED Fixtures	Coupons	Total
PY9 Sales	2,625,479	0	0	11,905,275	3,309,608	1,388,782	831,268	0	20,060,412
PY8 Sales	7,205,656	0	0	3,896,077	1,578,687	*	302,241	0	12,982,661
PY7 Sales	10,347,580	989,999	0	471,710	427,824	*	0	0	12,237,113
PY6 Sales	8,965,546	2,125,179	0	0	0		0	0	11,090,725
PY5 Sales	9,633,227	1,197,896	8,767	9,472	18,758		24,268	5,506	10,897,894
PY4 Sales	11,419,752	1,097,670	84,539	2,592	22,327		16,551	5,599	12,649,030
PY3 Sales	9,893,196	1,217,723	86,943	0	0		0	0	11,197,862

Prior to PY9 LED specialty bulbs were included in the LED Directional category.
Source: ComEd tracking data and Navigant team analysis.

7.2 Differences in Evaluation Methods

7.2.1 Differences in Parameter Values

Differences between the PY9 ex ante and verified gross savings parameters are shown in the following table. It is these differences, along with the application of the residential and nonresidential split described in the section below that led to RR that were slightly less than 100%.

[5] PY9 consists of a 19-month program year, all prior program years consisted of 12 months.

Table 7-2. PY9 Ex-Ante vs Verified Parameter Values When Different

Gross Impact Parameters	Measure	PY9 Ex Ante	PY9 Verified
Leakage	All Measures	NR	2.2%
Interactive Effects (IE)	Energy –Exterior Fixtures	1.06	1
	Demand - Exterior Fixtures	1.12	1
Summer Peak Coincidence Factor (Summer Peak CF)[6]	Res Standard CFLs	NR	0.071
	Res Omni-Directional LEDs	NR	0.081
	Res Directional LEDs - Reflector	NR	0.094
	Res Directional LEDs - Globe	NR	0.075
	Res Directional LEDs - Decorative	NR	0.121
	Res LED Interior Fixtures	NR	0.091
	Res LED Exterior Fixtures	NR	0.273
	Non-Res All Measures – Excluding Exterior Fixtures	NR	0.58
	Non-Res Exterior Fixtures	NR	0
Winter Peak Coincidence Factor (Winter Peak CF)[7]	Res Standard CFLs	NR	0.116
	Res Omni-Directional LEDs	NR	0.116
	Res Directional LEDs - Reflector	NR	0.134
	Res Directional LEDs - Globe	NR	0.107
	Res Directional LEDs - Decorative	NR	0.173
	Res LED Fixtures – Interior and Exterior	NR	0.134
	Non-Res All Measures – Excluding Exterior Fixtures	NR	0.55
	Non-Res Exterior Fixtures	NR	0

NR = Not Reported

7.2.2 Application of Residential and Non-Residential splits

As part of calculating savings for the residential lighting program, four percent of lamps sold in the upstream program are assumed to be installed in non-residential locations. The ex ante parameter values included in the tracking data are blended values based on the 96%/4% split of program lamps in residential and non-residential spaces. The program implementer correctly applied unblended HOU values, however, incorrectly applied blended ISR and WHFe values when calculating ex ante savings. In the future, the evaluation team recommends exclusively using unblended values. It would also be helpful to have the tracking data include the residential and non-residential parameter values so that discrepancies can be more readily determined.

[6] The evaluation team recommends that ComEd use the Summer Peak Coincidence Factors in this table for Residential Lighting, dated 2/2/2015.
[7] The evaluation team recommends that ComEd use the Winter Peak Coincidence Factors in this table for Residential Lighting, dated 2/2/2015.

7.3 Carryover Savings Estimation

7.3.1 PY9 Carryover Savings

The evaluation team calculated the PY9 carryover estimate using the Illinois TRM (v4 and v5) and the PY7 and PY8 reports. The energy and demand savings from these PY7 and PY8 2nd and 3rd year installations are calculated based on the following parameters:

- Delta Watts – Verified savings estimate from the year of installation (source: Illinois TRM v5)
- Res/Non-Res Split - Evaluation research from the year of purchase (PY7 and PY8 Reports)
- HOU and Peak CF – Verified savings estimate from the year of installation (source: Illinois TRM v5)
- Energy and Demand IE – Verified savings estimate from the year of installation (source: Illinois TRM v5)
- Installation Rate - Verified savings estimate from the year of purchase (source: IL TRM v3 and Illinois TRM v4)
- NTGR – Evaluation research from the year of purchase (source: PY7 and PY8 Reports)

Table 7-3 shows that in PY9 a total of 2,373,351 bulbs (1,317,793 EEPS bulbs and 1,055,558 IPA bulbs) that were purchased during PY7 or PY8, are expected to be installed within ComEd's service territory. The table below provides both the gross and net energy and demand savings from these bulbs attributable to the EEPS and IPA portfolios. Combined across these two portfolios, the total net energy savings estimate is 46,870,541 kWh, 46,847 kW, 5,321 Summer Peak kW, and 6,021 Winter Peak kW which will be counted in PY9 as Residential Lighting Discounts Program carryover savings.

Table 7-3. PY9 Carryover Savings Estimates from PY7 and PY8 Bulb Sales

PY9 Carryover Savings	EEPS PY7 Bulbs	IPA PY8 Bulbs	Total PY9 Carryover
Carryover Bulbs Installed During PY9	1,317,793	1,055,558	2,373,351
Average Delta Watts	32.2	31.7	N/A
Average Daily Hours of Use	2.52	2.64	N/A
Summer Peak Load Coincidence Factor	0.095	0.102	N/A
Winter Peak Load Coincidence Factor	0.126	0.132	N/A
Installation Rate	10.8%	8.1%	N/A
Energy Interactive Effects	0.86	1.06	N/A
Demand Interactive Effects	1.15	1.12	N/A
Gross kWh Impact per unit	31.5	32.6	N/A
Gross kW Impact per unit	0.032	0.032	N/A
Carryover Gross Energy Savings (kWh)	41,574,846	34,429,116	76,003,962
Carryover Gross Demand Savings (kW)	42,420	33,468	75,888
Carryover Gross Summer Peak Demand Savings (kW)	4,624	4,014	8,638
Carryover Gross Winter Peak Demand Savings (kW)	5,338	4,422	9,760
Net-to-Gross Ratio	0.63	0.60	N/A
Carryover Net Energy Savings (kWh)	26,095,320	20,775,221	46,870,541
Carryover Net Demand Savings (kW)	26,651	20,196	46,847
Carryover Net Summer Peak Demand Savings (kW)	2,900	2,422	5,321
Carryover Net Winter Peak Demand Savings (kW)	3,351	2,670	6,021
EUL (Res/Nonres)	4/3	5/3	4/3

Source: Navigant team analysis

7.3.2 CY2018 Preliminary Carryover Savings

The evaluation team calculated a preliminary[8] CY2018 carryover estimate using the Illinois TRM (v5 and v6) and the PY8 and PY9 reports. The energy and demand savings from these PY8 and PY9 2nd and 3rd year installations are calculated based on the following parameters:

- Delta Watts – Verified savings estimate from the year of installation (source: Illinois TRM v6)
- Res/Non-Res Split - Verified savings from the year of purchase (source: Illinois TRM v4 and v5)
- HOU and Peak CF – Verified savings estimate from the year of installation (source: Illinois TRM v6)
- Energy and Demand IE – Verified savings estimate from the year of installation (source: Illinois TRM v6)
- Installation Rate - Verified savings estimate from the year of purchase (source: Illinois TRM v4 and v5)

[8] These are considered preliminary due to the fact that the PY9 NTGR is not final.

- NTGR – Evaluation research from the year of purchase (source: PY8 and PY9 Evaluation Research[9]) – this value is subject to change based upon the final evaluated NTGR from PY9.

Table 7-4 shows that in CY2018 a total of 1,516,638 bulbs that were purchased in PY8 or PY9 are expected to be installed within ComEd's service territory. The table below provides both the gross and net energy and demand savings from these bulbs attributable to the IPA portfolio. Combined across these two years of carryover, the **preliminary** total net energy savings estimate is expected to be around 30,164,792 kWh, 28,762 kW, 3,349 Summer Peak kW, and 3,832 Winter Peak kW which will be counted in CY2018 as Residential Lighting Discounts Program carryover savings.

Table 7-4. CY2018 Preliminary Carryover Savings Estimates from PY8 and PY9 Bulb Sales

Preliminary CY2018 Carryover Savings	IPA PY8 Bulbs	IPA PY9 Bulbs	Total CY2018 Carryover
Carryover Bulbs Installed During CY2018	899,919	616,719	1,516,638
Average Delta Watts	31.7	34.6	N/A
Average Daily Hours of Use	2.64	2.64	N/A
Summer Peak Load Coincidence Factor	0.102	0.097	N/A
Winter Peak Load Coincidence Factor	0.132	0.136	N/A
Energy Interactive Effects	1.06	1.06	N/A
Demand Interactive Effects	1.12	1.12	N/A
Gross kWh Impact per unit	32.6	34.9	N/A
Gross kW Impact per unit	0.032	0.035	N/A
Carryover Gross Energy Savings (kWh)	29,343,827	21,499,949	50,843,776
Carryover Gross Demand Savings (kW)	28,544	19,945	48,490
Carryover Gross Summer Peak Demand Savings (kW)	3,419	2,218	5,637
Carryover Gross Winter Peak Demand Savings (kW)	3,769	2,685	6,454
Net-to-Gross Ratio	0.60	0.58	N/A
Carryover Net Energy Savings (kWh)	17,715,190	12,449,602	30,164,792
Carryover Net Demand Savings (kW)	17,234	11,528	28,762
Carryover Net Summer Peak Demand Savings (kW)	2,064	1,285	3,349
Carryover Net Winter Peak Demand Savings (kW)	2,277	1,554	3,832
EUL (Res/NonRes)	4/3	6/4	5/4

Source: Navigant team analysis

7.3.3 CY2019 Preliminary Partial Carryover Savings from PY9

The evaluation team calculated a preliminary partial CY2019 carryover savings estimate based on the bulbs sold during PY9 (CY2018 sales are not known at this time of this report's development) that are estimated to be installed in CY2019. We are calling these preliminary as a number of the parameters used to estimate CY2019 carryover savings are based on deemed parameters from the year of install (Delta Watts, HOU and Peak CF, and Energy and Demand IE) which for CY2019 would be IL TRM v7. Since IL TRM v7 is not yet finalized, the evaluation team used v6 of the TRM to estimate the Delta Watts, IE, HOU and Peak CF estimates. Hence the **preliminary** parameters for the partial CY2019 carryover savings are taken from:

[9] PY9 NTG has not been finalized at this time of this report's development.

- Delta Watts – Verified savings estimate from the year of installation (source: Illinois TRM v6[10]) – this value is subject to change and will ultimately use the values from Illinois TRM v7.
- Res/Non-Res Split - Verified savings from the year of purchase (source: Illinois TRM v5) – this value is not subject to change.
- HOU and Peak CF – Verified savings estimate from the year of installation (source: Illinois TRM v6) – this value is subject to change and will ultimately use the values from Illinois TRM v7.
- Energy and Demand IE – Verified savings estimate from the year of installation (source: Illinois TRM v6) – this value is subject to change and will ultimately use the values from Illinois TRM v7.
- Installation Rate - Verified savings estimate from the year of purchase (source: Illinois TRM v5) – this value is not subject to change.
- NTGR – Evaluation research from the year of purchase (source: PY9 Eval Research[11]) – this value is subject to change based upon the final evaluated NTGR from PY9.

Table 7-5 shows that in CY2019 a total of 530,726 bulbs that were purchased in PY9 are expected to be installed within ComEd's service territory. The table below provides both the gross and net energy and demand savings from these bulbs attributable to the IPA portfolio. The total preliminary net energy savings estimate from these PY9 bulbs is 10,710,902 kWh, 10,639 kWh, 1,215 Summer Peak kW, and 1,451 Winter Peak kW which will be counted in CY2019 as one piece of the Residential Lighting Discounts Program carryover savings.

[10] Since the IL TRM v7 is not yet finalized v6 was used as a proxy. It is for this reason these CY2019 savings are label as "preliminary".
[11] PY9 NTG is also preliminary at this time of this report's development.

Table 7-5. CY2019 Preliminary Carryover Savings Estimates from PY9 Bulb Sales

Preliminary Partial CY2019 Carryover Savings	IPA PY9 Bulbs
Carryover Bulbs Installed During CY2019	530,726
Average Delta Watts	34.6
Average Daily Hours of Use	2.63
Summer Peak Load Coincidence Factor	0.097
Winter Peak Load Coincidence Factor	0.135
Energy Interactive Effects	1.06
Demand Interactive Effects	1.12
Gross kWh Impact per unit	34.8
Gross kW Impact per unit	0.035
Carryover Gross Energy Savings (kWh)	18,494,383
Carryover Gross Demand Savings (kW)	18,387
Carryover Gross Summer Peak Demand Savings (kW)	2,095
Carryover Gross Winter Peak Demand Savings (kW)	2,504
Net-to-Gross Ratio	0.58
Carryover Net Energy Savings (kWh)	10,710,902
Carryover Net Demand Savings (kW)	10,639
Carryover Net Summer Peak Demand Savings (kW)	1,215
Carryover Net Winter Peak Demand Savings (kW)	1,451
EUL (Res/NonRes)	6/4

Source: Navigant team analysis

8. Appendix 3. Total Resource Cost Detail

Table 8-1, below, shows the Total Resource Cost (TRC) variables for the Residential Lighting Discounts Program for PY9. This TRC variable table only includes cost-effectiveness analysis inputs available at the time of finalizing PY9 impact evaluation reports. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to evaluation at a later date. EULs are subject to change and are not final.

Table 8-1. Total Resource Cost Savings Summary[12]

Research Category	Units	Quantity	Effective Useful Life	Ex Ante Gross Savings (kWh)	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)	NTGR	Heating Penalty (Therms)
Standard CFL (Res)	Lamps	2,520,460	4	60,151,637	NR	50,089,293	4,397	0.57	(1,128,616)
Standard CFL (Non-Res)	Lamps	105,019	3			8,901,999	1,784	0.57	(114,338)
Standard LED (Res)	Lamps	11,429,064	10	405,204,405	NR	340,443,332	34,093	0.58	(7,670,895)
Standard LED (Non-Res)	Lamps	476,211	5			62,662,380	12,555	0.58	(804,838)
Directional LED (Res)	Lamps	3,177,224	10	176,419,238	NR	151,238,548	16,708	0.60	(3,407,718)
Directional LED (Non-Res)	Lamps	132,384	7			26,462,463	5,302	0.60	(339,885)
Specialty LED (Res)	Lamps	1,333,231	10	59,924,908	NR	51,707,066	5,642	0.60	(1,165,068)
Specialty LED (Non-Res)	Lamps	55,551	6			8,000,431	1,603	0.60	(102,758)
LED Fixtures (Res)	Fixtures	798,017	10	47,348,951	NR	39,518,520	4,231	0.73	(890,434)
LED Fixtures (Non-Res)	Fixtures	33,251	14			6,006,436	1,270	0.73	(77,147)
Carryover (Res)	Lamps	2,254,747	4	83,285,600	NR	65,930,878	6,619	0.62	(1,485,560)
Carryover (Non-Res)	Lamps	79,071	3			10,073,084	2,019	0.61	(129,379)

Source: ComEd tracking data, IL TRM, and Navigant team analysis.

* Residential and non-residential values are combined. Tracking data does not contain separate residential and non-residential savings.

NR = Not Reported

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

[12] In 2020 the baseline shifts from halogen to CFL and thus the resulting savings will be reduced for future program years. A separate working document has been created and should be used to conduct the TRC analysis for the residential lighting program.

Appendix C. ComEd PY9 Residential Lighting In-store Intercepts Results Memo 2018-06-14_FINAL

230 Horizon Drive
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Verona, WI 53593

Memorandum

To: Vince Gutierrez, ComEd
CC: Martin Montes, ComEd
Jennifer Morris, ICC Staff
Jeff Erickson, Randy Gunn, Patricia Plympton, Navigant
From: Amy Buege and Ethan Barquest, Navigant Evaluation Team
Date: June 14, 2018
Re: PY9 ComEd Residential Lighting Program In-store Data Collection Memo - Final

Introduction

This memo presents the results of the PY9 ComEd Residential Lighting Discounts Program in-store data collection research. This includes the preliminary gross impact parameter estimates resulting from analysis of the spring and fall waves of the PY9 in-store intercepts surveys (817 surveys),[1] as well as supporting findings from the analysis of the PY9 in-store shelf surveys (24 surveys).[2] This memo provides ComEd with a preliminary review of the in-store data analysis and the resulting parameter estimates that we will use to calculate the PY9 evaluation research savings estimates and to update the deemed parameter estimates included in future versions of the IL TRM.

The preliminary[3] evaluation research impact parameter estimates presented in this memo include:

- Installation Rates
- Leakage Rate
- Residential and Non-residential Installation Location Split

This memo also presents the results of the reflector installation location analysis that the evaluation will use to determine the appropriate hours of use (HOU) estimates to be applied for various reflector types.[4]

When the PY9 program tracking data is finalized, the evaluation team will use the PY9 tracking data to estimate the final PY9 bulb sales, the associated delta watt estimates, and to reweight the parameters included in this memo to make them reflective of the distribution of bulbs sold through ComEd's PY9 Residential Lighting Discounts Program. These parameters, along with the deemed parameters found in the IL TRM v5.0,[5] will be used to calculate the PY9 verified savings and evaluation research impacts.

Preliminary PY9 Parameter Estimates

Table 1 presents the preliminary impact parameter findings from the analysis of the PY9 in-store intercept surveys. This table includes the PY9 evaluation research impact parameter estimates by bulb type, alongside the relative precision (one-tailed 90% confidence interval (CI)) around the gross parameter estimates based on the PY9 intercept surveys, and the PY8 parameter estimates. The derivation of the PY9 parameter estimates is provided in the sections below. The installation rates provided in the following

[1] In PY9 in-store intercept surveys were again conducted at four program retail chains. Two of the retailers were DIY, one was a big box store and one was a warehouse store.
[2] A memo containing the complete findings from the analysis of the PY9 shelf surveys will be delivered to ComEd in January 2018.
[3] These parameter estimates are labeled as "preliminary" since all weighting done to estimate these parameters is based upon the Wave 1 dataset that included PY9 invoices between July 12, 2016 and May 23, 2017. When the final PY9 tracking data is available (anticipated January 2018), these parameter estimates will be updated based on the final PY9 program sales.
[4] The PY9 Residential Lighting net-to-gross (NTG) results will be presented in a separate NTG memo delivered to ComEd in January 2018.
[5] Hours of Use, Peak CF, and Energy and Demand Interactive Effects will also be weighted based upon the final program tracking data and the deemed or evaluated Res/NR split.

table are weighted by program retailer type based on PY9 bulb sales invoiced between July 2016 and May 2017. The final PY9 evaluation report will include updated PY9 installation rates that have been re-weighted using the final PY9 bulb sales. As this table shows, installation rates for LEDs have declined since PY8 due to price decreases for LEDs and LED socket saturation increases. The results are also significantly lower than the PY9 Deemed ISRs (IL TRM v5.0) which were 95% for all LED types. Estimates of leakage have been stable since PY8 and the residential and non-residential split increased slightly for omni-directional lamps and decreased slightly for directional lamps. PY9 is the first year the volume of specialty LEDs has been large enough to warrant a separate analysis.

Table 1. PY9 Gross Impact Parameter Estimates

Parameter Estimate	LED Type	n	Preliminary PY9 Estimate	Rel Precision @ 90% CI	PY8 Eval Estimate
Installation Rate	Omni-directional	417	74%	6%	90%
	Directional	124	81%	12%	93%
	Specialty	102	74%	14%	N/A
Leakage	Omni-directional	333	0.5%	0.6%	0.0%
	Directional	94	1.9%	1.1%	1.6%
	Specialty	42	2.0%	1.2%	2.8%
Res/NR Split	Omni-directional	336	97%/3%	2%	98%/2%
	Directional	94	96%/4%	4%	91%/9%
	Specialty	41	96%/4%	5%	N/A

Source: Evaluation Team Analysis

In addition to the updates to these parameter estimates, analysis of the bulbs being purchased by intercept respondents also led to the following notable findings (described in further detail in the subsequent sections):

1. Warehouse intercept respondents' only purchased LED lamps – the majority of which were program lamps (84%). The shelf survey found that warehouse stores did not stock any CFL, halogen or incandescent lamps and that most of the LEDs stocked were program bulbs (69%).
2. The majority of non-program bulb purchasers at big box and DIY stores were buying halogen or incandescent bulbs (62%, 45%). The share of non-program bulbs at big box and DIY stores that were halogen or incandescent based on the shelf survey data were 46% and 34%, respectively.[6]
3. CFLs made up only 2% of total bulbs purchased by intercept respondents -- down from 34% in PY8 – and were only purchased at DIY stores. The shelf surveys found that CFLs were not stocked at any of the warehouse or big box stores sampled, which helps explain the intercept finding.

The findings above indicate that a reduction in incentives is likely appropriate for warehouse stores that have transitioned their stocked product to LEDs, and thus shoppers have no choice but to purchase LEDs if they buy their lighting from these retailers. Reducing the incentives at these retailers would allow for an expansion of program dollars to big box and DIY stores that continue to experience high sales volumes of halogen and incandescent bulbs. These findings also support ComEd's decision to eliminate CFLs from the program since CFLs are rapidly disappearing from the market.

[6] Complete results on the share of lighting technologies being stocked for the primary lamp types (standard, directional, globe, candelabra, and 3-way) is included is the shelf survey findings memo.

Data Collection Summary

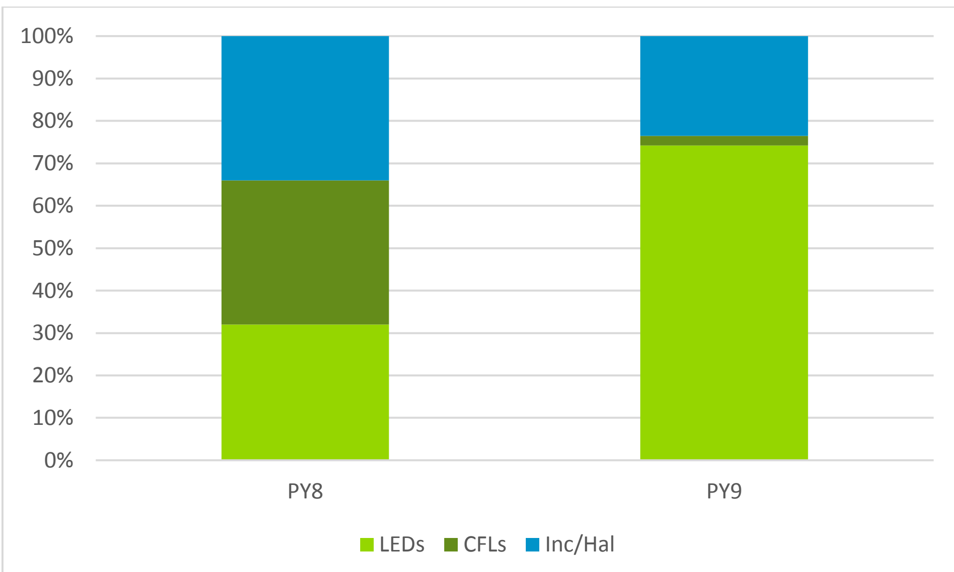
In-store Intercept Surveys

The PY9 the evaluation team completed 817 in-store intercept surveys with customers purchasing program and non-program medium screw-based (MSB) light bulbs from program retailers. The targeted sample size of 800 was determined to allow for a large enough sample of completed surveys with customers who were purchasing each program LED type of interest -- omni-directional (or standard), directional and specialty -- to allow for the estimation of program impact parameters by LED type. In PY9, CFLs were phased out of the program. Incentives on CFLs ended at the end of March 2017.

Out of the 817 surveys, 417 (51%) were completed with customers purchasing one or more program bulbs, and 437 (53%) were completed with customers purchasing one or more non-program bulbs.[7] In total, 4,854 MSB bulbs were purchased by the customers included in the analysis.

As shown in Figure 1 below, PY9 intercept survey respondents purchased LED bulbs much more frequently than the PY8 intercept survey respondents (LED bulbs made up 74% of intercept respondents bulb sales in PY9 compared with only 32% in PY8). The percentage of respondents purchasing CFLs dropped significantly from 34% in PY8 to 2% in PY9, and the percentage purchasing halogen/incandescent bulbs also dropped from 34% in PY8 to 24%.

Figure 1. Distribution of Lamps Purchased by Intercept Respondents



and Table 2 below provide the distribution of the number of program and non-program bulbs purchased by survey respondents. As this table shows, the majority of standard and directional LEDs being purchased were program bulbs (75% for each), however only 35% of specialty LEDs being purchased were program bulbs. The process memo which will also be delivered in January 2018 will explore the reasons customers are purchasing non-program LEDs at stores where program LEDs are available. The majority of CFLs being purchased were standard lamps (94%) and the majority of halogen/incandescent lamps being purchased were either standard (38%) or candelabra lamps (34%).

[7] Thirty-seven surveys were completed with customers purchasing both program and non-program bulbs.

Figure 2. Distribution of Intercept Respondents Bulb Purchases by Bulb Type

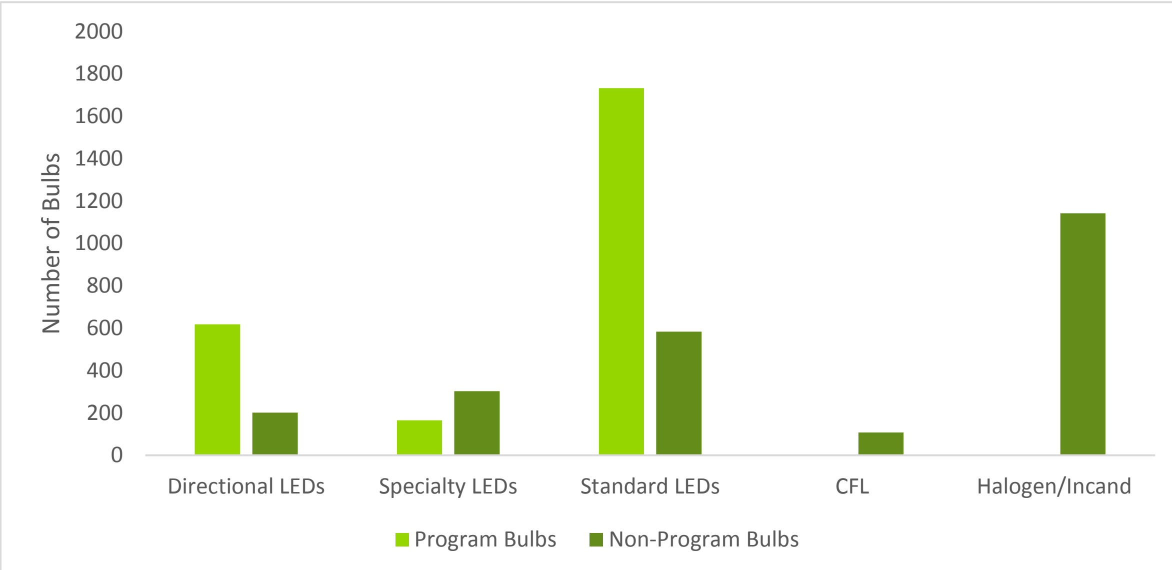


Table 2. Distribution of Intercept Respondents Bulb Purchases by Bulb Type

Program Bulb Status	Bulb Type	# Bulbs Sold	% Bulbs Sold
Program Bulbs	Omni-directional LED	1,733	36%
	Directional LED	618	13%
	Specialty LED	165	3%
	Total	2,516	52%
Non-Program Bulbs	Halogen/Incandescent	1,142	24%
	CFL	108	2%
	Omni-directional LED	584	12%
	Directional LED	202	4%
	Specialty LED	302	6%
	Total	2,338	48%

Source: Evaluation Team Analysis

Table 3 and Table 4 below show the percentage of PY9 intercept respondents who purchased a program or a non-program bulb at each of the three retailer types[8] and Table 5 presents the distribution of shelf space by program status (program vs. non-program) and retailer and bulb type. There are a number of interesting findings from these tables:

1. Warehouse intercept respondents purchased program bulbs more frequently than non-program bulbs (84% vs. 16%, respectively), whereas at DIY and big box stores respondents purchased non-program bulbs more frequently (55% and 63%, respectively). Results of the shelf survey data analysis (presented in shed some light on these significant differences in program versus non-program bulb purchasing patterns across retailer types. As this table shows, program bulbs comprised a much larger share of the available lamps at warehouse stores than at DIY or big box stores (69% of the bulbs inventoried in warehouse stores were program bulbs compared to DIY

[8] The total number of respondents is greater than 817 as some customers purchase multiple bulb types.

and big box stores where 24% and 20% of the bulbs inventoried were program bulbs). Across all three retailer types program bulbs were purchased in greater shares than their shelf survey shares, which is an indication of shoppers' preference for discounted lamps.

2. While omni-directional LEDs were the most frequently purchased type of program bulb across all three retailer types, the percentage of program lamps purchasers at DIY stores that were buying directional lamps (26%) was 3 to 9 times higher than at warehouse or big box stores and the percentage of program lamps purchasers at warehouse stores that were buying specialty lamps (16%) was 2 to 3 times higher than at DIY or big box stores. Again, this aligns with the results of the shelf survey data analysis which found that 71% of program bulbs at big box stores were omni-directional compared to 45% and 43% of program bulbs at DIY and warehouse stores (Table 5).
3. CFLs were only purchased by intercept respondents at DIY stores and shelf surveys results indicate that was mostly likely due to CFLs no longer being stocked at warehouse or big box stores (Table 5). This confirms their rapid departure from the market.
4. All warehouse intercept survey respondents were purchasing LEDs (the majority of which were program LEDs). A review of the shelf survey data found that was to be expected as none of the warehouse stores surveyed were actively stocking CFL, halogen or incandescent bulbs.
5. The majority of non-program bulb purchasers at big box and DIY stores were buying halogen or incandescent bulbs (62% and 45%, respectively).

Findings 4 and 5 above indicate that ComEd should consider significantly reducing or eliminating incentives at warehouse stores where LEDs made up all stocked bulbs and transferring those program dollars to big box and DIY stores to reduce the quantity of halogen and incandescent bulbs being purchased.

Table 3. Distribution of PY9 Program Bulb Purchasers by Retailer and Bulb Type

Retailer Type	Program Bulb Purchasers (All LEDs)				
	n	% Surveyed	Omni	Dir	Spec
Big Box	69	44%	91%	3%	6%
DIY	292	49%	66%	26%	8%
Warehouse	56	84%	75%	9%	16%
Total	417	51%	71%	20%	9%

Source: Evaluation Team Analysis of PY9 Intercept Data

Table 4. Distribution of PY9 Non-Program Bulb Purchasers by Retailer and Bulb Type

Retailer Type	Non-Program Bulb Purchasers						
	n	% Surveyed	CFL	Hal/Inc	Omni	Dir	Spec
Big Box	99	63%	0%	62%	23%	4%	11%
DIY	327	55%	6%	45%	27%	9%	12%
Warehouse	11	16%	0%	0%	55%	18%	27%
Total	437	53%	5%	48%	27%	8%	12%

Source: Evaluation Team Analysis of PY9 Intercept Data

Table 5. Distribution of Shelf Space by Program Status, Retailer and Bulb Type (unweighted)

Retailer Type	Program Bulbs				Non-Program Bulbs					
	Omni	Dir	Spec	All	Omni	Dir	Spec	CFL	Inc /Hal	All
Big Box	71%	20%	9%	20%	36%	9%	10%	0%	46%	80%
DIY	45%	25%	30%	24%	32%	16%	12%	5%	34%	76%
Warehouse	43%	31%	26%	69%	79%	21%	0%	0%	0%	31%
Total	25%	24%	51%	25%	34%	14%	11%	4%	37%	75%

Source: Evaluation Team Analysis of PY9 Shelf Survey Data

Table 6 and Table 7 below are similar to Table 3 and Table 4 above except they show the distribution of the number of bulbs purchased by PY9 intercept respondents.

Table 6. Distribution of PY9 Program Bulbs Purchased by Intercepts Respondents

Retailer Type	Program Bulbs (All LEDs)				
	n	% Total	Omni	Dir	Spec
Big Box	276	42%	94%	3%	3%
DIY	1,880	50%	64%	31%	5%
Warehouse	360	87%	76%	8%	17%
Total	2,516	52%	69%	25%	7%

Source: Evaluation Team Analysis of PY9 Intercept Data

Table 7. Distribution of PY9 Non-Program Bulbs Purchased by Intercepts Respondents

Retailer Type	Non-Program Bulbs						
	n	% of Total	CFL	Hal/Inc	Omni	Dir	Spec
Big Box	388	58%	0%	69%	18%	3%	10%
DIY	1,895	50%	6%	46%	26%	9%	13%
Warehouse	55	13%	0%	0%	40%	33%	27%
Total	2,338	48%	5%	49%	25%	9%	13%

Source: Evaluation Team Analysis of PY9 Intercept Data

Table 8 below shows the average number of bulbs purchased by retailer and bulb type. As this table shows, on average survey respondents purchased the highest quantity of bulbs from warehouse stores (Sam's Club) and the lowest quantity of bulbs at big box stores (Walmart). On average, directional LEDs were purchased in the largest quantities; however, this was primarily driven by two customers who were each buying 60 directional LEDs from Home Depot. With these two individuals removed, the average number of directional LEDs purchased at Home Depot drops significantly (to six for program bulbs and to 3.9 for non-program bulbs).

Table 8. Average Number of Bulbs Purchased by PY9 Intercepts Respondents

Retailer	Program Bulbs				Non-Program Bulbs				All Bulbs
	Omni LED	Dir LED	Spec LED	Pgm	CFL	LED	Hal/ Inc	Non Pgm	
Home Depot	5.4	7.1	3.4	5.6	5.1	5.8	5.0	5.2	5.4
Lowe's	4.6	3.5	4.0	4.3	4.2	4.4	4.9	4.6	4.5
Sam's Club	6.5	4.7	6.0	6.2	n/a	6.8	n/a	4.6	5.9
Wal-Mart	4.0	4.0	1.6	3.8	n/a	3.0	4.1	3.7	3.8

Source: Evaluation Team Analysis of PY9 Intercept Data

Shelf Survey Data

In total, 24 shelf surveys were conducted across 14 unique program retailers. The primary objective of the retailer shelf surveys was to collect data (via in-store lighting inventories) to assess current retailer (program and non-program) efficient lighting stocking levels within ComEd's service territory and to examine the effect ComEd's Residential Lighting Discounts Program is having on the price of LEDs at program stores. These shelf surveys were conducted in May 2017 and included only medium-screw based lamps. The previous shelf surveys conducted for ComEd's Residential Lighting Discounts Program were completed in October 2015 as part of the PY8 evaluation, hence comparisons made to the PY8 results show the differences over a 20-month period.

Installation Rates

Table 9 below provides the estimated (forecasted) installation rates (ISR) by LED type (omni-directional, directional and specialty) for a number of different population groupings based on analysis of the PY9 in-store intercept survey data. Analysis of the data by demonstration event status (whether a demonstration was occurring in the store at the time of the survey) found slight lifts in the estimated installation rates during demonstration events; however, none of these lifts were statistically significant. The table below also shows that installation rates continued to vary by retailer type with the lowest ISRs occurring at warehouse stores. The correlation between higher installation rate and lower volume of bulbs purchased continued to be evident in PY9. Due to the variation in ISR by retailer type and vast differences in the percent of program sales each retailer makes up, the evaluation team recommends using the retailer type sales-weighted[9] ISR estimates shown in bold below.

[9] Retailer sales weights are based on the Wave 1 PY9 sales data given to the evaluation team in June of 2017 and include PY9 invoiced sales from July 2016 – May 2017.

Table 9. Installation Rate Estimates by LED Type and Respondent Characteristic

Population		In-store Intercept Installation Rate		
		Omni-directional	Directional	Specialty
Total – Non-Weighted		75%	82%	78%
Demo vs. Non-Demo	Demo	76%	88%	80%
	Non-Demo	75%	80%	77%
Retailer Type	Big Box	75%	85%	77%
	DIY	77%	82%	78%
	Warehouse	68%	80%	75%
	Retailer Sales Weighted	74%	81%	77%
Total Bulbs Purchased	1	79%	100%	100%
	2 - 4	76%	80%	83%
	5 -10	75%	76%	71%
	11 or more	75%	87%	79%

Source: Evaluation Team Analysis of PY9 Intercept Data

The estimated installation rate (IR) for LEDs declined by more than 10% from the PY8 estimate. Installation rates for omni-directional LEDs fell from 90% in PY8 to 74% in PY9 and ISRs for directional LEDs fell from 93% in PY8 to 81% in PY9 (specialty LED ISR were not calculated separately in PY8 due to small sample sizes). This decline in ISRs for LEDs is to be expected as the price of LEDs has decreased and customers' usage of LEDs (and household LED saturation) has increased.

Program Bulb Leakage

In PY9, the evaluation team estimated the overall leakage rate across bulb types and retailer types to be 1%. In total, five program LED bulb purchasers (out of 415)[10] reported they planned to install the program bulbs they were purchasing in a location that received electrical service from an entity other than ComEd. Table 10 provides the details about the five respondents who reported the program bulbs would be installed outside of ComEd territory. As the table shows, three of the five respondents who planned to install the program bulbs outside ComEd service territory purchased the program bulbs at a suburban retail store, one purchased them from a store within Chicago (Urban), and the fifth respondent purchased the program bulbs from a store in an outlining area (Rockford, IL).

Table 10. Bulb Type, Quantity, and Location of Leakage Purchases and Reason for Leakage

LED Type	Retailer Type	Retailer City	Service Provider	Bulbs
Directional	DIY	Downers Grove	City of Naperville	6
Omni-Directional	DIY	Rockford	Rock Energy	2
Omni-Directional	DIY	Downers Grove	City of Naperville	2
Directional	DIY	Chicago	MidAmerican Energy	6
Specialty	WH	Lockport	Batavia	3

Source: PY9 In-store Intercept Surveys

[10] Two respondents were dropped from the analysis. One was dropped as they were unsure who provided electrical service to the location where they were planning to install the program bulbs and the other since they reported it was Nicor (a gas utility) who provided their electrical service.

Residential and Non-residential Installation Location Split

To estimate the residential and nonresidential split, intercept survey respondents were asked if they planned to install the program bulbs they were purchasing in their home, business, or a combination of both. Respondents who reported they planned to install the program bulbs in their business were asked a follow up question about the type of this business where they would be installed. If the business was either an apartment building or a hotel or motel, the respondent was asked if the bulbs would be installed in a common area of the building or within an individual unit or room. Bulbs that would be installed in an individual unit or room were classified as residential installations and bulbs being installed in common areas were classified as non-residential installations. Table 11 shows the percentage of program bulbs (by bulb type) reportedly being installed in residential versus non-residential locations, along with the business type of non-residential installation locations. As this table shows, across all three bulb types between 96% and 97% of bulbs were being installed in residential locations.

Table 11. Program Bulb Installation Location

Installation Location	Omni Directional			Directional			Specialty		
	n	Bulbs	%	n	Bulbs	%	n	Bulbs	%
Residential Installs	324	1,668	97%	90	580	96%	40	141	96%
Non-Res Installs	12	57	3%	4	27	4%	1	6	4%
Apartment / MF Common	6	27	1.6%	--	--	--	1	6	4.1%
Retail/Services	2	26	1.5%	1	23	3.8%	--	--	--
Public Assembly	4	4	0.2%	1	4	0.6%	--	--	--

Source: Evaluation team analysis of PY9 Intercept Data

Reflector Installation Location

ComEd and CLEAResult have been considering recommending an update to the HOU in the TRM for certain reflector bulbs (primarily PAR lamps) based on the belief that they are primarily being installed in outdoor locations and thus the savings for these measures would be more accurately represented if an exterior HOU estimate was utilized. To gather data to test this hypothesis, the evaluation team added two questions to the fall round of intercept surveys. The first question collected the type of reflector being purchased and the second question asked the respondent if the reflector would be installed in an indoor or outdoor location.

Table 12 below shows that respondents who were purchasing PAR reflectors reported they planned to install these reflector in outdoor locations more frequently than those who were purchasing non-PAR reflectors (36% versus 9%, respectively). Given that the majority of PAR reflectors were reportedly going to be installed in indoor locations, utilizing an exterior HOU estimate will lead to an overestimation of program savings. Based on the findings from the intercept surveys, the evaluation team recommends updating the HOU estimate for the PAR reflectors with a weighted average (using the intercept results) of the interior and exterior HOU estimates. Applying this weighting results in a revised HOU estimate of 1,442 and a Peak CF of 0.157 based on the deemed HOU and Peak CF estimates found in the IL-TRM v6 (shown in Table 13 below).

Table 12. Directional Bulb Installation Location

Directional Bulb Type	n	Bulbs	% Outdoors	% Indoors
Non-PAR Reflectors	60	317	9%	91%
PAR Reflectors	18	55	36%	64%

Source: Evaluation team analysis of PY9 Intercept Data

Table 13. HOU and Peak CF for PAR Directional Lamps

Installation Location	% of Lamps	Deemed HOU Estimate	Deemed CF Estimate
Indoors	64%	861	0.091
Outdoors	36%	2,475	0.273
Weighted Average Estimate		1,442	0.157
Deemed Estimate – Unknown Location		891	0.094

Source: Evaluation team analysis of PY9 Intercept Data

Appendix D. ComEd Residential Lighting Discounts PY9 NTGR Memo 2018-08-28

230 Horizon Drive
Suite 101B
Verona, WI 53593

Memorandum

To: Vince Gutierrez, ComEd

CC: Jennifer Morris, ICC Staff
Jeff Erickson, Randy Gunn, Nishant Mehta and Rob Neumann, Navigant

From: Amy Buege and Ethan Barquest, Navigant Evaluation Team

Date: August 28, 2018

Re: ComEd Residential Lighting Discounts Program Recommended NTGR Updates

1. Introduction

This memorandum presents the evaluation research[1] net-to-gross ratio (NTGR) estimates for omni-directional, directional and specialty LEDs sold through ComEd's Residential Lighting Discounts Program during PY9.

2. Results Summary

The table below presents the PY9 Evaluation Research NTGR estimates for program omni-directional, directional and specialty LEDs. These results were estimated using the same participant self-report method used in previous evaluation years. This method is consistent with the methodology used to estimate the NTGR for lamps sold through Ameren Illinois's residential lighting program. The NTGR results in Table 2-1 are inclusive of participant and non-participant spillover and are calculated using a 5%/95% Demo/Non-Demo weighting.

Table 2-1: PY9 Evaluation Research NTGR Results

LED Type	Segment	Free-Ridership	Participant[2] Spillover	Nonparticipant Spillover	NTGR
Omni-Directional	Non-Demo Periods	0.41	0.02	0.06	0.67
	Demo Periods	0.32	0.02	0.06	0.76
	Recommended PY9 Estimate	**0.41**	**0.02**	**0.06**	**0.67**
Directional	Non-Demo Periods	0.47	0.02	0.06	0.61
	Demo Periods	0.49	0.02	0.06	0.59
	Recommended PY9 Estimate	**0.47**	**0.02**	**0.06**	**0.61**
Specialty	Non-Demo Periods	0.55	0.02	0.06	0.53
	Demo Periods	0.43	0.02	0.06	0.65
	Recommended PY9 Estimate	**0.55**	**0.02**	**0.06**	**0.53**

Source: PY9 In-store Intercept Surveys

[1] It should be noted that the NTGR estimates presented here are the evaluation verified estimates (based on the PY9 in-store intercept surveys) and weighted by the number of program sold in PY9.
[2] Note that the evaluation team developed a single estimate for participant spillover and a single estimate for non-participant spillover across all LED types.

As shown in Table 2-1, the NTGR estimates for omni-directional and specialty LEDs purchased during demonstration events were higher than the NTGR estimates for bulbs purchased during non-demonstration event periods. Though the NTGR for directional LEDs at demonstration events was lower than during non-demonstration even periods, the difference was very small (0.02 difference in NTGR). Due to the increased program sales which occurred during demo events, and the fact that the in-store data collection methodology resulted in an over-sampling of demonstration period data,[3] the final results were estimated separately for demonstration and non-demonstration event periods and then weighted by the estimated percentage of bulbs sold during demonstration events. The recommended NTGR results below assumed a 5%/95% demonstration/non-demonstration event period split which represents an upper bound on the likely percentage of program bulbs sold annually during demonstration events. Sensitivity analyses performed on the demonstration/non-demonstration event split (ranging from a 1%/99% demo/non-demo split to a 10%/90% demo/non-demo split) found little difference in the resulting NTGR estimates.

3. PY9 NTGR Methodology

The evaluation research NTGR estimates included in this memo are based on a total of 817 in-store intercept surveys conducted during the PY9 evaluation. Table 3-1 below shows (by retailer type and overall) the number of retail store locations where intercept surveys were conducted in PY9, the number of days of interviewing that took place, the distribution of completed intercept surveys, and the PY9 program LED bulb sales used for NTGR analysis retailer weighting. As this table shows, a total of 75-person days were spent in retail stores conducting intercept surveys and a total of 25[4] program retail stores were visited across the four program retailers included in the sample. This table also shows that the greatest proportion of PY9 intercept surveys were conducted with lighting purchasers (program and non-program) in DIY stores (73%). DIY stores account for 44% of PY9 program LED bulb sales. The average number of intercept surveys completed per day varied by retailer type, ranging from a high of 14.1 in DIY stores, to a low of 4.5 in warehouse stores. The NTGR results presented in this memo are weighted by PY9 retailer type program bulb sales in order to make the results representative of the distribution of PY9 Residential Lighting Discounts program bulb sales.

Table 3-1. PY9 Intercept Survey Summary by Retailer Type

Retailer Type	Stores	Person -Days	PY9 Intercepts		Average Intercepts/ Day	PY9 LED Bulb Sales	
			#	%		#	%
Big Box	6	18	158	19%	8.8	2,420,878	15%
DIY	14	42	592	73%	14.1	7,298,796	44%
Warehouse	5	15	67	8%	4.5	5,177,639	31%
Other	0	0	0	0%	n/a	1,706,352	10%
Total	25	75	817	100%	10.9	16,603,665	100%

Source: PY9 In-store Intercept Surveys

Table 3-2 below shows the distribution of PY9 intercept survey respondents by retailer and bulb type purchased. As this table shows, 51% of intercept survey respondents purchased one or more program bulb (the majority of the bulbs purchased were omni-directional LEDs) and 53% of respondents purchased one or more non-program bulb (the majority of these being incandescent bulbs).

[3] Each three-day data collection period at a program retailer commenced with a half day demonstration event so that the program implementation staff were on hand to introduce the intercept surveyor to retail staff and secure approval for the in-store data collection activities. Demonstration events occurred on 13 of the 75 days when intercepts were being conducted (17% of the data collection period), which is a significantly higher percentage of time than throughout the remainder of the program year.

[4] Two stores (one Big Box and one DIY) were visited in both the fall and spring intercept survey efforts, they are counted twice in the total store count (i.e., there were 23 distinct store locations visited).

Table 3-2. Distribution of PY9 Intercept Survey Respondents by Bulb Type Purchased

Retailer Type	Program Bulbs				Non-Program Bulbs						All
	Omni	Dir	Spec	All	Omni	Dir	Spec	CFL	Inc /Hal	All	
Big Box	63	2	5	69	23	4	13	0	61	99	**158**
DIY	198	82	28	292	97	30	43	22	154	327	**592**
Warehouse	42	6	10	56	7	2	3	0	0	11	**67**
Total	303	90	43	417	127	36	59	22	215	437	**817**
% Surveyed	37%	11%	5%	51%	16%	4%	7%	3%	26%	53%	**100%**
% Pgm Lamps	70%	71%	42%								

Source: Evaluation Team Analysis of PY9 Shelf Survey Data

Table 3-2 above shows that in PY9, around 70% of intercept respondents purchasing omni-directional and directional LEDs were buying program lamps. This was not the case for specialty lamps where only 42% of the lamps purchased were program lamps. This was primarily driven by specialty LED purchases at big box and DIY stores, where only 28% and 39% of purchases were program lamps.

Table 3-3 shows that the overall number of LEDs incentivized in PY9 at the four program retailers where intercepts were performed was virtually unchanged between PY8 and PY9 (209 LED models in PY8 vs. 207 models in PY9). However, as the table shows, the number of program models at big box stores decreased by roughly half the program models at DIY and warehouse stores increased by 30% or more.

Table 3-3. Number of Unique Model Numbers of Incentivized LEDs Sold by Intercept Retailers

Retailer Type	PY9[5]				PY8				
	Omni	Dir	Spec	All	Omni	Dir	Spec	All	YOY Increase
Big Box	25	9	5	39	21	28	32	81	48%
DIY	47	48	56	151	44	57	16	117	129%
Warehouse	5	4	8	17	4	4	3	11	155%
Total	77	61	69	207	69	89	51	209	99%

Source: Evaluation Team Analysis of PY9 Shelf Survey Data

Table 3-4 below presents the number of intercepts conducted and the volume of program versus non-program bulbs purchased during ComEd sponsored in-store demonstration events (demo events) versus during non-demonstration event periods. In-store interviewers accompanied program implementation staff into program retail stores during demonstration events to familiarize themselves with the program offerings. As this table shows, demonstration events were being conducted during roughly 17% of the time in-store intercepts were being conducted and 24% of completed surveys occurred during a demonstration event. Program bulbs were purchased at a higher rate during demonstration events (76% of bulbs sold during demo events were program bulbs vs 67% being program bulbs during non-demo events). Typically, 20 to 40 ComEd-sponsored demonstration events occur each month across all program retailers and thus intercepts occurring during demonstration events are likely over-represented in

[5] PY9 model numbers were taken from the bulb list provided to the evaluation team from ComEd on October 16, 2017.

our sample.[6] To account for this over-representation, the NTGR estimates were calculated separately for demo vs. non-demo event periods and the final NTGR results were weighted based upon an estimate of the percent of annual sales that occurred during demo event periods.

Table 3-4. PY9 Demo Event versus Non-Demo Event Intercept Survey Summary

Demo Event?	Person-Days[7]		Intercepts		Bulb Sales			
	#	%	#	%	Pgm LEDs	%	NonPgm LEDs	%
Demo Event	13	17%	192	24%	746	76%	235	24%
Non-Demo Event	62	83%	625	76%	1,770	67%	853	33%
Total	75	100%	817	100%	2,516	70%	1,088	30%

Source: Evaluation Team Analysis of PY9 Shelf Survey Data

4. PY9 NTGR Estimation Methodology

In PY9, NTGR estimates for LEDs were calculated using the customer self-report method based on data collected during the PY9 in-store intercept surveys. The NTGR definition used in the state of Illinois includes both Free-ridership and Participant and Non-Participant spillover and is calculated as follows:

NTGR = 1 – Free-ridership + Spillover (participant and non-participant)

The calculation of Free-ridership and Participant and Non-Participant Spillover are provided in the sections below.

5. PY9 Evaluation Verified Free-ridership Results

Free-ridership was estimated by calculating two separate free-ridership scores. These scores were the following:

1) *Program Influence Score* (PI Score) - The degree of influence the program[8] had on the customers' decision to install LEDs, on a scale of 0 to 10.
2) *No-Program Score* (NP Score) – The customer's self-reported purchasing plans if the ComEd incentive had not been offered and the bulbs had been more expensive.

Once these scores were calculated for all program bulb purchasers, free-ridership was calculated as:

Free-Ridership = 1 – (PI Score + NP Score) / 20

Table 5-1 through Table 5-3, below, present the ***unweighted*** free-ridership estimates for omni-directional, directional, and specialty LEDs, as well as the free-ridership results segmented by Demo Event (whether the intercept survey occurred during an in-store demonstration event), Retailer Type (big box, DIY, or warehouse), and Demo Event and Retailer Type. As shown in the tables below, the number of intercept surveys completed with customers purchasing directional and specialty bulbs in big box and warehouse retailers was very low (ten or less). For this reason, the final weighted free-ridership estimates were not weighted by retailer type for these bulb types.

[6] The evaluation team estimates that between 1% and 5% of all annual program sales occur during a demonstration event period. This assumption is based on roughly 40 demonstration events occurring monthly, roughly 800 participating retail store fronts and a four-fold increase in the rate of sale during a demonstration events.
[7] Demonstration events lasted approximately 4 hours and so were considered 0.5 of a day.
[8] Program influence could be attributable to the program incentive, in-store information materials, placement of incentivized bulbs, or information from retail store personnel who call out the ComEd program.

Table 5-1. Unweighted PY9 Omni-Directional LED Free-Ridership Segmentation Analysis

Omni-Directional LED Free-Ridership		N	Free-Ridership	Lower 90%CL	Upper 90%CL
All Omni-Directional LEDs		302	0.38	0.35	0.41
Demo Event	Yes	95	0.32	0.27	0.36
	No	207	0.41	0.37	0.45
Retailer Type	Big Box	62	0.35	0.28	0.41
	DIY	198	0.42	0.38	0.46
	Warehouse	42	0.24	0.17	0.31
Demo Event and Retailer Type	Big Box – No Demo	50	0.39	0.31	0.47
	Big Box – Demo	12	0.23	0.15	0.31
	DIY – No Demo	132	0.45	0.40	0.50
	DIY - Demo	66	0.35	0.29	0.41
	Warehouse – No Demo	25	0.22	0.14	0.31
	Warehouse - Demo	17	0.26	0.14	0.38

Table 5-2. Unweighted PY9 Directional LED Free-Ridership Segmentation Analysis

Directional LED Free-Ridership		N	Free-Ridership	Lower 90%CL	Upper 90%CL
All Directional LEDs		90	0.48	0.42	0.53
Demo Event	Yes	24	0.49	0.38	0.59
	No	66	0.47	0.40	0.54
Retailer Type	Big Box*	2	0.59	0	1
	DIY	82	0.48	0.42	0.54
	Warehouse	6	0.28	0.15	0.41
Demo Event and Retailer Type	Big Box – No Demo*	2	0.59	0	1
	Big Box – Demo	0	n/a	n/a	n/a
	DIY – No Demo	58	0.48	0.41	0.56
	DIY - Demo	24	0.49	0.38	0.59
	Warehouse – No Demo	6	0.28	0.15	0.41
	Warehouse - Demo	0	n/a	n/a	n/a

* Confidence limits bounded by 0 and 1.

Table 5-3. Unweighted PY9 Specialty LED Free-Ridership Segmentation Analysis

Specialty LED Free-Ridership		N	Free-Ridership	Lower 90%CL	Upper 90%CL
All Specialty LEDs		43	0.52	0.43	0.62
Demo Event	Yes	13	0.43	0.24	0.61
	No	30	0.55	0.44	0.66
Retailer Type	Big Box	5	0.31	0.14	0.49
	DIY	28	0.53	0.43	0.63
	Warehouse	10	0.55	0.28	0.81
Demo Event and Retailer Type	Big Box – No Demo	4	0.29	0.07	0.50
	Big Box – Demo	1	0.50	n/a	n/a
	DIY – No Demo	18	0.59	0.48	0.70
	DIY - Demo	10	0.38	0.17	0.59
	Warehouse – No Demo	8	0.54	0.23	0.86
	Warehouse – Demo*	2	0.57	0	1

* Confidence limits bounded by 0 and 1.

5.1 Weights

Because the in-store intercept surveys conducted and used to calculate free-ridership for PY9 were based on a convenience sample, the evaluation team applied case weights to the segmented results to correct for the over-representation of demo event completes within the final sample and also retailer type for omni-directional LEDs where the sample was large enough to support such segmentation. The goal of applying these weights is to derive LED bulb type free-ridership estimates that are representative of the final distribution of PY9 bulb sales. Table 5-4 below shows the distribution of PY9 omni-directional, directional and specialty LEDs sales by retailer-type and intercept-store status (whether intercepts were conducted at one or more retail storefronts for a given retailer). As this table shows the four stores where intercepts were conducted were responsible for slightly more than half of program bulbs sold in PY9. While the optimal data collection effort would include all retailers participating in the PY9 program, this is not possible due to the daily program bulb sales rate in some retailers being too low to be able to cost-effectively include the retailer in the data collection effort and issues gaining permission to conduct in-store research at other retailers.

Table 5-4. PY9 LED Sales for Analysis Weights

Intercept Retailer?	Retailer Type	Omni-Directional	%	Directional	%	Specialty	%
Yes	Big Box	1,722,876	14%	27,397	1%	45,450	3%
	DIY	4,170,549	35%	1,624,368	49%	552,603	40%
	Warehouse	732,002	6%	65,365	2%	63,679	5%
	Intercept Stores	**6,625,427**	**56%**	**1,717,130**	**52%**	**661,732**	**48%**
No	Big Box	555,951	5%	52,182	2%	17,022	1%
	Discount	82,243	1%	10,732	0%	7,501	1%
	DIY	638,667	5%	266,067	8%	46,542	3%
	Dollar Stores	135,461	1%	0	0%	0	0%
	Electronics	128,955	1%	41,197	1%	5,495	0%
	Grocery/ Drug	410,569	3%	566	0%	1,331	0%
	Online	58,464	0%	15,592	0%	3,286	0%
	Small Hardware	526,535	4%	209,349	6%	69,076	5%
	Warehouse	2,743,003	23%	996,793	30%	576,797	42%
	Non-Intercept Stores	**5,279,848**	**44%**	**1,592,478**	**48%**	**727,050**	**52%**

5.2 Weighted Free-ridership Results

While the distribution of program bulbs sales by demonstration event status is unknown, it is believed to be 5% or less. As in past years, weighted free-ridership estimates have been calculated assuming three different demo/non-demo splits (1/99, 5/95, 10/90) to test the sensitivity of the free-ridership estimate to this split. Table 5-5 through Table 5-7 below present the weighted free-ridership estimates for omni-directional, directional, and specialty LEDs by demo event period and 3 different demo-non-demo splits. The recommended weighted free-ridership estimates are shown in the tables in **bold**.

Table 5-5 provides the free-ridership results for omni-directional LEDs. As this table shows, omni-directional LED free-ridership level was not very sensitive to a +/-5% shift in the percentage of program sales occurring during a demo event and thus the evaluation team recommends using a 5/95 demo/non-demo split as in previous years to calculate the final omni-directional free-ridership estimate. This weighted free-ridership estimate is slightly lower than the PY8 estimate (0.41 in PY9 versus 0.49 in PY8). The evaluation team speculates that this may be due to the fact that the PY8 omni-directional LED free-ridership score included specialty bulbs, which have been estimated separately in PY9 (due to increased sales volumes). As shown in Table 5-7 below, free-ridership for specialty LEDs in PY9 was much higher than for omni-directional LEDs (the specialty LED free-ridership score in PY9 was calculated to be 0.55).

Table 5-5. Weighted Omni-Directional LED Free-Ridership Estimates

Event Period	Free-ridership Estimate
Non-Demo Event Period	0.41
Demo Event Period	0.32
Weighted 1/99 demo/non-demo	0.41
Weighted 5/95 demo/non-demo	**0.41**
Weighted 10/90 demo/non-demo	0.40

Table 5-6 shows the free-ridership results for program directional LEDs. As this table shows, directional LED free-ridership was also not sensitive to a +/-5% shift in the percentage of program sales occurring during a demonstration event and thus the evaluation team recommends using a 5/95 demo/non-demo split as in previous years to calculate the final directional free-ridership estimate. The weighted PY9 directional LED free-ridership estimate is slightly higher than the PY8 estimate (0.47 in PY9 and 0.42 in PY8). This is likely due to customers' greater familiarity with the technology and increasing market acceptance of LEDs.

Table 5-6. Weighted Directional LED Free-Ridership Estimates

Event Period	Free-ridership Estimate
Non-Demo Event Period	0.47
Demo Event Period	0.49
Weighted 1/99 demo/non-demo	0.47
Weighted 5/95 demo/non-demo	**0.47**
Weighted 10/90 demo/non-demo	0.47

Table 5-7 shows the free-ridership results for program specialty LEDs. Again, the results show that weighted Specialty LED free-ridership estimates are fairly insensitive to a +/- 5% shift in the percentage of annual bulbs sold during demonstration events. Free-ridership for specialty LEDs was not calculated separately in PY8 due to low program specialty LED sales.

Table 5-7. Weighted Specialty LED Free-Ridership Estimates

Event Period	Free-ridership Estimate
Non-Demo Event Period	0.55
Demo Event Period	0.43
Weighted 1/99 demo/non-demo	0.55
Weighted 5/95 demo/non-demo	**0.55**
Weighted 10/90 demo/non-demo	0.54

6. Spillover

In PY9, participant and non-participant omni-directional, directional, and specialty LED spillover was also estimated based on data collected during the in-store intercept surveys. Unlike the free-ridership results presented above, the spillover results were not broken down by intercepts occurring during demo and non-demo events, due to small sample sizes. The participant and non-participant spillover results are presented below.

6.1 Participant Spillover

Participant spillover occurs when a customer who is purchasing a program LED is influenced by the program to also purchase a non-program non-discounted LED bulb. A single participant spillover estimate was developed for all LED types. Table 6-1 below present the results of the LED participant spillover analysis.

As shown in Table 6-1 below, a total of 27 respondents who purchased a program LED also purchased a non-discounted LEDs. Of these 27 respondents, 15 respondents reported that the program influenced their decision to purchase the non-program LEDs. Based on this data, LED participant spillover rate was calculated as the ratio of the spillover LEDs bulb purchases to the program LED purchases. As the table below shows, this yielded a participant LED spillover rate of 2.2%.

Table 6-1 – PY9 Participant LED Spillover Results – Self-Report Method

Participant LED Spillover	n	Bulb/Purchase	Bulbs
Non-Pgm LED Purchases by Participants	27	4.88	132
Spillover Purchases	15	3.67	55
Program Purchases	417	6.03	2,516
Participant LED Spillover Rate			**2.2%**

6.2 Nonparticipant Spillover

Nonparticipant spillover occurs when a survey respondent who is not purchasing a program LED reports that the program in some way influenced them to purchase a non-program LED bulb. A single nonparticipant spillover estimate was developed for all LED types. Table 6-2 present the results for the nonparticipant spillover analysis. Survey respondents were included in this analysis if they did not purchase any program LEDs but purchased one or more non-program LED.

As shown in Table 6-2, 42 customers who were not purchasing program LEDs reported they were influenced by ComEd's Residential Lighting Program to purchase one or more non-program LEDs. Based on this data and the respondents stated purchase intentions when they entered the store, the nonparticipant spillover rate was extrapolated to the estimated population of ComEd non-participant customers to yield an estimated 661,586 non-program LEDs being purchased by program nonparticipants. Dividing these extrapolated spillover purchases by the annualized[9] quantity of program LEDs sold in PY9 resulted in an estimated nonparticipant spillover rate of 6.0%.

[9] PY9 program sales were extrapolated to a 12-month sales number.

Table 6-2. PY9 Nonparticipant LED Spillover Results

Nonparticipant LED Spillover	n	Bulbs / Purchase	Total Bulbs
Nonparticipant LED Spillover Purchases	42	3.78	158.9
Population Extrapolated Spillover Purchases	174,868	3.78	661,586
Annualized Program LED Sales			11,069,110
Nonparticipant LED Spillover Rate			**6.0%**

7. Final NTGR

Table 7-1 through Table 7-3 below present the overall self-reported PY9 bulb-weighted NTGR estimates for omni-directional, directional, and specialty LEDs. Table 7-1 shows the NTGR for omni-directional LEDs purchased during demo events was 0.76 and the NTGR for Omni-directional LEDs purchased outside demo events was 0.67. The sensitivity analysis performed on the demo/non-demo rate showed little change on the NTGR estimate when the demo rate was increased to 10%. The evaluation recommended NTGR estimate for omni-directional LEDs based on the PY9 analysis is 0.67.

Table 7-1. PY9 Omni-directional LED NTGR

Segmentation	Free-Ridership	Participant Spillover	Nonparticipant Spillover	NTGR
Non-Demo Event Periods	0.41	0.022	0.06	0.67
Demo Event Periods	0.32	0.022	0.06	0.76
Recommended PY9 Estimate (5/95 Demo/Non-Demo)	**0.41**	**0.022**	**0.06**	**0.67**

Table 7-2 shows the NTGR for directional LEDs purchased during a demo event was 0.59 and the NTGR for directional LEDs purchased outside of a demo event was 0.61. The sensitivity analysis performed on the demo/non-demo rate showed no change in the NTGR estimate when the demo rate was increased to 10%. As a result, the evaluation recommended NTGR estimate for directional LEDs based on the PY9 analysis is 0.61.

Table 7-2. PY9 Directional LED NTGR

Segmentation	Free-Ridership	Participant Spillover	Nonparticipant Spillover	NTGR
Non-Demo Event Periods	0.47	0.022	0.060	0.61
Demo Event Periods	0.49	0.022	0.060	0.59
Recommended PY9 Estimate (5/95 Demo/Non-Demo)	**0.47**	**0.022**	**0.060**	**0.61**

Table 7-3 shows the NTGR for specialty LED purchased during a demo event was 0.65 and the NTGR for specialty LEDs purchased outside of a demo event was 0.53. The sensitivity analysis performed on the demo/non-demo rate showed only a small fluctuation in the NTGR estimate when the demo rate was increased to 10%. The evaluation recommended NTGR estimate for specialty LEDs based on the PY9 analysis is 0.53.

Table 7-3. PY9 Specialty LED NTGR

Segmentation	Free-Ridership	Participant Spillover	Nonparticipant Spillover	NTGR
Non-Demo Event Periods	0.55	0.022	0.060	0.53
Demo Event Periods	0.43	0.022	0.060	0.65
Recommended PY9 Estimate (5/95 Demo/Non-Demo)	**0.55**	**0.022**	**0.060**	**0.53**

Table 7-4 below presents the PY9 evaluation NTGR results alongside the NTGR results from PY7 and PY8. PY7 was the first year net-to-gross ratios were calculated for LEDs as it was the first program year that LED sales were large enough to allow for such an analysis.[10] The bottom row of the table below shows the drastic increase in the number of LED lamps sold through the program from PY7 to PY9. The PY7 NTGR was estimated based on data from all LEDs bulb types as there were not large enough samples of LED Reflector or Specialty bulbs to support a distinct NTGR. In PY8, a distinct NTGR was calculated for LED Reflectors and Specialty bulbs (again due to sample sizes) and it wasn't until PY9 that the data allowed for three unique net-to-gross ratios to be estimated. The NTGR for Standard LEDs increased in PY9 which the evaluation team believes is likely attributable to PY9 being the first year that the price for a program Standard LED was lowered to a level similar to the non-LED alternatives.[11] Program Reflector LEDs have also come down in price to be more aligned with halogen and incandescent alternatives, however those lamps are still typically more than $4 a lamp which may reduce the number of customers who are would be persuaded by the incentive to try this newer technology or replace less efficient lamps that still work. In PY9 Specialty LEDs continued to be significantly more expensive than less efficient alternatives even with program incentives which tends to increase the portion of "early adopters" (who are more likely to be free-riders) buying program bulbs.

Table 7-4. Historical NTGR Evaluation Research Results

Lighting Measure	Parameter	PY7	PY8	PY9
Standard LEDs	FR	0.44	0.49	0.41
	SO	0.17	0.07	0.08
	NTGR	**0.73**	**0.58**	**0.67**
Reflector LEDs	FR	0.44	0.45	0.47
	SO	0.17	0.03	0.08
	NTGR	**0.73**	**0.58**	**0.61**
Specialty LEDs	FR	0.44	0.45	0.55
	SO	0.17	0.03	0.08
	NTGR	**0.73**	**0.58**	**0.53**
LEDs Sold Through Program		**~900,000**	**~5,500,000**	**~17,000,000**

[10] Prior to PY7 the largest number of LEDs sold through the program was ~28,000 LEDs (in PY5). In PY6 no LEDs were sold through the program.
[11] Results of the PY9 shelf survey found the average price of an Standard LED was ~$2.19 compared to the average price of a less efficient halogen and incandescent alternatives that were $1.87 and $2.09, respectively.

8. Appendix: ComEd Instant Lighting Discounts NTGR History for LEDs

The table below shows the Deemed NTGR estimates for all program years since PY7 when LEDs entered the program in large numbers. The final row of the table shows the source of the deemed NTGR estimate.

Table 8-1. Historical Deemed NTGR Results

Lighting Measure	Parameter	PY7	PY8	PY9	CY2018	CY2019
Standard LEDs	FR		0.44	0.49	0.49	0.41
	SO		0.17	0.07	0.07	0.08
	NTGR	**0.75**	**0.73**	**0.58**	**0.58**	**0.67**
Reflector LEDs	FR		0.44	0.42	0.45	0.47
	SO		0.17	0.02	0.03	0.08
	NTGR	**0.75**	**0.73**	**0.60**	**0.58**	**0.61**
Specialty LEDs	FR		0.44	0.42	0.49	0.55
	SO		0.17	0.02	0.07	0.08
	NTGR	**0.75**	**0.73**	**0.60**	**0.58**	**0.53**
Source of Deemed NTG		**SAG Concensus Process**	**PY7 Research**	**PY8 Research (not final)**	**PY8 Research (final)**	**PY9 Research**

The table below was taken from the ComEd NTG History and PY10 Recommendation document dated 3/1/2017. It has been updated to reflect a few errors found in this table and reflects the NTGR for LED bulbs and fixtures only.

	Residential Lighting – Smart Lighting Discounts – LED Lamps and Fixtures
EPY1	**LEDs not sold through the program**
EPY2	**LEDs not sold through the program**
EPY3	**LEDs not sold through the program**
EPY4	**A small number of LEDs sold through the program (24k)** **Deemed NTG for LEDs based on average of CFL PY2 Research** **EPY4 Research NTG:** 0.54 Other – Fixture/LEDs **Free-Ridership: 0.48** Other – Fixture/LEDs **Spillover:** 0.02 **Method**: Customer self-report method based on in-store intercept surveys.
EPY5	**A small number of LEDs sold through the program (28k)** **Deemed NTG for LEDs based on average of Specialty CFL NTG** **EPY5 Research NTG:** 0.80 Specialty CFL, LED bulbs and fixtures
EPY6	**LEDs not sold through the program**
EPY7	**LEDs sold in larger numbers through program (900k)** **Deemed NTG for LEDs based SAG consensus process not evaluation research.** **LED Bulbs: 0.75** **LED Fixtures: 0.75**

	Residential Lighting – Smart Lighting Discounts – LED Lamps and Fixtures
EPY8	**LEDs sold through program in very large quantities (5.5MM)** **Deemed NTGR for LEDs based on PY7 Research:** **NTG LED Bulbs: 0.73** **NTG LED Fixtures: 0.73** **PY7 NTG Research:** PY7 NTG LED Bulbs: 0.73 FR LED Bulbs: 0.44 SO LED Bulbs: 0.17 PY7 NTG LED Fixtures: 0.73 FR LED Fixtures: 0.44 SO LED Fixtures: 0.17
EPY9	**LEDs primary bulb type sold through the program (17MM of 20MM bulbs and fixtures)** **Deemed NTGR for LEDs based on PY8 Research (preliminary bulb weighting, final bulb weighting decreased NTG for Directional LEDs to 0.58):** **NTG LED Bulbs – Omnidirectional: 0.58** **NTG LED Bulbs – Directional: 0.60** **NTG LED Fixtures: 0.73 (from PY7 research)** **PY8 NTG Research:** PY8 NTG LED Bulbs – Omni-Directional: 0.58 FR LED Bulbs – Omni-Directional: 0.49 Participant spillover LED Bulbs – Omni-Directional: 0.009 Nonparticipant spillover LED Bulbs – Omni-Directional: 0.065 PY8 NTG LED Bulbs – Directional: 0.60 (preliminary, fell to 0.58 with final program weighting) FR LED Bulbs – Directional: 0.42 (increased to 0.45 with final program weights) Participant spillover LED Bulbs – Directional: 0.009 Nonparticipant spillover LED Bulbs – Directional: 0.014 (increased to 0.26 with final program weighting) PY7 NTG LED Fixtures: 0.73 FR LED Fixtures: 0.44 SO LED Fixtures: 0.17

	Residential Lighting – Smart Lighting Discounts – LED Lamps and Fixtures
EPY10	**NTG Standard CFL: 0.54** **NTG Specialty CFL: 0.43** **NTG CFL Fixtures: 0.56** **NTG LED Bulbs – Omnidirectional: 0.58** **NTG LED Bulbs – Directional: 0.58** **NTG LED Fixtures: 0.73** **NTG Coupon: As above** **PY8 NTG Research:** NTG Standard CFL: 0.54 Free Ridership Standard CFL: 0.47 Participant Spillover Standard CFL: 0.004 Nonparticipant Spillover Standard CFL: 0.010 PY6 NTG Specialty CFL: 0.43 Free Ridership Specialty CFL: 0.59 Spillover Specialty CFL: 0.02 PY6 NTG CFL Fixtures: 0.56* (no research in PY7, PY8 SAG Consensus Value) CFL Fixtures FR: none CFL Fixtures SO: none PY8 NTG LED Bulbs – Omni-Directional: 0.58 FR LED Bulbs – Omni-Directional: 0.49 Participant spillover LED Bulbs – Omni-Directional: 0.009 Nonparticipant spillover LED Bulbs – Omni-Directional: 0.058 PY8 NTG LED Bulbs – Directional: 0.58 FR LED Bulbs – Directional: 0.45 Participant spillover LED Bulbs – Directional: 0.009 Nonparticipant spillover LED Bulbs – Directional: 0.026 PY6 NTG LED Fixtures: 0.73 FR LED Fixtures: 0.44 SO LED Fixtures: 0.17 **NTG Research Source:** PY8 In-store intercept survey, results weighted on verified savings.