Opinion Dynamics

Table of Figures

Figure 2-1. Installation Rate Components 13
Figure 2-2. Breakdown of Free-Ridership Rates 22
Figure 2-3. Participation Over Time 25
Figure 2-4. Participant Lighting Awareness and Usage 28
Figure 2-5. Pre-Program LED Saturation 28
Figure 2-6. Bulb Mix in Participant Homes 29
Figure 2-7. Product Mix by Room Type 30
Figure 2-8. Cross-Program Awareness 31
Figure 2-9. Cross-Program Participation 32
Figure 2-10. Satisfaction with Shipping Timelines 32
Figure 2-11. Satisfaction Ratings 33
Figure 3-1. Installation Rate Components 51
Figure 3-2. Breakdown of Free-Ridership Rates 61
Figure 3-3. Sales of Program Bulbs Over Time 67
Figure 3-4. Program Pricing Analysis 68
Figure 3-5. Percent of Sockets Containing Technology 70
Figure 3-6. Bulb Mix in Participant Homes 71
Figure 3-7. Product Mix by Room Type 72
Figure 3-8. Sources of Program Awareness 73
Figure 3-9. Amount of Information Displayed on the Online Store Website 74
Figure 3-10. Ease of Understanding the Information on the Online Store Website 74
Figure 3-11. Shipping Timeline 75
Figure 3-12. Satisfaction with Shipping Timelines 75
Figure 3-13. Satisfaction Ratings 76

1. Introduction and Report Structure

This report presents evaluation results from two distinct components of Duke Energy Ohio (DEO) Energy Efficient Appliances and Devices program:

- Free LED program
- Online Savings Store program

Both of these programs offer energy efficient lighting products to DEO electric customers. The two programs are unique in their design and implementation. We conducted a separate evaluation of each program and present the evaluation results in separate sections. First, we present the evaluation results from the Free LED program. Following that are the evaluation results from the Online Savings Store program.

Appendix 1, accompanying this report, contains the evaluation details for the Free LED program, while Appendix 2 contains the results for the Online Savings Store program. Appendix 3 contains details from the LED Hours of Use (HOU) study that we conducted to support the development of the HOU and coincidence factors (CF) for both programs.

2. Free LED Program Evaluation Results

This section presents the evaluation methodology and results for the Free LED program.

2.1 Evaluation Summary

2.1.1 Program Summary

The DEO Free LED program represents a transition from the Free CFL program that Duke Energy had offered previously. The program started offering LEDs in January 2016. Select eligible customers received a business reply card (BRC) in the mail to redeem for a free kit with six 9-watt LEDs. During the program period under evaluation, eligible customers were ones who had not reached the 15-bulb maximum in the Free CFL program, as well as new customers in the jurisdiction. To better manage program budgets, program marketing and outreach was limited to the BRCs, which has been the only means of program participation as well.

Our evaluation covers the program period from February 29, 2016 through April 25, 2017.

2.1.2 Evaluation Objectives, Conclusions, and Recommendations

This evaluation of the Free LED program includes process and impact assessments and addresses several major research objectives:

- Assess program performance and estimate gross and net annual energy (MWh) and peak demand (MW) savings associated with program activity
- Assess program implementation processes and marketing strategies and identify opportunities for improvement
- Understand participant lighting awareness, preferences, and purchasing behaviors, and obtain insight into lighting market dynamics

To achieve these research objectives, the evaluation team completed a range of data collection and analytical activities, including interviews with program staff, a participant survey, program-tracking data analysis, an LED Hours of Use study, a deemed savings review, an impact analysis, and an analysis of the survey results. Through the primary data collection, the evaluation team developed estimates of LED HOU, LED coincidence factors, a first-year in-service rate (ISR) and net-to-gross ratio (NTGR). Table 2-1 provides an overview of the ex post gross savings parameters, the sample sizes used to develop those estimates, and the associated confidence and precision.

Table 2-1. Summary of Gross Savings Inputs Estimates

Parameter	Sample Size	Estimate	Relative Precision (at 90% Confidence)
LED HOU	118[a]	2.74	12%
LED summer peak CF	118[a]	0.07	16%
LED winter peak CF	118[a]	0.13	11%
First-year ISR	158	64.4%	7%
NTGR	397	51.6%	9%

[a] Number of loggers

From February 29, 2016 through April 25, 2017, DEO shipped 53,844 LED kits and a total of 323,064 LED bulbs. A total of 51,246 customers[1] participated in the program. Based on the estimated number of 135,565 households in the DEO jurisdiction,[2] 51,246 participants represent more than a third (38%) of the DEO customer base – a relatively broad reach of the program in the jurisdiction.

The program achieved 9,097 MWh in ex post gross energy savings, 0.75 MW in ex post gross summer peak demand savings, and 1.19 MW in winter peak demand savings. The program realized 56% of gross energy savings, 47% of gross summer peak demand savings, and 39% of gross winter peak demand savings.

While the overall ISR was high, at 83.3%, the first-year ISR was relatively low, at 64.4%, indicating that customers tended to store on average two of the six bulbs that they received through the program.

The program NTGR of 51.6% was low compared to the previous evaluation of this program, when CFLs were the program measure (86.1%). The decline in the NTGR is a likely result of increased customer knowledge of energy efficient lighting products and their benefits and positive results of the previous Free CFL program interventions. Free LED program participants were more likely to be homeowners, have higher-incomes and higher levels of education, than the overall population. All of these demographic groups had higher free-ridership (FR) and consequently lower NTGRs.

After applying the program NTGR to ex post savings, the program achieved 4,694 MWh in net energy savings, 0.39 MW in net summer peak demand savings, and 0.61 MW in net winter peak demand savings. Table 2-2 provides a summary of the program's gross and net impacts overall and by year in which the products were distributed.

Table 2-2. Overview of Program Impacts

Year	Metric	Ex Ante Results	Ex Post Gross Results	Gross Realization Rate	Ex Post Net Results	Net Realization Rate[a]
2016	Bulbs	297,240	297,240			
	Energy savings (MWh)	15,057	8,391	56%	4,330	33%
	Summer peak demand savings (MW)	1.47	0.69	47%	0.36	28%
	Winter peak demand savings (MW)	2.77	1.10	40%	0.57	24%
2017	Bulbs	25,824	25,824			
	Energy savings (MWh)	1308	705	54%	364	32%
	Summer peak demand savings (MW)	0.13	0.06	45%	0.03	27%

[1] A customer is defined as a unique account.

[2] https://censusreporter.org/profiles/16000US3915000-cincinnati-oh/.

Year	Metric	Ex Ante Results	Ex Post Gross Results	Gross Realization Rate	Ex Post Net Results	Net Realization Rate[a]
	Winter peak demand savings (MW)	0.24	0.09	38%	0.05	23%
Total	Bulbs	323,064	323,064			
	Energy savings (MWh)	16,365	9,097	56%	4,694	33%
	Summer peak demand savings (MW)	1.60	0.75	47%	0.39	28%
	Winter peak demand savings (MW)	3.01	1.19	39%	0.61	24%

Note that total savings, both gross and net, as well as realization rates, were developed using unrounded values.
[a] Denominator is ex ante net savings.

Table 2-3**Error! Reference source not found.** provides per-bulb ex post gross and net savings. As can be seen in the table, per-bulb ex post gross energy savings are 28.16 kWh and peak demand savings are 0.0023 kW and 0.0037 kW for summer and winter, respectively. Per-bulb ex post net energy savings are 14.53 kWh and peak demand savings are 0.0012 kW and 0.0019 kW for summer and winter, respectively.

Table 2-3. Per-Bulb Ex Post Gross and Net Savings

Per-Bulb Savings	Ex Post Gross Savings	Ex Post Net Savings
Energy savings (kWh)	28.16	14.53
Summer peak demand savings (kW)	0.0023	0.0012
Winter peak demand savings (kW)	0.0037	0.0019

Table 2-4 provides a second estimate of per-LED gross and net savings, representing savings claimable under Ohio Senate Bill 310 (SB 310). As can be seen in the table, DEO will claim 50.65 kWh in gross energy savings, 0.0049 kW in gross summer peak demand savings, and 0.0093 kW in gross winter peak demand savings per-LED. After applying the NTGR of 51.6%, DEO will claim 26.14 kWh in net energy savings, 0.0025 kW in net summer peak demand savings, and 0.0048 kW in net winter peak demand savings per-LED.

Table 2-4. Per-Bulb Gross and Net Savings Claimable Under SB 310

Savings Type	Per-Bulb Gross Savings Claimable Under SB 310	Per-Bulb Net Savings Claimable Under SB 310
Energy savings (kWh)	50.65	26.14
Summer peak demand savings (kW)	0.0049	0.0025
Winter peak demand savings (kW)	0.0093	0.0048

Note that both gross and net estimates incorporate ISR.

The program implementation processes ran smoothly and effectively, resulting in high levels of customer satisfaction with the program. Program-tracking data were complete and accurate. Instances of products mailed and installed outside of the DEO jurisdiction were minimal.

Recommendations

We recommend that Duke Energy calculates future savings from the Free LED program using the savings values claimable under Ohio Senate Bill 310 (SB 310).

To increase program efficacy, we recommend that the program deploys targeted marketing and outreach strategies aimed at increasing participation among lower-income customers and customers with lower levels of educational attainment, while also continuing to reach out to renters. Those customers are less likely to be free-riders and the program therefore will be more likely to affect change in their lighting preferences and behaviors. Such targeting can be achieved by overlaying census data with customer data and targeting customers in geographic units (such as census block groups) with higher shares of the desired segment. The evaluation team recognizes, however, the effort that may be required to effectively target those underserved segments without cannibalizing the savings from other programs, such as the multifamily program or the Low-Income program. Focusing on rental single-family properties, 2–4 unit properties, and areas with a high prevalence of moderate-income residents may present a "sweet spot" for the program. Deploying targeted marketing efforts is frequently more involved and therefore costly than relying on broader mass-marketing efforts.

To improve its first-year ISR and subsequently the overall ISR, we recommend that the program staff include collateral with the LED kits urging customers to install as many of the LEDs as possible by replacing working, less-efficient bulbs in their homes. This will help the program avoid the loss of energy and demand impacts from future installations due to EISA truncation. Based on the feedback from the program staff, it is our understanding that starting in the second quarter of 2018, the program collateral includes messaging emphasizing product installation and replacement.

2.2 Program Description

2.2.1 Program Design

Eligible customers can receive a free kit with six 9-watt LEDs per electric account. During the program period under evaluation, eligible customers were limited to DEO electric customers who had not reached the 15-bulb maximum in the Free CFL program, as well as new customers in the jurisdiction. To better manage program budgets, program marketing and outreach was limited to business reply cards (BRCs), which has been the only means of program participation as well.

Our evaluation covers a program period from February 29, 2016 through April 25, 2017.

2.2.2 Program Implementation

DEO manages the Free LED program and is responsible for selecting customers for the BRC mailing, sending BRCs, and maintaining the program-tracking database. AM Conservation Group (AMC) implements the Free LED program on behalf of DEO, handles fulfillment of customer orders, and maintains all order records. More specifically, AMC handles packing, shipping, and tracking orders, as well as any shipment or product issues. AMC provides daily updates on fulfilled orders and monthly reports on performance metrics to DEO.

Free LED program marketing has been focused and consisted of BRC outreach exclusively.

2.2.3 Program Performance

From February 29, 2016 through April 25, 2017, AMC shipped 53,844 LED kits with a total of 323,064 LEDs. Table 2-5 provides a summary of shipments, bulbs, and energy and demand savings achieved during the program period.

Table 2-5. Summary of Program-Tracking Data for Program Period

Parameter	Result
Kits mailed	53,844
Bulbs mailed	323,064
Ex ante gross savings (MWh)	16,365
Ex ante gross summer coincident savings (MW)	1.60
Ex ante gross winter coincident savings (MW)	3.01

2.3 Key Research Objectives

This evaluation of the Free LED program includes process and impact assessments and addresses several major research objectives:

- Assess program performance and estimate gross and net annual energy (MWh) and peak demand (MW) savings associated with program activity
- Assess program implementation processes and marketing strategies and identify opportunities for improvement
- Understand participant lighting awareness, preferences, and purchasing behaviors, and obtain insight into lighting market dynamics

We designed our evaluation tasks based on the following impact-related research objectives:

- Estimate program ex post gross energy and demand savings
- Estimate program ex post net energy and demand savings
- Develop updated ISRs, HOU, summer peak CF (summer CF), and winter peak CF (winter CF)

We estimated savings using the Uniform Methods Project (UMP) recommended approach, which satisfies the Ohio Public Utilities Commission requirements for lighting savings evaluations. Per the UMP protocols, energy savings calculations include delta watts and ISR. The evaluation also provides process and market information that DEO can use to modify the design of the program in a rapidly changing lighting market.

As part of the process assessment, we explored the following research questions:

- What are the sources of program information?
- How effective are the program implementation and data tracking practices?
- What is the program's reach? What percentage of DEO's customer base has participated in the programs?

- Are participants satisfied with their program experiences?
- How effective are the program's marketing, outreach, and educational tactics?
- What customer segments should the program target to minimize FR?
- What are participant lighting preferences and purchase behaviors?

2.4 Overview of Evaluation Activities

To answer the research questions listed in the previous section, the evaluation team performed a range of data collection and analytical activities. Table 2-6 provides a summary of evaluation activities and associated areas of inquiry. Following the table, we provide detail on each activity's scope, sampling approach (if applicable), and timing of the activity.

Table 2-6. Overview of Evaluation Research Activities

#	Evaluation Activity	Scope	Impact	Process/ Market	Purpose of Activity
1	Program staff interviews	n=2		X	Provide insight into program design and delivery Support process assessment
2	Materials review	All materials provided	X	X	Provide insight into program design and delivery Inform previously used and alternative savings assumptions
3	Deemed savings review	All data provided	X		Review accuracy and appropriateness of energy savings assumptions and determine alternative savings inputs
4	Impact analysis	All data provided	X		Calculate gross and net energy and demand savings
5	Participant survey	n=402	X	X	Estimate first-year ISR Estimate FR and spillover (SO) Assess participant lighting knowledge and preferences Support process assessment
6	LED HOU study	n=43 (HOU, CF) n=46 (lighting composition)	X	X	Estimate HOU and CFs for LEDs installed in customer homes Assess lighting composition and use among participants

2.4.1 Program Staff Interviews

The evaluation team completed the initial interview with program staff at Duke Energy early in the evaluation process in August 2016 and then followed up with a brief interview in January 2017. The interviews explored changes in program design and implementation, program performance, incentivized product specifications, and data tracking and communication processes, among other topics.

2.4.2 Materials Review

In support of the impact and process evaluation, the evaluation team reviewed program materials and data, including marketing materials, plans, and past evaluation reports and research studies. This information informed our research design, provided insight into program design and delivery, and supported the assessment of program impacts.

2.4.3 Deemed Savings Review

In support of the impact evaluation, the evaluation team reviewed program-tracking databases and energy savings assumptions. The objectives of the review were to identify the deemed savings values that DEO used to calculate impacts; review the deemed savings values for reasonableness; verify their accurate application; and identify data gaps, omissions, inconsistencies, and errors.

To assess the reasonableness of the savings assumptions, we reviewed past evaluations of the DEO Residential lighting programs, the Ohio Technical Reference Manual (TRM), and evaluation reports and TRMs from other jurisdictions, as well as ongoing evaluations in Ohio.

As part of the deemed savings review process, we also checked program-tracking data for accuracy, consistency, and completeness.

2.4.4 Impact Analysis

The impact analysis included calculating ex post gross and net program savings using updated savings assumptions. We calculated savings using the UMP recommended approach.

2.4.5 Participant Survey

The evaluation team completed a mixed-mode (telephone and online) survey with a representative sample of DEO Free LED program participants. The key goals of the survey were to gather information to support the assessment of gross impacts, program attribution, program processes, and market dynamics. Specifically, we used the survey results to produce updated estimates of the first-year ISR, FR, SO, lighting knowledge and preferences, and participant experiences with the program.

Sample Design and Fielding

For most customers, lighting products are a low-cost and low-importance purchase. Therefore, when using the self-report method to estimate program FR, it is best to conduct interviews with participants as close to their participation as possible to facilitate accurate recall of the factors that affect bulb purchase or order decisions. On the other hand, it is best to let some time pass when measuring SO effects and first-year ISR so that participants have time to install the products and take additional program-induced actions.

To address these competing priorities, Opinion Dynamics conducted the participant survey in waves and staggered the timing of the interviews based on the survey objective. We drew one sample from the most recent participants to estimate FR and a separate sample from earlier participants to estimate SO and ISR. The phased approach to survey administration is more accurate than if we relied just on the most recent participants and extrapolated the results to all participants regardless of when they participated.

We completed a total of three waves of the participant survey equally timed over the course of the program period. We administered the first wave in December 2016, the second wave in March and April 2017, and the third wave in May and June 2017.

For each wave, we used two distinct sample frames from which we drew a random sample of program participants. The sample frame used to estimate FR included customers who participated in the program during the 3 months prior to the survey. The sample frame used to estimate SO and ISR included customers who participated in the program between 3 months and 6 months prior to the survey fielding date.

We completed a total of 402 interviews over the course of the three waves. Overall, 247 interviews supported the FR estimate and 155 interviews supported the estimate of SO and ISR. We used all survey respondents to assess program processes

Table 2-7. Participant Survey Sample Sizes and Number of Completed Interviews by Sample Frame

Sample Frame	Sample Frame Size[a]	Sample Size	Number of Completed Interviews[b]
FR	31,598	1,385	247
SO/ISR	29,469	1,080	155
Total	**50,566**	**2,465**	**402**

[a] Note that total sample frame does not equal the sum of FR and SO sample frames, because from one survey wave to the next all or a portion of participants in the FR sample frame could become a part of the SO sample frame.
[b] Please note that seven additional participants completed the survey but did not receive either the FR or SO modules. Those participants did not verify their participation in the program. Their responses are used in our calculation of the ISR only.

We sent participants either mail or email invitations and reminders to take the survey depending on the availability of email addresses; participants could choose to take the survey online or call our phone center to take it over the telephone. Participants who did not have an email address on file received an invitation letter and two postcard reminders in the mail, while participants with email addresses received invitations and reminders via email. To increase response rates, we offered participants incentives in the form of several cash prize drawings.

Survey Dispositions and Response Rate

Table 2-8 provides the final survey dispositions.

Table 2-8. Participant Survey Disposition Summary

Disposition	Count
Completed interviews	**402**
Internet survey complete	333
Phone survey complete	69
Partial interviews	**21**
Household with undetermined survey eligibility	**2,024**
Partial complete - survey eligibility unknown	14
Answering machine	17
Not available	1
Language problems	1

Disposition	Count
Respondent scheduled appointment	1
Non-specific callback	3
Initial refusal	6
Added to DNC list	2
No response	1,979
Undetermined if eligible household	**1**
No answer	1
Survey-ineligible household	**5**
Known ineligible (screened out)	5
Not an eligible household	**12**
Bounced email	11
Customer indicated called already	**1**
Total participants in sample	**2,465**

We calculated response rates using the Response Rate 3 (RR3) methodology specified by the American Association of Public Opinion Research (AAPOR). We achieved a 17% survey response rate. We do not report a cooperation rate – the proportion of participants who *completed* the survey out of all eligible participants *contacted* – because it is difficult to estimate it accurately with both mailed and emailed survey invitations. While we recorded returned mail invitations and bounce-back email invitations, we cannot say with certainty that the ones that were not returned were received and opened by qualified participants. Therefore, we do not have an accurate number of eligible contacted participants to use to calculate a cooperation rate.

Survey Data Weighting

The survey sample resembled the participant population across a range of known participant characteristics; therefore, there was no need to apply post-stratification weights.

Targeted and Achieved Confidence and Precision

The evaluation targeted 10% precision at a 90% confidence level for both first-year ISR and NTGR. These precision goals were met (Table 2-9)

Table 2-9. Precision and Margin of Error at 90% Confidence for First-Year ISR and NTGR

Metric	Relative Precision
First-year ISR	7%
NTGR	9%

2.4.6 LED HOU Study

Opinion Dynamics completed a lighting logger study among Free LED and Online Savings Store program participants who had LED bulbs installed. The key goal of the study was to estimate HOU and CFs for LEDs. As part of the study, we also collected valuable data on lighting socket composition, which allowed us to assess and characterize lighting usage in participant homes. This study was the first study in Ohio that yielded LED-specific estimates of HOU and CF. Previous studies completed in Ohio were focused on CFLs.

As part of the study, we conducted a lighting inventory and deployed loggers in homes of a representative sample of 101 participants, of which 46 participated in the Free LED program and 56 participated in the Online Savings Store program. The analysis of lighting product mix is based on all 101 participants, while the analysis of HOU and CFs is based on 96 participants, 43 from the Free LED and 53 from the Online Store program. We did not include five participants in the analysis because of issues with logger data quality. Appendix 3, provided with this report, details the study's methodology and results.

The evaluation targeted 10% precision at a 90% confidence level for LED HOU and CF, both summer and winter, across the two programs – Free LED and Online Savings Store. These precision goals were met. Precision estimates around program-specific results are slightly worse than 90/10 (Table 3-10). Despite slightly worse than 90/10 relative precision around the Free LED program specific HOU and CF, Opinion Dynamics used those when calculating energy and demand impacts from the program.

Table 2-10. Precision and Margin of Error at 90% Confidence for LED HOU and CF

Statistic	Total			Free LED			Online Store		
	# of Loggers	Result	Relative Precision	# of Loggers	Result	Relative Precision	# of Loggers	Result	Relative Precision
HOU	300	**2.66**	7%	118	**2.74**	12%	182	**2.43**	9%
Summer CF		**8%**	10%		**7%**	16%		**11%**	12%
Winter CF		**14%**	6%		**13%**	11%		**16%**	8%

2.5 Impact Evaluation

This section describes the methodology for conducting the gross impact analysis and the results of the analysis. The evaluation team completed the following activities:

- Reviewed program-tracking data and savings assumptions for accuracy, completeness, and consistency
- Conducted engineering analysis of energy and demand savings and developed ex post gross savings estimates based on the UMP

2.5.1 Methodology

The evaluation team reviewed reported savings assumptions and verified that the algorithms and inputs used to calculate those assumptions were in line with the previous evaluation's recommendations.

As part of the impact evaluation, we conducted a deemed savings review through which we identified the deemed savings values that DEO used to calculate program savings; reviewed the deemed savings values for reasonableness; verified their accurate application; and identified data gaps, omissions, inconsistencies, and errors. As part of the deemed savings review process, we also checked program-tracking data for accuracy, consistency, and completeness.

To assess the reasonableness of the savings assumptions, we reviewed past evaluations of the DEO Residential lighting programs, the Ohio TRM, and evaluation reports and TRMs from other jurisdictions, as well as ongoing evaluations in Ohio.

We developed a program-specific estimate of first-year ISR using the participant survey and program-specific estimates of HOU and CF using the LED HOU study.

We estimated savings using the UMP recommended approach. Per the UMP protocols, energy savings calculations include delta watts and ISR. Equation 2-1 provides the formula that we used to estimate energy savings, while Equation 2-2 provides the formula that we used to estimate demand savings.

Many upstream lighting programs[3] also account for leakage of discounted products outside of the utility service territory and for installation of program-discounted lighting in commercial applications. Leakage results in decreased savings, whereas installations in commercial applications lead to higher savings. Unlike upstream residential lighting programs that often have little control over who purchases discounted lighting products, DEO's Free LED program tightly controls who receives program LEDs and where customers can receive their LEDs, thus making leakage to non-DEO customers and installations in commercial applications unlikely. We explored the incidence of leakage and commercial installations through the participant survey and found that both were minimal (see Section 2.5.1 of this report). Therefore, we chose not to revise the equation to add a separate adjustment factor for leakage. However, we did account for program bulb leakage outside of the DEO service territory as part of the ISR by removing these bulbs from the installed base. This resulted in only a negligible change to the ISR. We also did not apply a separate set of savings assumptions to account for installations in commercial applications because of the minimal number of bulbs installed in such applications.

Equation 2-1. Algorithm for Energy Savings

$$\Delta kWh = ISR * \frac{(Watts * HOU)_{base} - (Watts * HOU)_{ee}}{1{,}000} * 365 * (1 + HVAC_c)$$

Equation 2-2. Algorithm for Peak Demand Savings

$$\Delta kW = ISR * \frac{Watts_{base} - Watts_{ee}}{1{,}000} * CF * (1 + HVAC_d)$$

Where:

ΔkWh = first-year electric energy savings
ΔkW = peak electric demand savings
ISR = in-service rate
$Watts_{base}$ = baseline wattage
$Watts_{ee}$ = efficient bulb wattage
HOU = residential annual operating hours
CF = peak coincidence factor
$HVAC_c$ = HVAC system interaction factor for energy
$HVAC_d$ = HVAC system interaction factor for demand

Table 2-11 presents a summary of the inputs used to calculate program gross energy and demand impacts and specifies the sources of the inputs. Following the table, we detail the source(s) behind each input and the rationale for the input selection. For reference purposes, Table 2-11 also provides savings assumptions used to estimate ex ante energy and demand savings.

[3] Upstream lighting programs provide incentives to retailers and manufacturers who, in turn, pass them on to customers in the form of price markdowns.

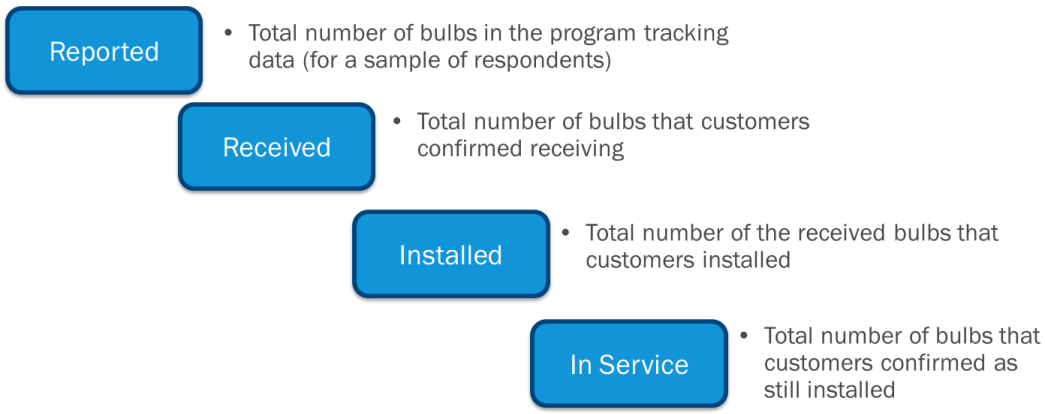
Table 2-11. Summary of Gross Savings Inputs

Parameter	Ex Ante Assumption	Ex Post Assumption	Ex Post Assumption Source
Baseline wattage	47.69	43	Shelf studies in the region
LED wattage	9	9	Actual bulb wattage
Average daily HOU	2.47	2.74	2017 DEO LED HOU Study
CF – summer	0.10%	0.07%	
CF – winter	0.096%	0.13%	
ISR	91.3%	83.3%	■ Free LED Participant Survey for first-year ISR (including leakage) ■ UMP recommendations for installation trajectory ■ DEO-specific discount rates to discount future savings
Interactive effects for energy ($HVAC_c$)	−0.0058	−0.0058	2012 DEO Smart $aver Program Evaluation
Interactive effects for summer peak demand ($HVAC_d$)	0.167	0.167	
Interactive effects for winter peak demand ($HVAC_d$)	0	0	Not used

In-Service Rate

We relied on the participant survey results to estimate the first-year ISR for the program. We administered the survey in three waves from December 2016 through June 2017 to capture participation over the course of the program period. As part of the survey, we asked program participants how many of the program bulbs they installed and how many were currently installed. We calculated the first-year ISR by dividing the total number of program LEDs reported in service by the total number of LEDs reported in the program-tracking database. We incorporated the receipt, installation, and persistence of program LEDs into the first-year ISR, as can be seen in Figure 2-1 below.

Figure 2-1. Installation Rate Components



The evaluation resulted in a first-year ISR of 64.4%. Relative precision around this point estimate is 7% at 90% confidence (Table 2-12).

Table 2-12. First-Year ISR

Metric	Total
n	158
First-year ISR	64.4%
Relative precision (at 90% confidence)	7%

Research studies across the country have found that, while customers may not install all of the program bulbs in the year that they receive them, they eventually install nearly all bulbs. Evaluators therefore need to account for those future savings in order to give the program proper credit for all the savings that it ultimately achieves. The two main approaches to claiming savings from these later installations are (1) staggering the savings over time and claiming some in later program years (staggered approach) and (2) claiming the savings from the expected installation in the program year that the customers received the product but discounting the savings by a societal or utility discount rate (discounted approach).

As part of our evaluation, we used the discounted approach. To allocate installations over time, we used the installation trajectory recommended by the UMP. The trajectory is based on a recent LED-specific Massachusetts study, which found that 24% of the LEDs that went into storage in year 1 were installed in year 2. Because the study is still ongoing, with only 2 years of data available at the time of the revised UMP publication, the UMP recommends that evaluators assume that customers continue to install LEDs in storage at a rate of 24% each year to estimate lifetime ISR. Table 2-13 shows the UMP-recommended installation rate trajectory, both incremental and cumulative.

Table 2-13. Installation Rate Trajectory

Year	Incremental ISR	Cumulative ISR
Year 1	Year 1 ISR	Year 1 ISR
Year 2	(1 – Year 1 ISR) * 24%	Year 1 ISR + Year 2 ISR
Year 3	(1 – Year 1 ISR – Year 2 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR
Year 4	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR
Year n	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR – … Year n ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR + …. Year n ISR

The UMP also recommends truncating the ISR trajectory to account for the impact of the second phase of EISA implementation, which goes into effect on January 1, 2020. The second phase increases the efficiency requirements of general service lightbulbs to 45 lumens per watt, which is effectively an energy efficient bulb. The UMP instructs evaluators to stop claiming savings from bulbs still in storage sometime after 2020, as the baseline for program LEDs will be an efficient bulb, thus resulting in no savings. We followed the UMP recommendations but set the truncation period starting in 2021, which allows for a 1-year sell-through period of noncompliant products. As a result, we claimed savings over 5 years for those products sold in 2016 and over 4 years for those sold in 2017.

Consistent with the discounted approach, we discounted the savings by the utility discount rate for future installations (see Equation 2-3). We used the DEO-specific discount rate of 8.10%.

Equation 2-3. Net Present Value Formula

$$NPV = \frac{R_t}{(1+i)^t}$$

Where:

R = savings
t = number of years in the future savings take place
i = discount rate

We made an additional adjustment to the installation trajectory to account for bulbs that participants never received. This adjustment was necessary because the installation rate trajectory assumes that light bulbs were acquired (purchased), and we found that not all program bulbs were received (and therefore could not be considered acquired). We made an additional adjustment to account for the program LEDs installed outside of the DEO jurisdiction (leakage) as part of the ISR. We assessed leakage through the participant survey and determined it to be minimal, at 1.2%. Table 2-14 provides a cumulative installation rate trajectory that we used to allocate savings over time. As can be seen in the table, the overall ISR for bulbs distributed in 2016 is 83.5%, while the overall ISR for bulbs distributed in 2017 is 80.8%. The overall ISR for all products distributed over the program period under evaluation is 83.3%

Table 2-14. Cumulative Installation Rate Trajectory

Program Year	Bulbs Distributed in 2016	Bulbs Distributed in 2017	Total
2016	63.6%	--	
2017	71.5%	63.6%	
2018	76.9%	71.5%	
2019	80.8%	76.9%	
2020	83.5%	80.8%	83.3%

Baseline Wattage

The kits distributed through the program contained LEDs that are the equivalent of 60-watt incandescents in terms of lumen output. The 2007 EISA required a gradual phase-out of general service incandescent products, which affects the baseline wattage that can be used to estimate energy savings. Manufacturers complied with EISA by creating a halogen bulb that met the efficiency requirements, effectively making halogens the new baseline. The EISA regulations affected 60-watt incandescent products in January 2014, but manufacturers and retailers were allowed to sell their existing inventory of incandescents, so products did not immediately disappear from the market. However, given that the program period under evaluation started in February 2016, it is unlikely that 60-watt incandescent light bulbs are available for purchase in the DEO jurisdiction. In fact, recent shelf stocking studies conducted in the region show that 60-watt incandescent products are very limited in availability on store shelves. As a result, we used the equivalent halogen wattage of 43 watts as the baseline wattage for program LEDs.

LED Wattage

LED wattage was based on the wattage of the actual bulbs distributed by the program during the evaluation period. Program kits featured 9-watt LEDs exclusively.

Hours of Use and Coincidence Factors

The industry standard to estimate HOU is to conduct lighting logger studies. As part of this evaluation, Opinion Dynamics completed an LED-specific HOU study in the DEO jurisdiction. As part of the study, we metered LED usage across a representative sample of 300 switches in the homes of 96 customers[4] who participated in the Free LED and Online Savings Store programs over the course of 2016. Of the 96 homes, 43 homes participated in the Free LED program. Across those homes, we deployed loggers on 118 switches with LEDs. Table 2-15 provides LED HOU and CF estimates from the study. Appendix 3, provided alongside this report, details the study's methodology and results.

Table 2-15. LED HOU and CF Assumptions

Statistic	LED Value
HOU	2.74
Summer CF	0.07
Winter CF	0.13

Interactive Effects

LEDs emit less heat than incandescents, resulting in increased heating loads, as more energy is needed to supplement heat emitted by incandescent light bulbs. LEDs also decrease cooling loads, as less energy is needed to compensate for heat given off by incandescents. Application of interactive effects accounts for the changes in heating and cooling loads in the estimation of savings.

The evaluation team chose to use the interactive effects for energy and summer demand estimated as part of the 2012 evaluation of the Process and Impact Evaluation of the Residential Smart $aver Energy Efficiency Products (CFL) Program in Ohio program by TecMarket Works. The interactive effects were taken from U.S. Department of Energy (DOE)-2 simulations of the residential prototype building and adjusted using customer-specific HVAC system information collected through Duke Energy's appliance saturation survey in Ohio. As such, these values more accurately represent the participant population than the deemed values in the Ohio TRM, which do not take into account the specifics of the DEO heating and cooling system specifics, and are therefore preferable to the TRM values.

Interactive factors for winter peak demand were not estimated as part of the most recent evaluations of the Residential CFL program, and reasonable and recent estimates from similar areas are not available because utilities in the Midwest are not winter peaking. We decided to use a factor of 0 (zero), which assumes that there is no electric heat loss due to the installation of program LEDs. Based on the results from the 2010–2013 American Community Survey, we estimate that fewer than one-third of homes in DEO service territory are electrically heated.

[4] Loggers were originally deployed in 101 homes. Loggers from five homes were dropped during the data cleaning and analysis process due to data quality reasons.

Table 2-16. Interactive Effects

Interactive Effect	Value
Interactive effects for energy ($HVAC_c$)	−0.0058
Interactive effects for summer peak demand ($HVAC_d$ – summer)	0.167
Interactive effects for winter peak demand ($HVAC_d$ – winter)	0

Due to differences in technologies, interactive effects caused by CFLs and LEDs are likely different. Furthermore, a change in interactive effects due to a shift in the baseline technology from incandescents to halogens is also possible. However, the difference in these effects is unclear, especially as it pertains to the DEO jurisdiction. We are unaware of any existing modeling or simulation efforts to estimate LED-specific interactive effects or interactive effects using halogens as the baseline. In our professional judgment, the difference between CFL and LED interactive effects is likely to have only a marginal impact on energy and peak demand savings. Given the small anticipated change in energy and peak demand savings estimates due to LED-specific interactive effects, and the relatively high cost of conducting the modeling and simulation needed to estimate those interactive effects, Opinion Dynamics relied on the previously established interactive effect estimates for CFLs from the sources cited above.

2.5.2 Gross Impact Results

The evaluation team received program-tracking data in two extracts. One extract contained product and shipment information and the other contained customer contact information. The shipment data extract did not contain participant contact information (phone numbers and email addresses) that is critical for conducting a participant survey. As such, we merged shipment information with customer information using the customer account number as the linking unique identifier.

Upon merging the program-tracking data files, the evaluation team analyzed the data for any gaps and inconsistencies. As part of the analysis, we performed the following steps:

- Checked the core data fields for missing values[5]
- Checked the data for temporal gaps (due to missing invoices, transactions, or other data gaps) by exploring reasonable variation in monthly invoiced sales

We found that necessary data fields were clean, fully populated, and contained all necessary information to proceed with the impact analysis.

Using the equations and inputs discussed in Section 2.5.1, we calculated gross energy and peak demand savings achieved by the program during the evaluation period. Table 2-17 presents the results of the analysis. The Free LED program realized 56% of the reported gross energy savings, 47% of the reported summer peak demand savings, and 39% of the reported winter peak demand savings.

[5] This excludes the email address data field, as we expect that not every participant would have provided his or her email address.

Table 2-17. Gross Impact Results

Year	Metric	Ex Ante Savings	Ex Post Gross Savings	Gross Realization Rate
2016	Bulbs	297,240	297,240	
	Energy savings (MWh)	15,057	8,391	56%
	Summer peak demand savings (MW)	1.47	0.69	47%
	Winter peak demand savings (MW)	2.77	1.10	40%
2017	Bulbs	25,824	25,824	
	Energy savings (MWh)	1308	705	54%
	Summer peak demand savings (MW)	0.13	0.06	45%
	Winter peak demand savings (MW)	0.24	0.09	38%
Total	Bulbs	323,064	323,064	
	Energy savings (MWh)	16,365	9,097	56%
	Summer peak demand savings (MW)	1.60	0.75	47%
	Winter peak demand savings (MW)	3.01	1.19	39%

Note that gross savings and gross realization rate were developed using unrounded values.

Using total ex post gross energy and demand savings, the evaluation team calculated per-bulb savings (Table 2-18). To develop program-level gross impacts for regulatory compliance, the evaluation team compared ex ante and ex post gross savings and used the higher of the two values. Section 2.7 details the process for developing those impacts and presents the results.

Table 2-18. Per-Bulb Gross Savings

Year	Savings Type	Ex Ante Gross Per-Bulb Savings	Ex Post Gross Per-Bulb Savings
2016	Energy savings (kWh)	50.65	28.23
	Summer peak demand savings (kW)	0.0049	0.0023
	Winter peak demand savings (kW)	0.0093	0.0037
2017	Energy savings (kWh)	50.65	27.31
	Summer peak demand savings (kW)	0.0049	0.0022
	Winter peak demand savings (kW)	0.0093	0.0036
Total	Energy savings (kWh)	50.65	28.16
	Summer peak demand savings (kW)	0.0049	0.0023
	Winter peak demand savings (kW)	0.0093	0.0037

2.5.3 References

Opinion Dynamics. *Impact and Process Evaluation of the 2015 Illinois Power Agency Residential Lighting Program.* Prepared for Ameren Illinois. March 9, 2017.

TecMarket Works. *Process and Impact Evaluation of the Residential Smart $aver Energy Efficiency Products (CFL) Program in Ohio*. Prepared for Duke Energy Ohio. September 28, 2012.

National Renewable Energy Laboratory (NREL). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Protocol.* October, 2017. https://www.nrel.gov/docs/fy17osti/68562.pdf

Environmental Protection Agency. *Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment.* October 1, 2011. *https://www.energystar.gov/ia/partners/manuf_res/downloads/lighting/EPA_Report_on_NGL_Programs_for_508.pdf.*

ENERGY STAR. *ENERGY STAR Program Requirements for Lamps (Light Bulbs).* September 30, 2014. *http://www.energystar.gov/products/spec/sites/products/files/ENERGY%20STAR%20Lamps%20V1.0%20Final%20Draft%20Specification.pdf.*

Department of Energy. *10 CFR Part 430. Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule.* July 14, 2009. *http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0131-0005.*

Opinion Dynamics. *Impact and Process Evaluation of the 2015 Illinois Power Agency Residential Lighting Program.* Prepared for Ameren Illinois. March 9, 2017. (http://ilsagfiles.org/SAG_files/Evaluation_Documents/Ameren/AIU_Eval_Reports_PY8/AIC-IPA_PY8_Residential_Lighting_Evaluation_Report_REVISED_FINAL_2017-09-12.pdf)

2.6 Net-to-Gross Analysis

This section describes our approach for estimating the NTGR for the Free LED program and presents the resulting NTGR and the program net impacts.

2.6.1 Methodology

The NTGR represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTGR represents the share of program-induced savings. The NTGR consists of FR and SO and is calculated as $(1 - FR + SO)$. FR is the proportion of the program-achieved verified gross savings that would have been realized absent the program. There are two types of SO: participant and nonparticipant. Participant SO occurs when participants take additional energy-saving actions that are influenced by program interventions but that did not receive program support. Nonparticipant SO is the reduction in energy consumption and/or demand by nonparticipants because of the influence of the program.

As part of this evaluation, the evaluation team estimated FR and participant SO. Quantifying savings from nonparticipant SO activities is a challenging task that warrants a separate study and was outside of the scope of this evaluation effort. In addition, the Free LED program design is less likely to result in significant amounts of nonparticipant SO than upstream lighting programs that exist in the larger market. Both FR and

SO components of the NTGR were derived from self-reported information from web surveys and telephone interviews with program participants.

The final NTGR is the percentage of gross program savings that can reliably be attributed to the program. We estimated a separate NTGR for each participant, which we weighted to reflect the relative contribution of each participant's savings to the overall program estimate.

Below is a general overview of the method for developing FR and SO estimates. Appendix 1, provided along with this report, contains the participant survey instrument and detail behind the FR and SO algorithms.

Free-Ridership

Free-riders are program participants who would have installed high-efficiency light bulbs on their own without the program. FR represents the percent of savings that would have been achieved in the absence of the program. Through participant surveys, we asked program participants a series of structured and open-ended questions about the influence of the program on their decision to order and install program LEDs. The survey questions measured the following areas of program influence:

- **Influence on efficiency:** We asked participants what type of light bulbs they would have purchased the next time they needed light bulbs if they had not received free LEDs through the program
- **Influence on timing:** We asked participants who replaced working incandescent bulbs if they would have replaced working light bulbs on their own if they had not received free LEDs, of if they would have waited for the bulbs to burn out
- **Influence on quantity:** We asked participants whether they would have purchased fewer LEDs if they had purchased the bulbs on their own instead of receiving them for free through the program.

As part of the FR survey module, we referenced retail bulb pricing to ground participant responses.[6] To reduce measurement error, we included follow-up questions to check participant responses for consistency

Spillover

SO represents energy savings from additional actions (expressed as a percent of total program savings) that were due to the program but that did not receive program financial support. While SO can result from a variety of measures, it is not possible to ask about a large number of potential SO measures on a survey due to the need to limit the length of the survey. The evaluation team chose to focus on the measures that participants would reasonably take following their program participation and would do so without additional program support. As such, we focused SO questions on CFLs and LEDs. We asked participants if they purchased any CFLs or LEDs after receiving program CFLs and LEDs. We asked those who purchased additional bulbs about the degree to which the program influenced their decision to purchase high-efficiency bulbs as opposed to less-efficient alternatives. We asked participants to rate the degree to which the program influenced their purchase decision, as well as to provide a rationale for their rating. We carefully reviewed participant responses to establish eligibility for SO participants and purchases.

To estimate the SO rate, we estimated savings for each SO measure using the standard savings equation and a set of engineering assumptions. We determined the program-level SO rate by dividing the sum of SO savings by the ex post gross savings achieved by the sample of participants who received SO questions (Equation 2-4).

[6] We used a per-bulb price of $2 for CFLs and $4 for LEDs. CFL pricing is based on the current market data, while retail LED pricing was supplied by the program team.

Equation 2-4. SO Rate Formula

$$Spillover\ Rate = \frac{Spillover\ Savings}{Evaluated\ Gross\ Savings\ in\ the\ Respondent\ Sample}$$

2.6.2 NTG Results

We estimate the overall FR to be 51.0% and SO to be 2.6%. The resulting program NTGR for the evaluation period is 51.6%. Relative precision around this point estimate is 9% at 90% confidence. Table 2-19 provides FR results, along with SO and final program-level NTGR. We applied the overall program-level NTGR of 51.6% to ex post gross impacts to arrive at the ex post net impacts.

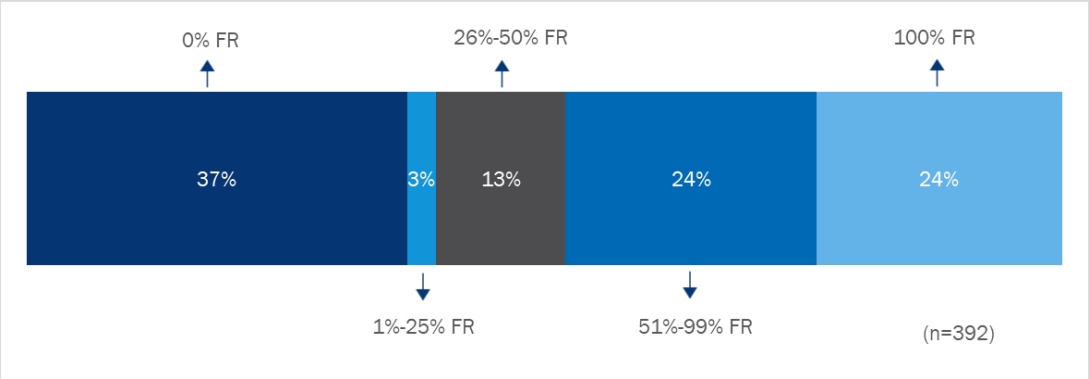
Table 2-19. NTG Results

NTG Component	n	Value	Relative Precision
FR	242	51.0%	9%
SO	155	2.6%	6%
NTGR	**397**	**51.6%**	**9%**

Free-Ridership

Our results show that FR rates varied across participants (see Figure 2-2). More than a third of participants (37%) are complete non-free-riders. That is, in the absence of the program's free LEDs, they would have purchased less-efficient alternatives, namely, halogens. At the opposite end of the FR spectrum, 24% are complete free-riders who reported that they would have purchased all of the LEDs that they received through the program on their own. A combined 40% of respondents are partial free-riders (FR between 1% and 99%). Participants could be partial free-riders for several reasons. Some of the partial free-riders are participants who reported that, in the absence of receiving the program's free LEDs, they would have purchased a mix of LEDs or CFLs and halogens the next time they needed to purchase light bulbs. Other partial free-riders are customers who reported that they would have purchased efficient bulbs (CFLs or LEDs) on their own but reported that the program motivated them to replace their working incandescent or halogen light bulbs with efficient bulbs, which they would not have done on their own. In essence, the program sped up their installation of energy efficient bulbs.

Figure 2-2. Breakdown of Free-Ridership Rates



The program NTGR of 51.6% is low compared to the previous evaluation of this program, when CFLs were the program measure (a NTGR of 86.1%) The decline in the NTGR is a likely result of the changing lighting market due, in part to increased customer knowledge of energy efficient lighting products and their benefits and positive results of the previous Free CFL program interventions. As compared to the general population of DEO customers, program participants are more likely to be homeowners and have higher incomes and higher levels of educational attainment, and all of these demographic groups have higher FR and consequently lower NTGRs. We discuss the differences in participant composition and their effect on FR in greater detail in Section 2.8.2 of this report.

Spillover

More than a quarter of the Free LED program participants (26%) purchased additional CFLs or LEDs since participating in the program. Overall, 7% of all participants qualified for SO by attributing these purchases to the experience with the Free LED program. The average SO participant purchased 5.9 bulbs that qualified for SO, most of those being LEDs.

2.6.3 Net Impact Results

Table 2-20 presents ex post gross and net savings, along with the net realization rates for the program period under evaluation. We developed net realization rates by dividing ex post net savings by program-reported net savings. We present net impact results by program year as well as overall. Overall, the program achieved 4,694 MWh in ex post net energy savings, 0.39 MW in ex post net summer peak demand savings, and 0.61 MW in ex post net winter peak demand savings, achieving 33%, 28%, and 24% net realization rates, respectively. The difference between the ex ante NTGR of 86.1% and the ex post NTGR of 51.6% drove the net realization rate further down.

Table 2-20. Ex Post Gross and Net Savings Evaluation Results

Year	Metric	Ex Post Gross Savings	Ex Post Net Savings	Net Realization Rate[a]
2016	Bulbs	297,240	297,240	
	Energy savings (MWh)	8,391	4,330	33%
	Summer peak demand savings (MW)	0.69	0.36	28%
	Winter peak demand savings (MW)	1.10	0.57	24%
2017	Bulbs	25,824	25,824	
	Energy savings (MWh)	705	364	32%
	Summer peak demand savings (MW)	0.06	0.03	27%
	Winter peak demand savings (MW)	0.09	0.05	23%
Total	Bulbs	323,064	323,064	
	Energy savings (MWh)	9,097	4,694	33%
	Summer peak demand savings (MW)	0.75	0.39	28%
	Winter peak demand savings (MW)	1.19	0.61	24%

Note that total savings, both gross and net, as well as net realization rate were developed using unrounded values.
[a] Denominator is ex ante net savings.

Table 2-21 presents per-bulb ex post net results for the Free LED program by year as well as overall. As can be seen in the table, per-bulb ex post net energy savings are 14.53 kWh, summer peak demand savings are 0.0012 kW, and winter peak demand savings are 0.0019 kW. To develop program-level net impacts for regulatory compliance, the evaluation team compared ex ante and ex post gross savings and multiplied the higher of the two by the program NTGR. Section 2.7 details the process for developing those impacts and presents the results.

Table 2-21. Per-Bulb Ex Post Net Impacts

Year	Savings Type	Ex Post Net Per-Bulb Savings
2016	Energy savings (kWh)	14.57
	Summer peak demand savings (kW)	0.0012
	Winter peak demand savings (kW)	0.0019
2017	Energy savings (kWh)	14.09
	Summer peak demand savings (kW)	0.0012
	Winter peak demand savings (kW)	0.0018
Total	Energy savings (kWh)	14.53
	Summer peak demand savings (kW)	0.0012

Year	Savings Type	Ex Post Net Per-Bulb Savings
	Winter peak demand savings (kW)	0.0019

2.7 Program-Level Impacts for Regulatory Compliance

In the state of Ohio, electric distribution utilities (EDUs), including DEO, are required to achieve a cumulative annual energy savings of more than 22% by 2027 per Ohio Senate Bill (SB) 310. SB 310 also introduced new mechanisms that adjust how EDUs may estimate their energy savings achieved through demand side management programs. Specifically, SB 310 requires the Ohio Public Utilities Commission (PUCO) to permit EDUs to account for energy-efficiency savings estimated on an "as-found" or a deemed basis. That is, an EDU may claim savings based on the baseline operating conditions found at the location where the energy-efficiency measure was installed, or the EDU may claim a deemed savings estimate.

To support compliance with SB 310, we developed a separate set of savings estimates. These estimates are based on the higher of ex ante and ex post savings values. We used the formula specified in the equation below to develop per-bulb gross impacts for SB 310 compliance.

Equation 2-5. Savings Estimation Approach for SB 310 Compliance Impacts

$$Sav_i = Max(ESTexante_i, ESTexpost_i)$$

Where:

Sav_i = Total annual savings for measure i

$ESTexante_i$ = Per unit ex ante deemed savings estimate for measure i (kW or kWh)

$ESTexpost_i$ = Per unit ex post deemed savings estimate for measure i (kW or kWh)

Table 2-22 provides per-bulb ex ante and ex post gross savings, as well as the per-bulb claimable savings under SB 310.

Table 2-22. Per-Bulb Ex Ante, Ex Post, and Claimable Under SB 310 Savings

Savings Type	Gross Per-Bulb Ex Ante Savings	Gross Per-Bulb Ex Post Savings	Gross Per-Bulb Savings Claimable Under SB 310	NTGR	Net Per-Bulb Savings Claimable Under SB 310
Energy savings (kWh)	50.65	28.16	50.65	51.6%	26.14
Summer peak demand savings (kW)	0.0049	0.0023	0.0049	51.6%	0.0025
Winter peak demand savings (kW)	0.0093	0.0037	0.0093	51.6%	0.0048

Note that both ex ante and ex post estimates incorporate ISR.

2.8 Process Evaluation

2.8.1 Methodology

The program process assessment leveraged the following data collection methods and research activities:

- Program staff interviews (n=2)
- Materials review
- Program-tracking data analysis
- Participant survey (n=402)
- LED HOU study (n=46)

We detailed each data collection method, as well as achieved confidence and precision, in Section 2.4 of this report.

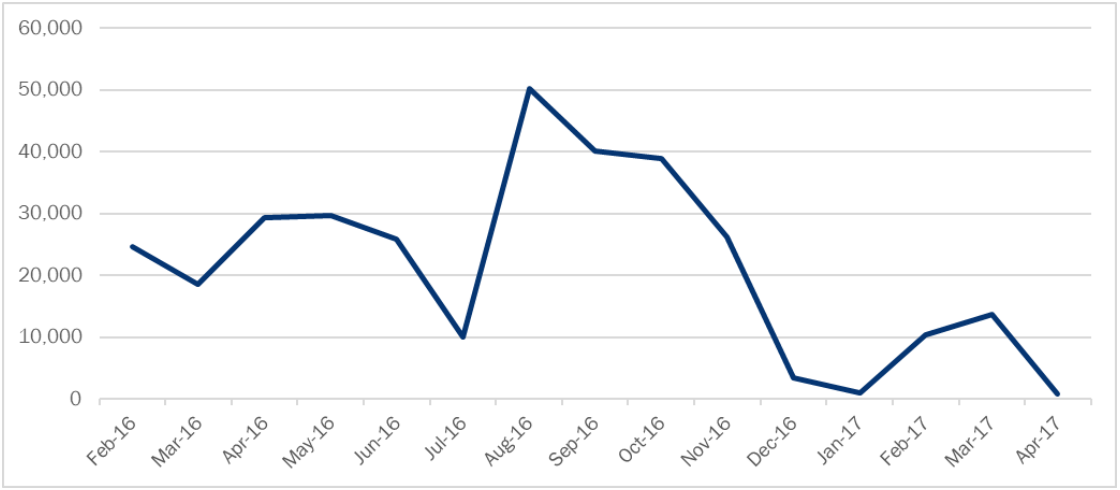
2.8.2 Key Findings

Program Performance

From February 29, 2016 through April 25, 2017, DEO shipped 53,844 LED kits and a total of 323,064 LED bulbs. A total of 51,246 customers participated in the program. Based on the estimated number of 135,565 households in the DEO jurisdiction, 51,246 participants represent more than a third (38%) of the DEO customer base—a relatively broad reach of the program in the jurisdiction.

Participation in the program varied over time. As can be seen in Figure 2-3, fluctuation in participation is due to the timing of the BRC mailings and the number of BRCs mailed.

Figure 2-3. Participation Over Time



No customers received more than six LEDs in a single order. However, 5% of customers received a total of 12 bulbs each over the course of the program under evaluation, and a select few (0.2%) received 18 bulbs

each. Customers receiving 12 bulbs reflected a change in the program implementation that allowed customers who had not reached their 15-bulb lifetime maximum to request and receive additional LEDs through the program for free.

Participant Composition

For the participant composition analysis, we compared participant sociodemographic and household characteristics gathered as part of the participant survey effort to the DEO population. We obtained population characteristics from the U.S. Census's American Community Survey (ACS) 2015 5-year data. As part of the analysis, we examined FR rates for each of the sociodemographic subgroups. The analysis allowed us to identify the customer types that the program is reaching and future targeting opportunities to improve the efficacy of the program in advancing energy efficiency in the jurisdiction.

Table 2-23 provides the results of the analysis. As can be seen in the table, during the program period under evaluation, program participant composition skews disproportionately toward older customers (67% of participants were over the age of 44 vs. 51% of the DEO customer base), homeowners (74% of program participants vs. 38% of the DEO customer base), customers with higher levels of education (44% of participants have at least a college degree vs. 37% of the DEO customer base), and customers with higher income levels (54% of participants have an annual income of at least $50,000 vs. 41% of the DEO customer base).

Disproportionate participation of homeowners, higher-income customers, and customers with higher education levels had a negative impact on the program's net impacts, because FR among those three customer groups is much higher than their respective counterparts. As can be seen in Table 2-23, FR among homeowners is 52%, while FR among renters is 47%. FR among customers with high school education or less is 42%, compared to the FR of 53% among those with some college, and 54% among those with at least a college degree. Similarly, FR among those with annual household incomes of less than $50,000 is 41%, while FRs among those with incomes of $50,000 to less than $100,000 and at least $100,000 are 59% and 64%, respectively.

These findings suggest that focusing program efforts on targeting customers in rental properties, lower-income customers, and customers with lower levels of educational attainment will help reduce the program FR rate, thus ensuring a more efficacious program. To avoid possible overlap with Duke Energy's multifamily program, which targets multifamily apartment complexes, the program should consider prioritizing rental single-family properties and rental units in smaller multifamily properties (fewer than five units, for example). The program could target customers living in census block groups with high concentrations of rental units and 2–4 unit properties.

Table 2-23. Comparison of Program Participants to DEO Population

Characteristic	FR	Participant Characteristics	Population Estimates
Age		**n=388**	**Census Data**
Under 25	43%	2%	9%
25-44	53%	31%	40%
45-64	49%	36%	32%
65+	51%	31%	19%
Home ownership		**n=400**	**Census Data**
Own	52%	74%	38%

Characteristic	FR	Participant Characteristics	Population Estimates
Rent	47%	26%	62%
Education		**n=396**	**Census Data[a]**
High school or less	42%	25%	37%
Some college	53%	31%	26%
College graduate +	54%	44%	37%
Income		**n=360**	**Census Data**
Under $50,000	41%	46%	59%
$50,000 to less than $100,000	59%	37%	25%
$100,000+	64%	17%	16%
Housing type		**n=402**	**Census Data**
Single-family	53%	77%	43%
Non-single-family (townhouse, mobile home, multi-family)	43%	23%	57%

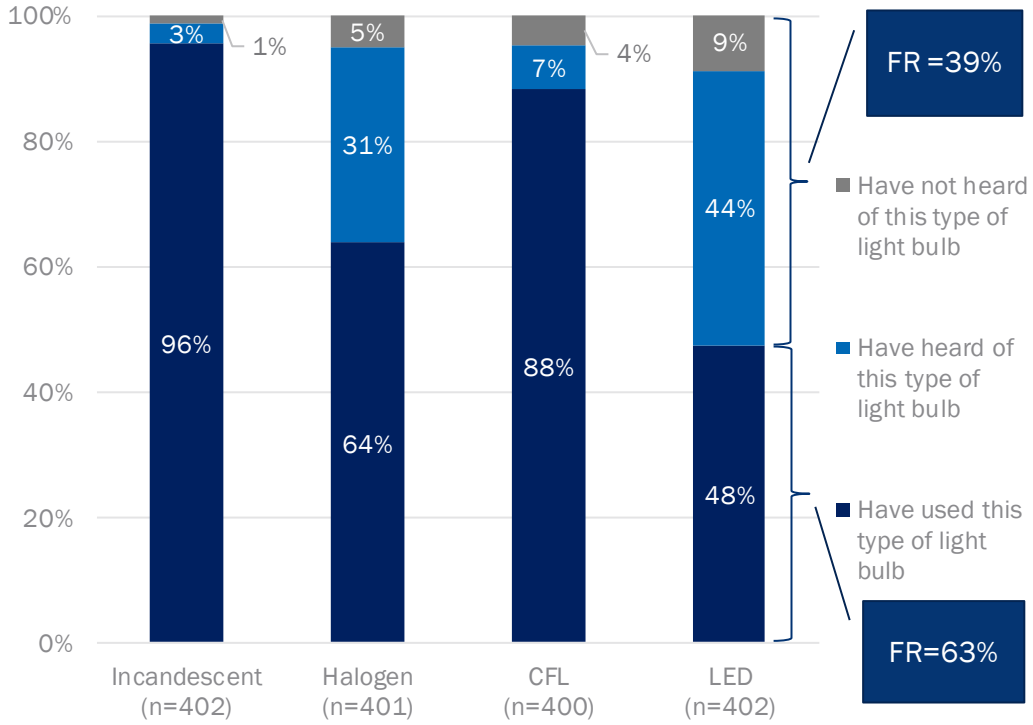
[a] Population-level estimate as opposed to the household-level estimate.

Participant Lighting Knowledge and Experience

As part of the participant survey, we explored participants' existing knowledge and experience with a variety of lighting products, along with their use of the various technologies. As can be seen in Figure 2-4, participants are knowledgeable and experienced with energy efficient technologies. More specifically, nearly all participants had heard of CFLs (95%) and 88% had used CFLs prior to participating in the program. Such high levels of previous CFL use are not surprising given the past efforts, both programmatic and non-programmatic, to advance CFL adoption in the jurisdiction. Based on the Opinion Dynamics estimates presented in the most recent 2015 evaluation of the Free CFL program, between January 2010 and March 2015, the Free CFL program had reached two-thirds (66%) of DEO's residential customers.

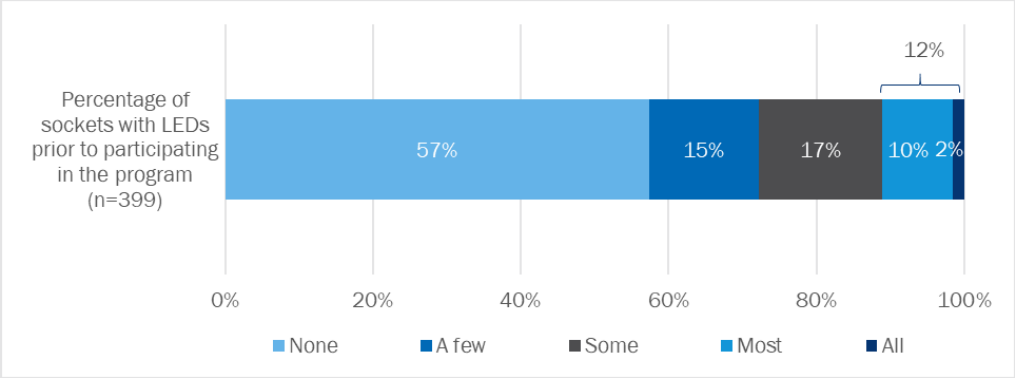
Nearly all participants had heard of LEDs prior to participating in the program (92%) and almost half (48%) had used LEDs. Not surprisingly, previous experience with LEDs drives FR rates; participants with LED experience have much higher FR rates than those who are aware of the technology but have not used it (63% FR vs. 39% FR). Customers residing in multifamily homes, customers who rent their homes, younger customers, and customers with lower levels of education and lower income levels are less likely to have prior experience with LEDs.

Figure 2-4. Participant Lighting Awareness and Usage



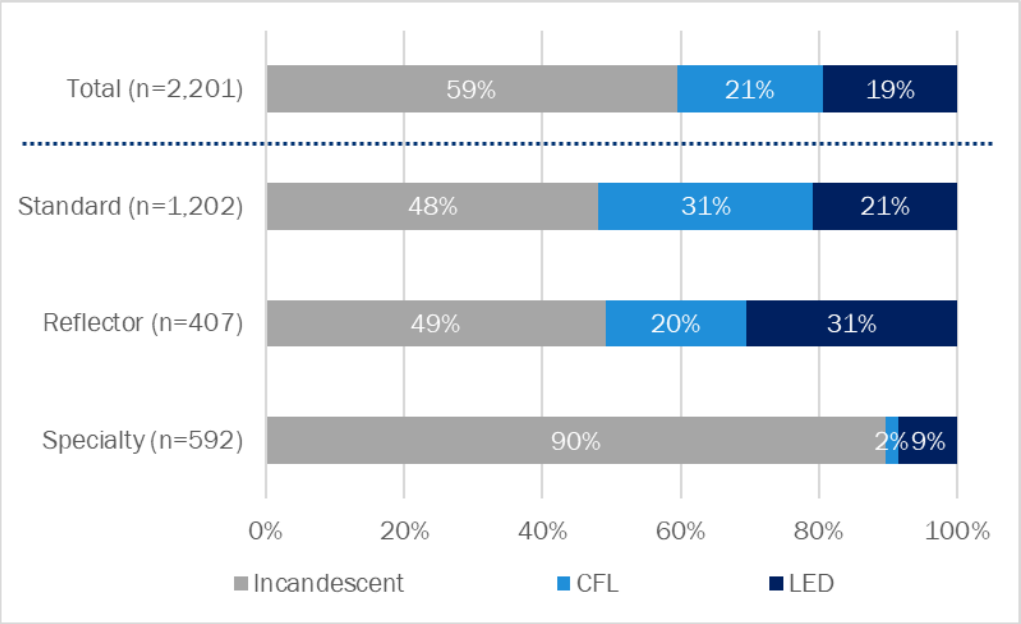
As part of the survey, we asked participants to estimate the percentage of light sockets in their homes that had LEDs prior to participating in the program. As shown in Figure 2-5, 43% had LEDs in at least a few of their sockets prior to participating in the program, and 12% had LEDs in most or all of their sockets.

Figure 2-5. Pre-Program LED Saturation



As part of the LED HOU study, we collected the data on the types of lighting products in customer sockets. As can be seen in Figure 2-6, after participating in the Free LED program, close to half of standard sockets in participant homes (48%) were filled with incandescents[7]. The program may be missing an opportunity to encourage early replacement of some of these incandescents. We found that many customers (74%) who had not installed all of the free LEDs they received said they were waiting for their existing bulbs to burn before installing them.

Figure 2-6. Bulb Mix in Participant Homes

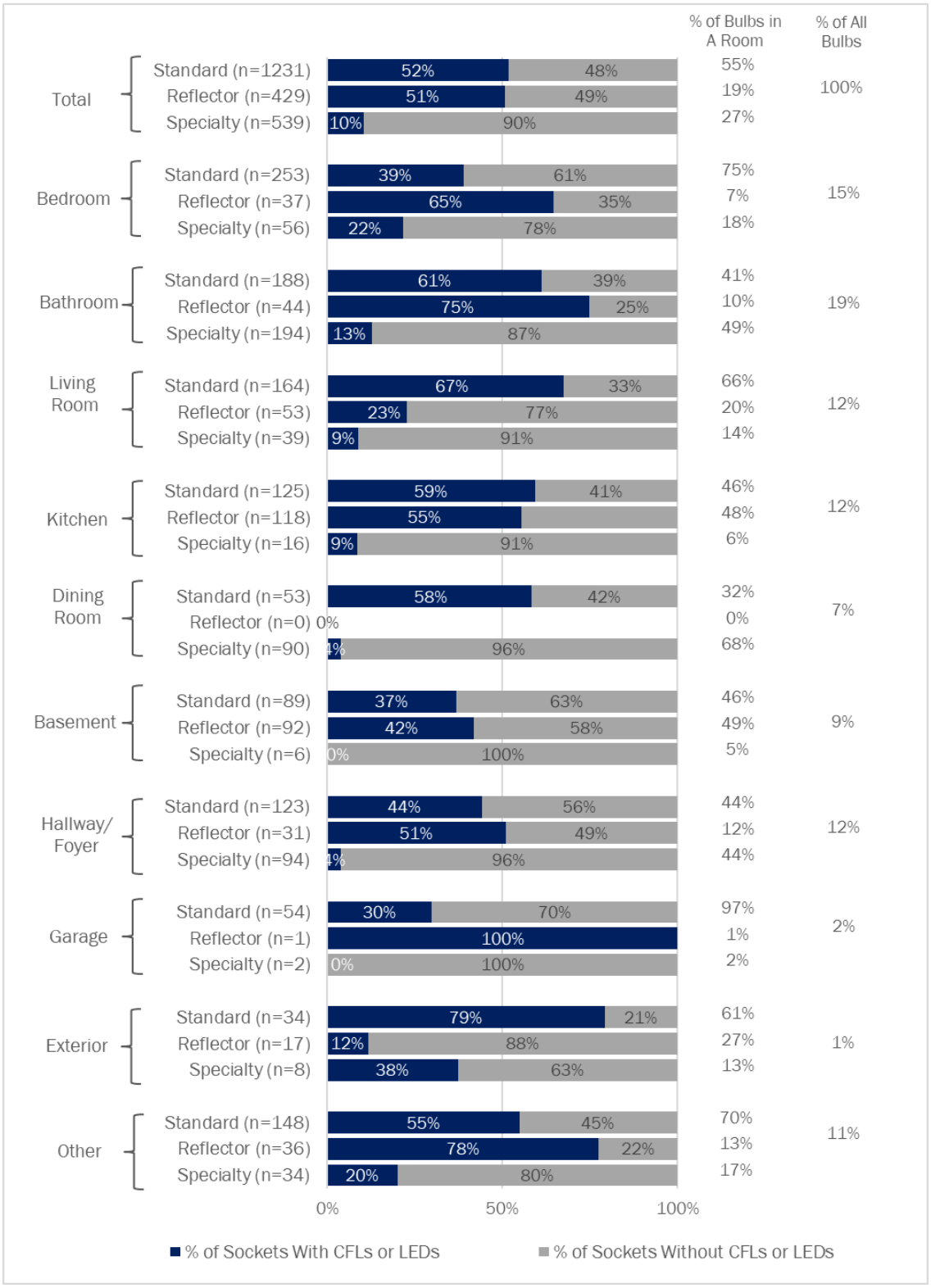


An analysis of socket saturation with energy efficient products by room provides further insight into the areas of the home that are still dominated by less-efficient technologies, such as incandescents and halogens. Figure 2-7 provides socket saturation rates by product type and room type. The graphic also contains estimates of the percent of bulbs each product type represents in a room, as well as the percent of all bulbs in a home that each room type accounts for. As can be seen in the figure, standard CFLs and LEDs are more likely to saturate standard sockets in high-usage rooms, such as living rooms, kitchens, and dining rooms, where they installed in 67%, 59%, and 58% of sockets, respectively. Bedrooms, basements, and foyers, on the other hand, have lower saturation of efficient bulbs in standard sockets (39%, 37%, and 44%, respectively). These findings indicate that customers are installing program LEDs in high-usage sockets, thus maximizing the savings from those products.

Specialty socket saturation of CFLs and LEDs lags behind standard sockets in most rooms. Continued cross-promotion of the Online Store specialty LED line-up would be a beneficial strategy to encouraging energy efficient product purchase and installation in specialty applications.

[7] This category includes both incandescent and halogens.

Figure 2-7. Product Mix by Room Type

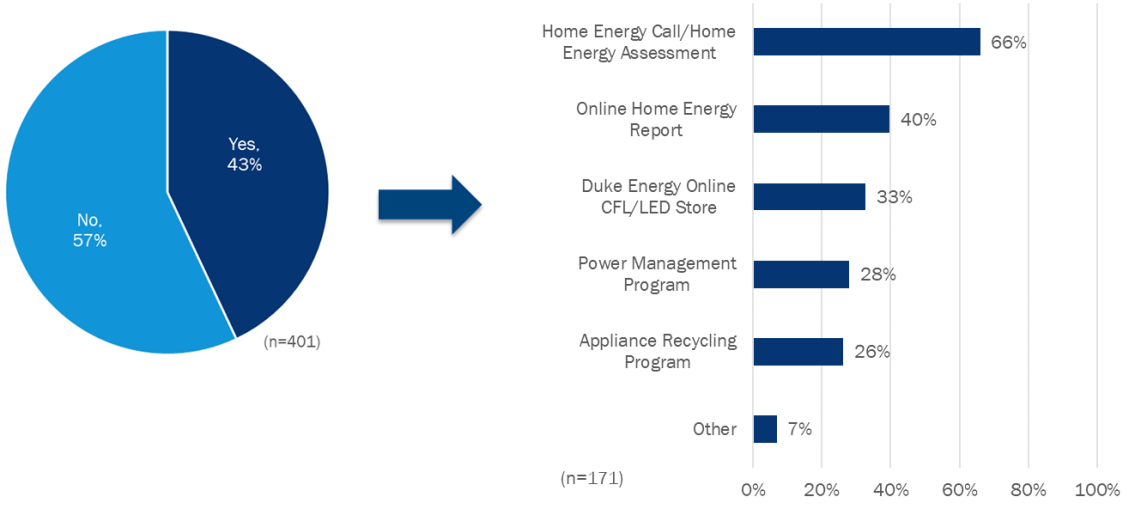


Program Marketing and Outreach

Program marketing efforts during the program period under evaluation consisted of the BRC offering exclusively.

As part of the participant survey, we asked respondents about their awareness of and previous participation in DEO's other energy efficiency programs. As can be seen in Figure 2-8, fewer than half of participants (43%) were aware of other Duke Energy programs. Of those who were aware of other Duke Energy programs, Home Energy Call/Home Energy Assessment, Online Home Energy Report, and Duke Energy Online CFL/LED Store were the most frequently cited programs by 66%, 40%, and 33% of participants, respectively. Most participants (86%) who were aware of Duke Energy's other programs learned about at least some of them before participating in the Free LED program. This may explain why 26% of participants aware of other Duke Energy programs (11% of all participants) reported being aware of the Appliance Recycling program, which had been discontinued a few years earlier.[8]

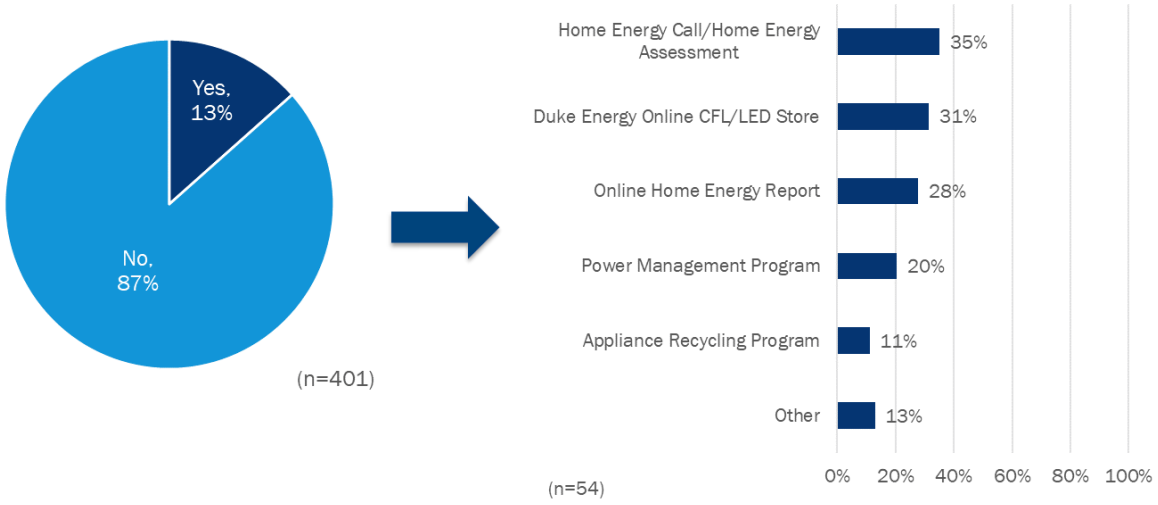
Figure 2-8. Cross-Program Awareness



A relatively small percentage of Free LED program participants also participated in the other Duke Energy programs. As can be seen in Figure 2-9, 13% of Free LED program participants also participated in other programs offered by DEO. Of those, close to a third (35%) received a home energy assessment, 31% purchased energy efficient lighting products from DEO's Online Store, 28% received home energy reports, 20% participated in the Power Management program, and 11% participated in the Appliance Recycling program.

[8] The program awareness question provided respondents a list of questions and included the Appliance Recycling program.

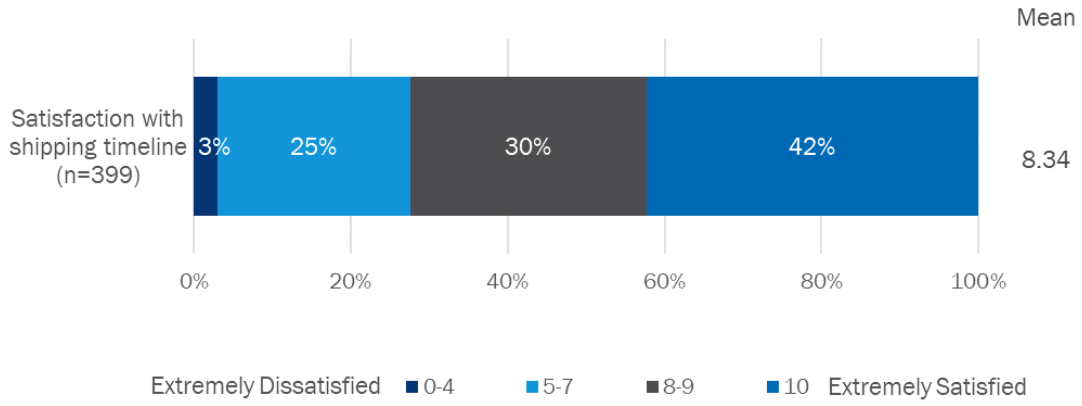
Figure 2-9. Cross-Program Participation



Program Delivery and Participant Satisfaction

Program delivery processes were smooth and well managed. Program-tracking data were clean and well maintained. The program implementer also worked hard to ensure prompt delivery of the ordered LED kits. Based on the participant survey results, 79% of participants who recalled how long it took them to receive their bulbs[9] reported receiving their LEDs in the mail within 3 weeks and nearly a quarter (24%) reported receiving their LEDs within 1 week. More than 7 in 10 (72%) reported being satisfied[10] with the time it took to receive their order; 42% of respondents reported being extremely satisfied[11] (Figure 2-10).

Figure 2-10. Satisfaction with Shipping Timelines



[9] Close to half of participants (47%) could not recall the shipping timeline.

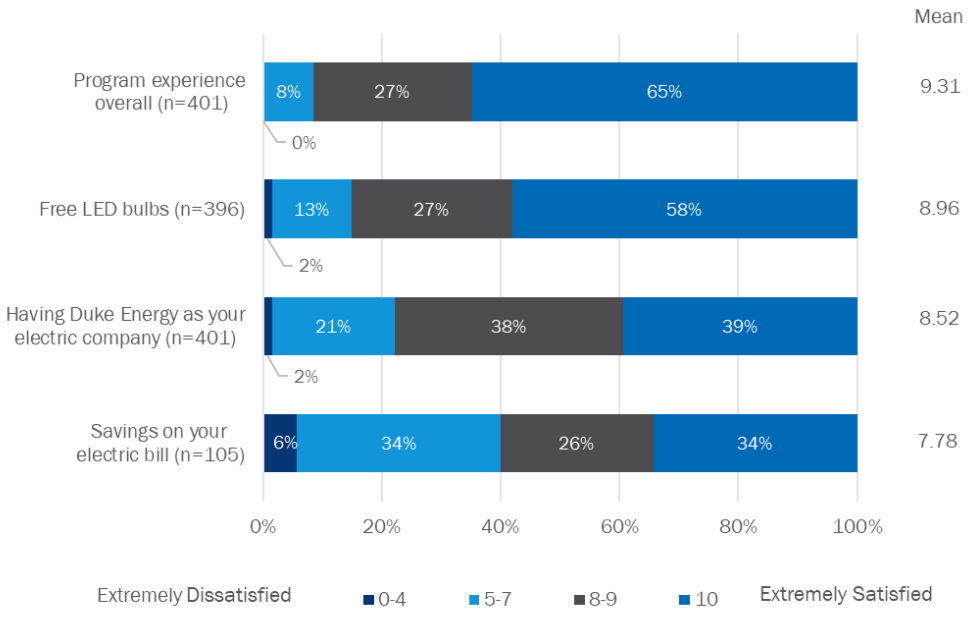
[10] A rating of 8, 9, and 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

[11] A rating of 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

Program-related inquiries from program participants were rare. Only 2% of participants reported contacting Duke Energy or program staff after receiving their bulbs. Most of those inquiries were focused on non-program-related questions or questions about other programs. Most customers (57%) were satisfied[12] with their communication with the Duke Energy staff.

Participants expressed high levels of satisfaction with the program, which is another indication that program processes are effective and well run. As can be seen in Figure 2-11, 92% of participants were satisfied with their program experiences overall and 85% were satisfied with the program LEDs.

Figure 2-11. Satisfaction Ratings



2.9 Conclusions and Recommendations

This section presents conclusions and recommendations resulting from the process and impact evaluations of the Free LED program.

2.9.1 Conclusions

From February 29, 2016 through April 25, 2017, DEO shipped 53,844 LED kits and a total of 323,064 LED bulbs. A total of 51,246 customers participated in the program. Based on the estimated number of 135,565 households in the DEO jurisdiction, 51,246 participants represent more than a third (38%) of the DEO customer base.

The program achieved 9,097 MWh in ex post gross energy savings, 0.75 MW in ex post gross summer peak demand savings, and 1.19 MW in winter peak demand savings. The program realized 56% of energy savings, 47% of summer peak demand savings, and 39% of winter peak demand savings.

[12] A rating of 8, 9, and 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

While the overall ISR was high, at 83.3%, the first-year ISR was relatively low, at 64.4%, indicating that customers tend to store on average two of the six bulbs that they received through the program.

The program NTGR of 51.6% was low compared to the previous evaluation of this program, when CFLs were the program measure (86.1%). The decline in the NTGR is a likely result of increased customer knowledge of energy efficient lighting products and their benefits and positive results of the previous Free CFL program interventions. Program participants were more likely to be homeowners, have higher-incomes and higher levels of education, than the overall population. All of these demographic groups had higher free-ridership (FR) and consequently lower NTGRs.

After applying the program NTGR to ex post savings, the program achieved 4,694 MWh in energy savings, 0.39 MW in summer peak demand savings, and 0.61 MW in winter peak demand savings. Table 2-24 provides a summary of the program's gross and net impacts overall and by year in which the products were distributed.

Table 2-24. Overview of Program Impacts

Year	Metric	Ex Ante Results	Ex Post Gross Results	Gross Realization Rate	Ex Post Net Results	Net Realization Rate[a]
2016	Bulbs	297,240	297,240			
	Energy savings (MWh)	15,057	8,391	56%	4,330	33%
	Summer peak demand savings (MW)	1.47	0.69	47%	0.36	28%
	Winter peak demand savings (MW)	2.77	1.10	40%	0.57	24%
2017	Bulbs	25,824	25,824			
	Energy savings (MWh)	1308	705	54%	364	32%
	Summer peak demand savings (MW)	0.13	0.06	45%	0.03	27%
	Winter peak demand savings (MW)	0.24	0.09	38%	0.05	23%
Total	Bulbs	323,064	323,064			
	Energy savings (MWh)	16,365	9,097	56%	4,694	33%
	Summer peak demand savings (MW)	1.60	0.75	47%	0.39	28%
	Winter peak demand savings (MW)	3.01	1.19	39%	0.61	24%

Note that total savings, both gross and net, as well as realization rates, were developed using unrounded values.
[a] Denominator is ex ante net savings.

Table 2-25**Error! Reference source not found.** provides per-bulb ex post gross and net savings.

Table 2-25. Per-Bulb Ex Post Gross and Net Savings

Per-Bulb Savings	Ex Post Gross Savings	Ex Post Net Savings
Energy savings (kWh)	28.16	14.53
Summer peak demand savings (kW)	0.0023	0.0012
Winter peak demand savings (kW)	0.0037	0.0019

Table 2-26 provides a second estimate of per-LED gross and net savings, representing savings claimable under Ohio Senate Bill 310 (SB 310). As can be seen in the table, DEO will claim 50.65 kWh in gross energy savings, 0.0049 kW in gross summer peak demand savings, and 0.0093 kW in gross winter peak demand

savings per-LED. After applying the NTGR of 51.6%, DEO will claim 26.14 kWh in net energy savings, 0.0025 kW in net summer peak demand savings, and 0.0048 kW in net winter peak demand savings per-LED.

Table 2-26. Per-Bulb Gross and Net Savings Claimable Under SB 310

Savings Type	Per-Bulb Gross Savings Claimable Under SB 310	Per-Bulb Net Savings Claimable Under SB 310
Energy savings (kWh)	50.65	26.14
Summer peak demand savings (kW)	0.0049	0.0025
Winter peak demand savings (kW)	0.0093	0.0048

Note that both gross and net estimates incorporate ISR.

The program implementation processes ran smoothly and effectively, resulting in high levels of customer satisfaction with the program. Program-tracking data were complete and accurate. Instances of products mailed and installed outside of the DEO jurisdiction were minimal.

2.9.2 Recommendations

We recommend that Duke Energy calculates future savings from the Free LED program using the savings values claimable under Ohio Senate Bill 310 (SB 310).

To increase program efficacy, we recommend that the program deploys targeted marketing and outreach strategies aimed at increasing participation among lower-income customers and customers with lower levels of educational attainment, while also continuing to reach out to renters. Those customers are less likely to be free-riders and the program therefore will be more likely to affect change in their lighting preferences and behaviors. Such targeting can be achieved by overlaying census data with customer data and targeting customers in geographic units (such as census block groups) with higher shares of the desired segment. The evaluation team recognizes, however, the effort that may be required to effectively target those underserved segments without cannibalizing the savings from other programs, such as the multifamily program or the Low-Income program. Focusing on rental single-family properties, 2–4 unit properties, and areas with a high prevalence of moderate-income residents may present a “sweet spot” for the program. Deploying targeted marketing efforts is frequently more involved and therefore costly than relying on broader mass-marketing efforts.

To improve its first-year ISR and subsequently the overall ISR, we recommend that the program include collateral with the LED kits urging customers to install as many of the LEDs as possible by replacing working, less-efficient bulbs in their homes. This will help the program avoid the loss of energy and demand impacts from future installations due to EISA truncation. Based on the feedback from the program staff, it is our understanding that starting in the second quarter of 2018, the program collateral includes messaging emphasizing product installation and replacement.

2.10 Summary Form

DEO Free LED Program

Completed EMV Fact Sheet

Duke Energy Ohio's Free LED program is a continuation of the Free CFL program. The transition from CFLs to LEDs occurred in January 2016. Eligible customers can receive a free kit with six 9-watt LEDs per electric account. Eligible customers have been limited to DEO electric customers who had not reached the 15-bulb maximum in the Free CFL program, as well as new customers in the jurisdiction. To better manage program budgets, program marketing and outreach have been limited to business reply cards (BRCs), which has been the only means of program participation as well.

Date	September 11, 2018
Region(s)	Duke Energy Ohio
Evaluation Period	February 29, 2016 through April 25, 2017
Gross Annual MWh impact	9,097 MWH 56% realization rate
Coincident MW impact	0.7 MW (summer) 47% realization rate (summer) 1.2 MW (winter) 39% realization rate (winter)
Measure life	12 years
Net to Gross	51.6%
Process Evaluation	Yes
Previous Evaluation(s)	November 10, 2015

Evaluation Methodology

The evaluation team reviewed reported savings assumptions to ensure that the inputs used to calculate those assumptions were in line with the previous evaluation's recommendations. The Evaluation Team also performed an engineering analysis of energy and demand savings to develop ex post savings estimates, including estimation of a net-to-gross ratio (NTGR) and first-year in-service rate (ISR) through a participant survey. The evaluation team conducted a long-term metering study with a subset of the Free LED program participants to develop LED-specific and program-specific estimates of the hours of use (HOU) and peak coincidence factors (CF), both winter and summer. The Evaluation Team also conducted a program process evaluation including results from a participant survey

Impact Evaluation Details

- The evaluation team relied on the Uniform Methods Project (UMP) recommended approach to estimate gross energy and peak demand savings, and incorporates additional adjustments as necessary
- The evaluation team estimated baseline wattages using the equivalent baseline wattage approach with consideration of applicable federal efficiency standards (e.g., EISA)
- The evaluation team estimated hours of use (HOU) and peak coincidence factors (CF) using long-term metering effort with the program participants
- The evaluation team relied on a participant research to estimate first-year in-service rate (ISR) and net-to-gross ratio (NTGR)
- The evaluation team used discounted approach to claiming savings from future LED installations which includes claiming the savings from all expected installations in the program year but discounting them by a utility discount rate. The evaluation team incorporated the UMP-recommended future installation trajectory and truncation of future savings post-EISA 2020 standards

3. Online Savings Store Program Evaluation Results

This section presents the evaluation methodology and results for the Online Savings Store program.

3.1 Evaluation Summary

3.1.1 Program Summary

Since its launch in 2013, the Duke Energy Ohio (DEO) Online Savings Store program has been offering DEO customers a wide range of discounted CFL and LED products spanning standard, specialty, and reflector bulb categories.[13] Customers are able to buy the discounted bulbs online, submit an order over the phone, or complete a business reply card (BRC) and mail it to Duke Energy. Customers can purchase up to 36 program-discounted bulbs per eligible account, but can supplement their purchase with non-program-discounted products, in cases when they need more bulbs.

Our evaluation covers the program period from December 17, 2015 through February 13, 2017.

3.1.2 Evaluation Objectives, Conclusions, and Recommendations

This evaluation of the Online Savings Store program includes process and impact assessments and addresses several major research objectives:

- Assess program performance and estimate gross and net annual energy (MWh) and peak demand (MW) savings associated with program activity
- Assess program implementation processes and marketing strategies and identify opportunities for improvement
- Understand participant lighting awareness, preferences, and purchasing behaviors, and obtain insight into lighting market dynamics

To achieve these research objectives, the evaluation team completed a range of data collection and analytical activities, including interviews with program staff, a participant survey, program-tracking data analysis, an LED Hours of Use (HOU) study, a deemed savings review, an impact analysis, and an analysis of the survey results. Through the primary data collection, the evaluation team developed estimates of LED HOU, LED coincidence factors, a first-year in-service rate (ISR) and net-to-gross ratio (NTGR). Table 3-1 provides an overview of the ex post gross savings parameters, the sample sizes used to develop those estimates, and the associated confidence and precision.

[13] The program offering has historically excluded 75-watt and 60-watt equivalent CFLs and 60-watt equivalent LEDs in order not to directly compete with the Free CFL and subsequent Free LED programs.

Table 3-1. Summary of Gross Savings Inputs

Parameter	Sample Size	Estimate	Relative Precision (at 90% Confidence)
LED HOU	182[a]	2.43	9%
LED summer peak CF	182[a]	0.11	12%
LED winter peak CF	182[a]	0.16	8%
First-year ISR	220	79.3%	6%
NTGR	356	63.5%	14%

[a] Number of loggers.

From December 17, 2015 through February 13, 2017, Duke Energy discounted 158,483 CFLs and LEDs. CFLs represented only a small share of all sales (10%), while reflector and specialty LEDs accounted for more than four-fifths of program sales (82%). A total of 10,621 unique customers[14] purchased program-discounted lighting products during the program period under evaluation. Based on the estimated number of 135,565 households in the DEO jurisdiction,[15] 10,621 participants represent an estimated 8% of the DEO customer base.

The program achieved 5,329 MWh in ex post gross energy savings, 0.757 MW in ex post gross summer peak demand savings, and 0.917 MW in ex post gross winter peak demand savings. The program realized 102% of gross energy savings, 158% of gross summer peak demand savings, and 142% of gross winter peak demand savings.

The first-year ISR is relatively high, at 79.3%, indicating that customers are installing most products shortly after purchase. The overall ISR is affected by the revised installation trajectory and truncation of savings due to the Energy Independence and Security Act (EISA) standards that will go into effect in 2020.

The program NTGR of 63.5% is lower than the previous evaluation of this program that established a NTGR of 77.8% for the program. While it is difficult to isolate the drivers of the NTGR changes, one possible reason for NTG decrease can be a shift in technology. The NTGR of 77.8% is for CFLs, while the NTGR of 63.5% is for LEDs. LEDs are superior to CFLs technology, and customers may be more likely to adopt it on their own. That said, when comparing participant composition from the previous evaluation to this evaluation, there are key differences that may contribute to different NTG. Current program participants are more likely to have higher incomes and are more likely to own their homes. Both of these customer segments have higher FR and, as a result, lower NTGR, as compared to their respective counterparts. Furthermore, compared to the general population of DEO customers, program participants are more likely to be homeowners, reside in single-family homes, and have higher incomes and higher levels of educational attainment. All of these demographic groups have higher free-ridership (FR) and consequently lower NTGRs.

After applying program NTGR to the ex post savings, the program achieved 3,384 MWh in net energy savings, 0.481 MW in net summer peak demand savings, and 0.582 MW in net winter peak demand savings. Table 3-2 provides a summary of the program's gross and net impacts overall and by year in which the products were distributed.

[14] Unique customer is defined as a unique account number.
[15] https://censusreporter.org/profiles/16000US3915000-cincinnati-oh/.

Table 3-2. Overview of Program Impacts

Year	Metric	Ex Ante Results	Ex Post Gross Results	Gross Realization Rate	Ex Post Net Results	Net Realization Rate[a]
2015	Bulbs	1,130	1,130			
	Energy savings (MWh)	39	41	107%	26	87%
	Summer peak demand savings (MW)	0.00	0.005	144%	0.003	118%
	Winter peak demand savings (MW)	0.01	0.006	95%	0.004	78%
2016	Bulbs	151,497	151,497			
	Energy savings (MWh)	4,986	5,086	102%	3,230	83%
	Summer peak demand savings (MW)	0.46	0.722	158%	0.459	129%
	Winter peak demand savings (MW)	0.61	0.876	143%	0.556	116%
2017	Bulbs	5,856	5,856			
	Energy savings (MWh)	215	202	94%	128	76%
	Summer peak demand savings (MW)	0.02	0.029	150%	0.018	122%
	Winter peak demand savings (MW)	0.03	0.036	138%	0.023	113%
Total	Bulbs	158,483	158,483			
	Energy savings (MWh)	5,241	5,329	102%	3,384	83%
	Summer peak demand savings (MW)	0.5	0.757	158%	0.481	129%
	Winter peak demand savings (MW)	0.6	0.917	142%	0.582	116%

Note that total savings, both gross and net, as well as realization rates, were developed using unrounded values.
[a] Denominator is ex ante net savings.

Table 3-3 provides ex post gross and net per-bulb savings. Measure categories in the table below are consistent with the DEO desired definitions.

Table 3-3. Per Bulb Ex Post Gross and Net Savings

	Ex Post Gross Savings			Ex Post Net Savings		
Measure	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	81.93	0.0095	0.0086	52.02	0.0060	0.0054
3-Way LED	35.42	0.0052	0.0064	22.49	0.0033	0.0041
A-Line CFL	26.51	0.0031	0.0028	16.83	0.0020	0.0018
A-Line LED	20.33	0.0030	0.0037	12.91	0.0019	0.0023
Candelabra CFL	17.88	0.0021	0.0019	11.35	0.0013	0.0012
Candelabra LED	26.85	0.0039	0.0049	17.05	0.0025	0.0031
Globe CFL	27.10	0.0031	0.0028	17.21	0.0020	0.0018
Globe LED	27.98	0.0041	0.0051	17.77	0.0026	0.0032
Recessed dimmable CFL	27.90	0.0032	0.0029	17.71	0.0021	0.0019

Measure	Ex Post Gross Savings			Ex Post Net Savings		
Recessed CFL	39.76	0.0046	0.0042	25.25	0.0029	0.0026
Recessed LED	41.66	0.0061	0.0076	26.45	0.0039	0.0048
Recessed outdoor CFL	40.22	0.0047	0.0042	25.54	0.0030	0.0027
Recessed outdoor LED	39.29	0.0057	0.0071	24.95	0.0036	0.0045
Spiral 13-watt CFL	24.61	0.0029	0.0026	15.63	0.0018	0.0016
Spiral 18-watt CFL	27.07	0.0031	0.0028	17.19	0.0020	0.0018
Spiral 23-watt CFL	40.20	0.0047	0.0042	25.53	0.0030	0.0027

Table 3-4**Error! Reference source not found.** provides a second estimate of per-bulb gross and net savings, representing savings claimable under Ohio Senate Bill 310 (SB 310).

Table 3-4. Per-Bulb Gross and Net Savings Claimable Under SB 310

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTGR	Net Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	81.93	0.0095	0.0086	63.5%	52.02	0.0060	0.0054
3-Way LED	44.11	0.0052	0.0097	63.5%	28.01	0.0033	0.0061
A-Line CFL	26.51	0.0031	0.0049	63.5%	16.83	0.0020	0.0031
A-Line LED	50.65	0.0049	0.0093	63.5%	32.17	0.0031	0.0059
Candelabra CFL	17.88	0.0021	0.0027	63.5%	11.35	0.0013	0.0017
Candelabra LED	26.85	0.0039	0.0049	63.5%	17.05	0.0025	0.0031
Globe CFL	27.10	0.0031	0.0032	63.5%	17.21	0.0020	0.0020
Globe LED	27.98	0.0041	0.0051	63.5%	17.77	0.0026	0.0032
Recessed dimmable CFL	42.04	0.0042	0.0092	63.5%	26.70	0.0027	0.0059
Recessed CFL	39.76	0.0046	0.0055	63.5%	25.25	0.0029	0.0035
Recessed LED	44.98	0.0061	0.0076	63.5%	28.56	0.0039	0.0048
Recessed outdoor CFL	64.82	0.0065	0.0142	63.5%	41.16	0.0041	0.0090
Recessed outdoor LED	119.89	0.0057	0.0228	63.5%	76.13	0.0036	0.0145
Spiral 13-watt CFL	24.61	0.0029	0.0026	63.5%	15.63	0.0018	0.0016
Spiral 18-watt CFL	27.07	0.0034	0.0028	63.5%	17.19	0.0022	0.0018
Spiral 23-watt CFL	40.69	0.0052	0.0043	63.5%	25.84	0.0033	0.0027

The program implementation processes ran smoothly and effectively, resulting in high levels of customer satisfaction with the program. Program-tracking data were complete and accurate. Instances of products mailed and installed outside of the DEO jurisdiction were minimal. Participants shopping on the Online Store website found the information about lighting products accessible and helpful. Customers valued the benefit of discounted shipping, and many would not have purchased their products without it. The benefits of the free shipping offer over the discounted shipping offer were much less pronounced.

Recommendations

We recommend that Duke Energy calculates future savings from the Online Savings Store program using the savings values claimable under Ohio Senate Bill 310 (SB 310).

Opinion Dynamics found program processes to be running smoothly and levels of participant satisfaction with the programs and its various components to be high. We recommend that the program continues smooth and balanced implementation practices.

Our evaluation research found that customers residing in single-family homes, customers with higher income levels, and higher levels of educational attainment are over-represented in the program participant pool. These customer segments, as compared to their respective counterparts, tend to have much higher levels of FR. To increase program efficacy, we recommend that the program deploys targeted marketing and outreach strategies aimed at increasing participation among customers residing in multi-family properties, lower-income customers, and customers with lower levels of educational attainment. Those customers are less likely to be free-riders and the program therefore will be more likely to affect change in customer lighting preferences and behaviors. To avoid possible overlap with Duke Energy's Multifamily program the program should consider identifying customers currently not targeted through the Multifamily program and targeting Online Store offerings to that group. To minimize the overlap with the Low-Income program, targeting census block groups with a high concentration of customers with moderate income levels could be a beneficial strategy. Similar targeting of census block group with high shares of customers with higher education levels can further help improve the effectiveness of the program. The evaluation team recognizes, however, the fine balance required between promoting the Online Savings Store program to the desired segments, and minimizing the cannibalization of the other programs' impacts. Additionally, it is important to recognize the need to balance the cost associated with deploying micro-targeting approaches with their impacts.

Understanding barriers to customer adoption of LEDs and key motivators that will drive customers to change their lighting shopping behaviors, especially among customer segments that are underserved through the program as well as the ones that exhibit low FR, can be helpful in devising more targeted program interventions and messaging strategies.

Another strategy toward increasing program efficacy is focusing program efforts around specialty LEDs and more specifically products such as globe, three-way, and candelabra LEDs. Our research shows that the FR for specialty LEDs is considerably lower than reflector LEDs ordered through the Online Store. Increasing the prominence of specialty LEDs on the Online Store website and in the program marketing collateral can help attract shopper attention to those products as well as attract shoppers who have a need or interest in specialty products, thus helping reduce free-ridership. It is our understanding that the program team are in the process of exploring targeting opportunities to enhance the reach and efficacy of the program.

To further improve the first-year ISR and subsequently the overall ISR, we recommend that the program staff include collateral with product shipments urging customers to install as many program LEDs as possible by replacing working, less-efficient bulbs in their homes. This will help the program avoid the loss of energy and demand impacts from future installations due to EISA truncation. Our evaluation explored differences in first-year ISR by product type and found no statistically significant differences, which suggests that the program should not focus the ISR messaging on a specific product type.

To further streamline program offerings, the program may want to consider minimizing the offer of free shipping. This offer does not have a significant impact on participant purchase decisions, as self-reported by surveyed program participants. Program staff should continue offering discounted shipping, however, as participant purchase decisions are affected by the presence of shipping discounts. We have limited

information on the differences in efficacy of the various levels of shipping discounts. The program may benefit from further research in this area to develop an optimal shipping discount offer.

Finally, expanding the Online Store offerings to include other product types may be an effective strategy for diversifying program offerings and increasing impacts. Similar Online Stores in Oregon, Massachusetts, and South Carolina recently started including such measures as advanced power strips, thermostats, showerheads, and even small appliances, such as dehumidifiers and air purifiers. The program may benefit from additional research into customer interest around those additional products and energy savings impacts. It is our understanding that the program staff added smart thermostats to the list of Online Store offerings in August 2018. The program team is in the process of expanding the list of measures further.

3.2 Program Description

3.2.1 Program Design

Since its launch in 2013, the DEO Online Savings Store program has been offering DEO customers a wide range of discounted CFL and LED products spanning standard, specialty, and reflector bulb categories. Customers are able to buy the discounted bulbs online, submit an order over the phone, or complete a BRC and mail it to Duke Energy. Customers can purchase up to 36 program-discounted bulbs per eligible account, but can supplement their purchase with non-program-discounted products, in cases when they need more bulbs. Duke Energy also limits the number of products sold to customers in each major category (e.g., three-way, candelabra, etc.).

The program's product mix is fairly fluid to ensure the best variety and quality for customers. Program incentives are fluid as well to ensure that the program keeps up with rapidly dropping LED prices.

To ensure customer satisfaction, all orders must be shipped within 2 days of being received.

Program marketing is varied and includes bill inserts, quarterly email blasts, new customer letters, events and conferences, online intercepts when customers are accessing their online account, and web banners and displays on Duke Energy and other vendor websites.

Our evaluation covers the program period from December 17, 2015 through February 13, 2017.

3.2.2 Program Implementation

DEO manages the Online Savings Store program and is responsible for overseeing program design, marketing, and operations. Energy Federation, Inc. (EFI) has implemented the program on behalf of DEO since the program's inception. EFI is responsible for taking customer orders, maintaining the call center, warehousing the product and maintaining inventory, handling order fulfillment and shipping logistics, and managing program tracking and reporting.

3.2.3 Program Performance

From December 17, 2015 through February 13, 2017, Duke Energy discounted 158,483 CFLs and LEDs, achieving 5,241 MWh in ex ante energy savings, 0.5 MW in ex ante summer peak demand savings, and 0.6 MW in ex ante winter peak demand savings. Table 3-5 provides a summary of the program sales and savings achievements.

Table 3-5. Summary of Program-Tracking Data for Program Period

Metric	Performance
Bulbs	158.483
Ex ante energy savings (MWh)	5,241
Ex ante summer peak demand savings (MW)	0.5
Ex ante winter peak demand savings (MW)	0.6

Table 3-6 provides a summary of the product mix discounted through the program during the program period under evaluation. As can be seen in the table, specialty and reflector LED accounted for 82% of sales, standard LEDs contributed another 8%, while all CFLs accounted for a total of 10% of sales during the program period under evaluation.

Table 3-6. Program Ex Ante Savings by Product Type

	Reported Bulbs		Ex Ante Energy Savings (kWh)		Ex Ante Summer Peak Demand Savings (kW)		Ex Ante Winter Peak Demand Savings (kW)	
Measure Type	Bulbs	% of Total Bulbs	kWh Savings	% of Total Savings	kW Savings	% of Total Savings	kW Savings	% of Total Savings
CFLs	**16,491**	**10%**	**482,896**	**9%**	**52**	**11%**	**92**	**14%**
CFL Standard	6,300	4%	213,133	4%	25	5%	33	5%
CFL Reflector	6,665	4%	152,574	3%	15	3%	33	5%
CFL Specialty	3,526	2%	117,188	2%	12	2%	26	4%
LEDs	**141,992**	**90%**	**4,757,775**	**91%**	**427**	**89%**	**554**	**86%**
LED Standard	12,230	8%	619,510	12%	60	13%	114	18%
LED Reflector	68,149	43%	1,290,568	25%	121	25%	172	27%
LED Specialty	61,613	39%	2,847,697	54%	246	51%	267	41%
Total	**158,483**	**100%**	**5,240,670**	**100%**	**479**	**100%**	**645**	**100%**

3.3 Key Research Objectives

This evaluation of the Online Savings Store program includes process and impact assessments and addresses several major research objectives:

- Assess program performance and estimate gross and net annual energy (MWh) and peak demand (MW) savings associated with program activity
- Assess program implementation processes and marketing strategies and identify opportunities for improvement
- Understand participant lighting awareness, preferences, and purchasing behaviors, and obtain insight into lighting market dynamics

We designed our evaluation tasks based on the following impact-related research objectives:

- Estimate program ex post gross energy and demand savings
- Estimate program ex post net energy and demand savings
- Develop updated ISRs, HOU, summer peak coincidence factor (summer CF), and winter peak coincidence factor (winter CF)

We estimated savings using the Uniform Methods Project (UMP) recommended approach, which satisfies the Ohio Public Utilities Commission requirements for lighting savings evaluations. Per the UMP protocols, energy savings calculations include delta watts and ISR. The evaluation also provides process and market information that DEO can use to modify the design of the program in a rapidly changing lighting market.

As part of the process assessment, we explored the following research questions:

- What are the sources of program information?
- How effective are the program implementation and data tracking practices?
- What is the program's reach? What percentage of DEO's customer base has participated in the program?
- Are participants satisfied with their program experiences?
- How effective are the program's marketing, outreach, and educational tactics?
- What are the strengths, weaknesses, and opportunities for program improvement?
- What customer segments should the program target to minimize FR?
- What is the level of participant knowledge of various lighting technologies?
- What are participant lighting preferences and purchase behaviors?

3.4 Overview of Evaluation Activities

To answer the research questions outlined in the previous section, the evaluation team performed a range of data collection and analytical activities. Table 3-7 provides a summary of evaluation activities and associated areas of inquiry. Following the table, we provide detail on each activity's scope, sampling approach (if applicable), and timing of the activity.

Table 3-7. Overview of Evaluation Research Activities

#	Evaluation Activity	Scope	Impact	Process/ Market	Purpose of Activity
1	Program staff interviews	n=2		X	Provide insight into program design and delivery Support process assessment
2	Materials review	All materials provided	X	X	Provide insight into program design and delivery Inform previously used and alternative savings assumptions
3	Deemed savings review	All data provided	X		Review accuracy and appropriateness of energy savings assumptions and determine alternative savings inputs
4	Impact analysis	All data provided	X		Calculate gross and net energy and demand savings
5	Participant survey	n=357	X	X	Estimate first-year ISR Estimate FR and spillover (SO) Assess participant lighting knowledge and preferences Support process assessment
6	LED HOU study	n=53 (HOU, CF) n=56 (lighting composition)	X	X	Estimate HOU and CFs for LEDs installed in customer homes Assess lighting composition and use among participants

3.4.1 Program Staff Interviews

The evaluation team completed the initial interview with program staff at Duke Energy early in the evaluation process in August 2016 and then followed up with a brief interview in December 2016. The interviews explored changes in program design and implementation, program performance, incentivized product specifications, and data tracking and communication processes, among other topics.

3.4.2 Materials Review

In support of the impact and process evaluation, the evaluation team reviewed program materials and data, including marketing materials, plans, and past evaluation reports and research studies. This information informed our research design, provided insight into program design and delivery, and supported the assessment of program impacts.

3.4.3 Deemed Savings Review

In support of the impact evaluation, the evaluation team reviewed program-tracking databases and energy savings assumptions. The objectives of the review were to identify the deemed savings values that DEO used to calculate impacts; review the deemed savings values for reasonableness; verify their accurate application; and identify data gaps, omissions, inconsistencies, and errors.

To assess the reasonableness of the savings assumptions, we reviewed past evaluations of the DEO Residential lighting programs, the Ohio Technical Reference Manual (TRM), and evaluation reports and TRMs from other jurisdictions, as well as ongoing evaluations in Ohio.

As part of the deemed savings review process, we also checked program-tracking data for accuracy, consistency, and completeness.

3.4.4 Impact Analysis

The impact analysis included calculating ex post gross and net program savings using updated savings assumptions. We calculated savings using the UMP recommended approach.

3.4.5 Participant Survey

The evaluation team completed a mixed-mode (telephone and online) survey with a representative sample of DEO Online Savings Store program participants. The key goals of the survey were to gather information to support the assessment of gross impacts, program attribution, program processes, and market dynamics. Specifically, we used the survey results to produce updated estimates of the first-year ISR, FR, SO, lighting knowledge and preferences, and participant experiences with the program.

Sample Design and Fielding

For most customers, lighting products are a low-cost and low-importance purchase. Therefore, when using the self-report method to estimate program FR, it is best to conduct interviews with participants as close to their participation as possible to facilitate accurate recall of the factors that affect bulb purchase or order decisions. On the other hand, it is best to let some time pass when measuring SO effects and first-year ISR so that participants have time to install the products and take additional program-induced actions.

To address these competing priorities, Opinion Dynamics conducted the participant survey in waves and staggered the timing of the interviews based on the survey objective. We drew one sample from the most recent participants to estimate FR and a separate sample from earlier participants to estimate SO and ISR. The phased approach to survey administration is more accurate than if we relied just on the most recent participants and extrapolated the results to all participants regardless of when they participated.

We completed a total of three waves of the participant survey equally timed over the course of the program period. We administered the first wave in November and December 2016, the second wave in March and April 2017, and the third wave in May and June 2017.

For the first two waves, we used two distinct sample frames from which we drew a random sample of program participants. The sample frame used to estimate FR included customers who participated in the program in the 3 months prior to the survey. The sample frame used to estimate SO and ISR included customers who participated in the program between 3 months and 6 months prior to the survey fielding date. For the last wave of the survey, per Duke Energy's request, we combined the two sample frames and

estimated FR, SO, and ISR using responses from respondents who had participated up to 6 months prior to the survey.

We completed a total of 357 interviews over the course of the three waves. Overall, 137 interviews supported the estimate of FR and 220 interviews supported the estimate of SO and ISR. We used all participants to assess program processes.

Table 3-8. Participant Survey Sample Sizes and Number of Completed Interviews by Sample Frame

Sample Frame	Sample Frame Size[a]	Sample Size	Number of Completed Interviews
FR	2,260	491	137
SO/ISR	4,624	936	220
Total	**5,392**	**1,427**	**357**

[a] Note that total sample frame does not equal the sum of FR and SO sample frames, because from one survey wave to the next all or a portion of participants in the FR sample frame could become a part of the SO sample frame.

We sent participants either mail or email invitations and reminders to take the survey depending on the availability of email addresses; participants could choose to take the survey online or call our phone center to take it over the telephone. Participants who did not have an email address on file received an invitation letter and two postcard reminders in the mail, while participants with email addresses received invitations and reminders via email. To increase response rates, we offered participants incentives in the form of several cash prize drawings.

Survey Dispositions and Response Rate

Table 3-9 provides the final survey dispositions.

Table 3-9. Participant Survey Disposition Summary

Disposition	Count
Completed interviews	**357**
Internet survey complete	332
Phone survey complete	25
Partial interviews	**33**
Household with undetermined survey eligibility	**888**
Partial complete - survey eligibility unknown	48
Answering machine	5
Initial refusal	1
No response	834
Survey-ineligible household	**2**
Known ineligible (screened out)	2
Not an eligible household	**21**
Bounced email	18
Returned to sender	3
Total participants in sample	**1,301**

We calculated response rates using the Response Rate 3 (RR3) methodology specified by the American Association of Public Opinion Research (AAPOR). We achieved a 28% survey response rate. We do not report a cooperation rate – the proportion of participants who *completed* the survey out of all eligible participants *contacted* – because it is difficult to estimate it accurately with both mailed and emailed survey invitations. While we recorded returned mail invitations and bounce-back email invitations, we cannot say with certainty that the ones that were not returned were received and opened by qualified participants. Therefore, we do not have an accurate number of eligible contacted participants to use to calculate a cooperation rate.

Survey Data Weighting

The survey sample resembled the participant population across a range of known participant characteristics; therefore, there was no need to apply post-stratification weights.

Targeted and Achieved Confidence and Precision

The evaluation targeted 10% precision at a 90% confidence level for both ISR and NTGR. These precision goals were met for ISR. Relative precision around the NTGR is slightly worse than 90/10 (Table 3-10).

Table 3-10. Precision and Margin of Error at 90% Confidence for First-Year ISR and NTGR

Metric	Relative Precision
First-year ISR	6%
NTGR	14%

3.4.6 LED HOU Study

Opinion Dynamics completed a lighting logger study among Free LED and Online Savings Store program participants who had LED bulbs installed. The key goal of the study was to estimate HOU and CFs for LEDs. As part of the study, we also collected valuable data on lighting socket composition, which allowed us to assess and characterize lighting usage in participant homes. This study was the first study in Ohio that yielded LED-specific estimates of HOU and CF. Previous studies completed in Ohio focused on CFLs.

As part of the study, we conducted a lighting inventory and deployed loggers in homes of a representative sample of 101 participants, of which 46 participated in the Free LED program and 56 participated in the Online Savings Store program. The analysis of lighting product mix is based on all 101 participants, while the analysis of HOU and CFs is based on 96 participants, 43 from the Free LED and 53 from the Online Store program. We did not include five participants in the analysis because of issues with logger data quality. Appendix 3, provided with this report, details the study's methodology and results.

Targeted and Achieved Confidence and Precision

The evaluation targeted 10% precision at a 90% confidence level for LED HOU and CF, both summer and winter, across the two programs – Free LED and Online Savings Store. These precision goals were met. Precision estimates around program-specific results are slightly worse than 90/10 (Table 3-11). Despite slightly worse relative precision around the Online Store specific summer CF estimate, Opinion Dynamics used the Online Store specific estimates of HOU and CF when calculating energy and demand impacts from the program.

Table 3-11. Precision and Margin of Error at 90% Confidence for LED HOU and CF

Statistic	Total			Free LED			Online Store		
	# of Loggers	Result	Relative Precision	# of Loggers	Result	Relative Precision	# of Loggers	Result	Relative Precision
HOU	300	**2.66**	7%	118	**2.74**	12%	182	**2.43**	9%
Summer CF		**8%**	10%		**7%**	16%		**11%**	12%
Winter CF		**14%**	6%		**13%**	11%		**16%**	8%

3.5 Impact Evaluation

This section describes the methodology for conducting the gross impact analysis and the results of the analysis. The evaluation team completed the following activities:

- Reviewed program-tracking data and savings assumptions for accuracy, completeness, and consistency
- Conducted engineering analysis of energy and demand savings and developed ex post gross savings estimates based on the UMP

3.5.1 Methodology

The evaluation team reviewed reported savings assumptions and verified that the algorithms and inputs used to calculate those assumptions were in line with the previous evaluation's recommendations.

As part of the impact evaluation, we conducted a deemed savings review through which we identified the deemed savings values that DEO used to calculate program savings; reviewed the deemed savings values for reasonableness; verified their accurate application; and identified data gaps, omissions, inconsistencies, and errors. As part of the deemed savings review process, we also checked program-tracking data for accuracy, consistency, and completeness.

To assess the reasonableness of the savings assumptions, we reviewed past evaluations of the DEO Residential lighting programs, the Ohio TRM, evaluation reports and TRMs from other jurisdictions, as well as ongoing evaluations in Ohio.

We developed a program-specific estimate of first-year ISR using the participant survey, and program-specific estimate of HOU and CF using the LED HOU study.

We estimated savings using the UMP recommended approach. Per the UMP protocols, energy savings calculations include delta watts and ISR. Equation 3-1 provides the formula that we used to estimate energy savings, while Equation 3-2 provides the formula that we used to estimate demand savings.

Many upstream lighting programs[16] also account for leakage of discounted products outside of the utility service territory and for installation of program-discounted lighting in commercial applications. Leakage results in decreased savings, whereas installations in commercial applications lead to higher savings. Unlike upstream residential lighting programs that often have little control over who purchases discounted lighting products, DEO's Online Savings Store program tightly controls who receives program LEDs and where

[16] Upstream lighting programs provide incentives to retailers and manufacturers who, in turn, pass them on to customers in the form of price markdowns.

customers can receive their LEDs, thus making leakage to non-DEO customers and installations in commercial applications unlikely. We explored the incidence of leakage and commercial installations through the participant survey and found that both are minimal (described further below). Therefore, we chose not to revise the equation to add a separate adjustment factor for leakage. However, we did account for program bulb leakage outside of the DEO service territory as part of the ISR by removing these bulbs from the installed base. This resulted in only a negligible change to the ISR. We also did not apply a separate set of savings assumptions to account for installations in commercial applications because of the minimal number of bulbs installed in such applications.

Equation 3-1. Algorithm for Energy Savings

$$\Delta kWh = ISR * \frac{(Watts * HOU)_{base} - (Watts * HOU)_{ee}}{1{,}000} * 365 * (1 + HVAC_c)$$

Equation 3-2. Algorithm for Peak Demand Savings

$$\Delta kW = ISR * \frac{Watts_{base} - Watts_{ee}}{1{,}000} * CF * (1 + HVAC_d)$$

Where:

ΔkWh = first-year electric energy savings
ΔkW = peak electric demand savings
ISR = in-service rate
$Watts_{base}$ = baseline wattage
$Watts_{ee}$ = efficient bulb wattage
HOU = residential annual operating hours
CF = peak coincidence factor
$HVAC_c$ = HVAC system interaction factor for energy
$HVAC_d$ = HVAC system interaction factor for demand

Table 3-12 presents a summary of the inputs used to calculate program gross energy and demand impacts and specifies the sources of the inputs. Following the table, we detail the source(s) behind each input and the rationale for the input selection.

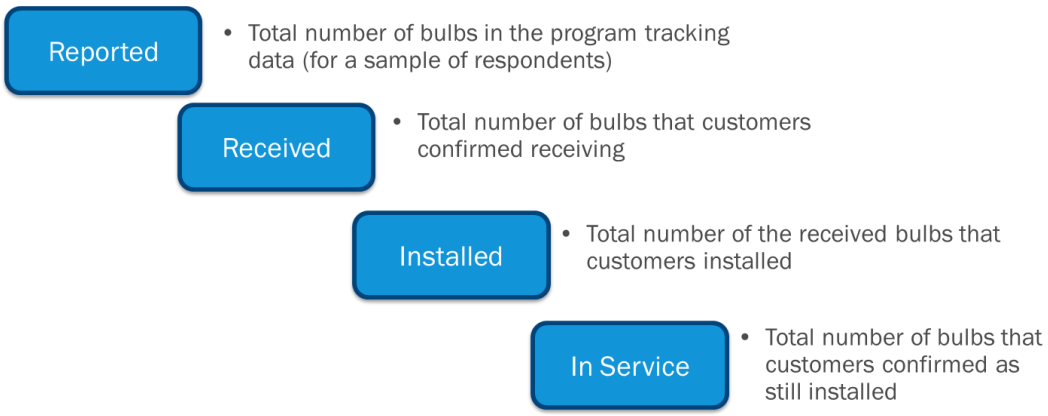
Table 3-12. Summary of Gross Savings Inputs

Parameter	Ex Post Assumption	Ex Post Assumption Source
Baseline wattage	Minimum efficiency baseline adjusted for applicable federal standards	
Replacement wattage	Actual bulb wattage	
Average daily HOU	2.53 (CFLs) 2.43 (LEDs)	■ 2015 Evaluation of DEO Online Savings Store Program ■ 2017 DEO LED HOU Study ■ 2013 DEP Energy Efficient Lighting Program
CF – summer	0.0914% (CFLs) 0.11% (LEDs)	
CF – winter	0.096% (CFL) 0.16% (LED)	
ISR	89.3%	■ Online Savings Store participant survey for first-year ISR (including leakage) ■ UMP recommendations for installation trajectory ■ DEO specific discount rates to discount future savings
Interactive effects for energy ($HVAC_c$)	−0.0058	2015 Evaluation of DEO Online Savings Store Program
Interactive effects for summer peak demand ($HVAC_d$)	0.167	
Interactive effects for winter peak demand ($HVAC_d$)	0	Not used

In-Service Rate

We relied on the participant survey results to estimate the first-year ISR for the program. We administered the survey in three waves from December 2016 through June 2017 to capture participation over the course of the program period. As part of the survey, we asked program participants how many of the program bulbs they installed and how many were currently installed. We calculated the first-year ISR by dividing the total number of program bulbs reported in service by the total number of bulbs reported in the program-tracking database. We incorporated the receipt, installation, and persistence of program bulbs into the first-year ISR, as can be seen in Figure 3-1 below.

Figure 3-1. Installation Rate Components



The evaluation resulted in a first-year ISR of 79.3%. Relative precision around this point estimate is 6% at 90% confidence (Table 3-13).

Table 3-13. First-Year ISR

Metric	Total
n	220
First-year ISR	79.3%
Relative precision (at 90% confidence)	6%

Research studies across the country have found that, while customers may not install all of the program bulbs in the year that they receive them, they eventually install nearly all bulbs. Evaluators therefore need to account for those future savings in order to give the program proper credit for all the savings that it ultimately achieves. The two main approaches to claiming savings from these later installations are (1) staggering the savings over time and claiming some in later program years (staggered approach) and (2) claiming the savings from the expected installation in the program year that the customers received the product but discounting the savings by a societal or utility discount rate (discounted approach).

As part of our evaluation, we used the discounted approach. To allocate installations over time, we used the installation trajectory recommended by the UMP. The trajectory is based on a recent LED-specific Massachusetts study, which found that 24% of the LEDs that went into storage in year 1 were installed in year 2. Because the study is still ongoing, with only 2 years of data were available at the time of the revised UMP publication, the UMP recommends that evaluators assume that customers continue to install LEDs in storage at a rate of 24% each year to estimate lifetime ISR. Table 3-14 shows the UMP-recommended installation rate trajectory, both incremental and cumulative.

Table 3-14. Installation Rate Trajectory

Year	Incremental ISR	Cumulative ISR
Year 1	Year 1 ISR	Year 1 ISR
Year 2	(1 – Year 1 ISR) * 24%	Year 1 ISR + Year 2 ISR
Year 3	(1 – Year 1 ISR – Year 2 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR
Year 4	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR
Year n	(1 – Year 1 ISR – Year 2 ISR – Year 3 ISR – … Year n ISR) * 24%	Year 1 ISR + Year 2 ISR + Year 3 ISR + Year 4 ISR + …. Year n ISR

The UMP also recommends truncating the ISR trajectory to account for the impact of the second phase of EISA implementation, which goes into effect on January 1, 2020. The second phase increases the efficiency requirements of general service lightbulbs to 45 lumens per watt, which is effectively an energy efficient bulb. The UMP instructs evaluators to stop claiming savings from bulbs still in storage sometime after 2020, as the baseline for program LEDs will be an efficient bulb, thus resulting in no savings. We followed the UMP recommendations but set the truncation period starting in 2021, which allows for a 1-year sell-through period of noncompliant products. As a result, we claimed savings over 6 years for products sold in 2015, over 5 years for those sold in 2016, and over 4 years for those sold in 2017.

Consistent with the discounted approach, we discounted the savings by the utility discount rate for future installations (see Equation 3-3). We used the DEO-specific discount rate of 8.10%.

Equation 3-3. Net Present Value Formula

$$NPV = \frac{R_t}{(1+i)^t}$$

Where:

R = savings
t = number of years in the future savings take place
i = discount rate

We made an additional adjustment to account for the program bulbs installed outside of the DEO jurisdiction (leakage) as part of the ISR. We assessed leakage through the participant survey and determined it to be minimal at 1.8%. Table 3-15 provides the cumulative installation rate trajectory that we used to allocate savings over time. As can be seen in the table, the overall ISR for bulbs distributed in 2015 is 90.5%, the overall ISR for bulbs distributed in 2016 is 89.4%, and the overall ISR for bulbs distributed in 2017 is 87.8%. The overall ISR for all products distributed over the program period under evaluation is 89.3%

Table 3-15. Cumulative Installation Rate Trajectory

Year	Bulbs Discounted in 2015	Bulbs Discounted in 2016	Bulbs Discounted in 2017	Total
2015	77.9%	–	–	
2016	82.4%	77.9%	–	
2017	85.6%	82.4%	77.9%	
2018	87.8%	85.6%	82.4%	
2019	89.4%	87.8%	85.6%	
2020	**90.5%**	**89.4%**	**87.8%**	**89.3%**

Baseline Wattage

The evaluation team used the minimum efficiency baseline approach to determine baseline wattages for program-discounted products. Minimum efficiency standards in the market vary by product type based on the federal standards. Below, we detail the methods used to calculate baseline wattages for each product type.

General Service Products

Incandescent products have historically been the lowest efficiency product on the market. The 2007 EISA gradually phased out general service incandescent products, replacing them with halogens and thus making them the new baseline. The EISA regulations affected 100-watt incandescent products in January 2012, 75-watt incandescent products in January 2013, and 60-watt and 40-watt incandescent products in January 2014. Manufacturers and retailers were allowed to sell through existing inventory of incandescents, so products did not immediately disappear from the market. However, given that the program period under evaluation starts in late 2015, it is unlikely that incandescent light bulbs were available for purchase in the DEO jurisdiction then. In fact, recent shelf stocking studies conducted in the region show that incandescent products were limited in availability on store shelves. Given that, we used halogen baseline wattages to estimate savings for general service CFLs and LEDs discounted through the program (Table 3-16).

Table 3-16. Baseline Wattages for General Service Products

Equivalent Incandescent Wattage	EISA Baseline Wattage
40-watt equivalents	29
60-watt equivalents	43
75-watt equivalents	53
100-watt equivalents	72

Reflector Products

To determine baseline wattages for flood lights and reflector bulbs and fixtures, we relied on the approach established by the Navigant Consulting team during its PY2013 evaluation of the Duke Energy Progress (DEP) Energy Efficient Lighting (EEL) program. Baselines were assigned based on a combination of maximum allowable wattage and the available information for replacement bulbs regarding wattage and lumen output. We accounted for higher efficiency standards introduced by the DOE energy conservation standards for some incandescent reflector lamps that went into effect in July 2012. We deemed this approach reasonable given the complexities associated with assigning baseline wattages to reflector products, which include a non-linear lumen-to-watt ratio, a variety of bulb shapes and sizes of varying efficacies, and the discrepancy between maximum allowable wattages and product availability on store shelves.

Table 3-17. Baseline Wattage Assumptions for Reflector and Flood Light Products

Bulb Type	Lumen Range		Baseline Watts	Exemption Status
	Lower End	Upper End		
R, PAR, ER, BR, BPAR, or similar bulb shapes with medium screw bases with diameter >2.5" (*see exceptions below)	600	739	50	
	740	849	50	
	850	999	55	
	1,000	1,300	65	
*ER30, BR30, BR40, ER40	400	449	40	Exempt
	450	499	45	Exempt
	500	1,419	65	Exempt
*R20	400	449	40	Exempt
	450	719	45	Exempt
*All reflector lamps below the lumen ranges specified above	200	299	30	
	300	399	40	

Specialty Products

Neither EISA nor DOE energy conservation standards for incandescent reflector lamps affect other specialty products, such as three-way bulbs, candelabra bulbs, and globe bulbs. As such, we used incandescent products as the baseline for these specialty products.

Replacement Wattage

For the replacement wattage, we used the actual bulb wattage associated with each discounted lighting product. We compared the listed wattage to lumen outputs and measure descriptions where possible to ensure that the most accurate wattage was applied.

Hours of Use and Coincidence Factors

The industry standard to estimate HOU is to conduct lighting logger studies. Depending on the technology, we relied on one of two metering studies for HOU and CF estimates.

For CFLs, we relied on the results of the metering study completed as part of the most recent evaluation of the DEO Online Savings Store program. As part of the study, 211 lighting loggers were installed on switches with CFLs in the homes of 79 survey participants. The study resulted in CFL-specific and program-specific HOU and summer peak CFs for CFLs. The study did not develop winter peak CFs. Because most utilities in the midwestern United States are not winter peaking, estimates of winter peak CFs are rarely developed and used. Therefore, we used the winter peak CF from the 2013 evaluation of the DEP EEL program. While DEP service territory is not proximate to DEO service territory geographically, the definition of the winter peak period is similar, which supports the selection of the estimate.

For LEDs, we relied on the LED-specific HOU study completed as part of this evaluation. We metered LED usage across a representative sample of 300 switches in 96[17] homes of customers who participated in the Free LED and Online Savings Store programs over the course of 2016. Of the 96 homes, 53 homes participated in the Online Savings Store program. Across those homes, we deployed loggers on 182 switches with LEDs. Appendix 3, provided alongside this report, details the study's methodology and results.

Table 3-18. CFL and LED HOU and CF Assumptions

Statistic	CFL	LED
HOU	2.53	2.43
Summer CF	0.0914%	0.11%
Winter CF	0.096%	0.16%

Interactive Effects

CFLs and LEDs emit less heat than incandescents, resulting in increased heating loads, as more energy is needed to supplement heat emitted by incandescent light bulbs. CFLs and LEDs also decrease cooling loads, as less energy is needed to compensate for heat given off by incandescents. Application of interactive effects accounts for the changes in heating and cooling loads in the estimation of savings.

The evaluation team chose to use the interactive effects for energy and summer demand estimated as part of the 2015 Process and Impact Evaluation of the Online Store Program in Ohio program by TecMarket

[17] Loggers were originally deployed in 101 homes. Loggers from five homes were dropped during the data cleaning and analysis process due to data quality reasons.

Works. The interactive effects were taken from DOE-2 simulations of the residential prototype building and adjusted using customer-specific HVAC system information collected through Duke Energy's appliance saturation survey in Ohio. As such, these values more accurately represent the participant population than the deemed values in the Ohio TRM, which do not take into account the specifics of the DEO heating and cooling system specifics, and are therefore preferable to the TRM values.

Interactive factors for winter peak demand were not estimated as part of the most recent evaluation of the Online Savings Store program, and reasonable and recent estimates from similar areas are not available because utilities in the Midwest are not winter peaking. We decided to use a factor of 0 (zero), which assumes that there is no electric heat loss due to the installation of program CFLs or LEDs. Based on the results from the 2010–2013 ACS, we estimate that fewer than one-third of the homes in the DEO service territory are electrically heated.

Table 3-19. Interactive Effects

Interactive Effect Type	Value
Interactive effects for energy ($HVAC_c$)	−0.0058
Interactive effects for summer peak demand ($HVAC_d$ – Summer)	0.167
Interactive effects for winter peak demand ($HVAC_d$ – Winter)	0

Due to differences in technologies, interactive effects caused by CFLs and LEDs are likely different. Furthermore, a change in interactive effects due to a shift in the baseline technology from incandescents to halogens for certain product categories is also possible. However, the difference in these effects is unclear, especially as it pertains to the DEO jurisdiction. We are unaware of any existing modeling or simulation efforts to estimate LED-specific interactive effects or interactive effects using halogens as the baseline. In our professional judgment, the difference between CFL and LED interactive effects is likely to have only a marginal impact on energy and peak demand savings. Given the small anticipated change in energy and peak demand savings estimates due to LED-specific interactive effects, and the relatively high cost of conducting the modeling and simulation needed to estimate those interactive effects, Opinion Dynamics relied on the previously established interactive effect estimates for CFLs from the sources cited above.

3.5.2 Gross Impact Results

Opinion Dynamics received program-tracking data for the Online Savings Store program in two extracts. One extract contained product and shipment information, while the other contained customer contact information. We merged and analyzed the data for any gaps or inconsistencies. As a part of the analysis, we performed the following steps:

- Checked the core data fields for missing values
- Checked the data for temporal gaps
- Checked shipment data for out-of-state shipments
- Checked the key data fields for reasonableness of the values

In reviewing the data, we found that the date fields were clean and fully populated. We did not observe any anomalies in participation over time. We also observed no anomalous observations in the analysis of incentives and bulb costs. We found that more than 99% of purchases were shipped within Ohio, indicating minimal leakage out of the DEO jurisdiction.

Using the equations and inputs discussed in Section 3.5.1, we calculated gross energy and peak demand savings achieved by the program during the evaluation period. Table 3-20 presents the results of the analysis. The Online Savings Store program realized 102% of the reported gross energy savings, 158% of the reported summer peak demand savings, and 142% of the reported winter peak demand savings.

Table 3-20. Gross Impact Results

Year	Metric	Ex Ante Savings	Ex Post Gross Savings	Gross Realization Rate
2015	Bulbs	1,130	1,130	
	Energy savings (MWh)	39	41	107%
	Summer peak demand savings (MW)	0.004	0.005	144%
	Winter peak demand savings (MW)	0.006	0.006	95%
2016	Bulbs	151,497	151,497	
	Energy savings (MWh)	4,986	5,086	102%
	Summer peak demand savings (MW)	0.456	0.722	158%
	Winter peak demand savings (MW)	0.614	0.876	143%
2017	Bulbs	5,856	5,856	
	Energy savings (MWh)	215	202	94%
	Summer peak demand savings (MW)	0.019	0.029	150%
	Winter peak demand savings (MW)	0.026	0.036	138%
Total	Bulbs	158,483	158,483	
	Energy savings (MWh)	5,241	5,329	102%
	Summer peak demand savings (MW)	0.479	0.757	158%
	Winter peak demand savings (MW)	0.645	0.917	142%

Note that gross savings and gross realization rate were developed using unrounded values.

Table 3-21 provides per-bulb ex post gross savings by measure. Measure categories in the table below are consistent with the DEO desired definitions. To develop program-level gross impacts for regulatory compliance, the evaluation team compared ex ante and ex post gross savings and used the higher of the two values. Section 3.7 details the process for developing those impacts and presents the results.

Table 3-21. Per Bulb Gross Savings

Measure	Ex Ante Gross Savings			Ex Post Gross Savings		
	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	34.31	0.0034	0.0075	81.93	0.0095	0.0086
3-Way LED	44.11	0.0040	0.0097	35.42	0.0052	0.0064
A-Line CFL	22.17	0.0022	0.0049	26.51	0.0031	0.0028
A-Line LED	50.65	0.0049	0.0093	20.33	0.0030	0.0037
Candelabra CFL	12.14	0.0012	0.0027	17.88	0.0021	0.0019
Candelabra LED	18.17	0.0017	0.0017	26.85	0.0039	0.0049
Globe CFL	14.45	0.0014	0.0032	27.10	0.0031	0.0028

Measure		Ex Ante Gross Savings				Ex Post Gross Savings
Globe LED	17.67	0.0016	0.0039	27.98	0.0041	0.0051
Recessed dimmable CFL	42.04	0.0042	0.0092	27.90	0.0032	0.0029
Recessed CFL	25.08	0.0025	0.0055	39.76	0.0046	0.0042
Recessed LED	44.98	0.0040	0.0040	41.66	0.0061	0.0076
Recessed outdoor CFL	64.82	0.0065	0.0142	40.22	0.0047	0.0042
Recessed outdoor LED	119.89	0.0021	0.0228	39.29	0.0057	0.0071
Spiral 13-watt CFL	22.25	0.0029	0.0024	24.61	0.0029	0.0026
Spiral 18-watt CFL	25.96	0.0034	0.0028	27.07	0.0031	0.0028
Spiral 23-watt CFL	40.69	0.0052	0.0043	40.20	0.0047	0.0042

3.5.3 References

TecMarket Works. *Process and Impact Evaluation of the Residential Energy Efficient Appliance and Devices: Lighting - Specialty Bulbs Program in Ohio*. Prepared for Duke Energy. May 13, 2015.

Navigant Consulting, Inc. and Apex Analytics, LLC. *EM&V Report for the 2013 Energy Efficient Lighting Program.* Prepared for Duke Energy Progress. August 13, 2014.

National Renewable Energy Laboratory (NREL). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Protocol.* October, 2017. https://www.nrel.gov/docs/fy17osti/68562.pdf.

Environmental Protection Agency. *Next Generation Lighting Programs: Opportunities to Advance Efficient Lighting for a Cleaner Environment.* October 1, 2011. *https://www.energystar.gov/ia/partners/manuf_res/downloads/lighting/EPA_Report_on_NGL_Programs_for_508.pdf.*

ENERGY STAR. *ENERGY STAR Program Requirements for Lamps (Light Bulbs).* September 30, 2014. *http://www.energystar.gov/products/spec/sites/products/files/ENERGY%20STAR%20Lamps%20V1.0%20Final%20Draft%20Specification.pdf.*

Department of Energy. *10 CFR Part 430. Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Final Rule.* July 14, 2009. *http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0131-0005.*

Opinion Dynamics. *Impact and Process Evaluation of the 2015 Illinois Power Agency Residential Lighting Program.* Prepared for Ameren Illinois. March 9, 2017. (http://ilsagfiles.org/SAG_files/Evaluation_Documents/Ameren/AIU_Eval_Reports_PY8/AIC-IPA_PY8_Residential_Lighting_Evaluation_Report_REVISED_FINAL_2017-09-12.pdf)

3.6 Net-to-Gross Analysis

This section describes our approach for estimating the NTGR for the Online Savings Store program and presents the resulting NTGR and the program net impacts.

3.6.1 Methodology

The NTGR represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTGR represents the share of program-induced savings. The NTGR consists of FR and SO and is calculated as $(1 - FR + SO)$. FR is the proportion of the program-achieved verified gross savings that would have been realized absent the program. There are two types of SO: participant and nonparticipant. Participant SO occurs when participants take additional energy-saving actions that are influenced by program interventions but that did not receive program support. Nonparticipant SO is the reduction in energy consumption and/or demand by nonparticipants because of the influence of the program.

As part of this evaluation, the evaluation team estimated FR and participant SO. Quantifying savings from nonparticipant SO activities is a challenging task that warrants a separate study and was outside of the scope of this evaluation effort. In addition, the Online Savings Store program design is less likely to result in significant amounts of nonparticipant SO than upstream lighting programs that exist in the larger market. Both FR and SO components of the NTGR were derived from self-reported information from web surveys and telephone interviews with program participants.

The final NTGR is the percentage of gross program savings that can reliably be attributed to the program. We estimated a separate NTGR for each participant, which we weighted to reflect the relative contribution of each participant's savings to the overall program estimate.

Below is a general overview of the method for developing FR and SO estimates. Appendix 2, provided along with this report, contains the participant survey instrument and detail behind FR and SO algorithms.

Free-Ridership

Free-riders are program participants who would have installed high-efficiency light bulbs on their own without the program. FR represents the percent of savings that would have been achieved in the absence of the program. Through participant surveys, we asked program participants a series of structured and open-ended questions about the influence of the program on their decision to order and install program bulbs. The survey questions measured the following areas of program influence:

- **Influence on efficiency:** We asked participants if, in the absence of the program discounts, they would have purchased the energy efficient products
- **Influence on timing:** We asked participants who replaced working incandescent bulbs if they would have replaced working light bulbs on their own if they had not received program-discounted products, or if they would have waited for the bulbs to burn out
- **Influence on quantity:** We asked participants whether they would have purchased fewer energy efficient products if they had purchased the bulbs on their own at full retail price

As part of the FR survey module, we referenced retail bulb pricing to ground participant responses.[18] To reduce measurement error, we included follow-up questions to check participant responses for consistency.

Spillover

SO represents energy savings from additional actions (expressed as a percent of total program savings) that were due to the program but that did not receive program financial support. While SO can result from a variety of measures, it is not possible to ask about a large number of potential SO measures on a survey due to the need to limit the length of the survey. The evaluation team chose to focus on the measures that participants would reasonably take following their program participation and would do so without additional program support. As such, we focused SO questions on CFLs and LEDs. We asked participants if they purchased any CFLs or LEDs after receiving program LEDs.[19] We asked those who purchased additional bulbs about the degree to which the program influenced their decision to purchase high-efficiency bulbs as opposed to less-efficient alternatives. We asked participants to rate the degree to which the program influenced their purchase decision, as well as to provide a rationale for their rating. We carefully reviewed participant responses to establish eligibility for SO participants and purchases.

To estimate the SO rate, we estimated savings for each SO measure using the standard savings equation and a set of engineering assumptions. We determined the program-level SO rate by dividing the sum of SO savings by the ex post gross savings achieved by the sample of participants who received SO questions (Equation 3-4).

Equation 3-4. SO Rate Formula

$$Spillover\ Rate = \frac{Spillover\ Savings}{Evaluated\ Gross\ Savings\ in\ the\ Respondent\ Sample}$$

3.6.2 NTG Results

We estimate the overall FR to be 38.7% and SO to be 2.3%. The resulting program NTGR for the evaluation period is 63.5%. Relative precision around this point estimate is 14% at 90% confidence. Table 3-22 provides FR results, along with SO and final program-level NTGR. We applied the overall program-level NTGR of 63.5% to ex post gross impacts to arrive at the ex post net impacts.

Table 3-22. NTG Results

NTG Component	n	Value	Relative Precision
FR	136	38.7%	23%
SO	220	2.3%	4%
NTGR	**356**	**63.5%**	**14%**

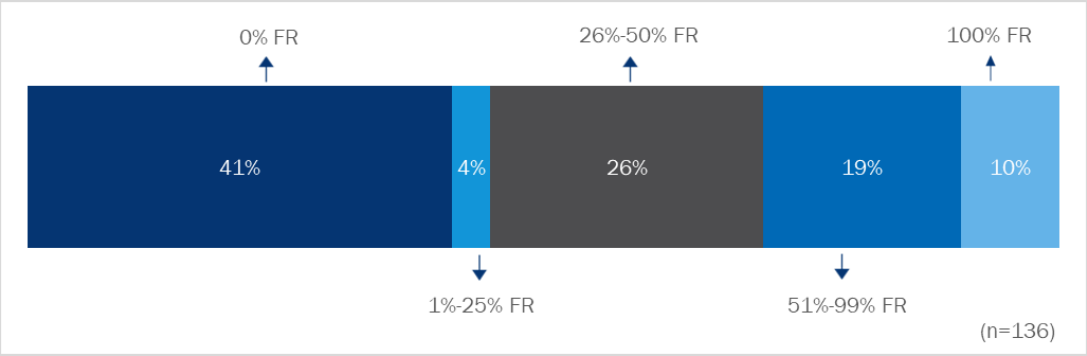
[18] We used a per-bulb retail prices for like-products provided as part of the Online Savings Store program participation data.

[19] Note that the assessment of program SO is based on Phase 0 and Phase 1 participants.

Free-Ridership

Our results show that FR rates varied across participants (see Figure 3-2). More than two-fifths of participants (41%) are complete non-free-riders. That is, in the absence of the program's discounts, they would have purchased less-efficient alternatives, namely, halogens. At the opposite end of the FR spectrum, only 10% are complete free-riders who reported that they would have purchased all of the energy efficient products that they received through the program on their own at full retail price. A combined 49% of respondents are partial free-riders (FR between 1% and 99%). Participants could be partial free-riders for several reasons. Some of the partial free-riders are participants who reported that, in the absence of receiving the program's discounts, they would have purchased a mix of LEDs or CFLs and halogens the next time they needed to purchase light bulbs. Other partial free-riders are customers who reported that they would have purchased efficient bulbs (CFLs or LEDs) on their own but reported that the program motivated them to replace their working incandescent or halogen light bulbs with efficient bulbs, which they would not have done on their own. In essence, the program sped up their installation of energy efficient bulbs.

Figure 3-2. Breakdown of Free-Ridership Rates



The program NTGR of 63.5% is low compared to the previous evaluation of this program that established a NTGR of 77.8% for the program. As compared to the general population of DEO customers, program participants are more likely to be homeowners, reside in single-family homes, and have higher incomes and higher levels of educational attainment, and all of these demographic groups have higher FR and consequently lower NTGRs. We discuss the differences in participant composition and their effect on FR in greater detail in Section 3.8.2 of this report.

Table 3-23 below provides FR by product type. Note that for standard CFLs and reflector CFLs the sample sizes are too small. FR is the lowest for specialty CFLs (27.3%).

Table 3-23. FR by Product Type

FR by Product Type	n	Mean	Relative Precision
Standard CFLs	6	76.9%	30%
Reflector CFLs	1	33.3%	--
Specialty CFLs	30	27.3%	40%
Standard LEDs	48	34.6%	29%
Reflector LEDs	28	41.8%	42%
Specialty LEDs	23	36.4%	33%
Total	**136**	**38.7%**	23%

Spillover

More than a quarter of the Online Savings Store program participants (29%) purchased additional CFLs or LEDs since participating in the program. Overall, 6% of all participants qualified for SO by attributing these purchases to the experience with the program. The average SO participant purchased 4.5 bulbs that qualified for SO, most of those being LEDs.

3.6.3 Net Impact Results

Table 3-24 presents ex post gross and net savings, along with the net realization rates for the program period under evaluation. We developed net realization rates by dividing ex post net savings by ex ante net savings. We present net impact results by program year as well as overall. Overall, the program achieved 3,384 MWh in ex post net energy savings, 0.481 MW in ex post net summer peak demand savings, and 0.582 MW in ex post net winter peak demand savings, achieving 83%, 129%, and 116% net realization rates, respectively.

Table 3-24. Ex Post Gross and Net Savings Evaluation Results

Year	Metric	Ex Post Gross Savings	Ex Post Net Savings	Net Realization Rate[b]
2015	Bulbs	1,130	1,130	
	Energy savings (MWh)	41	26	87%
	Summer peak demand savings (MW)	0.005	0.003	118%
	Winter peak demand savings (MW)	0.006	0.004	78%
2016	Bulbs	151,497	151,497	
	Energy savings (MWh)	5,086	3,230	83%
	Summer peak demand savings (MW)	0.722	0.459	129%
	Winter peak demand savings (MW)	0.876	0.556	116%
2017	Bulbs	5,856	5,856	
	Energy savings (MWh)	202	128	76%
	Summer peak demand savings (MW)	0.029	0.018	122%
	Winter peak demand savings (MW)	0.036	0.023	113%
Total	Bulbs	158,483	158,483	
	Energy savings (MWh)	5,329	3,384	83%
	Summer peak demand savings (MW)	0.757	0.481	129%
	Winter peak demand savings (MW)	0.917	0.582	116%

Note that total savings, both gross and net, as well as net realization rate were developed using unrounded values.
[a] Denominator is ex ante net savings.

Table 3-25 provides per-bulb ex post net savings by measure. Measure categories in the table below are consistent with the DEO desired definitions. To develop program-level net impacts for regulatory compliance, the evaluation team compared ex ante and ex post gross savings and multiplied the higher of the two by the program NTGR. Section 3.7 details the process for developing those impacts and presents the results.

Table 3-25. Per-Bulb Ex Post Net Savings

Measure	Ex Post Net kWh	Ex Post Net Summer Peak kW	Ex Post Net Winter Peak kW
3-Way CFL	52.02	0.0060	0.0054
3-Way LED	22.49	0.0033	0.0041
A-Line CFL	16.83	0.0020	0.0018
A-Line LED	12.91	0.0019	0.0023
Candelabra CFL	11.35	0.0013	0.0012
Candelabra LED	17.05	0.0025	0.0031
Globe CFL	17.21	0.0020	0.0018
Globe LED	17.77	0.0026	0.0032
Recessed dimmable CFL	17.71	0.0021	0.0019
Recessed CFL	25.25	0.0029	0.0026
Recessed LED	26.45	0.0039	0.0048
Recessed outdoor CFL	25.54	0.0030	0.0027
Recessed outdoor LED	24.95	0.0036	0.0045
Spiral 13-watt CFL	15.63	0.0018	0.0016
Spiral 18-watt CFL	17.19	0.0020	0.0018
Spiral 23-watt CFL	25.53	0.0030	0.0027

3.7 Program-Level Impacts for Regulatory Compliance

In the state of Ohio, electric distribution utilities (EDUs), including DEO, are required to achieve a cumulative annual energy savings of more than 22% by 2027 per Ohio Senate Bill (SB) 310. SB 310 also introduced new mechanisms that adjust how EDUs may estimate their energy savings achieved through demand side management programs. Specifically, SB 310 requires the Ohio Public Utilities Commission (PUCO) to permit EDUs to account for energy-efficiency savings estimated on an "as-found" or a deemed basis. That is, an EDU may claim savings based on the baseline operating conditions found at the location where the energy-efficiency measure was installed, or the EDU may claim a deemed savings estimate.

To support compliance with SB 310, we developed a separate set of savings estimates. These estimates are based on the higher of ex ante and ex post savings values for each measure. We used the formula specified in the equation below to develop per-bulb gross impacts for SB 310 compliance. We used ex ante measure definitions that DEO uses for cost-effectiveness calculations in DSMORE.

Equation 3-5. Savings Estimation Approach for SB 310 Compliance Impacts

$$Sav_i = Max(ESTexante_i, ESTexpost_i)$$

Where:

Sav_i = Total annual savings for measure i

$ESTexante_i$ = Per unit ex ante deemed savings estimate for measure i (kW or kWh)

$ESTexpost_i$ = Per unit ex post deemed savings estimate for measure i (kW or kWh)

Table 3-26 provides per-bulb ex ante and ex post gross savings, as well as the per-bulb savings used to estimate savings claimable under SB 310.

Table 3-26. Per-Bulb Ex Ante, Ex Post, and Claimable Under SB 310 Savings

	Ex Ante Gross Per-Bulb Savings			Ex Post Gross Per-Bulb Savings			Per-Bulb Gross Savings Claimable Under SB 310		
Measure	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	34.31	0.0034	0.0075	81.93	0.0095	0.0086	81.93	0.0095	0.0086
3-Way LED	44.11	0.0040	0.0097	35.42	0.0052	0.0064	44.11	0.0052	0.0097
A-Line CFL	22.17	0.0022	0.0049	26.51	0.0031	0.0028	26.51	0.0031	0.0049
A-Line LED	50.65	0.0049	0.0093	20.33	0.0030	0.0037	50.65	0.0049	0.0093
Candelabra CFL	12.14	0.0012	0.0027	17.88	0.0021	0.0019	17.88	0.0021	0.0027
Candelabra LED	18.17	0.0017	0.0017	26.85	0.0039	0.0049	26.85	0.0039	0.0049
Globe CFL	14.45	0.0014	0.0032	27.10	0.0031	0.0028	27.10	0.0031	0.0032
Globe LED	17.67	0.0016	0.0039	27.98	0.0041	0.0051	27.98	0.0041	0.0051
Recessed dimmable CFL	42.04	0.0042	0.0092	27.90	0.0032	0.0029	42.04	0.0042	0.0092
Recessed CFL	25.08	0.0025	0.0055	39.76	0.0046	0.0042	39.76	0.0046	0.0055
Recessed LED	44.98	0.0040	0.0040	41.66	0.0061	0.0076	44.98	0.0061	0.0076
Recessed outdoor CFL	64.82	0.0065	0.0142	40.22	0.0047	0.0042	64.82	0.0065	0.0142
Recessed outdoor LED	119.89	0.0021	0.0228	39.29	0.0057	0.0071	119.89	0.0057	0.0228
Spiral 13-watt CFL	22.25	0.0029	0.0024	24.61	0.0029	0.0026	24.61	0.0029	0.0026
Spiral 18-watt CFL	25.96	0.0034	0.0028	27.07	0.0031	0.0028	27.07	0.0034	0.0028
Spiral 23-watt CFL	40.69	0.0052	0.0043	40.20	0.0047	0.0042	40.69	0.0052	0.0043

Note that both ex ante and ex post estimates incorporate ISR.

Table 3-27provides per-bulb gross and net savings claimable under SB 310. Net savings were calculated by multiplying gross savings claimable under SB 310 by the NTGR of 63.5% developed through this evaluation.

Table 3-27. Per-Bulb Gross and Net Savings Claimable Under SB 310

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTGR	Net Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	81.93	0.0095	0.0086	63.5%	52.02	0.0060	0.0054
3-Way LED	44.11	0.0052	0.0097	63.5%	28.01	0.0033	0.0061
A-Line CFL	26.51	0.0031	0.0049	63.5%	16.83	0.0020	0.0031
A-Line LED	50.65	0.0049	0.0093	63.5%	32.17	0.0031	0.0059
Candelabra CFL	17.88	0.0021	0.0027	63.5%	11.35	0.0013	0.0017
Candelabra LED	26.85	0.0039	0.0049	63.5%	17.05	0.0025	0.0031
Globe CFL	27.10	0.0031	0.0032	63.5%	17.21	0.0020	0.0020
Globe LED	27.98	0.0041	0.0051	63.5%	17.77	0.0026	0.0032
Recessed dimmable CFL	42.04	0.0042	0.0092	63.5%	26.70	0.0027	0.0059
Recessed CFL	39.76	0.0046	0.0055	63.5%	25.25	0.0029	0.0035
Recessed LED	44.98	0.0061	0.0076	63.5%	28.56	0.0039	0.0048
Recessed outdoor CFL	64.82	0.0065	0.0142	63.5%	41.16	0.0041	0.0090
Recessed outdoor LED	119.89	0.0057	0.0228	63.5%	76.13	0.0036	0.0145
Spiral 13-watt CFL	24.61	0.0029	0.0026	63.5%	15.63	0.0018	0.0016
Spiral 18-watt CFL	27.07	0.0034	0.0028	63.5%	17.19	0.0022	0.0018
Spiral 23-watt CFL	40.69	0.0052	0.0043	63.5%	25.84	0.0033	0.0027

3.8 Process Evaluation

3.8.1 Methodology

The program process assessment leveraged the following data collection methods and research activities:

- Program staff interviews (n=2)
- Materials review
- Program-tracking data analysis
- Participant survey (n=357)
- LED HOU study (n=56)

We detail each data collection method, as well as achieved confidence and precision, in Section 3.4 of this report.

3.8.2 Key Findings

Program Performance

From December 17, 2015 through February 13, 2017, Duke Energy discounted 158,483 CFLs and LEDs. CFLs represented only a small share of all sales (10%), while reflector and specialty LEDs accounted for more than three-quarters of program sales (82%).

Table 3-28. Program Technology Shares by Product Type

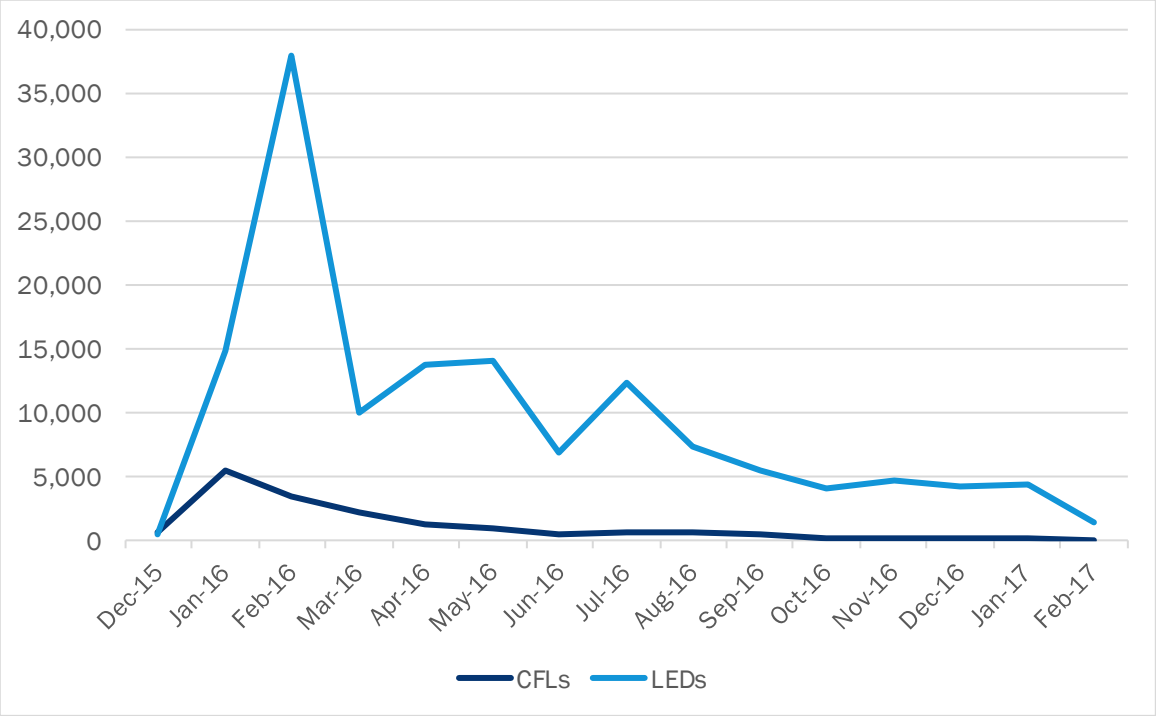
Bulb Technology	Bulbs Distributed	Percent of Total Bulbs
Standard CFL	6,300	4%
Reflector CFL	3,526	2%
Specialty CFL	6,665	4%
Standard LED	12,230	8%
Reflector LED	61,613	39%
Specialty LED	68,149	43%
Total	**158,483**	**100%**

A total of 10,621 unique customers purchased program-discounted lighting products during the program period under evaluation. Based on the estimated number of 135,565 households in the DEO jurisdiction, 10,621 participants represent an estimated 8% of the DEO customer base.

More than three-quarters of participants (77%) participated in the program via the online store website and the remaining 22% participated via online services (OLS) intercepts.

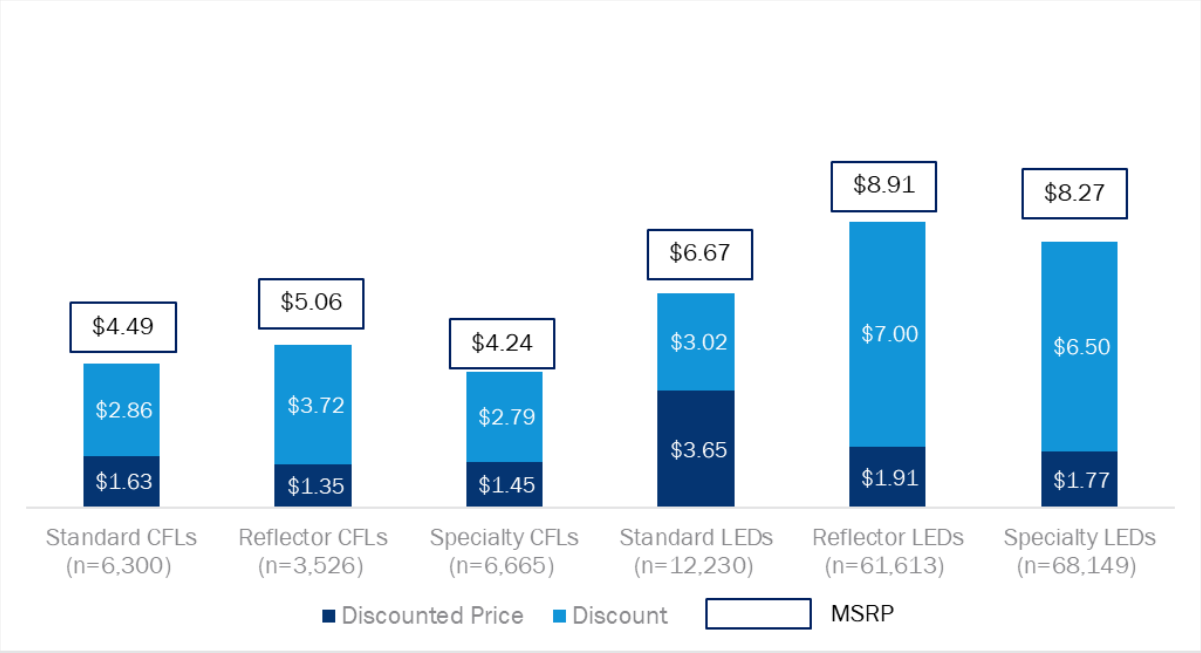
Participation in the program varied over the course of the program period, with a spike in early 2016. Program CFL sales decreased considerably after the first quarter of 2016 (Figure 3-3).

Figure 3-3. Sales of Program Bulbs Over Time



Average program discounts ranged from $2.79 for specialty CFLs to $8.91 for reflector LEDs. Depending on the product category, the average discount as a percentage of the retail price (or MSRP) ranged from 15% for standard LEDs to 88% for specialty LEDs. The average program discount across all product categories was $6.07, which represents on average 74% of MSRP. Figure 3-4 provides an overview of the program discounts by product type over the course of the program period under evaluation. As can be seen in the figure, discounts on specialty and reflector LED products were higher than discounts on any other product, in part as a result of the technology being generally more expensive. Discounts on standard LEDs were among the lowest, with participants paying the most post-discount on average for products in this category. Average LED discounts ranged from $3.02 for standard LEDs to $7.00 for reflector LEDs.

Figure 3-4. Program Pricing Analysis



Non-discounted products are excluded from the analysis.

Participant Composition

For the participant composition analysis, we compared participant sociodemographic and household characteristics gathered as part of the participant survey effort to the DEO population. We obtained population characteristics from the 2015 U.S. Census's American Community Survey (ACS) 5-year data. As part of the analysis, we examined FR rates for each of the sociodemographic subgroups. The analysis allowed us to identify the customer types that the program is reaching and future targeting opportunities to improve the efficacy of the program in advancing energy efficiency in the jurisdiction.

Table 3-29 provides the results of the analysis. As can be seen in the table, during the program period under evaluation, program participant composition skews disproportionately toward older customers (79% of program participants were over the age of 44 vs. 51% of the DEO customer base), homeowners (97% of program participants vs. 38% of the DEO customer base), single-family residents (88% of program participants vs. 43% of the DEO customer base), customers with higher levels of education (65% of program participants have at least a college degree vs. 37% of the DEO customer base), and customers with higher income levels (80% of program participants have an annual income of at least $50,000 vs. 41% of the DEO customer base).

Disproportionate participation of single-family home residents, higher-income customers, and customers with higher education levels had a negative impact on the program's net impacts, because FR among those three customer cohorts is much higher than their respective counterparts. As can be seen in Table 3-29, FR among single-family home residents is 39%, while FR among non-single-family home residents is 25%. FR among customers with high school education or less is 21%, compared to the FR of 44% among those with some college, and 40% among those with at least a college degree. Similarly, FR among those with annual household incomes of less than $50,000 is 25%, while FRs among those with incomes of $50,000 to less than $100,000 and at least $100,000 are 29% and 48%, respectively.

These findings suggest that focusing program efforts on targeting customers in multifamily homes, lower-income customers, and customers with lower levels of educational attainment will help reduce the program FR rate, thus ensuring a more efficacious program. To avoid possible overlap with Duke Energy's Multifamily program the program should consider identifying customers currently not targeted through the Multifamily program and targeting Online Store offerings to that group. To minimize the overlap with the Low-Income program, focusing on areas with a high concentration of customers with moderate income levels could be a beneficial strategy. The evaluation team recognizes, however, the fine balance required between promoting the Online Savings Store program to the desired segments, and minimizing the cannibalization of the other programs' impacts.

Table 3-29. Comparison of Program Participants to DEO Population

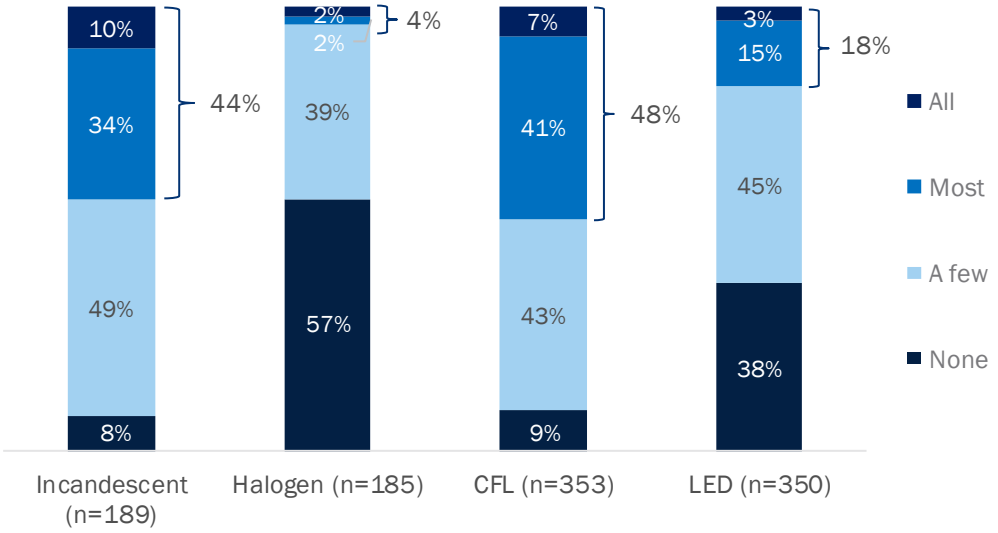
Characteristic	FR	Participant Characteristics	Population Estimates
Age		**n=344**	**Census Data**
Under 25	--	0%	9%
25–44	50%	21%	40%
45–64	36%	42%	32%
65+	34%	37%	19%
Home ownership		**n=355**	**Census Data**
Own	40%	97%	38%
Rent	0%[a]	3%	62%
Education		**n=350**	**Census Data[b]**
High school or less	21%	9%	37%
Some college	44%	25%	26%
College graduate +	40%	65%	37%
Income		**n=320**	**Census Data**
Less than $50,000	25%	20%	59%
$50,000 to less than $100,000	29%	38%	25%
$100,000+	48%	42%	16%
Housing type		**n=356**	**Census Data**
Single-family	39%	88%	43%
Non-single-family (townhouse, mobile home, multifamily)	25%	12%	57%

[a] Based on three observations.
[b] Population-level estimate as opposed to the household-level estimate.

Participant Lighting Knowledge and Experience

As part of the participant survey, we explored participants' existing knowledge and use of the various technologies. We asked participants to estimate how many of the light sockets in their homes contained each of the lighting technologies **before** participating in the Online Savings Store program. Based on participant self-report, in nearly half of homes (48%), CFLs had been installed in all or most light sockets, and in 18% of homes, LEDs had been installed in all or most sockets (Figure 3-5). Combined, 62% of the participant homes had either CFLs or LEDs in all or most of their sockets. It is worth noting that questions about sources of program awareness can be prone to measurement error due to the difficulty of estimating the share of bulbs in the home by technology.

Figure 3-5. Percent of Sockets Containing Technology

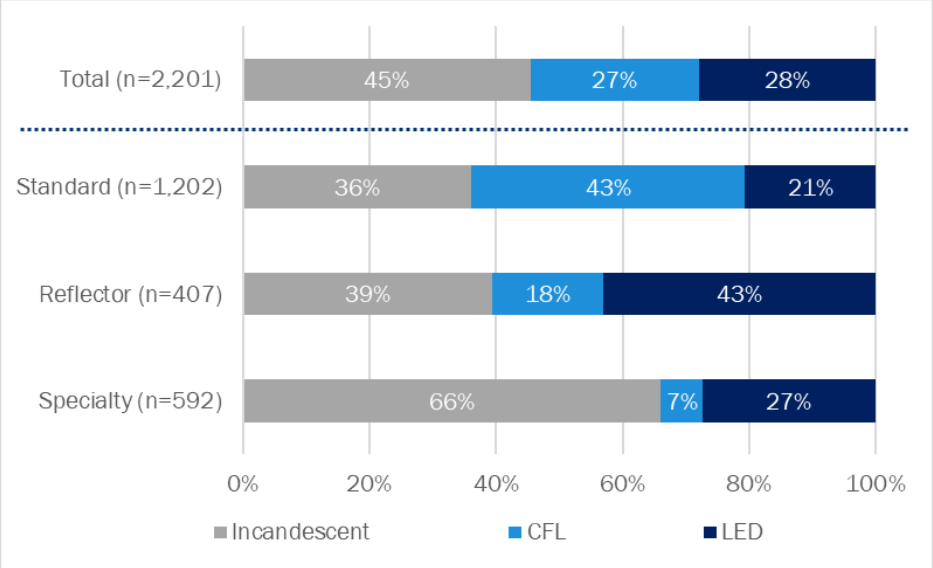


Such a high presence of energy efficient products in participant homes indicates that participants had high existing levels of awareness and familiarity with the products and an increased likelihood to select those products moving forward. The results also suggest that many participants could end up replacing existing energy efficient products with new program CFLs and LEDs. As part of the participant survey, we asked what types of products participants replaced with program CFLs and LEDs and found that just under half of participants (49%) installed at least some program CFLs or LEDs in place of energy efficient products. Overall, 29% of all installed program CFLs or LEDs were installed in place of other energy efficient products.

As part of the LED HOU study, we collected information on the types of products in participant sockets. The data were collected **after** customers participated in the DEO program. As can be seen in Figure 3-6, after participating in the Online Savings Store program, slightly fewer than half of sockets overall were filled with incandescents (45%). Standard sockets had the highest energy efficient saturation, followed by reflector sockets (combined CFL and LED saturation rates of 64% and 61%, respectively). Specialty sockets lagged behind with a third of sockets (34%) containing CFLs or LEDs.

The presence of incandescent products in 45% of customer sockets may indicate that the program may be missing an opportunity to encourage early replacement of some of these incandescents. We found that many customers (82%) who had not installed all of the CFLs and LEDs they purchased said they were waiting for their existing bulbs to burn before installing them.

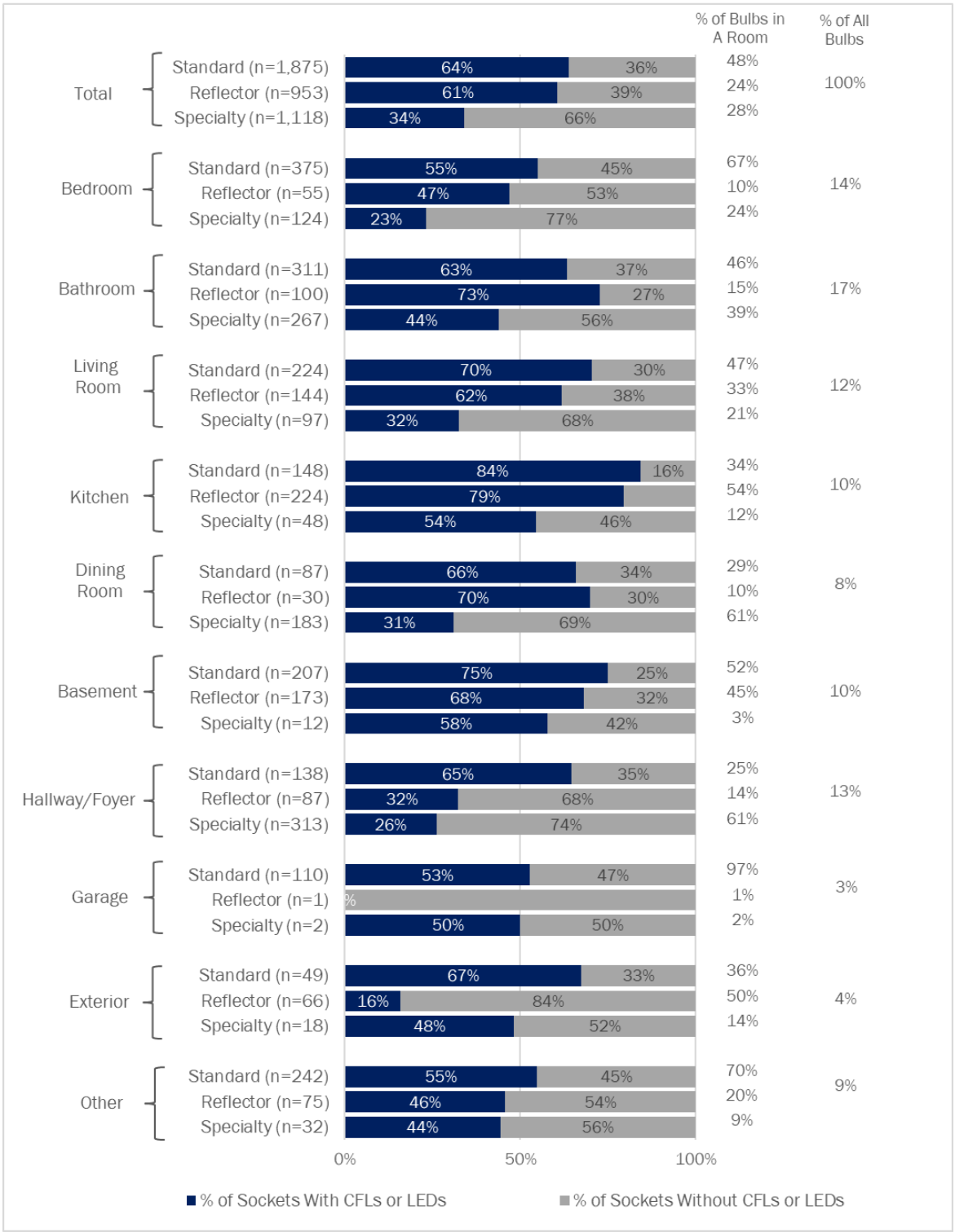
Figure 3-6. Bulb Mix in Participant Homes



Saturation analysis by product type and room type shows that CFL and LED saturation in standard sockets is high across most rooms, with high-usage rooms, such as living rooms and kitchens, featuring higher-than-average saturation (70% and 84%, respectively) (Figure 3-7). These findings indicate that customers are installing program products in high-usage sockets, thus maximizing the savings from those products.

Saturation of energy efficient reflector and specialty products varies by room type more than that of standard products. Energy efficient reflectors are more likely to be present in bathrooms, kitchens, and dining rooms and less likely to be present in bedrooms, hallways, garages, and outside. Energy efficient specialty products are more likely to be present in kitchens, basements, and outside, and less likely to be present in bedrooms and hallways.

Figure 3-7. Product Mix by Room Type



Participant Lighting Shopping Behaviors

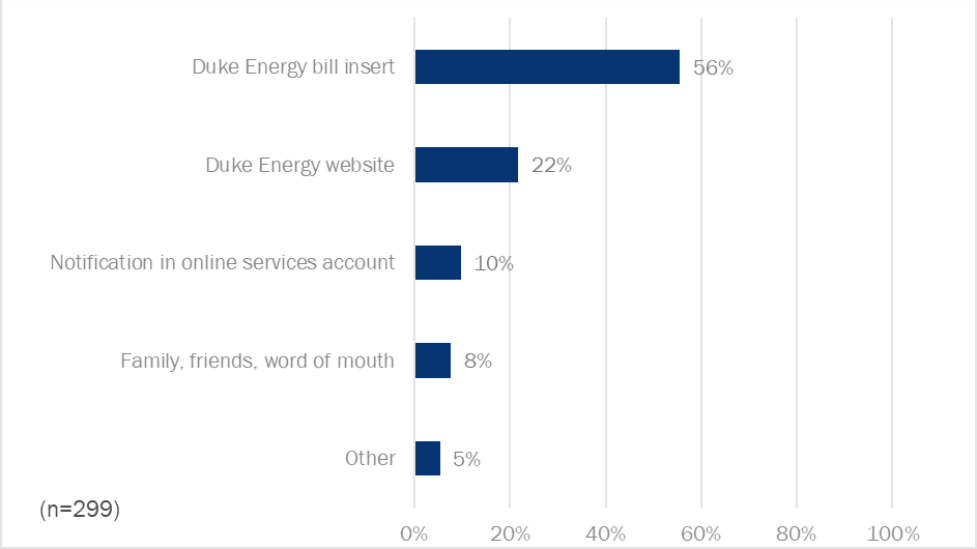
Most participants purchase light bulbs at brick and mortar locations; fewer than a third of participants (31%) reported shopping for light bulbs online prior to participating in the program.

When shopping for light bulbs on the Duke Energy Online Store, more than three-quarters (78%) of participants compared prices for similar products with a local retailer either by visiting the store or by going to the retailer's website before placing their order with Duke Energy.

Program Marketing and Outreach

Slightly more than half of participants who placed orders through the Online Store platform (56%) reported learning about the Online Savings Store program through Duke Energy bill inserts. Slightly more than a fifth of participants (22%) learned about the program through the Duke Energy website. Other, less common sources of information about the program included notifications in online services account, family, friends, and word of mouth (Figure 3-8). It is worth noting that questions about sources of program awareness can be prone to measurement error due to recall issues and possible exposure to the program through multiple sources. More specifically, participants likely meant business reply cards when selecting the bill insert option, as the program did not include program collateral in the electric bills.

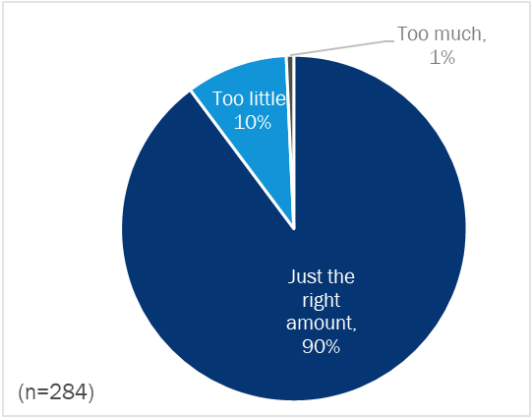
Figure 3-8. Sources of Program Awareness



Online Savings Store Website Experiences

The DEO Online Savings Store website features educational information about the CFLs and LEDs discounted through the program. Most participants who purchased program-discounted products through the Online Store website (90%) found the amount of information presented on the website to be just right, and only 10% thought that the website did not contain enough information (Figure 3-9).

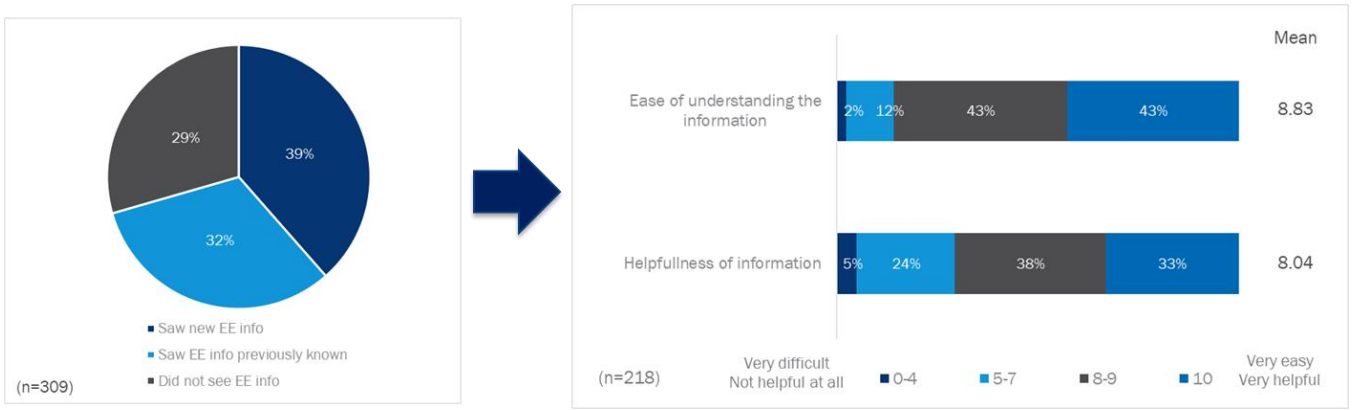
Figure 3-9. Amount of Information Displayed on the Online Store Website



Values sum to more than 100% due to rounding.

Furthermore, more than a third of participants (39%) shopping through the Online Store saw information about CFL and LED energy efficiency features that was previously unknown to them. Finally, participants who saw information about energy efficiency of CFLs and LEDs found it easy to understand and very helpful (Figure 3-10).

Figure 3-10. Ease of Understanding the Information on the Online Store Website



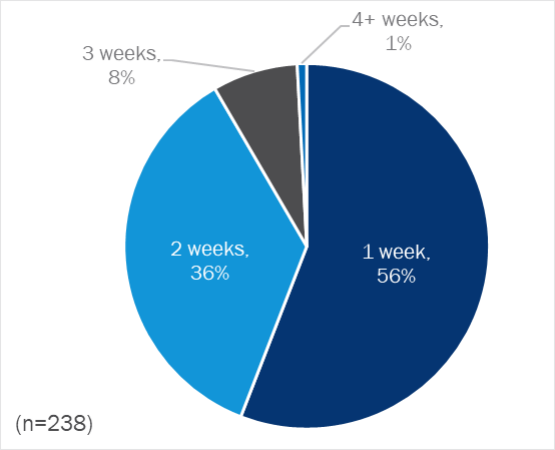
Value of Free and Discounted Shipping

As part of the participant survey, we asked participants who had their program bulbs shipped to them for free or at a discounted rate whether they would have purchased program bulbs if they had not received the shipping offer. More than two-fifths of participants (44%) reported that they would not have purchased any bulbs without the shipping discounts or a free shipping offer. This finding points to the value of offering shipping discounts. We also asked participants who received free shipping, if they would have purchased the same number of program products, fewer, or more, had their free shipping been a $5 flat rate. Over eight in ten (83%) would have purchased the same number of program bulbs if they had to pay a $5 flat rate. Continuing to offer discounted shipping but cutting back on the free shipping is likely to help maintain customer engagement with the Online Store platform and decrease program costs.

Program Delivery and Participant Satisfaction

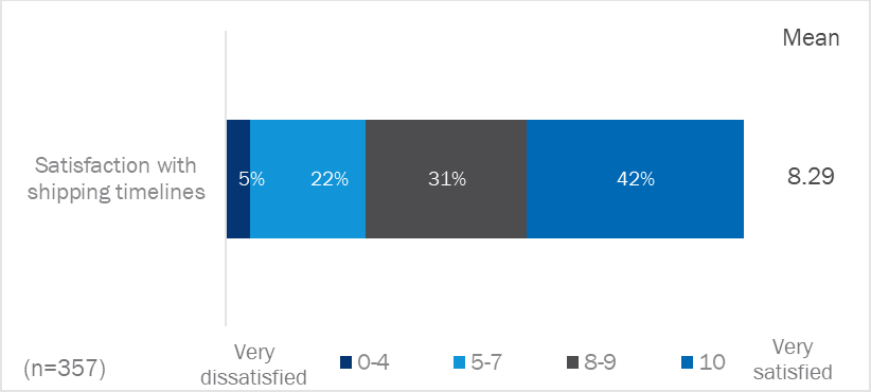
Program delivery processes were smooth and well managed. Both Duke Energy and EFI were generally satisfied with the interactions with each other, their nature, and their frequency. Program-tracking data were clean, well maintained, and detailed. EFI worked hard to ensure prompt delivery of the products to participant homes. Based on the participant survey results, 92% of participants who recalled how long it took them to receive their bulbs[20] reported receiving their products within 2 weeks.

Figure 3-11. Shipping Timeline



Participants are very satisfied with the time it took to receive their bulbs. As can be seen in Figure 3-12, 73% of participants reported being satisfied with the shipping timeline[21] and 42% reported being very satisfied.[22]

Figure 3-12. Satisfaction with Shipping Timelines

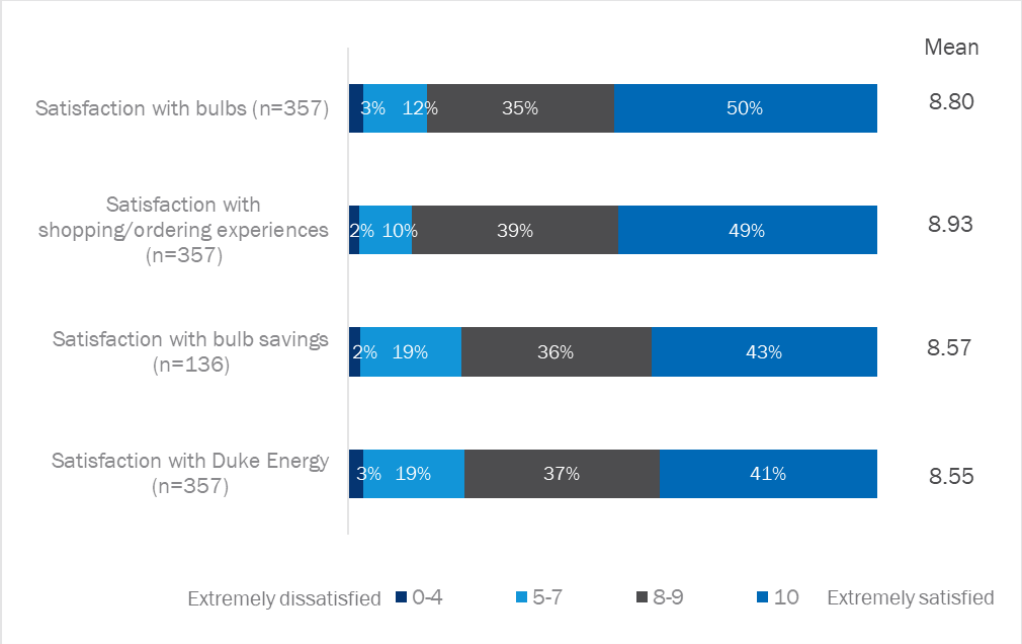


[20] A third of participants (33%) could not recall the shipping timeline.
[21] A rating of 8, 9, and 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.
[22] A rating of 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

Few customers contacted Duke Energy with questions (7%). Reasons for outreach included receiving broken bulbs, the wrong bulbs, and bulbs that were not on par with participant expectations. The few participants who reached out to Duke Energy were generally satisfied with the way Duke Energy handled their concerns and questions (average rating of 7.3).[23]

Participant satisfaction is very high across all program components. As can be seen in Figure 3-13, 85% of participants are satisfied with the bulbs they received, 88% are satisfied with their shopping and ordering experience, and 79% are satisfied with the savings from the bulbs they received through the program.

Figure 3-13. Satisfaction Ratings



3.9 Conclusions and Recommendations

This section presents conclusions and recommendations resulting from the process and impact evaluations of the Online Savings Store program.

3.9.1 Conclusions

From December 17, 2015 through February 13, 2017, Duke Energy discounted 158,483 CFLs and LEDs. CFLs represented only a small share of all sales (10%), while reflector and specialty LEDs accounted for more than three-quarters of program sales (82%). A total of 10,621 unique customers purchased program-discounted lighting products during the program period under evaluation. Based on the estimated number of 135,565 households in the DEO jurisdiction, 10,621 participants represent an estimated 8% of the DEO customer base.

The program achieved 5,329 MWh in ex post gross energy savings, 0.757 MW in ex post gross summer peak demand savings, and 0.917 MW in ex post gross winter peak demand savings. The program realized 102%

[23] On a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

of gross energy savings, 134% of gross summer peak demand savings, and 94% of gross winter peak demand savings.

The program's first-year ISR is relatively high, at 79.3%, indicating that customers install most products shortly after purchase. The overall ISR of 89.3% is affected by the revised installation trajectory and truncation of savings due to EISA standards scheduled to go into effect in 2020.

The program NTGR of 63.5% is lower compared to the previous evaluation of this program that established a NTGR of 77.8% for the program. Compared to the general population of DEO customers, program participants are more likely to be homeowners, reside in single-family homes, have higher incomes and higher levels of educational attainment. Each of these demographic groups have higher FR and consequently lower NTGRs.

After applying the program NTGR to ex post savings, the program achieved 3,384 MWh in energy savings, 0.481 MW in summer peak demand savings, and 0.582 MW in winter peak demand savings. Table 3-30 provides a summary of the program's gross and net impacts overall and by year in which the products were distributed.

Table 3-30. Overview of Program Impacts

Year	Metric	Ex Ante Results	Ex Post Gross Results	Gross Realization Rate	Ex Post Net Results	Net Realization Rate[a]
2015	Bulbs	1,130	1,130			
	Energy savings (MWh)	39	41	107%	26	87%
	Summer peak demand savings (MW)	0.004	0.005	144%	0.003	118%
	Winter peak demand savings (MW)	0.006	0.006	95%	0.004	78%
2016	Bulbs	151,497	151,497			
	Energy savings (MWh)	4,986	5,086	102%	3,230	83%
	Summer peak demand savings (MW)	0.456	0.722	158%	0.459	129%
	Winter peak demand savings (MW)	0.614	0.876	143%	0.556	116%
2017	Bulbs	5,856	5,856			
	Energy savings (MWh)	215	202	94%	128	76%
	Summer peak demand savings (MW)	0.019	0.029	150%	0.018	122%
	Winter peak demand savings (MW)	0.026	0.036	138%	0.023	113%
Total	Bulbs	158,483	158,483			
	Energy savings (MWh)	5,241	5,329	102%	3,384	83%
	Summer peak demand savings (MW)	0.479	0.757	158%	0.481	129%
	Winter peak demand savings (MW)	0.645	0.917	142%	0.582	116%

Note that total savings, both gross and net, as well as realization rates, were developed using unrounded values.
[a] Denominator is ex ante net savings.

Table 3-31**Error! Reference source not found.** provides ex post gross and net per-bulb savings by measure. Measure categories in the table below are consistent with the DEO desired definitions.

Table 3-31. Ex Post Gross and Net Per-Bulb Savings

Measure	Ex Post Gross Savings			Ex Post Net Savings		
	kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	81.93	0.0095	0.0086	52.02	0.0060	0.0054
3-Way LED	35.42	0.0052	0.0064	22.49	0.0033	0.0041
A-Line CFL	26.51	0.0031	0.0028	16.83	0.0020	0.0018
A-Line LED	20.33	0.0030	0.0037	12.91	0.0019	0.0023
Candelabra CFL	17.88	0.0021	0.0019	11.35	0.0013	0.0012
Candelabra LED	26.85	0.0039	0.0049	17.05	0.0025	0.0031
Globe CFL	27.10	0.0031	0.0028	17.21	0.0020	0.0018
Globe LED	27.98	0.0041	0.0051	17.77	0.0026	0.0032
Recessed dimmable CFL	27.90	0.0032	0.0029	17.71	0.0021	0.0019
Recessed CFL	39.76	0.0046	0.0042	25.25	0.0029	0.0026
Recessed LED	41.66	0.0061	0.0076	26.45	0.0039	0.0048
Recessed outdoor CFL	40.22	0.0047	0.0042	25.54	0.0030	0.0027
Recessed outdoor LED	39.29	0.0057	0.0071	24.95	0.0036	0.0045
Spiral 13-watt CFL	24.61	0.0029	0.0026	15.63	0.0018	0.0016
Spiral 18-watt CFL	27.07	0.0031	0.0028	17.19	0.0020	0.0018
Spiral 23-watt CFL	40.20	0.0047	0.0042	25.53	0.0030	0.0027

Table 3-32 provides a second estimate of per-bulb gross and net savings, representing savings claimable under Ohio Senate Bill 310 (SB 310).

Table 3-32. Per-Bulb Gross and Net Savings Claimable Under SB 310

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTGR	Net Per-Bulb Savings Claimable Under SB 310		
	kWh	Summer Peak kW	Winter Peak kW		kWh	Summer Peak kW	Winter Peak kW
3-Way CFL	81.93	0.0095	0.0086	63.5%	52.02	0.0060	0.0054
3-Way LED	44.11	0.0052	0.0097	63.5%	28.01	0.0033	0.0061
A-Line CFL	26.51	0.0031	0.0049	63.5%	16.83	0.0020	0.0031
A-Line LED	50.65	0.0049	0.0093	63.5%	32.17	0.0031	0.0059
Candelabra CFL	17.88	0.0021	0.0027	63.5%	11.35	0.0013	0.0017
Candelabra LED	26.85	0.0039	0.0049	63.5%	17.05	0.0025	0.0031
Globe CFL	27.10	0.0031	0.0032	63.5%	17.21	0.0020	0.0020
Globe LED	27.98	0.0041	0.0051	63.5%	17.77	0.0026	0.0032
Recessed dimmable CFL	42.04	0.0042	0.0092	63.5%	26.70	0.0027	0.0059

Measure	Gross Per-Bulb Savings Claimable Under SB 310			NTGR	Net Per-Bulb Savings Claimable Under SB 310		
Recessed CFL	39.76	0.0046	0.0055	63.5%	25.25	0.0029	0.0035
Recessed LED	44.98	0.0061	0.0076	63.5%	28.56	0.0039	0.0048
Recessed outdoor CFL	64.82	0.0065	0.0142	63.5%	41.16	0.0041	0.0090
Recessed outdoor LED	119.89	0.0057	0.0228	63.5%	76.13	0.0036	0.0145
Spiral 13-watt CFL	24.61	0.0029	0.0026	63.5%	15.63	0.0018	0.0016
Spiral 18-watt CFL	27.07	0.0034	0.0028	63.5%	17.19	0.0022	0.0018
Spiral 23-watt CFL	40.69	0.0052	0.0043	63.5%	25.84	0.0033	0.0027

Note that total savings, both gross and net, were developed using unrounded values.
Note that both gross and net estimates incorporate ISR.

The program implementation processes ran smoothly and effectively, resulting in high levels of customer satisfaction with the program. Program-tracking data were complete and accurate. Instances of products mailed and installed outside of the DEO jurisdiction were minimal. Participants shopping on the Online Store website found the information about lighting products accessible and helpful. Customers valued the benefit of discounted shipping, and many would not have purchased their products without it. The benefits of the free shipping offer over the discounted shipping offer were much less pronounced.

3.9.2 Recommendations

We recommend that Duke Energy calculates future savings from the Online Savings Store program using the savings values claimable under Ohio Senate Bill 310 (SB 310).

Opinion Dynamics found program processes to be running smoothly and levels of participant satisfaction with the programs and its various components to be high. We recommend that the program continues smooth and balanced implementation practices.

Our evaluation research found that customers residing in single-family homes, customers with higher income levels, and higher levels of educational attainment are over-represented in the program participant pool. These customer segments, as compared to their respective counterparts, tend to have much higher levels of FR. To increase program efficacy, we recommend that the program deploys targeted marketing and outreach strategies aimed at increasing participation among customers residing in multi-family properties, lower-income customers, and customers with lower levels of educational attainment. Those customers are less likely to be free-riders and the program therefore will be more likely to affect change in customer lighting preferences and behaviors. To avoid possible overlap with Duke Energy's Multifamily program the program should consider identifying customers currently not targeted through the Multifamily program and targeting Online Store offerings to that group. To minimize the overlap with the Low-Income program, targeting census block groups with a high concentration of customers with moderate income levels could be a beneficial strategy. Similar targeting of census block group with high shares of customers with higher education levels can further help improve the effectiveness of the program. The evaluation team recognizes, however, the fine balance required between promoting the Online Savings Store program to the desired segments, and minimizing the cannibalization of the other programs' impacts. Additionally, it is important to recognize the need to balance the cost associated with deploying micro-targeting approaches with their impacts.

Understanding barriers to customer adoption of LEDs and key motivators that will drive customers to change their lighting shopping behaviors, especially among customer segments that are underserved through the

program as well as the ones that exhibit low FR, can be helpful in devising more targeted program interventions and messaging strategies.

Another strategy toward increasing program efficacy is focusing program efforts around specialty LEDs and more specifically products such as globe, three-way, and candelabra LEDs. Our research shows that the FR for specialty LEDs is considerably lower than reflector LEDs ordered through the Online Store. Increasing the prominence of specialty LEDs on the Online Store website and in the program marketing collateral can help attract shopper attention to those products as well as attract shoppers who have a need or interest in specialty products, thus helping reduce free-ridership. It is our understanding that the program team are in the process of exploring targeting opportunities to enhance the reach and efficacy of the program.

To further improve the first-year ISR and subsequently the overall ISR, we recommend that the program staff include collateral with the product shipments urging customers to install as many program LEDs as possible by replacing working, less-efficient bulbs in their homes. This will help the program avoid the loss of energy and demand impacts from future installations due to EISA truncation. Our evaluation explored differences in first-year ISR by product type and found no statistically significant differences, which suggests that the program should not focus the ISR messaging on a specific product type.

To further streamline program offerings, the program may want to consider minimizing the offer of free shipping. This offer does not have a significant impact on participant purchase decisions, as self-reported by surveyed program participants. Program staff should continue offering discounted shipping, however, as participant purchase decisions are affected by the presence of shipping discounts. We have limited information on the differences in efficacy of the various levels of shipping discounts. The program may benefit from further research in this area to develop an optimal shipping discount offer.

Finally, expanding the Online Store offerings to include other product types may be an effective strategy for diversifying program offerings and increasing impacts. Similar Online Stores in Oregon, Massachusetts, and South Carolina recently started including such measures as advanced power strips, thermostats, showerheads, and even small appliances, such as dehumidifiers and air purifiers. The program may benefit from additional research into customer interest around those additional products and energy savings impacts. It is our understanding that the program staff added smart thermostats to the list of Online Store offerings in August 2018. The program team is in the process of expanding the list of measures further.

3.10 Summary Form

DEO Online Savings Store Program

Completed EMV Fact Sheet

Since its launch in 2013, the DEO Online Store program has been offering DEO customers a wide range of discounted CFL and LED products spanning standard, specialty, and reflector bulb categories. Customers are able to buy the discounted bulbs online, submit an order over the phone, or complete a business reply card (BRC) and mail it to Duke Energy. Customers can purchase up to 36 program-discounted bulbs per eligible account, but can supplement their purchase with non-program-discounted products, in cases when they need more bulbs.

Date	September 11, 2018
Region(s)	Duke Energy Ohio
Evaluation Period	December 17, 2015 through February 13, 2017
Gross Annual MWh impact	5,329 MWH 102% realization rate
Coincident MW impact	0.8 MW (summer) 158% realization rate (summer) 0.9 MW (winter) 142% realization rate (winter)
Measure life	12 years for LEDs 5 years for CFLs
Net to Gross	63.5%
Process Evaluation	Yes
Previous Evaluation(s)	May 13, 2015

Evaluation Methodology

The evaluation team reviewed reported savings assumptions to ensure that the inputs used to calculate those assumptions were in line with the previous evaluation's recommendations. The Evaluation Team also performed an engineering analysis of energy and demand savings to develop ex post savings estimates, including estimation of a net-to-gross ratio (NTGR) and first-year in-service rate (ISR) through a participant survey. The evaluation team conducted a long-term metering study with a subset of the Free LED program participants to develop LED-specific and program-specific estimates of the hours of use (HOU) and peak coincidence factors (CF), both winter and summer. The Evaluation Team also conducted a program process evaluation including results from a participant survey

Impact Evaluation Details

- The evaluation team relied on the Uniform Methods Project (UMP) recommended approach to estimate gross energy and peak demand savings, and incorporates additional adjustments as necessary
- The evaluation team estimated baseline wattages using the equivalent baseline wattage approach with consideration of applicable federal efficiency standards (e.g., EISA)
- The evaluation team estimated hours of use (HOU) and peak coincidence factors (CF) using long-term metering effort with the program participants
- The evaluation team relied on a participant research to estimate first-year in-service rate (ISR) and net-to-gross ratio (NTGR)
- The evaluation team used discounted approach to claiming savings from future LED installations which includes claiming the savings from all expected installations in the program year but discounting them by a utility discount rate. The evaluation team incorporated the UMP-recommended future installation trajectory and truncation of future savings post-EISA 2020 standards

For more information, please contact:

Kessie Avseikova
Director, Opinion Dynamics

617-492-1400 tel
617-497-7944 Fax
kavseikova@opiniondynamics.com

1000 Winter Street
Waltham, MA 02451

APPENDIX L - ENERGY EFFICIENCY SAVINGS SUMMARY

Ohio Utility Energy Efficiency Savings Summary

1 Incremental Savings from Programs in Year 2018

	Ex Ante Gross Savings			Realization Rate (1)		Actual Expenditures			Participation		Weighted Program Measure Life	TRC Test Ratio	PAC Test Ratio
	A	B	C	D	E	F	G=F/A	H=F/C	I	J	K=C/A	L	M
	First Year Annual Energy Savings	First Year Peak Demand Savings	Lifetime Savings	Energy Savings (Ex Ante Gross/Ex Post Gross)	Demand Savings (Ex Ante Gross/Ex Post Gross)	Program Costs	Ex Ante First Year Cost Per First Year Annual Savings (F/A)	Ex Ante First Year Cost per Lifetime Savings (F/C)	Participation Number	Description (Units Description is provided in the PSR)	Years	By Program	By Program
	MWh	MW	MWh	%	%	$	$/kWh	$/kWh				C/E Ratio	C/E Ratio
Residential Programs													
Energy Efficiency Education Program for Schools	3,549	1.0	24,841	37%	15%	$ 547,145	$ 0.15	$ 0.02	6,634	Per Participant	7	5.64	3.73
Home Energy Comparison Report	102,340	26.1	102,340	82%	49%	$ 3,728,702	$ 0.04	$ 0.04	398,070	Per Participant	1	2.42	2.07
Low Income Neighborhood Program	461	0.1	3,688	N/A	N/A	$ 453,888	$ 0.98	$ 0.12	1,024	Per Participant	8	1.89	0.70
Residential Energy Assessments	3,277	0.4	46,544	119%	88%	$ 1,117,050	$ 0.34	$ 0.02	15,173	Various	14	2.44	1.90
Smart $aver® Residential	112,658	12.1	1,389,723			$ 10,402,802	$ 0.09	$ 0.01	1,894,713	Various	12	8.25	5.65
Smart $aver Residential - Free LEDs				56%	47%								
Smart $aver Residential - Online Savings Store				102%	158%								
Low Income Weatherization - Pay for Performance	1,033	0.1	6,334	N/A	N/A	$ 206,866	$ 0.20	$ 0.03	12,859	Per KWH	6	5.91	1.59
Power Manager®	-	71.4	-	N/A	83% (2)	$ 1,002,774	N/A	N/A	-	N/A	0	35.63	13.38
Total Residential	**223,318**	**111.3**	**1,573,471**			**17,459,227**	**$ 0.08**	**$ 0.01**	**2,328,473**		**7**	**6.71**	**4.86**
Business Programs													
Power Manager® for Business	638	2	5,100	N/A	N/A	$ 514,286	N/A	N/A	682	N/A	8	1.28	1.19
Small Business Energy Saver	16,365	3.0	166,834	104%	74%	$ 3,430,384	$ 0.21	$ 0.02	15,116,778	Per KWH	10	1.83	2.97
Smart $aver® Non Residential Custom	29,057	3.6	413,680	90%	92%	$ 3,321,038	$ 0.11	$ 0.01	4,070	Various	14	0.74	4.87
Smart $aver® Non Residential Prescriptive	75,768	13.1	1,049,285	N/A	N/A	$ 8,167,492	$ 0.11	$ 0.01	1,088,544	Various	14	2.95	4.22
PowerShare®	-	49.3	-	N/A	100%	$ 1,791,190	N/A	N/A	-	N/A	0	-29.81	5.22
Total Business	**121,828**	**70.7**	**1,634,899**			**17,224,390**	**$ 0.14**	**$ 0.01**	**16,210,074**		**9**	**1.80**	**4.11**
Other Programs													
Mercantile Self-Direct	2,271	0.5	29,908	N/A	N/A	$ 244,648	$ 0.11	$ 0.01	130,638	Various	13	0.89	6.91
Low Income Weatherization	330	0.1	N/A	N/A	N/A	N/A	N/A	N/A	313	Various	N/A	N/A	N/A
Total Other	**2,601**	**0.5**	**29,908**			**244,648**	**$ 0.11**	**$ 0.01**	**130,951**		**13**	**0.89**	**6.91**
Portfolio Total	**347,747**	**182.5**	**3,238,278**			**34,928,265**	**$ 0.10**	**$ 0.01**	**18,669,498**		**10**	**2.94**	**4.50**

(1) - Realization rate for programs with EMV results filed in 2018 status update filing. See Appendices D-K.
(2) - This value is per household. Aggregate realization rate based on capability is 101%

2 Information Relative to Statutory Targets for Year 2018

3 year baseline retail normalized (mercantile, weather, opt-out, etc.) sales.	19,755,498
2018 Annual Benchmark Target (%)	1%
2018 Savings (MWh)	606,640
2018 Achievement (%)	3%

3 Banked Savings in Year 2018

2018 Excess Savings Banked Toward Future Compliance	409,085
Total Banked Savings Remaining After 2018	2,368,442

4 Opt Out - Three year baseline in 2018

Total Opt Out load (MWh)	5,853,904

APPENDIX M - SB310 2018 UPDATE REPORT

REPORT

Nexant

Reimagine tomorrow.

Ohio Senate Bill 310 Energy Efficiency Savings Analysis, 2018 Update

Submitted to Duke Energy Ohio

October 3, 2018

Contents

1 Executive Summary 1

2 Introduction 3
2.1 SB 310 Legislation 3

3 Secondary Data Analysis 5
3.1 Residential Appliance Saturation Survey (RASS) 5
3.1.1 Methods 5
3.1.1.1 Approach and Rationale 6
3.1.1.2 Data Sources and Parameter Assumptions 6
3.1.1.3 Algorithm and Calculations 7
3.1.1.4 Results 8
3.2 ENERGY STAR® Shipment Data and Deemed Savings 8
3.2.1.1 Approach and rationale 8
3.2.1.2 Parameter Assumptions and sources 10
3.2.1.3 Algorithm and example calculations 11
3.2.2 Results 12
3.2.2.1 Energy Star Total Calculations 12
3.3 Historic EM&V Report Review 14
3.3.1 Methods 15
3.3.1.1 Approach and rationale 15
3.3.1.2 Data Sources and Parameter Assumptions 15
3.3.2 Results 17
3.4 State and Federal Codes and Standards 18
3.5 Overall findings 18

Appendix A Senate Bill 310 Legislation on Energy Efficiency Accounting A-1

Appendix B ENERGY STAR® Equipment and National Shipment Data B-1

List of Figures

Figure 3-1: Methodology for Disaggregation of National Equipment Sales 9
Figure 3-2: Incremental ENERGY STAR Savings by End Use 13

List of Tables

Table 1-1: Summary of Analysis Energy Savings - kWh 1
Table 1-2: Summary of Analysis Demand Savings - kW 2
Table 3-1: Programmable Thermostat Parameter Inputs 7
Table 3-2: RASS Energy Savings, 2013 – 2016 - kWh 8
Table 3-3: Refrigerator Algorithm and Parameters 12
Table 3-4: Example ENERGY STAR Calculations for Refrigerator Energy Savings (kWh) 12
Table 3-5: Total ENERGY STAR incremental savings by year 13
Table 3-6: ENERGY STAR Energy Savings - kWh 14
Table 3-7: ENERGY STAR Demand Savings - kW 14
Table 3-8: Summary of DEO Program Evaluations from 2016 to 2017 16
Table 3-9: Summary of Analysis Energy Savings - kWh 18
Table 3-10: Summary of Analysis Demand Savings - kW 18
Table 3-11: Incremental Energy Savings as Percentage of DEO Program Portfolio 19
Table 3-12: Incremental Demand Savings as Percentage of DEO Program Portfolio 19

1 Executive Summary

In 2016, Duke Energy retained Nexant, Inc. (Nexant) to perform a market potential study for its operating company in Ohio. As an additional task, Nexant estimated the energy and demand savings attributable to Duke Energy by the passage of Ohio Senate Bill 310 (SB 310)[1]. That analysis covered the period 2006 – 2015. This report provides an update to the 2016 study, with an analysis of additional savings in 2016 and 2017.

Four secondary data sources were examined by Nexant to estimate additional energy savings achieved in 2016 and 2017:

- Residential Appliance Saturation Survey (RASS) data
- ENERGY STAR sales and shipment data
- Prior evaluation and reported savings results
- Codes & Standards

Nexant examined each of these data sources to determine incremental savings that could be credited to Duke Energy under Senate Bill 310. Such savings are incremental to savings previously achieved by Duke Energy programs. The results of Nexant's analysis are presented below in Table 1-1 and Table 1-2. The remainder of the report describes the data sources, Nexant's approach to the SB 310 analysis, and our findings.

Table 1-1: Summary of Analysis Energy Savings - kWh

Sector	RASS Incremental Savings (kWh)	ENERGY STAR Incremental Savings (kWh)	EM&V Incremental Savings (kWh)	Codes & Standards Incremental Savings (kWh)	Total Incremental Savings (kWh)
Residential, 2016 - 2017	8,556,932	125,092,268	67,600	0	133,649,553
Non-residential, 2016 - 2017	0	48,620,825	0	0	48,620,825
Total	**8,556,932**	**173,713,092**	**67,600**	**0**	**182,337,624**

[1] An excerpt of SB 310 is included in Appendix A for reference

Table 1-2: Summary of Analysis Demand Savings - kW

Sector	RASS Incremental Savings (kW)	ENERGY STAR Incremental Savings (kW)	EM&V Incremental Savings (kW)	Codes & Standards Incremental Savings (kW)	Total Incremental Savings (kW)
Residential	0	14,520	0	0	14,520
Non-residential	0	1,386	0	0	1,386
Total	**0**	**15,906**	**0**	**0**	**15,906**

These findings indicate that Duke Energy Ohio (DEO) should claim an additional 182.3 GWh of energy savings and 16.0 MW of demand savings for the period of 2016 through 2017 based on the provisions of SB 310.

2 Introduction

Duke Energy Ohio (DEO) retained Nexant to assess the effect of Ohio's Senate Bill (SB) 310[1] on the utility's historical estimated energy-efficiency savings. DEO's territory accounts for approximately 9.4%[2] of electricity sales in the state of Ohio and serves approximately 840,000 electricity customers in the Cincinnati metro area. The company began offering energy-efficiency programs to its customers in 2006 and continues to provide a suite of program offerings. Like other investor-owned utilities in the state, DEO is subject to Ohio's energy-efficiency cumulative electricity savings target of 22% by 2027.

This report outlines the data collection and analysis that Nexant used to reliably characterize the company's historical energy-efficiency savings not already claimed though DEO's energy-efficiency programs. To understand and assess the effects of SB 310 on DEO's energy-efficiency savings estimates, we used multiple analysis approaches on independent but complementary data sources. This process increased the reliability of the final estimate because each approach and each supporting data source was not without limitation; using multiple approaches and data sources reduced the emphasis on any one input.

2.1 SB 310 Legislation

In the summer of 2014, the Ohio legislature passed SB 310, which was subsequently signed into law on June 13, 2014. SB 310 amended SB 221. SB 221 went into effect in 2008 and stipulated that electric distribution utilities (EDUs) had to achieve a cumulative annual energy savings of more than 22% by the end of 2025.[3] Under SB 310, EDUs are no longer required to secure energy-efficiency savings in 2015 or 2016; the bill also extends the timeframe for surpassing the 22% benchmark to 2027.[4] In addition to revising the schedule for complying with the savings target, SB 310 introduced new mechanisms that adjust how EDUs estimate their energy savings. Specifically, the bill allows EDUs to retroactively adjust their achieved cumulative energy savings based on amended energy-efficiency accounting and through the inclusion of additional energy-efficiency resources.

SB 310 requires the Ohio Public Utilities Commission (PUC) to permit EDUs to account for energy-efficiency savings estimated on an "as-found" or a deemed basis. That is, an EDU may claim savings based on the baseline operating conditions found at the location where the energy-efficiency measure was installed, or the EDU may claim its own calculated deemed savings estimate. For example, if a DEO commercial customer installed an electronically commutated motor fan on a furnace, DEO can claim energy savings based on its own assumed deemed or calculated energy savings estimate. Such claims can be made independent of third

[1] State of Ohio Substitute Senate Bill 310 Section 4928.662, sections (A) through (G), pages 30 and 31.

[2] Energy Information Administration, electricity data: http://www.eia.gov/electricity/data.cfm#sales

[3] Ohio Legislative Service Commission, Am. Sub. S.B. 221 127th General Assembly.

[4] Ibid.

party evaluation, measurement, and verification. SB 310 requires that if a customer undertook an action that complied with federal standards, the resulting savings must also be accounted for, even if the actions occurred independent of an EDU energy-efficiency program. SB 310 permits EDUs to apply these accounting techniques retroactively to 2006. EDUs may carry forward any additional savings identified under SB 310's energy-efficiency accounting and apply those savings to future energy-efficiency targets.[5]

DEO benefits from quantifying the effect of these amended savings because it will help the company understand its progress toward its energy efficiency goals. Additionally, DEO may need to reassess its energy-efficiency program portfolio to successfully optimize energy-savings potential and resource management as the company pursues its 2027 compliance target.

[5] Ohio Legislative Service Commission, Am. Sub. S.B. 310 130th General Assembly.

3 Secondary Data Analysis

Nexant relied on secondary research and analysis to estimate the energy savings achieved within DEO's territory under the accounting guidelines of SB 310. Nexant previously estimated SB 310 savings for DEO for the period 2006 – 2015. This report provides an update that includes additional incremental savings that accrued during 2016 and 2017. We focused on four available data sources:

- Duke Energy Residential Appliance Saturation Survey (RASS)
- ENERGY STAR® shipment data and deemed savings
- Duke Energy Historic EM&V reports
- State and Federal codes and standards

We conducted stand-alone analyses on each of the four sources; when appropriate, we also used each source to inform the others. We also identified data gaps and defined parameter assumptions to serve as proxies. We developed algorithms and calculations to make a final estimate of the energy savings achieved, according to the source in question. Finally, we completed a roll-up analysis, taking the four sources and their associated results and carefully combined them to guard against double-counting. This effort provided a robust overall assessment of energy savings impact resulting from SB 310 within DEO's territory.

3.1 Residential Appliance Saturation Survey (RASS)

Duke Energy periodically collects Residential Appliance Saturation Survey (RASS) data to better understand the current saturation of fuel sources and appliances in customers' homes. The surveys do not include research on specific efficiency levels or shares of these appliances by efficiency level; nevertheless, the surveys collect data on measures that typically have a reliable deemed energy savings. Changes or trends detected for these measures across multiple iterations of a RASS indicate customer adoption of specific energy saving measures.

Nexant compared summary statistics for the 2013 and 2016 editions of the DEO RASS. This comparison of sample proportions for applicable energy efficiency measures indicates the degree of change in customer adoption over the intervening span of three years[1]. The RASS provides insight on energy-saving measures installed in DEO customers' homes, which DEO may count towards savings targets under SB 310.

[1] At the time of the prior (2006-2015) analysis, the 2013 RASS was the most recent data available.

3.1.1.1 Approach and Rationale

SB 310 requires any action taken by a utility customer that results in energy savings be included as part of the utility's compliance goal. Nexant therefore investigated: 1) how DEO's residential market characterization has changed with regard to saturation of energy-saving measures, and 2) the rate of measure uptake. Nexant first identified the specific measures for which energy savings could be reliably estimated using energy-savings algorithms. This prerequisite limited our analysis to measures that were characteristically homogenous or that offered easily defined efficiencies. Based on these conditions, Nexant limited its investigation to three measures:

- Light-emitting diode (LED) lamps
- Compact-fluorescent (CFL) lamps
- Programmable thermostats

Savings algorithms can be used to estimate the energy-savings from customer adoption of these measures. Although these measures' energy savings can be quantified, understanding the trend of customer uptake for any specific measure depends on consistent survey questions being asked for each RASS iteration. These data would enable Nexant to have comparable metrics through time.

3.1.1.2 Data Sources and Parameter Assumptions

To assess the trend changes in uptake for the above-mentioned measures, Nexant reviewed the survey data collected by Duke Energy for the DEO territory. Nexant examined the 2013 and 2016 editions of the DEO RASS. Therefore, Nexant could only quantify the impacts of any trends in measure uptake for this three-year period. After reviewing the data sources, Nexant concluded the following:

- Questions on LED and CFL lamps were included in the 2013 and 2016 RASS
- The RASS only provided the share of efficient lamps among all lamps installed in a customer's home
- Nexant did not have sufficient lighting inventory data to convert RASS proportions to an actual quantity of lamps, so we did not quantify the potential uptake in efficient lighting by DEO residential customers
- Programmable thermostats were included in both the 2013 and 2016 RASS
- DEO asked its customers whether their homes contained a programmable thermostat in both editions of the RASS
- This survey question allows Nexant to estimate the saturation of installed programmable thermostats in 2016 compared to 2013

From 2013 to 2016, DEO offered a rebate and incentive type for programmable thermostats through its residential program portfolio, called the HoM program. However, after the first evaluation, it was found to be not cost effective. Therefore, Nexant needed to determine a per-unit savings value. Additionally, Nexant needed to calculate the total number of homes that

installed programmable thermostats between 2013 and 2016. To estimate these values, we used parameter inputs sourced from the RASS data (Table 3-1), customer premises data provided by Duke Energy, and assumptions sourced primarily from the 2016 Pennsylvania Technical Reference Manual (PA TRM).[2] Nexant reviewed the Ohio TRM and identified effective full load hour assumptions; however, the TRM does not provide an algorithm nor a deemed savings estimate for programmable thermostats.

Table 3-1: Programmable Thermostat Parameter Inputs

Parameter	Value	Source
Population of homes with programmable thermostats		
Incremental percentage increase of homes with installed programmable thermostats	7.0%	Duke Energy 2013 and 2016 RASS
Incremental quantity of homes with installed programmable thermostats	41,988	DEO residential customer premises data
Programmable thermostat energy savings		
HVAC system efficiencies[1] SEER/ HSPF	13 seasonal energy efficiency ratio (SEER); 7.7 heating seasonal performance factor (HSPF)	Federal minimum code for 2010 to 2013
HVAC heating technology	Heat pump: 31.8% Resistance heating: 68.2%	2013 Ohio RASS
HVAC cooling technology	Heat pump: 24% Central air conditioner: 82%	2013 Ohio RASS
System capacity ($\mathrm{CAPY_{cool}}/\mathrm{CAPY_{heat}}$)	32,000 BTU/h	2016 Pennsylvania Technical Reference Manual
Duct efficiency $\mathrm{Eff_{duct}}$	80%	2016 Pennsylvania Technical Reference Manual
Effective full load hours (EFLH) $\mathrm{EFLH_{cool}}/\mathrm{EFLH_{heat}}$	Cooling: 941 Heating; 713	2010 Ohio Technical Reference Manual
Energy savings factor $\mathrm{ESF_{cool}}/\mathrm{ESF_{heat}}$	Cooling: 2.0% Heating: 3.6%	2016 Pennsylvania Technical Reference Manual

3.1.1.3 Algorithm and Calculations

Nexant calculated the estimated per-unit savings using Equation 3-1listed below.

Equation 3-1: Programmable Thermostat

$$\Delta kWh/yr = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = \frac{CAPY_{cool}}{1000\frac{W}{kW}} \times \frac{1}{SEER \times Eff_{duct}} \times EFLH_{cool} \times ESF_{cool}$$

$$\Delta kWh_{heat} = \frac{CAPY_{heat}}{1000\frac{W}{kW}} \times \frac{1}{HSPF \times Eff_{duct}} \times EFLH_{heat} \times ESF_{heat}$$

[2] Technical Reference Manual, State of Pennsylvania. Act 129 Energy Efficiency and Conservation Program & Act 213 Alternative Energy Portfolio Standards, June 2016, Table 2-41.

This calculation yielded an estimated energy savings per programmable thermostat of 220 kWh. We used this per-unit savings value and applied it to the number of homes reported to have installed a programmable thermostat between 2013 and 2016, estimating the total impact of this customer action.

3.1.1.4 Results

Extrapolating the calculated per-unit savings by the incremental quantity of homes that installed programmable thermostats resulted in a total energy savings of 9,232,932 kWh. As noted above, DEO offered a residential program that included rebates or other incentives for programmable thermostats, the HoM program, in 2015. Therefore, we reduced RASS savings by the amount achieved in 2015 by the HoM program to ensure no double counting had occurred. The final energy savings attributable to the RASS analysis are illustrated in Table 3-2 below.

Table 3-2: RASS Energy Savings, 2013 – 2016 - kWh

Measure	Total RASS Savings (kWh)	DEO Program Savings (kWh)	Incremental Savings (kWh)
Programmable thermostat	9,232,932	676,000	8,556,932
Total	**9,232,932**	**676,000**	**8,556,932**

The Ohio TRM and the PA TRM deems zero kW savings for programmable thermostats so no demand reductions were attributed to this end use.

3.2 ENERGY STAR® Shipment Data and Deemed Savings

Due to the provisions of SB 310 which allow an EDU to claim energy savings from actions that customers take outside of utility energy efficiency programs, Nexant focused on estimating the energy impact of ENERGY STAR equipment. Specifically, we investigated what the total shipments of ENERGY STAR equipment was into DEO's service territory in 2016 and 2017 and quantified the energy savings impacts of those measures. Nexant's analysis on the effect of ENERGY STAR equipment focused on understanding the savings generated by each unit, as well as the total shipments of these measures to DEO's service territory.

3.2.1.1 Approach and rationale

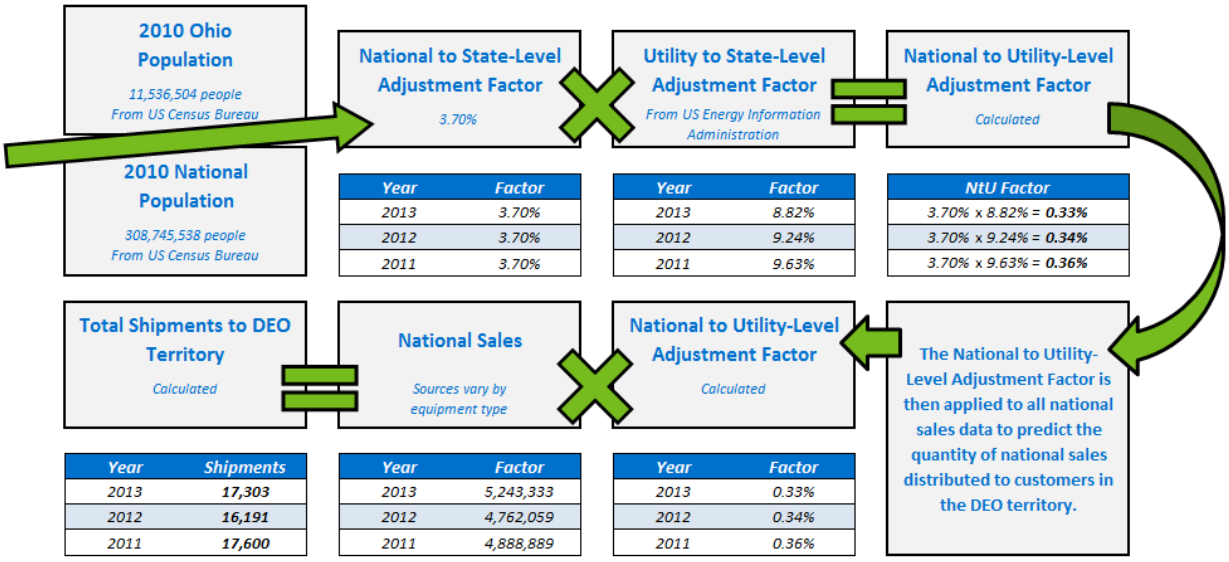
Nexant estimated total shipments to Ohio and DEO's service territory for 2016 and 2017. We estimated shipments by incorporating available national equipment sales data, regional equipment saturation data, commercial survey data, US Census data, and equipment estimated useful life (EUL). We extrapolated savings to all units shipped by using ENERGY STAR calculators and algorithms sourced from the 2010 Ohio TRM.

National equipment shipment data were available for 2016 and 2017 from the ENERGY STAR program. Shipment data is collected by ENERGY STAR from program partners each year. ENERGY STAR does not adjust or attempt to extrapolate savings if it does not receive shipment

data from all program partners. Therefore, ENERGY STAR considers the reported shipment totals for each product a conservative estimate[3]. The ENERGY STAR equipment included in our analysis includes appliances, lighting, HVAC, office equipment, and consumer electronics. Please see Appendix B for a complete list of included equipment and associated national shipments from 2016 – 2017.

To estimate total shipments within DEO's service territory, Nexant employed a top-down approach based on the national sales data, as depicted in Figure 3-1:

Figure 3-1: Methodology for Disaggregation of National Equipment Sales



For residential measures, Nexant used the utility to state-level adjustment factor provided by the US Energy Information Administration, which compares quantities of residential customers at the utility and state-levels.

We followed a similar disaggregation methodology for non-residential measures using 2012 commercial floor space as provided by the US Energy Information Administration's Commercial Buildings Energy Consumption Survey (CBECS) in place of the US Census Bureau-supplied population values to determine the National to State-Level adjustment factor. CBECS presents total commercial floor space in regions, with Ohio falling in the "East North Central" division. Nexant used state population data from the 2010 census to disaggregate the floor space reported in the East North Central Division in order to isolate the portion belonging to the state of Ohio. The utility to state-level adjustment factor provided by the US Energy Information Administration in the case of non-residential measures is based on documented electricity sales rather than customers.

[3] ENERGY STAR® Unit Shipment and Market Penetration Report. Available online at https://www.energystar.gov/index.cfm?c=partners.unit_shipment_data. Accessed 10/02/2018.

Having established the annual estimated shipments within DEO's territory, Nexant calculated energy savings for each measure type based on the per unit energy savings. We multiplied the per-unit savings by the number of annual shipments to determine the total savings of all purchased equipment in each year. Nexant reviewed DEO's program filings from 2016 through 2017 and identified any program that incentivized an ENERGY STAR measure. Our review found that DEO's programs during this time period offered its customers the following ENERGY STAR measures:

- Refrigerators and Freezers
- Fryers
- Holding Cabinet
- Icemaker
- Steamer
- Central Air Conditioner
- Heat Pump
- CFLs
- LEDs
- LED Exit Sign
- LED Display Case/Case Lighting
- Pool Pump

Nexant subtracted the total savings associated with these program measures from the ENERGY STAR savings totals in order to avoid crediting DEO with savings it had previously claimed. Therefore DEO program savings were netted out of the total ENERGY STAR savings to estimate final incremental savings from shipments of ENERGY STAR measures to DEO's territory.

3.2.1.2 Parameter Assumptions and sources

To estimate shipments, Nexant began with national sales data provided by ENERGY STAR based on product reporting from program partners. On average, 89% of partners reported shipment data to ENERGY STAR[4]. To distill these shipment data to DEO's territory, Nexant relied on the following sources:

- The US Census Bureau's 2010 Census
- The US Energy Information Administration's Commercial Buildings Energy Consumption Survey
- The US Energy Information Administration's Electricity Detailed Survey Data Files

[4] Ibid.

Nexant relied on ENERGY STAR calculators and the 2010 Ohio and 2016 Pennsylvania TRMs to estimate per unit energy and demand savings. The vast majority of ENERGY STAR measures' energy savings were derived from the ENERGY STAR calculators. All calculators used to estimate per unit savings were based on the most recent version except in the case of measures that experienced a federal standard change such as refrigerators or dehumidifiers. For these measures, Nexant quantified pre- and post-standard per unit savings and applied each to the appropriate shipment years. In cases where an ENERGY STAR measure was not available for a specific measure, Nexant used deemed savings values provided in the 2010 Ohio TRM.

To estimate demand savings, Nexant relied on the Ohio and Pennsylvania TRMs as the ENERGY STAR calculators do not provide demand results. For most measures, Nexant applied the demand savings algorithm to the previously calculated energy savings to estimate the per unit demand reduction. We relied on the provided coincidence factor and hours of use listed in the TRM to complete our calculations.

3.2.1.3 Algorithm and example calculations

As discussed above, Nexant calculated energy savings primarily based on the ENERGY STAR calculator algorithms and utilized the Ohio and Pennsylvania TRM algorithms to estimate demand savings. These savings were extrapolated based on the total shipments of a given measure within DEO's territory.

An example of Nexant's savings calculation for residential refrigerators is shown below (Table 3-3). Based on 2014 national shipment data and the 2013 ENERGY STAR appliance calculator, we determine the total energy savings for 2016 and 2017.

Table 3-3: Refrigerator Algorithm and Parameters

Configuration	ΔkWh	Source
Manual Defrost and Partial Automatic Defrost	80	2013 ENERGY STAR Appliance calculator via 2014 PA TRM
Top mount freezer without door ice	111	
Side mount freezer without door ice	156	
Bottom mount freezer without door ice	154	
Side mount freezer with door ice	139	
Bottom mount freezer with door ice	122	
Refrigerator only - single door without ice	89	
Refrigerator/Freezer – single door	102	
Average per unit energy savings	**119**	

Nexant extrapolated the per unit savings for refrigerators to DEO's territory based on the estimated total shipments to the territory. We then subtracted energy savings from the Weatherization Pilot program's rebated refrigerators to ensure savings are not double counted.

Table 3-4 illustrates this process for refrigerators and shows that DEO may claim over 2.4 million kWh from ENERGY STAR refrigerators in the 2014 compliance year.

Table 3-4: Example ENERGY STAR Calculations for Refrigerator Energy Savings (kWh)

Year	Total ENERGY STAR Units Shipped (U.S.)	% Shipped to DEO Territory	ENERGY STAR Units Shipped (DEO)	ENERGY STAR Per Unit Savings (kWh)	ENERGY STAR Total Savings (kWh)	DEO Program Annual Savings (kWh)	Incremental ENERGY STAR Savings (kWh)
2014	7,347,000	0.32%	23,790	119	2,833,934	395,319	2,438,615

3.2.2.1 Energy Star Total Calculations

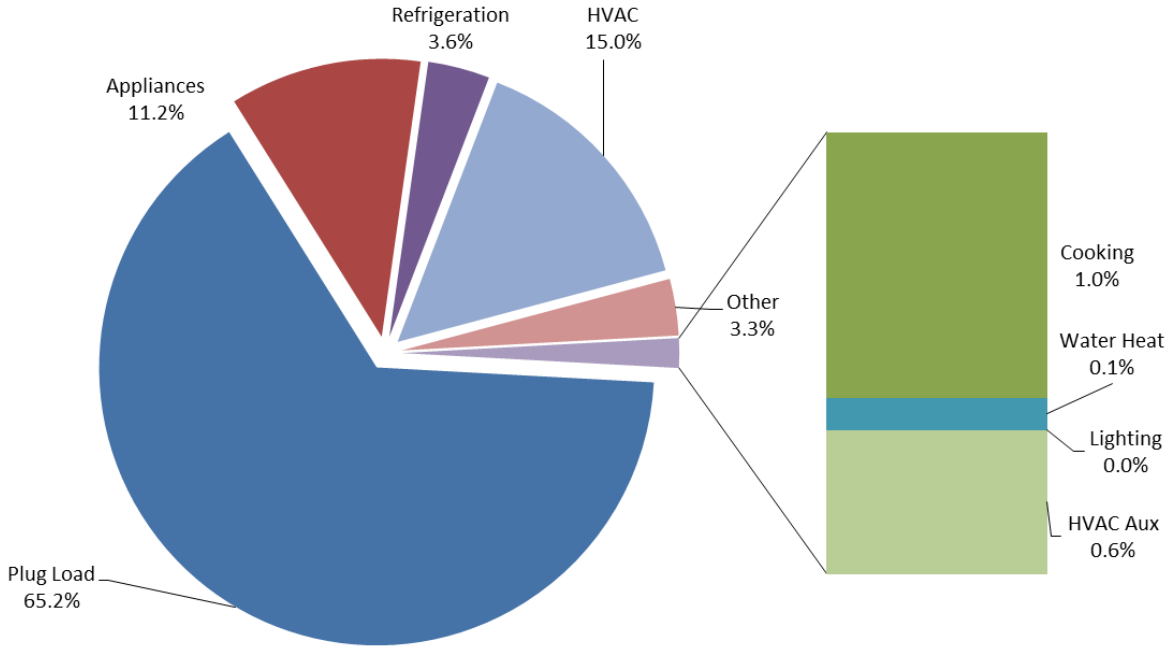
Nexant completed its analysis for each ENERGY STAR measure and totaled the incremental savings. We found ENERGY STAR measures contribute nearly 174 million kWh of achieved savings over the 2 year period from 2016 to through 2017. Total incremental savings by year are presented in Table 3-5.

Table 3-5: Total ENERGY STAR incremental savings by year

Year	Total ENERGY STAR Units Shipped (U.S.)	% Shipped to DEO Territory	ENERGY STAR Units Shipped (DEO)	ENERGY STAR Annual Savings (kWh)	DEO Program Annual Savings (kWh)	Incremental ENERGY STAR Savings (kWh)
2016	4,746,444,000	0.37%	17,775,883	149,176,935	41,526,554	107,650,381
2017	669,385,000	0.38%	2,522,734	98,020,040	31,957,329	66,062,711
Total	**5,415,829,000**	**0.37%**	**20,298,618**	**247,196,975**	**73,483,883**	**173,713,092**

Figure 3-2 illustrates how the ENERGY STAR energy savings are distributed by end use. Plug load captured nearly two thirds of the incremental savings followed by appliances at just over 10%. This distribution of shares is a result of the program portfolio design offered by DEO which does not prioritize plug load measures but does focus on lighting as well as HVAC and refrigeration measures.

Figure 3-2: Incremental ENERGY STAR Savings by End Use



The final energy and demand savings attributable to the ENERGY STAR analysis are presented by sector in Table 3-6 and Table 3-7.

Table 3-6: ENERGY STAR Energy Savings - kWh

Sector	ENERGY STAR Savings (kWh)	DEO Program Savings (kWh)	Incremental Savings (kWh)
Residential	161,351,606	41,536,554	125,092,268
Non-residential	85,845,369	31,957,329	48,620,825
Total	**247,196,975**	**73,483,883**	**173,713,092**

Table 3-7: ENERGY STAR Demand Savings - kW

Sector	ENERGY STAR Savings (kW)	DEO Program Savings (kW)	Incremental Savings (kW)
Residential	20,760	6,239	14,520
Non-residential	7,836	6,450	1,386
Total	**28,595**	**12,689**	**15,906**

3.3 Historic EM&V Report Review

DEO's program portfolio energy savings, which the utility files for regulatory compliance, are informed by evaluation, measurement, and verification (EM&V) reports conducted by third-party contractors on a periodic basis. Third-party contractors often complete these assessments by assuming the baseline equipment is equivalent to the prevailing code or standard. DEO program EM&V reports provided an estimated energy savings value independent from what DEO's program initially reported. After receiving an EM&V report, DEO updates its assumed energy savings per the findings of the report and revises subsequent filings to align with the EM&V reported savings values. DEO uses the EM&V report savings values until another updated EM&V report is delivered to DEO, at which time filed energy savings are again updated.

However, under the direction of SB 310, DEO may align program savings based on either a deemed savings assumption or an "as-found" baseline assumption. For example, DEO may establish its filed energy savings based on its own reported savings value for a measure, or it may recalculate the energy savings for a measure based on the pre-existing equipment efficiency. Therefore, DEO may opt to record its own reported savings value, irrespective of the EM&V report. DEO may also retrospectively amend its filed savings values to align with its reported or deemed savings values rather than the value stipulated by the EM&V report.

Nexant focused its investigation on historic program energy savings filings that could be amended to reflect: 1) a deemed per-unit energy savings value, or 2) a per-unit energy savings value based on an "as-found" condition efficiency level. When we amended historic filings based on either an "as found" baseline or on a revised deemed savings value, we recalculated the measure and program savings to the higher value, as allowed by SB 310.

3.3.1.1 Approach and rationale

Nexant extracted multiple savings metrics from DEO-provided program EM&V reports, including participation data, gross annual ex-ante savings (kW and kWh), realization rates, gross annual ex-post savings (kW and kWh), net annual savings, net-to-gross ratios, "as-found" data describing the baseline equipment efficiency (if provided), and code baseline data. When "as-found" data appeared in an EM&V report, Nexant determined whether the evaluator used this baseline to calculate savings. We either ensured that the evaluator used the "as-found" baseline when computing savings or, if the "as-found" baseline was not used, we re-calculated the savings using the respective algorithm detailed in the 2010 Ohio Technical Reference Manual (Ohio TRM). If the "as-found" baseline did not appear in the evaluation report, Nexant reviewed the report for the code baseline that the evaluator assumed, using it to estimate the energy savings for each evaluated measure. If we could not identify the code baseline, we reviewed federal codes and the International Energy Conservation Code (IECC) to determine their effects on the measure energy savings. For affected measures, we re-calculated savings using the respective Ohio TRM algorithm and the appropriate code baseline. Finally, Nexant recorded and included in its comparative analysis deemed savings values provided by the Ohio TRM.

After reviewing the energy savings values for the ex-ante value, ex-post value, realization rate, "as-found" value, code baseline value, Ohio TRM value, and the net savings value, Nexant used the highest per-unit savings value among these to compare with the per-unit values listed in the DEO program energy savings filings. For residential programs, if we found a higher value from our review of the EM&V report, we calculated an adjusted program savings to reflect the participation listed in DEO's filings and the identified, higher per-unit energy savings value. For non-residential programs, Nexant relied on the EM&V realization rate to make any program savings adjustments. It was necessary to apply the realization rate to non-residential programs, as the EM&V reports often did not consistently provided measure-level data but rather provided end use realization rates. In these cases we could not amend individual measures; however, we were able to adjust end uses presented in the DEO filing based on the end use realization rates provided in the EM&V reports. The incremental increase between DEO's initial filed program savings and the amended program savings based on our analysis represented the additional savings credited to DEO under SB 310.

3.3.1.2 Data Sources and Parameter Assumptions

Nexant used the historical program EM&V reports provided by DEO to extract the various savings metrics discussed above. Nexant's previous SB 310 incremental analysis report from 2016 included incremental program savings achieved during the years 2006 to 2015. This report reviews additional EM&V reports that were not available at that time. In most cases, new EM&V

data are not yet available from the Duke Energy programs. Nexant requested that DEO provide evaluation reports that were completed after the previous analysis. Table 3-8 indicates the program reports provided by Duke Energy to Nexant. That table also states the measure impact period and indicates whether the report contains new data not reviewed by Nexant in 2016 and 2017.

Table 3-8: Summary of DEO Program Evaluations from 2016 to 2017

Duke Energy Ohio Program	Included in 2016 SB 310 Report? (Years)	Provided by DEO for 2018 Update?	Incremental Savings?
Appliance Recycling	Yes (1)	No	N/A
Home Energy House Call	Yes (4)	Yes	N/A; no new performance data
Energy Efficiency Education Program for Schools	Yes (4)	Yes	N/A; no new performance data
Low Income	Yes (5)	Yes	N/A; no new performance data
Multi-Family Energy Efficiency	Yes (1)	Yes	N/A; no new performance data
Non-Residential Smart $aver Prescriptive Program	Yes (5)	Yes	N/A; no new performance data
Non-Residential Smart $aver Custom Program	Yes (2)	Yes, Process only	N/A; process only
Non-Residential Energy Assessments	Yes (1)	No	N/A
MyHER Energy Reports	Yes (1)	Yes	N/A; EM&V impact > deemed savings
Residential Smart $aver CFL Program	Yes (5)	No	N/A
Residential Smart $aver HVAC Program	Yes (3)	Yes	N/A; no new performance data
Residential Smart $aver Program	No (1)	Yes	N/A; EM&V includes SB310
Specialty Bulbs	Yes (1)	Yes	No; no new performance data
Energy Star Energy Efficiency Washer Program	Yes (1)	No	N/A
Small Business Energy Saver Program	No (1)	Yes	No; NTG ratio is 1
PowerShare Program	No (3)	Yes	N/A; “as found” only
Power Manager	No (1)	Yes	N/A; “as found” only
HōM® Energy Manager Program	No (1)	Yes	Yes

As shown in the table above, all program evaluations collected by Nexant were either included in the prior 2006-2015 analysis or already incorporated SB310 or “as found” conditions. One exception is the HōM® Energy Manager program, which existing during 2015. That program consisted of 3,308 program participants that saved an estimated 200 kWh per participating household. Nexant’s review of the programmable thermostats for the RASS analysis found a “deemed” value of 220 kWh per programmable thermostat, as calculated from the OH TRM. Therefore, Nexant estimates an additional 67,600 kWh for incremental program savings in 2016 and 2017 based on our review of currently available evaluation reports.

3.4 State and Federal Codes and Standards

SB 310 allows actions taken by customers that comply with specified codes and standards to count towards the EDU energy-efficiency compliance mandate. Thus, Nexant conducted a review of current codes and standards to determine if any applicable changes would impact energy consumption by Duke Energy customers in 2016 and 2017. Nexant's codes and standards review did not find any codes or standard changes between that would add additional impacts beyond those already quantified in the previous 2006 to 2015 analysis.

3.5 Overall findings

The summation of each analysis represents the total incremental energy savings achieved as a result of SB 310. As discussed in each analysis section, Nexant carefully reviewed DEO program savings to ensure each analysis did not double count savings already being credited from DEO programs. Additionally, when aggregating total savings across all four analyses, we reviewed measures to again ensure no double counting of saving occurred. Table 3-9 and Table 3-10 present the summary energy and demand savings from each analysis and the overall achieved savings.

Table 3-9: Summary of Analysis Energy Savings - kWh

Sector	RASS Incremental Savings (kWh)	ENERGY STAR Incremental Savings (kWh)	EM&V Incremental Savings (kWh)	Codes & Standards Incremental Savings (kWh)	Total Incremental Savings (kWh)
Residential	8,556,932	125,092,268	67,600	0	133,716,800
Non-residential	0	48,620,825	0	0	48,620,825
Total	**8,556,932**	**173,713,092**	**67,600**	**0**	**182,337,624**

Table 3-10: Summary of Analysis Demand Savings - kW

Sector	RASS Incremental Savings (kW)	ENERGY STAR Incremental Savings (kW)	EM&V Incremental Savings (kW)	Codes & Standards Incremental Savings (kW)	Total Incremental Savings (kW)
Residential	0	14,520	0	0	14,520
Non-residential	0	1,386	0	0	1,386
Total	**0**	**15,906**	**0**	**0**	**15.906**

To understand the impact of SB 310 on DEO's program performance, Nexant compared the total incremental savings over the reviewed period (i.e., 2016-2017) to DEO's 2016 and 2017 program portfolio annual energy savings.

Table 3-11 and Table 3-12 present the results of this comparison.

Table 3-11: Incremental Energy Savings as Percentage of DEO Program Portfolio (2016 – 2017)

Sector	RASS Incremental Savings (kWh)	ENERGY STAR Incremental Savings (kWh)	EM&V Incremental Savings (kWh)	Codes & Standards Incremental Savings (kWh)	Total Incremental Savings (kWh)
Total Incremental Savings	8,556,932	173,713,092	67,600	0	182,337,624
Total DEO Portfolio Savings			533,835,108		
Percent of Program Savings	**1.6%**	**32.5%**	**0.01%**	**0.0%**	**34.2%**

Table 3-12: Incremental Demand Savings as Percentage of DEO Program Portfolio (2016 – 2017)

Sector	RASS Incremental Savings (kW)	ENERGY STAR Incremental Savings (kW)	EM&V Incremental Savings (kW)	Codes & Standards Incremental Savings (kW)	Total Incremental Savings (kW)
Total Incremental Savings	0	15,906	0	0	15,906
Total DEO Portfolio Savings			236,260		
Percent of Program Savings	**0.0%**	**6.7%**	**0.0%**	**0.0%**	**6.7%**

We found the incremental energy savings amounted to 34.7% of DEO's program portfolio while the demand savings amounted to 6.7% of portfolio. Hence, the impact of SB 310 significantly increases DEO's historical portfolio performance.

Appendix A Senate Bill 310 Legislation on Energy Efficiency Accounting

130th General Assembly Senate Bill Number 310

Sec. 4928.662. For the purpose of measuring and determining compliance with the energy efficiency and peak demand reduction requirements under section 4928.66 of the Revised Code, the public utilities commission shall count and recognize compliance as follows:

(A) Energy efficiency savings and peak demand reduction achieved through actions taken by customers or through electric distribution utility programs that comply with federal standards for either or both energy efficiency and peak demand reduction requirements, including resources associated with such savings or reduction that are recognized as capacity resources by the regional transmission organization operating in Ohio in compliance with section 4928.12 of the Revised Code, shall count toward compliance with the energy efficiency and peak demand reduction requirements.

(B) Energy efficiency savings and peak demand reduction achieved on and after the effective date of S.B. 310 of the 130th general assembly shall be measured on the higher of an as found or deemed basis, except that, solely at the option of the electric distribution utility, such savings and reduction achieved since 2006 may also be measured using this method. For new construction, the energy efficiency savings and peak demand reduction shall be counted based on 2008 federal standards, provided that when new construction replaces an existing facility, the difference in energy consumed, energy intensity, and peak demand between the new and replaced facility shall be counted toward meeting the energy efficiency and peak demand reduction requirements.

(C) The commission shall count both the energy efficiency savings and peak demand reduction on an annualized basis.

(D) The commission shall count both the energy efficiency savings and peak demand reduction on a gross savings basis.

(E) The commission shall count energy efficiency savings and peak demand reductions associated with transmission and distribution infrastructure improvements that reduce line losses. No energy efficiency or peak demand reduction achieved under division (E) of this section shall qualify for shared savings.

(F) Energy efficiency savings and peak demand reduction amounts approved by the commission shall continue to be counted toward achieving the energy efficiency and peak demand reduction requirements as long as the requirements remain in effect.

(G) Any energy efficiency savings or peak demand reduction amount achieved in excess of the requirements may, at the discretion of the electric distribution utility, be banked and applied toward achieving the energy efficiency or peak demand reduction requirements in future years.

Appendix B ENERGY STAR® Equipment and National Shipment Data

Measure	ENERGY STAR 2016 Units Shipped (U.S)	ENERGY STAR 2017 Units Shipped (U.S)	Total ENERGY STAR Units Shipped (U.S.)-2016-2017
Audio/Video Products - Consumer - Blu-ray Players	4,641,000	1,285,000	5,926,000
Audio/Video Products - Consumer - DVD Players	3,746,000	2,765,000	6,511,000
Audio/Video Products - Consumer - Soundbars	2,772,000	334,000	3,106,000
Computer Servers	682,000	8,699,000	9,381,000
Computers - Desktops	9,238,000	44,005,000	53,243,000
Computers - Notebooks	37,904,000	23,447,000	61,351,000
Computers - Tablets	24,491,000	852,000	25,343,000
Computers - Thin Clients	850,000	187,000	1,037,000
Computers - Workstations	177,000	54,000	231,000
Data Center Storage	32,000	2,252,000	2,284,000
Dehumidifiers - post code	1,665,000	19,009,000	20,674,000
Displays - LCD Monitors	10,752,000	197,000	10,949,000
Displays - Signage Display	85,000	21,755,000	21,840,000
Imaging Equipment - Multi-function Devices	22,327,000	1,838,000	24,165,000
Room Air Cleaners	1,500,000	202,000	1,702,000
Set-top Boxes - Cable	1,171,000	2,009,000	3,180,000
Set-top Boxes - IP	3,057,000	3,677,000	6,734,000
Set-top Boxes - Satellite	4,519,000	319,000	4,838,000
Set-top Boxes - Thin Client/Remote	8,915,000	7,991,000	16,906,000
Set-top Boxes - Thin Client/Remote	7,879,000	25,250,000	33,129,000
Small Network Equipment	805,000	3,135,000	3,940,000
Telephony	4,241,000	41,000	4,282,000
Televisions	28,434,000	1,596,000	30,030,000
Uninterruptible Power Supplies	3,070,000		3,070,000
Vending Machines	56,000		56,000
Water Coolers	1,520,000		1,520,000