Customer Characteristics

C1 What is the main business activity at [PREMISE_ADDR]?

01 Office/Professional
02 Warehouse or distribution center
03 Food sales
04 Food service
05 Retail (other than mall)
06 Mercantile (enclosed or strip malls)
07 Education
08 Religious worship
09 Public assembly
10 Health care
11 Lodging
12 Public order and safety
13 Industrial/manufacturing [SPECIFY]
14 Agricultural [SPECIFY]
15 Vacant (majority of floor space is unused)
16 Other [SPECIFY]
88 Don't know

C2 Are your company's budget decisions made locally, regionally, nationally, worldwide, or something else?

01 Locally
02 Regionally
03 Nationally
04 Worldwide
05 Other (specify)
88 Don't know

C3 When creating budgets and financial plans, how far into the future does your company plan?

00 Less than 1 year
01 One year
02 Two years
03 Three years
04 Four years
05 Five years
06 More than 5 years
07 Other (specify)
88 Don't know

C4 Does your business' production schedule or business cycle affect when you can implement energy efficiency projects?

[PROBE: A business cycle refers to time periods when your business' activities might be significantly different. For example, a school might have to wait until summer to implement projects, while a manufacturing facility might wait until production is lower."]

01 Yes (Please describe that schedule or cycle)
02 No
03 Don't know

C7 Would you like someone from Duke Energy to contact you directly to provide more information or answer any questions you might have about their energy efficiency programs?

[PROBE: We will not share your responses to this survey, only pass along your contact information]

01 Yes
02 No [SKIP TO C9]

C8_phone To confirm, what's the best number to reach you at?

[RECORD VERBATIM]

C8_name And who should they get in touch with? [Can you spell your name?]

[RECORD VERBATIM]

C9 [IF MULTFLAG=1 SHOW: "[INTERVIEWER, If R has more surveys to complete read: Now I'd like to ask you a smaller selection of questions about another location we have on record for your firm." OTHERWISE READ: "Those are all the questions I have. I'd like to thank you for your help with this survey."]
Do you have any comments you would like to share with Duke Energy?

01 Yes [SPECIFY]
02 No

INT99 That completes the survey, thank you very much for your time.

Duke Energy Midwest SmartSaver Custom Incentive Program
Participating Trade Ally Survey

Sample Variables

CONTACT Primary customer contact name

Company Customer company name

Territory Territory state

Introduction and Screening

INT01 Hello, my name is <NAME> and I am calling on behalf of Duke Energy. May I speak with <CONTACT_NAME, or> the person most familiar with your company's participation in <PROGRAM>?

01 Yes
02 No

PREAMBLE I'm calling from Tetra Tech, an independent research firm. We were hired by Duke Energy to talk with contractors such as yourself about their participation in the SmartSaver Custom Incentive program.

[If needed: We are working with Duke Energy to evaluate their SmartSaver Custom Incentive program. As part of this evaluation, we are speaking to contractors such as yourself. We will be asking about your experience with the program in the past and improvements you would suggest for the future.]

I'd like to assure you that I'm not selling anything, I would just like to ask your opinion about this program. Your responses will be kept confidential and your name will not be revealed to anyone. For quality and training purposes, this call will be recorded.

01 Continue

I1 Are you familiar with the Duke Energy SmartSaver Custom Incentive Program?

01	Yes, I'm able to answer	[SKIP TO C_QAL]
02	Yes, but information isn't quite right (specify)	[SKIP TO C_QAL]
03	No, I'm not able to answer	
04	We have not participated	[THANK AND TERMINATE]
99	Refused	[THANK AND TERMINATE]

OTHER_R Is it possible that someone else in your organization would be more familiar with the program or the project that was completed?

01	Yes	[SKIP TO AVAILABLE_R]
02	No	[THANK AND TERMINATE]
88	Don't' know	[THANK AND TERMINATE]
99	Refused	[THANK AND TERMINATE]

AVAILABLE_R May I please speak with that person?

01	Yes	[SKIP TO INT01]
02	Yes, but R is not currently available	
03	No, we have not participated	[THANK AND TERMINATE]
88	Don't know	[THANK AND TERMINATE]
99	Refused	[THANK AND TERMINATE]

Trade Ally Background

TA1 I want to begin by asking you a few background questions about you and your company.

What is your role at <company>? (Select one)

01	Owner, partner
02	President, vice president
03	Sales
04	Incentive manager
05	Engineer
06	Other (specify)
88	Don't know
99	Refused

TA2 What equipment and services does your company provide to your customers? (Select all that apply)

01 Application completion assistance
02 Architectural and engineering firm
03 Building shell (insulation, window film, windows, doors, etc.)
04 Cool roof
05 Food service
06 HVAC (heating, ventilation, air conditioning, chillers)
07 Information technology
08 Lighting
09 Motors, pumps or drives
10 Performance
11 Plumbing
12 Process (air compressors, injection molding, etc.)
13 Other (specify)
88 Don't know
99 Refused

TA3 In what states do you provide these services? (Select all that apply)

01 Ohio
02 Indiana
03 Kentucky
04 Others (specify)
88 Don't know
99 Refused

TA4 How long has <company> been participating in the Duke Energy SmartSaver Custom Incentive program?

01 Less than 1 year
02 1 to 2 years
03 3 to 5 years
04 More than 5 years
88 Don't know
99 Refused

TA5 About how many projects would you say you have completed through the SmartSaver program since then?

01 Less than 5 projects
02 5 to 9 projects
03 10 to 19 projects
04 20 to 49 projects
05 50 to 99 projects
06 100 projects or more
88 Don't know
99 Refused

TA6 Thinking about the number of projects you did through the program in the last 12 months, do you think the number of 2018 projects will be higher, lower or about the same?

01 Higher
02 Lower
03 About the same
88 Don't know
99 Refused

TA7 Why do you think your 2018 projects will be <TA6 response>?

[RECORD VERBATIM]

TA8 Are you registered with Duke Energy's trade ally network and appear on their website?

[if needed, you would have had to complete a code of conduct and agreement form to appear on Duke Energy's website.]

01 Yes
02 No, [SPECIFY: Why not?]
88 Don't know
99 Refusal

Program Interaction

PI1 Did you receive any training or information from Duke Energy as part of the Custom program?

01 Yes
02 No [SKIP TO PI3]
88 Don't know [SKIP TO PI3]
99 Refusal [SKIP TO PI3]

PI2 Is there any additional training or information Duke Energy could provide?

01 Yes – [SPECIFY: What additional training or information would you like?]
02 No
88 Don't know
99 Refused

PI3 What percent of your customers know about the Custom program prior to you telling them about it?

___ [RECORD 0-100%]
888 Don't know
999 Refused

PI4 Based on your own interactions with customers, how do customers become aware of the SmartSaver Custom program? (Do not read; Select all that apply)

01 Direct contact from <company>
02 Contractor marketing materials such as direct mail, ad, etc.
03 Another contractor
04 Duke Energy bill insert
05 Duke Energy website
06 Duke Energy employee, account representative, customer service representative
07 Colleague, family or friends
08 Program brochure
09 Other (specify)
88 Don't know
99 Refused

PI5 What types of concerns do customers have about the program, if any? (Select all that apply)

01 No concerns
02 Unsure if the equipment qualifies
03 Unsure if the savings will be achieved
04 Unsure if the incentive will be as high as estimated
05 Uncertainty around the preapproval
06 Other (specify)
88 Don't know
99 Refused

PI6 Do you use the program as a sales tool?

01 Yes
02 No SKIP TO AT1
88 Don't know SKIP TO AT1
99 Refusal SKIP TO AT1

PI7 How helpful is the Duke Energy program in selling energy efficient equipment? Do you think it is. . .? [READ LIST]

01 Very helpful
02 Somewhat helpful
03 Neither helpful nor unhelpful
04 Not very helpful
05 Not at all helpful
88 [DO NOT READ] Don't know
99 [DO NOT READ] Refused

Attribution

AT1 Approximately how many projects did you complete through the SmartSaver Custom Incentive program in the past 12 months?

__ [RECORD # OF PROJECTS 0-50]
888 Don't know
999 Refused

AT2 In what percent of your sales situations did you recommend high-efficiency equipment *before* you learned about the SmartSaver Custom Incentive program?

___ [RECORD 0-100%]
888 Don't know
999 Refused

AT3 And in what percent of your sales situations do you recommend high-efficiency equipment now that you have worked with the SmartSaver Custom Incentive program?

___ [RECORD 0-100%]
888 Don't know
999 Refused

AT4 Using a scale from 0 to 10 where 0 is "not at all important" and 10 is "very important", how important was the SmartSaver Custom Incentive program in influencing your decision to recommend high-efficiency equipment to your customers?

__ [RECORD 0-10]
88 Don't know
99 Refused

AT5 And using a scale from 0 to 10 where 0 is “not at all likely” and 10 is “very likely”, how likely is it that you would have recommended the high efficiency equipment to your customers if the SmartSaver Custom Incentive Program had not been available?

__ [RECORD 0-10]
88 Don't know
99 Refused

AT6 And in what percent of your sales situations did the customer choose to go with higher efficiency equipment based on the availability of a Duke Energy rebate?

___ [RECORD 0-100%]
888 Don’t know
999 Refused

AT7 What percent of the projects in the last 12 months where you sold or installed high-efficiency equipment were eligible but DID NOT receive an incentive through a Duke Energy energy-efficiency program?

___ [RECORD 0-100%]
888 Don’t know
999 Refused

AT8 [if AT7 > 0] Did you request an incentive for any of those projects?

01 Yes
02 No [SKIP TO AT10]
88 Don’t know [SKIP TO AT11]
99 Refused [SKIP TO AT11]

AT9 [if AT8 = 1] If you requested an incentive but did not receive one, why was that?

[RECORD VERBATIM RESPONSE]

AT10 [if AT8 = 2] Why did you or your customers not request an incentive for these energy efficiency projects?

[RECORD VERBATIM RESPONSE]

AT11 What percent of your sales in the last 12 months were for each of the following five categories?

a. planned replacement of working equipment?
b. equipment for new facilities?
c. new equipment for existing facilities?
d. failed or emergency equipment replacement?
e. other?

AT11_OTR [if AT11E>0 and AT11E<>888] You mentioned that [from AT11E] percent of your sales were because of some other reason. What were these reasons?

01 Other (Specify)

AT12 [if AT11a > 0 and AT11<>888] Would you say the working equipment you replaced was typically in good, fair, or poor condition?

01 Good
02 Fair
03 Poor
04 Other (specify)
88 Don't know
99 Refused

T12 Lamp Questions

[if TA2 = 8, ask this section, else skip to SA1_INT]

TL1 Next I have a few questions about lighting systems.
Of your linear fluorescent lighting system sales in 2017, what percent were T12s?

___ [RECORD 0-100%]
888 Don't know
999 Refused

TL2 Are you still stocking and selling linear fluorescent T12 lighting systems and replacement lamps?

01 Yes
02 Yes [SPECIFY: Capture any additional contractors comments in TL2 (e.g., yes, but…]
03 No
04 No [SPECIFY: Capture any additional contractors comments in TL2 (e.g., no, but…]
88 Don't know
99 Refused

TL3 [if TL2 = 1 or 2] Thinking of your 2018 sales of linear fluorescent lighting system sales, what percent will be T12s?

___ [RECORD 0-100%]
888 Don't know
999 Refused

Satisfaction

SA1_INT Next I'm going to read a list of aspects related to your experience with the SmartSaver Custom Incentive Program. Using a scale where 0 is "not at all satisfied" and 10 is "very satisfied," how satisfied are you with the following program aspects…

[RANDOMIZE A THROUGH G]

For SA1A THROUGH SA1G
__ [RECORD 0-10]
88 Don't know
99 Refused

a. The time it took to receive pre-approval
b. The pre-approval application process
c. The program process once the project is pre-approved
d. The incentives available through the SmartSaver Custom program
e. The timeliness of rebate payment to customers
f. The training and information received through the program
g. The level of communications with program staff

SA2 Using this same scale (0 being "not at all satisfied" and 10 being "very satisfied"), how satisfied are you with the SmartSaver Custom Incentive program overall?

__ [RECORD 0-10]
88 Don't know
99 Refused

SA3 And how satisfied are you with Duke Energy (if needed: using the same scale where 0 is "not at all satisfied" and 10 is "very satisfied")?

__ [RECORD 0-10]
88 Don't know
99 Refused

SA4 Would you say your communication with Duke Energy program staff was very effective, somewhat effective, neither effective nor ineffective, not too effective, or not at all effective?

01 Very effective
02 Somewhat effective
03 Neither effective nor ineffective
04 Not too effective
05 Not at all effective
88 Don't know
99 Refused

Customer Interaction

CI1 Now I'd like to ask a few questions about your customers.
Based on your experiences, what factors most influence the type of equipment nonresidential customers purchase? (Do not read; Select all that apply)

01 Equipment cost
02 Rebate and incentive availability
03 Contractor recommendation
04 Desire to reduce energy bills
05 Availability of equipment for emergency replacement
06 Equipment specifications
07 Other (specify)
88 Don't know
99 Refused

CI2 Are some nonresidential customers more receptive than others to high efficiency equipment?

01 Yes [PROBE: "What types of customers are more receptive? What types are less receptive?"]
02 No
88 Don't know
99 Refused

CI3 Why do some projects drop out or why do some customers not move forward with projects?

[RECORD VERBATIM RESPONSE]

Program Participation

***Added option of (specify) to choice 03 on 11/08/2017

PP1 How do you typically estimate savings for projects submitted through the SmartSaver Custom program? (Read list; Select all that apply)

[note: the "classic custom calculator" is an Excel sheet (workbook) and the "custom-to-go calculator" is an actual non-Excel based calculator.]

01 Using Duke's custom-to-go calculator
02 Using Duke's classic custom calculator
03 Using your own calculators (specify)
04 Other (specify)
88 Don't know
99 Refused

PP2 [if PP1 = 1] Using a scale from 0 to 10 where 0 is "not at all useful" and 10 is "very useful", how useful is the custom-to-go calculator in estimating energy savings?

[note: the "classic custom calculator" is an Excel sheet (workbook) and the "custom-to-go calculator" is an actual non-Excel based calculator.]

__ [RECORD 0-10]

PP3 [if PP1 = 2] Using a scale from 0 to 10 where 0 is "not at all useful" and 10 is "very useful", how useful is the classic custom calculator in estimating energy savings?

[note: the "classic custom calculator" is an Excel sheet (workbook) and the "custom-to-go calculator" is an actual non-Excel based calculator.]

__ [RECORD 0-10]

PP4 [PP1<>1 OR PP1 <>2, if do not use Duke's custom-to-go or classic custom calculator] Why haven't you used Duke's <fill from PP1: custom-to-go and/or classic custom> calculators?

[RECORD VERBATIM]

PP5 After submitting an application, have you ever received requests for more information?

01	Yes	
02	No	SKIP TO PP7
88	Don't know	SKIP TO PP7
99	Refused	SKIP TO PP7

PP6 [if PP5 = 1] What was the request for?

[RECORD VERBATIM RESPONSE]

PP7 Are there any enrollment paperwork or rebate submission processes that could be simplified to encourage customers to complete projects?

01	Yes	What process could be simplified?
02	No	
88	Don't know	
99	Refused	

PP8 Were you aware there was an online application portal to submit the application online?

01	Yes
02	No
88	Don't know
99	Refused

PP9 [If PP8 = 1] Have you used the online portal?

01	Yes
02	No
88	Don't know
99	Refused

PP10 [if PP9 = 1] Using a scale from 0 to 10 where 0 is "not at all useful" and 10 is "very useful", how useful is the online portal?

__ [RECORD 0-10]

PP11 [if PP9 =02,88,99] Is there anything preventing you from using this portal?

01 Yes What is preventing you from using the portal?
02 No
88 Don't know
99 Refused

PP12 What program aspect is most influential in customers' decision to move forward with the project?

01 The incentive
02 The energy savings
03 The engineering support provided by Duke
04 Other (specify)
88 Don't know
99 Refused

PP13 From your perspective, what is the most valuable part of the SmartSaver Custom Incentive program? (DO NOT READ)

01 The incentive
02 The energy savings
03 The engineering support provided by Duke
04 Other (specify)
88 Don't know
99 Refused

PP14 From your perspective, what part of the SmartSaver Custom Incentive program could be improved?

[RECORD VERBATIM RESPONSE]
77 Nothing

Wrap up

WU1 Do you have any other feedback that you would like to share with Duke Energy about this program?

01 Yes [record comments]
02 No
88 Don't know
99 Refused

INT99 Those are all the questions I have. Thank you for your time.

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ATTACHMENT 7-
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Duke Energy Ohio

Residential Energy Assessments Program Evaluation Report – Final

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Opinion Dynamics

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1. Evaluation Summary

1.1 Program Summary

The Duke Energy Ohio (DEO) Residential Energy Assessments (REA) program is a home assessment program that provides customers with a customized energy report that includes recommendations to help lower energy bills. Customers also receive an Energy Efficiency Starter Kit that contains two LEDs, a low-flow shower head, two faucet aerators (one kitchen faucet aerator and one bathroom faucet aerator), a 17-foot roll of weather stripping, and six outlet seals, which the energy specialist (or auditor) who performs the assessment installs free of charge. Up to six additional LEDs may also be installed based on the auditor's assessment findings. Auditors also encourage behavioral changes related to energy use and recommend higher-cost energy-saving investments to customers, such as a new HVAC system or energy-efficient appliances.

The REA program targets owner-occupied, single-family residences[1] and relies primarily on direct mail marketing. Opinion Dynamics conducted an evaluation of the REA program for the period of May 1, 2016 to April 30, 2017.

1.2 Evaluation Objectives

The overall objectives of the evaluation were to:

- Estimate energy savings using monthly billing data
- Verify the accuracy of deemed per-unit savings estimates and develop in-service rates (ISRs)
- Estimate energy, summer demand, and winter demand savings at the measure level using an engineering analysis
- Assess the likelihood that participants would have installed program measures had the energy efficiency kit not been provided (i.e., free-ridership [FR])
- Document spillover (SO) associated with program participation
- Identify the most successful components of the program's implementation
- Identify the barriers to participation and provide recommendations to address these barriers

To achieve these objectives, Opinion Dynamics completed several data collection and analytic activities, including an interview with the program manager, a review of program materials, a participant telephone survey, an analysis of the survey results, an analysis of program-tracking data, a billing analysis, a deemed savings review, and an engineering analysis. Through the primary data collection efforts, the evaluation team developed estimates of measure-level ISRs and measure- and program-level net-to-gross ratios (NTGRs).

[1] The participant count is based on the *vendor_update_ts* date variable in the program-tracking data. This represents the date at which the customer was input into the database, not the date of the assessment.

1.3 High-Level Findings

Table 1-1 presents the participant- and program-level net savings from the billing analysis for the evaluation period (May 1, 2016 through April 30, 2017). These results include the savings from the measures included in the distributed energy efficiency kits, as well as from additional LEDs provided to program participants. The results also include savings from behavioral changes that participants made based on the recommendations received during the assessment, as well as participant SO attributable to the program.

Table 1-1. Net Impact Savings from Billing Analysis

Net Participant Savings			Net Program Savings		
Energy (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Energy (MWh)	Summer Peak Demand (MW)	Winter Peak Demand (MW)
1,059	0.0958	0.0945	2,384	0.2158	0.2127

Using information collected during the participant survey, we estimated ISRs ranging from 30% for weather stripping to 87% for LEDs. Table 1-2 presents the ISR estimates and relative precision values for the measures included in the energy efficiency kits. We designed our sample to achieve a relative precision of 10% with 90% confidence; however, for most measures, we were unable to achieve this target due to low rates of installation among the surveyed participants.

Table 1-2. ISR Results and Relative Precision

	Kit Average	By Measure				
		LEDs	Faucet Aerators	Low-Flow Shower Head	Outlet Seals	Weather Stripping
Sample size (n)	149	137	143	149	102	92
Estimated ISR	49%	87%	40%	39%	45%	30%
Relative precision (at 90% confidence)	7.7%	4.9%	14.4%	17.1%	17.9%	25.7%

Table 1-3 presents per-participant gross impact results, based on an engineering review of the measures included in the energy efficiency kit and application of the ISRs. The table presents estimated gross savings for the kit only and for the kit plus additional LEDs, based on the average number provided per participant for the evaluation period.[2]

[2] Participants were eligible to receive up to six additional LEDs per home. Note that we found instances in the program-tracking data where more than six additional LEDs were provided.

Table 1-3. Gross Impact Results Per Home from Engineering Review (Inclusive of ISR)

Measure		May 2016–April 2017			
		Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Percent of Total kWh Savings
Energy Efficiency Kit	LEDs (2 9W bulbs)	55.4	0.0044	0.0038	19%
	Low-Flow Shower Head (1)	52.9	0.0018	0.0036	19%
	Bathroom faucet aerator (1)	6.6	0.0006	0.0011	2%
	Kitchen faucet aerator (1)	39.8	0.0017	0.0035	14%
	Outlet Seals (package of 6)	4.3	0.0004	0.0018	2%
	Weather Stripping (per roll)	18.7	0.0086	0.0042	7%
Total Kit Only		**177.8**	**0.0174**	**0.0180**	**62%**
Additional LEDs (average of 3.4 bulbs)		107.8	0.0085	0.0075	38%
Total Per-Home Estimate		**285.6**	**0.0259**	**0.0255**	**100%**

The gross impact results from the engineering analysis per household is far lower than those that we found using a billing analysis. It is common to see a lower estimate from an engineering analysis, as it does not incorporate behavioral changes that customers make due to their interaction with a program.

Based on responses to questions in the participant survey, which focused on each measure from the Energy Efficiency Starter Kit, NTGRs (defined as 1 – FR + SO) were calculated for each interviewed customer (see Table 1-4). FR survey questions asked customers about each measure included in the Energy Efficiency Starter Kit that they installed, while SO questions asked about measures installed outside of the program for which no incentives were received but that were likely a consequence of participation in the REA program. The evaluation team estimated FR at the measure level and SO at the program level.

Table 1-4. Net-to-Gross Ratio Results

Component	FR	SO	NTGR
Energy Efficiency Kit*	27.4%	8.3%	80.9%
LEDs**	52.4%		55.8%
Low-flow shower head	18.2%		90.1%
Faucet aerators***	11.9%		96.4%
Outlet seals	16.8%		91.5%
Weather stripping	20.5%		87.8%

* FR for the Energy Efficiency Kit is the weighted average of the measure-level FR values.
**FR for LEDs applies to LEDs in the kit as well as additional ones supplied.
***FR questions for faucet aerators did not differentiate between kitchen and bathroom aerators.

Table 1-5 below compares the deemed ex ante and ex post per household and program-level net energy and demand savings and presents the savings claimable under SB 310 (final column). As can be seen in the table, DEO will claim 1,059 kWh per household and 2,384 MWh for the program during the evaluation period. Total program savings are calculated as the per-household savings multiplied by the number of participating households in the evaluation period.

Table 1-5. Comparison of Deemed Ex Ante and Ex Post Net Savings

Energy and Demand Savings	Net Deemed (Planning) Savings	Net Ex Post Savings	Claimable Savings under SB 310
Energy Savings			
Total Per-Household Savings (kWh)	890.1	1,058.5	1,058.5
Additional LEDs (kWh) (average of 3.4 bulbs per household)	*96.1*	*59.7*	*96.1*
Energy Efficiency Kit, excluding Additional Bulbs (kWh)	*794.0*	*998.9*	*962.4*
Total Program Savings (MWh)	**2,004.5**	**2,383.7**	**2,383.7**
Summer Coincident Demand Savings			
Total Per-Household Savings (kW)	0.1095	0.0958	0.0958
Additional LEDs (kW) (average of 3.4 bulbs per household)	*0.0094*	*0.0047*	*0.0094*
Energy Efficiency Kit, excluding Additional Bulbs (kW)	*0.1001*	*0.0912*	*0.0865*
Total Program Savings (kW)	**246.5**	**215.8**	**215.8**
Winter Coincident Demand Savings			
Total Per-Household Savings (kW)	0.1130	0.0945	0.0945
Additional LEDs (kW) (average of 3.4 bulbs per household)	*0.0177*	*0.0041*	*0.0177*
Energy Efficiency Kit, excluding Additional Bulbs (kW)	*0.0953*	*0.0903*	*0.0768*
Total Program Savings (kW)	**254.5**	**212.7**	**212.7**

The values included in the DS More inputs table are based on the net savings values claimable under SB 310 and are provided in Table 1-6.

Table 1-6. DS More Inputs

DS More Inputs	Energy Savings (kWh)	Summer Peak Savings (kW)	Winter Peak Savings (kW)
Net energy efficiency kit savings per participant (excluding additional LEDs)	962.4	0.0865	0.0768
Net savings per additional LED bulb*	28.3	0.0028	0.0052

*Net savings per additional LED = ex ante gross savings per additional LED (as provided by Duke Energy) * NTGR for LEDs (55.8%)

1.4 Evaluation Recommendations

We developed the following recommendations based on the results of our evaluation:

- **Auditors should install all measures in distributed energy efficiency kits. If unable to install all measures, auditors should track the barriers that prevent them from doing so.** If the program could improve measure installation, it is likely that measure ISRs and program savings would improve, particularly because we found high persistence rates (PRs) for all measures. We understand that there may be safety concerns related to the installation of outlet seals, which may lead auditors to leave these measures uninstalled, but our understanding is that Duke Energy has an expectation that all measures will be installed during home assessments. It should be noted that in subsequent conversations, the evaluation team learned from Duke Energy that in the spring of 2017, after the close of this evaluation period, additional training of implementation staff occurred to address this issue and to instruct installers to document why measures were not installed.

Specifically, to address faucet aerators that do not fit, we recommend providing adaptors to participants to increase the installation rate of this measure.

- **Provide education on the benefits of early light bulb replacement.** Participants report "not needing them" as the most common reason for not installing the LEDs provided in the kit, suggesting that participants are waiting for their current bulbs to burn out. While more emphasis on installing all measures during the audit (see recommendation above) will help with ISRs, providing additional education on the savings potential of LEDs might lead to additional spillover savings by encouraging participants to more quickly replace inefficient bulbs in the future as well.

- **Channeling efforts by auditors that direct participants of the REA program to other Duke Energy programs could be improved.** While our data preparation for the billing analysis showed that a majority of REA participants have participated in other Duke Energy programs prior to participation, our survey findings showed that only a small portion of customers recalled hearing about other Duke Energy programs through the REA program. If Duke Energy is interested in using the REA program to channel customers to their other offerings, program staff may want to direct auditors to leave behind applicable materials to market its other programs. Additionally, we recommend that auditors familiarize themselves with Duke Energy's other programs and make recommendations to program participants based on the programs that are most suitable.

  According to Duke Energy, the program refreshed the technology and audit report in March 2017 to provide a more user-friendly report to the customer, outlining audit recommendations as well as cross-program recommendations. Additionally, the implementer now has the ability to report back to Duke Energy all recommendations, including cross-promotional referrals. Finally, in addition to including FindItDuke referrals in the audit report, advisors can now generate (where relevant) and email referrals to the customer during the assessment.

- **Ensure that auditors provide all applicable recommendations to customers during assessment visits.** Based on a review of program-tracking data and responses to the participant survey, the evaluation team found that several recommendations were provided to fewer than 20% of customers, with the exceptions being sealing air leaks, installing insulation, removing an extra refrigerator, and replacing old heat pumps. It is unclear whether auditors provided recommendations but did not account for them in their program tracking or whether they did not provide the recommendations to customers because they were not applicable or for some other reason.

  The energy savings from the program could be improved if auditors provided customers with more recommendations on which they could act, since they may not be knowledgeable about the amount of energy that they could save by making changes, such as replacing furnace filters and adjusting thermostat settings. As noted above, Duke Energy has provided additional training to implementation staff to address providing recommendations to program participants that can help them save energy in their homes and has improved the content of the audit reports.

2. Program Description

The Duke Energy Ohio (DEO) Residential Energy Assessments (REA) program is a home assessment program that provides customers with a customized energy report with recommendations to help lower energy bills. The program targets residents of owner-occupied, single-family households who have been in their homes for at least four months and uses direct mailing as its main source of marketing and outreach.

2.1 Program Design

The REA program has two main components. The first is the home energy assessment, branded to customers as the "Home Energy House Call." During the assessment, energy specialists (auditors) enter participants' homes to inspect and assess energy-centric equipment in the home, including their heating and cooling equipment and the state of duct and home insulation. Auditors also look for places where customers could either make an improvement to equipment (e.g., replacing an outdated heat pump, removing older secondary appliances) or adjust the way that they use current equipment (e.g., adjusting the settings for their furnace fan, using window shades in the summer). These recommendations are meant to steer customers toward home improvements that will help them save more energy.

The second component is a free kit of low-cost, energy-efficient measures. The Energy Efficiency Starter Kit consists of two 9W LEDs, two faucet aerators (one kitchen aerator and one bathroom aerator), a low-flow shower head, outlet seals (a package of four outlet and two switch seals), and a 17-foot roll of closed cell foam weather stripping. Customers can also receive up to six additional LEDs, regardless of bulbs received from other Duke Energy programs.

In its program-tracking databases, DEO tracks the date that customers were input into the database, the recommendations made by the auditor during the assessment, and the number of additional light bulbs given to the customer.

2.2 Program Implementation

During the evaluation period, DEO contracted with Franklin Energy to implement the REA program. The program was implemented using a multichannel marketing approach, including bill inserts and direct mail letters, as well as a paid search on Google. The successful marketing of the program led to a backlog of participants, causing DEO to scale back its marketing during the evaluation period.

2.3 Program Performance

The program period under evaluation is May 1, 2016 through April 30, 2017. Over this period, the program served 2,252 unique participants. Based on our impact evaluation, the program saved participants, on average, 1,059 kWh per household per year. Coincident demand savings per household were 0.096 kW in summer and 0.095 kW in winter.

3. Key Research Objectives

This evaluation included a gross impact evaluation, a net-to-gross (NTG) analysis, and a process evaluation. The overall objectives of the REA program evaluation were to:

- Estimate energy savings using monthly billing data
- Verify the accuracy of deemed per-unit savings estimates and develop in-service rates (ISRs)
- Estimate energy, summer demand, and winter demand savings at the measure level using an engineering analysis
- Assess the likelihood that participants would have installed program measures had the energy efficiency kit not been provided (i.e., free-ridership [FR])
- Document spillover (SO) associated with program participation
- Identify the most successful components of the program's implementation
- Identify the barriers to participation and provide recommendations to address these barriers

4. Overview of Evaluation Activities

4.1 Program Staff Interview

Opinion Dynamics conducted an in-depth interview with the current REA program manager in March 2017. The purpose of the interview was to gauge the current environment of, and expectations for, the REA program, including the program's goals, successes, and challenges over the evaluation period. During the interview, we discussed the multichannel approach to marketing the program and additional training provided to program implementation staff to educate customers about energy efficiency, as well as the receptiveness of DEO customers to participating in this offering.

4.2 Program Materials Review

Opinion Dynamics reviewed program materials, including implementation plans, marketing and outreach materials, training materials, and the program-tracking database. We found program materials relating to the assessment, recommendations, and marketing to be complete and of high quality.

4.3 Participant Survey

Opinion Dynamics implemented a computer-assisted telephone interviewing (CATI) survey in June and July 2017. The survey gathered data to verify participation in the program; develop measure-level estimates of installation, persistence, and ISRs; estimate the program net-to-gross ratio (NTGR); and support our process evaluation.

The survey sample design and sample size were based on customers who participated during the evaluation period. Of the 2,252 participants in the database, we drew a random sample of 1,001 valid telephone numbers. We used this sample to complete 150 participant telephone interviews.

The average length of the interviews was approximately 21 minutes; the response rate was 19%.

4.4 Billing Analysis

Opinion Dynamics conducted a billing analysis to determine the net savings attributable to the REA program for the 2016-2017 evaluation period. The evaluation team used a linear fixed effects regression (LFER) model to estimate the overall net ex post program savings. The fixed effect in our model is the customer, which allows us to control for all household factors that do not vary over time. The billing analysis used customers who participated from May 2016 through April 2017 as the treatment group and those who participated from May 2017 through December 2017 as the comparison group. A summary of the billing analysis approach is provided in Section 5.1.1; a detailed description of the billing analysis methodology is presented in Appendix F of the accompanying appendices.

4.5 Deemed Savings Review and Engineering Analysis

Opinion Dynamics conducted a review of Duke Energy's deemed savings values and assumptions for each of the measures included in the Energy Efficiency Starter Kit. The deemed savings review had two main objectives:

1. Develop updated measure-level savings algorithms and input assumptions that are consistent with standard industry practice and comparable with applicable technical reference manuals (TRMs)

2. Develop a ratio between energy and demand savings that can be applied to the billing analysis energy savings to determine net demand savings

To conduct our deemed savings review, we prioritized the use of the Ohio TRM (OH TRM) and Indiana TRM (IN TRM V2.2)[3] and other secondary resources and developed per-unit savings estimates for each kit measure. For each of the reviewed measures, we identified recommendations and suggested approaches for quantifying savings for this evaluation.

Our evaluation also relied on telephone survey data to confirm measure installation and persistence, which were combined with engineering estimates for each measure to develop per-unit gross energy and demand savings by measure type. Program-level energy savings are estimated through a billing analysis. Appendix E provides more detail on the methods used in the deemed savings review and engineering analysis.

[3] Ohio Technical Reference Manual. August 6, 2010; Indiana Technical Reference Manual Version 2.2. July 28, 2015.

5. Impact Evaluation

5.1 Methodology

5.1.1 Billing Analysis

Opinion Dynamics conducted a billing analysis to determine the net savings of the REA program. Our billing analysis used participants from May 2016 through April 2017 as the treatment group and participants from May 2017 through December 2017 as the comparison group. This type of comparison group is referred to as a "future participant comparison group," because comparison group participants participated in the future, relative to the evaluation period. A comparison group allows us to establish a counterfactual, i.e., the baseline energy that participants in the treatment group would have used in the absence of the program. In addition, because the comparison group represents energy use in absence of the program, results from the billing analysis are net results, and application of a NTGR to billing analysis results is unnecessary.

Our method requires pre- and post-installation electricity usage data for the treatment group. To be included in the treatment group, we need both pre- and post-installation usage data for at least nine months before and after participation. For the control group, the model includes electricity usage data only from before their participation. The analysis includes all customers who participated during the evaluation period.

Table 5-1 summarizes information about the treatment and comparison groups included in the analyses.

Table 5-1. Accounts Included in Final Billing Analysis Model

Metric	Treatment Group	Comparison Group
Months of participation	May 2016–April 2017	May 2017–December 2017
# customers included in the analysis	538	250
Usage data included	At least 9 months of pre- and post-participation data	At least 9 months of pre-participation data

The number of treatment customers included in the analysis is approximately 24% of those who participated during the evaluation period, and 20% of those who participated between May and December of 2017. The main reason customers were dropped from the analysis was due to participation in other Duke Energy programs (approximately 56% in the treatment group and 69% in the comparison group). The evaluation team recognizes that this is a large number of customers to exclude from the analysis but took this necessary step to limit the risk of the effects of other programs being confounded with the treatment effect of the REA program. It should be noted that while these customers were not included in the billing analysis model, average modeled savings are still applied to them, i.e., the program receives credit for their savings.

The billing analysis employed a LFER model, which accounts for time-invariant factors, such as square footage, appliance stock, habitual behaviors, household size, and other factors that do not vary over time. The model accounts for differences in weather and pre-program energy use between participants. We also added dummy variables for each calendar month, i.e., binomial terms with "1" signifying that the bill occurred in that month of year and "0" otherwise. The monthly variables help control for seasonal trends in energy use and allow for a more accurate estimate of baseline usage absent the program. The model includes interaction terms between weather and the post-participation period for the treatment group, to account for differences in weather patterns across years.

A more detailed discussion of the billing analysis methodology, including data-cleaning steps, the comparison group assessment, and the final model, is provided in Appendix F of the accompanying appendices.

5.1.2 Engineering Analysis

As part of our impact evaluation, Opinion Dynamics conducted an engineering analysis for each measure contained in the REA Energy Efficiency Starter Kit. The purposes of the engineering estimates were to:

1. Provide a ratio of kW coincident demand to kWh energy savings, which is then applied to the billing analysis energy savings to estimate demand savings
2. Provide insight into the individual measure contributions to the overall kit savings

We used the IN TRM V2.2 and other references and assumptions to conduct our engineering analysis. The engineering analysis takes into consideration the measure ISRs to ensure only savings for installed measures are counted.[4] Additional details and information on the engineering analysis are provided in Appendix E of the accompanying appendices.

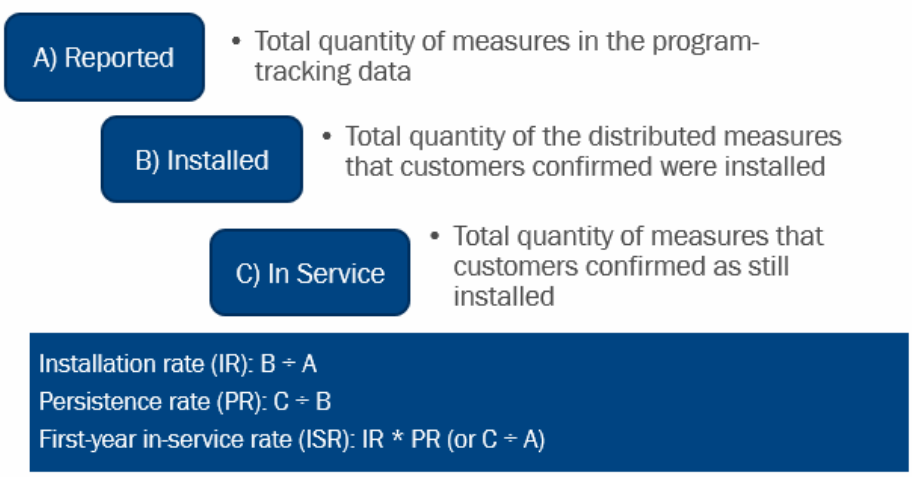
It should be noted that the billing analysis determines actual energy (kWh) impacts for the program; the engineering analysis only supplements the billing analysis for the two reasons mentioned above.

Installation Verification and Persistence

As part of the participant survey, we verified measure installation and persistence to obtain measure-level ISRs. Our engineering estimates use these values in calculations for annual per-customer savings (Figure 5-1). Specifically, we asked sampled participants to confirm the quantity of installed kit measures and, when necessary, to provide the corrected quantity. We then divided the number of measures verified by the respondent by the quantity that they received in the kit. This verified installation rate (IR) is the first component of the total ISR. Where applicable, we also asked participants to confirm whether program measures remained installed in their homes to create a persistence rate (PR). We then created a measure-specific total ISR by multiplying the two components.

[4] We reviewed several TRMs, including regional TRMs (e.g., Mid-Atlantic) as part of our engineering review. Many of these TRMs reference consistent methodologies for savings calculations, and we ultimately followed the IN TRM V2.2 methods to remain consistent with other Duke Energy evaluations, but made DEO-specific updates as applicable based on weather and survey data.

Figure 5-1. Installation Rate Components



5.2 Results

5.2.1 Billing Analysis Results

This section provides billing analysis results and savings estimates for the DEO REA program evaluation period. Appendix F contains a detailed methodology for data cleaning and analysis, as well as complete results of the models. Table 5-2 shows the results of the billing model for REA program participants. The variable "Post" represents the unadjusted treatment effect, i.e., the change in average daily consumption (ADC) attributable to participation in the REA.

Table 5-2. Results of Billing Analysis Models

Variable	Coefficient
Post (REA program participation)	−5.1650*
Heating Degree-Days (HDD)	0.2223**
Cooling Degree-Days (CDD)	0.0276**
Post-participation period CDD	0.0173
Post-participation period HDD	0.0036
Constant	27.9608**
R-squared	0.6412
Additional Terms	**Included**
Monthly effects included	YES
Post-participation period interacted with months included	YES

* p<0.1; ** p<0.01.

Due to post-participation period interaction terms in the model, it is necessary to recalculate the coefficient of the treatment effect (Post) by combining the average value with the coefficient for each interaction term. The coefficient seen in the regression represents the reduction of daily consumption during the post-participation period, separate of any effect of the included interaction terms. Making these adjustments (detailed in

Appendix F), Opinion Dynamics found that REA program participants included in the model realized 2.9 kWh of daily energy savings, on average.

Table 5-3 shows the per-home and program-level savings for the program. Overall, customers who participated in the REA program saved 1,059 kWh per year. During the evaluation period, the program realized 2,384 MWh of energy savings.

Table 5-3. Annual Savings from Billing Analysis

Annual Savings	
May 2016–April 2017 participants	2,252
Per-home daily savings (kWh)	2.9
Per-home annual savings (kWh)	1,059
Program savings (MWh)	**2,384**

5.2.2 Engineering Analysis Results

This section provides the results of the engineering analysis, including ex post deemed savings values, survey-based ISRs, and application of measure quantities to determine per-participant gross energy and demand savings. Table 5-4 shows the ex post deemed savings values from the deemed savings review completed by the evaluation team (see Appendix E). Note that these values do not yet include ISR.

Table 5-4. Ex Post Deemed Savings for Energy Efficiency Starter Kit Measures

Measure	Ex Post Deemed Savings Per Unit (kWh)	Ex Post Deemed Savings Per Kit (kWh)*
LED	32.0	63. 9
Low-flow shower head	136.5	136.5
Bathroom faucet aerator	16.2	16.2
Kitchen faucet aerator	98.4	98.4
Outlet seals	1.6	9.7
Weather stripping	3.7	63.2
Energy Efficiency Kit	N/A	387.9

* Energy efficiency kit contains two LEDs, six outlet seals and 17 feet of stripping; the per unit value for weather stripping is for 1 foot.

Table 5-5 provides the IR, PR, and ISR by measure. Except for LEDs, the evaluation found relatively low ISRs for measures included in the kit. Many participants reported that auditors often do not install all kit measures during the assessments, resulting in low IRs. However, PRs are high, suggesting that once installed, most measures stay in place.

Table 5-5. Measure-Level IRs, PRs, and ISRs

Measure	IR	PR	ISR
LED	88.1%	98.4%	86.7%
Low-flow shower head	40.1%	96.6%	38.7%
Bathroom faucet aerator	42.3%	95.7%	39.5%
Kitchen faucet aerator			

Measure	IR	PR	ISR
Outlet seal	44.7%	100.0%	44.7%
Weather stripping	29.6%	100.0%	29.6%
Additional LEDs*	100.0%	98.4%	98.4%

*The IR of additional LEDs is assumed to be 100%. The PR is based on survey responses about LEDs provided in the kit.

To calculate per-participant engineering gross impacts, we multiplied the deemed savings values by measure-level ISRs and the average distributed quantity of each measure included in the kit. Table 5-6 shows the resulting estimated energy and demand savings for each measure included in the kit. In addition to the kit measures, the program reported distributing 7,721 extra LEDs to customers through the assessments, an average of 3.4 per household. The estimated energy savings for these additional LEDs is also included in Table 5-6. The lighting portion of the kit and the additional LEDs accounted for approximately 51% of the energy savings for each household. These estimates of energy savings include the ISRs presented in Table 5-5 above.

Table 5-6. Engineering Analysis Gross Impact Results

Measure		May 2016–April 2017			
		Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Percent of Total kWh Savings
Energy Efficiency Kit	LEDs (2 9W bulbs)	55.4	0.0044	0.0038	19%
	Low-Flow Shower Head (1)	52.9	0.0018	0.0036	19%
	Bathroom faucet aerator (1)	6.6	0.0006	0.0011	2%
	Kitchen faucet aerator (1)	39.8	0.0017	0.0035	14%
	Outlet Seals (package of 6)	4.3	0.0004	0.0018	2%
	Weather Stripping (per roll)	18.7	0.0086	0.0042	7%
Total Kit Only		**177.8**	**0.0174**	**0.0180**	**62%**
Additional LEDs (average of 3.4 bulbs)		107.8	0.0085	0.0075	38%
Total Per-Home Estimate		**285.6**	**0.0259**	**0.0255**	**100%**

Using the estimated savings from Table 5-6, we can calculate an overall kW per kWh savings ratio from the engineering analysis. Table 5-7 displays two different ratios: one for the kit only and one for the kit plus additional LEDs.

Table 5-7. Engineering Demand-to-Energy Ratios

	Total Gross Energy Savings (kWh)	Summer Coincident Peak Savings (kW)	Winter Coincident Peak Savings (kW)	Summer Ratio Multiplier (summer demand/energy savings)	Winter Ratio Multiplier (winter demand/energy savings)
Kit only	177.8	0.017	0.018	0.0000978	0.0001014
Kit + additional LEDs	285.6	0.026	0.025	0.0000905	0.0000892

5.2.3 Comparison between Billing Analysis and Engineering Results

We estimated that the program realized per-participant energy savings of 1,059 kWh during the evaluation period. Savings from our engineering analysis (286 kWh per participant) are smaller in comparison to the billing analysis results. Differences in the estimated savings from these analyses are expected due to differences in methodology and the fact that the engineering analysis addresses only a subset of program

savings (i.e., the Energy Efficiency Starter Kit and the additional LEDs that can be included). In contrast, the billing analysis provides a comprehensive estimate of program impacts. In addition to the components addressed by the engineering analysis, the billing analysis includes reduced energy consumption associated with improvements made due to assessment recommendations and behavioral changes. In addition, the billing analysis captures other unobserved factors that might have resulted in additional energy savings among participants.

6. Net-to-Gross Analysis

6.1 Methodology

Our participant survey included a NTG module to determine both program and measure-level NTGRs. 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 tracked savings that are attributable to the program. For this evaluation, the NTGR consists of FR and participant SO components.

6.1.1 Free-Ridership

Free-riders are program participants who would have paid for an assessment or installed energy efficiency products on their own, without the program. FR scores represent the percentage of savings that would have been achieved in the absence of the program. We categorized participants who reported that they would not have installed a measure without the program as 0% free-riders and participants who would have installed the measure without the program as 100% free-riders. Partial scores were assigned to customers who had plans to install the measure, but the program had at least some influence over that decision, particularly in terms of timing (i.e., the program accelerated the installation) or quantity (i.e., the program led to the installation of additional measures). We asked questions for each program measure, to enable us to develop measure-level FR estimates. The survey questions measured the following areas of program influence:

- Influence on installation: We asked participants about the likelihood that they would have purchased and installed each kit measure if they had not received it with the assessment.
- Influence on timing: We asked participants when they would have installed the measure on their own, whether that would have been around the same time, within six months, within a year, or longer.
- Influence on quantity: We asked participants whether they would have purchased the same quantity, more, or fewer on their own.

As part of the FR survey module, we included follow-up questions to check participant responses for consistency. We checked survey data for item non-response, and calculated the FR rate per the algorithms presented in Appendix C of the accompanying appendices.

6.1.2 Spillover

SO represents energy savings from additional actions (expressed as a percentage of total program savings) that were the result of program participation, but that did not receive program financial support. While SO can result from a variety of measures, it is not possible to ask about all possible SO measures on a survey due to the need to limit its length. Thus, Opinion Dynamics chose to focus on actions that participants would reasonably take following their program participation and would do so without additional program support.

The participant survey included a series of questions to assess overall SO among program participants. To qualify for program-induced SO, we asked two main questions:

- Did the participant make any additional improvements (or change his or her behavior) to reduce household energy consumption since participation in the program for which he or she received no rebate or incentive?

- *If the respondent indicates making additional improvements (or changing behaviors):* How would the participant rate (on a scale from 0 to 10, with 0 indicating no influence and 10 indicating complete influence) how much influence the experience with the program had on the decision to make these improvements?

We asked participants to rate the degree to which the program influenced their action and to provide a rationale for their rating. We attributed SO for all respondents who gave a program influence score of 7 or higher. These respondents were asked a series of follow-up questions to assess the efficiency of measures.

To estimate the SO rate, we estimated savings for each SO measure using engineering algorithms and assumptions. We determined the program-level SO rate by dividing the sum of measure-level SO savings by the evaluated gross savings achieved by the sample of participants who received SO questions (Equation 6-1).

Equation 6-1. Spillover Rate

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

6.1.3 Net-to-Gross Ratios

To calculate measure-level NTGRs, we combined the FR and SO rates using Equation 6-2:

Equation 6-2. Net-to-Gross Ratio

$$NTGR_{measure} = 1 - FR_{measure} + SO_{program}$$

6.2 Net-to-Gross Results

This section presents our estimates of FR and participant SO, and the resulting NTGRs. Both FR and SO components of the NTGR were derived from self-reported information from telephone interviews with program participants. The final NTGR is the percentage of gross program savings that can be attributed to the program.

Table 6-1 shows FR estimates at the measure level and the SO estimate at the program level. Appendix A of this report contains the participant survey instrument, which includes the questions used in our algorithms. Appendix C provides an overview of the FR algorithm. We estimate program FR to equal 27.4% and program SO to equal 8.3%. The resulting NTGR for the REA program for the evaluation period is 80.9%. When applied to engineering gross estimates, the estimated SO rate of 8.3% represents an average of about 24 kWh per household.

Table 6-1. Measure-Level NTGRs

Component	FR	SO	NTGR
Energy Efficiency Kit*	27.4%	8.3%	80.9%
LEDs**	52.4%		55.8%
Low-flow shower head	18.2%		90.1%
Faucet aerators***	11.9%		96.4%
Outlet seals	16.8%		91.5%
Weather stripping	20.5%		87.8%

*FR for the Energy Efficiency Kit is the weighted average of the measure-level FR values.
**FR for LEDs applies to LEDs in the kit as well as additional ones supplied.
***FR questions for faucet aerators did not differentiate between kitchen and bathroom aerators.

6.2.1 Measure-Level Free-Ridership

Based on responses to FR questions in our participant survey, which focused on each measure from the Energy Efficiency Starter Kit, FR scores were calculated for customers who installed the measure. Table 6-2 shows the FR estimate for each measure as well as the relative precision, which was calculated around 1 - FR.

Table 6-2. Net-to-Gross Results and Relative Precision

	LEDs	Faucet Aerators	Low-Flow Shower Head	Outlet Seals	Weather Stripping
Sample size (n=)	103	124	131	93	79
FR estimate	52.4%	11.9%	18.2%	16.8%	20.5%
1 - FR	47.6%	88.1%	81.8%	83.2%	79.5%
Relative precision around 1 – FR (at 90% confidence)	10.6%	4.2%	5.0%	5.6%	6.5%

6.2.2 Spillover Savings

From our participant survey, we collected information on participants who were influenced by the program and installed additional energy-savings measures in their homes and for which they received no incentive or rebate. In all, 41 unique participants qualified for SO out of the survey sample of 150. More detail on measures that contributed to participant SO savings is shown in Table 6-3. We estimated a SO rate of 8.3% by taking the total measure-level SO estimates from survey respondents in Table 6-3 (i.e., 3,537 kWh) and dividing it by the total engineering savings from survey respondents (42,840 kWh).[5]

Table 6-3. Engineering Spillover Summary

Measure Type	Quantity of Measure Type	Total Energy Savings (kWh)	Total Coincident Demand Savings (kW)	Source of Savings
LEDs	80	2,556	0.376	Duke REA Kit deemed savings value
Clothes Washer	3	274	0.035	Il TRM V6.0
Clothes Dryer	2	185	0.025	Il TRM V6.0
Dishwasher	2	154	0.054	In TRM V2.2
Faucet Aerators	2	139	0.021	Duke REA Kit deemed savings value
Refrigerator	2	100	0.015	Il TRM V6.0
Hot Water Pipe Wrap	1	82	0.009	Il TRM V6.0
Attic Insulation	3,749	30	0.027	Il TRM V6.0
Wall insulation	400	15	0.013	Il TRM V6.0
Total	**4,241**	**3,537**	**0.576**	

[5] Total engineering savings of participants is calculated by multiplying the average engineering savings per home (i.e., 285.6 kWh) by the total number of survey respondents (i.e., 150). Note that numbers are rounded.

6.2.3 SB 310 Claimable Savings and DS More Inputs

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, Table 6-4 below compares net deemed (ex ante) and net ex post per household and program-level energy and demand savings and presents the savings claimable under SB 310 (final column). In 2017, Duke Energy developed revised deemed values that it could claim under SB310 for the energy efficiency kit and additional LEDs that households could receive in addition to those provided in the kit. Duke Energy provided these revised values to the Evaluation Team for analysis of SB 310 impacts.

Per SB 310, DEO will claim 1,059 kWh of energy savings and 0.1130 kW and 0.1095 kW of peak summer and winter demand savings, respectively, per household for the 2016-2017 program years. These values are the higher of the Duke Energy provided deemed values and the impact evaluation-based ex post savings values.

Table 6-4. Savings Claimable under Senate Bill 310 (SB 310)

Energy and Demand Savings	Net Deemed (Planning) Savings	Net Ex Post Savings	Claimable Savings under SB 310
Energy Savings			
Total Per-Household Savings (kWh)	890.1	1,058.5	1,058.5
Additional LEDs (kWh) (average of 3.4 bulbs per household)	*96.1*	*59.7*	*96.1*
Energy Efficiency Kit, excluding Additional Bulbs (kWh)	*794.0*	*998.9*	*962.4*
Total Program Savings (MWh)	**2,004.5**	**2,383.7**	**2,383.7**
Summer Coincident Demand Savings			
Total Per-Household Savings (kW)	0.1095	0.0958	0.0958
Additional LEDs (kW) (average of 3.4 bulbs per household)	*0.0094*	*0.0047*	*0.0094*
Energy Efficiency Kit, excluding Additional Bulbs (kW)	*0.1001*	*0.0912*	*0.0865*
Total Program Savings (kW)	**246.5**	**215.8**	**215.8**
Winter Coincident Demand Savings			
Total Per-Household Savings (kW)	0.1130	0.0945	0.0945
Additional LEDs (kW) (average of 3.4 bulbs per household)	*0.0177*	*0.0041*	*0.0177*
Energy Efficiency Kit, excluding Additional Bulbs (kW)	*0.0953*	*0.0903*	*0.0768*
Total Program Savings (kW)	**254.5**	**212.7**	**212.7**

*Total Program Savings = total number of households (2,252) * total per-household savings.

The evaluation team also developed gross and net energy and demand savings values to serve as inputs to the DS More tables used by Duke Energy for planning purposes (see Table 6-5). These inputs reflect the following:

- Duke Energy requires separate per-participant savings values for the energy efficiency kit and additional LED bulbs.
- For DEO, DS More planning values reflect savings claimable under SB 310, i.e., the higher of ex ante and ex post values.
- Since the kit savings were developed based on a billing analysis, which yielded a net estimate, the same savings estimate is used for both gross and net savings.

Table 6-5. Summary of Energy and Demand Savings for DS More Table

DS More Inputs	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Gross savings per additional LED bulb*	50.65	0.0049	0.0093
Net savings per LED additional bulb**	28.27	0.0028	0.0052
Gross/Net kit savings per participant (excluding additional LEDs)***	962.4	0.0865	0.0768

*Gross ex ante planning values provided by Duke Energy.
**Calculated as gross savings * LED NTGR (55.8%)
***Savings for *Energy Efficiency Kit, excluding Additional Bulbs* from Table 6-4 above.

7. Process Evaluation

7.1 Researchable Questions

Based on discussions with Duke Energy program and evaluation, measurement, and verification (EM&V) staff, the evaluation team developed the following process-related research questions:

- What are the most successful components of the program? What improvements can be made to the program's design and implementation?
- Are customers satisfied with the participation process and program measures?
- Do participants find the assessment recommendations useful and actionable?
- Are eligible customers channeled into other Duke Energy programs?
- What kind of behavioral changes do participants make following the assessment?

7.2 Methodology

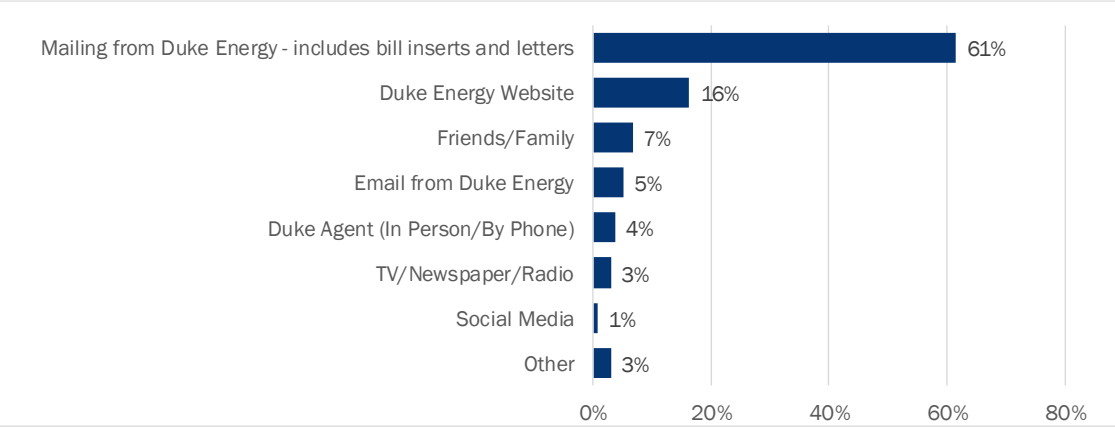
Our process evaluation relied primarily on our interview with program staff, our review of program materials and program-tracking data, and our analysis of the participant survey. The full survey document can be found in Appendix A of the accompanying appendices.

7.3 Key Findings

7.3.1 Marketing and Channeling

Duke Energy has relied heavily on a direct mail marketing strategy to generate interest in the REA program. As shown in Figure 7-1, the majority of respondents (61%) reported first hearing about the program via a direct mailing from Duke Energy (e.g., a bill insert or a letter). Given the length of time between the customer learning about the program and taking the survey, we do not distinguish between the types of mailed items. Customers may simply remember receiving "something" in the mail.

Figure 7-1. Sources of Program Awareness



REA auditors are instructed to inform program participants about other suitable Duke Energy programs for which they might be eligible. However, only about a quarter of REA participants (27%) recalled learning about other Duke Energy programs during their assessment. Of these participants, the largest share reported hearing about the residential Smart $aver program (30%), followed by the Power Manager program (28%). A third of the respondents who said that they recalled hearing about other programs could not recall the names of those programs (see Table 7-1).

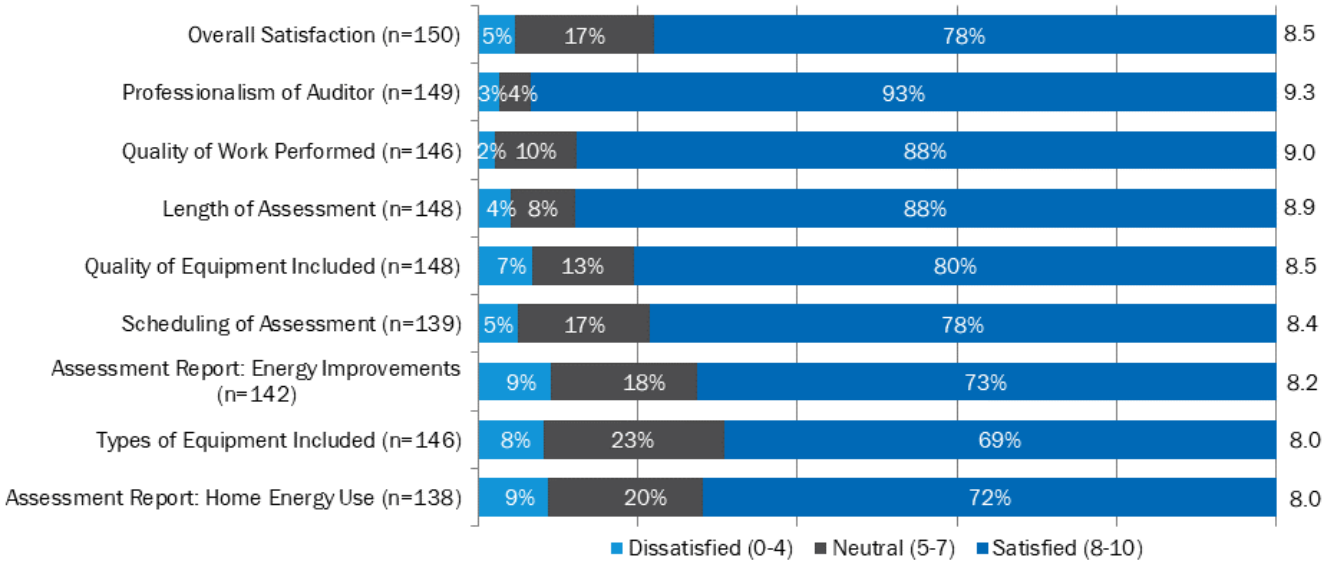
Table 7-1. Channeling to Other Duke Energy Programs

Which programs did you recall hearing about? (multiple responses accepted) (n=40)	
Smart $aver	30%
Power Manager	28%
Other	10%
Don't know	33%

7.3.2 Satisfaction

Overall, program satisfaction was high across various aspects of the program. Seventy-eight percent of customers said that they were "satisfied" with the program overall (see Figure 7-2). The areas of highest satisfaction relate to the professionalism of the auditor (9.3 out of 10) and to the quality and speed of the auditor's work (mean ratings of 9.0 and 8.9, out of 10, respectively). The ratings related to how the assessment report improved the participant's understanding of where energy improvements can be made in the home and of their home energy use, along with the types of equipment included in the kits, were the lowest rated components of the program. Overall, however, all program aspects had a mean satisfaction rating of 8 or above out of 10 and low levels of dissatisfaction (a rating of 4 or less). The mean satisfaction rating of the program overall was 8.5 out of 10.

Figure 7-2. Program Satisfaction



Equal proportions of participants have noticed savings on their Duke Energy bill (38%) as have *not* noticed savings on their Duke Energy bill since participating in the program (also 38%), while the remaining participants were not sure (24%). Participants who reported noticing bill savings or said that they were not sure about bill savings had higher satisfaction ratings for the program overall compared to those who reported not noticing savings (with mean scores of 9.2 and 8.9 vs. 7.7 out of 10, respectively). It is possible that the satisfaction with the program is related to whether participants noticed bill savings.

7.3.3 Program Value

Understanding customers' motivations for participating can help in developing effective program marketing strategies. Opinion Dynamics asked participants for their reason(s) for participating in the program (Table 7-2). A majority (51%) mentioned saving money on energy bills as a reason for their participation; reducing energy consumption was also cited frequently (33% of participants). Only a small share of participants (9%) cited "it was free" as a reason for participation.

Table 7-2. Reasons for Participating

Why did you choose to participate? (n=150) (multiple responses accepted)	
Save money on energy/electric/gas bill	51%
Reduce energy consumption	33%
It was free	9%
Make your home more comfortable	8%
Learn more about home energy use and the program	7%
New house or selling current house	5%
Other	6%
Don't know	4%

Note: Because multiple responses are accepted, total will not sum to 100%.

To assess participants' perception of the value of the REA offerings, the survey asked how much money they would be willing to pay for the energy assessment and for the kit. Participants reported valuing the assessment lower than its stated value. Customers who would be willing to pay for the assessment (39% of respondents) valued it at an average of $48.67, which is less than a third of the stated value ($180) on Duke Energy's website. Customers who would be willing to pay for the kit (44% of respondents) valued it at an average of $28.74, which approximates the stated value of $30.00 on the website.[6] The average willingness-to-pay for both is $77.41. The majority of participants found the LEDs most valuable among the kit items (74%); fewer participants found shower heads (17%) and faucet aerators (16%) to be the most valuable measures.

7.3.4 Experience with Measures and Program Improvement Suggestions

Respondents who installed some or all of the measures in the energy efficiency kit were asked whether they, the auditor, or both installed each measure (i.e., for those measures where more than one unit was provided). LEDs were installed equally by auditors and customers. The majority of the installations of water measures were performed by the auditor, whereas the outlet seals and weather stripping were predominately installed by the customers. In subsequent conversations with Duke Energy staff, the evaluation team learned about

[6] Note that these averages were calculated separately, excluding respondents who valued the item at $0 (22%) or who did not know (25%).

additional implementation staff training on measure installation, occurring after the evaluation period, to address this issue. Table 7-3 shows full details of measure installations.

Table 7-3. Measure Installations

Measure	IRs	Auditor Installed	Customer Installed	Both Installed
LEDs (n=127)	88%	46%	46%	8%
Faucet aerators (n=82)	42%	62%	32%	4%
Shower head (n=59)	40%	58%	42%	N/A
Outlet seals (n=47)	45%	15%	83%	<1%
Weather stripping (n=30)	30%	20%	77%	3%

Additionally, respondents whose energy efficiency kit measures were not still installed were asked to provide reasons for not installing them. Common reasons varied across the measure types. For LEDs, the majority reported that they were waiting for their current bulbs to burn out to install their new ones (67%), suggesting that they may benefit from additional education about the energy savings benefits of replacing existing bulbs with LEDs. For faucet aerators, the most common response was the measure not fitting (26%) while for shower heads, the customers did not like the measure (33%) or already had an efficient shower head (24%). Most respondents who had not installed all of their weather stripping reported not seeing a need (43%), whereas for outlet seals respondents had not had the time to install them yet (30%). Table 7-4 shows full details of the responses by measure.

Table 7-4. Common Reasons for Not Installing Measures

Common reasons for not installing	LEDs (n=24)	Faucet Aerators (n=105)	Shower Head (n=87)	Outlet Seals (n=57)	Weather Stripping (n=67)
Haven't needed the equipment yet	67%	19%	0%	0%	0%
Did not see a need	4%	8%	2%	16%	43%
Did not like the measure	13%	5%	33%	0%	0%
Haven't had time	8%	5%	10%	30%	16%
Did not fit	4%	26%	13%	5%	0%
Already have the measure	4%	14%	24%	9%	6%
Unable to install/needed assistance	0%	1%	0%	9%	12%
Did not receive enough/only received one*	0%	4%	0%	0%	1%
Not enough water pressure	N/A	0%	5%	N/A	N/A
Don't know	0%	7%	2%	25%	18%

Note: The n values represent the number of respondents who said that they had installed only some or none of the measure.
*This response was given by participants who, for example, had more showers, outlet seals, and faucet aerators than could be accommodated by the measures in the kit. In the case of weather stripping, there was not enough to weather strip around all windows and doors in the home.

The evaluation team also inquired about what additional measures participants would have liked to receive. The majority of participants reported that the kit equipment was sufficient (67%) or that they did not know what other equipment they would have liked in the kit (7%). Another 14% reported that they would have liked to receive more of the measures currently offered in the kit. The list of additional measures that participants reported that they would have liked to receive in addition to those in the kit are listed in Table 7-5. The top suggestions were to offer different types of LEDs and to offer insulation, while some of the "other" responses included premium testing (e.g., thermal readings and draft checks).

Table 7-5. Additional Measures

What equipment would you have liked to receive? (n=21)	
Other types of LEDs	29%
Insulation	19%
Smart thermostats/smart plugs	14%
Variety of outlet seals	14%
Hot water measures	10%
Other	19%

Participants were also asked to rate their interest in receiving a "Home Energy Score," which uses a 1–10 scale to rate the efficiency of the home's energy usage; 78% said that they were at least somewhat interested in receiving their score.

Consistent with the high satisfaction levels, the majority of respondents (55%) did not have any recommendations to improve the program, while others did not know what could be done to improve it (9%). Of the 37% who did provide suggestions for improvement, the most common were to include additional measures in the energy efficiency kit, to increase communication and follow-up regarding their assessment, and to increase the quantity of the current measures—all mentioned by fewer than 10% of respondents (see Table 7-6).

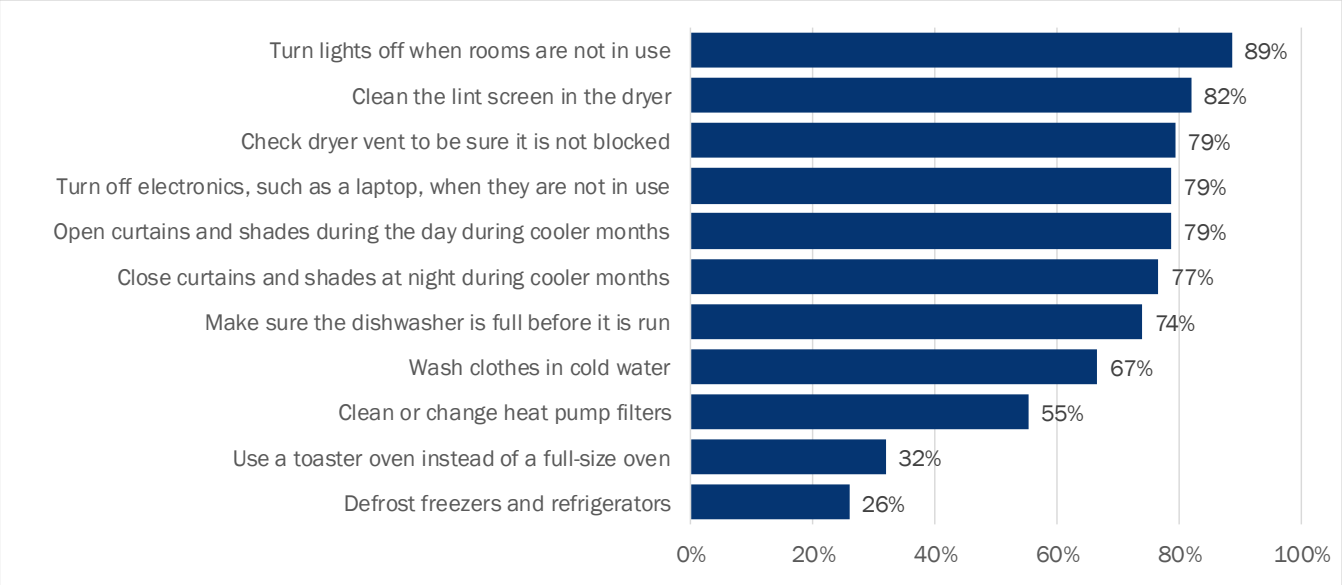
Table 7-6. Suggested Program Improvements

What, if anything, could be done to improve the program? (n=150)	
Nothing	55%
Expand the kit to include more measures	9%
Improve measure quality/increase amount of measures in kits	6%
Have auditor do a more thorough assessment/install all the measures	5%
Increase follow-up and communication before/after assessment	3%
Improve clarity of the report	3%
Offer advanced home assessment features (e.g., thermal imaging, draft checks)	3%
Provide a list of qualified contractors	2%
Increase allowance for additional bulbs	1%
Other	3%
Don't know	9%

7.3.5 Education

As part of the Energy Efficiency Starter Kit, customers received a "Department of Energy, Energy Savers Booklet." This educational material outlines how energy is used, and wasted, in the home. The booklet provides insights about the effects that insulation, lighting, appliances, and other items can have on energy use in the home. Included in the booklet is a list of energy-saving tips. Most respondents remember receiving the booklet (81%), and 76% of those participants reported taking the time to read it. All participants were asked about any behavioral changes that they have made since participating and, overall, these measures have had high uptake (see Figure 7-3). The only exceptions are two recommendations related to kitchen appliances.

Figure 7-3. Behavioral Changes



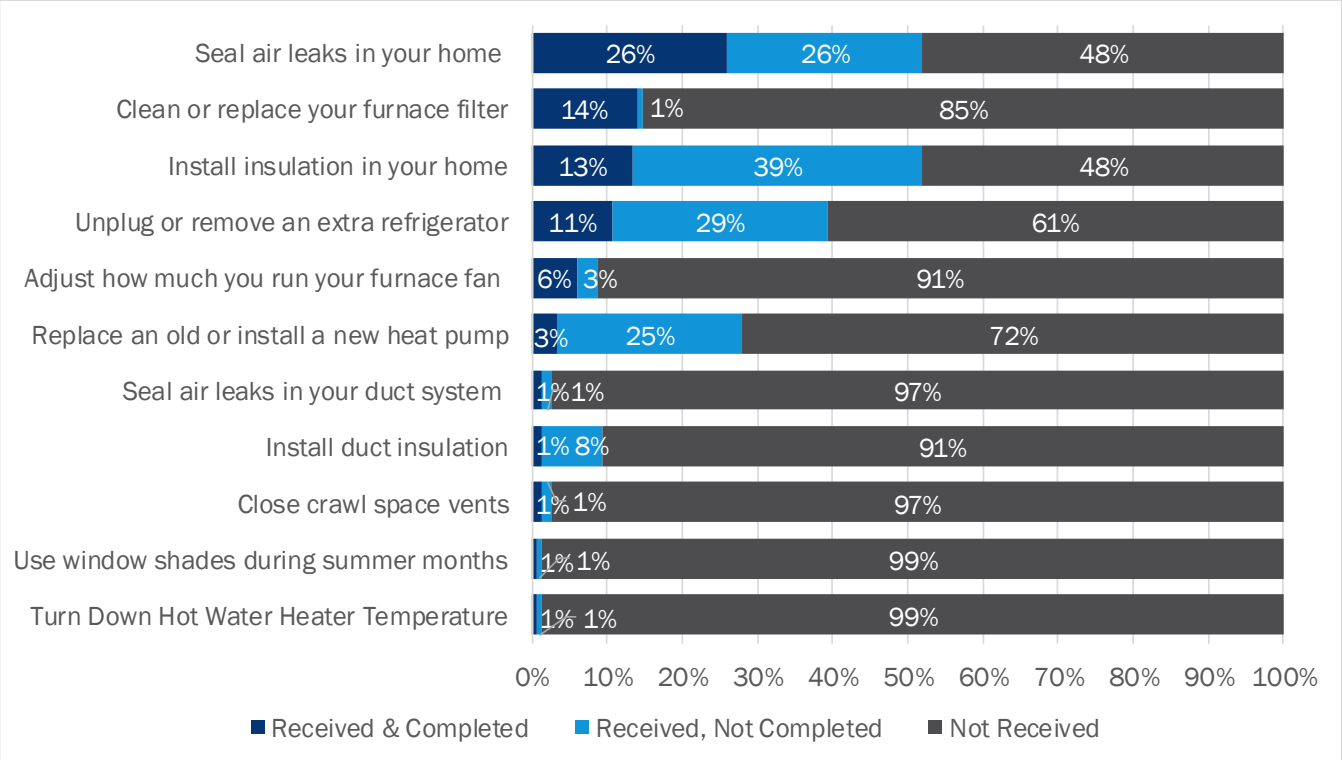
7.3.6 Assessment Recommendations

The program-tracking data includes information about specific recommendations on energy efficiency actions provided to DEO REA program participants during the assessment. The telephone survey then asked participants to confirm that they had received the tracked recommendations, which ones they had completed, and whether they planned to implement any of those recommendations not yet completed. Note that to reduced survey response burden similar recommendations were grouped into categories for the survey. For example, “seal leaky fireplace”, “seal leaky windows”, and “seal leaky doors” were all grouped into the category “seal air leaks” in the survey instrument.

The proportion of participants who received and acted on the given recommendations is shown by the dark blue bars in Figure 7-4. The lighter blue bars represent recommendations that were received but not carried out by participants. The grey bars show recommendations not received. Figure 7-4 shows that several of the recommendations were given to participants less than 20% of the time (as shown by the sum of the percentages of the dark blue and lighter blue bars), with the exceptions being sealing air leaks, installing insulation, unplugging or removing an additional refrigerator, and replace old heat pump. It is not clear why auditors did not provide recommendations more often, such as those related to cleaning or replacing furnace filters, sealing home ducts, installing duct insulation, closing crawl space vents, and turning down the water heater temperature, though one possible explanation is that they did not think that they were applicable.

According to Duke Energy, the program implementer has since received additional training to ensure that all appropriate audit recommendations are provided. In addition, the program refreshed its audit reports in March 2017 to make sure to cover applicable audit recommendations. Among respondents who had not completed one or more of their received recommendations, the majority said that they were currently planning to complete some or all of the remaining recommendations (46%), while the rest either had no plans to complete them (43%) or said that they did not know (11%).

Figure 7-4. Received and Completed Recommendations



8. Conclusions and Recommendations

Below we present the key findings from our evaluation, and, where applicable, accompanying recommendations.

Finding: Overall, Opinion Dynamics found that the DEO REA program performed well. Participants were highly satisfied with the program, and net savings were in line with results from most prior evaluations. We found that most participants first heard about the program through Duke Energy mailings, which is consistent with Duke's marketing efforts.

Finding: Like the REA program that operates in other Duke Energy jurisdictions, not all measures from the Energy Efficiency Starter Kit were installed by auditors. Almost half of the kit measures were not installed by the auditor during the home assessment (weighted average of 52% were installed). However, measures that save more energy, such as LEDs, faucet aerators, and low-flow shower heads, were installed more frequently than outlet seals and weather stripping. Of the 70% who did not have their faucet aerators installed, one-quarter said it was because they did not fit and of the 16% of customers who did not have their free LEDs installed, about two-thirds said they were waiting for their old bulbs to burn out first.

> **Recommendation: Auditors should install all measures in distributed energy efficiency kits. If unable to install all measures, auditors should track the barriers that prevent them from doing so.** If the program could improve measure installation, it is likely that measure ISRs and program savings would improve, particularly because we found high PRs for all measures. We understand that there may be safety concerns related to the installation of outlet seals, which may lead auditors to leave these measures uninstalled, but our understanding is that Duke Energy has an expectation that all measures will be installed during home assessments. It should be noted that in subsequent conversations, the evaluation team learned from Duke Energy that in the spring of 2017, after the close of this evaluation period, additional training of implementation staff occurred to address this issue and to instruct installers to document why measures were not installed.
>
> Specifically, to address faucet aerators that do not fit, we recommend providing adaptors to participants to increase the installation rate of this measure.
>
> **Recommendation: Provide education on the benefits of early light bulb replacement.** Participants report "not needing them" as the most common reason for not installing the LEDs provided in the kit, suggesting that participants are waiting for their current bulbs to burn out. While more emphasis on installing all measures during the audit (see recommendation above) will help with ISRs, providing additional education on the savings potential of LEDs might lead to additional spillover savings by encouraging participants to more quickly replace inefficient bulbs in the future as well.

Finding: While our data preparation for the billing analysis showed that a majority of REA participants have participated in other Duke Energy programs, our survey findings show that only a small portion of customers recalled hearing about other Duke Energy programs through the REA program.

> **Recommendation: Channeling efforts by auditors that direct participants of the REA program to other Duke Energy programs could be improved.** While our data preparation for the billing analysis showed that a majority of REA participants have participated in other Duke Energy programs prior to participation, our survey findings show showed that only a small portion of customers recalled hearing about other Duke Energy programs through the REA program. If Duke Energy is interested in using the REA program to channel customers to their other offerings, program staff may want to direct auditors to leave behind applicable materials to market its other programs. Additionally, we recommend that

auditors familiarize themselves with Duke Energy's other programs and make recommendations to program participants based on the programs that are most suitable.

According to Duke Energy, the program refreshed the technology and audit report in March 2017 to provide a more user-friendly report to the customer, outlining audit recommendations as well as cross-program recommendations. Additionally, the implementer now has the ability to report back to Duke Energy all recommendations, including cross-promotional referrals. Finally, in addition to including FindItDuke referrals in the audit report, advisors can now generate (where relevant) and email referrals to the customer during the assessment.

Finding: Based on a review of the program-tracking data, some energy saving recommendations were provided less than 20% of the time to customers. During assessment visits, auditors are expected to provide participants with all applicable recommendations to improve energy efficiency in their homes. It is unclear if recommendations were not provided because they were not applicable or for some other reason. According to Duke Energy, the program implementer has since received additional training to ensure that all appropriate audit recommendations are provided. In addition, the program refreshed its audit reports in March 2017 to make sure to cover applicable audit recommendations.

Recommendation: The energy savings from the program could be improved if auditors provided customers with more recommendations on which they could act. They may not be knowledgeable about the amount of energy that they could save by making changes, such as replacing furnace filters and adjusting thermostat settings. As noted above, Duke Energy has provided additional training to implementation staff to address providing recommendations to program participants that can help them save energy in their homes.

9. DSMore Inputs

For planning purposes, Duke Energy requires separate per-participant savings values for the energy efficiency kit and the additional bulbs distributed to participants. To provide these estimates, the evaluation team took the following steps:

1. We estimated **net savings per additional LED** by multiplying gross savings per additional LED by the LED NTG ratio of 55.8 %.

2. We estimated **net savings of the kit exclusive of additional LEDs** by subtracting net savings for the average number of additional LEDs (3.4 bulbs) from per household savings based on the billing analysis.

Developing these separate inputs ensures that savings from the additional bulbs are not double-counted for planning purposes, as their savings are already included in the billing analysis estimate.

Table 9-1presents the development of the DSMore inputs.

Table 9-1. Development of DSMore Inputs

Data for Development of DSMore Inputs	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Gross savings per additional LED bulb: Engineering analysis	50.65	0.0049	0.0093
LED NTG ratio = 55.8%			
Net savings per LED additional bulb: Engineering analysis	28.27	0.0028	0.0052
Program savings per participant: Billing analysis	1058.50	0.0958	0.0945
Net Savings for additional LED Bulbs	96.10	0.0094	0.0177
Net kit savings per participant (excluding additional LEDs)	962.40	0.0865	0.0768

The DSMore Inputs are included in the embedded Microsoft Excel file.

DEO Residential Assessments_DSMor

10. Summary Form

Residential Energy Assessments

Completed EM&V Fact Sheet

The REA program provides, free of cost, a home energy assessment, which includes a kit of low-cost energy efficiency measures. A report of recommended upgrades and behavioral changes is given to the customer at the end of the assessment.

Residential customers in DEO service territory who have owned their single-family home for at least four months are eligible for the program. Homes must have an electric water heater, electric heat, or central air conditioning.

Date	October 16, 2018
Region(s)	Duke Energy Ohio
Evaluation Period	May 2016–April 2017
Claimed Savings Per SB 310	
Annual kWh Savings	2,383,742 kWh
Annual kWh Savings (per participant)	1,059 kWh
Coincident kW Impact	254.5 kW (Summer) 246.5 kW (Winter)
Ex Post Savings	
Annual kWh	2,383,742 kWh
Per Participant Net kWh	1,059 kWh
Per Participant Coincident Net kW	215.8 kW (Summer) 212.7 kW (Winter)
Measure Life	Not Evaluated
Net-to-Gross Ratio	81%
Process Evaluation	Yes
Previous Evaluation(s)	Yes, 2014 evaluation

Evaluation Methodology

The evaluation team verified measure-level deemed savings estimates using an engineering analysis of savings assumptions and calculations. The evaluation team also leveraged a participant survey to verify IRs and ISRs for each measure and to estimate measure- and program-level NTGRs. The evaluation team conducted a billing analysis to estimate energy savings and used a combination of billing analysis and engineering analysis results to estimate coincident demand savings.

Impact Evaluation Details

- The evaluation team based assumptions and inputs, for deemed savings and gross impacts on the OH TRM as well as other relevant TRMs (e.g., the IN TRM V2.2). The engineering analysis applied deemed savings values to measures distributed and in service (e.g., via an Energy Efficiency Starter Kit and additional LEDs).
- To comply with SB 310, claimed net savings are based on the larger of the ex ante and ex post savings.
- Results from the billing analysis reflect savings associated with measures installed, assessment recommendations, SO, and potential behavioral changes from energy efficiency knowledge gained through participation in the REA program.

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ATTACHMENT 8-
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Duke Energy Ohio

Free LED & Online Savings Store Program
Final Evaluation Report

September 11, 2018

Opinion Dynamics

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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.

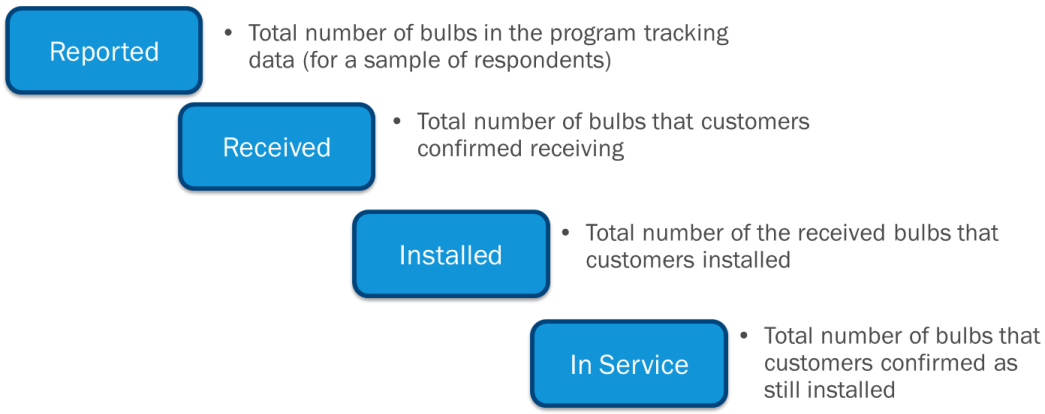
Table 2-11. Summary of Gross Savings Inputs

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.

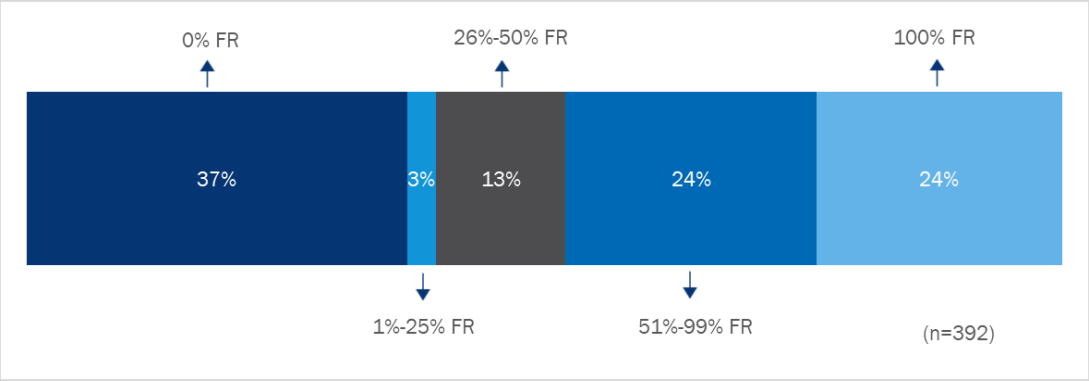
Table 2-19. NTG Results

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.

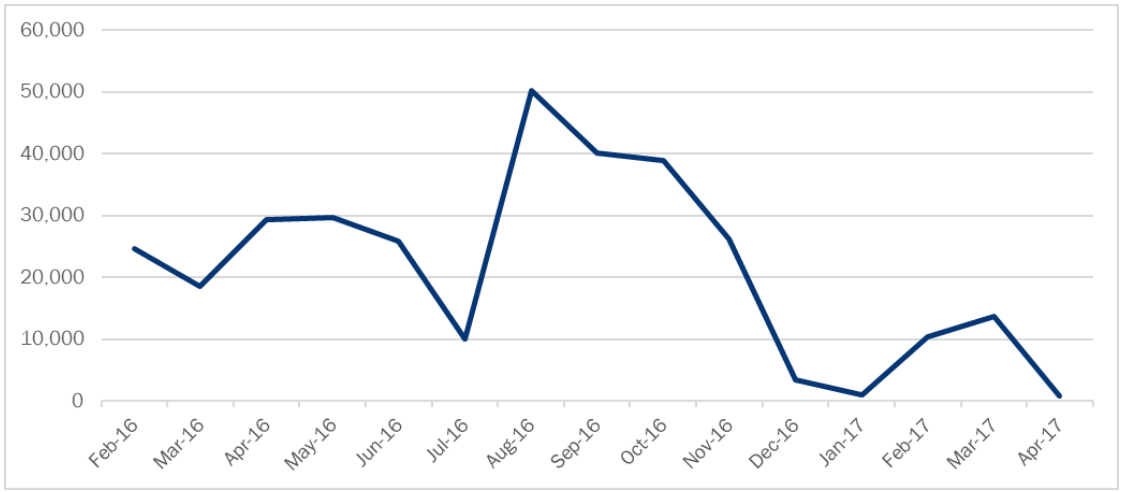
2.8.2 Key Findings

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%

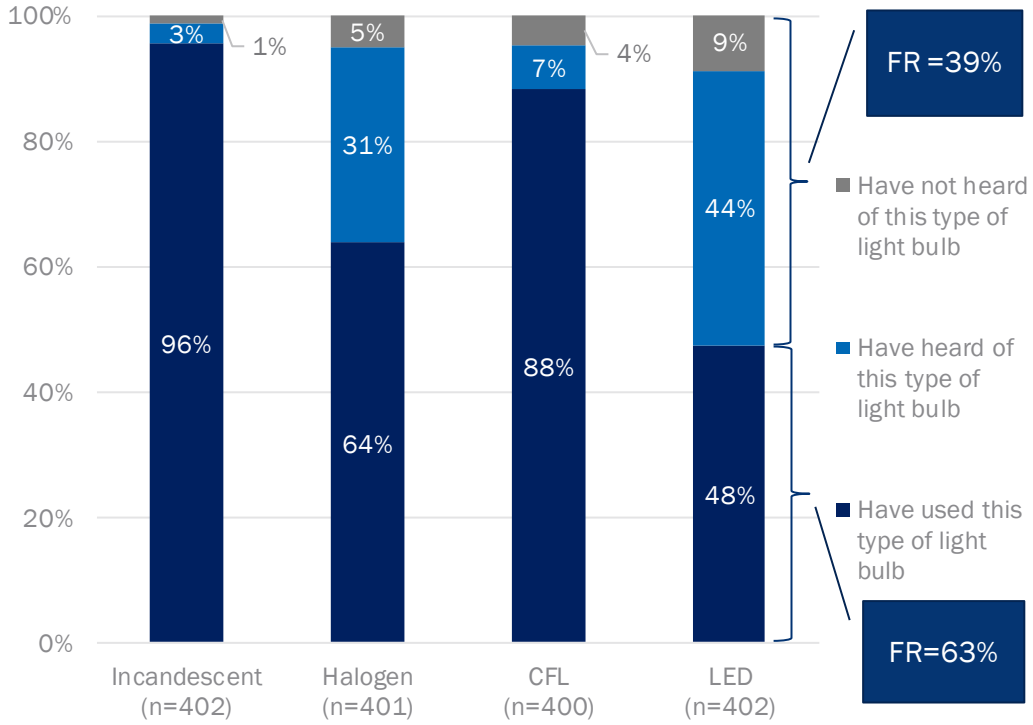
[a] Population-level estimate as opposed to the household-level estimate.

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.

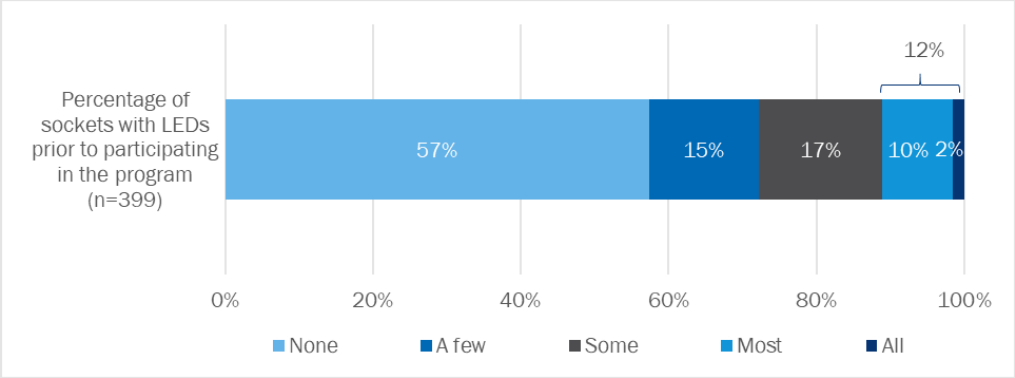
Nearly all participants had heard of LEDs prior to participating in the program (92%) and almost half (48%) had used LEDs. Not surprisingly, previous experience with LEDs drives FR rates; participants with LED experience have much higher FR rates than those who are aware of the technology but have not 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



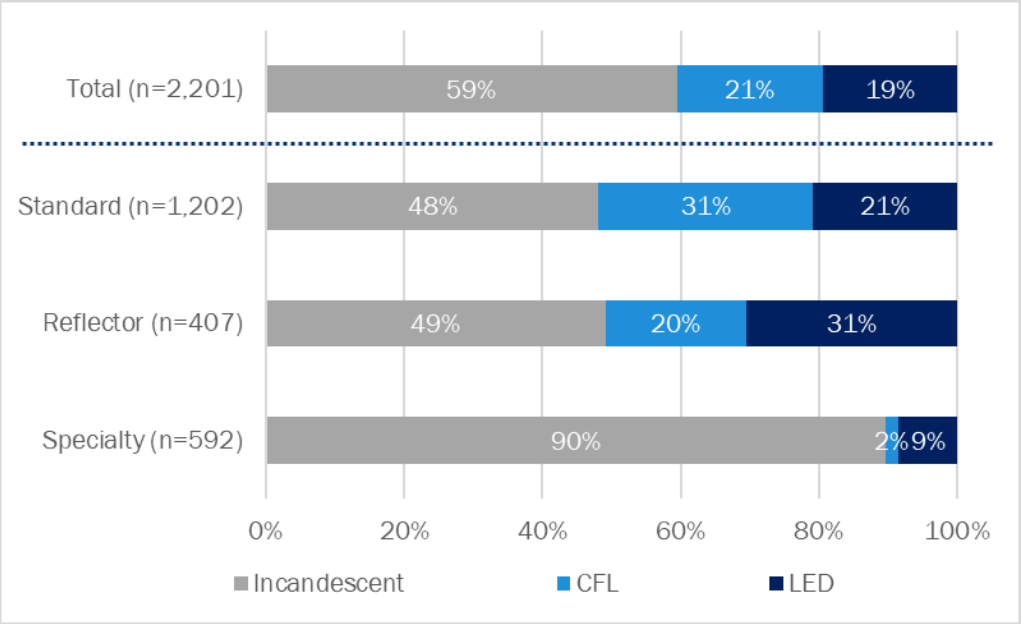
As part of the survey, we asked participants to estimate the percentage of light sockets in their homes that had LEDs prior to participating in the program. As shown in Figure 2-5, 43% had LEDs in at least a few of their sockets prior to participating in the program, and 12% had LEDs in most or all of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

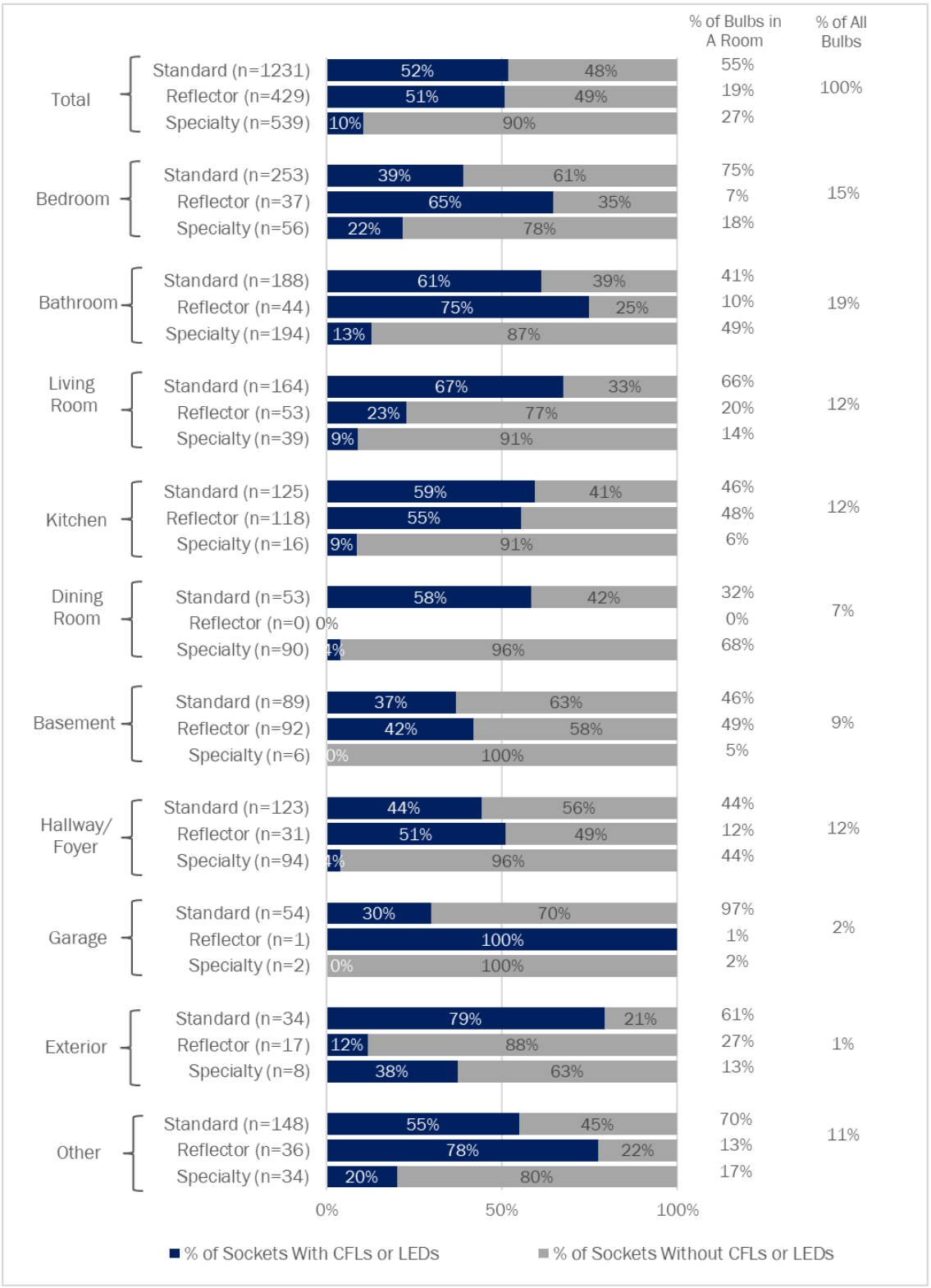


An analysis of socket saturation with energy efficient products by room provides further insight into the areas of the home that are still dominated by less-efficient technologies, such as incandescents and halogens. Figure 2-7 provides socket saturation rates by product type and room type. The graphic 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

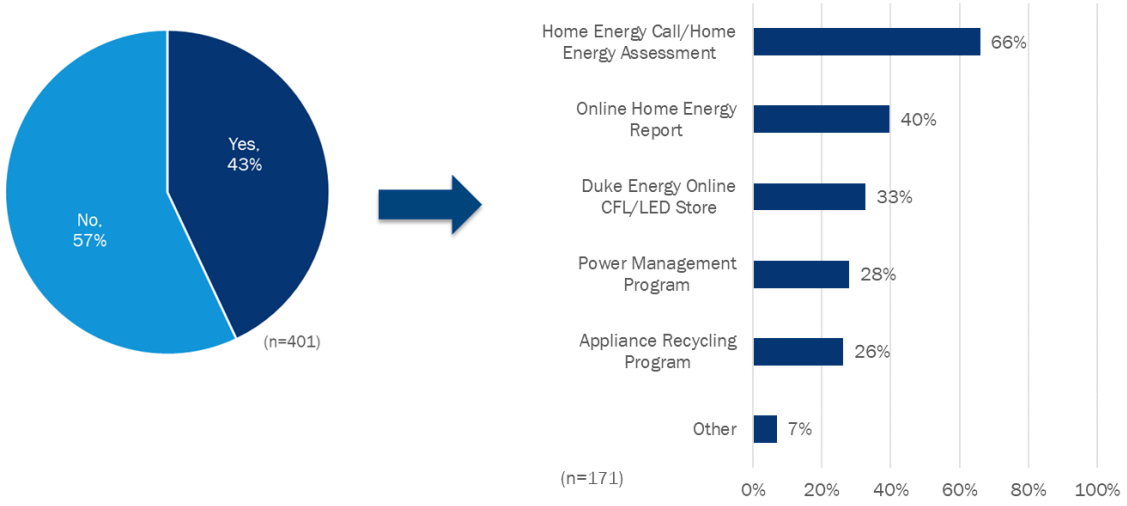


Program Marketing and Outreach

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]

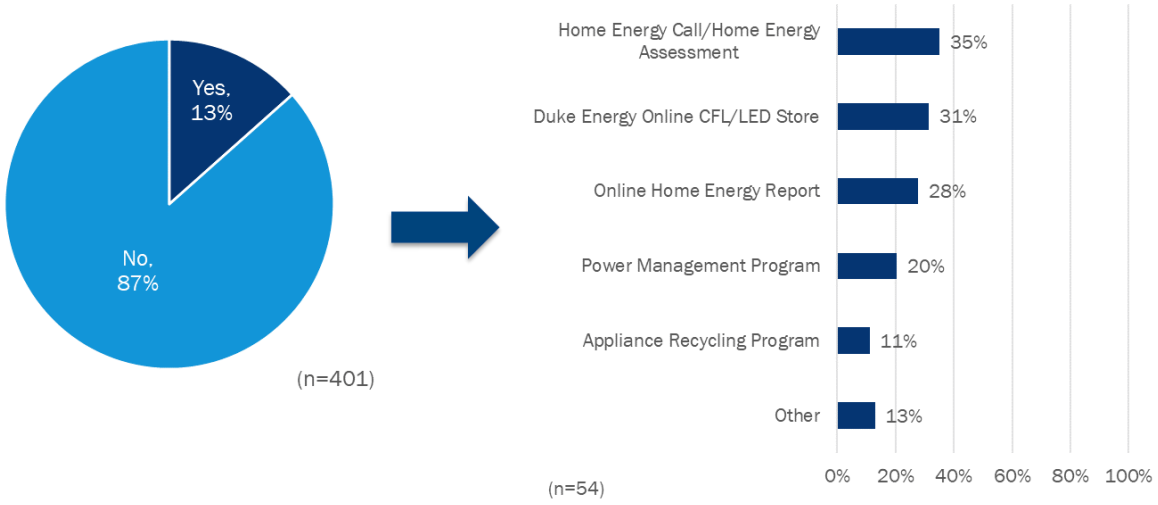
Figure 2-8. Cross-Program Awareness



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.

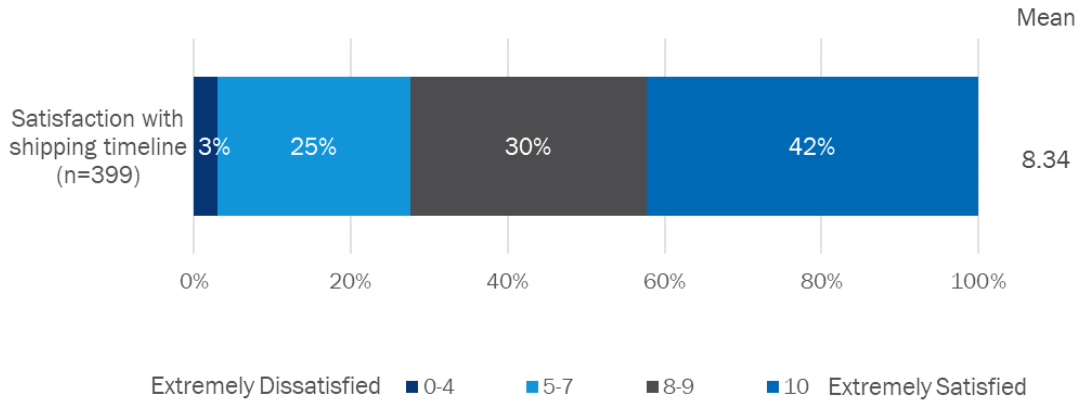
Figure 2-9. Cross-Program Participation



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.

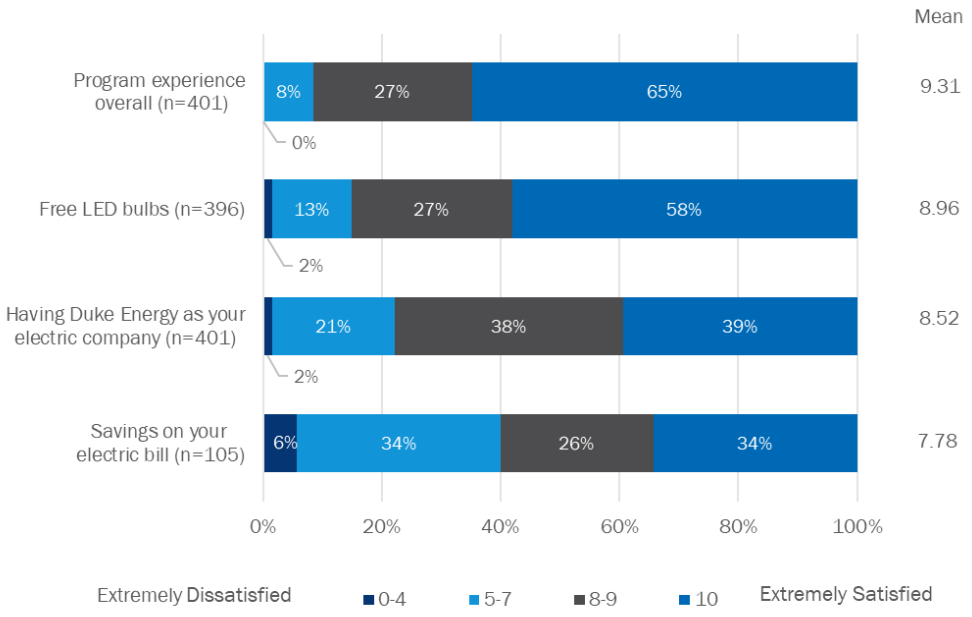
[10] A rating of 8, 9, and 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

[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

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

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.

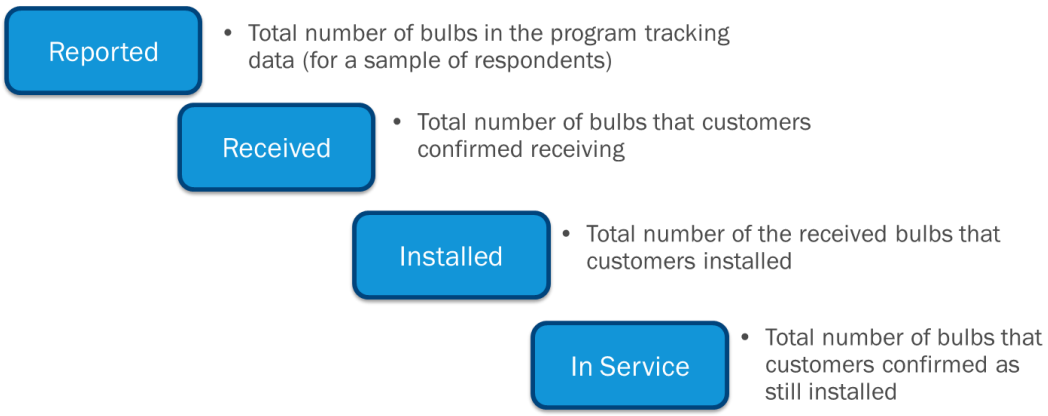
Table 3-12. Summary of Gross Savings Inputs

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%**

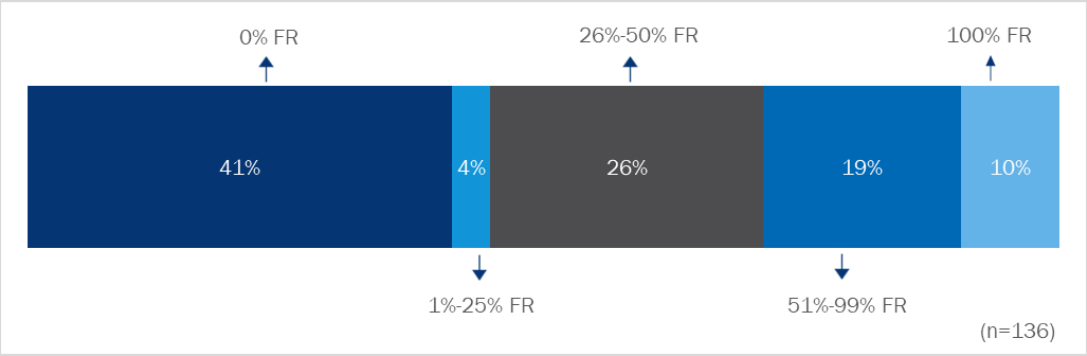
[18] We used a per-bulb retail prices for like-products provided as part of the Online Savings Store program participation data.

[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

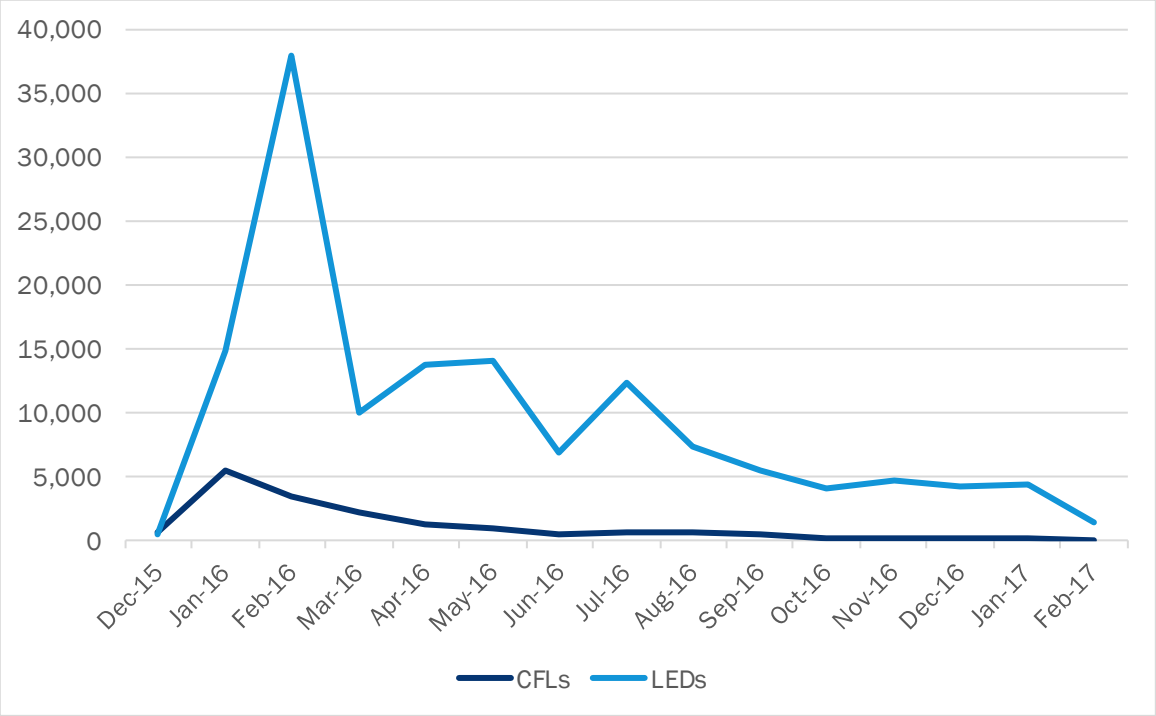
Bulb Technology	Bulbs Distributed	Percent of Total Bulbs
Standard CFL	6,300	4%
Reflector CFL	3,526	2%
Specialty CFL	6,665	4%
Standard LED	12,230	8%
Reflector LED	61,613	39%
Specialty LED	68,149	43%
Total	**158,483**	**100%**

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.

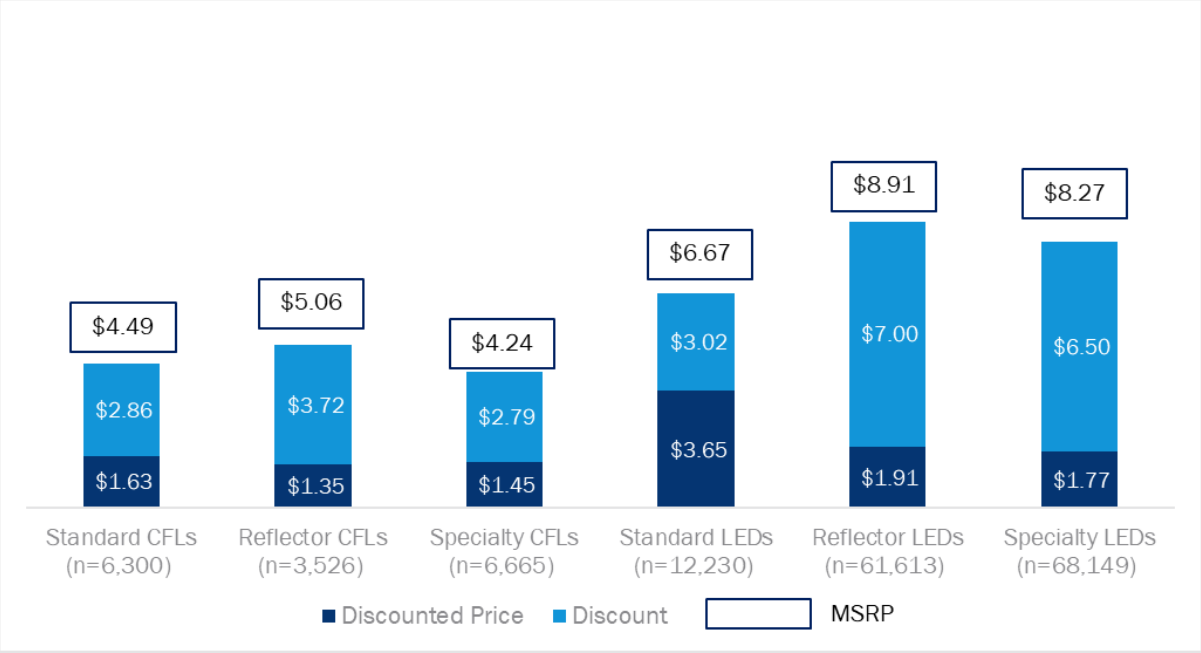
Participation in the program varied over the course of the program period, with a spike in early 2016. Program CFL sales decreased considerably after the first quarter of 2016 (Figure 3-3).

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

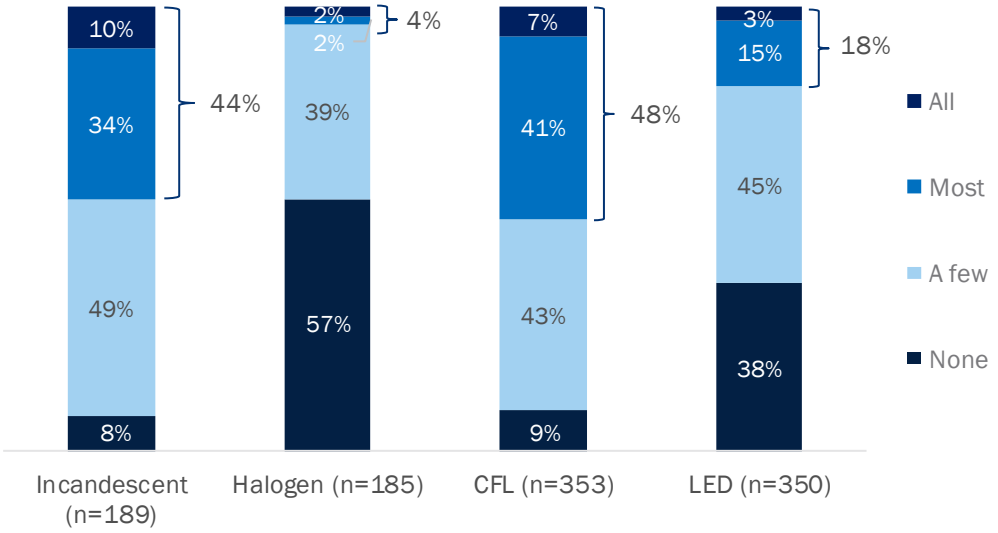
Characteristic	FR	Participant Characteristics	Population Estimates
Age		**n=344**	**Census Data**
Under 25	--	0%	9%
25–44	50%	21%	40%
45–64	36%	42%	32%
65+	34%	37%	19%
Home ownership		**n=355**	**Census Data**
Own	40%	97%	38%
Rent	0%[a]	3%	62%
Education		**n=350**	**Census Data[b]**
High school or less	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

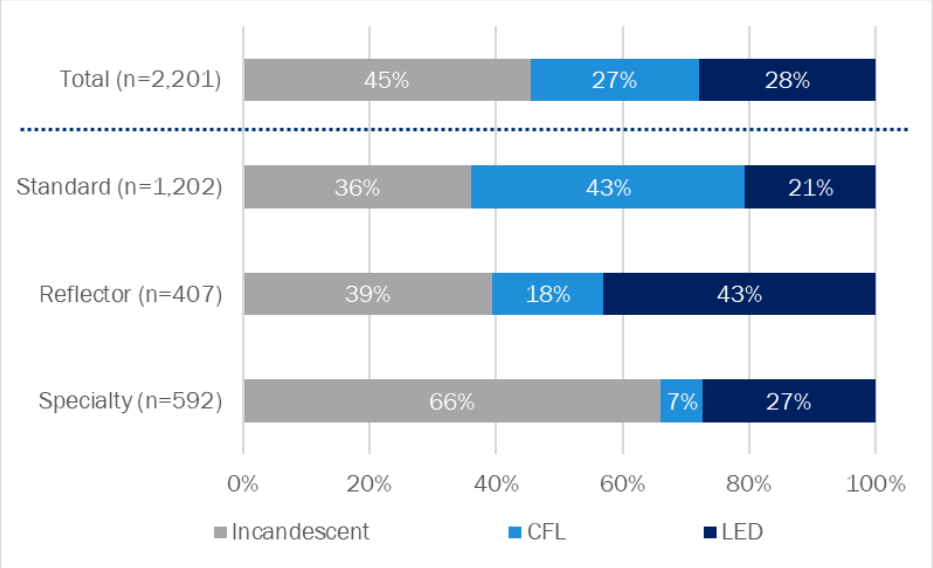


Such a high presence of energy efficient products in participant homes indicates that participants had high existing levels of awareness and familiarity with the products and an increased likelihood to select those products moving forward. The results also suggest that many participants could end up 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.

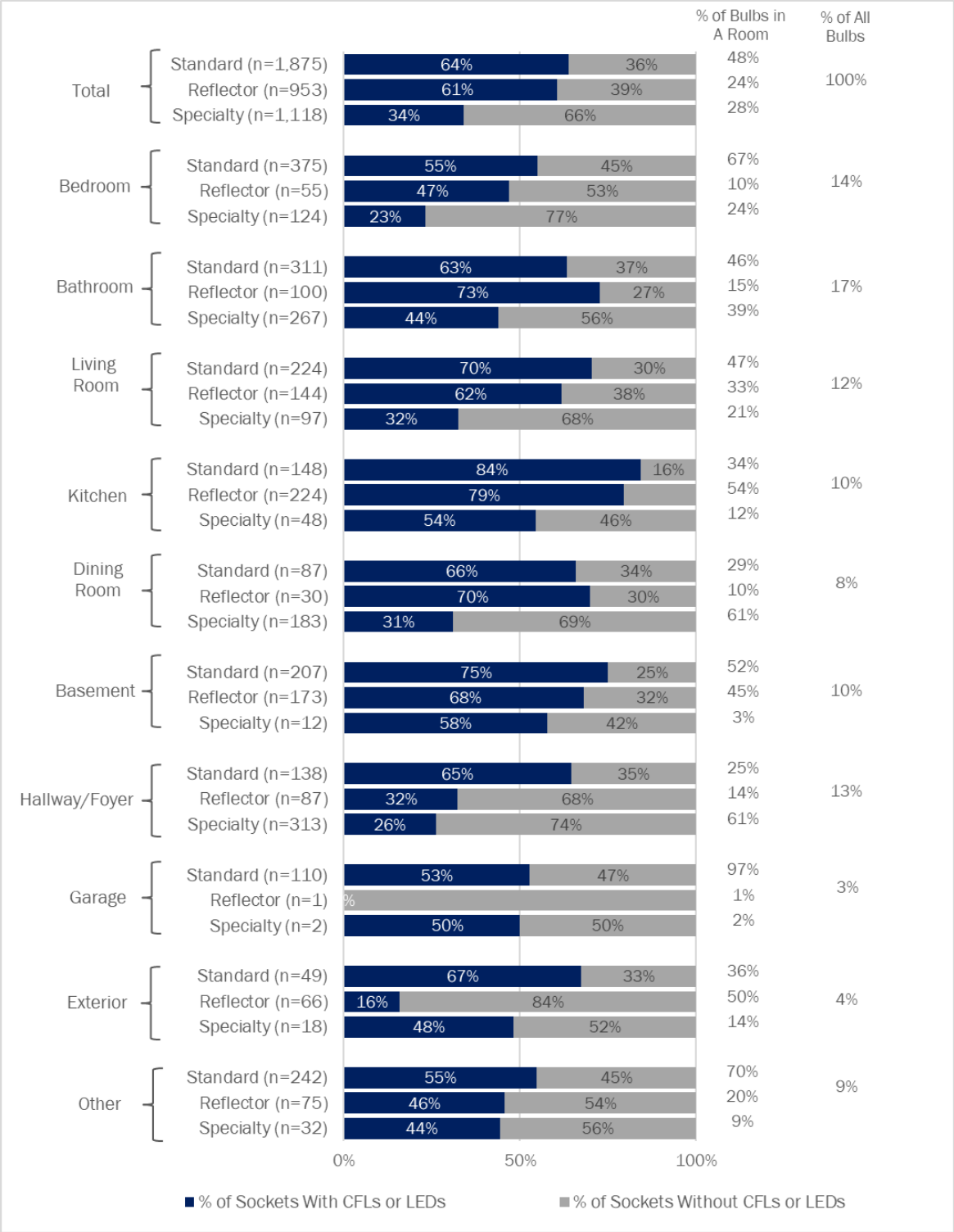
Figure 3-6. Bulb Mix in Participant Homes



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

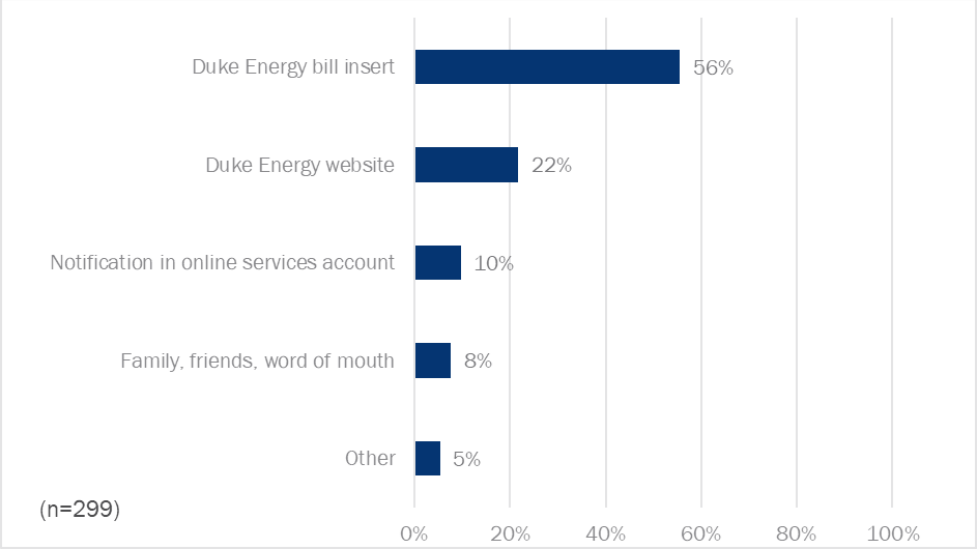
Most participants purchase light bulbs at brick and mortar locations; fewer than a third of participants (31%) reported shopping for light bulbs online prior to participating in the program.

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.

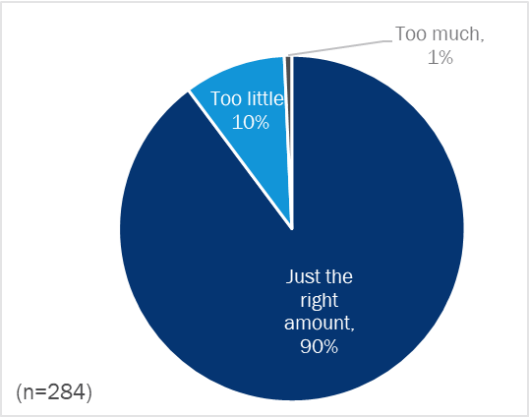
Figure 3-8. Sources of Program Awareness



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).

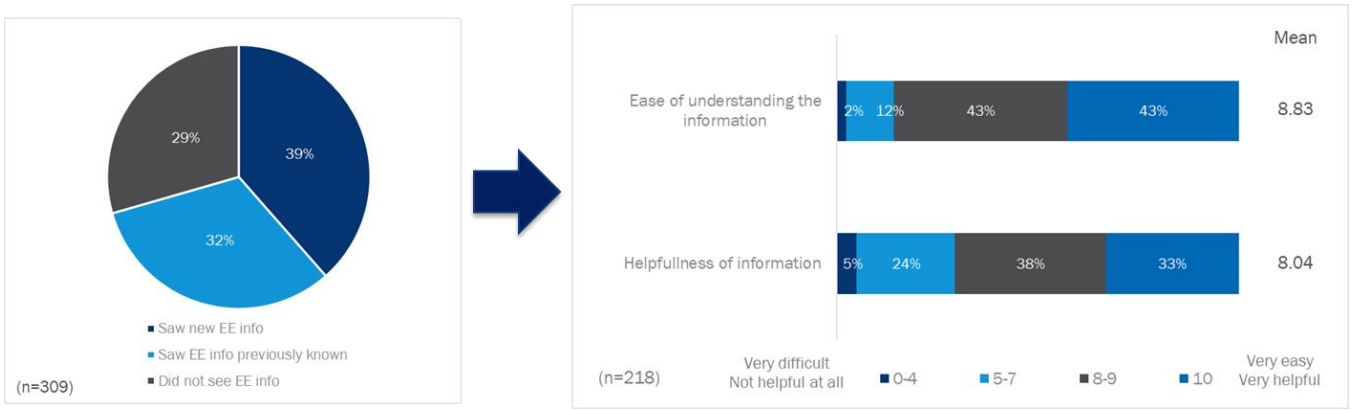
Figure 3-9. Amount of Information Displayed on the Online Store Website



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



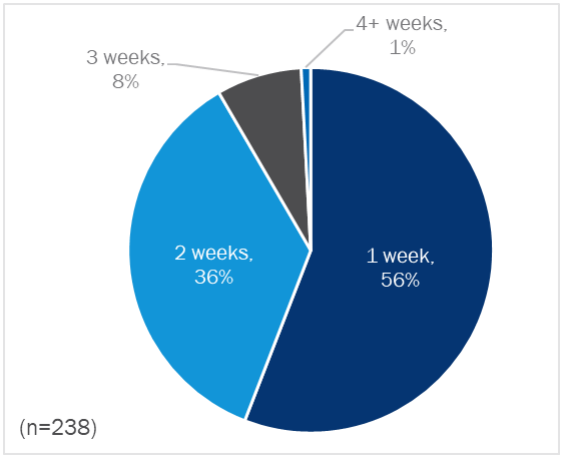
Value of Free and Discounted Shipping

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

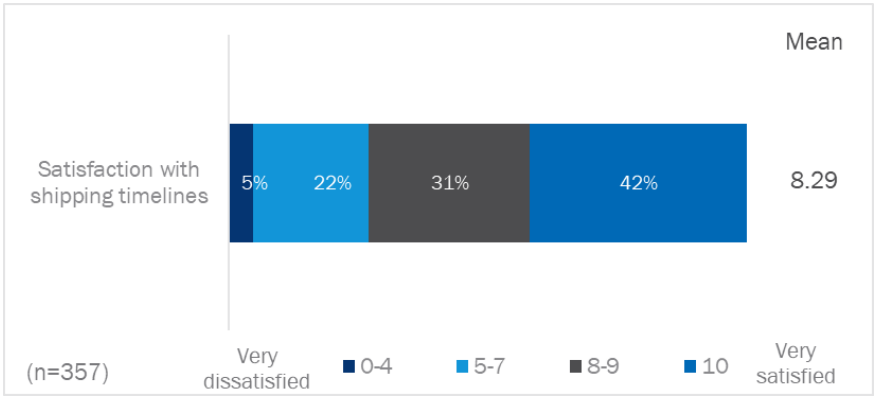
Program delivery processes were smooth and well managed. Both Duke Energy and EFI were generally satisfied with the interactions with each other, their nature, and their frequency. Program-tracking data were clean, well maintained, and detailed. EFI worked hard to ensure prompt delivery of the products 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

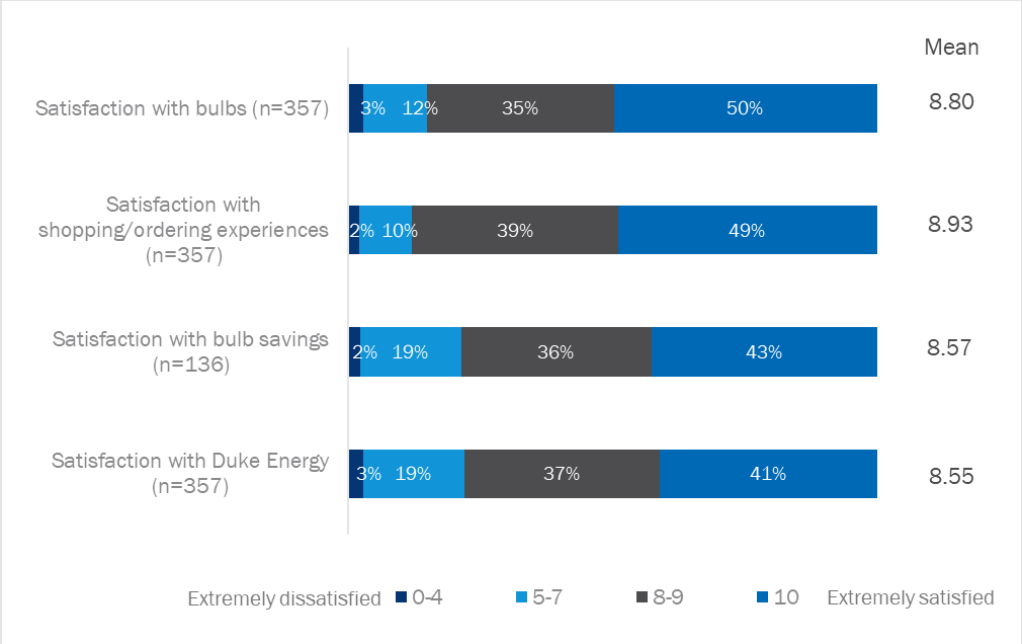


[20] A third of participants (33%) could not recall the shipping timeline.
[21] A rating of 8, 9, and 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.
[22] A rating of 10 on a scale from 0 to 10, where 0 is very dissatisfied and 10 is very satisfied.

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

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