APPENDIX G-

Energy Efficiency in Schools Program Evaluation

Energy Efficiency in Schools Program

November 2, 2015

Evaluation, Measurement, & Verification for Duke Energy Ohio

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Evaluation Summary

Duke Energy engaged Cadmus (the Cadmus team) to perform process and impact evaluations of the Duke Energy Ohio Energy Efficiency Education for Schools Program (Energy Efficiency in Schools Program).[1] This report covers the impact and process evaluation findings for the evaluation period of June 1, 2014, through May 31, 2015.

Program Description

The Energy Efficiency in Schools Program is an energy conservation program available to K-12 students in Indiana, Ohio, North Carolina, South Carolina, and Kentucky public and private schools. The Energy Efficiency in Schools Program provides principals and teachers with an innovative math and science-related curriculum that educates students about energy, natural resources, electricity, ways in which energy is wasted, and ways to use resources wisely. Duke Energy partners with three third-party contractors to implement the program: The National Theatre for Children (NTC), AM Conservation, and Relationship 1.

The Energy Efficiency in Schools Program launched in 2011. While program stakeholders update the storyline and curriculum each year, the focus remains on energy efficiency, and the program's delivery mechanisms have not been changed. The current program uses a pirate-themed storyline to educate students in kindergarten through eighth grade. The program uses classroom and take-home assignments to engage students' families and to encourage students, in concert with their families, to complete a home energy survey, thus receiving an Energy Efficiency Home Kit; this contains energy-saving measures such as CFLs and energy-efficient showerheads. The program offers the contests, classroom activities, and prizes to encourage program participation and use of the Energy Efficiency Home Kit.

Evaluation Objectives

The Cadmus team's evaluation objectives included estimating energy savings, documenting program operations, and identifying improvement areas for future program implementation and customer experience with the program.

High-Level Impact Findings

This section summarizes the Cadmus team's key impact findings for the evaluation period.

Energy Efficiency in Schools Program Savings

The Cadmus team conducted a billing analysis to estimate overall net energy savings for the Energy Efficiency in Schools Program in Duke Energy Ohio, per household. The Cadmus team also conducted an engineering analysis to estimate the relative savings contributions from items provided in the Energy

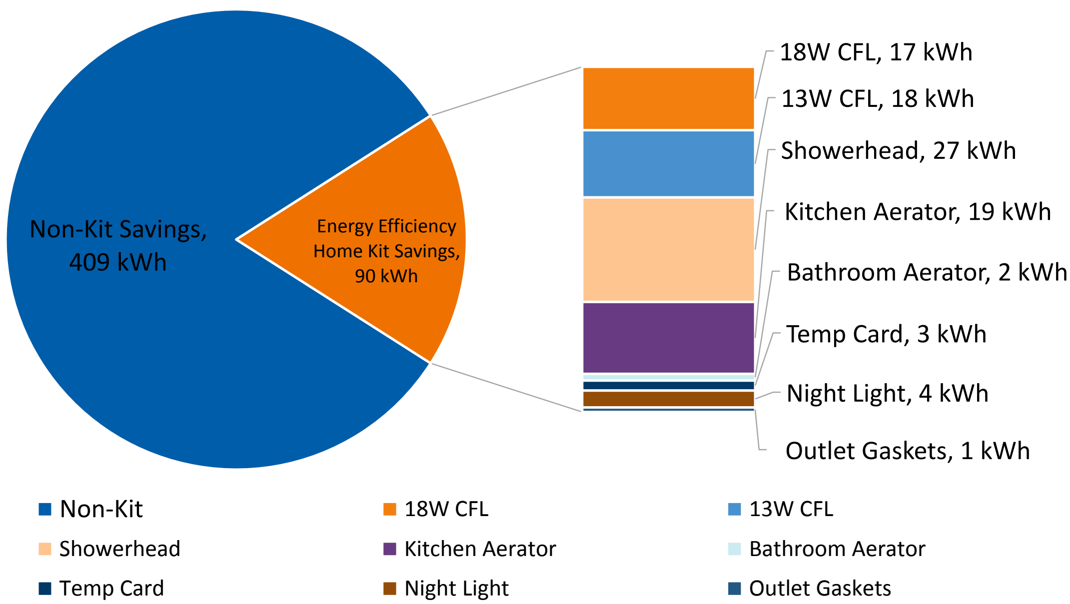
[1] While the tariffed program name is Energy Efficiency Education Program for Schools, the working title is Energy Efficiency in Schools program.

Efficiency Home Kit and a net-to-gross analysis to account for freeridership and spillover adjustments. By conducting billing, engineering, and net-to-gross analysis, the Cadmus team could determine the portion of net energy savings achieved per household, as achieved through installation of Energy Efficiency Home Kit items and the portion of savings resulting from participants' energy-saving actions and behaviors.

Based on billing analysis results, the average participant household saved approximately 499 kWh through participating in the Energy Efficiency in Schools Program. Engineering results, which relied on participant surveys, indicated approximately 18% (90 kWh) of these savings resulted from participants installing Energy Efficiency Home Kits items. Based on these findings, the Cadmus team estimated that the remaining 82% of the household savings resulted from energy-saving actions (including non-like spillover) and behaviors taken by participants because of their education through the program.

Figure 1 shows the contribution of Energy Efficiency Home Kit savings (by each measure) and estimated behavior savings, totaling to the 499 kWh determined by the billing analysis.

Figure 1. Energy Savings from Energy Efficiency Home Kit and Behaviors



Net Impacts

To conduct the impact analysis, the Cadmus team compared the customer's electric meter readings before and after the program; as such, the billing analysis represents net savings, and we did not need to calculate gross savings. As shown in Table 1, Table 2, Table 3 the Energy Efficiency in Schools Program exceeded its net energy goals.

Table 1. Program Projected, Claimed, and Evaluated Net Energy Impacts

Program	Net Savings Goal (kWh)*	Net Reported Savings (kWh)**	Net Evaluated Savings (kWh)***
Energy Efficiency in Schools Program	1,990,800	1,448,544	3,218,051

*Based on previously evaluated savings of 237 kWh per Energy Efficiency Home Kit and the program goal of delivering 8,400 Energy Efficiency Home Kits delivered from July 2014 through June 2015.
**Based on previously evaluated savings of 237 kWh per Energy Efficiency Home Kit and the reported delivery of 6,112 Energy Efficiency Home Kits from July 2014 through June 2015.
***Based on the reported delivery of 6,449 Energy Efficiency Home Kits from June 2014 through May 2015.

Table 2. Program Projected, Claimed, and Evaluated Net Peak Demand Impacts

Program	Net Savings Goal (kW)*	Net Reported Savings (kW)**	Net Evaluated Savings – Summer Coincident (kW)***	Net Evaluated Savings – Winter Coincident (kW)****
Energy Efficiency in Schools Program	252	183	866	849

*Based on previously evaluated savings of 0.03 kW per Energy Efficiency Home Kit and the program goal of delivering 8,400 Energy Efficiency Home Kits delivered from July 2014 through June 2015.
**Based on previously evaluated savings of 0.03 kW per Energy Efficiency Home Kit and the reported delivery of 6,112 Energy Efficiency Home Kits from July 2014 through June 2015.
***Based on the reported delivery of 6,449 Energy Efficiency Home Kits from June 2014 through May 2015 and DSMore modeled kW savings of 0.134 kW.
****Based on the reported delivery of 6,449 Energy Efficiency Home Kits from June 2014 through May 2015 and DSMore modeled kW savings of 0.132 kW.

Table 3. Household Net Energy and Demand Savings—2015

Program Year Evaluated	Annual Energy Savings Per Participant (kWh)	Annual Demand Savings Per Participant – Summer Coincident (kW)*	Annual Demand Savings Per Participant – Winter Coincident (kW)*
2015	499	0.134	0.132
*Based on DSMore modeling.			

Evaluation Parameters

The Cadmus team used a billing analysis to conduct the impact evaluation of the Energy Efficiency in Schools Program. Table 4 lists parameters for these activities.

Table 4. Evaluated Parameters with Value and Units

Parameter	Value	Units
Average Billing Analysis Savings per Home	499	kWh/household (net savings)

Table 5 lists the start and end dates for activities conducted for the impact evaluation, along with the total number of interviews and participants included in the analysis.

Table 5. Sample Period Start and End Dates and Dates Evaluation Activities Conducted

Evaluation Component	Sample Period	Dates Conducted	Total Conducted
Stakeholder Interviews	—	May 2015	5
Participant Surveys (used for engineering and net-to-gross analysis)	June 1, 2014–April 30, 2015	May 2015	118
Billing Analysis	June 1, 2014–May 27, 2015	July–August 2015	6,447

High-Level Process Findings

The section summarizes the Cadmus team's key process findings for the evaluation period.

Stakeholder Feedback

Interviews with program stakeholders (program management and implementation staff) focused on elements of program process and delivery, which have remained fundamentally unchanged since the previous evaluation. Stakeholders reported that the program ran smoothly and was successful at engaging and entertaining students. Duke Energy offers multiple contests and incentives to encourage schools and students to get the most value out of the program by ordering Energy Efficiency Home Kits and installing the included items.

Stakeholders reported minimal challenges with the Energy Efficiency in Schools Program this year. As with previous evaluations, stakeholders reported that the program requirement that participants can only receive one Energy Efficiency Home Kit during a three-year period may be impacting participation.

Energy Efficiency Home Kit

The Cadmus team asked respondents a series of questions regarding their use of items in the Energy Efficiency Home Kits. Specifically, we asked participants to indicate one of the following outcomes:

- They were currently using the item (or had used it in the case of single-use items).
- They were not currently using the item, but planned to in the future.
- They were not currently using the item, and were not intending to use it.
- They had installed the item but had removed it.

Participants most often reported installing the lighting items included in the Energy Efficiency Home Kits (installation rates greater than 70%). Respondents reported much lower installation rates for the kitchen aerator (35%), bathroom aerator (24%), showerhead (31%), and outlet gasket insulations (19%) at the time of the survey. Forty percent of respondents said they used the water heater temperature card that was included in the Energy Efficiency Home Kit, while 18% reported using the water flow meter bag. Participants who did not currently have items installed (either because they had never installed the measures or installed and subsequently removed the measures) provided the following explanations for low satisfaction with the items:

- Dissatisfied with item performance.
- Item could not be installed or used because it did not fit.
- Item was difficult to install or use.
- Item was damaged or defective.
- Dissatisfied with quality.

Energy Saving Tools and Behaviors

The Energy Efficiency Home Kit also included an informational booklet (Energy Savers booklet). When we asked participants to estimate how much of the information they had read, 32% (n=118) said they had read most or all of the information, 36% said they had read some of the information, 28% reported they had glanced at the information, and 3% said they did not look at the Energy Savers booklet at all. Respondents generally reported that the booklet was easy to understand, informative, and helpful.

The Cadmus team asked participants who read the Energy Savers booklet what actions they took based on the prescriptive advice found inside. Participants most frequently reported turning off electronics when not in use (89%) and choosing efficient CFL and LED lighting (84%); about one-half of the participants reported sealing leaks (44%) and maintaining and upgrading HVAC equipment (52%).

Previous and Future Experience with Energy Efficiency Home Kit Items

The Cadmus team asked respondents about their experiences with energy-saving items similar to those included in the Energy Efficiency Home Kit prior to participating in the program and after participating in the program. Respondents reported having installed CFLs and energy-efficient showerheads (81%, n=112; 32%, n=111) most frequently prior to participating in the Energy Efficiency in Schools Program. We asked respondents whether they had intended to purchase items similar to those provided in the Energy Efficiency Home Kit before participating in the Energy Efficiency in Schools Program: 61% (n=111) of respondents said they had intended to or maybe would have purchased CFLs; and 50% (n=109) said they had intended to or maybe would have purchased LEDs. Seventeen percent (n=115) of respondents reported they had not intended to purchase an energy-efficient showerhead as they already had one installed; and 17% (n=111) said they had not intended to purchase CFLs as they already had them installed throughout their homes. When we asked participants if they purchased additional energy efficiency items after receiving the Energy Efficiency Home Kit, 54% (n=118) said they had, with CFLs and LEDs purchased most frequently by respondents.

Participant Feedback

Survey respondents reported high satisfaction levels with the overall program and with the items included in the Energy Efficiency Home Kit. The Limelight night light most frequently received favorable responses, followed by the water heater temperature card, outlet gasket insulators, and water flow meter bag. Conversely, the CFLs and energy-efficient showerhead received the lowest satisfaction ratings among respondents, with light bulbs burning out and lower water pressure cited most often as reasons for their dissatisfaction.

When asked if their knowledge on how to save energy and reduce energy bills changed after their household's participation in the program, participants most frequently responded that their knowledge increased "somewhat" (42%, n=117).

Program Comparison

The Cadmus team conducted a review of similar energy education programs provided by utilities in the Midwest. We found that other programs realized net savings ranging from 324 kWh to 490 kWh per kit. Additionally, we observed a difference in the kit configurations offered by other utilities. Notably, one program offered six CFLs per its kit and other items not included in Duke Energy's Energy Efficiency Home Kit such as a filter tone alarm and digital thermometer.

Conclusions and Recommendations

The Cadmus team's evaluation revealed a few areas for potential improvements. This section summarizes conclusions resulting from our process and impact evaluation activities and provides potential areas Duke Energy could explore to further refine program operations or expand program benefits.

Conclusion: **The Energy Efficiency in Schools Program is successful as measured by multiple metrics, though opportunities may exist to increase participation.** The evaluation indicated that the Energy Efficiency in Schools Program exceeded its savings goals. The NTC performance results in energy savings within student homes (through installation of Energy Efficiency Home Kit items and encouraging behavior changes). However, the program did not meet participation goals for the year and it was noted that half of the eligible schools participated in the program.

Recommendation: Continue using the same program delivery mechanism and processes. Consider conducting research into reasons for lower participation among schools and providing schools with additional incentives for engaging in energy-saving installations and behaviors. One potential option would be offering a financial incentive to the school with the highest evaluated per-student energy savings.

Conclusion**: The Energy Efficiency in Schools Program successfully encourages energy-saving behaviors among participants and may be able to increase energy savings realized by Energy Efficiency Home Kit items by adjusting the quantity and type of items.** While the program exceeded its savings goals, opportunities for increasing savings through modifications to the Energy Efficiency Home Kit may exist.

The Cadmus team noted that similar energy education programs, offering slightly different Energy Efficiency Home Kit configurations, achieve greater energy savings per Energy Efficiency Home Kit. Additionally, lower installation rates for showerheads and faucet aerators result in lower energy savings for the Energy Efficiency in Schools Program. Some participants also indicated quality or performance issues with Energy Efficiency Home Kit items.

Recommendations: **Consider modifying the quantity and type of items included in the Energy Efficiency Home Kits, if Duke Energy finds it cost-effectively and sufficiently beneficial to do so.** Because participants installed CFLs most often and night lights received the highest satisfaction ratings, consider increasing lighting measures included in Energy Efficiency Home Kits. Additionally, to address quality issues and make products more attractive to participants, consider researching higher quality models of items provided in the Energy Efficiency Home Kit. Consideration may also be given to reducing or eliminating measures that are less frequently installed.

Conclusion**: The Energy Efficiency in Schools Program successfully engages students through the NTC presentation and may be able to increase energy savings by engaging parents.** While most respondents remembered discussing aspects of the Energy Efficiency in Schools Program presentation with their children, they also indicated that their knowledge about energy and reducing energy bills stayed the same after their children participated in the Energy Efficiency in Schools Program. The business reply cards, currently completed and returned by parents, may provide an opportunity to educate and connect at the household level.

Recommendations: **Consider increasing outreach to adults in the students' households through modifications to business reply cards included in Energy Efficiency Home Kits or through additional follow-up surveys.** Use of participant surveys may prompt parents to follow up on installing items from their Energy Efficiency Home Kits and may serve as a reminder about potential energy-saving activities. The business reply cards, currently used to survey parents and assess installation rates, also could be modified to provide additional education. For example, in addition to asking if parents installed the CFLs included in the Energy Efficiency Home Kits, the survey could provide information on how much energy each CFL saves in the average home.

Conclusion**: Staff from participating schools and nonparticipating schools may offer additional insights into the primary factors motivating school and student participation and into primary participation barriers.** Stakeholders reported that recruitment of new schools could be challenging. In previous evaluations, feedback from staff at participating schools has been limited and interviews with nonparticipating schools have yet to be conducted. More in-depth discussions with school staff may reveal opportunities for increasing student participation within the schools and identifying barriers to school participation.

Recommendations: **Future evaluations should consider including additional, in-depth, phone interviews with school staff that have participated in the program and with staff at schools that have not participated in the program.** Interviews should be designed to capture participation reasons, participation barriers, and suggestions for helping schools and students participate in the program. Samples should be determined based on the number of schools in the service territory.

***Conclusion*: Potential opportunities may exist for Energy Efficiency Home Kit items not installed by participants.** Participants do not install all items provided in the Energy Efficiency Home Kits and may dispose of items they do not install.

***Recommendations:* Consider providing schools with bins to collect unused Energy Efficiency Home Kit items for inclusion in future Energy Efficiency Home Kits.** When communicating with students, include education about reducing waste and information on how returned, unused items will be used.

***Conclusion*: A substantial portion of savings result from behavior changes and additional energy efficiency improvements.** The performances successfully educated and motivated students and their families, and savings may be seen at homes for children and families not receiving Energy Efficiency Home Kits.

***Recommendations:* Future evaluations should consider including a control group in the billing analysis.** Cadmus recommends two groups for billing analysis: program Energy Efficiency Home Kit participants; and a control group of homes not exposed to the performances and outreach (provided those populations are available). The billing analysis will allow a more complete understanding of the savings attributable to behavior change versus energy efficiency improvements.

Introduction

Program Description

The Energy Efficiency in Schools Program is an energy conservation program available to K-12 students in Indiana, Ohio, North Carolina, South Carolina, and Kentucky public and private schools in Duke Energy's service territory (this report focuses on findings from the evaluation of Duke Energy Ohio only). The Energy Efficiency in Schools Program provides principals and teachers with an innovative math and science-related curriculum that educates students about energy, natural resources, electricity, ways in which energy is wasted, and ways to use natural resources wisely. In implementing the program, Duke Energy partners with the following three, third-party contractors:

- The National Theatre for Children (NTC), the implementer of the Energy Efficiency in Schools Program. NTC develops and presents live theatrical productions with targeted material for elementary and middle school students.
- AM Conservation, which is the fulfillment vendor for the Energy Efficiency Home Kits.
- Relationship 1, which is Duke Energy's data management vendor. Relationship 1 processes all Energy Efficiency Home Kit requests and surveys, verifies eligibility, hosts the program website, maintains the program dashboard, and provides data reporting.

Duke Energy launched the Energy Efficiency in Schools program in 2011. While NTC updates the storyline and curriculum each year, the focus remains on energy efficiency, and program delivery mechanisms have not been changed. The current program uses a pirate-themed storyline to educate students in elementary schools and an improvisational storyline to educate middle school students. The program uses classroom and take-home assignments to engage student's families and to encourage students to complete a home energy survey with their families to receive an Energy Efficiency Home Kit. The Energy Efficiency Home Kit contains the following measures and materials:

- 1.5 gpm energy-efficient showerhead
- 1.5 gpm kitchen faucet aerator with swivel and flip valve
- Water flow meter bag
- Water temperature gauge card (Hot Water Temperature Card)
- 13-watt ENERGY STAR®-rated mini compact fluorescent bulb (60-watt incandescent equivalent), with 12,000 hour life
- 18-watt ENERGY STAR-rated mini compact fluorescent bulb (75-watt incandescent equivalent), with 12,000 hour life
- 1.0 gpm needle spray bathroom faucet aerator
- Combination pack of switch and outlet gasket insulators—eight outlets and four socket gasket insulators
- Energy-efficient Limelight style night light

- Duke Energy-labeled U.S. Department of Energy (DOE) Energy Savers booklet
- Roll of Teflon tape for showerhead
- Product information and instruction sheet
- Glow ring toy

Non-Duke Energy customers at participating schools can receive a smaller Energy Efficiency Home Kit, containing the following materials:

- Water flow meter bag
- Water temperature gauge card (Hot Water Temp Card)
- 13-watt ENERGY STAR-rated mini compact fluorescent bulb (60-watt incandescent equivalent), with 12,000 hour life
- Eight outlet gasket insulators
- Duke Energy-labeled DOE Energy Savers booklet
- Product information and instruction sheet
- Glow ring toy

Program Design and Goals

The primary goal of the Energy Efficiency in Schools Program is to educate students about energy, natural resources, how to make electricity, ways in which energy is wasted, and ways to use these resources wisely. Additionally, Duke Energy strives to meet the following goals through the program:

- Integrate grade-appropriate energy efficiency learning activities and Duke Energy's Energy Efficiency Home Kit into existing science and math-based curricula.
- Achieve target participation and energy impacts through delivery of Energy Efficiency Home Kits and participant installation of energy-saving measures in eligible households.
- Create program sustainability by reaching new participants each year (i.e., participants who have not received an Energy Efficiency Home Kit in the previous three years).

The Energy Efficiency in Schools Program did not meet its 2014–2015 participation goals in Duke Energy Ohio, with 6,449 Energy Efficiency Home Kits delivered to households within Duke Energy's service territory during the evaluation period. Table 6 lists program goals and actual performance.

Table 6. Energy Efficiency Home Kit Participation Goals and Actual Performance

Program Year*	Participation Goal	Actual Participation
2014-2015	8,400	6,449 **

*Program year defined from July 1, 2014 through June 30, 2015.

**Duke Energy reported Energy Efficiency Home Kits distributed during the evaluation period, June 1, 2014, through May 31, 2015.

Evaluation Methodology

In evaluating Duke Energy's Energy Efficiency in Schools Program, the Cadmus team identified the following objectives:

- Estimate the program's net energy savings through billing analysis;
- Estimate energy and demand savings resulting from installation of Energy Efficiency Home Kit items through engineering analysis;
- Assess freeridership and spillover through participant surveys;
- Assess the program's performance against goals; and
- Assess participant experience, satisfaction, and decision-making motivations.

Stakeholder Interviews

Cadmus conducted interviews with two program managers and three members of the implementation staff to capture insights about program operations and challenges. Specifically, Cadmus interviewed the following individuals:

- Duke Energy Program Staff
  - Program Manager: Christine Smith (5/12/2015)
  - Residential Market Manager: Lari Granger (5/12/2015)
- NTC Program Staff
  - Program Manager: Katie Miesen (05/14/2015)
- AM Conservation Staff
  - Senior Account Executive: Charlene Moody (05/14/2015)
- Relationship 1 Staff
  - Chief Operating Officer: Howard Mertz (05/27/2015)

Participant Surveys

The Cadmus team designed participant surveys to cover impact evaluation and process evaluation topics, including use of Energy Efficiency Home Kit items, energy-saving behavior changes, freeridership, spillover, participant decision making, and satisfaction. Duke Energy administered the online surveys, and the Cadmus team analyzed the survey responses.

Duke Energy sent survey invitations to 2,780 eligible customers who received Energy Efficiency Home Kits between June 16, 2014, and February 27, 2015.[2] Eighty-eight percent (n=184) of participants who

[2] The program distributed 6,449 Energy Efficiency Home Kits (reported), but available participant data only included 2,780 e-mail addresses. Duke Energy contacted survey respondents by e-mail and conducted the survey online.

began the online survey remembered receiving the Energy Efficiency Home Kit, while 10% said they did not receive the Energy Efficiency Home Kit. Two percent could not recall whether they had received the Energy Efficiency Home Kit. We did not ask respondents who did not receive or did not recall receiving the Energy Efficiency Home Kit further questions about the program. In total, 118 respondents completed the entire survey. The survey sampling methodology achieved precision of ±7.5 % at the 90% confidence interval, based on the total of 6,449 participants who received Energy Efficiency Home Kits during the evaluation period.

Billing Analysis

The billing analysis relied on consumption data for 6,447 electric customers who participated in the program between June 2014 and May 2015.[3] The Cadmus team tested two panel regression models to estimate program impact on post-treatment electric consumption, controlling for individual customers' fixed effects mean usage, month-specific trends, weather effects, and participation in other Duke Energy programs. Ultimately, we selected and used the model with the best precision values to estimate net energy savings per household. The results were statistically significant at the 90% confidence level.

Engineering Analysis

The Cadmus team conducted an engineering analysis to determine the Energy Efficiency Home Kit's contribution to the household net energy savings (as determined through the billing analysis). We collected data through participant surveys and used energy savings algorithms and variable inputs taken from the Ohio and Illinois Technical Reference Manuals (TRMs). We used the analysis results, in conjunction with the net-to-gross analysis, to estimate net energy savings for items included in the Energy Efficiency Home Kits.

Net-to-Gross Analysis

To provide context for the net energy savings estimated through the billing analysis and to inform engineering calculations, the Cadmus team conducted a net-to-gross analysis. We used participant surveys to collect data necessary to estimate participant freeridership and spillover.

Program Comparison

The Cadmus team reviewed programs similar in design to the Energy Efficiency in Schools Program to provide reference for savings estimates that we determined for this program through the billing and engineering analyses. We prioritized programs with similar design characteristics, ultimately comparing two energy education programs offered through seven Midwest utilities. We gathered information on energy-saving items offered, participation, and net savings per participant.

3 While the Cadmus team calculated program savings based on the 6,449 reported Energy Efficiency Home Kits distributed through the program during the evaluation period, we conducted the billing analysis with electric participants who met specific consumption requirements and passed through a screening process.

Threats to Validity, Sources of Bias, and How These Were Addressed

Billing Analysis

The model specification used in the billing analysis attempted to avoid the potential of omitted variable bias by including monthly variables to capture any non-program effects affecting energy usage as well as other Duke Energy offers. The two models tested by the Cadmus team did not correct for self-selection bias as the program remains voluntary. Given that many customers in the population participated in late 2014 or early 2015, the number of post-treatment months' worth of billing data were few. This led to an unbalanced panel between the pre- and post-period billing months which could have impacted the precision of the models' estimates. In order to help correct for this unbalanced panel, Cadmus tested a second model which utilized a matching method. This is discussed in more depth in the Billing Analysis section below. Additionally, as the program design did not include a control group, we could not control for naturally occurring changes in consumption during the post-period.

Engineering Analysis

To estimate per-unit, net savings for each item in the Energy Efficiency Home Kit, the Cadmus team used engineering algorithms and variable inputs from Ohio and Illinois TRMs, along with participant-specific inputs captured through the participant survey. As this analysis relied, in part, on participant responses, results could have been affected by self-selection bias, false-response bias, or positive-result bias.

Process Evaluation Findings

This section presents the Cadmus team's process evaluation findings for Duke Energy's Energy Efficiency in Schools Program, dividing these findings into three sections: Stakeholder Interviews, Participant Surveys, and Program Comparison. Table 7 lists the primary evaluation activities and the dates that the Cadmus team conducted these.

Table 7. Process Evaluation Data Collection and Analysis

Evaluation Component	Dates of Data Collection	Total Conducted
Stakeholder Interviews	May 12–27, 2015	5
Participant Surveys	May 5–18, 2015	118

Stakeholder Interviews

The Cadmus team interviewed program stakeholders to gain an in-depth understanding of the program and to identify its successes and challenges. Results of these discussions follow below, presented by topic.

Communication

All program staff and partners reported they communicate on a regular basis and that communications are positive and effective. Duke Energy conducts weekly conference calls with NTC and Relationship 1 to discuss scheduling, communications, problems that arise, and associated solutions and program delivery strategies. During those meetings, NTC and Relationship 1 report to Duke Energy about any issues they have identified during the week. NTC and Duke Energy meet in-person twice a year.

In addition, NTC corresponds with Duke Energy via e-mail on a daily basis. NTC staff stated that Duke Energy welcomed any program suggestions, such as adjusting the marketing plan and introducing new initiatives. In addition, AM Conservation staff attends in-person meetings with Duke Energy four times throughout the year. None of the program stakeholders reported communication issues or concerns.

Program Delivery

NTC delivers the Energy Efficiency in Schools Program to interested schools within Duke Energy's service territory. NTC contacts principals through mass mailings, occurring two to three times a year, as well as through smaller, more targeted efforts throughout the year. Once a school decides to participate in the program, NTC provides scheduling information for the performance. NTC has flexibility in choosing schools and grades, based on scheduling, routes, and the saturation of previous participants from past participation. If any issue arises with weather, NTC contacts affected schools to schedule a new appointment to maintain participation rates.

Once the principal (or other school administrator) has confirmed the performance date and time, NTC delivers the curriculum materials to the principal's attention for teacher distribution two weeks prior to the performance. Materials include school posters, teacher guides, and classroom and family activity books. After attending the NTC performance, students are encouraged to complete a home energy survey with their family (via their activity book or online) to receive an Energy Efficiency Home Kit that contains specific energy efficiency measures to reduce home energy consumption. Non-Duke Energy customers at participating schools can receive a smaller Energy Efficiency Home Kit, designed specifically for noncustomers.

NTC also produces contest materials for the performance and conducts follow-up outreach activities to encourage future participation. Follow-up outreach includes newsletters and engaging in social media. Figure 2 shows the full program performance process.

Figure 2. K-12 Performance Delivery Process*

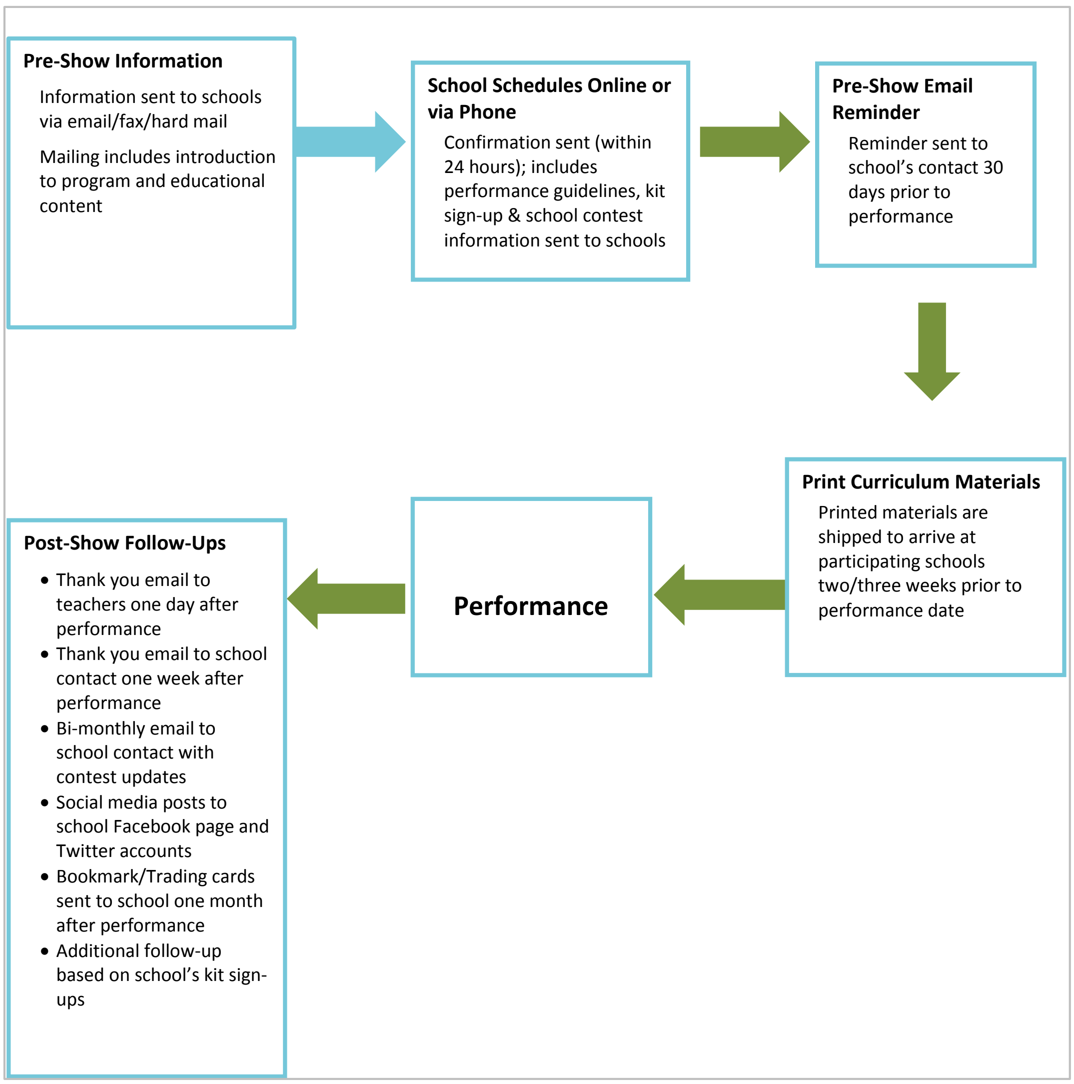


*Image provided courtesy of Duke Energy.

Promotion and Marketing

Program and implementation staff provided feedback regarding outreach and offerings delivered through the program. As in previous years, Duke Energy provided NTC with zip codes within Duke Energy's territory in Ohio and supplied statistics on the number of Duke Energy customers within each zip code. This allowed NTC to target schools more likely to have a high number of Duke Energy customers' children enrolled. In total, 218 of the 430 eligible schools in Duke Energy Ohio participated in the program this year. In addition to newly participating schools, this number included schools that participated previously.

School Incentives

Duke Energy offers the following incentives to schools and students to encourage participation in the program:

- **Contests**. NTC sends invitations to participate in the program via e-mail and mail to the school principal or other administrator. During the interviews, NTC staff said that schools participate because it is an engaging activity for the students, and they are further incentivized by the contests provided by NTC. Each participating school in the Ohio system is eligible to win a $10,000 prize for enrolling a minimum of 75 students.
- **Theatrical Performance**. The theatrical performance changes each school year according to NTC policy. Duke Energy reviews and approves the script before NTC performs it at the schools.
- **Classroom Activities.** NTC provides the teachers with a workbook containing classroom activities and an online whiteboard. [4]
- **Household Prizes.** Eligible households that sign up to receive an Energy Efficiency Home Kit and return the business reply card are entered into a drawing to receive a family prize package valued at $2,500.
- **Energy Efficiency Home Kits**. The Energy Efficiency Home Kits are available to student family and teacher households that have not received an Energy Efficiency Home Kit in the previous three years.

Duke Energy and Implementer Data Tracking

NTC maintains a database of participating and eligible schools, including school staff and student counts. When NTC receives a request for an Energy Efficiency Home Kit, Relationship1 and Duke Energy review the request for eligibility. Duke Energy uploads the verified list of participants weekly for AM Conservation, and AM Conservation then distributes the Energy Efficiency Home Kits, sending out shipments approximately once a week.

[4] All whiteboard activities are in SMARTboard notebook format and can be found online at: https://www.resourcereward.org/tour-central.html.

AM Conservation's system uses FedEx to track shipments; customers may inquire about the status of their order.

The Cadmus team identified minimal issues during the interviews. AM Conservation reported that customers who have billing addresses other than their home addresses may not be aware when their Energy Efficiency Home Kits have been delivered. For example, if a P.O. Box is on file as the customer's billing address, and the customer does not check the P.O. Box regularly, the Energy Efficiency Home Kit may be returned to the utility by post office. AM Conservation also reported that customers occasionally move after ordering an Energy Efficiency Home Kit. In both instances, AM Conservation notes in the database that the customer did not receive an Energy Efficiency Home Kit and is not subject to the three-year waiting period to receive another Energy Efficiency Home Kit.

Market Barriers and Program Challenges

Both program and vendor staff agreed that the most challenging part of the program every year is recruiting new schools. Interviewed staff said that due to a limited number of schools to reach out to, it was difficult to recruit more schools each year. According to Duke Energy, roughly half of the targeted schools contacted through the program go on to participate.

Stakeholders also said that keeping past participants engaged in the program was another challenge. Because participants can only receive Energy Efficiency Home Kits every three years, AM Conservation recommended distributing different Energy Efficiency Home Kits to customers who have participated within the past three years to ensure further participation in the program.

Program Feedback and Suggestions

Program and implementation staff provided feedback and suggestions when asked about what worked well for the program and what changes could be considered for future years.

Interviewed staff reported that the program is working well across multiple components. They stated that marketing is efficient at getting the word out and reaching new households. Staff also said that the presentation provides a positive message and actions participants can take to improve energy efficiency in their homes. NTC staff said that, overall, the program improves every year and that "It teaches. It entertains. It inspires."

The Cadmus team asked program staff and partner staff what suggestions they have to increase program participation. Duke Energy staff recommended more in-depth, prioritized targeting of schools by working with Duke Energy community leaders in areas where there are strong relationships with schools. AM Conservation and NTC suggested having different Energy Efficiency Home Kits for households that have already participated in the program within the three-year limit.

Participant Surveys

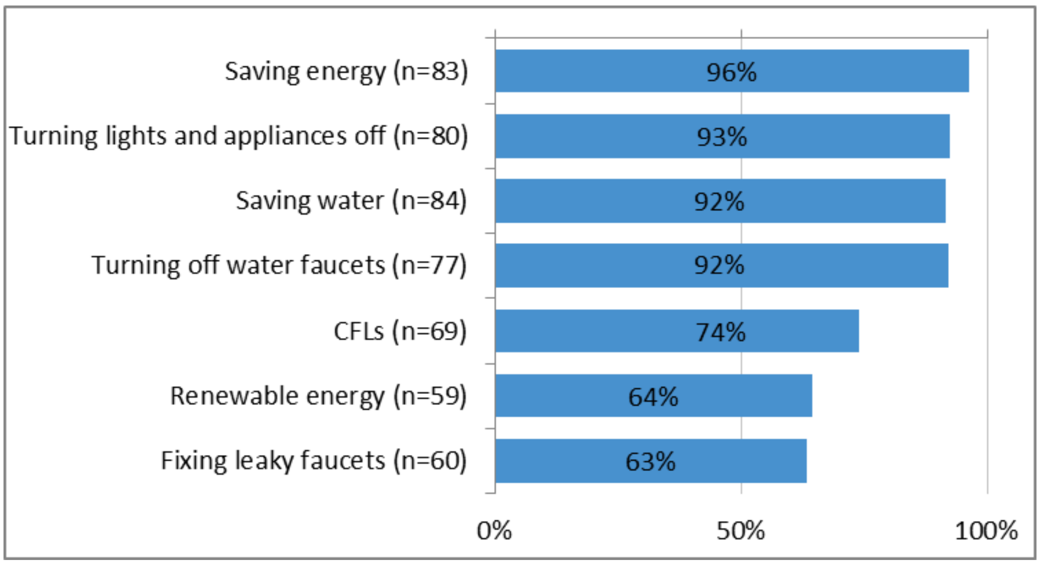
The Cadmus team analyzed feedback from online surveys completed by 118 Duke Energy Ohio customers who received Energy Efficiency Home Kits though the Energy Efficiency in Schools Program.

This section presents the results of our analysis by topic. Except where noted, the Cadmus team excluded “don’t know” and “refused” responses, which is reflected in accompanying n-values.

Student Discussion of Performance

The Cadmus team asked customers if they remembered discussing the NTC performance with their children, with 73% of 118 respondents answered affirmatively. Almost all cited “saving energy,” “turning lights and appliances off,” “saving water,” and “turning off faucets” as specific topics they discussed with their children, as shown in Figure 3. A little more than one-half of respondents recalled talking to their children about renewable energy and fixing leaky faucets.

Figure 3. Program Performance Topics Discussed with Family



Source: Participant Survey Questions A2.1-7. Did your child say they heard about...? (Multiple responses permitted.)

Energy Efficiency Home Kit

The survey asked respondents about their experiences with the Energy Efficiency Home Kit, including their recollection of receiving the Energy Efficiency Home Kit, use of energy-saving items, and satisfaction with these items.

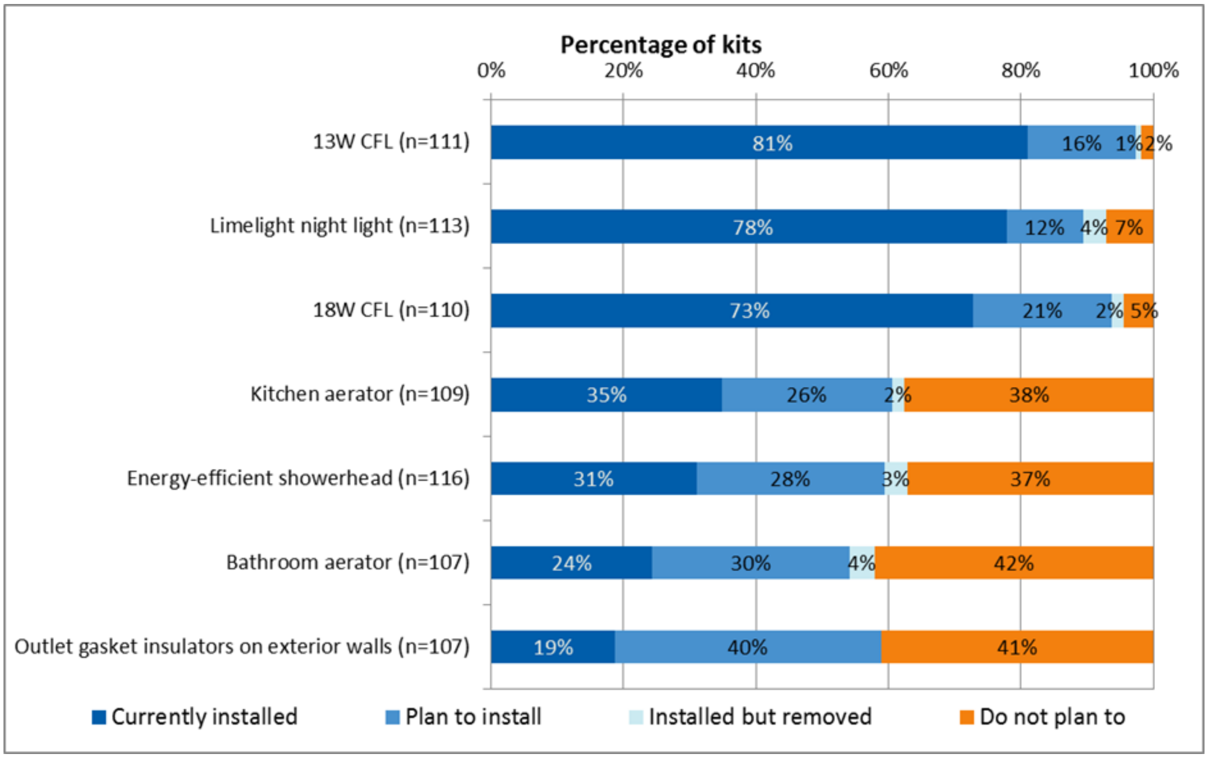
Use of Energy Efficiency Home Kit Items

The survey asked respondents a series of questions regarding their use of items in the Energy Efficiency Home Kits, specifically asking participants to indicate one of the following outcomes:

- Currently using the item (or had used it in the case of single-use items).
- Not currently using the item but planned to use it in the future.
- Not currently using the item and were not intending to use it.
- Installed the item but already removed it.

Participants most often reported installing the lighting items included in the Energy Efficiency Home Kits, as shown in Figure 4. Only about one participant in five installed the outlet gasket insulators on exterior walls, though another two out of five said they still intended to install these items. No more than 4% of participants reported installing and then removing aerators, showerheads, Limelight night lights, or CFLs.

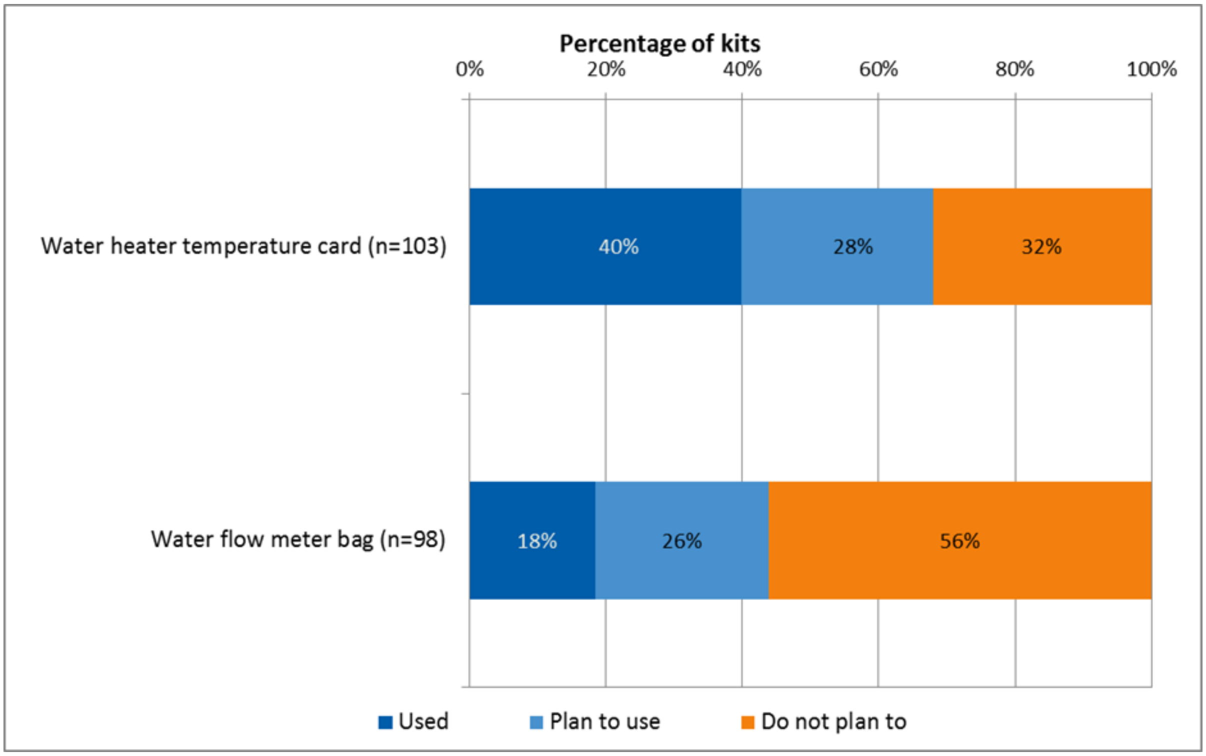
Figure 4. Installation of Items from the Energy Efficiency Home Kit



Source: Participant Survey Questions. Are the [items] that were provided in the Energy Efficiency Home Kit currently installed in your home?

Energy Efficiency Home Kits also include a water heater temperature care and a water flow meter bag. When asked if they used the additional energy efficiency tools included with the Energy Efficiency Home Kit, almost one-half of respondents reported checking their water temperature using the card, though only one in five participants used the bag to check water flow.

Figure 5. Use of Items from the Energy Efficiency Home Kit



Source: Participant Survey Questions. Did you use the [item] that was provided with the kit?

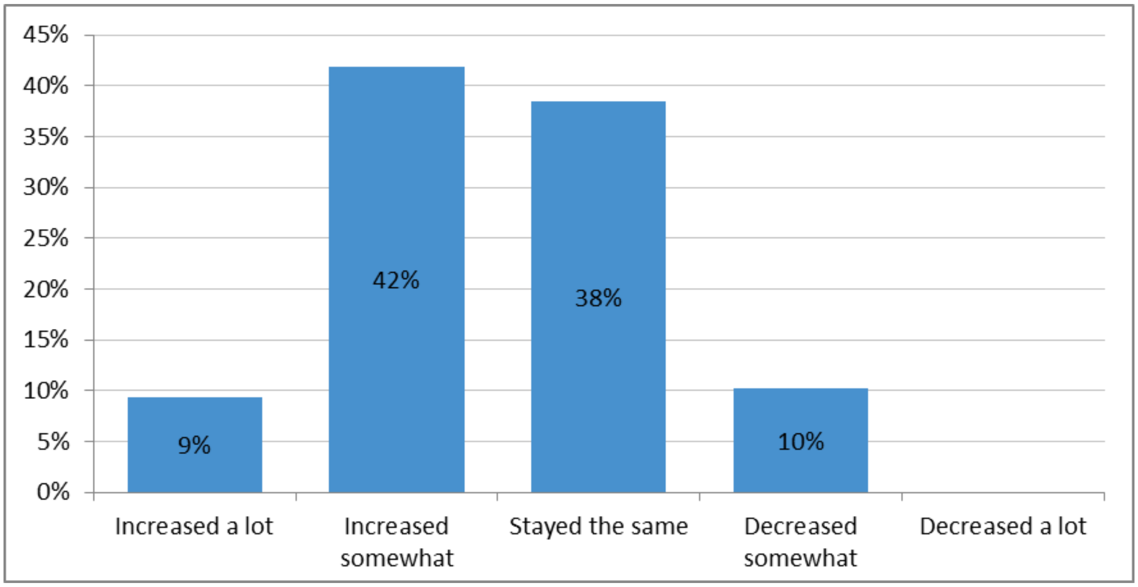
Appendix F. Energy Efficiency in Schools Program Participant Survey contains further details regarding installation and use of items provided in the Energy Efficiency Home Kits.

Energy-Saving Behaviors

The Energy Efficiency Home Kit included an informational booklet (Energy Savers booklet). When asked to estimate how much information they read in the Energy Saver booklet, 32% (n=118) of participants said they read most or all of the information, 36% said they read some, 28% reported they glanced at the information, and 3% said they did not look at the Energy Savers booklet.

When asked if their knowledge on how to save energy and reduce energy bills increased or decreased after their household's participation in the program, 51% (n=117) of participants said their knowledge increased somewhat or a great deal, as shown in Figure 6. Ten percent of respondents reported their knowledge somewhat decreased.

Figure 6. Increased Knowledge of How to Save Energy and Reduce Utility Bill

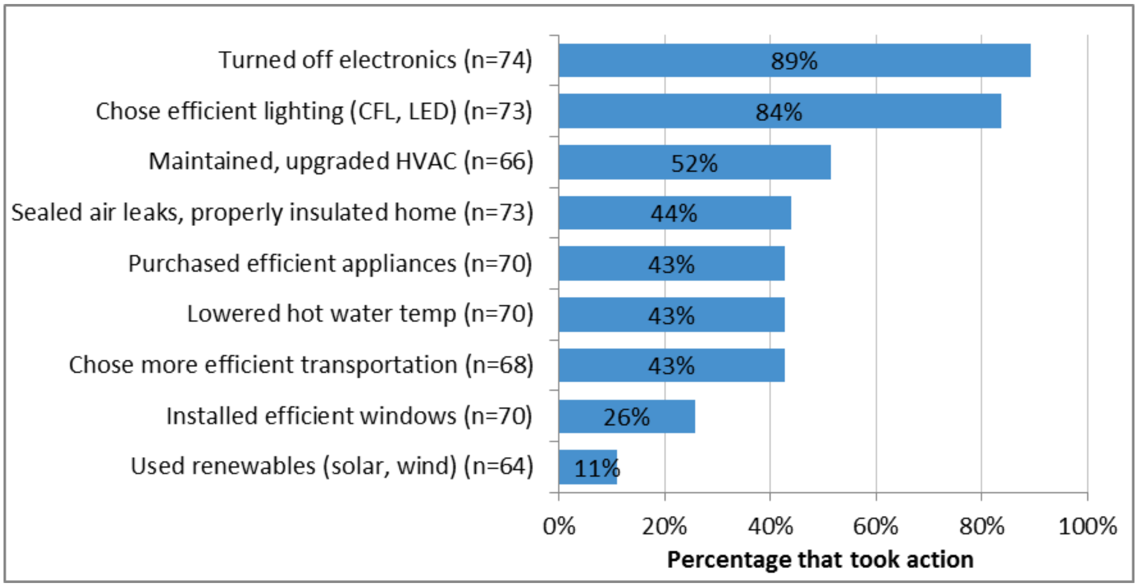


Source: Participant Survey Question A84. Since receiving the kit, has your knowledge of how to save energy and reduce your utility bill… (n=117)

The majority of the participants who read at least some of the Energy Savers booklet found the booklet easy to understand (78%, 62 out of 79) and informative (81%, 64 out of 79). Appendix F. Energy Efficiency in Schools Program Participant Survey contains further detail regarding participant responses to the Energy Savers booklet.

Despite that many participants reported their knowledge of how to save energy and reduce utility bills did not change based on information provided, many participants reported one or more behavior changes resulting from program participation. The Cadmus team asked participants who read the Energy Savers booklet which actions they took, based on prescriptive advice found inside. As shown in Figure 7, participants most frequently reported turning off electronics when not in use (89%) and choosing efficient CFL and LED lighting (84%); about one-half reported maintaining and upgrading HVAC equipment (52%). Appendix F. Energy Efficiency in Schools Program Participant Survey contains further details regarding participants' actions taken due to reading the Energy Savers booklet.

Figure 7. Actions Taken Based on Energy Savers Booklet



Source: Participant Survey Questions A82.1-9. Based on the advice in the booklet, have you taken any of the following actions? (Multiple responses permitted. Percentages are of total number of respondents and exceed 100%.)

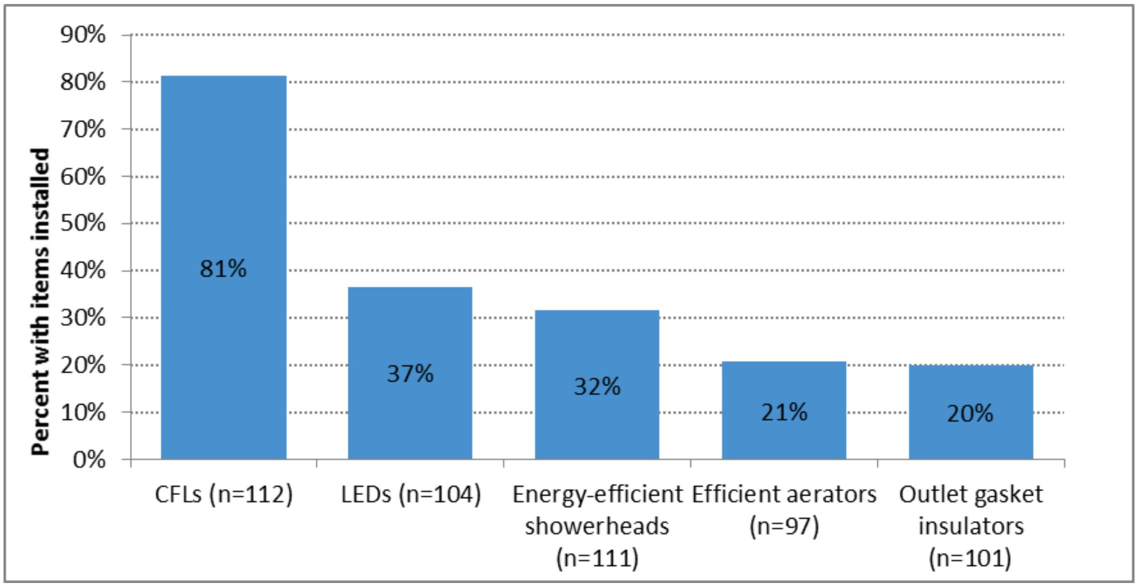
Previous and Future Experience with Energy Efficiency Home Kit Items

The survey asked participants about their experiences, prior to and after participating in the program, with energy-saving items similar to those included in the Energy Efficiency Home Kit

Energy-Efficient Items Installed Before the Program

The survey asked participants if they had previously installed items similar to those provided in the Energy Efficiency Home Kit prior to participating in the program. As shown in Figure 8, of 112 participants who responded, 81% had installed CFLs before the program and more than one-third installed LEDs before the program (37%, n=104).

Figure 8. Items Installed Before the Program



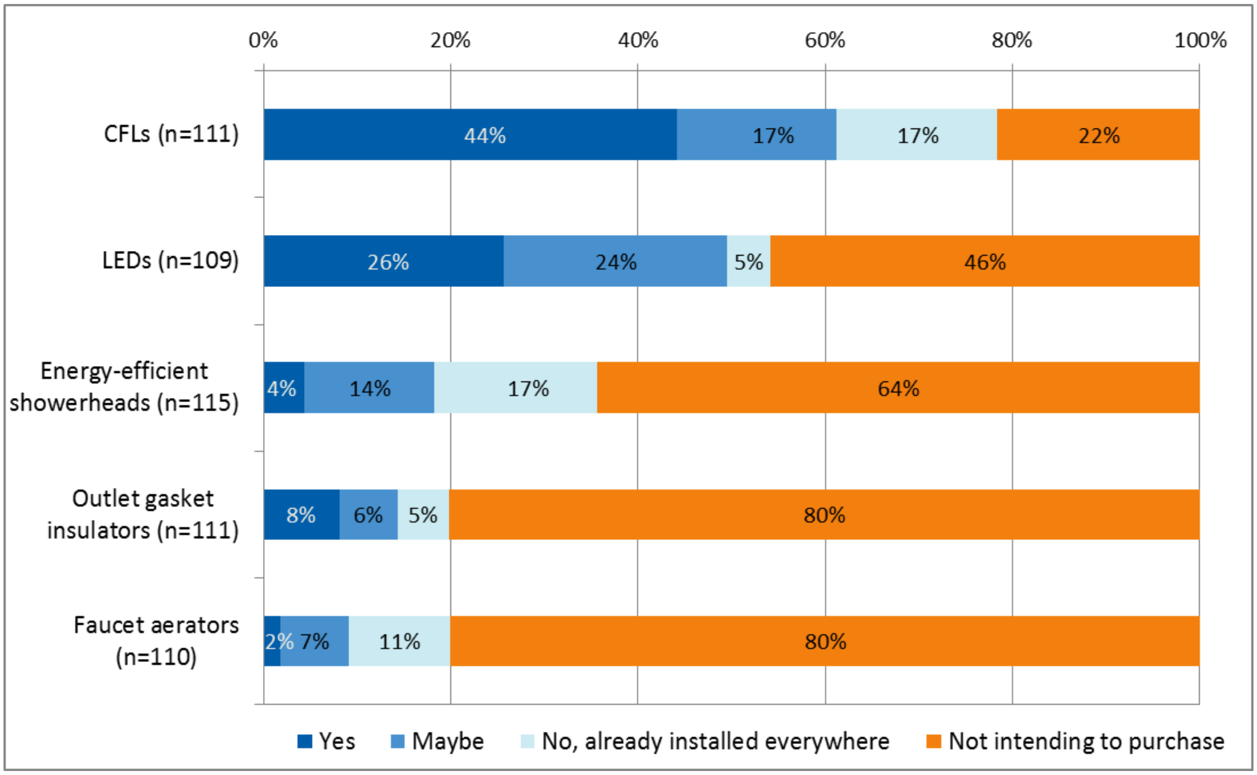
Source: Source: Participant Survey Questions A14, A21, A35, A49, and A59. Did you have any [items] installed in your home before receiving the kit? (Multiple responses permitted; percentages are for the total number of respondents and exceed 100%.)

Appendix F. Energy Efficiency in Schools Program Participant Survey contains additional information about CFLs and LEDs respondents installed before participating in the program.

Intention to Purchase Energy-Efficient Items

The survey asked participants if they intended to purchase items provided by the Energy Efficiency Home Kit before their household participated in the program. As shown in Figure 9, 61% (n=111) of respondents indicated they intended to or would maybe purchase CFLs, and 50% (n=109) reported the same for LEDs. About one participant in six did not intend to purchase efficient showerheads or CFLs as they already had these items installed in their homes. (Note: the Cadmus team used these survey questions to estimate freeridership for participants who installed these measures; the results presented here include all participants, including those who did not install these measures.)

Figure 9. Intention to Purchase Items Before Receiving the Energy Efficiency Home Kit

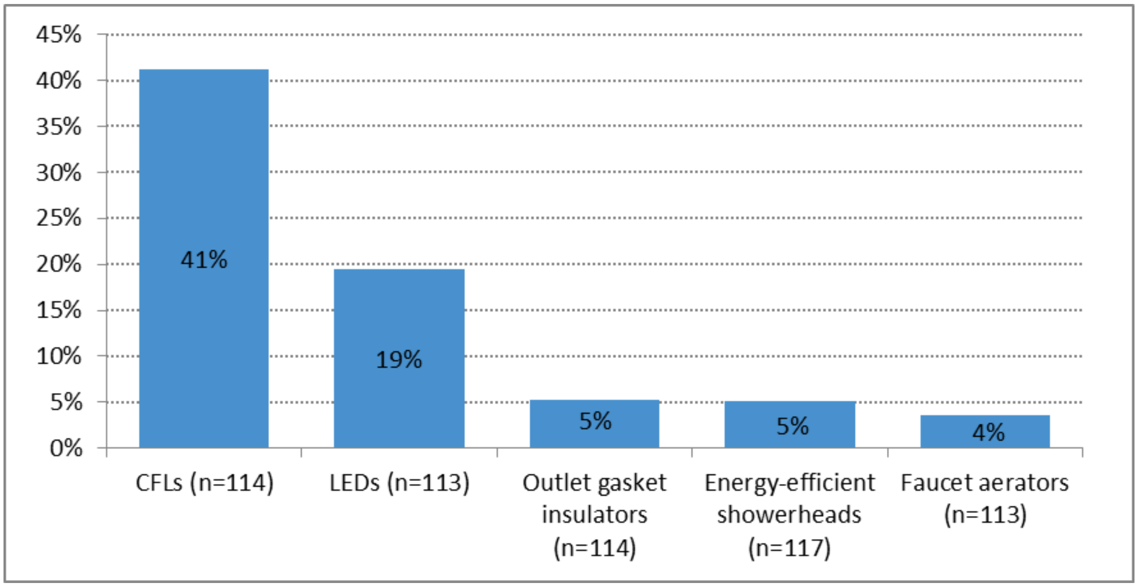


Source: Participant Survey Questions A16, A23, A36, A50, and A60. Were you planning on buying [items] for your home before you received the kit?

Additional Items Purchased and Installed Since Receiving the Energy Efficiency Home Kit

When asked if they purchased additional energy efficiency items after receiving the Energy Efficiency Home Kit, 54% of 118 respondents said they had. As shown in Figure 10, CFLs and LEDs were the items respondents most frequently purchased. Appendix F. Energy Efficiency in Schools Program Participant Survey contains more information about additional measures participants purchased and installed after participating in the program.

Figure 10. Purchase of Additional Items Since the Program



Source: Participant Survey Questions A17, A24, A37, A51, and A61. Have you purchased any additional [items] since receiving the kit?

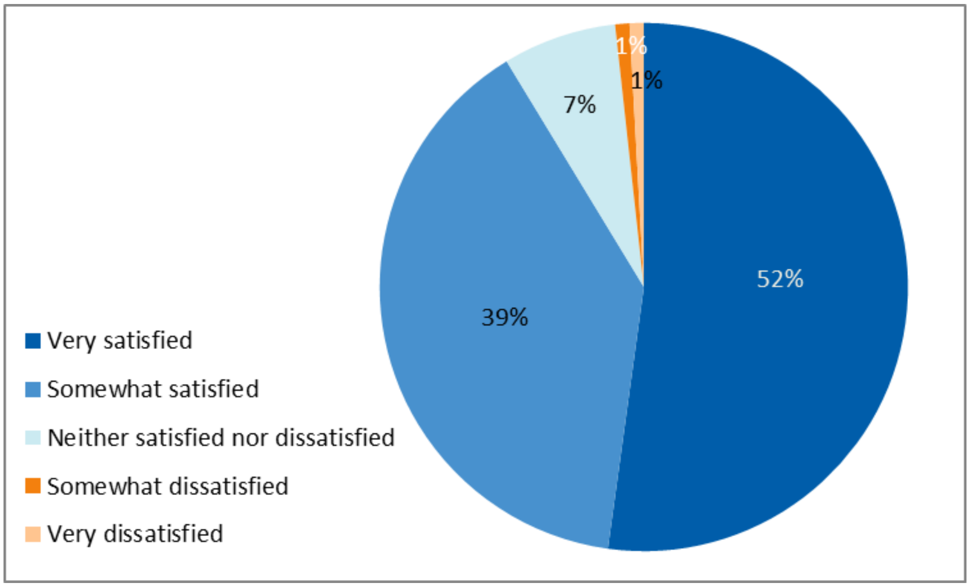
Satisfaction

Program Satisfaction, Improvements, and Benefits

The survey asked Duke Energy Ohio participants to rate their overall satisfaction with the program on a five-point Likert scale,[5] with 91% reported they were either "very" or "somewhat" satisfied with the program, as shown in Figure 11. Only 2% reported they were "very" or "somewhat" dissatisfied.

[5] A Likert scale is a psychometric response scale used to ascribe quantitative values to a qualitative concept, such as agreement with a statement or satisfaction with a program. A non-comparative scaling technique, the scale is unidimensional (only measures a single trait) as well as bipolar and symmetrical (extreme values are equidistant from a neutral midpoint).

Figure 11. Overall Satisfaction with the Program (Duke Energy Ohio Scale)



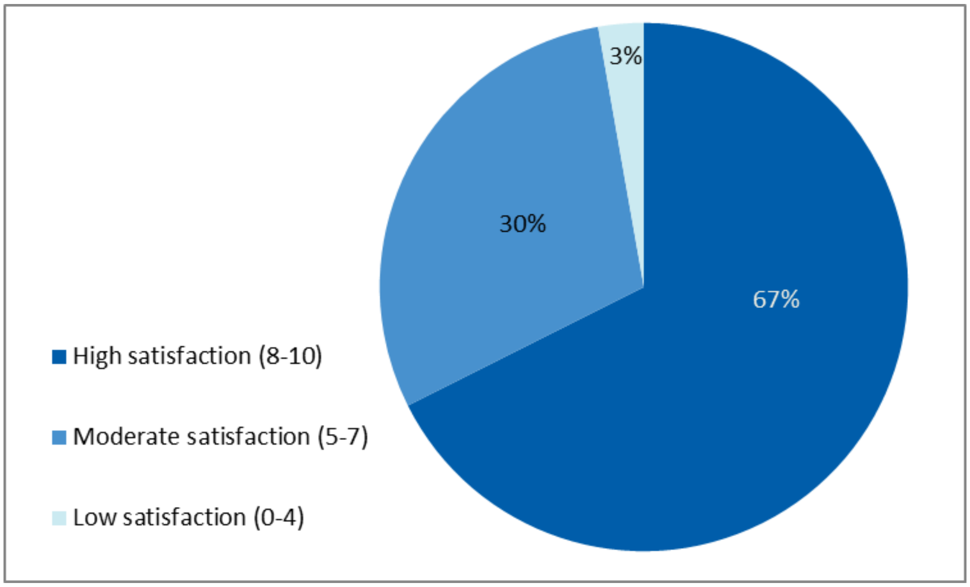
Source: Participant Survey Question A87. If you were rating your overall satisfaction with the Duke Energy / National Theater for Children program, would you say you are...? (n=115)

The survey also asked participants to rate their overall satisfaction with the program on a 10-point scale, where 0 indicated *extremely dissatisfied* and 10 indicated *extremely satisfied.* As shown in Figure 12 (below), 67% of respondents (n=108) provided satisfaction ratings of 8 or higher, which included 36% who rated the program a 10 out of 10. Only 3% of respondents gave the program satisfaction ratings of 4 or lower. Average satisfaction for the program was 8.1, with a median rating of 8 out of 10.

The two participants saying they were dissatisfied with the program offered explanations for their dissatisfaction:

- One customer said: “There is no purpose to bringing this into the schools. These are adult decisions, not children’s decisions.”
- The other customer expressed very strong concerns about resource conservation and reducing carbon footprints, though they did not specify what facet of the Duke Energy program left them dissatisfied.

Figure 12. Overall Satisfaction with the Program



Source: Participant Survey Question A4. Thinking about the Duke Energy / National Theater for Children Program overall, on a scale from 0 to 10, where 0 is *extremely dissatisfied* and 10 is *extremely satisfied*, how would you rate your overall satisfaction with the program? (n=108)

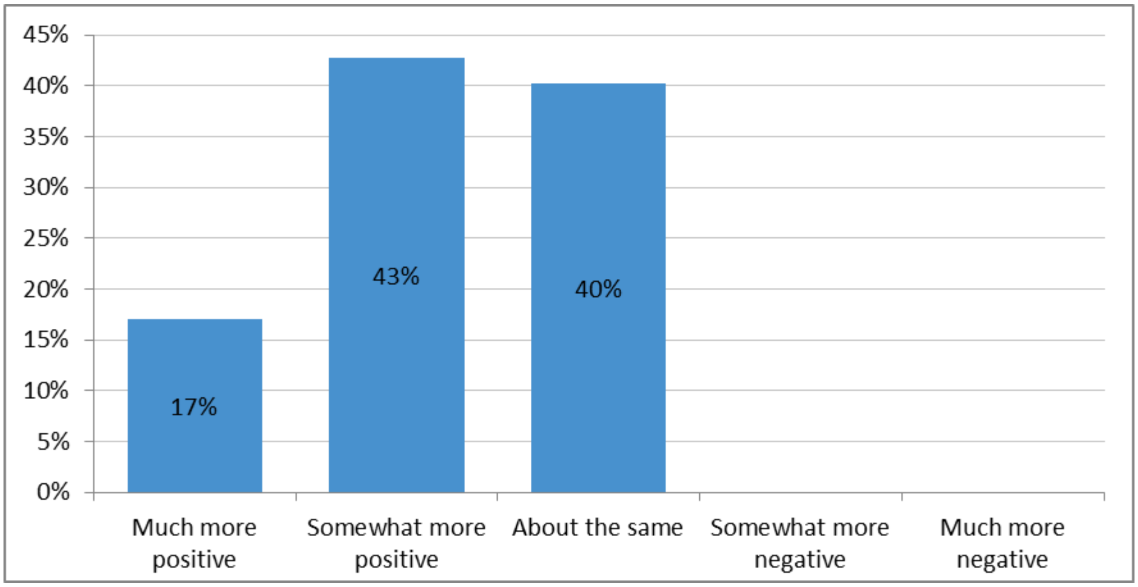
When asked for suggestions to improve this program, 10 of the 118 surveyed participants offered the responses summarized in Table 8.

Table 8. Participant Suggestions to Improve the Program

Suggestion	Count of Responses (n=10)
Target older children	2
Provide more informational material with the program	2
Give the Energy Efficiency Home Kits to children at school rather than shipping them by mail	1
Provide different energy-saving tips for older homes as well as newer homes	1
Make the program ongoing, rather than once per school year	1
Allow customers to choose the best light bulb style for their home	1
Provide light bulbs that do not contain mercury	1
The Energy Efficiency Home Kit should only provide items manufactured in the USA	1

When asked if program participation made them feel more positively or more negatively toward their utility, 60% of participants (n=117) felt more positive toward Duke Energy, while none felt more negative, as shown in Figure 13.

Figure 13. Effect of Program Participation on Attitudes Towards Duke Energy

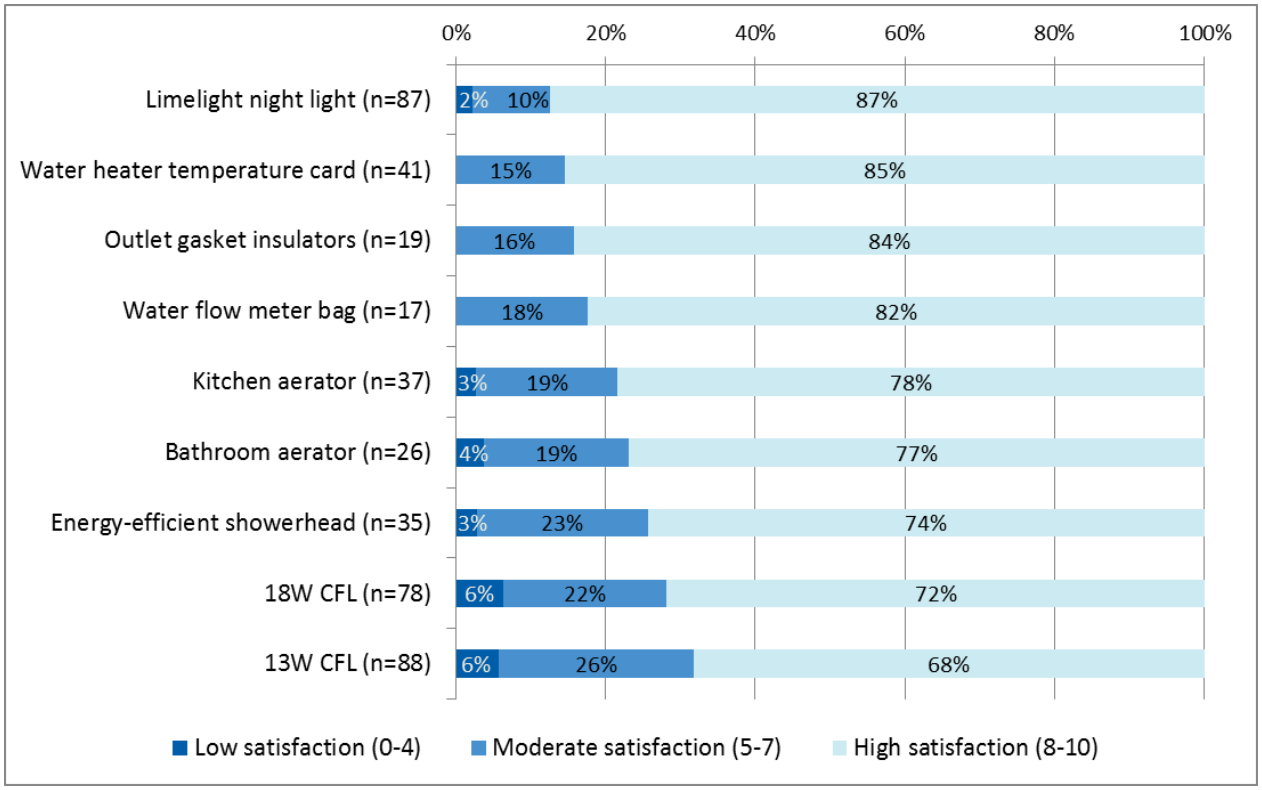


Source: Participant Survey Question A91. As a result of participating in this National Theatre for Children program, would you say your attitude toward Duke Energy is… (n=117)

Satisfaction with Energy Efficiency Home Kit Items

The survey asked respondents who reported using or installing items provided in the Energy Efficiency Home Kit to rate their satisfaction with these items on a 10-point scale, where 0 was *extremely unsatisfied* and 10 was *extremely satisfied.* The Limelight night light received the highest satisfaction ratings, with 87% of respondents reporting high satisfaction levels. Figure 14 shows the satisfaction ratings for each of the Energy Efficiency Home Kit items. The average satisfaction rating for all installed or used items was 8.5 on a 10-point scale, ranging from 8.1 (13-watt CFL) to 9.1 (Limelight night light).

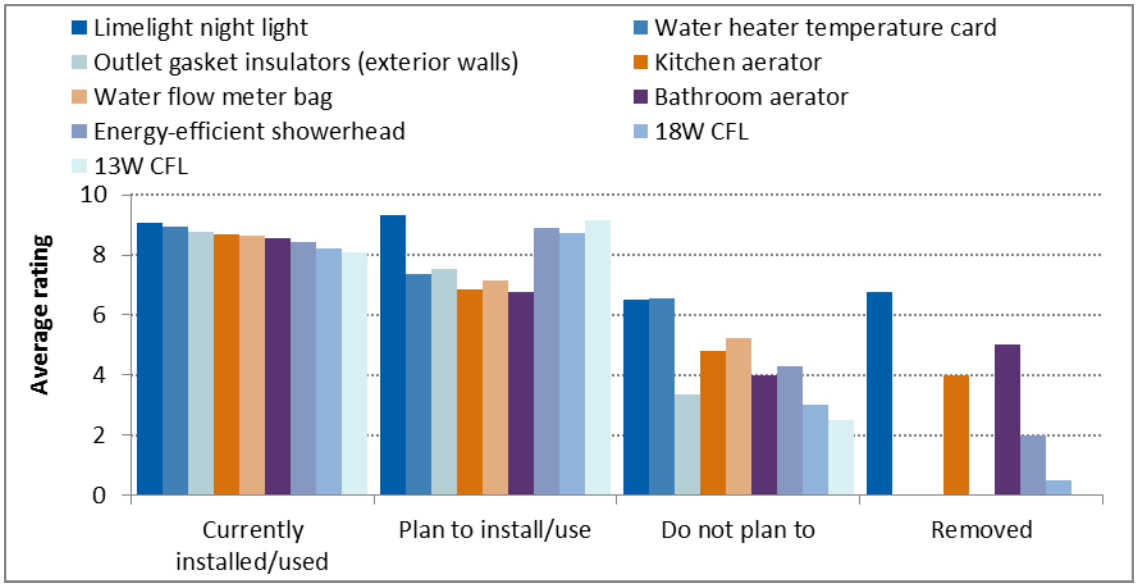
Figure 14. Satisfaction Ratings for Energy Efficiency Home Kit Items Installed or Used



Source: Participant Survey Questions A9, A11, A33, A44, A47, A57, A68, A74, and A78. On a scale from 0 to 10, where 0 is *extremely dissatisfied* and 10 is *extremely satisfied*, how satisfied are you with…

The survey also asked participants who reported not installing or using an item from the Home Energy Efficiency Kit to rate their satisfaction with the items, using the same 10-point satisfaction scale. Figure 15 shows the results. Participants who still planned to use or install these items gave satisfaction ratings only slightly lower than for those who had already used or installed the items (average rating of 7.8 for items they planned to use or install). Participants who did not plan to install or use these items gave much lower satisfaction ratings (average rating 4.6), and participants who installed but removed items gave the lowest ratings of all (average rating 3.8).

Figure 15. Satisfaction Ratings for Energy Efficiency Home Kit Items not Installed or Used



Source: Participant Survey Questions. On a scale from 0 to 10, where 0 is *extremely dissatisfied* and 10 is *extremely satisfied*, how satisfied are you with… (Valid n=41 to 99 by measure.)

The survey asked participants who gave satisfaction ratings of 4 or lower the reasons for their low satisfaction levels with Energy Efficiency Home Kit measures. Table 9 lists a summary of satisfaction ratings, by reason, for each measure. These responses include participants who installed the items but then removed them.

Table 9. Reasons for Low Satisfaction with Energy Efficiency Home Kit Measures

Reason for Lower Satisfaction (Count o Responses)	CFLs	Shower-heads	Aerators	Outlet gasket insulators	Water flow meter bag	Water heater temp card	Limelight night light	Total
Dissatisfied with performance of product	5	7	7	1			2	22
Damaged/defective item	9				1		1	11
Dissatisfied with quality	4	3		3				10
Does not fit/cannot install			7					7
Difficult to install/use					1			1
Other reasons			3					3

Program Comparison

The Cadmus team reviewed recent evaluations of two energy efficiency education programs that distribute energy-saving kits at schools. While these programs are similar to the Energy Efficiency in Schools Program, we found the following notable differences in process and delivery:

- The comparison programs do not provide educational performance.
- The customer validation process may be different or absent; for example, household accounts may not be verified.

The comparison programs feature additional delivery channels, provided in parallel with energy kit delivery.

Table 10 lists programs included in the review and items provided through each program.

Table 10. Programs Included in Comparison

Program (year)	Grades Covered	State	Energy Kit Items
Energizing Indiana Schools Education Program (2013)	5	Indiana	• Three CFLs (13-watt) • Three CFLs (23-watt) • Energy-efficient showerhead • Faucet aerator • LED night light • Filter tone alarm • Flow rate test bag • Digital thermometer • Reminder sticker and magnet pack • Parent/guardian comment card
Dayton Power and Light (2012)	5-12	Ohio	• CFLs* • LED night light • Bathroom faucet aerator • Kitchen faucet aerator • Energy-efficient showerhead

*Quantity not available.

Program Savings

The Cadmus team determined kit-level savings by dividing program-level savings by the number of participants. As shown in Table 11, savings per kit ranged from 324 kWh to 490 kWh. We used engineering analysis and participant surveys to calculate gross savings.

Table 11. Annual Savings (kWh) and Participation

Program		Annual Savings (kWh)	Participating Kits	Gross Savings Per Kit (kWh)*
Energizing Indiana Schools Education Program	Duke Energy	22,047,728	44,426	496
	IPL	5,300,004	11,611	456
	I&M	3,484,496	7,939	439
	NIPSCO	4,356,224	13,464	324
	IMPA	1,331,056	2,743	485
	Vectren Indiana	1,283,318	3,039	422
Dayton Power & Light		4,527,447	9,226	490

*Energizing Indiana: Net kWh; DP&L: Gross kWh.

Impact Evaluation Findings

This chapter presents the results of the Cadmus team's impact evaluation for Duke Energy Ohio's Energy Efficiency in Schools Program. The findings divide into four sections: Program Savings, Billing Analysis, Engineering Analysis, and Net-to-Gross Analysis. Table 12 lists the primary evaluation activities and the dates in which the Cadmus team conducted them.

Table 12. Impact Evaluation Data Collection and Analysis

Evaluation Component	Participation Dates	Data Source(s)	Dates of Data Collection/Analysis
Billing Analysis	June 1, 2014–May 27, 2015	• Utility billing data (n=6,447 program participants)	July–August 2015
Engineering Analysis	June 16, 2014–February 27, 2015	• Participant survey (n=118) • Illinois TRM • Ohio Draft TRM	May 2015/July–August 2015
Net-to-Gross Analysis	June 16, 2014–February 27, 2015	• Participant survey (n=118)	May 2015/July–August 2015

Energy Efficiency in Schools Program Savings

The Cadmus team conducted a billing analysis to estimate overall net energy savings per household for the Energy Efficiency in Schools Program in Duke Energy Ohio. We also performed an engineering analysis to estimate relative savings contributions from items provided in the Energy Efficiency Home Kit and a net-to-gross analysis to account for freeridership and spillover adjustments. By conducting billing, engineering, and net-to-gross analyses, Cadmus determined the portion of net energy savings achieved per household that resulted from installation of items from the Energy Efficiency Home Kit and the portion that resulted from energy-saving actions and behaviors taken by participants.

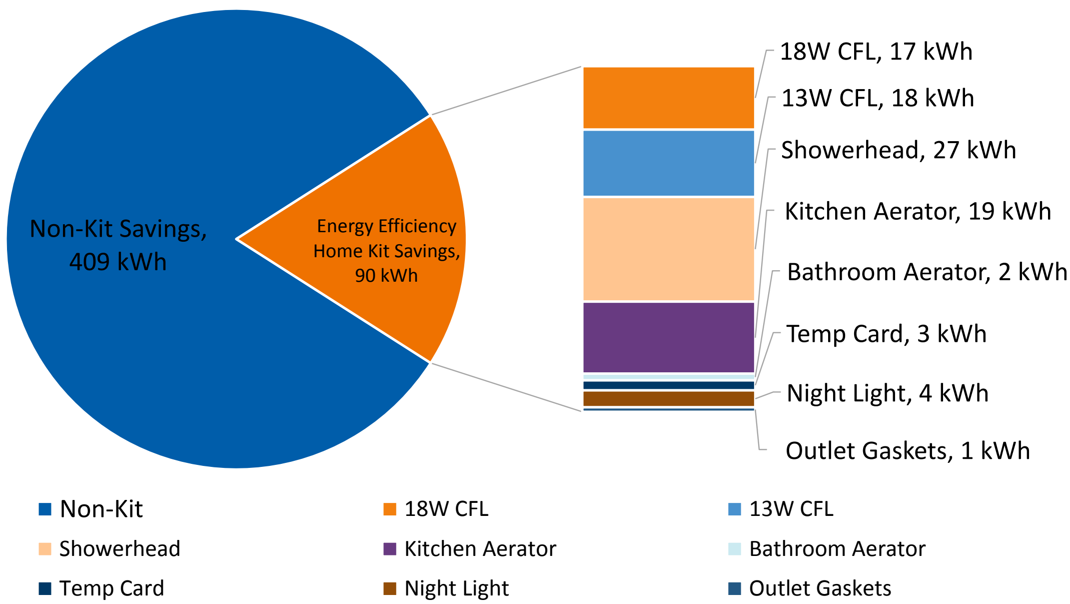
Billing analysis results indicate the average participant household saved approximately 499 kWh through participating in the Energy Efficiency in Schools Program. Engineering results indicate approximately 18% (90 kWh) of these savings came from participants installing Energy Efficiency Home Kits items. The remaining 82% of household savings resulted from participants taking energy-saving actions and behaviors due to education received through the program. As discussed in the participant survey findings, participants reported taking the following energy-saving actions in their homes:

- Turned off lights and electronic items when not in use
- Sealed air leaks and properly insulated the home
- Maintained and upgraded HVAC equipment and major household appliances
- Used less heating and cooling (thermostat adjustments)
- Used lower power cycles or temperature settings for appliances

- Installed a programmable thermostat
- Upgraded windows and doors
- Unplugged a spare refrigerator
- Conserving water

The Cadmus team used the proportion of energy savings associated with each item in the Energy Efficiency Home Kit to calculate its relative contribution to the overall household savings. Figure 16 shows the contribution of savings from each measure as well as the overall contribution of estimated savings from behavior changes.

Figure 16. Energy Savings from Energy Efficiency Home Kit and Behaviors



In total, 6,449 Duke Energy participants received an Energy Efficiency Home Kit between June 2014 and May 2015, and the average participant saved 499 kWh.

Table 13 lists total net Energy Efficiency in Schools program savings and Table 14 presents the Energy Efficiency Home Kit item metrics and savings details. Finally, the following sections present detailed results from the billing analysis, engineering analysis, and net-to-gross analysis.

Table 13. Energy Efficiency in Schools Program Net Savings

Measure	Count*	Net kWh Savings per Participant	Net kWh
Duke Energy Energy Efficiency Home Kit	6,449	499	3,218,051

*The number of Energy Efficiency Home Kits distributed, as reported by Duke Energy.

Table 14. Engineering Analysis Energy Efficiency Home Kit Savings Details

Metric	13W CFL	18W CFL	Energy-efficient Showerhead	Kitchen Aerators	Bathroom Aerators	Hot Water Temp Card	Lime-light Night Light	Outlet Gasket Insulators	Entire Energy Efficiency Home Kit
Units	Bulb	Bulb	Showerhead	Aerator	Aerator	Change	Light	12 pack	Kit
ISR	88%	83%	31%	35%	24%	9%	78%	7%	
Gross kW Per Unit	0.0035	0.0029	0.0032	0.0043	0.0030	0.0003	0.0000	0.0006	0.0178
Gross kWh Per Unit	26.64	25.14	27.03	16.07	1.48	2.22	3.79	1.37	103.73
Freeridership Rate	51.3%	51.3%	16.0%	0.0%	0.0%	0.0%	0.0%	30.0%	30.1%
Spillover Rate	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%
NTG Ratio	65.9%	65.9%	101.2%	117.1%	117.1%	117.1%	117.1%	87.1%	87.0%
Net kW Per Unit	0.0023	0.0019	0.0032	0.0051	0.0035	0.0003	0.0000	0.0005	0.0168
Net kWh Per Unit	17.54	16.56	27.34	18.83	1.73	2.60	4.44	1.19	90.24
Measure Life (Years)*	5	5	10	9	9	2	8	15	7
EUL Net kWh Per Unit	87.72	82.79	273.41	169.47	15.58	5.21	35.50	17.91	645.83

*To calculate overall measure life, the Cadmus team used a weighted average derived from the effective useful lives of the individual Energy Efficiency Home Kit items. We assigned weights based on each item's contribution to gross kWh savings.

Billing Analysis

Cadmus conducted a billing analysis of participants in the Energy Efficiency in Schools Program in Duke Energy Ohio. Duke Energy reported deliveries of 6,449 Energy Efficiency Home Kits for the evaluation period ending May 31, 2015. Duke Energy provided billing data for electric customers who participated in the Duke Energy Ohio Energy Efficiency in Schools Program between June 1, 2014, and May 27, 2015.

Cadmus tested two panel model specifications (Model 1 and 2) to determine program impacts, in which the dependent variable was daily electricity consumption from January 2011 to May 2015. Table 15 shows the results of the selected 2015 billing analysis.

Table 15. Estimated Impact of Duke Energy Ohio Energy Efficiency in Schools Program

Program Year Evaluated	kWh Per Participant Annual Savings (Net)
2015	499

For this analysis, Cadmus had access to data for both households (i.e., cross-sectional) and over time (i.e., time-series). With this type of data, also known as panel data, it was possible to control, simultaneously, for differences across households, as well as differences across time, through the use of a fixed-effects panel model specification. Fixed-effect refers to the model specification aspect that differences across homes that did not vary over the estimation period (such as square footage, heating system, etc.) could be explained, in large part, by customer-specific intercept terms that captured the net change in consumption due to the program, controlling for other factors that did change with time (e.g., the weather).

Because the consumption data in the panel model included months before and after the installation of measures through the program, we could define the period of program participation (or the participation window) for each customer. This feature of the panel model allowed for the pre-installation months of consumption to act as controls for post-participation months. Because we knew the month of participation in the program for each participant, we were able to construct customer specific models that measured the change in usage consumption immediately before and after the date of program participation, while also controlling for weather and customer characteristics such as participation in other Duke Energy efficiency programs.[6]

The fixed effects model can be viewed as a type of simple differencing model that captures all home characteristics independent of time and determines the energy consumption level within customer-

6 The participation month is defined by the date that the household receives the Energy Efficiency Home Kit, as reported by the vendor. We assumed participants used the Energy Efficiency Home Kits in the same month they were delivered.

specific constant terms. The following equation describes the general fixed-effect panel data model used in the evaluation:

$$y_{it} = \alpha_i + \beta x_{it} + \varphi P_{it} + \theta T + \delta DP_{it} + \varepsilon_{it}$$

Where:

y_{it} = average daily consumption for home *i* during month *t*

α_i = constant term for home *i* (the fixed-effect)

T = indicator variables for each month-year in the analysis

P = indicator variable for whether the month is pre- or post-treatment. This variable equals 1 in months following arrival of the Energy Efficiency Home Kit and 0 otherwise.

DP = indicators for other utility-sponsored programs[7]

ß,φ,ϑ,δ = vectors of estimated coefficients

x = vector of nonprogram variables that represent factors causing changes in energy consumption for home *i* during month *t* (i.e., weather)

ε = error term for home *i* during month *t.*

Using this specification, the only information necessary for estimation included factors that varied month-to-month for each customer and that affected energy use (i.e., weather conditions and participation in other Duke Energy programs). The model captured other non-measurable, time-variant factors (such as economic conditions and season loads) through use of monthly indicator variables.[8] To control for weather effects, we included cooling degree days and heating degree days in the model.[9]

To estimate the Energy Efficiency in Schools Program's effect, the Cadmus team included an indicator variable equal to one for all months after a household participated in the program. The coefficient on this variable equaled savings associated with the program. To account for differences in billing days, we normalized usage by days in the billing cycle.

The Cadmus team used the above equation as a foundation for Model 1 and Model 2, including the same set of variables in both specifications. The two models primarily differed in the months included in

7 See Table 32 for the list of other programs.

8 Wooldridge, Jeffrey. *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press. 2002. 283-284. Includes a discussion of this model and its applicability to program evaluation.

9 CDD and HDD variables were set using a 65 degree Fahrenheit base.

the dataset. Model 1 included all pre- and post-period months; Model 2 set a restriction on the months (t), as described below.

The 2013 evaluation used Model 1. For the 2015 evaluation, Model 1 estimated statistically significant savings, though with a relatively high margin of error.[10] Model 1's imprecision most likely resulted from the unbalanced panel present in the 2015 program year—the majority of participants received Energy Efficiency Home Kits at the end of calendar year 2014. This allowed for very little post-period data (the mean number of participants' post-month bills was only 6.0). Model 1 compared participants' consumption in these few post-months to that of nearly 35 pre-period months for the average participant. As a result, the month-year indicators could not absorb all seasonal variations between consumption in the post-period months, which primarily occurred during lower-consumption winter and spring months and in pre-period months.

To adjust for the limited post-installation data in Model 2, we paired pre- and post-installation months to prevent seasonal bias that would result from using mismatched months. For example, if participants received an Energy Efficiency Home Kit in November 2014, their post-period months would include six months (December 2014 to May 2015). In Model 2, we used these participants' pre-period consumption for the same six months in 2011 through 2013, dropping those years' remaining six months. This allowed for a direct comparison of pre- and post-months in the absence of many post-period months. As such, we did not include the month-year indicators (T, in the equation above). As shown in Table 16, the Cadmus team could estimate statistically significant savings using Model 2.

To account for customers with insufficient data, the Cadmus team used a number of screening methods. For both models, we removed customers' month-bills if they were less than 30 kWh or if they included less than 15 days (when we assumed homes were vacant). We also excluded large outliers when annual consumption exceeded 60,000 kWh, and we excluded customers with fewer than 10 months of pre-period data. Data screening reduced the Model 1 sample size by approximately 2.4%.

Model 2 involved additional screening at the customer level to adequately select pre- and post-month pairs. In Model 2, we limited the allowable amount of a customer's change in consumption from the mean pre-period months to the post-period months to ±50%. In other words, if customers' usage shifted in the post-period by more than 50%, we excluded them from the dataset. This step removed 15.8% of customers who met this outlier criterion in the Model 2 dataset.

[10] At the 90% confidence level, we divided the two-tailed critical value of 1.645 by the reported t-test of 3.44 from the 2013 evaluation, then took the absolute value and converted to a percentage to get 48%. The same methodology was used to determine precision for Model 2 in the current 2015 evaluation. If precision is found to be below 100% at the given confidence level, then the savings estimates are statistically significant, meaning that we can reject the Null hypothesis. Note that this precision calculation should not be confused with the 90/10 sampling rule used in the survey methodology.

Table 16. Detailed Savings Model Estimates

Evaluation Year	Number of Accounts	Model[1]	Number of Observations[2]	Post-Coefficient (Daily kWh)	Yearly Savings Per Customer (kWh)[3]	Standard Error	T-Test	Precision	Mean Annual Per-Customer Pre-Usage	Percentage of Savings[4]
2013	7,279	Model 1	119,103	-0.650	237 (124,351)	0.19	-3.44	48%	16,133	1.47% (0.77%,2.18%)
2015	5,180	Model 2	122,110	-1.37	499 (435,563)	0.11	-12.87	13%	14,825	3.37% (2.93%, 3.80%)

[1]Model 1: ALL PRE/POST DATA: customer fixed-effects + weather + month-year indicators + other programs

Model 2: PAIRED MONTHS: customer fixed-effects + weather + other programs, 50% change or less

[2]The exact number of observations from the 2013 study is not known, rather was estimated using the breakdown of account numbers by state.

[3]90% Confidence intervals in parentheses.

[4]Percentage of savings calculated as yearly savings, divided by pre-treatment usage; 90% confidence intervals in parentheses.

In Table 16, daily energy use serves as the dependent variable, and a *reduction* in usage reflects positive savings. To calculate annual kWh savings, Cadmus annualized the post-period coefficient by multiplying by 365, which resulted in 499 kWh savings per year. We calculated the equivalent percentage as the coefficient (daily kWh) divided by average pre-program usage—499 kWh divided by the average annual pre-program usage of 14,825 kWh. Appendix C. Billing Analysis Regression Details contains the complete estimated model, including weather and time factors.

Engineering Analysis

Cadmus used engineering analysis to determine the proportion of household energy savings resulting from use of items included the Energy Efficiency Home Kit. In addition, the engineering estimates provided a ratio of coincident kW reduction to kWh savings. This section presents details of the engineering analysis and high-level results; Appendix D. Engineering Analysis Energy Efficiency Home Kit Savings Details provides additional details.

CFLs

The Energy Efficiency Home Kit distributed to Duke Energy customers included one 13-watt CFL and one 18-watt CFL. Table 17 lists estimated savings associated with each of these CFLs.

Table 17. Savings Estimates per CFL Distributed to Duke Energy Customers*

Bulb Type	In Service Rate	Average Wattage of Bulb Removed	Average Adjusted Daily Hours of Use	Gross kWh	Gross kW	NTG	Net kWh	Net kW
13-watt	88%	42.7	2.60	26.64	0.0035	65.9%	17.54	0.0023
18-watt	83%	44.5	3.17	25.14	0.0029	65.9%	16.56	0.0019

*Cadmus obtained inputs to the engineering algorithm from participant surveys and the Ohio TRM.

In Service Rate Calculation

To remain consistent with the Ohio TRM algorithm used for the CFL measures, Cadmus adjusted the first-year, in service rate (ISR) reported by survey participants to reflect future installations. An example of this adjustment follows.

Participant surveys indicated the 18-watt CFL distributed in the Energy Efficiency Home Kit's had a first year ISR of 73%. That is, 73% of the 18-watt CFLs distributed to survey participants were installed at the time of the survey. We calculated the ISR as 83% using the following formula:

ISR = first year ISR + (43% * remainder) = **73% + (43% * 24%) = 83%**

Where, the remainder is the percentage of bulbs not installed in the first year (100% - 73% = 27%), less 3% for the 97% lifetime ISR.[11] In this case, the remainder is 24%. The 43% represents the percentage of the remainder that will replace an incandescent bulb rather than a CFL.[12]

Self-Reporting Bias

Previous CFL evaluations conducted for Duke Energy (2010–2013) included customer surveys and lighting loggers. These studies compared customers' self-reported hours of operation to actual hours of operation, indicating that customers who responded to the survey overestimated their lighting usage by 27%.[13]

As the 2015 impact evaluation did not employ lighting loggers, the Cadmus team did not have appropriate data to make a similar comparison for the Energy Efficiency in Schools Program. Consequently, we reduced the self-reported hours-of-use obtained from the survey by 27%, as established through collection of data from previous programs. This bias only applied to CFLs.

Table 18 shows unadjusted average hours-of-use values and updated average hours-of-use values after applying the self-reporting bias. The final value for average daily hours-of-use for a Duke Energy customer is 2.60 for 13-watt CFLs and 3.17 for 18-watt CFLs.

Table 18. Adjusted Average Daily Hours of Use

Adjustment	Magnitude of Adjustment	Average Daily Hours-of-Use (13W)	Average Daily-Hours-of Use (18W)
Unadjusted	N/A	3.57	4.34
Self-Reporting Bias Applied	27%	2.60	3.17

Energy-Efficient Showerhead

Each Energy Efficiency Home Kit contained one energy-efficient showerhead. Survey results indicated 31% of the showerheads provided to participants were installed, and approximately 38% of households used electric water heaters. Table 19 lists the ISR, electric water heater saturation, and savings estimates for this measure.

11 Nexus Market Research, RLW Analytics, and GDS Associates. *New England Residential Lighting Markdown Impact Evaluation*. 2009.

12 Nexus Market Research and RLW Analytics. *Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs.* 2004. Table 6-4: 24 out of 56 respondents indicated they did not purchase CFLs as spares.

13 The adjustment for the self-reporting bias used in this study was determined using paired lighting logger and customer self-reported data from Kentucky, Ohio, North Carolina, South Carolina, and Indiana, referenced in the Duke Energy *Process and Impact Evaluation of the Energy Efficiency for Schools Program.* 2014.

Table 19. Savings Estimates per Showerhead Distributed*

ISR	Electric Water Heating**	gpm base	gpm low	Gross kWh	Gross kW	NTG	Net kWh	Net kW
31%	38%	2.35	1.5	27.03	0.0032	101.2%	27.34	0.0032

*Inputs to the engineering algorithm were obtained from participant surveys and the Illinois TRM.

**This measure produces zero kW or kWh savings in households that use gas water heaters.

Faucet Aerators

The Energy Efficiency Home Kits included one kitchen aerator and one bathroom faucet aerator. Survey results indicated that 35% of the kitchen aerators were installed, 24% of the bathroom aerators were installed, and approximately 38% of households used electric water heaters. Table 20 presents the ISR, electric water heater saturation, and savings estimates for this measure.

Table 20. Savings Estimates per Aerator Distributed*

Measure	ISR	Electric Water Heating**	Gross kWh	Gross kW	Net to Gross	Net kWh	Net kW
Kitchen Aerator	35%	38%	16.07	0.0043	117.1%	18.83	0.0051
Bathroom Aerator	24%	38%	1.48	0.0030	117.1%	1.73	0.0035

*Inputs to the engineering algorithm were obtained from participant surveys and the Illinois TRM.

**This measure produces zero kW or kWh savings in households that use gas water heaters.

Outlet Gasket Insulators

The Energy Efficiency Home Kits included a 12-pack of switch and outlet gasket insulators. Survey results indicated that 7% were installed. Table 21 lists the ISR, along with gross and net savings estimates per unit distributed.

Table 21. Savings Estimates per 12-Pack Distributed to Duke Energy Customers

ISR*	Gross kWh	Gross kW	Net to Gross	Net kWh	Net kW
7%	1.37	0.0006	87.1%	1.19	0.0005

*We only included outlet gasket insulators installed in exterior walls in the ISR, as outlet gasket insulators installed in interior walls do not result in energy savings.

Limelight Night Light

The Energy Efficiency Home Kits included one Limelight night light. Survey results indicated that 78% were installed. However, previous research indicates that approximately 58% of installations[14] do not replace an existing light and, therefore, do not result in energy savings. Additionally, some participants replaced LED night lights with the Limelight night light, resulting in minimal energy savings.

For installations that replaced an existing incandescent night light, the Cadmus team assumed the replaced bulb was 5 watts. Once we factored in the new installations and LED replacements, the average wattage for replaced bulbs fell to 1.76 watts. Table 22 lists the ISR, average wattage, and average hours-

[14] Based on 2013 Duke Energy Energy Education Program Evaluation.

of-use, along with gross and net savings estimates per unit distributed. We assumed demand savings to be zero for this measure.

Table 22. Savings Estimates per Limelight Night Light Distributed

ISR	Average Wattage Light Removed	Average Daily Hours of Use Base	Average Daily Hours of Use EE	Gross kWh	Gross kW	Net to Gross	Net kWh	Net kW
78%	1.76	8	24	3.79	0.0000	117.1%	4.44	0.0000

Water Heater Temperature Card

The Energy Efficiency Home Kits included a water heater temperature card. Survey results indicated that 9% of respondents used the card and went on to reduce the temperature of their hot water heaters by an average of -12 degrees Fahrenheit. Table 23 lists the ISR and average temperature, along with gross and net savings estimates per unit distributed.

Table 23. Savings Estimates per Hot Water Temperature Card Distributed

ISR	Electric Water Heating*	Average Temperature Adjustment (°F)	Gross kWh	Gross kW	Net to Gross	Gross and Net kWh	Gross and Net kW
9%	38%	-12	2.22	0.0003	117.1%	2.60	0.0003

*This measure produces zero kW or kWh savings in households that use gas water heaters.

Net-to-Gross Findings

This report presents freeridership and spillover findings for informational purposes only. The Cadmus team did not use these estimates to adjust gross energy impacts to report net savings. Because the impact analysis approach compares the customer's electric meter readings before and after the program, the impact findings already represent net savings and do not need to be adjusted further. We conducted freeridership and spillover analysis for four measures to allow stakeholders to understand the degree of these influences. This section presents net-to-gross results; Appendix E. Net-to-Gross Ratio Calculations contains further information about the calculation of freeridership and spillover rates.

Cadmus calculated freeridership separately for the Energy Efficiency Home Kit[15] items shown in Table 24.

[15] Energy education programs that provide energy kits to all student participants and do not require parents to request the energy kits commonly assume a net-to-gross ratio of 1.

Table 24. Freeridership for Energy Efficiency Home Kit Items*

Measure (n=Participants who Installed the Measure)	Number of Freeriders	Freeridership %
CFLs (n=94)	82	51.3%
Energy-efficient showerhead (n=36)	7	16.0%
Faucet aerators (n=43)	3	0.0%**
Outlet gasket insulators (n=20 on outside walls)	7	30.0%

*Freeridership questions were not asked for the Limelight night light, and a 0% freeridership score is applied.
**Freeridership is deemed at 0.0% per the Illinois TRM. Savings for faucet aerators are calculated using a common practice baseline that includes previously installed low-flow fixtures and accounts for use of faucets at a less-than-rated flow rate, debris buildup, and water system pressures lower than rated flow rates.

As shown in Table 25, the Cadmus team estimated spillover for the Energy Efficiency Home Kit portion of the program as 17.1% of the survey sample gross program savings. Appendix E. Net-to-Gross Ratio Calculations contains more information on the spillover estimation.

Table 25. Spillover for Energy Efficiency Home Kit Items*

Measure	Spillover %
CFL	16.4%
Energy-efficient showerhead	0.4%
Faucet aerators	0.1%
Outlet gasket insulators	0.1%
Overall	**17.1%**

*Survey sample program kWh savings used in the spillover calculation did not include behavior savings; they only included Energy Efficiency Home Kit measure savings. The behavior of kWh savings estimated for the program included any "non-like" program measure spillover activity.

Summary Form

Energy Efficiency in Schools Program

Duke Energy Ohio
Completed EMV Fact Sheet
2015 Evaluation – Cadmus Group

Program Description

Energy Efficiency in Schools is designed to provide energy education and low-cost energy-efficiency measures to K-12 public and private school students. Participants in this program attend a presentation designed to educate students about energy and complete a home energy survey to receive free Energy Efficiency Home Kits by mail. The program also encourages energy-saving behaviors and actions through education, increased awareness, and family engagement.

Date	November 2, 2015
Region(s)	OH
Evaluation Period	June 2014 to May 2015
Gross Energy Savings (kWh)	n/a
Net Coincident kW Impact (Summer/Winter)	866/849
Measure life	Various
Net Energy Savings (kWh)	3,218,051
Process Evaluation	Yes
Previous Evaluation(s)	Yes

Evaluation Methodology

To estimate net energy savings and demand reduction resulting from installing kit items and related actions and behavior changes through billing analysis, participant surveys, and TRM-based savings analyses.

Impact Evaluation Details

- Baseline Description: electric energy usage for the household absent the installation of kit items, behavior changes, and other program-related actions.
- Eligibility: a student in the household attended an eligible school and the household has not received an Energy Efficiency in Schools kit during the previous three years.
- Savings Calculation: Cadmus calculated net program savings using billing analysis, and performed an engineering analysis to determine the portion of savings contributed by the installation of kit items. When possible, Cadmus used averaged survey responses in place of TRM assumed values to give recent, regional values tailored to DEO's service territory. The engineering analysis of kit item savings included NTGR calculated from survey responses.

Appendix A. Participant Household Characteristics and Demographics

Table 26. Participant Household Characteristics and Demographics

Household Characteristics	n value/Percentage
Home Ownership	n=116
Home owner	73%
Renter	27%
Type of Home	n=118
Single-family home, detached construction	80%
Single-family home, manufactured or modular	1%
Single-family mobile home	1%
Two- or three-family attached homes	3%
Apartment homes (4+ families)	10%
Condominium	3%
Other	2%
Home Age	n=108
Built before 1959	37%
1960 – 1979	24%
1980 – 1989	6%
1990 – 1997	6%
1998 – 2000	6%
2001 – 2007	14%
2008 – present	6%
Home Size	n=107
500 – 999 square feet	16%
1,000 – 1,499 square feet	23%
1,500 – 1,999 square feet	27%
2,000 – 2,499 square feet	12%
2,500 – 2,999 square feet	12%
3,000 – 3,499 square feet	4%
3,500 – 3,999 square feet	4%
4,000 or more square feet	2%

Household Characteristics	n value/Percentage
Home Heating System	n=116
Central forced air furnace	78%
Heat pump	12%
Electric baseboard heat	3%
Geothermal heat pump	3%
Other systems	6%
Home Cooling System	n=118
Central air conditioning	81%
Wall or window AC unit(s)	8%
Heat pump for cooling	7%
Geothermal heat pump for cooling	2%
None	2%
Primary Fuel Used for Heating	n=115
Natural gas	61%
Electricity	36%
Oil or kerosene	3%
Wood	1%
Propane	0%
Primary Fuel Used for Water Heating	n=114
Natural gas	57%
Electricity	40%
Oil or kerosene	1%
Wood	1%
Other	1%
Number of People in the Household (Year-Round)	n=117
1	2%
2	12%
3	22%
4	32%
5	16%
6 or more	15%

Household Characteristics	n value/Percentage
Number of People Under Age 18 in the Household	n=117
Zero	9%
1	27%
2	37%
3	18%
4	6%
5	3%
Age of Respondent	n=116
18 – 24	0%
25 – 34	21%
35 – 44	47%
45 – 54	22%
55 – 64	7%
65 – 74	3%
75 or older	0%
Annual Household Income	n=112
Under $15,000	4%
$15,000 - $29,999	6%
$30,000 - $49,999	15%
$50,000 - $74,999	16%
$75,000 - $99,999	13%
Over $100,000	26%
Prefer not to answer	21%

Appendix B. Impact Algorithms

General Impact Algorithms by Measure

CFLs

Gross Summer Coincident Demand Savings

$$\Delta kW = ISR \times \left[\frac{Watts_{base} - Watts_{ee}}{1000}\right] \times CF \times WHF_d$$

Gross Annual Energy Savings

$$\Delta kWh = ISR \times \left[\frac{(Watts \times HOU)_{base} - (Watts \times HOU)_{ee}}{1000}\right] \times 365 \times WHF_c$$

Where:

ΔkW = gross coincident demand savings

ΔkWh = gross annual energy savings

$Watts_{ee}$ = connected load of energy-efficient unit

$Watts_{base}$ = connected (nameplate) load of baseline unit(s) displaced

HOU = Average daily hours of use (based on connected load)

CF = coincidence factor = 0.11

WHF_c = HVAC system interaction factor for annual electricity consumption = 1.07

WHF_d = HVAC system interaction factor for demand = 1.21

The Cadmus team took the coincidence factor and HVAC interaction factors for this analysis from the Draft Ohio TRM.

Outlet Gasket Insulators

Gross Summer Coincident Demand Savings

$$\Delta kW = (\Delta cfm/unit) \times (kW / cfm) \times DF \times CF$$

Gross Annual Energy Savings

$$\Delta kWh = (\Delta cfm/unit) \times (kWh / cfm)$$

Where:

ΔkW = gross coincident demand savings

ΔkWh = gross annual energy savings

Δcfm/unit = unit infiltration airflow rate (ft^3/min) reduction for each measure

DF = demand diversity factor = 0.8

CF = coincidence factor = 1.0

kW/cfm = demand savings per unit cfm reduction

kWh/cfm = electricity savings per unit cfm reduction

Unit cfm Savings Per Measure

We estimated cfm reductions for each measure from equivalent leakage area (ELA) change data taken from the ASHRAE Handbook of Fundamentals (ASHRAE, 2001). We then converted the ELA changes to infiltration rate changes using the Sherman-Grimsrud equation:

$$Q = ELA \times \sqrt{A \times \Delta T + B \times v^2}$$

Where:

A = stack coefficient (ft^3/min-in^4-°F)
= 0.015 for one-story house

ΔT = average indoor/outdoor temperature difference over the time interval of interest (°F)

B = wind coefficient (ft^3/min-in^4-mph^2)= 0.0065 (moderate shielding)

V = average wind speed over the time interval of interest measured at a local weather station at a height of 20 ft (mph)

Table 27 lists location-specific data.

Table 27. Location Assumptions

Location	Average Outdoor Temp	Average Indoor/Outdoor Temp Difference	Average Wind Speed (mph)	Specific Infiltration Rate (cfm/in^2)
Cincinnati	53	15	8.9	0.86

Table 28 lists measure ELA impact and cfm reductions.

Table 28. ELA Impacts and CFM Reductions

Measure	Unit	ELA change (in^2/unit)	ΔCfm/unit
Outlet Gasket Insulators	each	0.357	0.307

Unit Energy and Demand Savings

The Cadmus team calculated the energy and peak demand impacts of reducing infiltration rates from infiltration rate parametric studies, conducted using the DOE-2 residential building prototype models, as described at the end of this appendix. Table 29 lists savings per cfm reductions by heating and cooling system type. We weighted these data according to HVAC system type weights, as shown in Table 29.

Cincinnati, OH; Covington, KY

Table 29. Savings per CFM

Heating Fuel	Heating System	Cooling System	Weight	kWh/cfm	kW/cfm
Other	Any except Heat Pump	Any except Heat Pump	0.0029	1.14	0
		None	0.0002	0	0
Any	Heat Pump	Heat Pump	0.0760	12.85	0.00248
Gas Propane Oil	Central Furnace	None	0.0111	0	0
		Room/Window	0.7571	1.14	0
		Central AC			
Electricity	Electric baseboard/ central furnace	None	0.0046	23.27	0.01238
		Room/Window	0.1433	23.84	0.01485
		Central AC			
None	None	Any	0.0049	0	0
Total Weighted Average			**1**	**5.37**	**0.00237**

Energy-Efficient Showerhead

Gross Summer Coincident Demand Savings

$$\Delta kW = \Delta kWh/Hours * CF \text{ Gross Annual Energy Savings}$$

$$\Delta kWh = \%ElectricDHW * ((gpm\_base * L\_base - gpm\_low * L\_low) * Household * SPCD * 365.25 / SPH) * EPG\_electric * ISR$$

Where:

- ΔkW = gross coincident demand savings
- ΔkWh = gross annual energy savings
- %ElectricDHW = proportion of water heating supplied by electric resistance heating = 38%
- gpm_base = flow rate of baseline showerhead = 2.35

gpm_low = flow rate of the energy-efficient showerhead = 1.5

L_base = shower length in minutes with baseline showerhead = 7.8

L_low = shower length in minutes with energy-efficient showerhead = 7.8

Household = average number of people per household = 2.51

SPCD = showers per capita per day = 0.6

365.25 = average days per year

SPH = showerheads per household = 1.70

EPG_electric = energy per gallon of hot water supplied by electric = 0.108

ISR = in service rate = 31%

Hours = annual electric DHW recovery hours for showerhead use = 236

GPH = gallons per hour recovery of electric water heater = 29.3

CF = coincidence factor for electric load reduction = 0.0278

Faucet Aerators

ΔkW = ΔkWh / Hours * CF

ΔkWh = %ElectricDHW * ((gpm_base * L_base - gpm_low * L_low) * Household * 365.25 *DF / FPH) * EPG_electric * ISR

Where:

%ElectricDHW = proportion of water heating supplied by electric resistance heating = 38%

gpm_base = Average flow rate, in gallons per minute, of the baseline faucet "as-used" = 1.39

gpm_low = Average flow rate, in gallons per minute, of the energy-efficient faucet aerator "as-used" = 0.94

L_base = Average baseline daily length faucet use per capita = 4.5 kitchen ; 1.6 bathroom

L_low = Average retrofit daily length faucet use per capita = 4.5 kitchen ; 1.6 bathroom

Household = Average number of people per household = 2.51

365.25 = Average days in a year

DF = Drain Factor = 75% kitchen; 90% bathroom

FPH = Faucets Per Household = 1 kitchen; 2.69 bathroom

EPG_electric = Energy per gallon of water used by faucet supplied by electric water heater

= 0.088 kitchen; 0.070 bathroom

ISR = In service rate = 35% kitchen; 24% bathroom

Hours = Annual electric DHW recovery hours for faucet use per faucet = 82 kitchen; 11 bathroom

GPH = Gallons per hour recovery of electric water heater = 29.3

CF = Coincidence Factor for electric load reduction = 0.022

Water Temperature Card

$$\Delta kW = \Delta kWh / Hours * CF$$

$$\Delta kWh = (UA * (Tpre - Tpost) * Hours) / (3412 * RE\_electric)$$

Where:

U = Overall heat transfer coefficient of tank (Btu/Hr-°F-ft2) = 0.083

A = Surface area of storage tank (square feet) = 24.99

Tpre = hot water setpoint prior to adjustment = 133

Tpost = new hot water setpoint = 121

Hours = Number of hours in a year = 8,766

RE_electric = Recovery efficiency of electric hot water heater = 0.98

CF = Summer Peak Coincidence Factor for measure = 1

Limelight Night Lights

$$\Delta kWh = ((W_{base} * h_{base}) - (WNL * h_{NL})) * 365 / 1000 * ISR$$

Where:

W_{NL} = Watts per electroluminescent nightlight = 0.03

W_{base} = Watts per baseline nightlight = 1.76

h_{NL} = Average hours of use per day per electroluminescent nightlight = 24

h_{base} = Average hours of use per day per baseline nightlight = 8

ISR = In service rate per electroluminescent nightlight = 78%

The Cadmus team took the baseline fixture wattages and hours-of-use from the FES-L6a CFL and LED Lighting Residential workpaper.

Appendix C. Billing Analysis Regression Details

Table 30. Model 1: ALL PRE/POST DATA - customer fixed-effects + weather + month-year indicators + other programs

Parameter	Parameter Estimate	Standard Error	t-value	Pr > |t|
bill_mo 201101	1.4019357	125660.4	0	1
bill_mo 201102	-1.9929402	125660.4	0	1
bill_mo 201103	-3.5307985	125660.4	0	1
bill_mo 201104	-5.3223325	125660.4	0	1
bill_mo 201105	-5.4796909	125660.4	0	1
bill_mo 201106	-3.2454498	125660.4	0	1
bill_mo 201107	-2.9198324	125660.4	0	1
bill_mo 201108	-1.2198657	125660.4	0	1
bill_mo 201109	-1.3524694	125660.4	0	1
bill_mo 201110	-3.415134	125660.4	0	1
bill_mo 201111	-5.4240912	125660.4	0	1
bill_mo 201112	-3.0644824	125660.4	0	1
bill_mo 201201	15.5755167	125660.4	0	0.9999
bill_mo 201202	-2.3507133	125660.4	0	1
bill_mo 201203	-3.6060351	125660.4	0	1
bill_mo 201204	-5.2638116	125660.4	0	1
bill_mo 201205	-4.2068981	125660.4	0	1
bill_mo 201206	-1.1143618	125660.4	0	1
bill_mo 201207	-3.8173982	125660.4	0	1
bill_mo 201208	-2.009781	125660.4	0	1
bill_mo 201209	0.0780669	125660.4	0	1
bill_mo 201210	-3.5570558	125660.4	0	1
bill_mo 201211	-5.7948527	125660.4	0	1
bill_mo 201212	-3.5454366	125660.4	0	1
bill_mo 201301	-0.5544318	125660.4	0	1
bill_mo 201302	-1.7403705	125660.4	0	1
bill_mo 201303	-2.6552038	125660.4	0	1
bill_mo 201304	-4.4214797	125660.4	0	1
bill_mo 201305	4.6174985	125660.4	0	1
bill_mo 201306	-2.2046621	125660.4	0	1
bill_mo 201307	-0.8935503	125660.4	0	1
bill_mo 201308	0.1592286	125660.4	0	1
bill_mo 201309	1.0399625	125660.4	0	1
bill_mo 201310	-1.0377794	125660.4	0	1
bill_mo 201311	-5.3631273	125660.4	0	1
bill_mo 201312	-2.7148108	125660.4	0	1
bill_mo 201401	1.2153262	125660.4	0	1

Parameter	Parameter Estimate	Standard Error	t-value	Pr > |t|
bill_mo 201402	0.8718922	125660.4	0	1
bill_mo 201403	-1.5607616	125660.4	0	1
bill_mo 201404	-4.1554575	125660.4	0	1
bill_mo 201405	-4.5384687	125660.4	0	1
bill_mo 201406	-0.9259952	125660.4	0	1
bill_mo 201407	0.3269076	125660.4	0	1
bill_mo 201408	-0.6312627	125660.4	0	1
bill_mo 201409	0.223926	125660.4	0	1
bill_mo 201410	-2.4004519	125660.4	0	1
bill_mo 201411	-5.0403712	125660.4	0	1
bill_mo 201412	-1.8059196	125660.4	0	1
bill_mo 201501	0.5119612	125660.4	0	1
bill_mo 201502	-0.6779415	125660.4	0	1
bill_mo 201503	-0.4578307	125660.4	0	1
bill_mo 201504	-3.6599601	125660.4	0	1
bill_mo 201505	-3.4962758	125660.4	0	1
bill_mo 201506	-0.2017373	125660.4	0	1
avghdd	0.5819805	0.0121	48.2	<.0001
avgcdd	2.3769251	0.0333	71.37	<.0001
Free_CFL_Date	0.5026636	0.1329	3.78	0.0002
CFL_special_date	-1.9617197	0.4198	-4.67	<.0001
HEHC_date	-2.141282	0.8671	-2.47	0.0135
LowInc_Weath_date	0.262433	0.9579	0.27	0.7841
PER_OHEC_date	-0.7830002	0.9242	-0.85	0.3969
SmSvr_HVAC_date	-3.6573986	0.4153	-8.81	<.0001
Insul_Seal_date	0.7594219	2.7458	0.28	0.7821
Appl_Recycle_date	-2.6363589	0.6423	-4.1	<.0001
Furnace_Replace_date	-5.4578153	3.2453	-1.68	0.0926
Refrige_Replace_date	9.0665787	4.2099	2.15	0.0313
Property_Mgr_date	0.5381652	1.4156	0.38	0.7038
MyHER_date	-0.3669396	0.1239	-2.96	0.0031
partpost	-0.4597249	0.1939	-2.37	0.0178

Table 31. Model 2. Paired Months: customer fixed-effects + weather + other programs 50% change or less

Parameter	Parameter Estimate	Standard Error	95% Confidence Limits		Z	Pr > |Z|
avghdd_custnorm	0.7189	0.0146	0.6902	0.7475	49.15	<.0001
avgcdd_custnorm	2.9508	0.0963	2.7621	3.1396	30.64	<.0001
Free_CFL_custnorm	0.0964	0.2169	-0.3288	0.5216	0.44	0.6568
CFL_special_custnorm	-1.5348	0.6542	-2.8171	-0.2526	-2.35	0.019
HEHC_custnorm	-2.519	1.2132	-4.8968	-0.1411	-2.08	0.0379
LowInc_Weath_custnor	1.3416	2.4076	-3.3771	6.0603	0.56	0.5774
PER_OHEC_custnorm	-0.2443	1.9056	-3.9792	3.4907	-0.13	0.898
SmSvr_HVAC_custnorm	-1.8478	0.9112	-3.6336	-0.0619	-2.03	0.0426
HVAC_tuneup_custnorm	0	0	0	0	.	.
Insul_Seal_custnorm	-3.4635	1.8815	-7.1512	0.2241	-1.84	0.0656
Appl_Recycle_custnor	-2.4923	1.192	-4.8286	-0.1561	-2.09	0.0365
Furnace_Replace_CUST	-0.793	0.9469	-2.6488	1.0628	-0.84	0.4023
Refrige_Replace_CUST	8.8496	0.9686	6.9511	10.7481	9.14	<.0001
Property_Mgr_custnor	-1.1057	0.7822	-2.6387	0.4273	-1.41	0.1575
MyHER_custnorm	0.6054	0.1514	0.3086	0.9021	4	<.0001
partpost_custnorm	-1.3668	0.1062	-1.575	-1.1587	-12.87	<.0001

Table 32. Other Duke Energy Programs in Ohio

Program Name
Free CFLs
CFL Special
Home Energy House Call
Low Income Weatherization
Personalized Energy Report/Online Home Energy Check
HVAC Tuneup
Smart Saver HVAC
Insulation Sealing
Appliance Recycling
Furnace Replacement
Refrigerator Replacement
Property Manager
My Home Energy Report

References

Itron, Inc., J.J. Hirsch and Associates, Synergy Consulting, and Quantum Consulting. *2004-2005 Database for Energy Efficiency Resources (DEER) Update Study: Final Report*. DEER. 2005. Available online: http://www.energy.ca.gov/deer/

Appendix D. Engineering Analysis Energy Efficiency Home Kit Savings Details

Table 33 presents the Energy Efficiency Home Kit metrics and savings details for the Energy Education in Schools Program.

Table 33. Engineering Analysis Energy Efficiency Home Kit Savings Details

Metric	13W CFL	18W CFL	Energy -Efficient Showerhead	Kitchen Aerators	Bathroom Aerators	Hot Water Temp Card	Lime-light Night Light	Outlet Gasket Insulators	Entire Energy Efficiency Home Kit
Units	Bulb	Bulb	Showerhead	Aerator	Aerator	Change	Light	12 pack	Kit
ISR	88%	83%	31%	35%	24%	9%	78%	7%	
Gross kW Per Unit	0.0035	0.0029	0.0032	0.0043	0.0030	0.0003	0.0000	0.0006	0.0178
Gross kWh Per Unit	26.64	25.14	27.03	16.07	1.48	2.22	3.79	1.37	103.73
Freeridership Rate	51.3%	51.3%	16.0%	0.0%	0.0%	0.0%	0.0%	30.0%	30.1%
Spillover Rate	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%	17.1%
NTG Ratio	65.9%	65.9%	101.2%	117.1%	117.1%	117.1%	117.1%	87.1%	87.0%
Net kW Per Unit	0.0023	0.0019	0.0032	0.0051	0.0035	0.0003	0.0000	0.0005	0.0168
Net kWh Per Unit	17.54	16.56	27.34	18.83	1.73	2.60	4.44	1.19	90.24
Measure Life (Years)*	5	5	10	9	9	2	8	15	7
EUL Net kWh Per Unit	87.72	82.79	273.41	169.47	15.58	5.21	35.50	17.91	645.83

*To calculate overall measure life, the Cadmus team used a weighted average derived from the effective useful lives of the individual Energy Efficiency Home Kit items. We assigned weights based on each item's contribution to gross
kWh savings.

Appendix E. Net-to-Gross Ratio Calculations

The Cadmus team provides this discussion of freeridership and spillover for informational purposes only and not to adjust gross energy impacts to report net savings. As the impact analysis approach compares a customer's electric meter readings before and after the program, impact findings already represent net savings and do not need to be adjusted further. Rather, the freeridership and spillover analysis serves to aid stakeholders in understanding the degree of these influences, which already are incorporated in reported net savings.

As the Cadmus team uses a different approach for estimating freeridership for energy-efficient lighting than for other energy-efficient items, we present freeridership for lighting separately.

Lighting Freeridership

The Cadmus team used a three-step approach to estimate freeridership for CFLs. This approach accounted for the increasing prevalence of LED bulbs, a technology that, until recently, has not been taken into consideration for the purposes of calculating freeridership. This approach based freeridership on responses to questions about the number of CFLs and LEDs in participants' homes prior to the program, whether or not participants would have purchased CFLs or LEDs in the program's absence, and their future purchasing intentions.[16]

Step One: Diffusion of Adoption Curve

A CFL program participant's freeridership score is determined predominantly through their past behavior regarding the technology. As past behavior serves as the best predictor of future behavior, it is assumed that the more CFLs and LEDs customers use in their homes, the more likely they are freeriders. To assess past behavior, the Cadmus group asked survey respondents how many energy-efficient light bulbs (CFLs and LEDs) already were installed in their homes before they received bulbs through the program.[17] As shown Table 34, we mapped their responses to the diffusion of adoption curve shown in Figure 17, with the resulting percentage considered their baseline freeridership levels.

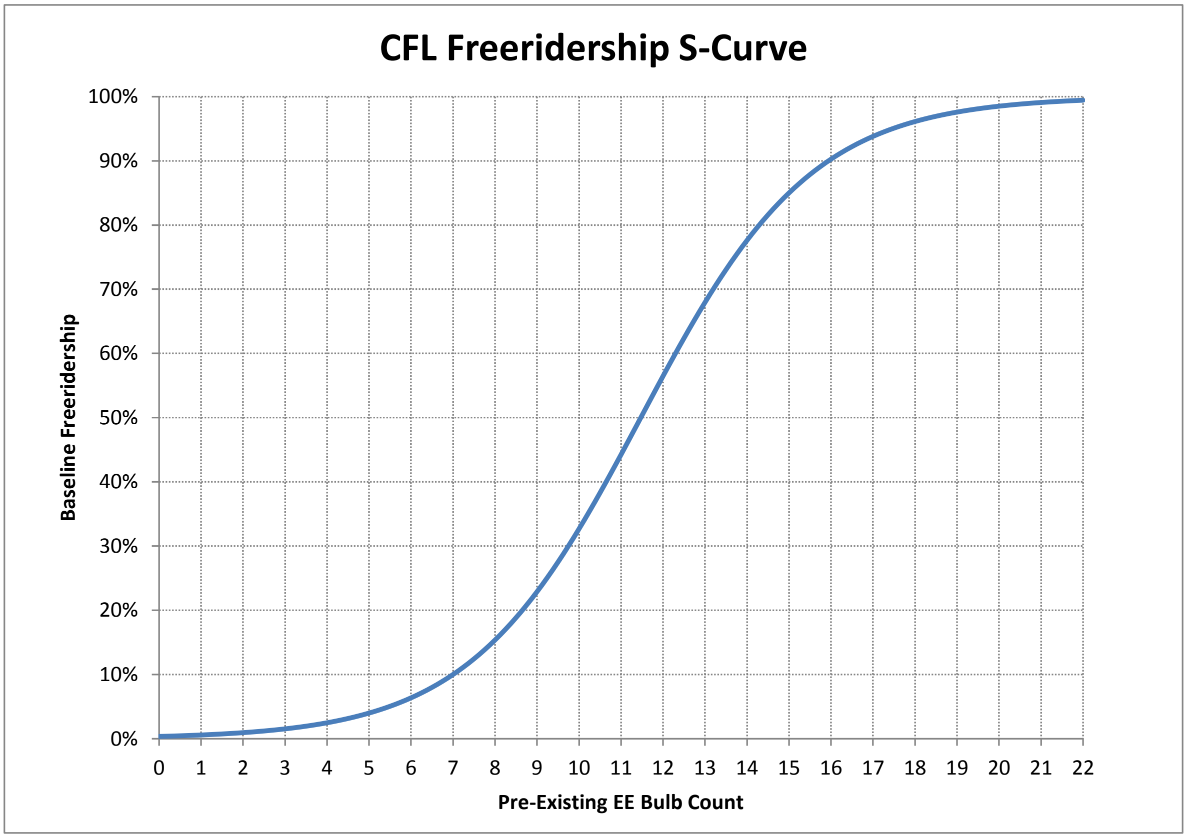
[16] Using participant surveys to assess freeridership is a current and accepted practice in the industry. Please see the Basic Approach method in the "Participant Net Impact Protocol" section of the *California Energy Efficiency Evaluation Protocols*, April 2006. TecMarket Works, et al.

[17] Table 34 presents the same data as in Appendix F. Energy Efficiency in Schools Program Participant Survey, except the table in this section only includes participants who installed CFLs from the Energy Efficiency Home Kits, and missing data have been replaced with median values.

Table 34. Efficient Light Bulbs Installed Before the Program and Baseline Freeridership Score (n=94)

Count of CFLs and LEDS Installed Before the Program	Baseline Freerider Percentage	Number of Respondents
0	0%	12
1	1%	1
2	1%	2
3	2%	2
4	2%	5
5	4%	7
6	6%	5
7	10%	2
8	15%	4
9	23%	1
10	33%	20
11	44%	0
12	56%	4
13	68%	1
14	78%	3
15	85%	9
16	90%	3
17	94%	0
18	96%	5
19	98%	0
20	99%	2
21	99%	0
22 or more	100%	6
Total		94

Figure 17. Diffusion of Adoption Curve for Determining Freeridership



Step Two: Purchasing Intentions Prior to Participation

As behavior changes over time, past purchasing behaviors must to be informed by future purchasing intentions to assess freeridership. While self-reports of future behavior do not prove as reliable a predictor as past behaviors and can be affected by several types of response bias, assessment of freeridership considers purchasing intent.

To accomplish this, the survey asked participants about their purchasing intentions prior to their program participation. If a survey respondent indicated they intended to purchase CFLs and/or LEDs, respondents were asked how many of their next 10 light bulb purchases would be CFL, LED, standard incandescent, or halogen bulbs. Participants were not asked this follow-up question if they had no intention of purchasing energy-efficient bulbs or already had installed them in all available sockets. The decision to move to step three of the analysis follows the logic matrix presented in Table 35.

Table 35. Step Two Decision Matrix, Based on Purchasing Intentions

LEDs → / CFLs ↓	Yes	No	Maybe	No, already installed in all sockets	DK/NS
Yes	Use step 3 multiplier	Use step 3 multiplier	Use step 3 multiplier	Automatic 100%	Use step 3 multiplier
No	Use step 3 multiplier	Multiply by 0.25	Use step 3 multiplier	Automatic 100%	Multiply by 0.25
Maybe	Use step 3 multiplier	Use step 3 multiplier	Use step 3 multiplier	Automatic 100%	Use step 3 multiplier
No, already installed in all sockets	Automatic 100%	Automatic 100%	Automatic 100%	Automatic 100%	Automatic 100%
DK/NS	Use step 3 multiplier	Multiply by 0.25	Use step 3 multiplier	Automatic 100%	Use step 3 multiplier

Step Three: Future Purchasing Intentions

To score future purchasing intentions, each of the three bulb categories (e.g., incandescent/halogen, CFL, LED) was assigned a freeridership adjustment factor (a multiplier), as shown in the example scenario presented in Table 36. Using this configuration, purchasing intent for incandescent or halogen bulbs resulted in a 75% decrease in freeridership, while purchasing intent for CFLs increased the respondent's freeridership by the same percentage. Purchasing intent for LEDs increased freeridership 75% over CFLs, as these respondents were considered ahead of the curve. Once a survey respondent's purchasing intentions had been collected for the next 10 bulbs, a weighted average freeridership multiplier was calculated.

Table 36 represents a scenario in which a respondent indicates they would likely purchase equal amounts of incandescent and CFL bulbs for their next 10 bulbs. The weighted average freeridership multiplier for this participant is shown in bold. This participant's freeridership score then serves as the product of their baseline freeridership and their weighted average freeridership multiplier. As the multipliers of CFL and incandescent bulbs mirror each other, they offset and, ultimately, freeridership remains unaffected. That is, freeridership equals the value from the diffusion of adoption curve shown in Figure 17.

Table 36. Bulb Purchase Intention Multipliers and Example Scenario

Type	Count	Multiplier
Incandescent or Halogen	5	0.25
CFL	5	1.75
LED	0	2.5
Weighted Multiplier		**1.0**

Every participant who installed at least one program-provided CFL was assigned a freeridership score using the approach outlined above.[18] The average of these scores represented the estimate for CFL freeridership, calculated as 51.3%.

Non-Lighting Freeridership

For energy-efficient showerheads, faucet aerators, and outlet gasket insulators, the Cadmus group determined the freeridership level using the responses to three survey questions, shown in Table 37 along with freeridership level applied to the energy savings. Though not shown in the table, all other possible combinations of answers to the series of questions resulted in 0% freeridership.

Table 37. Freeridership Factors for Non-Lighting Energy Efficiency Kit Items

Did you have any [ITEMS] installed before you got the kit?	Were you planning on buying additional [ITEMS] before you got the kit?	Have you purchased any [ITEMS] since you got the kit?	Freeridership Score
Yes	Yes	Yes	1.00
Yes	Yes	No	1.00
No	Yes	No	0.50
No	Yes	Yes	0.50
Don't know	Yes	Yes	0.75
Don't know	Yes	No	0.50
Yes	Already installed in all available sockets	Yes	1.00
Yes	Already installed in all available sockets	No	1.00
Yes	Already installed in all available sockets	Don't know	1.00
Don't know	Maybe	Yes	0.25

18 To calculate a freerider score for every participant, missing data had to be replaced with values derived from the survey results. If a participant could not recall whether they had CFLs or LEDs before the program, they were assigned the median valid response for preinstalled bulbs of that type (six for CFLs and zero for LEDs). If they recalled having a bulb type but could not provide a bulb count, they were assigned the median number of bulbs installed by surveyed participants who installed that type of bulb and who could provide counts (10 for CFLs and five for LEDs). Participants who did not answer questions about future bulb purchase intentions were assigned the average “step three” multiplier value from all valid responses (e.g., 1.79).

Did you have any [ITEMS] installed before you got the kit?	Were you planning on buying additional [ITEMS] before you got the kit?	Have you purchased any [ITEMS] since you got the kit?	Freeridership Score
Yes	Maybe	No	0.25
Yes	Yes	Don't know	1.00
Don't know	Yes	Don't know	0.50
No	Yes	Don't know	0.50

Applying the scores to participants' responses to questions about energy-efficient showerheads, faucet aerators (combined), and outlet gasket insulators (combined) yielded the overall freeridership scores for each item, shown in Table 38.

Table 38. Freeridership for Showerheads, Aerators, and Outlet Gasket Insulators

Measure (n=participants installing)	Number of Participants with Freeridership	Freeridership %
Energy-efficient showerhead (n=36)	7	16.0%
Faucet aerators (n=43)	3	0.0%*
Outlet gasket insulators (n=20 on outside walls)	7	30.0%

*The Illinois TRM uses a common practice approach to defining the baseline condition: average measured flow rates used as the baseline reflect the penetration of previously installed efficient fixtures, use of the faucet at less-than-rated flow, debris buildup, and lower-than-rated water system pressure. Therefore, this measure has a freerider rate of zero.

Validity and Reliability of the Freerider Estimation Approach

The basic freeridership assessment approach, as specified in the California Evaluation Protocols, requires the construction of questions that allow the evaluation contractor to estimate the freeridership level. This evaluation's approach, based on the results of a set of freerider questions incorporated into participant survey instruments, examined how the program impacted a customer's acquisition and use of energy-efficient items in their home. A freeridership factor was allocated for each type of response contained in the survey questions. The allocation approach assigned high freeridership values to participants who would have acquired energy-efficient items on their own, with that factor influenced by their past purchasing behaviors and their stated future intentions.

Spillover Estimation

The evaluation measured spillover for the program's Energy Efficiency Home Kit portion by asking participants if, due to their program participation, they installed additional energy-efficient measures akin to those they received through the Energy Efficiency Home Kit. If respondents indicated they made energy-efficient improvements and/or purchased and installed products similar to those in the Energy Efficiency Home Kit, the survey asked how influential they deemed the program on their purchasing decisions. Participants could choose from a 0 to 10 rating scale, where 0 meant "not at all influential" and 10 meant "extremely influential." Participants who awarded a rating of 9 or 10 had 100% of estimated spillover measure savings attributed to the program. Participants who awarded a rating of 6, 7, or 8 had 50% of estimated spillover measure savings attributed to the program, while any measures awarded a rating under 5 did not receive attribution towards the program.

Table 39 shows the quantities, per-unit kWh savings estimates, and total calculated spillover savings attributed to the program. The spillover percent estimate was calculated by dividing the survey sample spillover kWh savings by the survey sample gross program kWh savings. The Cadmus team estimated overall spillover for the program's Energy Efficiency Home Kit portion as 17.1% of the survey sample gross program savings.

Table 39. Spillover for Energy Efficiency Home Kit Items

Spillover Measure	Quantity	Per Units kWh Savings	Total Spillover kWh Savings	Total Survey Sample Program kWh Savings	Spillover %
CFLs	77.75	25.89	2,012.71	12,241*	16.4%
Energy-efficient showerhead	2.0	27.03	54.05		0.4%
Faucet aerators	1.5	8.78	13.16		0.1%
Outlet gasket insulators	13.0	1.37	17.81		0.1%
Overall	**N/A**	**N/A**	**2,098**	**12,241***	**17.1%**

*Survey sample program kWh savings do not include behavior savings; they only include Energy Efficiency Home Kit measure savings. The behavior savings estimate portion of the program includes any "non-like" program measure spillover activity.

Appendix F. Energy Efficiency in Schools Program Participant Survey

This appendix to be provided separately for the draft report.

Appendix G. Energy Efficiency in Schools Program Participant Survey Frequency Tables

This appendix to be provided separately for the draft report.

APPENDIX H-

Residential Energy Assessments Program Evaluation

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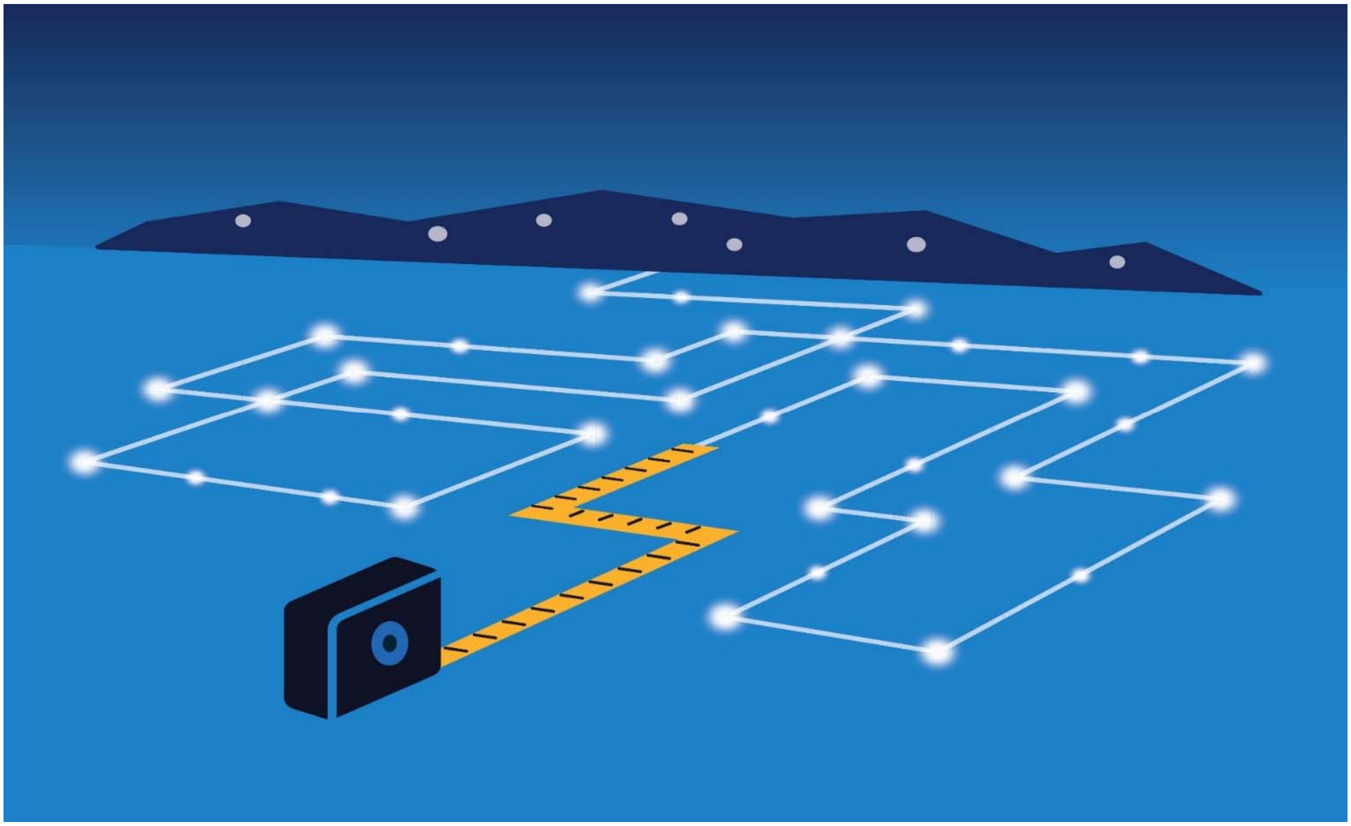

Duke Energy Ohio

Residential Energy Assessments Program
2014 Evaluation Report

November 30, 2015

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1. Evaluation Summary

1.1 Program Summary

Duke Energy Ohio's (DEO) Residential Energy Assessments (REA) program is a home assessment program that provides customers with a customized energy report with low and no-cost recommendations to help lower energy bills. Customers receive an energy efficiency starter kit that contains three CFLs and other lower-cost measures, such as a low-flow shower head, faucet aerators, weatherstripping, and outlet seals, which the energy specialist (or auditor) who performs the assessment can install free of charge. Auditors also encourage behavioral change and inform customers of higher-cost energy-saving investments, such as a new HVAC system or energy-efficient appliances.

The REA program targets owner-occupied, single-family residences. The program relies on several marketing and outreach tactics, including radio advertising, email and digital marketing, and direct mail. Opinion Dynamics conducted an evaluation of the effectiveness of the REA program. Our evaluation includes information from 2,896 program participants in 2014. The evaluation also includes information from 831 REA program participants from the fall of 2013 (August–December). For brevity, we refer to fall 2013 and all 2014 participants collectively as 2014 participants.

1.2 Evaluation Objectives and High-Level Findings

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

- Verify the accuracy of deemed savings estimates and in-service rate (ISR) assumptions
- Estimate energy and coincident demand savings at the measure level
- Estimate energy and coincident demand energy savings using monthly billing data
- Assess the likelihood that participants would have installed program measures had the energy efficiency kit not been provided
- 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
- Identify participants' sources of program information
- Determine how much customers are willing to pay for the assessment and kit
- Estimate the level of customer knowledge about energy efficiency in the home
- Determine participants level of satisfaction with the various program components
- Determine the effectiveness of the program implementation and data tracking practices

To achieve these research objectives, Opinion Dynamics completed a number of data collection and analytic activities, including an interview with a program staff member, participant and general population surveys, analysis of the survey results, analysis of program-tracking data, a deemed savings review, an engineering analysis, and a billing analysis. Through the primary data collection, the evaluation team developed estimates of ISRs and a net-to-gross ratio (NTGR).

Table 1-1 presents the gross impacts for each of the measures in the kit and for additional CFLs participants have received[1] based on our engineering analysis.

Table 1-1. Gross Impact Results from Engineering Review

Measure Type		Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	% of Total kWh
Energy Efficiency Starter Kit	13W CFLs (2)	77	0.0083	0.0066	27%
	20W CFL (1)	39	0.0042	0.0034	14%
	Faucet Aerators (2)	14	0.0015	0.0015	5%
	Low-Flow Shower Head (1)	26	0.0028	0.0028	9%
	Weatherstripping and Outlet Seals	7	0.0014	0.0047	2%
Additional CFLs	Average of 3.2 CFLs per home	124	0.0130	0.0110	43%
Total		286	0.0318	0.0300	100%

Table 1-2 presents the net savings results of our billing analysis, which includes savings from the kit measures and additional CFLs, as well as savings from the assessment recommendations and any behavioral changes and participant SO attributable to the program. These savings are significantly greater than estimates from the previous evaluation. Although the methods used for this evaluation are substantially different from those used before, we can say with confidence that much of this increase in savings is due to improved performance from the program.

Table 1-2. Net Program Impact Results from Billing Analysis

		Ex Ante Net Savings (kWh)	
	N	Average Daily Savings	Average Yearly Savings
Program Savings	3,356*	2.67	975
Previous Evaluation**	3,474	1.74	634

* We received billing data for 3,709 Fall 2013–2014 participants; 3,356 participants were included in final billing model.
** Results are from the April 2013 *Process and Impact Evaluation Report of the Residential Energy Assessments Program in Ohio* by TecMarket Works. The evaluation covered participants from April 2011 to June 2012.

Table 1-3 gives both gross and net program level savings for REA participants in calendar year 2014. Gross savings estimates relate only to installed measures from the Energy Efficiency Starter Kit, while savings from the billing analysis account for the reduced energy consumption associated with improvements made due to assessment recommendations, SO, and behavioral changes, in addition to the kit measures. The difference between the two estimates is representative of the impact of the program's educational components and of the ability of the auditors to influence participants to make additional home energy improvements.

[1] Customers are eligible to receive a total of 15 CFLs per home, between the starter kit and additional free CFLs. On average, 2014 participants received 3.2 additional CFLs per home.

Table 1-3. Annual Evaluated Gross and Net Program Savings

Savings Type	Evaluated Gross Savings (Engineering Analysis)	Evaluated Net Program Savings (Billing Analysis)
Energy savings (kWh)	1,033,872	2,823,600
Summer coincident demand savings (kW)	130	356
Winter coincident demand savings (kW)	125	339

Based on results from the participant survey, we estimated a program NTGR of 0.89 and measure in-service rates ranging from 0.29 for faucet aerators to 0.69 for CFLs.Table 1-4 presents these estimates and their relative precision. We aimed to achieve a relative precision of 10% with 90% confidence; however, for a few measures, we were unable to achieve this target due to low installation rates amongst surveyed participants.

Table 1-4. NTGR and ISR Results and Relative Precision

	NTGR	ISR				
		CFLs	Faucet Aerators	Low-Flow Shower Head	Outlet Seals	Weather stripping
Sample size (n)	154	164	144	155	138	149
Estimate	89%	0.69	0.29	0.32	0.50	0.53
Relative Precision (at 90% Confidence)	4%	8%	16%	6%	12%	6%

Over the past few years, the REA program has fallen short of its participation goal of 3,422 per year. However, the program has been increasing participation each year, and, in 2014, the program had 2,896 participants. Based on our billing analysis, overall and per-home evaluated savings for the program increased substantially compared to the previous evaluation.

1.3 Evaluation Recommendations

Based on our evaluation, Opinion Dynamics has the following recommendations for the program. More details on each recommendation are provided throughout the report and particularly in Section 7.

- Ensure that contractors install all possible measures from the kit to improve installation rates and increase savings.
- Continue offering the "Home Energy House Call" at no cost, but consider including additional diagnostic tests for a fee.
- Implement reminder emails or follow-up calls to improve uptake of assessment recommendations.
- Conduct research to determine what, if any, additional lighting measures the program could provide to increase savings.
- Collect additional primary data, during the assessment, to aid with engineering estimates, such as average removed bulb wattage and share of homes with electric hot water heaters and central air conditioning.

2. Program Description

Duke Energy Ohio's (DEO) Residential Energy Assessments (REA) program is a home assessment program that provides customers with a customized energy report with low and no-cost recommendations to help lower energy bills. The program targets owner-occupied, single-family residences, relying primarily on direct mailings for marketing and outreach.

2.1 Program Design

The REA program has two main components. The first component is the home energy assessment, branded to customers as the "Home Energy House Call" (HEHC). During the assessment, energy specicialists (auditors) enter participant homes and inspect a number of items, 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., adding insulation or draft proofing, 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 given to the customer in hopes that they will follow them and thus save more energy.

The second component is the free kit of low-cost energy-efficient measures. The Energy Efficiency Starter Kit includes three CFLs, two faucet aerators, a low-flow shower head, outlet seals, and weatherstripping. Customers may also receive up to 12 additional CFLs (a limit of 15 free CFLs is imposed on customers across all Duke Energy energy efficiency programs). If a participant has not received any free CFLs from DEO, s/he is eligible to have the full 12 additional CFLs installed by the assessment contractor; otherwise, s/he may receive only the number of CFLs such that the total number of free CFLs does not exceed 15.

DEO tracks the date of the assessment, the recommendations of the contractor, and the number of additional CFLs given to the customer in its program tracking databases.

2.2 Program Implementation

For the 2014 program year, DEO contracted with Wisconsin Energy Conservation to implement the REA program. According to our interview with the program staff member, no fundamental changes were made to the program between 2013 and 2014. Some improvements were made on the back end in attempts to streamline communication and processing.

3. Key Research Objectives

This evaluation includes a process analysis, a net-to-gross (NTG) analysis, and an impact analysis. The key research objectives of this evaluation were to:

- Verify the accuracy of deemed savings estimates and in-service rate (ISR) assumptions
- Estimate energy and coincident demand savings at the measure level
- Estimate energy and coincident demand energy savings using monthly billing data
- Assess the likelihood that participants would have installed program measures had the energy efficiency kit not been provided
- 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 Identify participants' sources of program information
- Determine how much customers are willing to pay for the assessment and kit
- Estimate the level of customer knowledge about energy efficiency in the home
- Determine participants level of satisfaction with the various program components
- Determine the effectiveness of the program implementation and data tracking practices

4. Overview of Evaluation Activities

The evaluation of the 2014 REA program leveraged the following data collection methods and research activities:

- Program staff interviews (n=1)
- Program materials review
- Participant survey (n=164)
- General population survey (n=435)
- Net-to-gross (NTG) analysis
- Gross impact analysis using engineering analysis
- Net impact analysis using billing analysis

Below we provide an overview of the methods used in each of these activities.

4.1 Program Staff Interviews

We conducted an in-depth interview with the current REA program manager. 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 in 2014.

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. Our analysis did reveal some data quality issues with the program tracking and billing databases. However, DEO staff were able to resolve all issues and to provide replacement or additional data when necessary.

4.3 Participant Survey

Opinion Dynamics implemented a computer-assisted telephone interviewing survey with 2014 HEHC participants in July 2015. The average length of the interviews was slightly over 21 minutes. Respondents were compensated for their time with a drawing for five $100 gift cards. The survey gathered data to develop measure-level estimates of installation and persistence rates, to estimate the program NTGR, and to support our process evaluation.

Sample Design

The survey sample design and sample size were based on customers who participated during calendar year 2014. Of the 2,896 participants in the database, we were able to use 1,790 valid telephone numbers from which to complete 164 participant telephone surveys. To meet precision targets for measure-level analyses (free-ridership and installation rate), the evaluation team set quotas for each measure. The quota was set at 65 to ensure that analyses meet the industry-standard two-tail 90/10 criterion in terms of sampling error at a measure level. This means that we would be 90% confident that our results are within 10% of the true value in the population.

4.4 General Population Surveys

Opinion Dynamics completed a survey with a sample of DEO customers. The survey was completed as part of the DEO Appliance Recycling Program (ARP). The goal of that survey was to identify customers who recently disposed of eligible appliances through means other than the ARP. The survey contained a separate module of questions pertaining to the REA program. To minimize the survey length, respondents who had disposed of an appliance without participating in the ARP did not receive the REA program module. We also applied survey weights, based on survey mode (phone/web) and home ownership, to correct for differences between the survey sample and the DEO population.

The REA question set explored assessment-specific topics, such as knowledge about saving energy in the home, barriers to saving energy in the home, awareness of HEHC, and the level of interest in having a free assessment.

Sample Design and Fielding

The survey was fielded via telephone and online. DEO provided a random sample of 50,000 customers. We emailed customers invitations to complete the survey online and sent out two email reminders. We called customers without email addresses and completed the survey over the telephone. We fielded the general population survey between June 10, 2015 and July 30, 2015, contacting a total of 4,442 customers; 435 completed the REA program module.

Table 4-1. General Population Survey Sample Sizes and Number of Completed Interviews

	Sample Size	Total Number of Interviews	Total Number of Interviews with REA Program Module Completed
General population survey	4,442	469	435

5. Impact Evaluation

5.1 Methodology

5.1.1 Engineering Analysis

As part of our impact evaluation, Opinion Dynamics conducted an engineering analysis for each item contained in the REA program kits. The purposes of the engineering estimates are 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 Draft Ohio Technical Reference Manual[2] (TRM) 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. Additional details and information on the engineering analysis are provided in Appendix E.

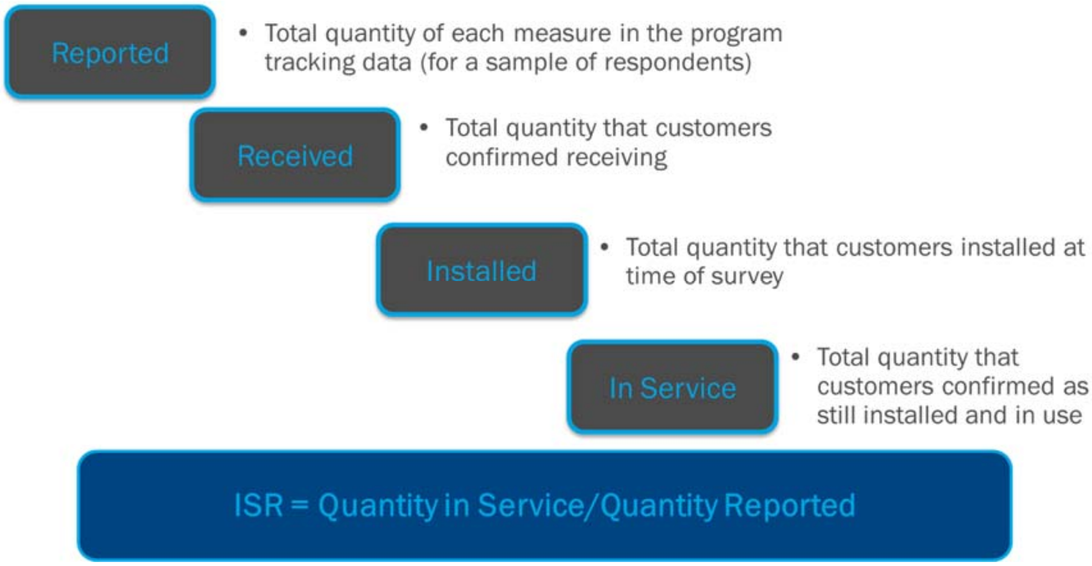
It should be noted that the billing analysis determines actual energy (kWh) impacts for the program; this engineering analysis only supplements the billing analysis for the aforementioned reasons.

Installation Verification and Persistence

As part of the participant survey effort, we verified measure installation and persistence to obtain measure-level in-service rates (ISRs). Our engineering estimates use these values in calculations for annual per-customer savings. 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.

[2] State of Ohio Energy Efficiency Technical Reference Manual. August 6, 2010.

Figure 5-1. Installation Rate Components



5.1.2 Billing Analysis

Opinion Dynamics conducted a billing analysis to determine the overall ex post net program savings of the REA program. Our billing analysis used 2014 participants as the treatment group. Our method requires post-installation electricity usage data for at least 6 months after participation. The comparison group consists of households that participated in REA in 2015. The comparison group helps us adjust the baseline for non-program influences, especially those representing self-selection into the program, for the treatment group (2014 participants) in the post-program period. As such, results from the billing analysis are net results and application of a NTGR is inappropriate.

Our billing analysis model is a linear fixed effects regression (LFER) model, which utilizes individual “dummy” variables to indicate participation in the REA and other DEO programs. The model also allows controls for all household factors that do not vary over time using individual constant terms in the equation. This includes such things as square footage, appliance stock, habitual behaviors, household size, and many other factors.

To improve our estimate of the baseline (what 2014 participants would have done during the post-program period absent the program), we included dummy variables for each month of the evaluation period. The monthly dummy variables provide information on time trends that appear across all customers, both treatment and comparison. We entered weather terms in the model, as well as interaction terms between weather and the post-program period for the treatment group, to account for differences in weather across years.

Billing analyses, using an appropriate comparison group, incorporate the effects of both FR and SO, thus providing program net savings. For example, the energy use patterns of the members of the comparison group during 2014 (their pre-participation period) reflect equipment installations and behavioral changes that treatment group participants might have performed in the absence of the program. In addition, any measures installed during the evaluation period beyond program measures (SO) would be picked up by an increased coefficient for the participation variables. Table 5-1 shows the final number of accounts from each group that was included in billing analysis.

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

	Year	Participants in Tracking Data	Accounts Removed	Accounts in Model
Treatment Group	2013	829	90	739
	2014	2,896	279	2,617
Comparison Group	2015	1,537	82	1,455

Opinion Dynamics used the billing analysis to determine the overall program energy savings. We did not investigate measure-level savings of the basic kit (Energy Efficiency Starter Kit), as the actual installation of the individual measures was not tracked by the program. The number of additional CFLs is included in the model to estimate savings associated with those bulbs.

5.2 Engineering Analysis Results

This section provides deemed energy and demand savings estimates for each item contained in the REA program efficiency kits.

The evaluation found relatively low ISRs for most measures included in the kit. Given findings from the participant survey, we know that auditors often do not install kit measures during the assessments. To improve the ISRs of measures from the Energy Efficiency Starter Kit, DEO should work with implementers to ensure that auditors install all possible measures. We applied measure-level ISRs, shown in Table 5-2, when calculating engineering gross impacts.

Table 5-2. In-Service Rates

Measure	Installation Rate	Persistence Rate	In-Service Rate
CFLs	0.75	0.92	0.69
Faucet Aerators	0.3	0.96	0.29
Outlet Seals	0.5	1	0.5
Low-Flow Shower Head	0.37	0.89	0.33
Weathers stripping[3]	0.53	–	–

Table 5-3 shows a breakdown of estimated energy and demand savings across the various measures included in the kits. In addition, the program reported 9,194 additional CFLs distributed to customers through the assessments. There was an average of approximately three CFLs per household, in addition to the CFLs contained in the kit. The estimated energy savings for these additional CFLs is also included in Table 5-3. As expected, the lighting portion of the kit and the additional CFLs accounted for approximately 90% of the energy savings for each household as a result of this program. These energy-savings estimates include ISRs developed based on responses to the participant survey.

[3] ISR was not calculated for weather stripping, because we did not ask participants if the weather stripping was still installed at the time of the survey. Gross savings calculations for this measure utilize the installation rate in place of ISR, and as such may represent marginally inflated savings.

Table 5-3. Engineering Gross Impact Results

Measure Type	2012*		2014		
	Energy Savings (kWh)	Summer Coincident Demand (kW)	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
13W CFL (two bulbs)	133	0.013	77	0.0083	0.0066
20W CFL (single bulb)	56	0.0065	39	0.0042	0.0034
Low-flow shower head (1)	30	0.0033	26	0.0028	0.0028
Faucet aerators (2)	4	0.00004	14	0.0015	0.0015
Weatherstripping and outlet seals	10	0.0033	7	0.0014	0.0047
Total kit only	232	0.026	162	0.018	0.019
Additional CFLs	153	0.016	124	0.013	0.011
Total per home estimate	385	0.042	286	0.032	0.030

* 2012 impact results are from April 2013 Process and Impact Evaluation Report of the REA program in Ohio by TecMarket Works. The 2012 evaluation covered participants from April 2011 to June 2012. All values include ISR.

Using the estimated savings from Table 5-3, we can calculate an overall kW per kWh savings ratio from the engineering analysis. Table 5-4 displays three different ratios: one for the kit only, one for the kit plus additional CFLs, and one for the kit plus additional CFLs and SO (see discussion of spillover in Section 6). We applied the ratio that included the kit, the additional CFLs, and SO to the billing analysis energy savings to estimate demand savings.

Table 5-4. Demand to Energy Engineering Ratios

Contents	Total Gross Energy Savings (kWh)	Total Gross Summer Coincident Demand Savings (kW)	Total Gross Winter Coincident Demand Savings (kW)	Ratio Multiplier (summer demand ÷ energy savings)	Ratio Multiplier (winter demand ÷ energy savings)
Kit + additional CFLs + SO	356	0.045	0.043	0.00013	0.00012
Kit + additional CFLs	286	0.032	0.030	0.00011	0.00010
Kit only	162	0.018	0.019	0.00011	0.00012

5.3 Billing Analysis Results

The regression model results in Table 5-5 show a reduction in electricity use after participants received their energy assessment from the REA program, controlling for weather, time, and the household characteristics (reflected in the constant term). Additional CFLs received during the assessment did not have any significant effect on the participant's consumption. These results reflect savings associated with kit measures, assessment recommendations, SO, and potential behavioral changes from energy efficiency knowledge gained during the assessment. The effects of these other non-measure program factors likely wash out any marginal effect from an additional CFL.

Table 5-5. Final LFER Model Results

Predictor	Coefficient	Robust Standard Error	T	P > |t|	90% Confidence Interval	
					Lower	Upper
REA	−5.7031	0.5261	−10.84	0.00	−6.7345	−4.6718
Additional CFLs	−0.0226	0.0356	−0.63	0.53	−0.0924	0.0473
MyHER	−0.1246	0.1896	−0.66	0.51	−0.4964	0.2472
Free CFL	−0.1282	0.2033	−0.63	0.53	−0.5267	0.2703
Low−Income Weatherization	−0.7364	0.7430	−0.99	0.32	−2.1931	0.7202
Smart $aver HVAC	−2.7306	0.5667	−4.82	0.00	−3.8415	−1.6197
Cooling Degree Days (CDD)	−0.0285	0.0080	−3.55	0.00	−0.0442	−0.0127
Heating Degree Days (HDD)	0.0000	0.0010	0.01	0.99	−0.0020	0.0020
Post-CDD	0.0579	0.0068	8.53	0.00	0.0446	0.0713
Post-HDD	0.0037	0.0009	3.89	0.00	0.0018	0.0055
Constant	−5.9099	11.669	−0.51	0.61	−28.787	16.967

Daily savings for the program are estimated by combining the effect of the post-program period weather interaction terms with the coefficient for REA. The value of the estimate represents the kWh change in average daily consumption (ADC) given a one-unit change in the treatment effect, e.g., treatment moving from 0 (pre-treatment) to 1 (post-treatment). The savings estimated here can be extrapolated to the overall net program savings for 2014 REA participants.

Table 5-6. Adjusted Estimate of the REA Program Effect on Daily Consumption

ADC	Estimate	Standard Error	T	P > |t|	90% Confidence Interval	
					Lower	Upper
(1)	−2.670183	0.2472088	−10.8	0	−3.076884	−2.263482

The adjusted estimate seen in Table 5-6 represents the average change in daily energy usage due to a customer participating the REA program. This daily savings of 2.67 kWh can then be extrapolated to give an annual savings estimate of 975 kWh per participant.

5.4 Program Savings

We estimated that the program realized 975 kWh of yearly savings for participants during the evaluation period. Table 5-7 shows that savings increased significantly from the previous evaluation (634 kWh). There are a number of differences between the model used here and the one from the previous evaluation. While both evaluations use LFER models, we account for weather and usage patterns differently. In the previous evaluation, average temperature and humidity were interacted with the time-series variables, and no terms were included to account for differences between the treatment and comparison groups' usage patterns. Since neither evaluation used a perfectly matched comparison of non-participants, these differences need to be addressed.

Table 5-7. Annual Savings from 2014 Billing Analysis

	N	Ex Ante Net Savings (kWh)	
		Average Daily Savings	Average Yearly Savings
Program Savings	3,356*	2.67	975
Previous Evaluation	3,474	1.74	634

* Fall 2013–2014 participants.

In this analysis, Opinion Dynamics includes weather terms[4] for each billing period, and adds an interaction between weather in the post-program period to account for changes in usage that may be attributable to weather fluctuations after participation. To address the differences in usage between treatment and comparison groups, as well as to account for changes in season usage in the pre-program period, we include time-series interactions with pre-program period, summer pre-program period, and winter pre-program period, These specifications allow us to state, with greater accuracy, that the savings seen with the model are attributable to participation in the REA program and are not due to changes in weather or differences between customers.

Opinion Dynamics's evaluation resulted in higher program energy savings than observed in the prior evaluation of the program. While some of the differences may be associated with differences in the methods and models used, we believe that the REA program has been able to increase the savings per participant over the past few years. When Opinion Dynamics attempted to mimic the model used in the previous evaluation, we found that the coefficient for participation in the program was similar to our model, despite other differences. This provides further evidence that the program is performing well.

As seen in Table 5-8, savings from our engineering analysis are much smaller in comparison to the billing analysis results. Major differences in the estimated savings from these analyses are expected, but do require some explanation. A detailed review of deemed measure-level savings, and engineering analysis of impacts for measures installed, gives insight into the savings attributable to the Energy Efficiency Starter Kit, the additional CFLs that can be included, and participant spillover. These savings, however, are only a portion of the savings that the program can influence.

Table 5-8. Comparison of Evaluated Annual Program Savings

Evaluation Method	Participant Savings			Program Savings		
	Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Billing Analysis	975	0.123	0.117	2,823,600	356	339
Engineering Analysis	357	0.045	0.043	1,033,872	130	125

We utilize the billing analysis in conjunction with engineering estimates for the combined effect of all program components. While engineering estimates relate only to installed measures from the kit and extra CFLs, savings estimated through the billing analysis account for the reduced energy consumption associated with

[4] As noted above, our weather terms are in the form of HDD and CDD. This method is calculated on a daily level, and aggregated monthly, making it more accurate in assigning temperature effects to usage given that most billing periods do not align with calendar months.

improvements made due to assessment recommendations, SO, and behavioral changes, in addition to the kit and extra CFL measures. The difference between the two estimates is primarily the savings associated with the auditor recommendations and any behavioral changes.

6. Net-to-Gross Analysis

6.1 Methodology

Our participant survey included a NTG module to determine both program and measure-level NTG ratios (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. The NTGR consists of FR and 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. Free-ridership (FR) scores represent the percent of savings that would have been achieved in the absence of the program. We categorize participants who state 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 (e.g., the program accelerated the installation) or quantity (e.g., the program led to the installation of additional measures). Through the participant survey, we asked program participants a series of structured and open-ended questions about the influence of the program on their decision to participate in the program. 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 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 6 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, without receiving them for free through the program.

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.

Table 6-1 presents the number of completed FR question-sets for each measure.

Table 6-1. Free-Ridership Quotas

Measure-Level Free-Ridership	Quota	Completed
CFLs	65	164
Faucet Aerators	65	66
Low-Flow Shower Head	65	50
Outlet Seals	65	76
Weatherstripping	65	79
Total Number of Interviews Completed		164

We calculated the FR rate per the algorithms presented in Appendix H.

6.1.2 Spillover

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. 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 spillover (SO) among program participants. To qualify for program-induced SO, we asked two main questions:

- Did the participant make any additional improvements (or changed their behavior) to reduce household energy consumption since beginning participation in the program?
- If the respondent indicates making additional improvements (or changing behaviors), how would they rate (on a scale from 0 to 10) how much experience with the program influenced 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.[5] 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 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 evaluated gross savings achieved by the sample of participants who received SO questions.

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

6.1.3 NTGR

To calculate measure-level NTGRs we combined the FR and SO rates using the following equation

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

6.2 NTG Results

This section presents our estimates of FR, participant SO, and the resulting NTGR. Quantifying savings from non-participant SO activities is a challenging task, which would warrant a separate study and was outside of the scope of this evaluation effort. 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 reliably be attributed to the program.

Table 6-2 shows FR and SO estimates. Appendix C of this report contains the participant survey instrument, which includes the questions used in our algorithms. Appendix H provides a detailed overview of the FR and

[5] We attribute SO to those respondents who gave a rating of 7 or higher on our program influence question. We base our SO threshold on spillover research currently being conducted for the California Public Utilities Commission. Our research indicates that there is a bimodal distribution of program influence scores, with respondents clustering both at 0 and at 7 or greater.

SO algorithms. We estimate FR to be 36% and SO to be 25%. The resulting NTGR for DEO for the evaluation period is 89%.

Table 6-2. NTGRs by Measure Category

NTGR Component	FR	SO*	NTGR
Program Overall	0.36	0.25	0.89
Assessment	0.04	0.25	1.21
CFLs	0.53		0.72
Faucet Aerators	0.15		1.10
Low-Flow Shower Head	0.21		1.04
Outlet Seals	0.21		1.04
Weatherstripping	0.41		0.84

* We did not differentiate SO between end use as data were not available at that level.

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. In all, 27 unique participants qualified for SO out of the survey sample of 164 participants. The total breakdown of SO savings from these participants is shown in Table 6-3. We estimated a SO rate of 25% by taking the total SO from survey participants in Table 6-3 (i.e., 11,529 kWh) and dividing it by the total engineering savings from survey participants (46,960 kWh).[6]

Table 6-3. Engineering Spillover Summary

Measure Type	Quantity of Measure Type	Total Energy Savings (kWh)	Total Coincident Demand Savings (kW)	Source of Savings
Clothes Washers	4	808	0.1120	Ohio TRM
Dishwashers	5	39	0.0041	No equation in Ohio TRM; used Illinois TRM
Refrigerators	5	602	0.1067	Ohio TRM
Room Air Conditioners	1	19	0.0240	Ohio TRM
Central Air Conditioners	8	1,226	0.8786	Ohio TRM
Additional CFLs	86	3,318	0.3607	Engineering calculations from REA program (see Appendix E)
Additional LEDs	116	5,276	0.6167	Engineering calculations from DEO Low-Income program
Faucet Aerators	1	7	0.0008	Engineering calculations from REA program (see Appendix E)
Low-Flow Shower Heads	4	103	0.0113	Engineering calculations from REA program (see Appendix E)
Window Replacements	6	132	0.0567	Ohio TRM
Total		11,529	2.1716	

[6] Total engineering savings of participants is calculated by multiplying the average engineering savings per home (i.e., 286 kWh) by the total number of survey participants (i.e., 164). Note numbers are rounded.

7. Process Evaluation

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

- What are participants' sources of program information?
- How much are customers willing to pay for the assessment and the kit?
- How effective are the program's marketing, outreach, and educational tactics?
- What is the level of customer knowledge about energy efficiency in the home?
- Are participants satisfied with their program experiences?
- What are the strengths and weaknesses of the program and what are the opportunities for program improvement?
- What are customer preferences and purchase behaviors for home energy assessments?
- How effective are the program implementation and data tracking practices?
- What is the program reach? What percentage of DEO's customer base has participated in the program? What are the differences between participants and non-participants?

7.1 Methodology

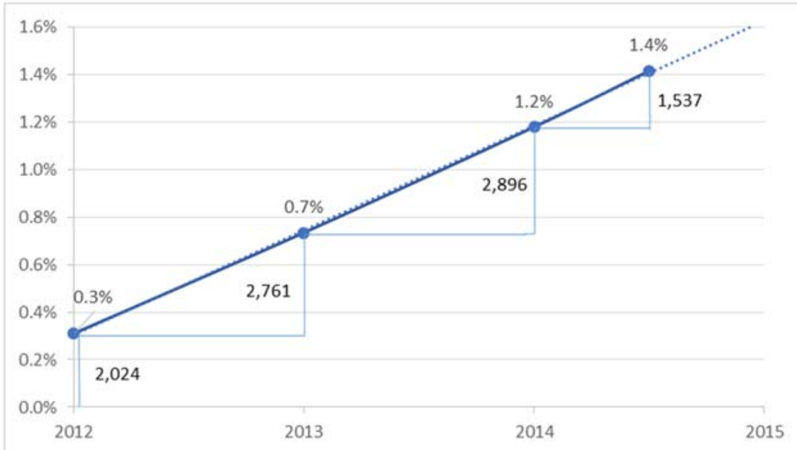
Our process evaluation primarily relied upon our interviews with program staff, review of program materials and participation data, participant survey, and general population survey. Each of these activities are described in Section 4 *Overview of Evaluation Activities*.

7.2 Process Evaluation Results

Program Participation

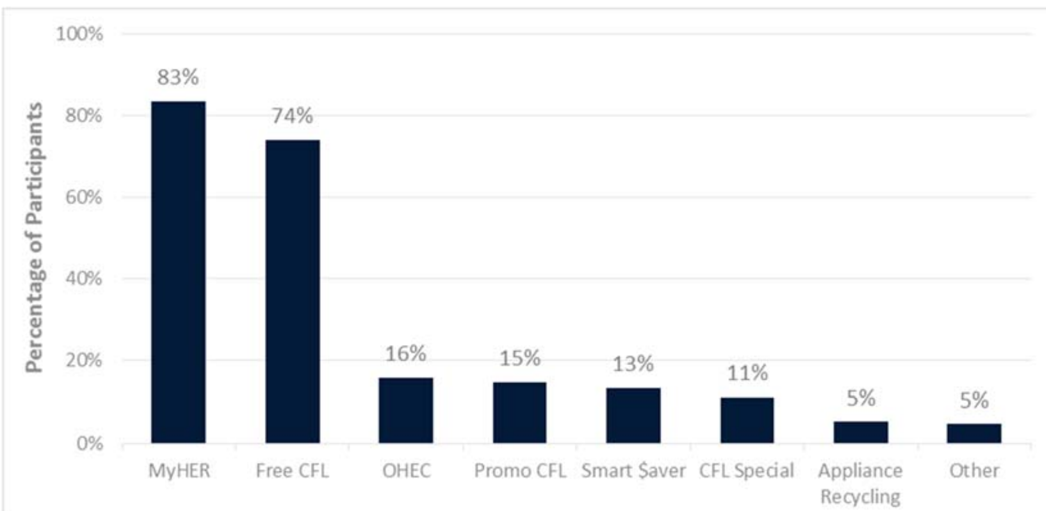
Increasing program participation is one of the main challenges facing the REA program. According to the REA program manager, the program has annual participation goals of 3,422. The program has not yet achieved its annual goals; however, participation in the program has been increasing steadily as shown in Figure 7-1. With 2,896 participants in 2014, DEO's REA program had its best year for participation thus far.

Figure 7-1. Participation Trend as Percentage of Customer Base



Increases in program participation may arise from additional channeling from other DEO programs. In the participant-tracking data we found that many REA customers have participated in other DEO programs. The most common are the MyHER and Free CFL programs.

Figure 7-2. Participation in Other Duke Energy Ohio Programs



Measure Installations

Given the very low installation rates that we found for kit measures, DEO could realize additional program savings by ensuring that auditors install as many measures as possible. The standard program practice is for the auditor to install each kit measure, unless he or she has concerns about the installation (e.g., conditions are dangerous or he or she risks damaging something during installation). However, results from our participant survey showed that auditors tended to leave kit measures behind for homeowners to install, More than 80% of respondents stated that they installed certain measures themselves, and a number of respondents who did not install some or all of those measures went further to say that they wished that the auditor had installed the measures during the assessment. The rate of measure installation by households is shown in Table 7-1.

Table 7-1. Rate of Measure Installations

Measure from Kit	Percent of Households That Installed Measure
CFLs	87%
Faucet Aerators	40%
Low-Flow Shower Head	35%
Outlet Seals	46%
Weatherstripping	48%

One reason that not all measures are being installed could be due to customers not wanting certain measures. However, we also found that some customers would have preferred that the auditors provide the installation. It is worth noting that a small number of participants reported that they did not receive some or all of some measures. Examples of program participants' statements include:

- "I got one CFL, not three"
- "Only received one [faucet aerator]."
- "Never received any [outlet seals]."
- "We would have liked to receive the free kit that we never got."

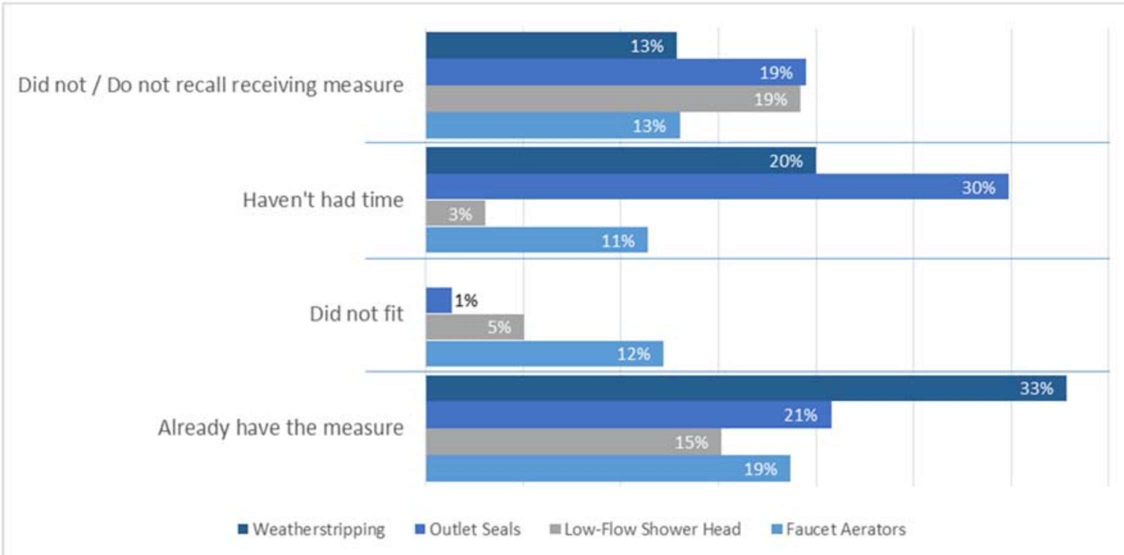
For customers who did have measures installed, we asked whether the auditor installed the measure or if they did it themselves. More than 80% of these customers indicated that they had installed the measure themselves.[7] As reported by participants:

- "I would have appreciated if the auditor helped install some of the items from the kit."
- "The auditor should offer to install the energy efficiency kit items."

If a customer did not install any particular measure, we followed up by asking why. Overall, the most common reason stated for not installing a certain measure was that the customer already had one installed. As stated above, a number of customers stated that they did not receive the measure in question. In some of these cases, the respondent stated that s/he did not recall receiving the measure, leaving room for the possibility that s/he simply forgot that it was included. This is still cause for some concern. Measures that are not installed represent missed opportunities for savings and wasted resources for DEO. Customers also mentioned time as being the main factor for failing to install items from the kit. Energy savings from these measures could exist, at present or in the future. However, we did not attempt to quantify future savings of measures in storage in this evaluation. Measures being placed in storage are uncommon in direct-install programs. DEO might consider including follow-up calls with participants to remind them to install these measures and to check progress on other energy-saving activities.

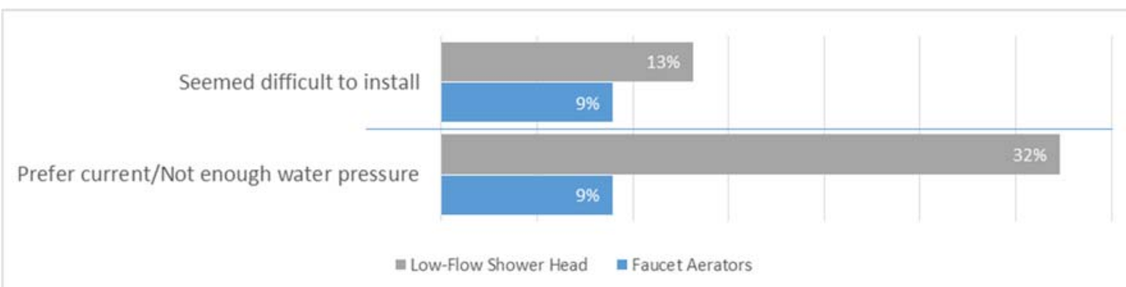
[7] This question was asked about installation for faucet aerators, shower heads, and outlet seals. The customer installed the measure on his own 79%, 88%, and 84%, respectively.

Figure 7-3. Kit Measures Not Installed



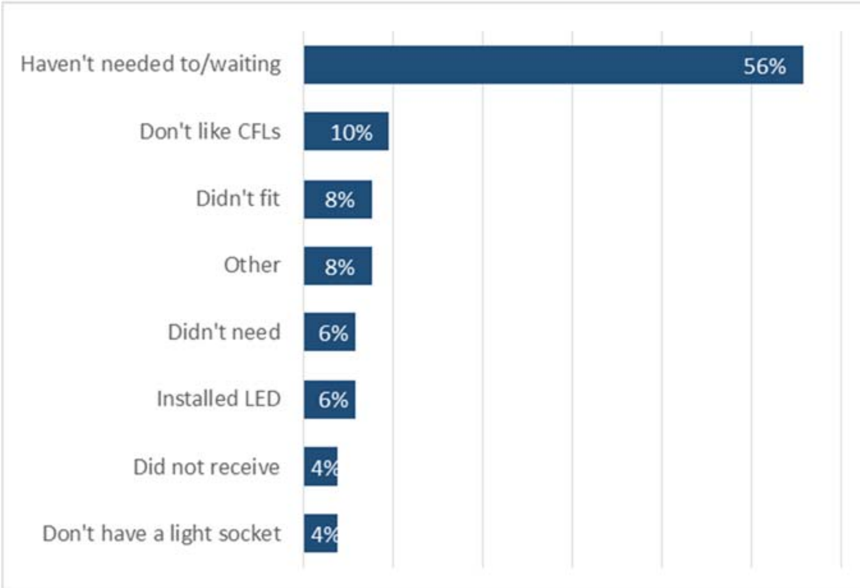
In the case of low-flow shower heads and faucet aerators, some participants have an issue with a reduction of water pressure as a result of the measures. These measures are also more labor intensive in their installation, which may prevent some customers from installing them on their own, if the auditor does not install them during the assessment.

Figure 7-4. Reasons Homeowner Did Not Install Low-Flow Shower Head and Faucet Aerators



For consistency with the analysis for the Residential Lighting program, we provided a number of predetermined response options for why the customer did not install all the free CFLs that they received. We found that many customers were waiting to install the CFLs, so they were likely in storage. Participants also stated that either they did not like CFLs in general or that they would prefer to receive LED bulbs.

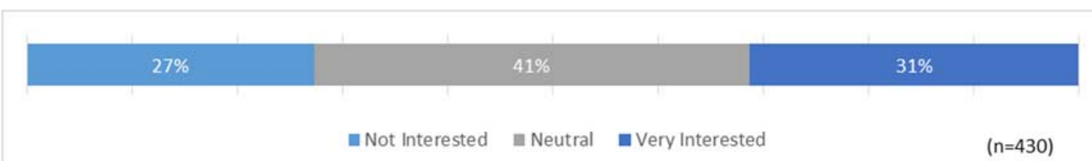
Figure 7-5. Reasons for Not Installing CFLs Received



Program Awareness and Marketing

Just over half (51%) of DEO customers responding to our general population survey are aware of the REA program and what it offers. When questioned on their interest in receiving a free home energy assessment, only about a third (31%) of respondents expressed high levels of interest (i.e., above 7 on a 11-point scale), as shown in Figure 7-6.

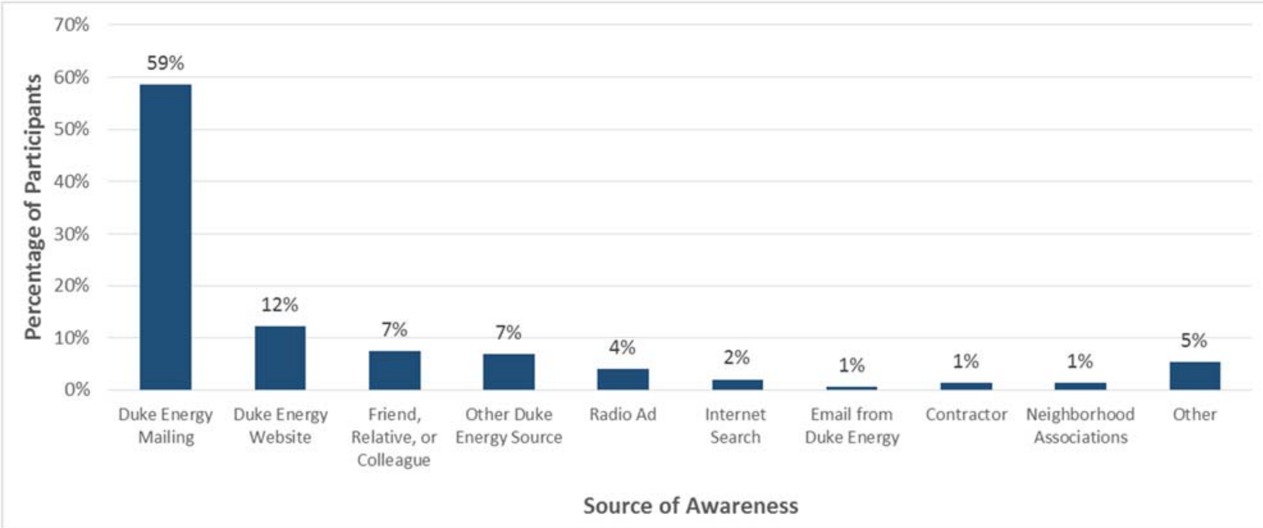
Figure 7-6. Interest in Receiving a Free Energy Assessment from Duke Energy Ohio



Customers saying that they would not be interested in the program cited a variety of reasons. Approximately 28% of respondents did not see any benefit in participating or felt that their home was already efficient. Another 22% did not wish to have someone in their home to conduct the assessment, and 16% said that it was difficult to find time for the housecall. Only 4% cited a lack of knowledge about the program as a reason that they would not participate.

Of program participants, most first learn about the program through a letter or other mailing from DEO (59%), which is the REA program's primary marketing channel. Other channels are reported by participants far less often, as shown in Figure 7-7.

Figure 7-7. Primary Source of Awareness of the REA Program



We asked participants to share some of the best ways for DEO to inform its customers about its program offerings. As shown in Table 7-2, participants predominantly prefer to have DEO inform them via the mail, through bill inserts (46%), letters (42%), or postcards (11%).

Table 7-2. Best Ways to Inform Customers about the REA Program (multiple responses)

Method (n=164)	Percent
Bill inserts	46%
Letter in the mail	42%
Email	24%
Postcard	11%
Phone call	5%
DEO website	4%
Door flyer	2%
Print advertisement	1%
Neighborhood associations	1%
Other	3%

However, REA program staff reported that they are limited to a specific number of times that they can reach out to customers directly by mail, and that limit is shared across all programs. Considering this limitation, supplementing the direct mailings with additional marketing channels could help to increase program participation.

Understanding customers' motivations for and barriers to participating can help in developing effective program marketing strategies. Opinion Dynamics asked participants for their reason(s) for participating in the program (Table 7-3). A majority (63%) mentioned saving money on energy bills as a reason for their participation. Respondents also noted reducing energy consumption (37%), the fact that the assessment was free (18%), and making their home more comfortable (15%) as factors.

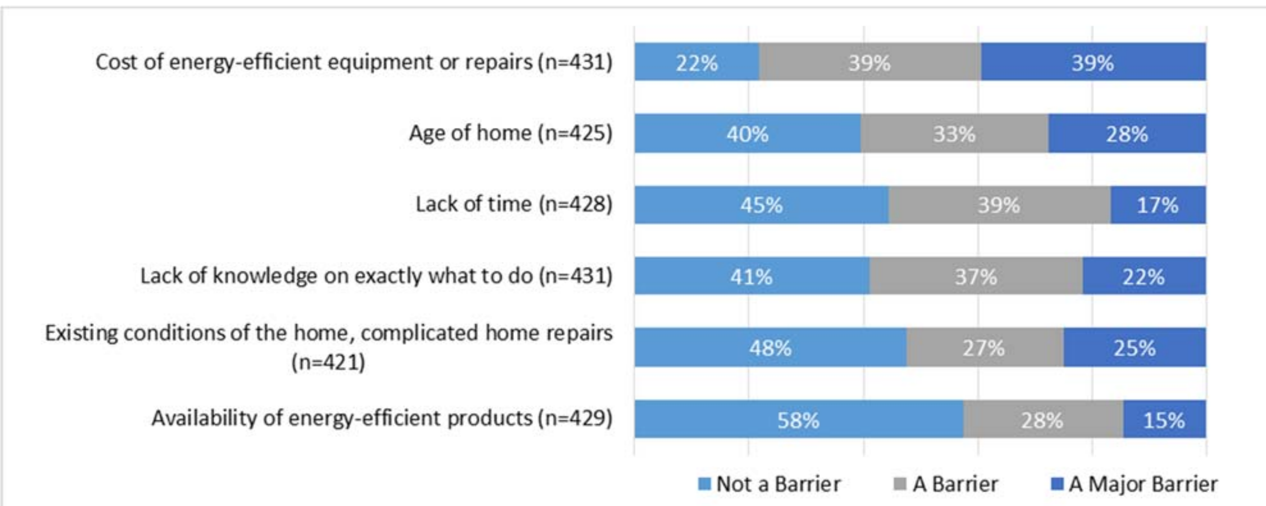
Table 7-3. Reasons for Participating in the REA Program (multiple responses)*

Reasons for Participation	Percent
Save money on energy/electric/gas bill	63%
Reduce energy consumption	37%
It was free	18%
Make your home more comfortable	15%
Learn more about energy efficiency	11%
Seemed like a good idea/curious about assessment	9%
Interested in addressing a specific problem	2%
To receive free equipment	1%

* One participant stated that he had previously participated.

Our analysis also aimed to identify barriers faced by non-participating DEO customers in implementing energy efficiency in their homes as shown in Figure 7-8. The cost of efficiency upgrades was the most commonly cited barrier.

Figure 7-8. Perceptions of Barriers to Saving Energy in Home

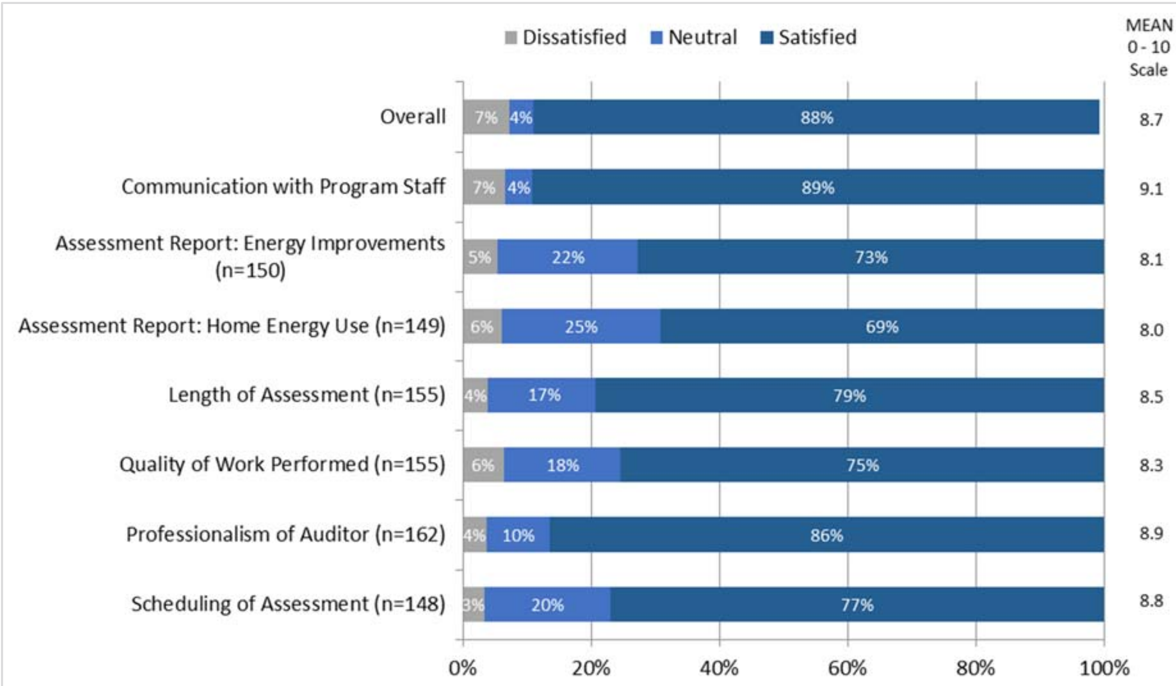


Program Satisfaction

The vast majority of participants are satisfied with all components of the program, from communication with staff to the assessment to the individual measures. However, one potential avenue for improvement lies in improving the practices of auditors pertaining to the installation of kit measures during the energy assessment.

Figure 7-9 shows participant satisfaction with various program components. The majority of respondents (88%) are satisfied with the program overall (i.e., they gave it a score of 8 or above on a scale of 0–10, where 0 is dissatisfied and 10 is satisfied). Participants are most satisfied with their communication with program staff (mean score of 9.1) and the professionalism of the auditors (8.9). Program participants are least satisfied with the audit report in helping understand the home's overall energy use (8.0), although satisfaction is still quite high.

Figure 7-9. Satisfaction with REA Program Components

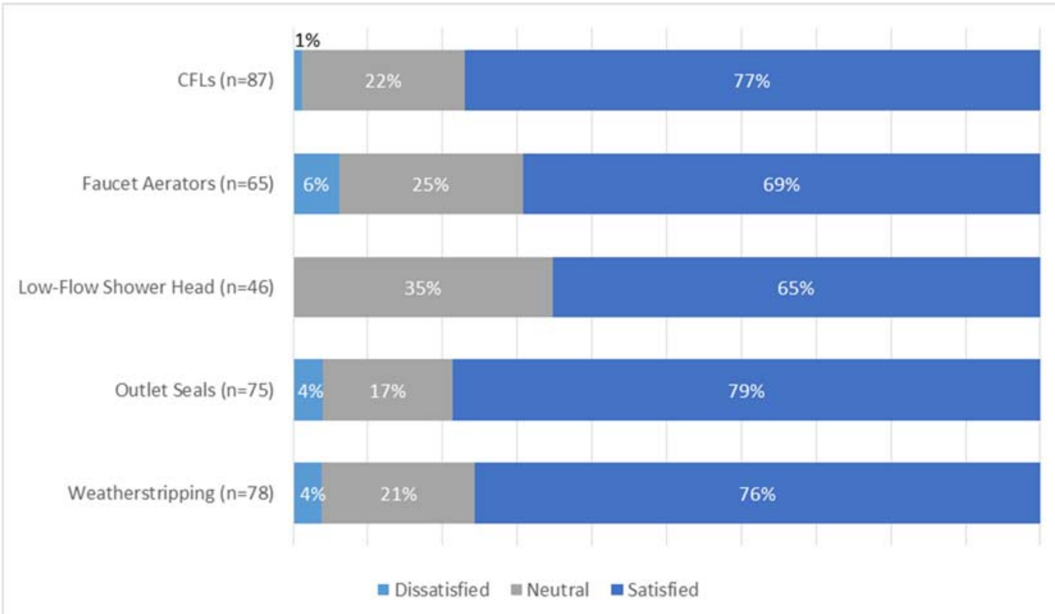


Overall, satisfaction with program staff is high. However, when asked about their dissatisfaction with the program, or improvements that could be made to the program, some respondents mentioned problems with the energy specialist, or auditor, who performed their energy assessment. A number of these responses mention a desire to have kit measures installed by the auditor, and some participants seem displeased with the amount of effort put forth by the auditor and his or her level of knowledge about energy efficiency. Some open-ended responses included:

- "Have auditors that are more informed and more willing to communicate."
- "Get better employees to help the senior citizens install stuff. They might be too old to install everything on their own."
- "… Send someone out that is more informed and willing to take the time to inform customers as well."
- "The auditor brought only light bulbs and outlet seals, but none of the other products that were promised with the assessment. The auditor also did nothing to assess my energy usage, or where it was being lost. Gave no advice on how to fix problem."
- "The auditor really didn't do anything. He came, sat, showed me pictures of his home, and did not check crawl spaces or insulation. He did, however, make recommendations about improving efficiency in my barn. He was here for 90 minutes and did not even take a look at our hot water heater. It was a waste of Duke's time and energy and money. I have had more thorough recommendations from appliance dealers and contractors with other companies. The auditor did not even offer to install any of the items included in the kit."

We also found that participants are generally satisfied with all measures from the kit, as shown in Figure 7-10. Each measure received an average satisfaction score greater than 8 (on a scale of 0–10, where 0 is dissatisfied and 10 is satisfied), thus indicating high levels of satisfaction across the board.

Figure 7-10. Measure Satisfaction



The relatively few respondents expressing dissatisfaction with the program measures, when asked to explain their dissatisfaction, generally either did not see any benefit in the measure or the measure did not fit.

When asked how the REA program could be improved, almost half either said that there was nothing (34%), or did not know (12%). Of those who did have suggestions, most focused on including additional features to the assessment, providing more information on how to save energy, and improving aspects related to the contractor, as shown in Table 7-4.

Table 7-4. Program Improvement Suggestions (multiple responses)

From your perspective, what, if anything, could be done to improve the program? (n=164)	Percent
Include additional features (thermal imaging/diagnostics/appliance or envelope inspections)	24%
Energy Specialist/Auditor (educate auditor/install kit measures/etc.)	9%
Provide more information on saving energy	9%
Add/alter equipment	8%
Offer rebates	4%
Improve assessment in general (speed up process/add follow-up/etc.)	4%
Advertise more	1%
(No/nothing)	34%
Other	5%
Don't know	12%

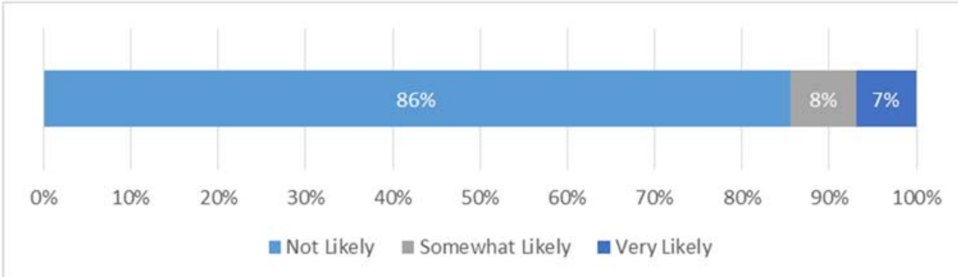
With regard to comments concerning the auditors, we saw two primary types of responses. The most prominent (mentioned by eight customers) was that they would like to see auditors be more knowledgeable about energy efficiency in the home. The other main response was to have auditors install the measures from the kit. As noted previously, customers installed a large majority of measures themselves.

Willingness-to-Pay

When asked how much money they would be willing to pay for the energy assessment and for the kit, participants report valuing the program components differently than DEO's cost estimates. While DEO states in its marketing materials that the value of the REA program assessment and kit is $180, we found that participants in general value it much lower. The average willingness-to-pay (WTP) of customers surveyed for the assessment and the kit are $23.70 and $16.48, respectively. Combined ($40.18), this represents less than a quarter of the value suggested by DEO. However, if we look solely at the customers who are willing to pay more than $0, the level of perceived value increases significantly, to $69.22 overall. It should be noted that this increased value represents only those customers who are willing to pay a price greater than $0, and, as such, the value is not representative of the population.

DEO should not be concerned about FR for the energy assessments component of the REA program. We asked participants to rate the likelihood that they would have paid for an energy assessment from another company, if they had not received one through the REA program. Figure 7-11 shows that 86% of respondents claim that it is "not likely" that they would have gone elsewhere for an assessment, which is in accordance with the relatively low WTP value reported.

Figure 7-11. Likelihood That a Customer Would Purchase Assessment from Another Company (n=160)



We also inquired about any additional features that participants would like to see included in the energy assessment. While nearly a quarter of respondents (23%) stated that there were no features that they would want to see added, those who did specify additional features were heavily focused on including more significant testing of their home's efficiency. Specifically, thermal imaging (mentioned by 43% of respondents), blower door testing (34%), appliance and hot water heater inspections (34%), and diagnostic testing of air quality (23%) were suggested. The overlap in responses to questions regarding program improvements and desired additions to the assessment may indicate that these are additional features for which customers would be willing to pay a higher (or some) price to see them included in the assessment, or potentially offered in conjunction with the assessment.

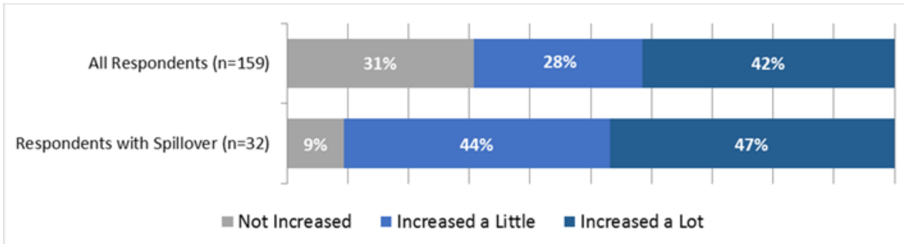
Table 7-5. Additional Features That Customers Would Like to See Added to Assessment (multiple responses)

What additional features would you like to see included in the energy assessment? (n=164)	Percent
Thermal Imaging (detect sources of heat loss)	43%
Blower Door Testing (check for air leaks)	34%
Appliance and Hot Water Heater Inspections	34%
Diagnostic Tests (assess air quality)	24%
Other	9%
Additional Information on Saving Energy	5%
Inspections of Home Envelope (attic, insulation, windows)	3%
Information on Other Programs	2%
Additional Energy-Efficient Equipment	2%
There are no features that I would like to see added	23%

Energy Education

The educational component of the energy assessments appears to be very effective. Nearly 70% of the participants stated that their knowledge of home energy improvements increased based on the information provided in the energy assessment. We observe an even higher rate of increased knowledge from the respondents who qualified for participant SO. A greater increase in knowledge is likely a significant factor in these participants installing additional energy-efficient measures, and may help explain the high rate of SO observed. With 91% of SO customers learning more about energy efficiency from the program, it is likely that some of the savings from the program's high rate of SO can be attributed to the educational materials and knowledge shared by the auditors. This finding indicates that it may be beneficial for DEO to put additional effort into ensuring that customers receive a solid education on how to save energy in their home during the assessment.

Figure 7-12. Comparison of Increased Knowledge for Spillover Participants



In addition to the energy-saving measures, the kit provided to REA program participants also includes the Department of Energy's "Energy Savers Booklet." This educational material outlines how energy is used, and wasted, in the home. The booklet provides insight into the effect that insulation, lighting, appliances, and other items in the home can have on energy use. We found that nearly 68% of participants take the time to read this booklet.

To find respondents' baseline understanding, we asked them to rate their level of knowledge on the subject of home energy improvements from **before**[8] they received their assessment from DEO understanding. Figure 7-13 shows the breakdown of customers by self-reported knowledge of home energy improvements.

Figure 7-13. Knowledge of Home Energy Improvements

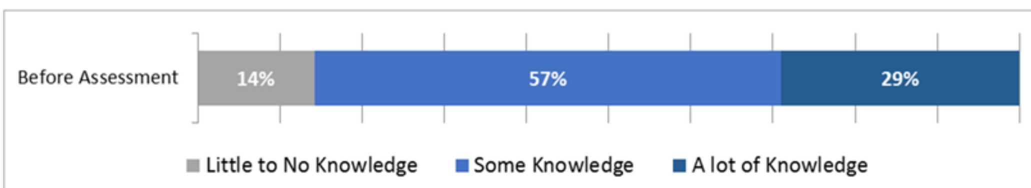
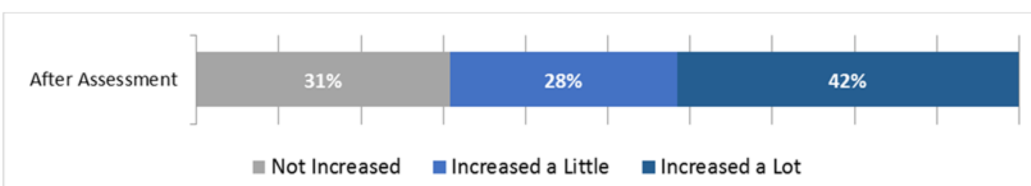


Figure 7-14 shows how much respondents reported that their knowledge of home energy improvements **increased**[9] based on the information provided to them during the energy assessment.

Figure 7-14. Increase of Energy Knowledge Gained from Assessment



Increasing customer knowledge of home energy improvements and causing behavioral changes in participants is one aim of the REA program. This high rate of increased knowledge will play a role in the amount of energy saved by those customers. These results show that the program's energy education component is effective.

[8] Customers rated their knowledge on a scale of 0–10, where 0 = "Not at all knowledgeable" and 10 = "Very knowledgeable."

[9] Customers rated the increase of their knowledge on a scale of 0–10, where 0 = "Not increased at all" and 10 = "Increased a Lot."

Assessment Recommendations

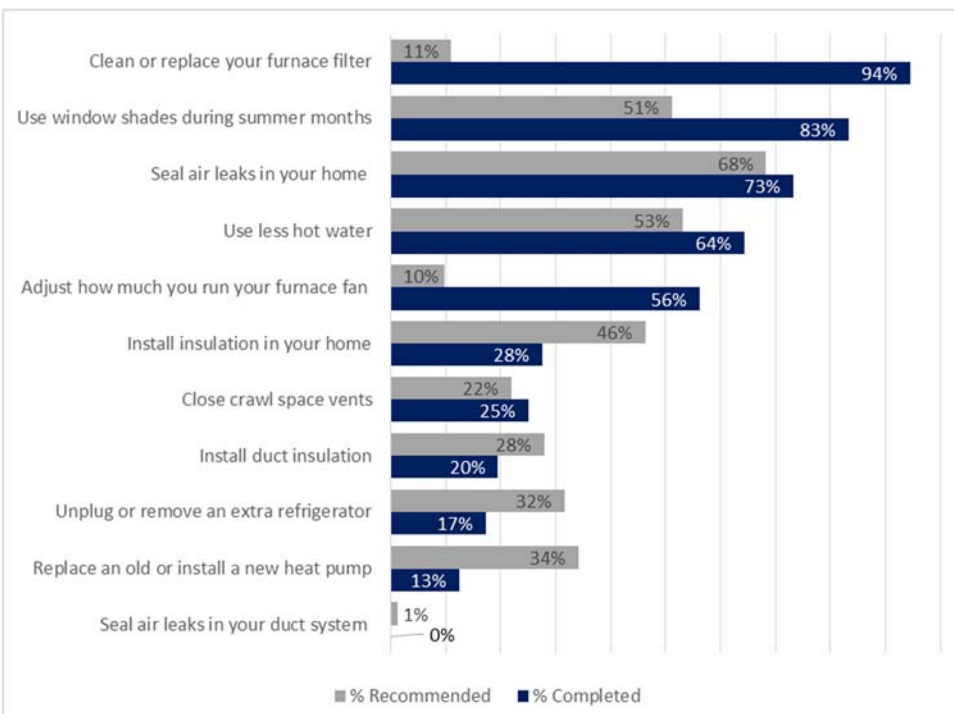
Based on data received on the recommendations given to customers during their assessment, we asked survey respondents whether they completed any of the recommendations for their home and whether they planned to implement any of those recommendations not yet completed. As shown in Table 7-6, a number of respondents in each category said that they did not recall the recommendations, despite remembering that they had at least received some recommendations. These respondents are included in the calculation, as it is unclear whether they forgot about the project being recommended, or if it was actually not recommended. Given the length and complexity of the assessment report, it may be prudent to follow up with customers via email or mail to remind them specifically which actions were recommended.

Table 7-6. Recollection of Assessment Recommendations

Recalls Receiving Recommendations (n=164)	Percent
Yes	82.3%
Plans to Complete Remaining Recommendations (n=111)	**Percent**
Yes, All	21.6%
Yes, Some	33.3%
None	37.8%

Not surprisingly, the easiest and least costly recommendations have the highest rates of completion. Beyond these low-hanging fruit, the percentage of completed recommendations (relative to the total number of households that received the recommendation, as seen in our data) declines sharply, as shown in Figure 7-15.

Figure 7-15. Percentage of Customers Who Completed Recommendations*



* Please note that the percentages of completed projects are based on only those customers who had that recommendation indicated in the data we received.

We asked participants who had not implemented all recommendations which ones they were unlikely to complete. Overall, only 9% of respondents indicated that they intend to complete all recommendations, and 22% were unsure of which recommendations were unlikely to be completed. Not surprisingly, the more expensive or time-consuming recommendations were mentioned most frequently in response to this question, as shown in Table 7-7.

Table 7-7. REA Program Recommended Improvements Unlikely to Be Completed (multiple responses)

Recommended Improvements	Percent
Don't know	22%
Unplug or remove an extra refrigerator	20%
Install insulation in your home	18%
Install duct insulation	17%
Replace an old or install a new heat pump	13%
Use less hot water	10%
Will eventually make all improvements	9%
Use window shades during summer months	7%
Close crawl space vents	6%
Seal air leaks in your home	6%
Adjust how much you run your furnace fan	2%
Seal air leaks in your duct system	1%
Clean or replace your furnace filter	0%

When asked why these recommendations were unlikely to be completed, many respondents indicated (n=30) that they felt that what they had already done was good enough or that they were not willing to make the change (72%). For instance, in response to the recommendation to remove a secondary refrigerator, these respondents stated that they used their second refrigerator and did not wish to get rid of it.

Housing Characteristics

As required by the state of Ohio, we included a standard set of questions about respondents' home type, size, and age. While the program is targeted specifically at single-family homes, we observed some variance in the type of homes visited. Over 90% of respondents state that they living in single-family homes of a detached or factory type construction, and 1% described their home as a row-house. One respondent stated that they live in a mobile home and 6% reported living in condominiums. These responses show that some non-eligible customers may be participating in the program. Most homes that received an assessment were 2,000 sq. ft. or smaller (69%), and 22% were between 2,001 and 3,000 sq. ft. The age of participants' homes were generally older: around a third were built before 1960 and a third were built between 1960 and 1989.

8. Conclusions and Recommendations

This section presents conclusions and recommendations resulting from the impact and process evaluation of Duke Energy Ohio's Residential Energy Assessments program.

Conclusions

Opinion Dynamics conducted a billing analysis of REA program participants to determine the overall ex post net program savings of the REA program. We also conducted an engineering analysis for each item contained in the REA program kits and the additional CFLs. The purposes of the engineering estimates are to:

1. Provide a ratio of kW 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

From the engineering analysis, we estimated the annual per participant savings to be 357 kWh and 0.045 summer demand kW, which includes only the kit measures and CFLs.

Based upon our billing analysis, we estimate that the program realized 975 kWh of yearly savings for participants during the evaluation period. While significantly higher than the engineering analysis estimates, the billing analysis results reflect savings associated with kit measures, assessment recommendations, SO, and potential behavioral changes from energy efficiency knowledge gained during the assessment. Our estimated program savings for both analyses are presented in Table 8-1.

Table 8-1. Comparison of Evaluated Annual Net Program Savings

Evaluation Method	Net Participant Savings			Net Program Savings		
	Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Billing Analysis	975	0.123	0.117	2,823,600	356	339
Engineering Analysis	357	0.045	0.043	1,033,872	130	125

Opinion Dynamics's evaluation resulted in higher program energy savings than observed in the prior evaluation of the program. While some of the differences may be associated with differences in the methods and models used, we believe that the REA program has been able to increase the savings per participant over the past few years.

Based upon these results, and the results of our process evaluation, we find that the REA program performs well. Customers are satisfied with the measures included in the Energy Efficiency Starter Kit and with the different components of the program. While we did find some opportunities to improve program implementation, and thus increase savings, our analysis shows that the program has a significant amount of influence in getting customers to reduce their energy use.

While program participation has increased each year, it has not been meeting program goals. The program manager noted some barriers to marketing the program through DEO's mailings, but some opportunities may exist in other media and through channeling participants from other programs, such as MyHER and the Free CFL programs.

We estimate that participants save an average of 975 kWh annually because of their experience with the REA program. Installation rates for measures included in the kit are rather low and uptake of assessment recommendations are relatively high, leading us to believe that a large portion of savings comes from actions that customers take after participation. Auditor recommendations and behavioral changes caused by the educational component of the assessments appear to account for a significant portion of savings. Nevertheless, opportunities may exist to further increase per-home savings by encouraging greater uptake in the auditor recommendations and a greater rate of direct installation of the kit measures by auditors.

Recommendations

We note a number of avenues for the program to make improvements. Based on results of the participant and non-participant surveys, billing analyses, our review of materials, and past experience with programs of this nature, we believe these recommendations would provide positive outcomes for the DEO REA program.

- Improve Installation Rates. For assessment programs, it is best practice for auditors to install as many of the free measures as possible during the assessment, and this is supposed to be a standard practice for HEHC assessments. However, in our participant survey, we found that a large percentage of customers had installed kit measures on their own. Customers also expressed interest in having the auditor install the measures. To improve installation rates and thus program savings, DEO should focus on ensuring that auditors install all possible measures from the kit during the assessment.

- Follow-Up Calls. To increase the uptake of assessment recommendations, DEO may consider implementing follow-up calls, or e-mails, to program participants a few months after the assessment, with the intent of reminding the customer about the recommendations made. Follow-up communications could also gauge customer satisfaction with program components when the visit is relatively fresh in their minds.

- Evaluate Efficient Light Offerings. Opinion Dynamics recommends that DEO explore adding specialty CFLs or LEDs to the kit of energy-efficient measures offered through the REA program. The evaluation of the DEO Residential CFL Program showed that this program has reached a sizeable share of the DEO residential customers, potentially limiting the opportunities for installing standard CFLs in REA participating homes. Specialty CFLs can fill sockets where a basic spiral CFL may not fit, look, or perform well. Specialty CFLs can include: dimmable and threeway bulbs, “covered” CFLs that have a decorative outer shell (e.g. globe, candle, and reflector shapes), and CFLs with candelabra (E12) bases. In addition, depending upon the results of this research, DEO may want to consider the addition of LED bulbs to the kit measures. Participants who did not install CFLs, or that removed their free CFLs, stated that they updated to LEDs in some cases. The inclusion of an LED bulb in the kit would likely be well received by participants. A sample LED bulb and educational materials may increase awareness and uptake of this technology and provide additional motivation for customers to participate in DEO lighting programs.

- Add-On Services. DEO expressed interest in understanding customers’ WTP for the services provided by the REA program, namely, the assessment and the kit. We found that customers value the assessment more than the kit of energy-efficient measures, although both are low in comparison to the $180 value advertised by DEO. The low perception of overall value provides evidence that DEO should continue to offer the program as it is for no cost. Immediately following our questions about customers’ WTP, we inquired about what additional features they would like to see included in the assessment. Customers expressed interest in a number of additional diagnostic tests, such as blower door testing, thermal imaging, and air quality tests. We believe customers may be willing to pay an optional fee to have such tests added to the standard assessment.

- **Data Collection.** We recommend collecting additional primary data for PY2015 to help refine the engineering savings estimates. Table 8-2 provides recommended parameters by measure type to be collected in the future either through the onsite assessments or through a phone survey with participants. These data may be collected based on a sample of homes rather than for every participant to reduce the average amount of time spent at each home.

Table 8-2. Recommended Primary Data Collection in Future

Measure	Data to Collect in the Future
CFLs	• Wattage of baseline bulbs • Hours of use
Faucet Aerators	• Flow rate of faucet before aerator • Number of people per home • Number of bathroom faucets • Number of kitchen faucets • Heating hot water type (electric vs. gas)
Low-Flow Shower Head	• Flow rate of old shower head • Number of people per home • Number of shower heads per home • Number of showers taken per week
Weatherstripping	• Prevalence of air conditioning in the home • Age of air conditioning equipment (for estimating efficiency)

Appendix A. Summary Form

Residential Energy Assessments

Completed EMV Fact Sheet

The Residential Energy Assessments Program provides a home energy assessment free of cost, which includes a kit of low cost energy-efficient measures. A report of recommended upgrades and behavioral changes is given to the customer at the end of the assessment.

Date	October 30, 2015
Region(s)	Duke Energy Ohio
Evaluation Period	August 2013 through December 2014
Net Annual kWh Savings	2,823,600
Annual kW Demand Savings	356 (summer) 339 (winter)
Net-to-Gross Ratio	89%
Process Evaluation	Yes
Previous Evaluation(s)	April 2013

Evaluation Methodology

The Evaluation Team verified deemed savings estimates using an engineering analysis of savings assumptions and calculations. The Evaluation Team also leveraged a participant survey to verify installation and in-service rates (ISR) for each measure, and estimate a net-to-gross ratio (NTGR). The Evaluation Team conducted a billing analysis to estimate energy savings and a combination of billing analysis results and engineering analysis to estimate coincident demand savings.

Impact Evaluation Details

- 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.
- The Evaluation Team based assumptions and inputs, for deemed savings and gross impacts, on the Draft Ohio TRM. The engineering analysis applied deemed savings values to measures distributed and in service (e.g., via Energy Efficiency Starter Kit and additional CFLs)
- Results from the billing analysis reflect savings associated with measures installed, assessment recommendations, spillover, and potential behavioral changes from energy-efficiency knowledge gained through participation in the Residential Energy Assessments program.
- Some overlap is present with other Duke Energy programs, especially with the MyHER and Free CFL programs.

Appendix B. Survey Disposition Reports

Participant Survey Disposition and Response Rate

We calculated the response rate using the standards and formulas set forth by the American Association for Public Opinion Research (AAPOR).[10] We chose to use AAPOR Response Rate 3 (RR3), which includes an estimate of eligibility for sample units that we were unable to reach. We present the formulas used to calculate RR3 below and display the definitions of each variable used in the formulas in the Survey Disposition tables that follow.

$$RR3 = I / ((I + P) + (R + NC + O) + e(UH + UO))$$

We also calculated a cooperation rate, which is the number of completed interviews divided by the total number of eligible sample units actually contacted. In essence, the cooperation rate is the percentage of participants with whom we spoke who completed an interview. To determine the cooperation rate we used AAPOR Cooperation Rate 1 (COOP1), which is calculated as:

$$COOP1 = I / ((I + P) + R))$$

Table B-1. Survey Response and Cooperation Rates

AAPOR Rate	Percent
Response rate (RR3)	18.3%
Cooperation rate (COOP1)	41.6%

Table B-2. Disposition Report

Disposition Code	Count
(DID NOT PARTICIPATE IN THE PROGRAM)	3
Added to the “Do Not Call” (DNC) List	9
Answering machine	191
Business/residential phone (ADJUST)	2
Busy	3
Callback to complete	4
Cell phone... Refused to do survey because it’s a cell phone	1
Complete	**164**
Computer tone	3
Customer indicated called already	1
Customer said wrong number	19
Disconnected phone	66
HARD REFUSAL - DO NOT CALL	10
Initial refusal	195
Language problems	1
Mid-interview terminate - DO NOT CALL BACK	11
No answer	91
Non-specific callback	117
Not available	59
Not called	790
Privacy line/number blocked	1
RESPONDENT SCHEDULED APPOINTMENT	49
Total	1,790

[10] *Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys*, AAPOR, 2011. http://www.aapor.org/AAPORKentico/AAPOR_Main/media/MainSiteFiles/StandardDefinitions2011_1.pdf.

General Population Survey Dispositions and Response Rate

Table B-3. General Population Survey Disposition Summary

Disposition	Count
Completed Interviews (I)	469
Web, complete	241
Phone, complete	228
Partial Interviews (P)	128
Eligible Non-interviews (NC)	1,035
Phone, answering machine	445
Phone, business/residential phone	21
Phone, callback to complete	14
Phone, cell phone callback	2
Phone, computer tone	15
Phone, customer indicated called already	13
Phone, customer said wrong number	51
Phone, language problems	13
Phone, non-specific callback/secretary/NTG	248
Phone, not available	133
Phone, scheduled appointment	48
Phone, terminate - not DEO customer	8
Web, terminate - not DEO customer	24
Unknown Eligibility, Non-Interviews (UH)	447
Open sample not called	346
Phone, busy	8
Phone, no answer	86
Phone, privacy line/number blocked	7
Not Eligible (NE)	232
Web, email bounced	21
Phone, disconnected phone	211
Refused (R)	2,131
Web, no response	1,627
Phone, initial refusal	460
Phone, hard refusal	21
Phone, add to DNC list	21
Phone, refusal because of cell phone	2
Total Participants in Sample	4,442

Table B-4 provides the survey response rate. We are not reporting a cooperation rate for the email sample frame, because it is difficult to estimate it accurately with emailed survey invitations. We do, however, report a cooperation rate for the sample targeted through outbound phone calls.

Table B-4. General Population Survey Response Rates

AAPOR Rate	Percent
Response rate	12%
Cooperation rate (outbound phone calls only)	30%

The evaluation targeted 10% precision at a 90% confidence level for all data collection tasks that involved sampling. These precision goals were met (Table B-5).

Table B-5. Precision and Margin of Error at the 90% Confidence Level

Metric of Interest	Standard Margin of Error
Process results	3.9%

Appendix C. Participant Survey Instrument

The Word documents embedded below contain the full participant survey used for the evaluation.

DEO Residential
Assessements Partici

Appendix D. Detailed Survey Results

The Word documents embedded below contain detailed survey results from the participant and general population survey efforts. We provide results in the form of the Wincross tables with breakdowns of the survey results across core customer household characteristics.

DEO Residential
Assessments Survey

Appendix E. Engineering Algorithms and Assumptions

Opinion Dynamics originally provided these algorithms and assumptions to DEO in a memo dated July 2, 2015.[11] We have since revised several of the assumptions using updated 2014 survey data and other inputs as deemed appropriate.

This section documents the engineering algorithms and assumptions used to estimate energy and demand savings for each measure contained in the efficiency kit. As previously mentioned, the REA program does not use these deemed savings values to estimate kWh savings. The program estimates energy impacts via a billing analysis. These engineering savings estimates produce a ratio between energy and demand savings that is then applied to the billing analysis energy savings to estimate demand savings and to gain insight on individual measure contributions to overall savings.

CFL Algorithms and Savings

Table E-1 provides the engineering algorithms used to estimate deemed savings for CFLs.

Table E-1. Algorithms for CFLs

Measure	Algorithm Type	Draft Ohio TRM Algorithm
13W CFLs	Energy Savings	(Baseline Watts – CFL Watts) / 1,000 * Hours * WHFe * ISR
	Demand Savings	(Baseline Watts – CFL Watts) / 1,000 * WHFd * CF * ISR
20W CFLs	Energy Savings	(Baseline Watts – CFL Watts) / 1,000 * Hours * WHFe * ISR
	Demand Savings	(Baseline Watts – CFL Watts) / 1,000 * WHFd * CF * ISR

Table E-2 displays the variable assumptions and inputs used to estimate savings from CFLs.

Table E-2. Variable Assumptions for 13W and 20W CFLs

Variable	13W CFL	20W CFL	Reference/Notes
Baseline Watts	63 watts	71 watts	From PY13 participant survey (n=81). Average wattage removed.
CFL Watts	13 watts	20 watts	Wattage of distributed CFLs.
Hours	1040.25	1040.25	Ohio TRM. Duke Energy, June 2010. Ohio Residential Smart Saver CFL Program.
Waste Heat Factor – Energy (WHFe)	1.07	1.07	Ohio TRM. Average result from REM/Rate modeling for various home configurations and Ohio locations.
Waste Heat Factor – Demand (WHFd)	1.21	1.21	
Summer Coincidence Factor (CF)	0.10	0.10	No source provided for Ohio TRM CF value (0.11). We chose to use 0.10 based on 2012 DTE Energy and Consumers Energy Evaluation study.
Winter CF	0.096	0.096	No winter peak factor available for Ohio or Midwest. We chose to use the factor from the 2013 evaluation of DEP's Energy-Efficient Lighting Program, which we believe to be the most reasonable assumption available.
ISR	68.86%	68.86%	PY14 participant survey (n=164).

[11] Deemed Savings Review for Duke Energy Ohio Residential Energy Assessments Program. July 2, 2015.

Table E-3 provides the deemed savings per bulb for the CFLs using the assumptions outlined in Table E-2.

Table E-3. Per-Measure Savings for CFLs

Measure	Savings Unit	Savings per Bulb
13W CFLs	Energy Savings	38.32 kWh
	Summer Demand Savings	0.00417 kW
	Winter Demand Savings	0.00331 kW
20W CFLs	Energy Savings	39.09 kWh
	Summer Demand Savings	0.00425 kW
	Winter Demand Savings	0.00337 kW

Faucet Aerator Algorithms and Savings

Table E-4 provides the engineering algorithms used to estimate deemed savings for faucet aerators. The Ohio TRM and previous evaluation reports do not estimate different savings for kitchen and bathroom faucet aerators. We recommend collecting additional data during the next evaluation cycle, such as number of faucet types per home and average flow rates of the faucets, prior to installing the aerators. These inputs will allow us to more accurately calculate savings separately for both kitchen and bathroom aerators. For the PY14 analysis, we used the same algorithm and inputs to estimate savings for both kitchen and bathroom aerators, similar to the method in the Ohio TRM.

Table E-4. Algorithms for Faucet Aerators

Measure	Algorithm Type	Draft Ohio TRM Algorithm
Faucet Aerator	Energy Savings	((GPMbase – GPMlow)/GPMbase) * #people/home * gals/day * days/yr * DR/Faucets/home) * 8.3 * (Tinlet – Tmains)/1,000,000 / RE / 0.003412 * ISR * %Electric
	Demand Savings	kWh savings / Hours * CF

Table E-5 displays the variable assumptions and inputs used to estimate savings from faucet aerators.

Table E-5. Variable Assumptions for Faucet Aerators

Variable	Assumption	Reference/Notes
GPMbase	2.2	Ohio TRM. Department of Energy-adopted maximum flow rate standard; 63 Federal Register 13307; March 1998.
GPMlow	1.25	Average flow rate between distributed aerators (1.5 and 1.0).
# People/home	2.88	U.S. Energy Information Administration, 2009 Residential Energy Consumption Survey (RECS), Ohio.
Gals/Day	10.9	Ohio TRM. U.S. EPA "Water Sense" Documentation.
DR	83%	Ohio TRM assumes 50%, but that is much lower than other TRMs and references. The Illinois TRM assumes 90% for bathroom and 75% for kitchen. We use the average of those two values here since the savings applies to both types of faucets.
Faucets/home	3.5	Ohio TRM. East Bay Municipal Utility District Study.
Tinlet	80°F	Ohio TRM. Connecticut Energy Efficiency Fund.
Tmains	57.8°F	Ohio TRM. Average from Ohio Joint Utility TRM (Table 39).
RE (electric water heater)	0.98	Ohio TRM. Air-conditioning, Heating, & Refrigeration Institute (AHRI)
Hours (water usage)	24.8	= (Gals/day * # people/home * 365) / (Faucets/home) / GPMbase / 60
CF	0.00262	Ohio TRM. Original source unknown. We use this same CF for both winter and summer peak as there are no data available to support using different CFs for aerators in summer vs. winter.
%Electric	38.57%	U.S. Energy Information Administration, 2009 RECS, Ohio.
ISR	29%	PY14 participant survey (n=164).

Table E-6 provides the deemed savings per aerator using the assumptions outlined in Table E-5.

Table E-6. Per-Measure Savings for Faucet Aerators

Measure	Savings Units	Savings per Aerator
Faucet Aerators	Energy Savings	7.2 kWh
	Summer Demand Savings	0.00076 kW
	Winter Demand Savings	0.00076 kW

Low-Flow Shower Head Algorithms and Savings

Table E-7 provides the engineering algorithms used to estimate deemed savings for shower heads.

Table E-7. Algorithms for Low-Flow Shower Heads

Measure	Algorithm Type	Draft Ohio TRM Algorithm
Low-Flow Shower Head	Energy Savings	ISR * (GPMbase - GPMlow) * kWh/GPMreduced * %Electric
	Demand Savings	kWh savings / hours * CF

Table E-8 displays the variable assumptions and inputs used to estimate savings from low-flow shower heads.

Table E-8. Variable Assumptions for Low-Flow Shower Heads

Variable	Assumption	Reference/Notes
GPMbase	2.87	Ohio TRM. Average flow rate of replaced shower head from Enbridge Gas Distribution, Inc. April 2010. DSM 2009 Annual Report.
GPMlow	1.5	Flow rate of distributed shower heads.
ISR	33%	PY14 participant survey (n=164).
%Electric	38.57%	U.S. Energy Information Administration, 2009 RECS, Ohio.
CF	0.00371	Ohio TRM. Aquacraft Water Engineering and Management "Disaggregated Hot Water Use"; assumes 9% of showers take place during peak. We used this same CF for both winter and summer peak as there are no data available to support using different CFs for shower heads in summer vs. winter.
kWh/GPMreduced	149	Ohio TRM. Enbridge metering study.
Hours	33.7	= (Gal/person * # people/home * days/yr) / SH/home/ GPM / 60
Gallons/person	11.6	Ohio TRM. U.S. EPA "Water Sense" Documentation.
# People/home	2.88	U.S. Energy Information Administration, 2009 RECS, Ohio.
Shower heads/home	2.1	Ohio TRM. Enbridge metering study.

Table E-9 provides the deemed savings per shower head using the assumptions outlined in Table E-8.

Table E-9. Per-Measure Savings for Low-Flow Shower Heads

Measure	Savings Units	Savings per Shower Head
Low-Flow Shower Head	Energy Savings	25.69
	Summer Demand Savings	0.00283 kW
	Winter Demand Savings	0.00283 kW

Weatherstripping and Outlet Seals Algorithms and Savings

Table E-10 provides the engineering algorithms used to estimate deemed savings for weatherstripping and outlet seals. We grouped these two measures together into one algorithm since they both improve the building envelope and savings from outlet seals will be relatively insignificant. The Draft Ohio TRM does not include algorithms for either measure, so we used the algorithm for air sealing and adjusted it to the expected savings that would be attributed to weatherstripping.

Table E-10. Algorithms for Weatherstripping

Measure	Algorithm Type	Algorithm
Weatherstripping and Outlet Seals	Energy Savings	Cooling Savings = (CFM50Exist - CFM50New) / Nfactor * 60 * CDH * DUA * 0.018 / 1000 /nCool * AF * LM * %AC Heating Savings = (CFM50Exist - CFM50New) / Nfactor * 60 * 24* HDD * 0.018 / 3,412 / nHeat * AF * %electric heat
	Summer Demand Savings	Cooling kWh Savings / FLHcool * 0.5
	Winter Demand Savings	Heating kWh Savings / FLHheat

Table E-11 displays the variable assumptions and inputs used to estimate savings from weatherstripping.

Table E-11. Variable Assumptions for Weatherstripping

Variable	Assumption	Reference/Notes
ISR	51%	PY14 participant survey (n=164).
Baseline ACH50	17.4	ENERGY STAR® savings analysis assumptions for southern Ohio (Climate Zone 4). Assume "Windows, Doors, Walls." https://www.energystar.gov/ia/home_improvement/home_sealing/ Measure_Upgrade_Assumptions.pdf?945a-eddc.
Upgrade ACH50	17.0	ENERGY STAR savings analysis assumptions for southern Ohio (Climate Zone 4). Assume "Windows, Doors, Walls." https://www.energystar.gov/ia/home_improvement/home_sealing/ Measure_Upgrade_Assumptions.pdf?945a-eddc.
Home volume (ft^3)	18,744	From U.S. Energy Information Administration, 2009 RECS, Ohio, average size of home in Ohio is 2,343 ft^2. Assume ceiling height of 8 ft.
Baseline CFM50	5,436	Converts ACH50 to CFM50 (= ACH50 * Volume / 60 minutes). http://www.pureenergyaudits.com/docs/ Blower_Door_Handout_ACI_Baltimore.pdf.
Upgrade CFM50	5,311	Converts ACH50 to CFM50 (= ACH50 * Volume / 60 minutes). http://www.pureenergyaudits.com/docs/ Blower_Door_Handout_ACI_Baltimore.pdf.
N-factor	29.4	Ohio TRM. Lawrence Berkeley National Labs (LBNL).
Conversion	60	Converts ft^3/min to ft^3/hr.
CDH	7,711	Assume Cincinnati since DEO territory is centered mostly there.
DUA	0.75	Discretionary Use Adjustment.
Heat capacity	0.018	Volumetric heat capacity of air.
Efficiency of air conditioning (nCool)	13	Assume 13 SEER based on several TRMs. Assume equipment installed after 2006.
Latent multiplier (LM)	6.9	Most TRMs assume a LM to account for latent cooling demand. Use Mid-Atlantic TRM assumption.
Weatherstripping adjustment factor (AF)	33%	Adjustment to account for the fact that this is weatherstripping only and not air sealing. ASHRAE recommends buildings that are weatherstripped will reduce infiltration by 33% (Energy Management Handbook, 8th Edition, Turner, Doty, 2013).
%AC	61%	U.S. Energy Information Administration, 2009 RECS, Ohio.
Cooling kWh Savings	2.8	Calculated.
HDD	4,744	ASHRAE Fundamentals 2013. Use Cincinnati, Ohio.
nHeat	1.2	Weighted average based on type of heating in Ohio.
% electric heat	24%	U.S. Energy Information Administration, 2009 RECS, Ohio.
% heat pump	18%	U.S. Energy Information Administration, 2009 RECS, Ohio.
% resistance	82%	U.S. Energy Information Administration, 2009 RECS, Ohio.
COP heat pump	2.3	Mid-Atlantic TRM.
COP electric resistance	1.0	Mid-Atlantic TRM.
Heating kWh Savings	10.1	Calculated.
FLHcool	996	EPA Calculator. Assume Cincinnati, Ohio.
Summer CF	0.5	Ohio TRM.
FLHheat	2,134	EPA Calculator. Assume Cincinnati, Ohio.

Table E-12 provides the deemed savings for weatherstripping and outlet seals using the assumptions outlined in Table E-11.

Table E-12. Per-Measure Savings for Weatherstripping and Outlet Seals

Measure	Savings Units	Savings per Household
Weatherstripping and Outlet Seals	Energy Savings	6.6 kWh
	Summer Demand Savings	0.0014 kW
	Winter Demand Savings	0.0047 kW

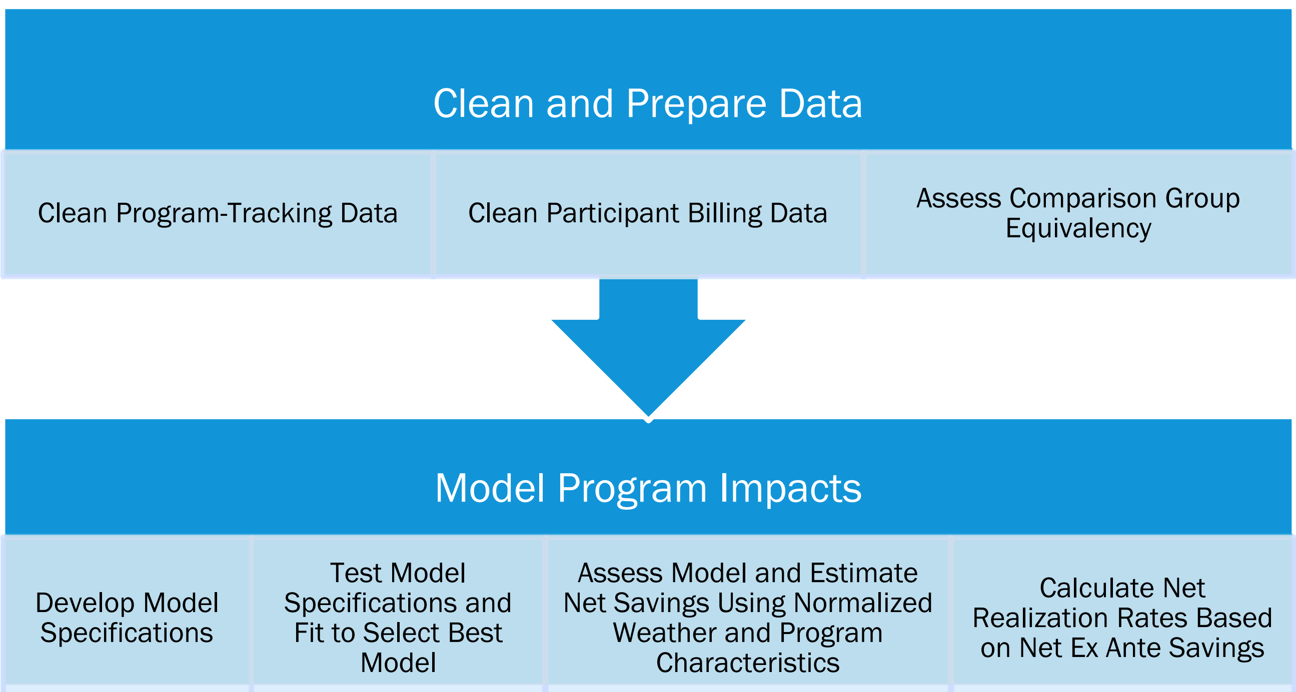
Appendix F. Detailed Methodology: Billing Analysis

Data Collection

The evaluation team conducted a billing analysis to determine the overall ex post net program savings of the REA or HEHC program. DEO provided participation data for participants from August 2013 through July 2015. DEO also provided a detailed billing history starting in 2009 for each of these participants. Our billing analysis used fall 2013 and all 2014 participants as the treatment group because the method requires post-installation electricity usage data for at least 6 months after participation. The comparison group consists of households that participated in 2015.

Prior to carrying out the statistical modeling, we matched, cleaned, and performed quality assurance on all data. We used the same data-cleaning procedures for all participants. Figure F-1 provides a summary of our steps for data collection, model specification, and analysis used in the evaluation.

Figure F-1. Billing Analysis Approach to Data Collection and Model Estimation



Choice of Comparison Group

A key challenge for estimating energy savings via a billing analysis is the identification of an appropriate comparison group to represent what participants would have done (and how much energy they would have consumed) in the absence of the program. There are two key considerations in the selection of a comparison group. A comparison group must have (1) similar energy usage patterns (compared to participants) in the pre-program period and (2) effectively address self-selection bias (the correlation between the propensity to participate in a program and energy usage).

For this evaluation, Opinion Dynamics used 2015 participants as the comparison group, using only pre-program billing data. Ideally, a comparison group is identical to the treatment group in all aspects, save for the treatment being evaluated (participation in the REA program in our case). A match of this type is impossible when studying the effects of energy efficiency programs, since no two customers are exactly alike. Given this, we aim to use a comparison group that exhibits very similar usage patterns prior to participation. This ensures that results from our analysis are representative of the actual effect that the program has on a customer's energy use.

Figure F-2 and Figure F-3 show that the weather experience by both groups is nearly identical. Given their proximity to each other this is not surprising.

Although we see slightly higher pre-program usage for the treatment group, the trends of energy use of our two groups are comparable. We accounted for differences in pre-program usage patterns by incorporating several adjustments into our LFER models. Specifically, we developed separate electric savings models for electric and non-electric space heat customers because there is a large disparity in usage (particularly during winter months) between these two sets of customers. Second, we included interactions between time (as measured by our month-year dummies) and seasonal pre-period usage, which adjusts for time-related trends beyond weather, such as economic, historical, and political conditions.

Data Cleaning and Preparation

Clean Program-Tracking Data

To conduct the billing analysis, we prepared a master participant database that combined the program-tracking databases from both years. Each of the individual databases had multiple datasets that we merged and appended together. We utilized records from the REA program-tracking database as the basis for our analysis sample, because these records had the DEO customer account number associated with each site identifier. Our analysis of participants included:

- Customer Data (by Account): Includes customer information, heating source, and dates of participation.
- Installations (by Measure): Includes measures and the quantity installed. Primary interest is the number of additional CFLs that were installed. Confirmed that each account received one kit.

The primary goal of cleaning program-tracking data is to create a dataset of unique accounts with all relevant data. Only those participants who have electricity service from DEO were kept for the analysis.[12]

- Measures: We reshaped the data so that each customer has separate fields for each measure with the quantity installed.
- Dates: We used the date of participation to calculate the program year for each account. We also checked for discrepancies in REA participation dates. We found only one, where the kit was installed on one date and the CFLs on another.
- Location: We separated the address and zip code of each customer in order to accurately merge regional weather data, later in the process.

[12] Twenty accounts that received only gas service from DEO were removed.

Clean Participant Billing Data

The participant billing data are monthly data from January 2009 to July 2015, provided by DEO. We merged 2014 and 2015 participant billing data and took a two-step approach to cleaning the data. First, we removed individual billing periods—i.e., meter reads—that were duplicative, cancelled, or had zero billing days. Second, we cleaned the data for customer accounts with anomalous or insufficient data for billing analysis. We describe each billing data cleaning step below.

- **Correcting Billing Records that were "Estimated" or "Adjusted":** If a bill was marked as an estimated or adjusted read, there were often several records for the affected month, with different usage amounts. We discussed this issue with DEO staff to determine the best way to handle these. Bills that were adjusted, often showing a negative usage for one record, were combined with the following record to generate a unique record. For estimated records, those flagged with a "Y" in the estimated field represented the actual usage that was billed to the customer, in which case that record was kept and any other record was discarded. A very few remaining records with negative usage were dropped from the dataset.
- **Combining Participant Data with Billing Records:** Opinion Dynamics merged usage data with the customer-specific (account-level) data, including measure installation dates. We then assigned pre- and post-treatment billing periods based on those dates. We assigned billing periods before the first installation date to the pre-period, all bills following the last installation date as the post-period, and any bills occurring between installation dates (or in the month of the audit and measure installations) to a dead-band period, which was not included in analysis.
- **Cleaning Individual Billing Periods:** We removed billing periods with a duration of zero days (i.e., same start and end date). Usage records for these billing periods recorded either zero kWh or positive kWh; many were the first read in the available billing history or a "Turn-On" read. We also dropped billing periods lasting less than 1 week or longer than 50 days, since we need to assign each billing period to a specific month for analysis purposes, and longer periods would introduce greater error into the model. Nearly all accounts had billing periods of around 30 days. For individuals with a short first bill, we combined the kWh usage and billing days with their second bill, as is standard practice for DEO when sending bills to customers. Additionally, we:
  - Determined average daily usage for each observation (based on usage and number of billing days in each period)
  - Assigned seasonal dummy variables to each of the monthly observations:
    - Winter: December, January, February
    - Spring: April, March, May
    - Summer: June, July, August
    - Fall: September, October, November
- **Removing Extremely High or Low Average Daily Consumption:** For the final analysis dataset, we removed customers with entire pre- or post-periods having very high or very low usage. This is to ensure that participants spent equivalent amounts of time in their homes in the months before and after program participation. We dropped households with average daily consumption at or below 2 kWh/day on average (across their billing history in both the pre- and post-program periods). We also dropped customers with extremely high usage (over 300 kWh/day). These households are likely to contain odd usage patterns that we can't easily control for and could bias our results.
- **Removing Inadequate Billing History before Program Participation:** The primary savings measures are expected to generate energy savings throughout the year. To be able to assess changes in consumption due to program measures before and after installation, we required participants to have a billing history

covering, at a minimum, six billing records or 180 days before the first day of program participation for both the 2014 and 2015 program participants.

- **Removing Inadequate Billing History in the Cooling Season before and after Program Participation:** For the treatment group, we also required participants to have a minimum of two billing records in the summer (cooling season). This is because we expect energy use to be generally weather sensitive both in terms of temperature and in terms of daylight hours. By ensuring that we have enough billing data in the months of June, July, and August, we allow for more rigorous savings estimates.

Table F-1. Accounts Removed from Model

Reason Account Was Dropped	Total Accounts	%	2013 Accounts	%	2014 Accounts	%	2015 Accounts	%
Total Unique Accounts	5235	-	829	-	2869	-	1537	-
No Billing Data	1	0.02%	0	-	1	0.03%	0	-
# of accounts remaining	5234	100%	829	100%	2868	100%	1537	100%
Less Than 6 Pre-Billing Periods	194	4%	48	6%	102	4%	44	3%
# of accounts remaining	5040	96%	781	94%	2766	96%	1493	97%
Less Than 6 Post-Billing Periods (Treat)	48	1%	10	1%	38	1.3%	0	0.0%
# of accounts remaining	4992	95%	771	93%	2728	95%	1493	97%
Low Overall ADC < 2 kWh	3	0.1%	0	0.0%	1	0.03%	2	0.1%
Low Overall Post ADC < 2 kWh	1	0.02%	0	0.00%	0	-	1	0.1%
# of accounts remaining	4988	95%	771	93%	2727	95%	1490	97%
High Overall Post ADC > 300 kWh	1	0.02%	0	-	1	0%	0	-
# of accounts remaining	4987	95%	771	93%	2726	95%	1490	97%
Less Than 2 Summer Billing Pre Period	104	2%	1	0%	69	2%	34	2%
# of accounts remaining	4883	93%	770	93%	2657	93%	1456	95%
Less Than 2 Summer Billing Post Period (Treat)	27	0.5%	11	1.3%	16	-	0	-
# of accounts remaining	4856	93%	759	92%	2641	92%	1456	95%
Less Than 6 Months in Pre-Period Days	43	0.8%	20	2%	22	-	1	-
# of accounts remaining	4813	92%	739	89%	2619	91%	1455	95%
Less Than 6 Months in Post-Period Days (Treat)	2	0%	0	0%	2	0.1%	0	-
# of accounts remaining	4811	92%	739	89%	2617	91%	1455	95%

The presence of electric space heating in participant households is of interest, especially due to the relatively cold climate seen in Ohio. The portion of participants with electric heat in our data was fairly consistent between years, which led us to include all customers in a single model. The breakdown of accounts with and without electric space heat is shown in Table F-2.

Table F-2. Electric Space Heat Homes (ESH) Accounts Included in Model

Program Year	All Electric Accounts	ESH Electric Accounts	Non-ESH Electric Accounts	Percentage of ESH Accounts
Fall 2013	739	167	572	23%
2014	2,617	658	1,959	25%
2015	1,455	405	1,050	28%

The final dataset used in our analysis is a clean and unique set of program participants, including the date of participation, their location, and all measures that were installed. This file is merged into the cleaned dataset of monthly bills, which brings in the customers' usage (in kWh) over time. Into this combined dataset, we add HDD and CDD for each customer based on the nearest weather station. Customers who do not meet the criteria necessary for accurate modeling are dropped.

Assess Comparison Group Equivalency

We utilized a comparison group of 2015 participants for our analysis because these customers are likely to possess many of the same attributes as earlier participants. Data limitations are also a driver for using this style of comparison group, over a match comparison group pulled from the full customer population, due to the large amount of data required for the latter. In the future, the evaluation team may consider requesting billing records for the entire population of customers to test potential improvements to our analysis utilizing a match comparison group over this method. The use of a comparison group mitigates self-selection bias that may be present in the evaluated group (2014 participants). It is important that 2014 and 2015 participants are equivalent on as many dimensions as possible. Based on the information at our disposal, we looked at three criteria to determine that 2014 participants were equivalent to the 2015 participants, and could be used as a valid comparison group. The three criteria are listed below:

- Measure Mix: We assessed the similarity in the distribution and variety of measures that were installed in 2013, 2014, and 2015 participant households.
- Weather[13]: We compared average monthly Heating Degree Days (HDD) and Cooling Degree Days (CDD).
- Baseline Period Average Daily Consumption: Similarity in ADC before engaging with the program might be a general proxy for behavioral similarities. As such, we compared the baseline monthly ADC for participants.

As a result of the equivalency check, we determined that treatment and control groups were comparable for analyzing the impacts of the REA program.

[13] *A "degree-day" is a unit of measure for recording how hot or how cold it has been over a 24-hour period. The number of degree-days applied to any particular day of the week is determined by calculating the mean temperature for the day and then comparing the mean temperature to a base values of 65 (HDD) and 75 (CDD) degrees F. (The "mean" temperature is calculated by adding together the high for the day and the low for the day, and then dividing the result by 2.)*

If the mean temperature for the day is, say, 5 degrees higher than 75, then there have been 5 cooling degree-days. On the other hand, if the weather has been cool, and the mean temperature is, say, 55 degrees, then there have 10 heating degree-days (65 minus 55 equals 10).

Quoted from http://www.srh.noaa.gov/ffc/?n=degdays.

Measure Mix

The measures included in the Energy Efficiency Starter Kit remained consistent between the 2014 and 2015. The only difference in measures that is possible between customers of the program is the number of additional CFLs that are installed. Per the program design, the auditor may install up to 12 additional CFLs on top of the 3 that are included in the kit. Table F-1-3 shows the average number of additional bulbs installed for each program year. A smaller percentage of customers received additional bulbs in 2015, and those participants also received fewer bulbs on average. Since only a portion of the participants from 2015 were included in our analysis, we did not draw any conclusions from this, as the rate of bulbs may increase over the remainder of the current program year. In our models, we included the number of additional bulbs installed in an effort to quantify the savings realized through their installation.

Table F-1-3. Additional CFLs Installed

	Participants Who Received Additional CFLs during Assessment		
	N	%	Average # Installed
Billing Analysis Treatment Group (2013 Participants)	251	34%	2.99
Billing Analysis Treatment Group (2014 Participants)	1,161	44%	3.22
Billing Analysis Comparison Group (2015 Participants)	1,455	100%	1.54

Weather

In order to include weather in our model, we used daily weather data from numerous weather stations across the DEO territory, utilizing the site geographically closest to each account's physical address. By using multiple sites, we increase the accuracy of the weather data being applied to each account. We obtained these data from the National Climatic Data Center (NCDC). Figure F-2 and Figure F-3 show that weather for the comparison and treatment groups are nearly identical.

Figure F-2. Average CDD per Participant

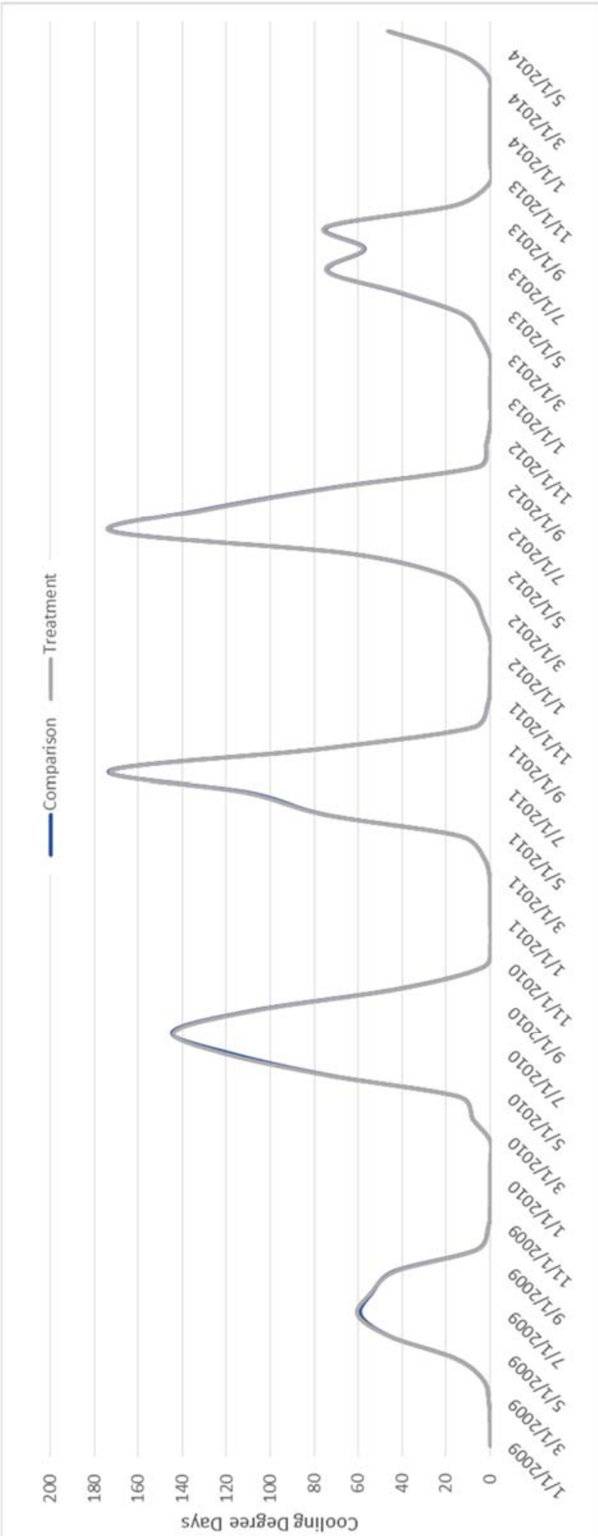
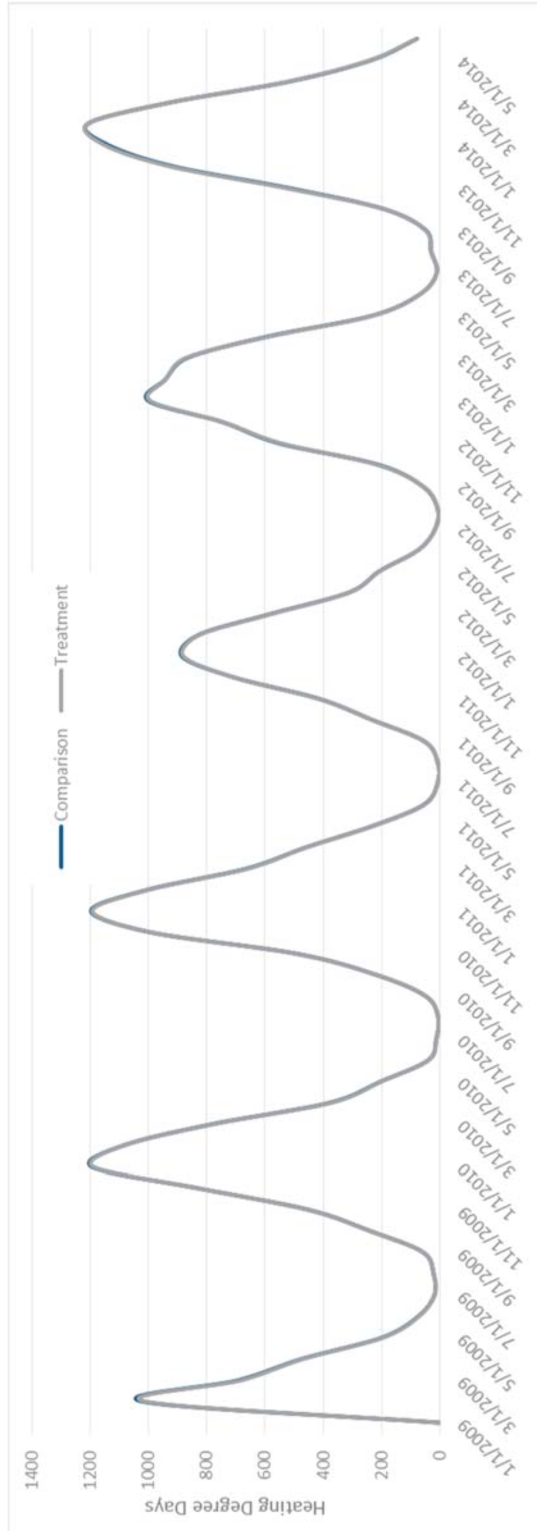


Figure F-3. Average HDD per Participant

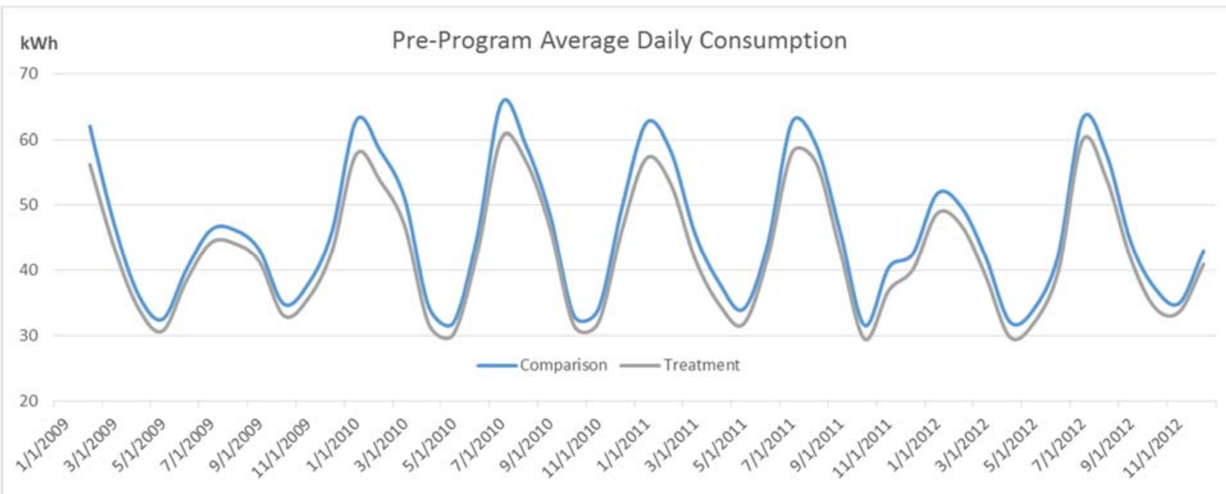


We calculated CDD and HDD for each day (in the analysis and historical period) based on average daily temperature. The daily weather data were then merged into the billing data set so that each billing period captures the HDD and CDD for each day within that billing period (including start and end dates[14]). For analysis purposes, we then calculated average daily HDD and average daily CDD, based on the number of days within each billing period.

Baseline Period Average Daily Consumption

An analysis of pre-program usage compared the treatment group of Fall 2013 and 2014 participants to the comparison group of 2015 participants. The graph below shows that the two groups use energy in a very similar manner. However, the comparison group is made of up of slightly higher energy users on average. In our final model, we included terms that help account for these slight differences in pre-program period consumption.

Figure F-4. ADC Comparison



Model Specifications

To estimate savings for the REA program, Opinion Dynamics evaluated a number of possible models, and chose to use a LFER model that incorporates weather, time, pre-program period usage, and participation in other DEO programs. We used a comparison group to help construct the counterfactual baseline for the treatment group in the post-program period. Our model includes a comparison group consisting of future participants or households that participated in 2015. Pre-program period billing records for 2015 participants were used as a comparison to billing data of the 2014 participants. This type of comparison group assumes that the early participants are the same as the future participants. A comparative analysis of the two groups shows that the comparison group has slightly higher usage. It is important to control for this difference, in order to make the two groups comparable.

Billing analyses using an appropriate comparison group incorporate the effects of both FR and participant SO, thus providing program net savings. For example, the energy use patterns of the members of the comparison group during 2014 (their pre-participation period) reflect equipment installations and behavioral changes that

[14] Daily weather is merged based on the given dates of the billing period, even though we noted earlier that the meter read date is incorrect. Despite the issue with dates, assigning weather this way provides a more accurate representation of the weather experienced during the billing period than does using weather for the calendar month of the bill.

treatment group participants might have performed in the absence of the program. Any measures installed during the evaluation period beyond program measures (SO) are picked up by an increased coefficient for the participation variables.

Develop and Test Model Specifications

All tested models included a comparison group consisting of households that participated in 2015. The 2015 comparison group is to help construct the counterfactual or baseline for the treatment group (2014 participants) in the post-program period. Up until the date on which each 2015 participant entered the program, his billing data can be compared to the billing data of the 2014 participants. As soon as a participant starts participation in the program, 2015 participant data are dropped from the analysis.

To improve our estimate of the counterfactual (what 2014 participants would have done during the post-program period absent the program), we added dummy variables for each month of the evaluation period. The monthly dummy variables provide information on time-related trends not specific to the comparison group per se. This method "allows" the comparison group to represent something closer to the counterfactual.

Our final model needed to fill a number of criteria. Primarily, we looked to use a model that explains as much about changes in the dependent variable as possible. The most direct measure of this is the overall R-sq, which gives an estimate of how much the model explains. An R-sq of 1.0 would represent a model that explains 100% of the variance in the depend variable, and an R-sq of 0.5 would explain 50%. In our quasi-experiment, R-sq will appear low because of our use of fixed effects, but a higher R-sq will be a significant factor. We also compare Akaike Information Criterion (AIC) values of different model specifications. The AIC provides a measure of relative quality between models; a lower value indicates a relatively more robust model.

We considered several possibilities for final model specification, including a relatively simple model of participation, controlling for weather. We also tested a model similar to the previous evaluation, including weather interacted with month-year terms, flags for participation in other programs, and the number of additional CFLs received.[15] Acknowledging the difference seen between our treatment and comparison groups, we moved to models that included the interactions of the month-year dummies with seasonal pre-program period usage terms. This allows for substantial model correction across participants. To build our final model, we include weather, in the form of CDD and HDD values for each billing period, and participation in other programs, and account for differences in pre-program period and seasonal pre-program period usage. We also entered interaction terms between weather and the post-program period for the treatment group, to account for the relationship between weather and consumption following treatment.

Final Model

Our testing revealed that the overall savings estimates were robust across a number of model specifications. The final model utilizes the LFER model with the specifications shown in the equation below to estimate savings for the program overall, and includes a term to estimate savings associated with additional bulbs installed. We also account for participation in other DEO programs in two ways: by including terms for participation for select programs in the pre-program period and by removing post-program period observations from the model for REA participants who showed participation in other program during the post-program

[15] The model that mimicked the previous evaluation resulted in a very low R-sq and comparatively high score for the AIC test. Further testing led us toward the final model.

period.[16] Doing this strengthens our estimate for savings associated strictly with participation in the REA program.

$$ADC_{it} = B_h + B_1Post_{it} + \ B_2CFL_{it} + B_3Programs_{it} + B_4HDD_{it} + B_5CDD_{it} + B_6Post \cdot HDD_{it} + B_7Post \cdot CDD_{it} + B_{t1}MY \cdot PreADC \ + B_{t3}MY \cdot SummerPreADC + B_{t4}MY \cdot WinterPreADC \ + B_tM + \ \varepsilon_{it}$$

where:

ADC_{it} = ADC (in kWh) for the billing period

$Post$ = Indicator for treatment group in post-program period (coded 0 if treatment group in pre-program period or comparison group in all periods)

HDD = Average daily HDD from NOAA

CDD = Average daily CDD from NOAA

$Programs$ = Separate terms for participation in other DEO programs

MY = Month-year dummies for all time periods in the model

$PreADC$ = Pre-program period ADC

$SummerPreADC$ = Pre-program period summer ADC

$WinterPreADC$ = Pre-program period winter ADC

B_h= Average household-specific constant

B_1= Main program effect (change in ADC associated with being a participant in the post-program period)

B_2= Incremental change in ADC associated with one unit increase in additional CFLs installed

B_3= Increment in ADC associated with one unit increase in HDD

B_4= Increment in ADC associated with one unit increase in CDD

B_5= Increment in ADC associated with each increment increase of HDD for participants in the post-program period (the additional program effect due to HDD)

B_6= Increment in ADC associated with each increment increase of CDD for participants in the post-program period (the additional program effect due to CDD)

B_t= Coefficients for each month-year period

B_{t1}= Coefficients for each month-year period for pre-program period ADC

B_{t2}= Coefficients for each month-year period for summer pre-program period ADC

B_{t3}= Coefficients for each month-year period for winter pre-program period ADC

ε_{it} = Error term

Participation with the program is interacted with weather terms, to partition the savings by weather conditions, i.e., there are usually more savings in more severe weather than we see in milder weather. The model also includes dummies for each calendar month covered by the evaluation period and interactions between these dummies and seasonal pre-program period usage because this helps control for the joint effects of other time-

[16] Due to extensive overlap with the MyHER (83%) and Free CFL (74%) programs, post-program period observations were not removed from the model for cross-participation in those programs. Additional models were run, interacting REA program participation with the other programs, and we found that MyHER participation coupled with the REA program produced slightly greater coefficients than REA program participants alone. This provides evidence that the two programs are complementary. Interaction with the Free CFL program did not show similar results.

related trends and weather. This approach allows the comparison group to more precisely represent the counterfactual.

Estimated Savings

This section contains the observed net savings and realization rates resulting from the billing analysis for 2014 participants. Results reflect savings associated with kit measures, assessment recommendations, SO, and potential behavioral changes from energy efficiency knowledge gained during the assessment.

Model Results

The regression model results presented in Table F-4 show a reduction in electricity use after participants received their energy assessment from the HEHC, controlling for weather, time, and the household characteristics (reflected in the constant term). An overall R-sq for this model is shown in the complete model results (Table F-4). However, we also ran this model with random effects to gain a more accurate understanding of how well the model performs. In this, we find the R-sq to be 0.67.

Table F-4. Final Model Results

					90% Confidence Interval	
Predictor	Coefficient	Robust Std. Err.	t	P > |t|	Lower	Upper
REA	−5.7031	0.5261	−10.84	0.00	−6.7345	−4.6718
Additional CFLs	−0.0226	0.0356	−0.63	0.53	−0.0924	0.0473
MyHER	−0.1246	0.1896	−0.66	0.51	−0.4964	0.2472
Free CFL	−0.1282	0.2033	−0.63	0.53	−0.5267	0.2703
Low-Income Weatherization	−0.7364	0.7430	−0.99	0.32	−2.1931	0.7202
Smart $aver HVAC	−2.7306	0.5667	−4.82	0.00	−3.8415	−1.6197
CDD	−0.0285	0.0080	−3.55	0.00	−0.0442	−0.0127
HDD	0.0000	0.0010	0.01	0.99	−0.0020	0.0020
postCDD	0.0579	0.0068	8.53	0.00	0.0446	0.0713
postHDD	0.0037	0.0009	3.89	0.00	0.0018	0.0055
Constant	−5.9099	11.669	−0.51	0.61	−28.787	16.967

Due to the weather interaction terms in the model, it is necessary to recalculate the coefficient of the treatment effect (REA) 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-program period, including any reduction caused by milder temperatures. Utilizing a simple equation that combines the coefficients of those interaction terms with the average post-program period values for each, we are able to estimate the overall savings associated with the program itself.

Table F-5. Adjusted Estimate of REA Program Effect on Daily Consumption

					90% Confidence Interval	
ADC	Estimate	Standard Error	T	P > |t|	Lower	Upper
(1)	−2.670183	0.2472088	−10.8	0	−3.076884	−2.263482

The value of the estimate represents the kWh change in ADC given a one unit change in the treatment effect, i.e., treatment moving from 0 (pre-treatment) to 1 (post-treatment). The savings estimated here can be extrapolated to the overall net program savings for 2014 REA program participants.

Table F-6. Estimated Annual Savings from Billing Analysis

	N	Ex Ante Net Savings (kWh)		90% Confidence Interval (Daily)	
		Average Daily Savings	Average Annual Savings	Lower	Upper
Program Savings	3,356	2.67	975	3.06	2.25

* Fall 2013–2014 participants.

We estimate that the program realized 975 kWh of yearly savings for participants during the evaluation period. While engineering estimates relate only to installed measures from the Energy Efficiency Starter Kit, savings from the billing analysis account for the reduced energy consumption associated with improvements made due to assessment recommendations, SO, and behavioral changes, in addition to the kit measures.

Full Results

The model is shown here in its entirety.

$$\boldsymbol{ADC_{it} = B_h + B_1Post_{it} + B_2CFL_{it} + B_3Programs_{it} + B_4HDD_{it} + B_5CDD_{it} + B_6Post \cdot HDD_{it} + B_7Post \cdot CDD_{it} + B_{t1}MY \cdot PreADC + B_{t3}MY \cdot SummerPreADC + B_{t4}MY \cdot WinterPreADC + B_tM + \varepsilon_{it}}$$

Table F-7. Final Model

Fixed-effects (within) regression					**Number of obs:**	293,500
Group variable: acct					**Number of groups:**	4,776
R-sq:					**Obs per group:**	
within:	0.3123				min:	6
between:	0.8963				avg:	62
overall:	0.6408				max:	78
corr(u_i, Xb):	0.5292				**F(332, 4775)**:	157.18
					Prob > F	0.0000
					(Std. Err. adjusted for 4811 clusters in acct)	

ADC	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
REA	-5.703135	0.526087	-10.84	0.000	-6.734509	-4.671762
Additional CFLs	-0.0225611	0.035629	-0.63	0.527	-0.092411	0.0472889
MyHER	-0.1245692	0.189649	-0.66	0.511	-0.4963683	0.2472299
Free CFL	-0.1281901	0.203273	-0.63	0.528	-0.5266978	0.2703176
Low Income Weatherization	-0.7364353	0.743008	-0.99	0.322	-2.193073	0.7202027
Smart $aver HVAC	-2.730591	0.566655	-4.82	0.000	-3.841496	-1.619685

CDD	-0.0284749	0.008031	-3.55	0.000	-0.0442191	-0.0127307
HDD	0.0000125	0.001007	0.01	0.990	-0.0019611	0.001986
postCDD	0.0579494	0.006795	8.53	0.000	0.0446282	0.0712705
postHDD	0.0036565	0.000941	3.89	0.000	0.0018125	0.0055006
Pre-Period ADC						
February-09	1.363608	1.087796	1.25	0.21	-0.7689738	3.496189
March-09	2.205706	1.163191	1.9	0.058	-0.0746848	4.486096
April-09	0.5767863	0.760066	0.76	0.448	-0.9132941	2.066867
May-09	0.8353847	0.663138	1.26	0.208	-0.4646713	2.135441
June-09	0	(omitted)				
July-09	1.426174	0.505965	2.82	0.005	0.4342495	2.418098
August-09	0.6755157	0.414716	1.63	0.103	-0.1375184	1.48855
September-09	1.328192	0.600482	2.21	0.027	0.1509704	2.505413
October-09	0.6341111	0.582911	1.09	0.277	-0.5086639	1.776886
November-09	-0.2485259	0.636105	-0.39	0.696	-1.495586	0.9985339
December-09	-0.4138471	0.886691	-0.47	0.641	-2.152171	1.324477
January-10	0.8028568	1.078279	0.74	0.457	-1.311068	2.916781
February-10	1.060402	1.021604	1.04	0.299	-0.9424128	3.063216
March-10	2.934418	0.92296	3.18	0.001	1.12499	4.743845
April-10	0.8184709	0.754023	1.09	0.278	-0.6597619	2.296704
May-10	0.3673353	0.612815	0.6	0.549	-0.8340638	1.568734
June-10	-0.5850472	0.973091	-0.6	0.548	-2.492754	1.32266
July-10	-0.9436054	1.150674	-0.82	0.412	-3.199456	1.312245
August-10	1.573553	0.514738	3.06	0.002	0.5644291	2.582676
September-10	0.896668	0.814474	1.1	0.271	-0.7000772	2.493413
October-10	1.482042	0.77674	1.91	0.056	-0.0407253	3.004809
November-10	0.0686939	0.7741	0.09	0.929	-1.4489	1.586287
December-10	-1.06034	0.999534	-1.06	0.289	-3.019886	0.899207
January-11	0.4795851	1.329917	0.36	0.718	-2.127666	3.086836
February-11	1.901676	0.989644	1.92	0.055	-0.0384818	3.841834
March-11	1.241825	0.740584	1.68	0.094	-0.21006	2.693711
April-11	1.074648	0.736238	1.46	0.144	-0.3687171	2.518014
May-11	0.5405612	0.605641	0.89	0.372	-0.6467738	1.727896
June-11	0.3107744	0.53578	0.58	0.562	-0.7396004	1.361149
July-11	-6.155136	0.922968	-6.67	0.000	-7.964578	-4.345694
August-11	2.311831	0.692955	3.34	0.001	0.9533197	3.670343
September-11	1.145009	0.66264	1.73	0.084	-0.1540707	2.444088
October-11	1.072932	0.584779	1.83	0.067	-0.0735041	2.219368
November-11	-2.102948	0.745073	-2.82	0.005	-3.563634	-0.6422628
December-11	0.9178214	0.715757	1.28	0.200	-0.4853929	2.321036

Appendix F. Detailed Methodology: Billing Analysis

January-12	1.244958	0.790114	1.58	0.115	-0.3040296	2.793946
February-12	1.522575	0.80754	1.89	0.059	-0.0605755	3.105724
March-12	1.672976	0.700076	2.39	0.017	0.3005051	3.045446
April-12	0.7881437	0.552729	1.43	0.154	-0.2954604	1.871748
May-12	0.7500727	0.527784	1.42	0.155	-0.2846271	1.784773
June-12	0.0202722	0.509775	0.04	0.968	-0.9791217	1.019666
July-12	-1.514201	0.772905	-1.96	0.050	-3.029451	0.0010497
August-12	0.7796948	0.599114	1.3	0.193	-0.3948453	1.954235
September-12	1.276276	0.577979	2.21	0.027	0.1431709	2.409381
October-12	0.0209878	0.594958	0.04	0.972	-1.145403	1.187379
November-12	0.7202893	0.610953	1.18	0.238	-0.4774609	1.91804
December-12	0.7622844	0.639506	1.19	0.233	-0.4914418	2.016011
January-13	0.8515837	0.713159	1.19	0.232	-0.5465358	2.249703
February-13	1.061225	0.658294	1.61	0.107	-0.2293351	2.351785
March-13	0.9528076	0.642063	1.48	0.138	-0.3059317	2.211547
April-13	0.8291259	0.608068	1.36	0.173	-0.3629667	2.021219
May-13	0.3866806	0.561526	0.69	0.491	-0.7141698	1.487531
June-13	0.4030871	0.546062	0.74	0.460	-0.6674467	1.473621
July-13	0.6318158	0.55053	1.15	0.251	-0.4474774	1.711109
August-13	0.4297891	0.562845	0.76	0.445	-0.6736459	1.533224
September-13	0.4380124	0.553839	0.79	0.429	-0.6477682	1.523793
October-13	0.4105014	0.562722	0.73	0.466	-0.6926928	1.513696
November-13	0.3909073	0.573916	0.68	0.496	-0.734233	1.516048
December-13	0.9269025	0.587345	1.58	0.115	-0.2245636	2.078369
January-14	1.318763	0.621342	2.12	0.034	0.1006456	2.53688
February-14	1.661784	0.632684	2.63	0.009	0.4214329	2.902136
March-14	1.320059	0.626761	2.11	0.035	0.0913186	2.548799
April-14	0.7126054	0.580795	1.23	0.220	-0.426021	1.851232
May-14	0.3662076	0.56262	0.65	0.515	-0.7367878	1.469203
June-14	0.3211278	0.560419	0.57	0.567	-0.777551	1.419807
July-14	0.3442795	0.56182	0.61	0.540	-0.757147	1.445706
August-14	0.3528827	0.560098	0.63	0.529	-0.7451673	1.450933
September-14	0.4131249	0.560849	0.74	0.461	-0.6863971	1.512647
October-14	0.26831	0.560611	0.48	0.632	-0.8307456	1.367366
November-14	0.3228908	0.570649	0.57	0.572	-0.7958438	1.441625
December-14	0.9414358	0.583689	1.61	0.107	-0.2028644	2.085736
January-15	1.101801	0.593313	1.86	0.063	-0.0613664	2.264969
February-15	1.20757	0.607515	1.99	0.047	0.0165612	2.398579
March-15	1.477214	0.615167	2.4	0.016	0.2712037	2.683223
April-15	0.5694422	0.575383	0.99	0.322	-0.5585734	1.697458
May-15	0.3342959	0.5656	0.59	0.555	-0.7745399	1.443132

June-15	0.3996197	0.564302	0.71	0.479	-0.7066725	1.505912
July-15	0.4336281	0.562191	0.77	0.441	-0.6685243	1.535781
August-15	-0.0658654	0.706166	-0.09	0.926	-1.450276	1.318546
Summer Pre-Period ADC						
February-09	0.1527246	0.116173	1.31	0.189	-0.0750274	0.3804766
March-09	-0.0323401	0.075206	-0.43	0.667	-0.1797786	0.1150983
April-09	0.1033558	0.045064	2.29	0.022	0.0150092	0.1917023
May-09	0	(omitted)				
June-09	0.1266135	0.068038	1.86	0.063	-0.006772	0.2599989
July-09	-0.0271505	0.067352	-0.4	0.687	-0.1591918	0.1048907
August-09	0.0427631	0.053223	0.8	0.422	-0.0615791	0.1471052
September-09	-0.0382505	0.046447	-0.82	0.410	-0.1293078	0.0528069
October-09	0.0578536	0.042064	1.38	0.169	-0.0246114	0.1403185
November-09	0.2604557	0.053719	4.85	0.000	0.1551414	0.36577
December-09	0.1519893	0.074462	2.04	0.041	0.0060087	0.2979699
January-10	0.2490115	0.107156	2.32	0.020	0.0389369	0.459086
February-10	0.1040255	0.106021	0.98	0.327	-0.1038253	0.3118762
March-10	-0.0617305	0.080155	-0.77	0.441	-0.2188706	0.0954097
April-10	0.0495551	0.032319	1.53	0.125	-0.0138044	0.1129146
May-10	0.0648242	0.03121	2.08	0.038	0.0036376	0.1260108
June-10	0.1171622	0.051484	2.28	0.023	0.0162295	0.218095
July-10	0.5548764	0.140032	3.96	0.000	0.2803501	0.8294027
August-10	-0.0958484	0.050237	-1.91	0.056	-0.1943353	0.0026385
September-10	0.0014244	0.055906	0.03	0.980	-0.1081772	0.1110261
October-10	-0.1052962	0.043196	-2.44	0.015	-0.18998	-0.0206124
November-10	0.1062431	0.045173	2.35	0.019	0.0176823	0.1948038
December-10	0.2716083	0.080794	3.36	0.001	0.1132147	0.4300019
January-11	0.2317385	0.109803	2.11	0.035	0.0164743	0.4470026
February-11	0.1106675	0.094012	1.18	0.239	-0.0736401	0.2949752
March-11	0.0897091	0.058638	1.53	0.126	-0.0252484	0.2046667
April-11	0.0753923	0.045665	1.65	0.099	-0.0141312	0.1649158
May-11	0.059559	0.03493	1.71	0.088	-0.0089198	0.1280378
June-11	0.1238724	0.050588	2.45	0.014	0.0246972	0.2230475
July-11	0.9517456	0.130636	7.29	0.000	0.6956387	1.207853
August-11	-0.1812308	0.072147	-2.51	0.012	-0.3226712	-0.0397904
September-11	0.0175653	0.049902	0.35	0.725	-0.0802655	0.1153961
October-11	-0.0029356	0.043838	-0.07	0.947	-0.0888787	0.0830075
November-11	0.4835193	0.078674	6.15	0.000	0.329283	0.6377555
December-11	0.0332401	0.064816	0.51	0.608	-0.093829	0.1603092
January-12	0.0286565	0.086556	0.33	0.741	-0.1410335	0.1983465

February-12	0.0871188	0.079674	1.09	0.274	-0.0690798	0.2433174
March-12	0.0408265	0.060436	0.68	0.499	-0.0776559	0.159309
April-12	0.051354	0.04044	1.27	0.204	-0.0279275	0.1306356
May-12	0.0523922	0.04012	1.31	0.192	-0.0262612	0.1310455
June-12	0.1410972	0.051015	2.77	0.006	0.0410844	0.24111
July-12	0.34333	0.065489	5.24	0.000	0.2149409	0.4717191
August-12	0.0650224	0.057298	1.13	0.257	-0.0473088	0.1773536
September-12	-0.0171767	0.044547	-0.39	0.700	-0.1045087	0.0701553
October-12	0.1705867	0.051408	3.32	0.001	0.0698026	0.2713707
November-12	0.0603303	0.046877	1.29	0.198	-0.03157	0.1522306
December-12	0.09083	0.051441	1.77	0.078	-0.0100177	0.1916776
January-13	0.1472361	0.057124	2.58	0.010	0.0352476	0.2592245
February-13	0.1665986	0.059418	2.8	0.005	0.0501121	0.2830851
March-13	0.1542925	0.055892	2.76	0.006	0.0447186	0.2638665
April-13	0.1006548	0.048764	2.06	0.039	0.0050543	0.1962553
May-13	0.0991605	0.042816	2.32	0.021	0.0152205	0.1831004
June-13	0.1121354	0.044086	2.54	0.011	0.0257074	0.1985634
July-13	0.0682822	0.047345	1.44	0.149	-0.0245359	0.1611002
August-13	0.1068841	0.046314	2.31	0.021	0.0160878	0.1976803
September-13	0.1025991	0.043759	2.34	0.019	0.0168114	0.1883868
October-13	0.0905302	0.042981	2.11	0.035	0.0062681	0.1747923
November-13	0.1150775	0.044841	2.57	0.010	0.0271687	0.2029862
December-13	0.1183085	0.047422	2.49	0.013	0.0253389	0.2112781
January-14	0.1132062	0.050965	2.22	0.026	0.0132919	0.2131205
February-14	0.11414	0.051936	2.2	0.028	0.0123224	0.2159576
March-14	0.1031909	0.04908	2.1	0.036	0.0069714	0.1994103
April-14	0.0885517	0.044468	1.99	0.046	0.0013749	0.1757285
May-14	0.0960174	0.042764	2.25	0.025	0.0121809	0.1798538
June-14	0.0955377	0.04306	2.22	0.027	0.0111204	0.179955
July-14	0.1098217	0.04443	2.47	0.013	0.0227193	0.1969241
August-14	0.0992355	0.044695	2.22	0.026	0.0116128	0.1868582
September-14	0.0993675	0.044488	2.23	0.026	0.0121512	0.1865838
October-14	0.127976	0.044674	2.86	0.004	0.0403951	0.215557
November-14	0.113912	0.044045	2.59	0.010	0.0275637	0.2002604
December-14	0.1055964	0.046515	2.27	0.023	0.0144054	0.1967875
January-15	0.1230844	0.047437	2.59	0.009	0.0300858	0.2160829
February-15	0.110691	0.049581	2.23	0.026	0.0134901	0.207892
March-15	0.0803859	0.049765	1.62	0.106	-0.0171773	0.177949
April-15	0.094197	0.043882	2.15	0.032	0.0081673	0.1802267
May-15	0.1028818	0.042585	2.42	0.016	0.0193957	0.1863678
June-15	0.0917121	0.043709	2.1	0.036	0.0060225	0.1774017

July-15	0.0984442	0.04459	2.21	0.027	0.0110263	0.185862
August-15	0.1714747	0.063005	2.72	0.007	0.0479561	0.2949933
Winter Pre-Period ADC						
February-09	-0.1452556	0.154233	-0.94	0.346	-0.4476238	0.1571125
March-09	-0.2786058	0.202275	-1.38	0.168	-0.675158	0.1179463
April-09	-0.1093949	0.129252	-0.85	0.397	-0.3627887	0.1439989
May-09	-0.1088022	0.119938	-0.91	0.364	-0.3439363	0.1263319
June-09	0	(omitted)				
July-09	-0.1980996	0.089407	-2.22	0.027	-0.3733788	-0.0228203
August-09	-0.0776496	0.068295	-1.14	0.256	-0.2115385	0.0562393
September-09	-0.169048	0.101996	-1.66	0.098	-0.3690074	0.0309114
October-09	-0.107791	0.096113	-1.12	0.262	-0.2962164	0.0806345
November-09	-0.0623595	0.099736	-0.63	0.532	-0.2578883	0.1331694
December-09	0.1784889	0.139838	1.28	0.202	-0.0956588	0.4526366
January-10	-0.0935982	0.157355	-0.59	0.552	-0.4020855	0.214889
February-10	-0.0278468	0.152557	-0.18	0.855	-0.3269291	0.2712355
March-10	-0.4145265	0.137831	-3.01	0.003	-0.6847385	-0.1443145
April-10	-0.1388025	0.133304	-1.04	0.298	-0.4001393	0.1225342
May-10	-0.0538583	0.107639	-0.5	0.617	-0.2648808	0.1571642
June-10	0.1714132	0.189238	0.91	0.365	-0.1995795	0.5424059
July-10	-0.1524779	0.194766	-0.78	0.434	-0.5343088	0.229353
August-10	-0.1496578	0.086723	-1.73	0.084	-0.3196755	0.0203598
September-10	-0.0913741	0.150142	-0.61	0.543	-0.3857221	0.2029739
October-10	-0.1743022	0.138623	-1.26	0.209	-0.4460668	0.0974624
November-10	0.0013809	0.135512	0.01	0.992	-0.2642852	0.267047
December-10	0.2540957	0.162284	1.57	0.117	-0.0640565	0.572248
January-11	0.0220414	0.222769	0.1	0.921	-0.4146882	0.4587711
February-11	-0.2503216	0.146897	-1.7	0.088	-0.5383076	0.0376644
March-11	-0.1875381	0.112122	-1.67	0.094	-0.4073493	0.0322732
April-11	-0.1957456	0.12041	-1.63	0.104	-0.4318052	0.040314
May-11	-0.0850452	0.104247	-0.82	0.415	-0.2894177	0.1193272
June-11	-0.0739652	0.090739	-0.82	0.415	-0.2518549	0.1039244
July-11	0.761948	0.139047	5.48	0.000	0.4893513	1.034545
August-11	-0.2533694	0.108967	-2.33	0.020	-0.4669942	-0.0397446
September-11	-0.18029	0.113963	-1.58	0.114	-0.4037094	0.0431295
October-11	-0.1747488	0.093272	-1.87	0.061	-0.3576047	0.0081071
November-11	0.1930822	0.115522	1.67	0.095	-0.033394	0.4195585
December-11	-0.0718041	0.106465	-0.67	0.500	-0.2805241	0.1369159
January-12	-0.0686581	0.108417	-0.63	0.527	-0.2812056	0.1438893
February-12	-0.2095592	0.115828	-1.81	0.070	-0.4366352	0.0175167

March-12	-0.2724049	0.102488	-2.66	0.008	-0.4733289	-0.0714809
April-12	-0.14753	0.084359	-1.75	0.080	-0.312912	0.017852
May-12	-0.1289109	0.083081	-1.55	0.121	-0.2917874	0.0339656
June-12	-0.0207272	0.078922	-0.26	0.793	-0.1754511	0.1339967
July-12	0.1986437	0.138364	1.44	0.151	-0.0726141	0.4699015
August-12	-0.1164372	0.095162	-1.22	0.221	-0.3029991	0.0701246
September-12	-0.1828341	0.093336	-1.96	0.050	-0.3658155	0.0001473
October-12	-0.0609238	0.094975	-0.64	0.521	-0.2471189	0.1252712
November-12	-0.1030964	0.096751	-1.07	0.287	-0.2927726	0.0865799
December-12	-0.0902623	0.097998	-0.92	0.357	-0.2823831	0.1018585
January-13	-0.0660146	0.112483	-0.59	0.557	-0.2865324	0.1545032
February-13	-0.1276576	0.095202	-1.34	0.180	-0.3142983	0.058983
March-13	-0.1186474	0.094488	-1.26	0.209	-0.3038867	0.0665919
April-13	-0.1310535	0.091715	-1.43	0.153	-0.3108561	0.0487492
May-13	-0.0910998	0.087312	-1.04	0.297	-0.2622721	0.0800726
June-13	-0.0945972	0.085629	-1.1	0.269	-0.2624685	0.073274
July-13	-0.0909143	0.086639	-1.05	0.294	-0.2607656	0.0789371
August-13	-0.0897791	0.08692	-1.03	0.302	-0.2601831	0.0806249
September-13	-0.0816169	0.085806	-0.95	0.342	-0.2498362	0.0866024
October-13	-0.1006077	0.087703	-1.15	0.251	-0.272546	0.0713305
November-13	-0.0814152	0.089558	-0.91	0.363	-0.2569898	0.0941595
December-13	-0.0983771	0.089472	-1.1	0.272	-0.2737842	0.07703
January-14	-0.0840558	0.095409	-0.88	0.378	-0.2711017	0.1029901
February-14	-0.1209539	0.095991	-1.26	0.208	-0.30914	0.0672322
March-14	-0.1303685	0.097716	-1.33	0.182	-0.3219374	0.0612003
April-14	-0.1078177	0.089458	-1.21	0.228	-0.2831957	0.0675603
May-14	-0.096822	0.087077	-1.11	0.266	-0.2675334	0.0738893
June-14	-0.0677418	0.088227	-0.77	0.443	-0.2407068	0.1052231
July-14	-0.0787509	0.087767	-0.9	0.370	-0.2508151	0.0933134
August-14	-0.0796873	0.086464	-0.92	0.357	-0.249196	0.0898214
September-14	-0.093407	0.086633	-1.08	0.281	-0.263247	0.076433
October-14	-0.0946867	0.086703	-1.09	0.275	-0.264664	0.0752905
November-14	-0.0868035	0.08881	-0.98	0.328	-0.260912	0.0873051
December-14	-0.1124624	0.089199	-1.26	0.207	-0.2873343	0.0624095
January-15	-0.1098523	0.09166	-1.2	0.231	-0.2895485	0.0698438
February-15	-0.1038125	0.094146	-1.1	0.270	-0.2883822	0.0807571
March-15	-0.1395873	0.094545	-1.48	0.140	-0.3249399	0.0457653
April-15	-0.1177345	0.08993	-1.31	0.191	-0.2940394	0.0585703
May-15	-0.0981524	0.088979	-1.1	0.270	-0.2725924	0.0762876
June-15	-0.0840382	0.08937	-0.94	0.347	-0.2592448	0.0911683
July-15	-0.0989568	0.087214	-1.13	0.257	-0.2699365	0.072023

August-15	-0.0533747	0.108154	-0.49	0.622	-0.2654071	0.1586578
Month-Year of Billing Period						
March-09	6.165905	1.628295	3.79	0.000	2.973697	9.358114
April-09	15.00154	1.807031	8.3	0.000	11.45893	18.54416
May-09	19.00552	2.068728	9.19	0.000	14.94986	23.06118
June-09	22.97207	2.584293	8.89	0.000	17.90566	28.03848
July-09	28.12959	2.604402	10.8	0.000	23.02376	33.23542
August-09	27.55055	2.40821	11.44	0.000	22.82935	32.27175
September-09	25.98903	2.686507	9.67	0.000	20.72224	31.25582
October-09	19.46336	2.228306	8.73	0.000	15.09485	23.83187
November-09	16.51091	1.842444	8.96	0.000	12.89887	20.12295
December-09	9.415404	1.535471	6.13	0.000	6.405174	12.42564
January-10	0.2593686	1.032437	0.25	0.802	-1.764684	2.283421
February-10	-0.5538668	1.323616	-0.42	0.676	-3.148764	2.04103
March-10	6.459285	1.163731	5.55	0.000	4.177836	8.740735
April-10	17.21264	1.779099	9.67	0.000	13.72478	20.70049
May-10	18.04794	2.136333	8.45	0.000	13.85975	22.23614
June-10	26.32184	2.543481	10.35	0.000	21.33545	31.30824
July-10	39.14328	3.10158	12.62	0.000	33.06275	45.22381
August-10	40.93649	2.39804	17.07	0.000	36.23522	45.63775
September-10	31.94055	2.31935	13.77	0.000	27.39356	36.48755
October-10	22.50049	2.009533	11.2	0.000	18.56088	26.4401
November-10	15.98107	1.939809	8.24	0.000	12.17815	19.78399
December-10	7.337337	1.542081	4.76	0.000	4.314147	10.36053
January-11	-2.420185	1.695963	-1.43	0.154	-5.745053	0.9046829
February-11	-0.5196261	1.264869	-0.41	0.681	-2.999352	1.960099
March-11	9.826148	1.382479	7.11	0.000	7.115851	12.53644
April-11	14.23739	1.627577	8.75	0.000	11.04659	17.4282
May-11	18.73626	1.961708	9.55	0.000	14.89041	22.58211
June-11	27.33557	2.209874	12.37	0.000	23.0032	31.66794
July-11	37.76494	3.030287	12.46	0.000	31.82418	43.7057
August-11	42.26201	2.400081	17.61	0.000	37.55674	46.96727
September-11	29.20878	2.273693	12.85	0.000	24.75129	33.66627
October-11	19.55298	1.960432	9.97	0.000	15.70963	23.39633
November-11	16.3764	2.271622	7.21	0.000	11.92298	20.82983
December-11	12.74271	1.533615	8.31	0.000	9.736121	15.7493
January-12	7.296788	1.732464	4.21	0.000	3.900361	10.69322
February-12	6.80341	1.414092	4.81	0.000	4.031139	9.575682
March-12	11.82425	1.495241	7.91	0.000	8.892888	14.75561
April-12	18.15873	1.90385	9.54	0.000	14.42631	21.89116

May-12	18.91581	1.980604	9.55	0.000	15.03291	22.79871
June-12	25.75164	2.264408	11.37	0.000	21.31236	30.19093
July-12	42.62038	2.607079	16.35	0.000	37.50931	47.73146
August-12	38.72893	2.224399	17.41	0.000	34.36808	43.08978
September-12	28.9272	2.044863	14.15	0.000	24.91833	32.93607
October-12	20.12721	2.136035	9.42	0.000	15.9396	24.31482
November-12	15.2572	1.625533	9.39	0.000	12.07041	18.44399
December-12	13.16586	1.420898	9.27	0.000	10.38024	15.95147
January-13	5.535812	1.270171	4.36	0.000	3.045692	8.025932
February-13	2.928694	1.271349	2.3	0.021	0.4362645	5.421124
March-13	5.342407	1.306961	4.09	0.000	2.78016	7.904654
April-13	13.25721	1.463977	9.06	0.000	10.38714	16.12728
May-13	18.19897	1.892092	9.62	0.000	14.4896	21.90835
June-13	23.26704	2.089232	11.14	0.000	19.17119	27.3629
July-13	31.01077	2.283867	13.58	0.000	26.53334	35.4882
August-13	30.19105	2.20504	13.69	0.000	25.86815	34.51394
September-13	32.91521	2.214235	14.87	0.000	28.57428	37.25613
October-13	22.31387	2.055936	10.85	0.000	18.28329	26.34445
November-13	17.12552	1.678272	10.2	0.000	13.83533	20.4157
December-13	9.032074	1.445534	6.25	0.000	6.198161	11.86599
January-14	0.5971915	1.437739	0.42	0.678	-2.221439	3.415822
February-14	-4.102623	1.559178	-2.63	0.009	-7.159332	-1.045915
March-14	3.387888	1.52451	2.22	0.026	0.399146	6.376631
April-14	15.39135	1.585223	9.71	0.000	12.28358	18.49912
May-14	21.6269	1.874059	11.54	0.000	17.95288	25.30092
June-14	27.72632	1.987696	13.95	0.000	23.82952	31.62312
July-14	33.02053	2.20574	14.97	0.000	28.69626	37.34479
August-14	30.47634	2.183674	13.96	0.000	26.19533	34.75735
September-14	32.99198	2.196993	15.02	0.000	28.68486	37.29909
October-14	25.44336	2.212803	11.5	0.000	21.10525	29.78147
November-14	20.82681	1.669865	12.47	0.000	17.5531	24.10052
December-14	12.85732	1.415962	9.08	0.000	10.08138	15.63326
January-15	8.358831	1.441835	5.8	0.000	5.532171	11.18549
February-15	5.941988	1.439008	4.13	0.000	3.120868	8.763107
March-15	4.981978	1.54796	3.22	0.001	1.947263	8.016693
April-15	20.99257	1.604615	13.08	0.000	17.84679	24.13836
May-15	24.61886	1.876675	13.12	0.000	20.93972	28.29801
June-15	28.72676	2.21846	12.95	0.000	24.37756	33.07596
July-15	33.10703	2.300539	14.39	0.000	28.59692	37.61715
August-15	35.70954	2.773982	12.87	0.000	30.27125	41.14782
Constant	-5.909879	11.66905	-0.51	0.613	-28.7866	16.96685

sigma_u	8.2591617	
sigma_e	183.78274	
rho	0.16202596	*(fraction of variance due to u_i)*

Appendix G. Detailed Analysis Tables

The Excel spreadsheet embedded below contains detailed analysis of program gross and net impacts. The file contains all of the gross savings assumptions, evaluated gross savings, NTGR, evaluated net savings, and recommended gross savings.

DEO Residential
Assessments Engine

Appendix H. Detailed Overview of the Net-to-Gross Approach

The Word document embedded below contains a detailed overview of the NTG approach used to estimate program FR and SO rates.

DEO Residential
Assessements NTG A

Appendix I. Chart with Measure-Level Inputs for Duke Energy Analytics

The Excel spreadsheet embedded below contains measure-level inputs for Duke Energy Analytics. Savings values in the spreadsheet represent our estimated values for the full Home Energy House Call with Energy Efficiency Starter Kit. We discuss the difference between the kit-specific savings, from the engineering analysis, and overall program savings from the billing analysis in Section 5.4. Opinion Dynamics included a measure life for the kit or 11 years, which remains consistent with the value from the previous evalution.

DEO Measure-Level
Inputs_Residential A

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APPENDIX I-

Smart $aver Residential –

CFLs Evaluation

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Duke Energy Ohio

Smart $aver Residential Program
Final Evaluation Report

November 5, 2015

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1. Evaluation Summary

1.1 Program Summary

Duke Energy Ohio (DEO) launched the Smart $aver Residential program in 2010 with the goal of reducing energy consumption and peak demand through increased awareness and adoption of energy efficient lighting technologies. The program consists of two components: a free CFL giveaway (Residential CFL program) and an online lighting store. This evaluation focuses on the Residential CFL program. Through this program, customers can request up to a lifetime limit of 15 CFLs online or over the phone. DEO manages the Residential CFL program and is responsible for marketing the program to their customers, receiving customer orders, and maintaining the program tracking database. AM Conservation Group (AMC) has implemented the Residential CFL program on behalf of DEO since April 2012 and handles fulfillment of customer orders. The program period under evaluation is from October 1, 2012 through March 30, 2015. During this period, AMC shipped 189,576 CFL kits totaling over 2.6 million CFLs. Most of the packs shipped were 15-bulb packs.

DEO markets the program through direct and email mailings, promotional banners on the Duke Energy website, online services intercepts, and through interactive voice response phone intercepts.[1]

1.2 Evaluation Objectives and High Level Findings

This evaluation of the Residential CFL program includes process and impact assessments, and addresses several major research objectives:

- Assess program performance and estimate gross and net annual energy (kWh) and peak demand (kW) savings associated with program activity
- Assess program implementation processes and marketing strategies and identify opportunities for improvement
- Understand customer awareness, preferences, purchasing behaviors, and lighting market dynamics

To achieve these research objectives, the Evaluation Team completed a number of data collection and analytic activities, including interviews with program staff, participant and general population surveys, analysis of program tracking data, deemed savings review, impact analysis, and analysis of the survey results. Through the primary data collection, the Evaluation Team developed estimates of a first-year in-service rate (ISR), an adjustment rate for efficient product replacement, and a net-to-gross ratio (NTGR). Table 1-1 provides an overview of the evaluated (ex-post) savings parameters, the sample sizes used to develop the estimates, and the associated confidence and precision.

[1] Note that the phone intercept option launched in late May 2014. Prior to that, customers had an option to request free program CFLs over the phone.

Table 1-1. Summary of Gross Savings Inputs

Assumption	Sample Size	Estimate	Relative Precision (at 90% Confidence)
First-year ISR	440	56.3%	4.4%
Adjustment for efficient product replacement	402	90.6%	2.5%
NTGR	424	86.1%	6.2%

The DEO Residential CFL program has been very successful. The program exceeded its participation goal with 186,172 customers participating. The program distributed over 2.6 million bulbs during the evaluation period, which is an average of 4,079 bulbs or 272 15-bulb kits per weekday. The program has reached a large share of DEO customers – we estimate that since 2010 and through March 2015, 66% of DEO customers had placed orders through the program. At the current participation rate, future program potential is limited. Aside from the remaining unserved customers, additional sources of participation would include new customers moving into the DEO service territory as well as new construction activity in the service territory. The savings potential from these additional sources of participation could be limited. New customers moving into existing premises previously serviced by the program may have program CFLs already installed, which could cause new participants to either hold off on installing their program CFLs or install them in low usage sockets previously filled with incandescents or halogens. New construction premises may already have high efficiency lighting in place, which may delay the installation of program CFLs.

The program realized 87% of the reported (ex-ante) gross energy savings, 103% of summer peak demand savings and 55% of winter peak demand savings. The Evaluation Team estimated evaluated (ex-post) gross energy savings of 79,797 MWh, summer peak demand savings of 10.4 MW, and winter peak demand savings of 8.5 MW. Gross realization rates are relatively high for both energy and summer peak demand savings. While the overall installation rate is 91.3%[2], first-year ISR is relatively low (56.3%). This is not surprising, given that most customers requested all 15 CFLs at once.

Table 1-2. Gross Impact Results

Savings Type	Total Number of CFLs	Reported (Ex-Ante) Gross Savings	Evaluated (Ex-Post) Gross Savings	Gross Realization Rate
Energy savings (MWh)	2,655,700	91,418	79,797	87%
Summer peak demand savings (MW)		10.1	10.4	103%
Winter peak demand savings (MW)		15.6	8.5	55%

Note that savings are rounded.

Evaluated gross per-bulb savings achieved during the evaluation period were 30.05 kWh for energy, 0.0039 kW for summer peak demand and 0.0032 kW for winter peak demand. Only a portion of program-discounted bulbs used EISA-adjusted wattages. Moving forward, energy and demand savings for *all* program bulbs need to use EISA-adjusted baseline wattages. As such, we recommend that the program uses per-bulb savings

[2] Overall installation rate incorporates a discount adjustment of future installations. This adjustment is discussed further in Section 5.1.

estimates calculated using current EISA-adjusted baselines to estimate savings from future installations. Table 1-3 contains evaluated per-bulb savings and per-bulb savings recommended for future use by the program.

Table 1-3. Evaluated and Recommended Per-Bulb Gross Impacts

Savings Type	Evaluated (Ex-Post) Per-Bulb Gross Savings During the Evaluation Period	Recommended Per-Bulb Gross Savings		
		13W CFL	18W CFL	Overall[A]
Energy savings (kWh)	30.05	22.25	25.96	23.99
Summer peak demand savings (kW)	0.0039	0.0029	0.0034	0.0031
Winter peak demand savings (kW)	0.0032	0.0024	0.0028	0.0026

[A] This assumes no changes to the program CFL wattage mix.

Through analysis of participant self-report survey results, the Evaluation Team estimated the program net-to-gross ratio (NTGR) to be 86.1%, which is relatively high. NTGR is comprised of a program free-ridership rate of 22.1% and program spillover of 8.2%. Net program impacts are 68,679 MWh in energy savings, 8.9 MW in summer peak demand savings and 7.4 MW in winter peak demand savings.

Table 1-4. Net Impact Results for 2012-2015 Evaluation Period

Savings Type	Evaluated (Ex-Post) Gross Savings	NTGR	Evaluated (Ex-Post) Net Savings[A]
Energy savings (MWh)	79,797	86.1%	68,679
Summer peak demand savings (MW)	10.4		8.9
Winter peak demand savings (MW)	8.5		7.4

[A] Evaluated net savings were calculated using unrounded NTGR.

Table 1-5 presents per-bulb net impact results for the evaluation period. Average per-bulb energy savings are 25.86 kWh and peak demand savings are 0.0034 and 0.0028 for summer and winter respectively.

Table 1-5. Per-Bulb Net Impact Results for 2012-2015 Evaluation Period

Savings Type	Evaluated Per-Bulb (Ex-Post) Gross Savings	NTGR	Evaluated Per-Bulb (Ex-Post) Net Savings[A]
Energy savings (kWh)	30.05	86.1%	25.86
Summer peak demand savings (kW)	0.0039		0.0034
Winter peak demand savings (kW)	0.0032		0.0028

[A] Evaluated net savings were calculated using unrounded NTGR.

The program implementation processes ran smoothly. Program tracking data were complete and accurate. Instances of products mailed and installed outside of the service territory were minimal. Instances of participants receiving more than 15 bulbs through the program were also minimal. Participants reported high levels of satisfaction with the program, indicating that program processes are effective and well run. A large majority of participants (84%) are satisfied with the program overall.[3] Timely receipt of program bulbs is key to high satisfaction, and 90% of participants report receiving bulbs within three weeks of placing their order. We also asked participants about their satisfaction with Duke Energy as their electric company and found approximately three-quarters are satisfied (72%).

During the evaluation cycle, we found that recent participants are younger, have lower incomes, and are more likely to be renters than the overall DEO population. It is possible that with approximately two-thirds of DEO customers having participated in the program, the program is now reaching customers that are often considered "harder to reach." Given cumulative participation levels to-date, reaching additional customers may prove challenging for the program moving forward.

1.3 Evaluation Recommendations

We recommend that program administrators calculate future savings from the Residential CFL program using the recommended per-bulb energy and summer peak savings presented in Table 1-3 above. We recommend that the program team estimates winter peak demand savings in DSMore and compares the savings estimate to the evaluation recommended per-bulb values. Depending on the assumptions used in DSMore, the program staff may choose to use DSMore modeled values in place of evaluation-estimated values.

To-date, the Residential CFL program has reached a sizeable share of DEO customers. As a result, it will be increasingly challenging for the program to maintain past participation levels. The reduction in baseline wattages due to EISA legislation means the program will achieve less savings than in the past. In addition, DEO customers are aware of CFLs, and CFLs are the bulb type that customers purchase most often. These trends could indicate rising free-ridership rates in the future. DEO may want to consider winding down the program as it is currently designed and exploring alternative designs and/or bulb types offered. Based on our knowledge of the lighting market dynamics along with the findings from this evaluation, we propose the following alternative designs:

- **Introduction of specialty products.** Depending on the cost-effectiveness screening results, one possible design solution is to offer deeply discounted or free specialty LED products. This offer can be used in conjunction with the online store, which already offers discounted specialty LEDs. This combined approach could be designed to reach a broad base of customers who have a need for specialty products, stimulate customer interest in LEDs, showcase the superior quality of LEDs in specialty applications, and drive future purchase of specialty LEDs through the online store. Given that three-way and reflector bulbs are among the most common specialty bulbs, the program could give participants a choice of bulbs that they would like to see in a kit. Kits could feature several configurations and contain three to five light bulbs. In most areas of the country, use of energy efficient bulbs in specialty sockets has lagged behind their use in standard sockets. Program intervention could be key to changing customer purchase behaviors when it comes to specialty lighting. Customers are generally more satisfied with specialty LEDs than CFLs and with the drop in price for LEDs, the bulbs are more likely to be cost-effective.
- **Targeted outreach to underserved customer segments.** It is our understanding that DEO can and have started using its customer data tracking systems to identify customers that have not participated in

[3] A rating of 8, 9, or 10 on the scale from 0 to 10 where 0 is extremely dissatisfied and 10 is extremely satisfied.

the Residential CFL program. We recommend that the future marketing (and messaging) efforts for the free CFL offerings continue be targeted to customers that are yet to participate. A targeted approach will expand the program's reach without unnecessarily marketing to previous participants who reached their 15-CFL lifetime limit. In addition, this approach may lead to lower free-ridership, as unserved customers are likely to have lower levels of knowledge and experience with energy efficient lighting products.

Regardless of the future changes to the program, we recommend that program administrators consider research to update its gross savings assumptions, namely hours of use, coincidence factors, and interactive effects. While we used the best available assumptions in this evaluation, they are either outdated or are based on research from other jurisdictions.

Additional research (lighting baseline and retailer shelf audit studies) to characterize the state of the lighting market in DEO service territory will help inform future program design.

2. Program Description

2.1 Program Design

Duke Energy Ohio (DEO) launched the Smart $aver Residential program in 2010 with the goal of reducing energy consumption and peak demand through increased awareness and adoption of energy efficient lighting technologies. The program consists of two components – a free CFL giveaway (Residential CFL program) and an online lighting store. The Residential CFL program is the focus of this evaluation. As part of this program, DEO offers a variety of free CFL kits that come with 3, 6, 8, 12, or 15 CFLs. Customers can request a total of 15 CFLs online or over the phone.[4] Fifteen CFLs is the lifetime limit per customer, and customers can choose to request all 15 CFLs at once or choose a lesser amount. To ensure that only DEO customers receive the CFLs, customers must provide their account number or the phone number associated with their account, as well as last four digits of their social security number. Once requested, program bulbs are shipped to the billing address associated with the customer's account.

2.2 Program Implementation

DEO manages the Residential CFL program and is responsible for marketing the program to their customers, receiving customer orders, and maintaining the program tracking database. AM Conservation Group (AMC) has implemented the Residential CFL program on behalf of DEO since April 2012 and handles fulfillment of customer orders. DEO supplies new orders to AMC on a daily basis. AMC handles packing, shipping, and tracking orders, as well as any shipment or product issues.[5] AMC provides daily updates on fulfilled orders and monthly reports on performance metrics to DEO.

DEO markets the program through direct and email mailings, promotional banners on the Duke Energy website, online services intercepts (OLS intercepts), and through interactive voice response phone intercepts (IVR intercepts). The bulk of program advertising are mailings such as bill inserts, new customer letters, and co-marketing with the online Saving Store. OLS intercepts target customers who log on to their online DEO account. The system checks to see if the customer has participated in the program and asks eligible customers if they would like to order their free CFL bulbs. IVR intercepts target customers who call in to Duke Energy's automated hotline with questions regarding their bill, to request a meter reading, and/or want to make a payment with a similar targeted offer for eligible customers. By regularly analyzing the program penetration of market segments, DEO adjusts marketing channels to reach the remaining potential market.

2.3 Program Performance

The program period under evaluation is from October 1, 2012 through March 30, 2015. Over this period, AMC shipped 189,576 CFL kits totaling over 2.6 million CFLs. Most of the packs shipped were 15-bulb packs. Program estimated energy savings totaled over 91 GWh. Table 2-1 provides a summary of shipments, bulbs, and energy and demand savings achieved during the program period.

[4] A small portion of CFL requests come through mail. While it is not a formal request format, DEO has been accommodating it.

[5] The program offers a two-year warranty on the shipped CFLs.

Table 2-1. Summary of Program Tracking Data for Program Period[A]

Kit Type Mailed	Kits Mailed	Bulbs Mailed	Reported (Ex-Ante) Gross Savings (kWh)	Reported (Ex-Ante) Gross Summer Coincident Savings (kW)	Reported (Ex-Ante) Gross Winter Coincident Savings (kW)
CFL 3-pack	4,174	12,522	431,048	48	73
CFL 6-pack	10,344	62,064	2,136,445	237	363
CFL 8-pack	1,667	13,336	459,069	51	78
CFL 12-pack	11,029	132,348	4,555,849	505	775
CFL 15-pack	162,362	2,435,430	83,835,424	9,290	14,263
Total	**189,576**	**2,655,700**	**91,417,834**	**10,130**	**15,553**

[A] Savings may not add due to rounding.

3. Key Research Objectives

This evaluation of the Residential CFL program includes process and impact assessments, and addresses several major research objectives:

- Assess program performance and estimate gross and net annual energy (kWh) and peak demand (kW) savings associated with program activity
- Assess program implementation processes and marketing strategies and identify opportunities for improvement
- Understand customer awareness, preferences, purchasing behaviors, and lighting market dynamics

We estimated savings using the Uniform Methods Project (UMP protocols) 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 Residential CFL 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?
- Are participants satisfied with their program experiences?
- How effective are the program's marketing, outreach, and educational tactics?
- What is the program reach? What percentage of DEO's customer base has participated in the program? What are the differences between participants and non-participants?
- What customer segments should the program target to minimize free-ridership?
- What are the strengths, weaknesses, and opportunities for program improvement?
- What are current and future trends in the lighting market?
- What are customer lighting preferences and purchase behaviors?
- What is the level of customer knowledge around lighting technologies?
- What is customer awareness of the Energy Independence and Security Act (EISA)?

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 analytic activities. Table 4-1 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 4-1. Overview of Evaluation Research Activities

#	Evaluation Activity	Impact	Process/ Market	Purpose of Activity
1	Program staff interviews		X	• Provide insight into program design and delivery • Support process assessment
2	Materials review	X	X	• Provide insight into program design and delivery • Inform previously used and alternative savings assumptions
3	Deemed savings review	X		• Review accuracy and appropriateness of energy savings assumptions and determine alternative savings inputs
4	Impact analysis	X		• Calculate gross and net energy and demand savings
5	Participant survey	X	X	• Estimate in-service rate • Estimate free-ridership and spillover • Assess lighting market • Support process assessment
6	General population survey (data analysis only)		X	• Support process assessment • Assess lighting market

4.1.1 Program Staff Interviews

The Evaluation Team completed two interviews with program staff at Duke Energy and at AMC. We completed interviews in March and April 2015. The interviews explored changes in program design and implementation, overview of program performance, incentivized product specifications, and data tracking and communication processes, among other topics.

4.1.2 Materials Review

In support of the impact and process evaluations, 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.

4.1.3 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 DEO used to calculate impacts, review the deemed savings values for reasonableness, verify their accurate application, and identify data gaps, omissions, inconsistencies, and errors. We reviewed reports from previous DEO evaluations and the Ohio Technical Reference Manual (TRM), as well as evaluation reports and TRMs from other jurisdictions to assess their reasonableness and develop recommendations for changes, where appropriate. Finally, as part of the review process, we also checked the program tracking data for accuracy, consistency, and completeness.

4.1.4 Participant Survey

The Evaluation Team completed a mixed-mode (telephone and online) survey with a sample of DEO Residential CFL program participants in June and July 2015.

Our key goals were to gather information to support the assessment of gross impacts, program attribution, program processes, and market dynamics.

Sample Design and Fielding

To improve participant recall of the 1) decision to participate and 2) participation in the program, we limited the survey sample frame to customers who received program CFLs between July 2014 and March 2015.

Free-ridership (FR) is best measured soon after customers participate in the program when it is easier to recall the decision to participate. In contrast, spillover (SO) is best measured after some time has passed after participation to allow participants time to experience the benefits of the energy efficiency measure and install additional measures because of their experience. Because the FR and SO effects are best measured over different time periods, we used two distinct sample frames of participants to estimate each. Since it takes time for SO effects to occur, the SO sample frame included customers who participated in the program between July and December 2014 (6 to 12 months prior to our survey field date). The sample frame for FR included customers who participated in the program between January and March 2015 (within 6 months of the survey field date). We drew random samples from each sample frame. Survey respondents from both samples received questions verifying the installation and persistence of program CFLs, as well as process and market-related questions. Table 4-2 presents participant survey sample sizes and number of completed interviews.

Table 4-2. Participant Survey Sample Sizes and Number of Completed Interviews by Sample Frame

Sample Frame	Sample Frame Size	Sample Size	Number of Completed Interviews
FR	15,688	2,378	204
SO	45,155	2,472	229
Total	**60,843**	**4,850**	**433**[A]

[A] Please note that seven additional participants completed the survey but did not receive either the free-ridership or spillover modules. These participants did not verify their participation in the program. Their responses are used in our calculation of the in-service rate only.

Participants received mail, email, or both mail and email invitations and reminders to take the survey; they also had a choice 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 one postcard reminder in the mail, while participants with email addresses received invitations and reminders via email and mail. We fielded the participant survey between June 22, 2015 and July 15, 2015. Participants were offered incentives in the form of several cash prize drawings.

Survey Dispositions and Response Rate

Table 4-3 provides the final survey dispositions.

Table 4-3. Participant Survey Disposition Summary

Disposition	Count
Completed Interviews (I)	**440**
Internet survey complete	386
Phone survey complete	54
Partial Interviews (P)	**52**
Eligible Non-interviews (NC)	**18**
Answering machine	1
Could not confirm program participation (did not receive CFLs)	2
Customer said wrong number	2
Disconnected Phone	1
Left voicemail	10
Non-specific callback/secretary/NTG	2
Not Eligible (NE)	**19**
Email bounce-back	9
Mail undeliverable	10
Refused (R)	**4,321**
Survey never initiated by participant	4,319
Web refusal	2
Total Participants in Sample	**4,850**

Table 4-4, below, provides the survey response rate. We do not report a cooperation rate because it is difficult to estimate it accurately with mailed and emailed survey invitations. The cooperation rate is the ratio of participants who completed the survey out of all eligible participants *contacted*. 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 calculate cooperation rate.

Table 4-4. Participant Survey Response Rate

AAPOR Rate	Rate
Response rate	9%

Survey Data Weighting

We completed a disproportionate number of interviews with customers with email addresses as compared to customers in our sample frame. Relative to customers who do not provide their email address to their utility, customers who do provide their email address are often more engaged with their utility and energy in general, and can also be different in terms of characteristics such as age or educational attainment. To ensure that our survey results were not biased due to the disproportionate number of respondents with email addresses, we applied post-stratification weights to the survey data to make it align with the population.

Targeted and Achieved Confidence and Precision

The evaluation targeted 10% precision at a 90% confidence level for all data collection tasks that involved sampling. These precision goals were met (Table 4-5).

Table 4-5. Precision and Margins of Error at 90% Confidence

Metric of Interest	Relative Precision (At 90% Confidence)
First-year in-service rate	4.4%
Adjustment for efficient product replacement	2.5%
Net-to-gross ratio	6.2%
Process results	4.0% (standard margin of error)

4.1.5 General Population Survey

The Evaluation Team completed a general population survey with a sample of DEO customers. The survey was completed as part of the DEO Appliance Recycling Program (ARP). The goal of the survey was to identify customers who recently disposed of eligible appliances through means other than the ARP. The survey contained a separate module of lighting questions. To minimize the survey length, the lighting module was not asked of respondents who had disposed of an appliance without participating in the DEO ARP. As described below, we also applied survey weights to correct for demographic differences between the survey sample and the DEO general population.

The lighting survey battery explored lighting-specific topics such as awareness of the DEO Residential CFL program, CFL and LED awareness and usage, lighting preferences and purchase behaviors, and customer awareness of EISA legislation.

Sample Design and Fielding

The survey was fielded via telephone and online. DEO provided a random sample of 50,000 customers. We emailed customers invitations to complete the survey online and sent up to two email reminders. We called customers without email addresses and completed the survey over the telephone. We fielded the general population survey between June 10, 2015 and July 30, 2015.

Lighting Battery Completes

The Evaluation Team contacted 4,442 customers as part of the Appliance Recycling survey, and 391 completed the residential lighting module.

Table 4-6. General Population Survey Sample Sizes and Number of Completed Interviews

	Sample Size	Total Number of Interviews	Total Number of Interviews With Lighting Module Completed
General population survey	4,442	469	391

Survey Dispositions and Response Rate

Table 4-7 provides the final survey dispositions.

Table 4-7. General Population Survey Disposition Summary

Disposition	Count
Completed Interviews (I)	**469**
Web, complete	241
Phone, complete	228
Partial Interviews (P)	**128**
Eligible Non-interviews (NC)	**1,035**
Phone, answering machine	445
Phone, business/residential phone	21
Phone, callback to complete	14
Phone, cell phone callback	2
Phone, computer tone	15
Phone, customer indicated called already	13
Phone, customer said wrong number	51
Phone, language problems	13
Phone, non-specific callback/secretary/NTG	248
Phone, not available	133
Phone, scheduled appointment	48
Phone, terminate - not DEO customer	8
Web, terminate - not DEO customer	24
Unknown Eligibility, Non-interviews (UH)	**447**
Open sample not called	346
Phone, busy	8
Phone, no answer	86
Phone, privacy line/number blocked	7
Not Eligible (NE)	**232**
Web, email bounced	21
Phone, disconnected phone	211
Refused (R)	**2,131**
Web, no response	1,627
Phone, initial refusal	460
Phone, hard refusal	21
Phone, add to DNC list	21
Phone, refusal because of cell phone	2
Total Participants in Sample	**4,442**

Table 4-8 provides the survey response rate. As with the participant survey, we do not report a cooperation rate for the email sample frame, because it is difficult to estimate it accurately with emailed survey invitations. We do however report cooperation rate for the sample targeted through outbound phone calls (Table 4-8).

Table 4-8. General Population Survey Response Rates

AAPOR Rate	Rate
Response rate	12%
Cooperation rate (outbound phone calls only)	30%

Survey Data Weighting

As with the participant survey, we observed differences between the survey participants and the sample frame in terms of email address presence. We also observed differences in home ownership rates. Because these characteristics are often correlated with customer lighting knowledge, behaviors, and preferences, we applied post-stratification weights to align respondents' characteristics with the population.

Targeted and Achieved Confidence and Precision

The evaluation targeted 10% precision at a 90% confidence level for all data collection tasks that involved sampling. These precision goals were met (Table 4-9).

Table 4-9. Precision and Margins of Error at 90% Confidence

Metric of Interest	Standard Margin of Error
Process results	4.2%

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 evaluated savings estimates

5.1 Methodology

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

As part of the engineering analysis, we compared the program savings assumptions to the 2010 Ohio Technical Reference Manual. We also reviewed the past evaluation of the Residential CFL program and checked the savings assumptions used to calculate program reported savings against the previous evaluation's recommended assumptions to confirm their accuracy. Additionally, we reviewed evaluation reports and TRMs from other jurisdictions to compare program savings assumptions, assess their reasonableness, and determine alternative assumptions, where appropriate. Using data collected as part of the participant survey, we developed an updated estimate of the first-year in-service rate (ISR) and an estimate of the rate at which program CFLs are replacing energy efficient lighting products (CFLs or LEDs).

We estimated savings using the Uniform Methods Project (UMP protocols) 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. Equation 5-1 provides the formula that we used to estimate energy savings, while Equation 5-2 provides the formula that we used to estimate demand savings.

Many upstream lighting programs[6] 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 oftentimes have little control over who purchases discounted lighting products, DEO's Residential CFL program tightly controls who receives program CFLs and where customers can receive their CFLs, 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 (see Section 7.2.1 for additional information on leakage). 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 a negligible change to ISR. We also did not apply a separate set

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

of savings assumptions to account for installations in commercial applications because of the small number of bulbs installed in such applications.

Equation 5-1. Algorithm for Energy Savings

$$\Delta kWh = ISR * \frac{(Watts * HOU)_{base} - (Watts * HOU)_{ee}}{1000} * EE_{adj} * 365 * (1 + HVAC_c)$$

Equation 5-2. Algorithm for Peak Demand Savings

$$\Delta kW = ISR * \frac{Watts_{base} - Watts_{ee}}{1000} * EE_{adj} * CF * (1 + HVAC_d)$$

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
EE_{adj}= adjustment for efficient product replacement
CF = peak coincidence factor
$HVAC_c$ = HVAC system interaction factor for energy
$HVAC_d$ = HVAC system interaction factor for demand

Table 5-1 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 rationale for the input selection. For reference purposes, Table 5-1 also provides savings assumptions used to estimate reported (ex-ante) energy and demand savings.

Table 5-1. Summary of Gross Savings Inputs

Assumption	Reported (Ex-Ante) Assumption	Evaluated (Ex-Post) Assumption	Evaluated (Ex-Post) Assumption Source
ISR	77.9%	91.3%[A]	Participant survey (for first-year ISR and trajectory adjustments) 2006-2008 California Upstream Lighting program evaluation study (for installation trajectory) DEO discount rate (for discounting future installations)
Baseline wattage	63.48	55.85[B]	Evaluation Team analysis using lumen equivalency conversion and EISA adjustment
Adjustment for efficient product replacement	Integrated as part of ISR and baseline wattage approach[C]	90.6%	Participant survey
CFL wattage	16.34	15.34	Program tracking database
Hours of use	2.58 hours/day	2.47 hours/day	Indiana Statewide Core 2014 Evaluation
Summer coincidence factor	0.100	0.100	DTE Energy and Consumers Energy 2012 Evaluation
Winter coincidence factor	Not used	0.096	2013 evaluation of Duke Energy Progress (DEP) Energy Efficient Lighting Program
$HVAC_c$	-0.0058	-0.0058	2012 Process & Impact Evaluation of Residential Smart $aver Energy Efficiency Products Program
$HVAC_d$ – Summer	0.167	0.167	
$HVAC_d$ – Winter	Not used	0.00	Evaluation Team assumption

[A] This ISR is presented with utility discount rate applied. Please see the ISR section below for further discussion.
[B] Please note that this is the average baseline wattage across all program bulbs. Individual baseline wattages ranged between 43 and 75 watts depending on the date of program bulb installation and program bulb wattage.
[C] The ex-ante ISR assumes that 43% of bulbs installed in future years replace other CFLs. In addition, the ex-ante baseline wattage is based on participant self-report from the previous evaluation, and incorporates program replacement of efficient bulbs.

Note that the reported savings assumptions presented in the table above are from the previous evaluation report. The final per-bulb savings were modeled in DSMore and are different. The reported (ex-ante) savings were estimated using the modeled values. Table 5-2 provides a comparison between previous evaluation reported and DSMore modeled per-bulb savings.

Table 5-2. Previous Evaluation Reported and DSMore Modeled Per-Bulb Savings Values

Assumption	Previous Evaluation Reported Per-Bulb Savings	DSMore Modeled Per-Bulb Savings
Energy savings	34.40	34.42
Summer peak demand savings	0.0043	0.0038
Winter peak demand savings	Not estimated	0.0058

In-Service Rate (ISR)

Although the first-year in-service rate (ISR) is generally less than 100%, research studies across the country have found that customers eventually install nearly all bulbs received through a program. Approaches to claiming savings from these later installations vary and include 1) staggering the claiming of savings over time and 2) claiming the savings from the expected installation in the program year but discounting them by a societal or utility discount rate. While the “staggered” approach allows program administrators to more accurately capture the timing of the realized savings, the “discounted” savings approach allows for simplicity of claiming all costs and benefits during the program year and eliminates the need to keep track of and claim savings from future installations. We chose to use the “discounted” savings approach for this evaluation.

To allocate installations over time, we used the installation trajectory from the 2006-2008 California Upstream Lighting program evaluation study that estimates that participants install 99% of bulbs within three years of purchase and equally allocates the bulbs not installed during the first year between the second and third years. In the absence of Ohio-specific installation rate trajectories, we chose this trajectory because of its simplicity and balanced allocation of future installations. We estimated the first-year ISR through the participant survey and discounted future savings by the utility discount rate using the net present value (NPV) formula (Equation 5-3). We used the DEO-specific utility discount rate of 8.10%.

Equation 5-3. Net Present Value Formula

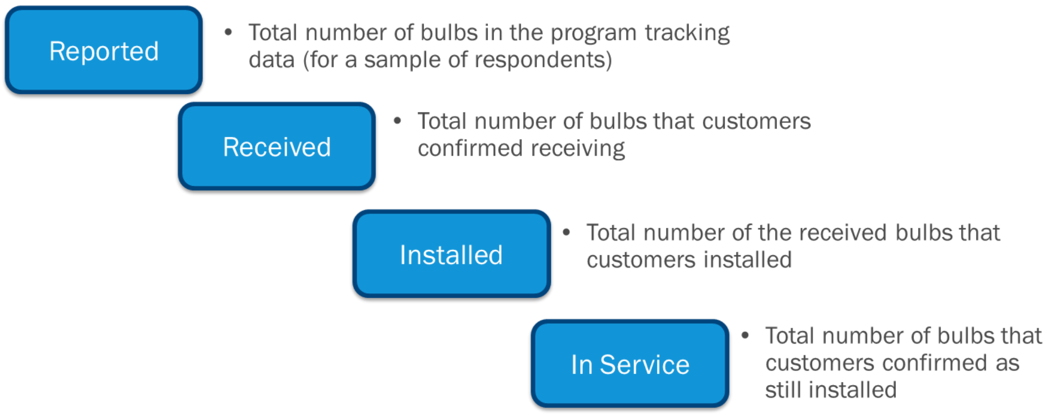
$$NPV = \frac{R_t}{(1+i)^t}$$

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 or received damaged. 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 some were received broken (and therefore cannot be considered acquired).

The first-year ISR is calculated by dividing the total number of program CFLs reported in service by the total number of CFLs reported in the program tracking database. We incorporated the receipt, installation, and persistence of program CFLs into the first-year ISR.

Figure 5-1. Installation Rate Components



The evaluation found a first-year ISR of 56.3%. Relative precision around this point estimate is 4.4% at 90% confidence.

Table 5-3. First-Year ISR

	Sample Size	ISR Estimate	Relative Precision (at 90% Confidence)
First-year ISR	440	56.3%	4.4%

After adjusting for CFLs that participants never received or received damaged, the overall installation rate decreased from 99% to 95.6%. Table 5-4 provides the installation rate trajectory that we used to allocate savings over time. After discounting the future installations by the DEO utility discount rate, the overall ISR decreased to 91.3%.

Table 5-4. DEO Cumulative Installation Rate Trajectory

Program Year	Installation Trajectory before Discounting Future Installations	Installation Trajectory after Discounting Future Installations
Year 1	56.3%	56.3%
Year 2	76.0%	74.5%
Year 3	95.6%	91.3%

Baseline Wattage

To estimate the baseline wattages of the bulbs replaced by program CFLs, the Evaluation Team used the equivalent baseline wattage approach. This approach assumes that customers will replace existing bulbs with CFLs that produce a similar lumen output. The provisions of the 2007 Energy Independence and Security Act (EISA) have slowly increased the efficiency requirements of general service incandescent light bulbs. The regulations were gradually phased in, affecting 75-watt incandescents in January 2013 and 60-watt incandescents in January 2014. Manufacturers responded to EISA by developing a halogen bulb that meets the new requirements and uses fewer watts per lumen. These new "EISA-compliant" halogens will replace incandescents as the baseline for calculating program savings. Because manufacturers and retailers were allowed to sell through their existing inventory of incandescents, products did not immediately disappear from the market, as shown by several studies across the country, including recent evaluations of the DEP Energy

Efficient Lighting Program, the Ameren Residential Lighting Program, and the Indiana Statewide Core Program. While there is no Ohio-specific information on the availability of incandescents, given the trends across the country, we feel that immediately adjusting the baseline to EISA-compliant halogens does not accurately reflect the bulbs available for purchase after EISA. In the absence of Ohio-specific market data, we deployed a six-month delay in the baseline adjustment resulting from EISA standards, as seen below in Table 5-5 below.

Table 5-5. Baseline Adjustments Due to EISA Standards

Program CFL Wattage	Pre-EISA Equivalent Baseline Wattage	Post-EISA Equivalent Baseline Wattage	EISA Effective Date
18-watt	75-watt	53-watt	July 1, 2013
13-watt	60-watt	43-watt	July 1, 2014

Depending on when the program CFLs were shipped and their wattage, we used different baseline wattages to estimate savings. Table 5-6 provides an overview of the baseline wattages by date and CFL wattage.

Table 5-6. Baseline Wattages by CFL Wattage by Date

<table>
<tr><th rowspan="2">Shipping Date</th><th colspan="2">Baseline Wattages</th></tr>
<tr><th>13-Watt CFLs</th><th>18-Watt CFLs</th></tr>
<tr><td>2012</td><td rowspan="4">60-watt</td><td rowspan="2">75-watt</td></tr>
<tr><td>2013 (January 1 – June 30)</td></tr>
<tr><td>2013 (July 1 – December 31)</td><td rowspan="4">53-watt</td></tr>
<tr><td>2014 (January 1 – June 30)</td></tr>
<tr><td>2014 (July 1-December 31)</td><td rowspan="2">43-watt</td></tr>
<tr><td>2015</td></tr>
</table>

Adjustment for Efficient Product Replacement

The Evaluation Team also adjusted the equivalent baseline wattage approach to account for instances in which customers installed program CFLs in sockets that already contained a CFL or LED. We developed these adjustments using participant survey data about the types of bulbs that respondents replaced when they installed their new program CFLs.

We found a low rate of program bulbs replacing CFLs or LEDs. Based on the participant survey results, 90.6% of program bulbs installed replaced incandescents or halogens. We applied this adjustment to the delta watts. Table 5-7 presents the adjustment for efficient product replacement and its relative precision.

Table 5-7. Adjustment for Efficient Product Replacement

	Sample Size	Adjustment Estimate	Relative Precision (at 90% Confidence)
Adjustment for efficient product replacement	402	90.6%	2.5%

CFL Wattage

CFL wattage was based on the counts and wattages of the actual bulbs distributed by the program during the evaluation period. Program kits featured mixes of 13-watt and 18-watt CFLs. We calculated an average bulb-weighted wattage of 15.34 watts.

Table 5-8. CFL Wattage

CFL Wattage	Number	Wattage
13-watt	1,411,118	13
18-watt	1,244,582	18
Total	2,655,700	15.34

Hours of Use (HOU)

The industry standard to estimate hours of use (HOU) is to conduct lighting logger studies. In the absence of a recent Ohio-specific HOU study, we used the HOU estimates from the 2014 Indiana Statewide Core evaluation. This evaluation estimated an average HOU of 2.47 hours per day. This estimate is based on the 2012 lighting logger study. We chose the Indiana study for the following reasons:

- Indiana is a neighboring state
- The HOU estimates are based on the lighting logger study with a relatively robust sample and an extensive logging period
- The study is relatively recent

Coincidence Factors (CF)

As with the HOU, the industry standard is to use a lighting logger study to estimate coincidence factors. In the absence of a recent Ohio-specific study, we chose to use a summer peak coincidence factor of 0.100 from the 2012 DTE Energy and Consumers Energy Evaluation. Because most utilities in the Midwestern United States are not winter peaking, estimates of winter peak coincidence factors are rarely developed and used. Therefore, the Evaluation Team used the winter peak coincidence factor from the 2013 evaluation of Duke Energy Progress's (DEP) Energy Efficient Lighting Program. This factor is 0.096. 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.

Interactive Effects

The Evaluation Team chose to use the HVAC system interaction factors for energy and summer demand estimated as part of the 2012 evaluation of this program by TecMarket Works. Our review of the estimates determined that these factors were reasonable, relatively recent, and based on Ohio-specific research. Interactive factors for winter demand were not estimated as part of the most recent evaluation 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 CFLs. Based on the results from the 2010-2013 American Community Survey, we estimate that less than one-third of homes in DEO service territory are electrically heated.

5.2 Gross Impact Results

The Evaluation Team received program tracking data as two extracts: shipment information and customer 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 customer account number as the linking unique identifier. Our merge resulted in a 99% match rate. A follow-up discussion with the Duke Energy evaluation staff revealed that the two extracts come from different sources and a small percent of unmatched cases is expected.

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[7]
- 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 the Gross Impact Methodology section of this report, we calculated gross energy and peak demand savings achieved by the program during the evaluation period. Table 5-9 presents the results of the analysis. The Residential CFL program realized 87% of the reported gross savings, 103% of the reported summer peak demand savings, and 55% of the reported winter peak demand savings.

Table 5-9. Gross Impact Results[A]

Savings Type	Total Number of CFLs	Reported (Ex-Ante) Gross Savings	Evaluated (Ex-Post) Gross Savings	Gross Realization Rate
Energy savings (MWh)	2,655,700	91,418	79,797	87%
Summer peak demand savings (MW)		10.1	10.4	103%
Winter peak demand savings (MW)		15.6	8.5	55%

[A] Gross realization rate was estimated using unrounded savings values.

The key drivers of the lower than reported energy savings included an adjustment to the baseline wattages per EISA and the use of a lower HOU estimate (see Table 5-1). Reported winter and summer peak demand savings are based on DSMore modeling. We do not have visibility into all savings assumptions used to estimate reported demand savings. As such, we cannot reliably comment on the complete list of factors driving the differences between reported and evaluated demand savings.

[7] This excludes email address data field as we expect that not every participant would have provided their email address.

Using total evaluated energy and demand savings, the Evaluation Team calculated average per-bulb savings (Table 5-10).

Table 5-10. Evaluated Total and Per-Bulb Gross Impacts[A]

Savings Type	Number of Bulbs	Evaluated (Ex-Post) Gross Savings	Evaluated (Ex-Post) Per-Bulb Gross Savings
Energy savings (kWh)	2,655,700	79,797,348	30.05
Summer peak demand savings (kW)		10,390	0.0039
Winter peak demand savings (kW)		8,547	0.0032

[A] Savings were calculated using unrounded assumptions.

Depending on the year program bulbs were mailed to customers, the Evaluation Team used different baseline wattages to account for the effects of EISA. Moving forward, energy and demand savings for all program bulbs need to use EISA-adjusted baseline wattages. As such, we recommend that the program uses per-bulb savings estimates calculated using EISA-adjusted baselines to estimate savings from future installations. Table 5-11 presents these assumptions by CFL wattage as well as overall.

Table 5-11. Recommended Per-Bulb Gross Impacts

Savings Type	Recommended Per-Bulb Gross Savings		
	13W CFL	18W CFL	Overall[A]
Energy savings (kWh)	22.25	25.96	23.99
Summer peak demand savings (kW)	0.0029	0.0034	0.0031
Winter peak demand savings (kW)	0.0024	0.0028	0.0026

[A] This assumes no changes to the program CFL wattage mix.

5.3 References

KEMA, Inc., The Cadmus Group, Inc. *Final Evaluation Report: 2006-2008 Upstream Lighting Program.* Prepared for the Energy Division of the California Public Utilities Commission. February 8, 2010.

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

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Opinion Dynamics and The Cadmus Group, Inc. *Michigan CFL Hours of Use Study.* Prepared for DTE Energy and Consumers Energy. August 7, 2012.

State of Ohio Energy Efficiency Technical Reference Manual. August 6, 2010.

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

TecMarket Works, Opinion Dynamics Corporation, The Cadmus Group, Integral Analytics, Building Metrics, and Energy Efficient Homes Midwest. *An Evaluation of the Core Final Year Energy Efficiency Programs.* Prepared for Indiana Utilities and DSMCC. May 1, 2015

6. Net-to-Gross Analysis

This section describes our approach for estimating the net-to-gross ratio (NTGR) for the Residential CFL program and presents the resulting NTGR and the program net impacts.

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 free-ridership (FR) and spillover (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 spillover – participant and nonparticipant. Participant spillover occurs when participants take additional energy-saving actions that are influenced by program interventions but did not receive program support. Nonparticipant spillover 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 spillover (SO). Quantifying savings from nonparticipant spillover activities is a challenging task that warrants a separate study and was outside of the scope of this evaluation effort. In addition, the free CFL program design is less likely to result in significant amounts of nonparticipant spillover 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 telephone interviews with program participants.

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

Free-ridership (FR) is best measured soon after customers participate in the program when it is easier to recall the decision to participate. In contrast, spillover (SO) is best measured after some time has passed after participation to allow participants time to experience the benefits of the energy efficiency measure and install additional measures because of their experience. Due to the fact that the FR and SO effects are best measured over different time periods, we used two distinct sample frames of participants to estimate each. Since it takes time for SO effects to occur, the SO sample frame included customers who participated in the program between July and December 2014 (6 to 12 months prior to our survey field date). The sample frame for FR included customers who participated in the program between January and March 2015 (within 6 months of the survey field date). We drew random samples from each sample frame. We asked survey respondents from both samples questions to verify the installation and persistence of program CFLs, as well as process and market-related questions.

Table 6-1. Free-Ridership and Spillover Sample Frames, Samples, and Number of Completed Interviews

NTGR Component	Sample Frame Size	Sample	Number of Completed Interviews
FR	15,688	2,378	204
SO	45,155	2,472	229

Below is a general overview of the method for developing FR and SO estimates. Section 12 of this report contains the participant survey instrument. Appendix A contains a detailed discussion of our spillover methodology. Appendix F provides a detailed overview of the FR and SO algorithm.

6.1.1 Free-Ridership

Free-riders are program participants who would have installed high efficiency lighting products 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 survey, 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 CFLs. The survey questions measured the following areas of program influence:

- Influence 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 CFLs 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 CFLs, of if they would have waited for the bulbs to burn out
- Influence on quantity – we asked participants whether they would have purchased fewer CFLs or 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 included follow-up questions to check participant responses for consistency. We also referenced retail bulb pricing to ground participant responses.[8]

We calculated FR rate per the agreed-upon algorithm. We checked survey data for item non-response. Nine respondents had missing data to FR questions. We dropped these respondents from the analysis.

6.1.2 Spillover

Spillover represents energy savings from additional actions (expressed as a percent of total program savings) that were due to the program but 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 spillover 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. We asked those who purchased additional bulbs about the degree to which 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 provide a rationale for their rating. We carefully reviewed participant responses to establish eligibility for spillover participants and purchases.

To estimate the spillover rate, we estimated savings for each spillover measure using the standard savings equation and a set of engineering assumptions. We determined the program-level spillover rate by dividing the sum of spillover savings by the evaluated gross savings achieved by the sample of participants who received spillover questions.

[8] We used a per-bulb price of $2.50 for CFLs and $10 for LEDs. This pricing was confirmed by the program staff.

Equation 6-1. Spillover Rate Formula

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

6.2 NTG Results

We estimate free-ridership to be 22.1% and spillover to be 8.2%. The resulting NTGR for DEO for the evaluation period is 86.1%. Relative precision around this point estimate is 6.2% at 90% confidence.

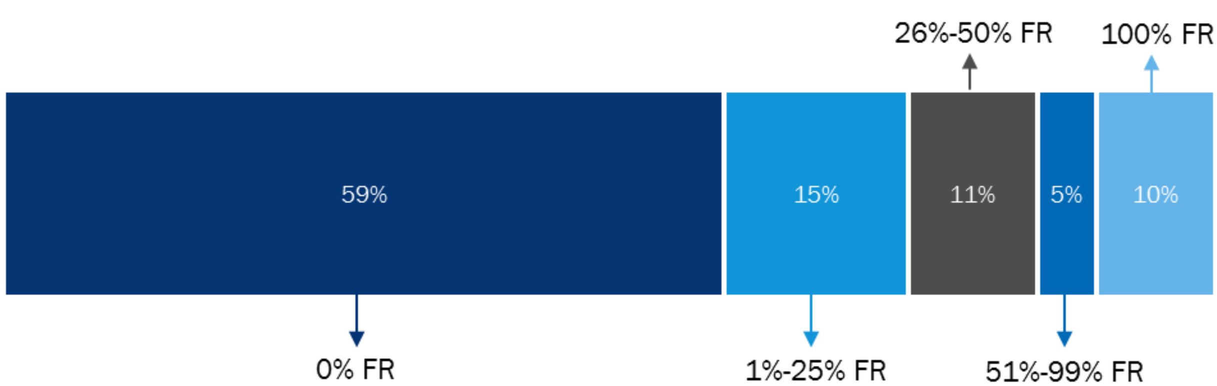
Table 6-2. NTG Results

NTGR Component	Estimate	Number of Completed Interviews	Relative Precision (At 90% Confidence)
FR	22.1%	195	–
SO	8.2%	229	
NTGR (1-FR+SO)	**86.1%**	-	**6.2%**

6.2.1 Free-Ridership

Nearly six in ten participants (59%) are complete non-free-riders. That is, they would not have purchased any of the CFLs they received for free through the program. At the opposite end of the free-ridership spectrum, one in ten (10%) are complete free-riders who reported that they would have purchased all of the CFLs they received. Approximately one-third (31%) are partial free-riders, because they would have purchased some, but not all of the CFLs they received, and, in addition, some replaced working light bulbs, which they would not have done on their own. These results indicate that the program not only caused participants to switch to CFLs, but also had an effect on the number of bulbs they installed and when they installed them.

Figure 6-1. Breakdown of Free-Ridership Rates



We observe noticeable differences in FR rates across customer socio-demographic and household characteristics. Table 6-3 presents FR rates broken out by characteristics of note. We observe statistically significant differences in FR rates by educational attainment, home vintage, and income level. The Evaluation Team also observes differences in FR by pre-program CFL saturation and home ownership, but these differences were not statistically significant. FR rate is considerably lower among customers who have not received a college degree, customers living in a home built before 2000, and customers with household incomes of less than $50,000 per year.

Table 6-3. Free-Ridership Rate by Participant Segment

Participant Subgroup	FR
Education	
Less than college (n=82)	13.8%*
College + (n=113)	28.3%*
Home Vintage	
Before 1999 (n=156)	20.3%*
2000 or later (n=35)	32.5%*
Annual Income	
Less than $50,000 (n=84)	15.5%*
$50,000 or greater (n=101)	27.5%*

* Indicates statistically significant difference at 90% confidence.

6.2.2 Spillover

Over four in ten DEO Residential CFL Program participants (44%) purchased light bulbs in addition to those they received through the program in the past year. Slightly more than half of these participants (55%, or 24% of all participants) purchased light bulbs since participating in the program, with nearly all purchasing efficient light bulbs (96%, or 23% of all participants). Of those, one-third (35%, or 8% of all participants) gave the program credit for motivating their purchase. Overall, 8% of all participants qualified for spillover. The average spillover participant purchased 11.6 bulbs which qualified for spillover, 60% of which were LEDs.

A number of customers also reported that the program influenced them to purchase incented efficient bulbs through the DEO online store. While these bulbs are not considered spillover, as they can be claimed as savings by the online store program, this provides evidence of effective channeling of customers from the Residential CFL program to the online store.

6.3 Net Impact Results

Table 6-4 presents evaluated gross and net savings for the evaluation period. The program achieved 68,679 MWh in net energy savings, 8.9 MW in net summer peak demand savings, and 7.4 MW in net winter peak demand savings.

Table 6-4. Net Impact Results for 2012-2015 Evaluation Period[A]

Savings Type	Evaluated (Ex-Post) Gross Savings	NTGR[A]	Evaluated (Ex-Post) Net Savings
Energy savings (MWh)	79,797	86.1%	68,679
Summer peak demand savings (MW)	10.4		8.9
Winter peak demand savings (MW)	8.5		7.4

[A] Unrounded NTGR was used to calculate evaluated net savings.

Table 6-5 presents per-bulb net impact results for the evaluation period. Average per-bulb energy savings are 25.86 kWh and peak demand savings are 0.0034 and 0.0028 for summer and winter respectively.

Table 6-5. Per-Bulb Net Impact Results for 2012-2015 Evaluation Period

Savings Type	Evaluated Per-Bulb (Ex-Post) Gross Savings	NTGR	Evaluated Per-Bulb (Ex-Post) Net Savings[A]
Energy savings (kWh)	30.05	86.1%	25.86
Summer peak demand savings (kW)	0.0039		0.0034
Winter peak demand savings (kW)	0.0032		0.0028

[A] Evaluated net savings were calculated using unrounded NTGR.

Table 6-6 presents net realization rates for the program. We developed net realization rates by dividing evaluated net savings by reported net savings. Because the NTGR we estimated for this evaluation is very similar to the one estimated as part of the previous evaluation, the net realization rate is very similar to the gross realization rate.

Table 6-6. Net Realization Rates

Savings Type	Reported (Ex-Ante) Gross Savings	Reported NTGR	Reported (Ex-Ante) Net Savings	Evaluated (Ex-Post) Net Savings	Net RR
Energy savings (MWh)	91,418	84.2%	76,974	68,679	89%
Summer peak demand savings (MW)	10.1		8.5	8.9	105%
Winter peak demand savings (MW)	15.6		13.1	7.4	56%

[A] Savings were calculated using unrounded assumptions.

7. Process Evaluation

7.1 Methodology

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=433)
- General population survey (n=391)

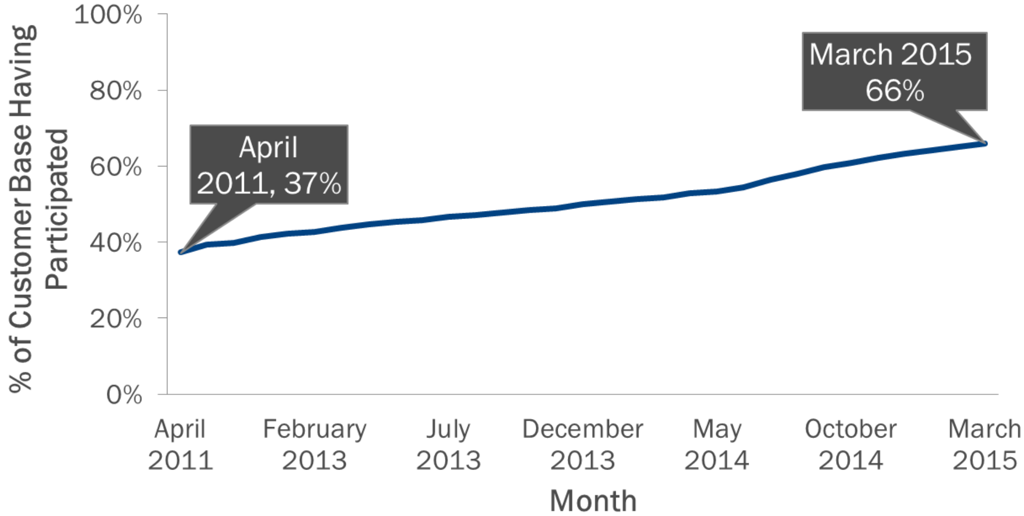
We provide a detailed overview of each data collection method, as well as achieved confidence and precision in Section 4 of this report.

7.2 Notable Findings

7.2.1 Program Implementation

The Residential CFL Program ran smoothly during this evaluation cycle (October 1, 2012 through March 30, 2015). The program exceeded its participation goals with 186,172 customers participating. The program has reached a large proportion of DEO customers. Based on the number of participants during the previous evaluation period and this one, we estimate that approximately two-thirds of DEO customers had participated in the program through March 2015 (Figure 7-1). At the current participation rate, future program potential is limited. Aside from the remaining unserved customers, additional sources of participation would include new customers moving into the DEO service territory as well as new construction activity in the service territory. The savings potential from these additional sources of participation could be limited. New customers moving into existing premises previously serviced by the program may have program CFLs already installed, which could cause new participants to either hold off on installing their program CFLs or install them in low usage sockets previously filled with incandescents or halogens. New construction premises may already have high efficiency lighting in place, which may delay the installation of program CFLs.

Figure 7-1. Cumulative Program Participation over Time[A]



[A] The starting percentage is the number of participants cited in the previous evaluation divided by the total number of DEO customers.

During the current evaluation cycle, the vast majority (98%) of customers placed only one order through the program. Most of the kits requested through the program (86%) were 15-bulb kits, the maximum allowable through the program, as seen in Table 7-1 below. On average, participants received 14.3 bulbs.

Table 7-1. Bulbs Distributed by the Program

Kit Type Mailed	Kits Mailed	% of Kits	Bulbs Mailed	% of Bulbs
CFL 3-pack	4,174	2%	12,522	<1%
CFL 6-pack	10,344	5%	62,064	2%
CFL 8-pack	1,667	1%	13,336	1%
CFL 12-pack	11,029	6%	132,348	5%
CFL 15-pack	162,362	86%	2,435,430	92%
Total	**189,576**		**2,655,700**	

The Evaluation Team found that 2,416 participants received more than 15 bulbs (1% of all participants totaling 57,544 bulbs or 2% of all bulbs). Most received 18 bulbs, which is likely due to additional bulbs received through the Home Energy Assessment program. Alternatively, ordering more than one kit of different size configurations can result in participants receiving more than 15 bulbs. Though this is a small number of bulbs and is not a large concern for the program, we did find that 49 customers received 45 or more bulbs. The program may want to review these cases to identify how these shipments happened, so it does not become a larger problem.

Program Satisfaction

Participants expressed high levels of satisfaction with the program, which is another indication that program processes are effective and well run. Figure 7-2 shows that a large majority of participants (84%) are satisfied with the program overall. Timely receipt of program bulbs is key to high satisfaction, and 90% of participants report receiving bulbs within three weeks of placing their order. We also asked participants about their satisfaction with Duke Energy as their electric company and found approximately three-quarters are satisfied (72%). Very few customers contacted Duke Energy or the program staff with questions. Of those who did, 71% are satisfied with their interactions.

Figure 7-2. Participant Satisfaction with Residential CFL Program, Duke Energy, and Communications

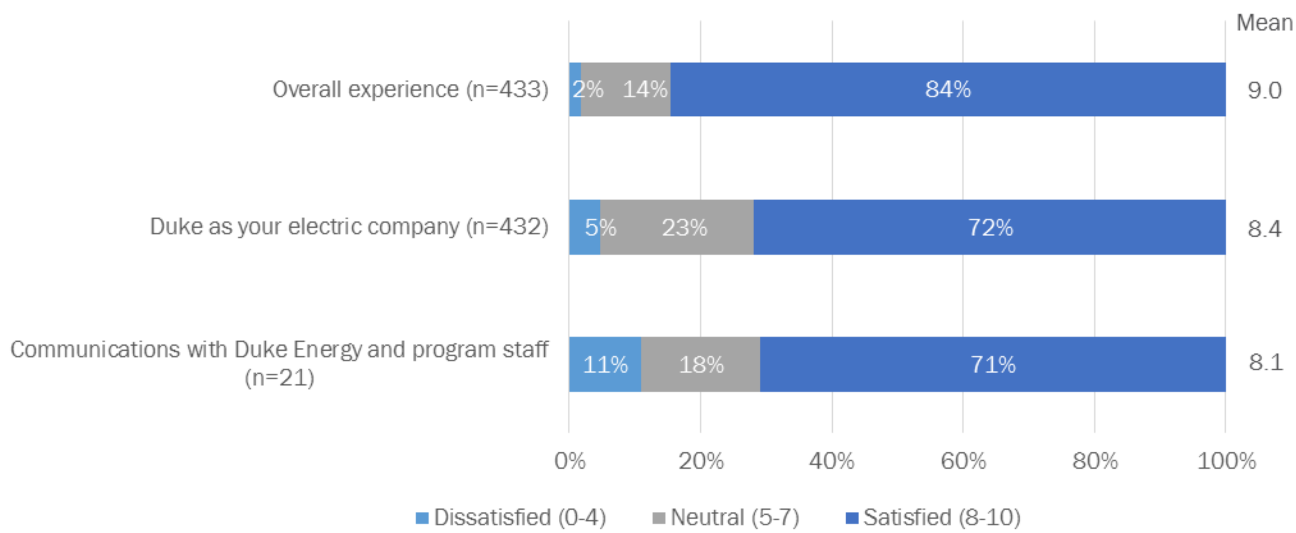
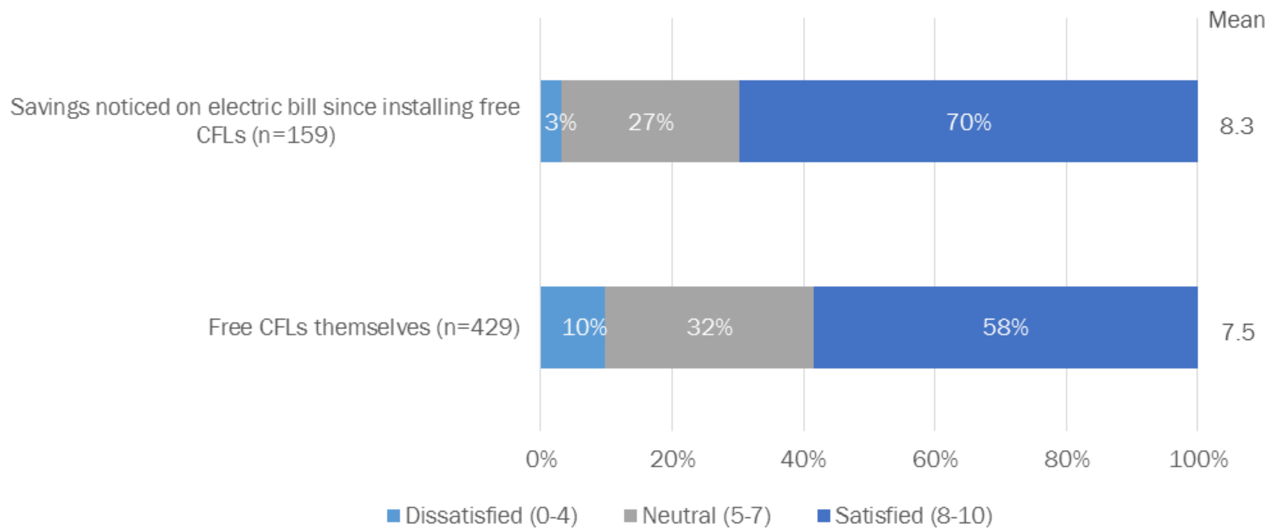


Figure 7-3 shows that compared to other program metrics, slightly fewer participants are satisfied with the program CFLs though a sizable majority are satisfied (58%) and few are dissatisfied (10%). Dissatisfied customers did not like the light color of the bulbs or thought the bulbs were too dim. Less than half (44%) of participants noticed savings on their electric bill since installing the free CFLs. Among those who did, seven in ten (70%) are satisfied with the savings.

Figure 7-3. Participant Satisfaction with CFLs and Electric Bill Savings



Program Leakage

The program ships the free CFLs to customers' billing addresses, which, in a small number of cases, 1) is not the same as the service address and 2) is outside DEO territory. While reviewing program data, the Evaluation Team found that the program shipped 17,039 bulbs (less than 1% of all program bulbs) to 1,148 customer addresses outside of Ohio. In order for customers to receive the bulbs, they must agree to install them at the account service address. While some customers with billing addresses in neighboring states may bring their bulbs back to DEO territory, it is likely that many install the bulbs at their out-of-territory billing address. In fact, through our participant survey, we found that 87% of participants with out-of-state billing addresses installed the bulbs at that billing address. Bulbs installed outside of DEO territory constitute leakage and energy savings that DEO will not realize. While the number of bulbs leaking out of the territory is small, mailing bulbs to the customer service address instead of the billing address would reduce leakage.

7.2.2 Program Marketing

DEO markets the program through direct mailings, online advertising, online services intercepts, and through interactive voice response (IVR) phone intercepts Program marketing efforts were focused around mailings, such as bill inserts, new customer letters, and ad space in other DEO program mailings. Online services intercepts target customers who log on to their online Duke Energy account. The system checks to see if the customer has participated in the program and asks eligible customers if they would like to order their free CFL bulbs. IVR intercepts target customers who call in to Duke Energy's automated hotline with a similar offer for eligible customers.

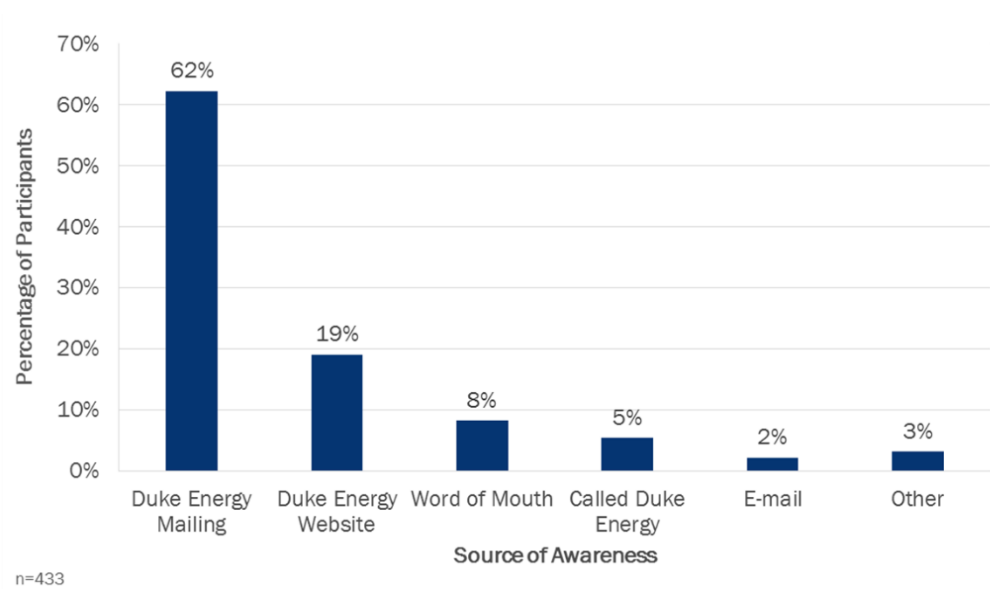
The level of program participation varied over time, some of which can be tied to program marketing. During the current evaluation cycle, the most significant shift in participation occurred during the summer of 2014. In a two-month span, the number of kits ordered more than tripled, as seen in Figure 7-4 below. This spike in participation corresponds to the introduction of IVR phone intercepts during the summer of 2014.

Figure 7-4. Program Bulb Shipments over the Evaluation Period

The 2015 marketing materials present data in a format that effectively links marketing efforts to program performance. This formatting, if continued consistently through the next evaluation cycle, should provide a useful source of information for the next evaluation.

IVR marketing may have encouraged many customers to participate in the program, but participants recall first learning about the program through Duke Energy mailings. According to our participant survey, nearly two-thirds of participants (62%) first heard about the program through mailings (Figure 7-5). Far fewer recall learning about the program through the Duke Energy website (19%) or from a call they placed to Duke Energy (5%).

Figure 7-5. Sources of Program Awareness

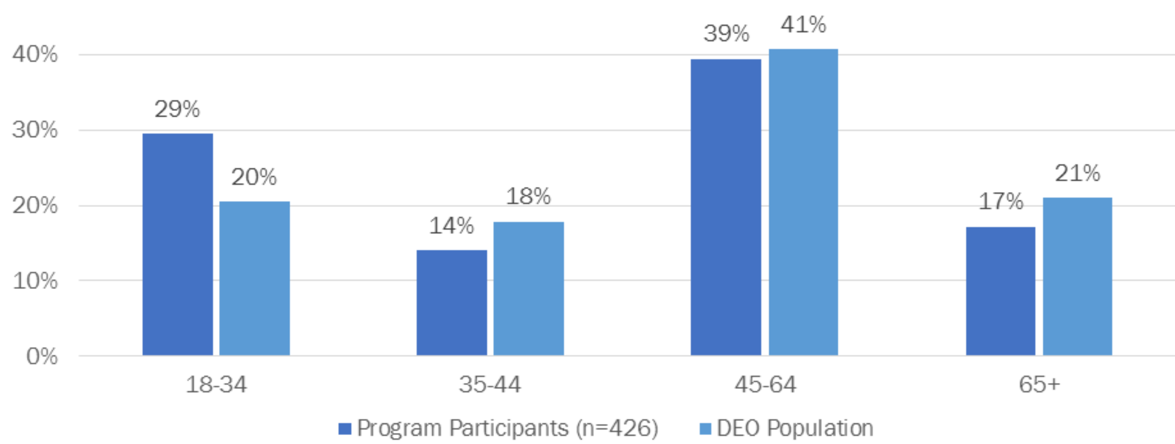


7.2.3 Who is the Program Reaching?

Demographics

To learn more about the types of customers the program is reaching, the Evaluation Team compared the demographics of program participants with those of DEO customers as a whole. We compared survey results of the most recent participants with data from the American Community Survey for DEO territory.[9] We found that recent participants are younger, have lower incomes, and are more likely to be renters than the overall DEO population (Figure 7-6, Figure 7-7, and Figure 7-8). It is possible that with approximately two-thirds of DEO customers having participated in the program, the program is now reaching customers that are often considered "harder to reach."

Figure 7-6. Age of Recent Participants and Customers



[9] The participant survey included customers who had participated between July 2014 and March 2015. We calculated DEO territory demographics from the 2009-2013 American Community Survey 5-year estimates at the census block group level.

Figure 7-7. Household Income of Recent Participants and Customers

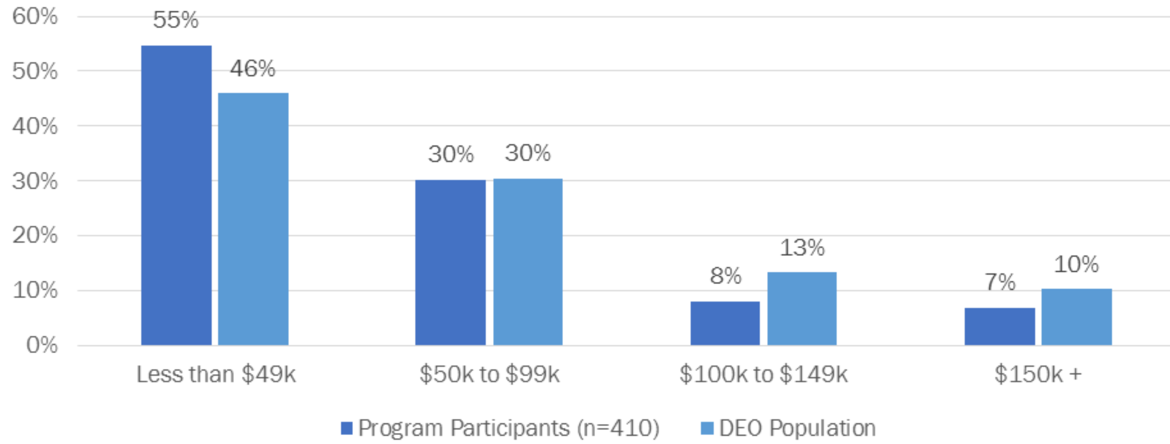
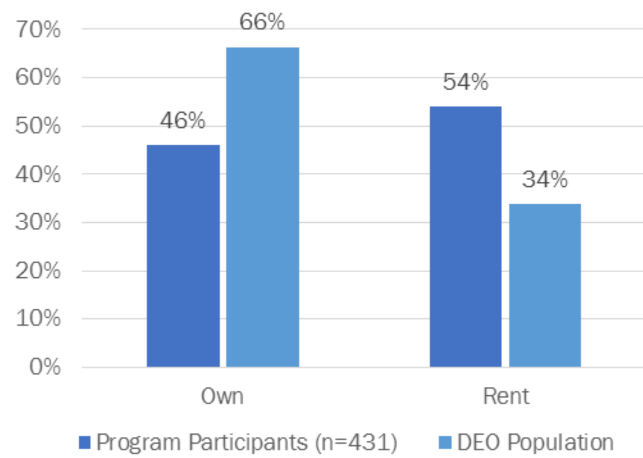


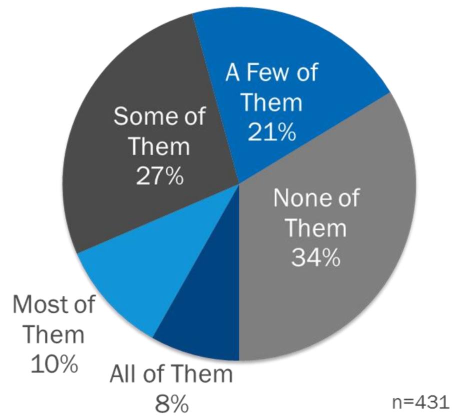
Figure 7-8. Home Ownership of Recent Participants and Customers



Lighting Awareness and Purchase Behaviors

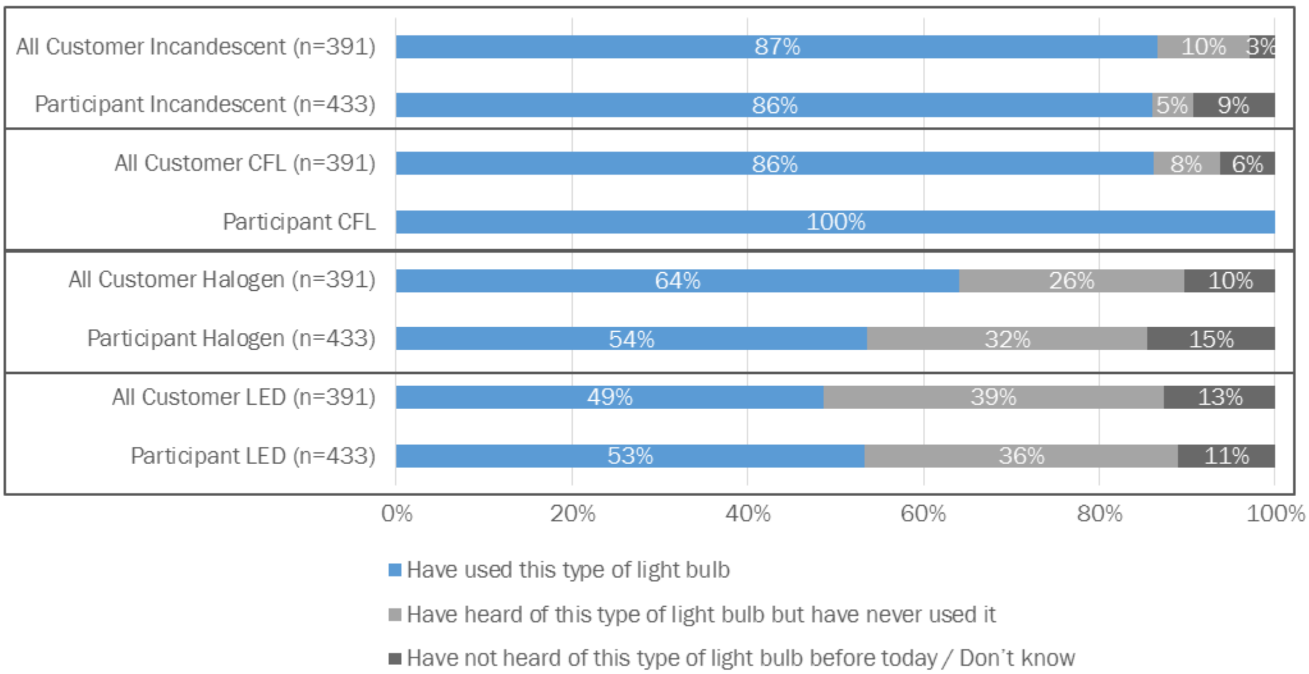
We asked recent participants about their prior use of CFLs. While a majority of participants reported having at least some CFLs installed prior to receiving the free CFLs from the program (66%), self-reported CFL saturation was low. One-third of recent participants (34%) did not have any CFLs installed and one-fifth (21%) had CFLs installed in just a few light sockets (Figure 7-9).

Figure 7-9. Sockets with CFLs in Home Prior to Participation



The Evaluation Team included lighting questions on a general population survey of DEO customers that was part of the DEO Appliance Recycling Evaluation. The results allow us to compare recent program participants with DEO customers as a whole in terms of their lighting usage and awareness to identify the types of customers the program is reaching. Recent participants are similar to all DEO customers in terms of their awareness and usage of different lighting technologies (Figure 7-10). A large majority of recent program participants, as well as DEO customers, is aware of and have used incandescent light bulbs. Recent participants are somewhat less likely to have used EISA compliant halogen bulbs, although awareness of the bulbs is high among both groups. CFL usage is high among DEO customers (86%); we assume that 100 percent of recent participants have used CFLs given their participation in the program. A majority of DEO customers and recent program participants are aware of LEDs, and approximately half of each group have used LEDs.

Figure 7-10. Awareness and Experience with Bulb Types



The Evaluation Team assumes that program participants have used CFL light bulbs as survey participants confirmed receiving program CFL bulbs, though we did not explicitly ask program participants of their awareness of CFLs.

Recent participants and DEO customers demonstrate a moderately high understanding of the energy use of different lighting technologies. Approximately two-thirds of both groups correctly identify incandescents as the most energy-intensive technology (Figure 7-11). However, recent participants show some confusion about the bulb that uses the least energy (Figure 7-12). Though LEDs use slightly less energy than CFLs, recent participants are more likely to think that CFLs are the most efficient bulb. DEO customers are more likely to correctly identify LEDs as the most efficient bulb. The confusion about LEDs among participants is understandable since LEDs are a new technology and the efficiency gains over CFLs are relatively small. Participants may also have concluded that the bulbs they recently received through the program would be the most efficient.

Figure 7-11. Understanding of Bulbs that Use the Most Energy

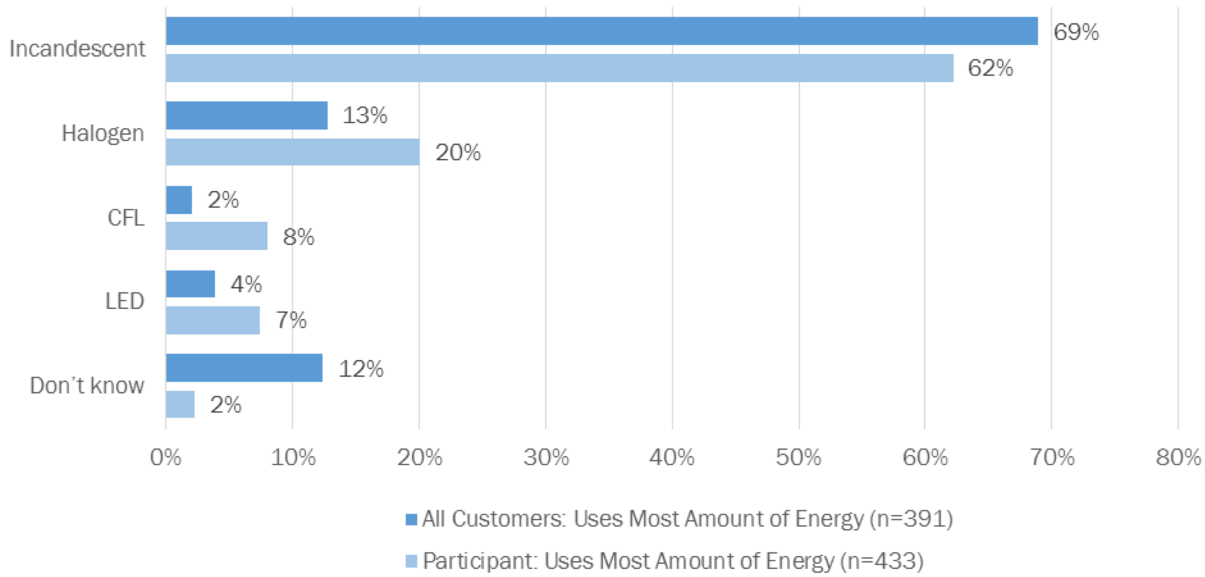
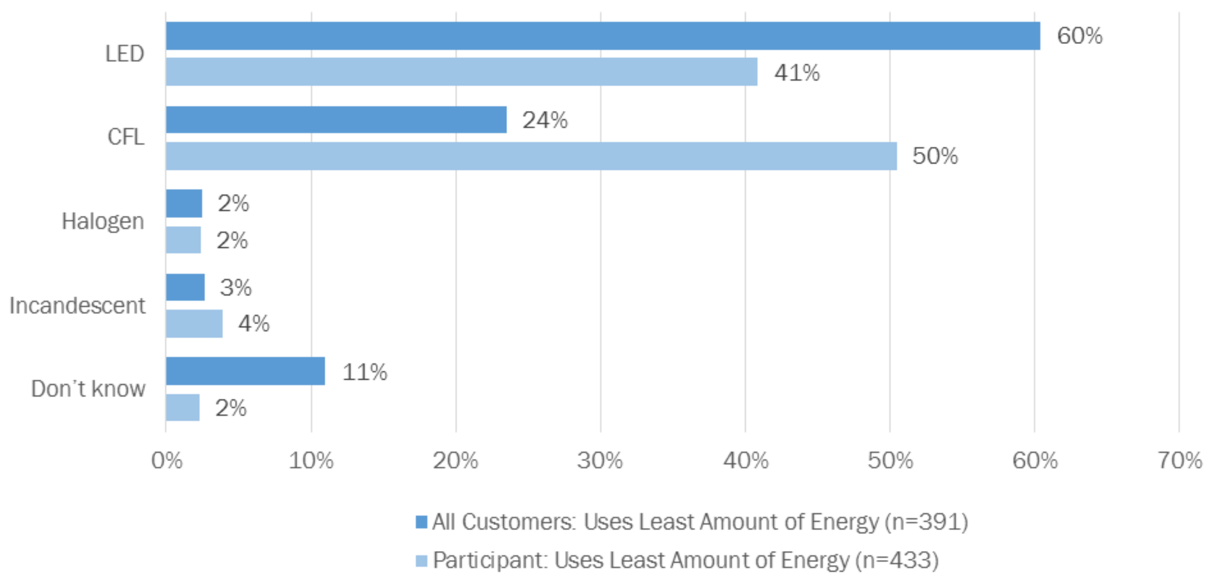


Figure 7-12. Understanding of Bulbs that Use the Least Energy

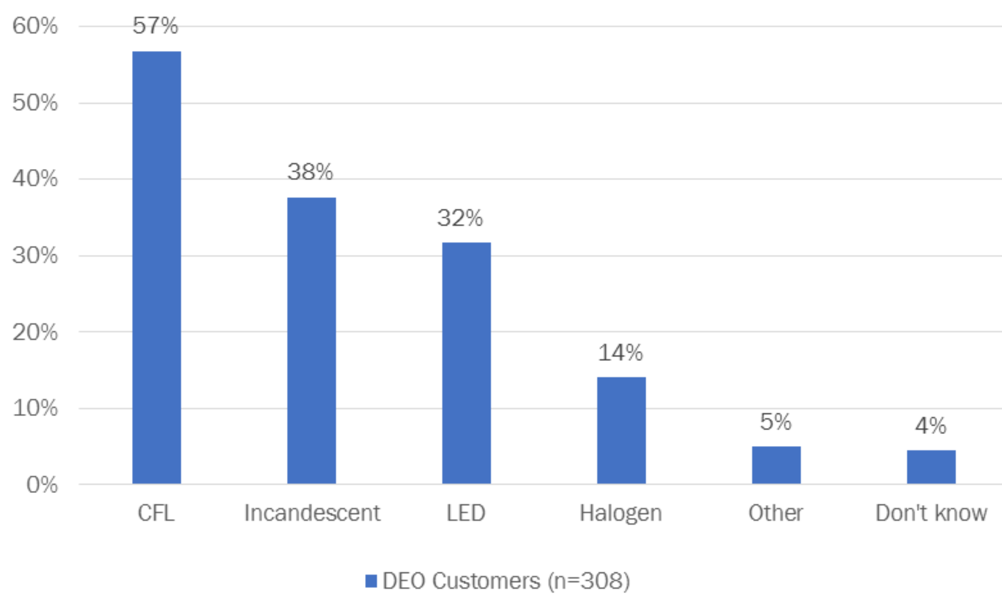


7.2.4 Future of the Program

As we noted earlier in this section, the Evaluation Team estimates that nearly two-thirds of DEO customers had participated in the program as of March 2015. At current participation rates, nearly all DEO customers will have participated in the Residential CFL program by March 2017. While reaching the remaining one-third of customers will likely be more challenging, the program is approaching the end in terms of its current design. The results of the lighting questions we asked on the general population survey provide information about customers purchasing habits that can help guide future program direction.

Though CFLs and LEDs last longer than incandescents and might slow the demand for new light bulbs, 73% of DEO customers said they had purchased light bulbs during the past year, regardless of type. CFLs were the most frequently purchased type of light bulb followed by incandescents (57% and 38%). LEDs are also a popular option with approximately one-third of customers purchasing LEDs (32%). More than four-fifths of customers (83%) report making their most recent light bulb purchase in a retail store.

Figure 7-13. Types of Bulbs Purchased by DEO Customers in the Last Year

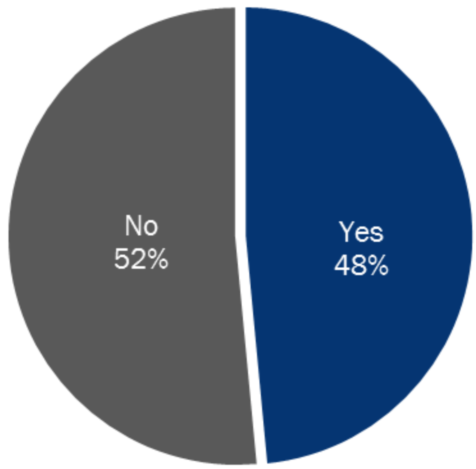


Note: Numbers sum to more than 100% because respondents could purchase more than one type of light bulb.

Since a majority of customers purchases CFLs on their own, the program may want to consider a shift in focus to LEDs. In particular, specialty LEDs may be the area where the program could have the greatest impact. CFL saturation in light sockets that utilize a specialty bulb has lagged behind standard light sockets. In an attempt to make inroads in this market, a number of lighting programs in other jurisdictions are dropping support of specialty CFLs in favor of specialty LEDs due to their superior light quality.

The program might also choose to put a greater emphasis on the online store. We asked DEO customers if they were aware of the Duke Energy online lighting store and approximately half had heard of the store, which is a relatively high number for an energy efficiency program (Figure 7-14). The program is currently growing awareness with additional marketing targeting past participants of the free CFL program.

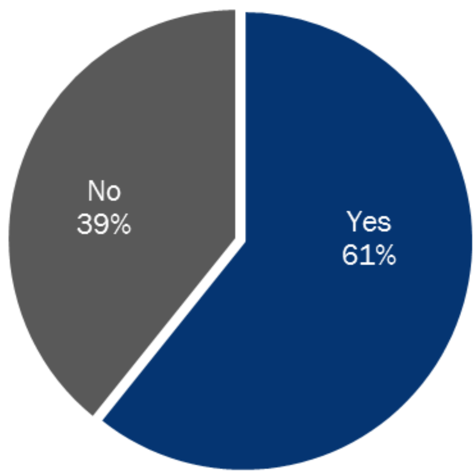
Figure 7-14. DEO Customer Awareness of Online Store



n=391

DEO customers are also facing a more challenging environment when they purchase light bulbs. In 2007, Congress passed the Energy Independence and Security Act (EISA), which set higher efficiency standards for light bulbs. We asked DEO customers if they were aware of EISA and found that slightly under two-thirds had heard of the regulations (Figure 7-15). Increasingly, customers will not find standard incandescents on shelves when they go to their local retailer to purchase light bulbs, and a sizable percentage will not know the reason why the bulbs are gone and what the best alternative may be. The DEO program can help fill this vacuum with educational marketing and by directing customers to the online store where DEO-endorsed products are sold.

Figure 7-15. DEO Customer EISA Awareness



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8. Conclusions and Recommendations

This section presents conclusions and recommendations resulting from the process and impact evaluation of the Residential CFL program.

Conclusions

The DEO Residential CFL program has been very successful. The program exceeded its participation goal with 186,172 customers participating. The program distributed over 2.6 million bulbs during the evaluation period, which is an average of 4,079 bulbs or 272 15-bulb kits per weekday. The program has reached a large share of DEO customers – we estimate that since 2010 and through March 2015, 66% of DEO customers had placed orders through the program. At the current participation rate, future program potential is limited. Aside from the remaining unserved customers, additional sources of participation would include new customers moving into the DEO service territory as well as new construction activity in the service territory. The savings potential from these additional sources of participation could be limited. New customers moving into existing premises previously serviced by the program may have program CFLs already installed, which could cause new participants to either hold off on installing their program CFLs or install them in low usage sockets previously filled with incandescents or halogens. New construction premises may already have high efficiency lighting in place, which may delay the installation of program CFLs.

The program realized 87% of the reported (ex-ante) gross energy savings, 103% of summer peak demand savings and 55% of winter peak demand savings. The Evaluation Team estimated evaluated (ex-post) gross energy savings of 79,797 MWh, summer peak demand savings of 10.4 MW, and winter peak demand savings of 8.5 MW. Gross realization rates are relatively high for both energy and summer peak demand savings. While the overall installation rate is 91.3%[10], first-year ISR is relatively low (56.3%). This is not surprising, given that most customers requested all 15 CFLs at once.

Table 8-1. Gross Impact Results

Savings Type	Total Number of CFLs	Reported (Ex-Ante) Gross Savings	Evaluated (Ex-Post) Gross Savings	Gross Realization Rate
Energy savings (MWh)	2,655,700	91,418	79,797	87%
Summer peak demand savings (MW)		10.1	10.4	103%
Winter peak demand savings (MW)		15.6	8.5	55%

Note that savings are rounded.

Evaluated gross per-bulb savings achieved during the evaluation period were 30.05 kWh for energy, 0.0039 kW for summer peak demand and 0.0032 kW for winter peak demand. Only a portion of program-discounted bulbs used EISA-adjusted wattages. Moving forward, energy and demand savings for *all* program bulbs need to use EISA-adjusted baseline wattages. As such, we recommend that the program uses per-bulb savings estimates calculated using current EISA-adjusted baselines to estimate savings from future installations. Table 8-2 contains evaluated per-bulb savings and per-bulb savings recommended for future use by the program.

[10] Overall installation rate incorporates a discount adjustment of future installations. This adjustment is discussed further in Section 5.1.

Table 8-2. Evaluated and Recommended Per-Bulb Gross Impacts

Savings Type	Evaluated (Ex-Post) Per-Bulb Gross Savings During the Evaluation Period	Recommended Per-Bulb Gross Savings		
		13W CFL	18W CFL	Overall[A]
Energy savings (kWh)	30.05	22.25	25.96	23.99
Summer peak demand savings (kW)	0.0039	0.0029	0.0034	0.0031
Winter peak demand savings (kW)	0.0032	0.0024	0.0028	0.0026

[A] This assumes no changes to the program CFL wattage mix.

Through analysis of participant self-report survey results, the Evaluation Team estimated the program net-to-gross ratio (NTGR) to be 86.1%, which is relatively high. NTGR is comprised of a program free-ridership rate of 22.1% and program spillover of 8.2%. Net program impacts are 68,679 MWh in energy savings, 8.9 MW in summer peak demand savings and 7.4 MW in winter peak demand savings.

Table 8-3. Net Impact Results for 2012-2015 Evaluation Period

Savings Type	Evaluated (Ex-Post) Gross Savings	NTGR	Evaluated (Ex-Post) Net Savings[A]
Energy savings (MWh)	79,797	86.1%	68,679
Summer peak demand savings (MW)	10.4		8.9
Winter peak demand savings (MW)	8.5		7.4

[A] Evaluated net savings were calculated using unrounded NTGR.

Table 8-4 presents per-bulb net impact results for the evaluation period. Average per-bulb energy savings are 25.86 kWh and peak demand savings are 0.0034 and 0.0028 for summer and winter respectively.

Table 8-4. Per-Bulb Net Impact Results for 2012-2015 Evaluation Period

Savings Type	Evaluated Per-Bulb (Ex-Post) Gross Savings	NTGR	Evaluated Per-Bulb (Ex-Post) Net Savings[A]
Energy savings (kWh)	30.05	86.1%	25.86
Summer peak demand savings (kW)	0.0039		0.0034
Winter peak demand savings (kW)	0.0032		0.0028

[A] Evaluated net savings were calculated using unrounded NTGR.

The program implementation processes ran smoothly. Program tracking data were complete and accurate. Instances of products mailed and installed outside of the service territory were minimal. Instances of participants receiving more than 15 bulbs through the program were also minimal. Participants reported high levels of satisfaction with the program, indicating that program processes are effective and well run. A large majority of participants (84%) are satisfied with the program overall.[11] Timely receipt of program bulbs is key to high satisfaction, and 90% of participants report receiving bulbs within three weeks of placing their order. We also asked participants about their satisfaction with Duke Energy as their electric company and found approximately three-quarters are satisfied (72%).

During the evaluation cycle, we found that recent participants are younger, have lower incomes, and are more likely to be renters than the overall DEO population. It is possible that with approximately two-thirds of DEO customers having participated in the program, the program is now reaching customers that are often considered "harder to reach." Given cumulative participation levels to-date, reaching additional customers may prove challenging for the program moving forward.

Recommendations

We recommend that program administrators calculate future savings from the Residential CFL program using the recommended per-bulb energy and summer peak savings presented in Table 8-2 above. We recommend that the program team estimates winter peak demand savings in DSMore and compares the savings estimate to the evaluation recommended per-bulb values. Depending on the assumptions used in DSMore, the program staff may choose to use DSMore modeled values in place of evaluation-estimated values.

To-date, the Residential CFL program has reached a sizeable share of DEO customers. As a result, it will be increasingly challenging for the program to maintain past participation levels. The reduction in baseline wattages due to EISA legislation means the program will achieve less savings than in the past. In addition, DEO customers are aware of CFLs, and CFLs are the bulb type that customers purchase most often. These trends could indicate rising free-ridership rates in the future. DEO may want to consider winding down the program as it is currently designed and exploring alternative designs and/or bulb types. Based on our knowledge of the lighting market dynamics along with the findings from this evaluation, we propose the following alternative designs:

- **Introduction of specialty products.** Depending on the cost-effectiveness screening results, one possible design solution is to offer deeply discounted or free specialty LED products. This offer can be used in conjunction with the online store, which already offers discounted specialty LEDs. This combined approach could be designed to reach a broad base of customers who have a need for specialty products, spur customer interest in LEDs, showcase the superior quality of LEDs in specialty applications, and drive future purchase of specialty LEDs through the online store. Given that three-way and reflector bulbs are among the most common bulb types, the program could give participants a choice of bulbs that they would like to see in a kit. Kits could feature several configurations and contain three to five light bulbs. In most areas of the country, use of energy efficient bulbs in specialty sockets has lagged behind their use in standard sockets. Program intervention could be key to changing customer purchase behaviors when it comes to specialty lighting. Customers are generally more satisfied with specialty LEDs than CFLs and with the drop in price for LEDs, the bulbs are more likely to be cost-effective.

- **Targeted outreach to underserved customer segments.** It is our understanding that DEO can and have started using its customer data tracking systems to identify customers that have not participated in the Residential CFL program. We recommend that the future marketing (and messaging) efforts for the free CFL offerings continue to be targeted to customers that are yet to participate. A targeted

[11] A rating of 8, 9, or 10 on the scale from 0 to 10 where 0 is extremely dissatisfied and 10 is extremely satisfied.

approach will expand the program's reach without unnecessarily marketing to previous participants who reached their 15-CFL lifetime limit. In addition, this approach may lead to lower free-ridership, as unserved customers are likely to have lower levels of knowledge and experience with energy efficient lighting products.

Regardless of the future changes to the program, we recommend that program administrators consider research to update its gross savings assumptions, namely hours of use, coincidence factors, and interactive effects. While we used the best available assumptions in this evaluation, they are either outdated or are based on research from other jurisdictions.

Additional research (lighting baseline and retailer shelf audit studies) to characterize the state of the lighting market in DEO service territory will help inform future program design.

9. Summary Form

Smart $aver Residential Program
Completed EMV Fact Sheet

The Residential CFL program, a subcomponent of the Smart $aver Residential Program, offers customers up to a lifetime limit of 15 free CFLs mailed directly to their homes by Duke Energy.

Date	October 26, 2015
Region(s)	Duke Energy Ohio
Evaluation Period	October 2012 through March 2015
Gross Annual kWh impact	87% realization rate
Coincident kW impact	103% realization rate (summer) 55% realization rate (winter)
Measure life	5 years
Net to Gross	86.1%
Process Evaluation	Yes
Previous Evaluation(s)	September 28, 2012

Evaluation Methodology

The Evaluation Team reviewed reported savings assumptions and verified 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 evaluated 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 also conducted a program process evaluation including results from participant and general population surveys.

Impact Evaluation Details

- The Evaluation Team estimates baseline wattages using the equivalent baseline wattage approach, and adjusts baseline wattage to account for the implementation of the Energy Independence and Security Act (EISA) during the evaluation period
- All Duke Energy Ohio customers who have not previously participated in the program are eligible to receive up to 15 free CFLs through the program
- The Evaluation Team uses the Uniform Methods Project (UMP) recommended approach to estimate gross energy savings, and incorporates additional adjustments as necessary
- Some overlap is present with other Duke Energy programs, including the Duke Energy Online Store and the Duke Energy Home Energy Assessment programs

10. Appendix A: Spillover Savings Assumptions

This section presents the approach for estimating energy and demand savings for spillover CFLs and LEDs.

Spillover represents additional savings (expressed as a percent of total program savings) that were achieved without program rebates but would not have occurred in the absence of the program. For the purposes of this study, we limited the exploration of spillover effects to CFLs and LEDs. We explored non-program CFL and LED purchases and the degree of program influence on those purchases through the participant survey. Overall, 19 participants qualified for spillover. We asked those participants about the types of bulbs (CFLs or LEDs) and the quantity of bulbs they purchased as a result of their experience with the program CFLs. We did not ask participants to report bulb wattages because customers typically have difficulty recalling wattage information, especially if they purchased bulbs across a range of wattages. Due to survey length, we did not ask questions about bulb type (standard or specialty). Equation 10-1 shows the formula we used to estimate spillover energy savings and Equation 10-2 shows the formula that we used to estimate spillover peak demand savings.

Equation 10-1. Spillover Energy Savings Formula

$$\Delta kWh = \frac{(Watts * HOU)_{base} - (Watts * HOU)_{ee}}{1000} * 365 * (1 + HVAC_c)$$

Equation 10-2. Spillover Peak Demand Savings Formula

$$\Delta kW = \frac{Watts_{base} - Watts_{ee}}{1000} * CF * (1 + HVAC_d)$$

Where:

ΔkWh = first-year electric energy savings
ΔkW = peak electric demand savings
$Watts_{base}$ = 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 10-1 shows the savings assumptions that we used to estimate spillover energy and demand savings and details the sources of those assumptions. We assumed that spillover bulbs were standard bulbs and assumed an efficient wattage of 13 watts for CFLs and 9.5 watts for LEDs. These wattages represent typical wattages of the standard CFLs and LEDs. We used the EISA-adjusted baseline wattages for 60-watt incandescent equivalents. All other savings assumptions mirror the ones we used to estimate energy and demand savings for program CFLs.

Table 10-1. Spillover Savings Assumptions

Assumption Type	Assumption Value	Assumption Source
Efficient bulb wattage – CFL	13	Typical standard CFL wattage
Efficient bulb wattage – LED	9.5	Typical standard LED wattage
Baseline wattage	43	EISA-adjusted wattage for 60-watt incandescent equivalents
Hours of use	2.47 hours/day	Indiana Statewide Core 2014 Evaluation
Summer coincidence factor	0.100	DTE Energy and Consumers Energy 2012 Evaluation
Winter coincidence factor	0.096	2013 evaluation of Duke Energy Progress (DEP) Energy Efficient Lighting Program
$HVAC_c$	-0.058	2012 Process & Impact Evaluation of Residential Smart $aver Energy Efficiency Products Program
$HVAC_d$ – Summer	0.167	
$HVAC_d$ – Winter	0.000	Evaluation Team assumption

Using the savings formula and the savings assumptions above, we estimated per-bulb kWh savings of 26.9 for CFLs and 30.0 for LEDs. We then multiplied the per-bulb savings by the total quantity of spillover CFLs and LEDs. Overall, the program achieved spillover savings of 5,955 kWh, 0.78 summer peak kW, and 0.64 winter peak kW.

Table 10-2. Spillover Savings Summary

Product Type	Total Number of Spillover Bulbs	Total Per-Bulb Savings			Total Spillover Savings		
		kWh	Summer Peak kW	Winter Peak kW	kWh	Summer Peak kW	Winter Peak kW
CFLs	83	26.9	0.0035	0.0029	2232	0.29	0.24
LEDs	124	30.0	0.0039	0.0032	3723	0.49	0.40
Total	**207**	**28.8**	**0.0037**	**0.0031**	**5,955**	**0.78**	**0.64**

Note that the values have been rounded.

We estimated the program spillover rate by dividing the spillover savings by the evaluated gross savings for the survey respondents who received spillover questions.

Equation 10-3. Spillover Rate Formula

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

The resulting spillover rate is 8.3%.

Table 10-3. Spillover Rate Estimate

	kWh	Summer Peak kW	Winter Peak kW
Spillover savings	5,955	0.78	0.64
Evaluated gross savings in the respondent sample	72,093	9.4	7.7
Spillover rate	8.3%	8.3%	8.3%

Note that the values have been rounded.

11. Appendix B: Detailed Analysis Tables

The Excel spreadsheet embedded below contains detailed analysis of program gross and net impacts. The data in the file is at the kit configuration and month and year of shipment level. The file contains reported (ex-ante) savings, all of the gross savings assumptions, evaluated gross savings, NTGR, evaluated net savings, and recommended gross savings.

Duke
Energy_Detailed Ana

12. Appendix C: Chart with Measure-Level Inputs for Duke Energy Analytics

The Excel spreadsheet embedded below contains measure-level inputs for Duke Energy Analytics. Per-bulb savings values in the spreadsheet represent our recommended values and not the evaluated values. We discuss the difference between the recommended and evaluated values in Section 5.2 of this report. Column O in the spreadsheet includes the estimate of NTG (1-FR+SO). Consistent with the previous evaluation, Opinion Dynamics included a CFL measure life of 5 years.

DEO Residential
CFL Chart for Duke I

13. Appendix D: Detailed Survey Results

The Word documents embedded below contain detailed survey results from the participant and general population survey efforts. We provide results in the form of the Wincross tables with breakdown of the survey results across core customer demographic and household characteristics.

DEO Residential CFL Detailed Particip

DEO Residential CFL Detailed Genera

14. Appendix E: Participant Survey Instrument

The Word document embedded below contains the participant survey instrument used as part of this evaluation.

DEC and DEO
Residential CFL Parti

15. Appendix F: Detailed Overview of the Net-To-Gross Approach

The Word document embedded below contains a detailed overview of the net-to-gross approach used to estimate program free-ridership and spillover rates.

DEO Residential
CFL NTG Algorithm (

For more information, please contact:

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APPENDIX J-

Smart $aver Residential – HVAC Evaluation

Evaluation of the Residential Smart $aver HVAC Program in Ohio

September 21, 2015

Duke Energy
139 East Fourth Street
Cincinnati, Ohio 45201

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Table of Contents

CADMUS

Introduction

The Duke Energy Residential Smart $aver HVAC program in Ohio encourages the installation of higher efficiency heating and cooling units in new and existing homes. Cadmus evaluated the program from January 2012 through October 2013. To estimate energy consumption for each HVAC system installed through the program, we used post-installation monthly electric bills and participation tracking information. To estimate each system's energy savings, we relied on local weather data and performed engineering calculations.

The evaluation findings presented in this report represent the savings for installation of high-efficiency central heat pump and air conditioners.

Program Description

Through Duke Energy's Residential Smart $aver HVAC program, residential customers, vendors, and home builders can receive a rebate for installing higher efficiency heating and cooling units in new and existing homes. The HVAC system must include an electronically commutated motor (ECM) fan. Residential customers receive rebates of $200 on qualified purchases. An additional $100 incentive goes directly to the participating HVAC contractor or dealer. New home builders who install qualified equipment are eligible for rebates of $300.

Duke Energy in Ohio contracts with a third-party vendor, GoodCents, which is responsible for daily administration of the program, including HVAC dealer and contractor recruitment, call center operations, rebate application processing and payments, and quality assurance. Participating trade allies discuss the program with Duke Energy Ohio customers who are considering the purchase of a replacement air conditioner or heat pump. At the point of sale, the trade ally presents the $200 incentive to the customer for selecting the high efficiency equipment option. After installing the qualifying unit, the trade ally fills out a rebate application form and submits it with a copy of the invoice and a certificate from the American Heating and Refrigeration Institute (AHRI). Within 45 days, GoodCents processes the paperwork and mails the checks ($100 to the contractor and $200 to the customer). New home builders can opt to keep the $300 rebate or pass it along to the home buyer.

Cadmus evaluated program participation during January 2012 through October 2013. Duke Energy database contains 6,383 participant records during this period[1].

[1] To estimate savings for any additional or missing measure participation (not included in the database used by Cadmus), use average savings values in Table 9 (784 kWh for air conditioners, 1,113 for heat pumps).

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Evaluation Objectives

In collaboration with Duke Energy in Ohio, Cadmus identified these impact evaluation objectives:

- **Estimate gross energy savings for central air conditioning systems.** Estimate savings for unitary installation of a central air conditioning system using all available data and engineering calculations.
- **Estimate gross energy savings for central heat pump systems.** Estimate savings for unitary installation of a central heat pump system using all available data and engineering calculations.
- **Estimate net savings.** Determine freeridership and spillover savings attributable to the Smart $aver program.

High-Level Impact Findings

This section summarizes the Cadmus Team's key impact findings.

Gross Impacts

As shown in Table 1 and Table 2 the Residential Smart $aver HVAC Program exceeded its gross energy and demand savings goals.

Table 1. Program Projected, Claimed, and Evaluated Gross Energy Impacts

Program	# Units Incented	Reported* Savings (kWh)	Evaluated Savings (kWh)
Smart $aver Central Air Conditioner	4,479	1,764,792	3,510,509
Smart $aver Central Heat Pump	1,904	2,974,119	2,119,541
Total	**6,383**	**4,738,911**	**5,630,050**

* Based on tracking database provided to Cadmus.
**Based on average savings by system type and mode of operation. Per-unit average gross savings of 784 kWh/central air conditioner and 1,113 kWh/heat pump.

Table 2. Program Projected, Claimed, and Evaluated Gross Peak Demand Impacts

Program	# Units Incented	Reported* Savings (kW)	Evaluated Savings (kW)**
Smart $aver Central Air Conditioner	4,479	885	2,152
Smart $aver Central Heat Pump	1,904	377	748
Total	**6,383**	**1,262**	**2,901**

* Based on tracking database provided to Cadmus.
** Calculated using DSMore with monthly energy savings values (See Table 8).

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Net Impacts

Based on the 6,383 central air conditioner and heat pump units incented through the Smart $aver HVAC program, the overall net energy and demand savings from the program was 3,507,521 kWh and 1,807 summer coincident peak kW (Table 3 and Table 4).

Table 3. Program Net Energy Impacts

Program	# Units Incented	Average Savings per Unit (kWh)	Evaluated Savings (kWh)
Smart $aver Central Air Conditioner	4,479	488	2,187,047
Smart $aver Central Heat Pump	1,904	694	1,320,474
Total	**6,383**	**550**	**3,507,521**

Table 4. Program Net Peak Demand Impacts

Program	# Units Incented	Average Savings per Unit (kW)	Evaluated Savings (kW)
Smart $aver Central Air Conditioner	4,479	0.299	1,341
Smart $aver Central Heat Pump	1,904	0.245	466
Total	**6,383**	**0.283**	**1,807**

Evaluation Parameters

The Cadmus team used multiple activities and analyses to conduct the impact evaluation of the Residential Smart $aver HVAC Program. Table 5 lists the parameters of these activities, along with the estimated precision values at the 90% confidence level. Heating and cooling precision estimates are based on the variance in consumption from billing analysis results, normalized by system size (tons). A census[2] of participants was used to determine heating and cooling consumption kWh/ton values.

[2] A total of 6.8% of participant service accounts were removed (see section: Method – Billing Analysis) for various reasons thus these were not included in the precision estimate.

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Table 5. Evaluated Parameters with Value, Units, and Precision and Confidence

Parameter	Sample Size	Units	Confidence/Precision
Cooling Consumption Estimate from Billing Analysis	5,821 utility bills	kWh/ton grouped by installation type	90% confidence with ±3% precision
Heating Consumption Estimate from Billing Analysis	1,981 utility bills	kWh/ton grouped by installation type	90% confidence with ±4% precision
Freeridership score	58 Vendor allies	% Freeridership	90% confidence with ±15.8% precision

Table 6 lists the start and end dates for activities conducted for the impact evaluation.

Table 6. Sample Period Start and End Dates

Evaluation Component	Sample Period	Dates Conducted	Total Conducted
HVAC Vendor Freeridership Surveys	Participation in 2012 and 2013	September 2013	58
Billing Analysis	Varies* (2012-2014)	May 2015	5,821

*Post-installation billing data used. In some cases two years of data were available so two separate results were calculated for one participant service account. In these cases we chose the consumption estimate with the higher R-square value.

Method

Cadmus relied on primary and secondary data to evaluate the Smart $aver HVAC program. We used PRISM software to estimate the heating and cooling HVAC load for each participant from monthly utility bills. To estimate consumption by unit rather than by participant, we grouped billing analysis results of each participant by type of installation as specified in the tracking database.[3] We used HVAC energy consumption estimates from billing analysis with local weather station data to predict energy consumption in normal temperature (typical meteorological year 3 [TMY3]) bins. We relied on secondary research to estimate ECM savings. We then applied manufacturer's equipment specifications to calculate savings for each type of HVAC system installed. We describe each of these methods in the next sections.

[3] Cadmus grouped all participants who installed only one central air conditioning or heat pump unit separately from all participants who installed more than one unit.

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Method – Billing Analysis

Cadmus conducted a statistical billing analysis on a minimum of 10 months of post-installation period billing data, using PRISM software to determine the most recent use. We followed these steps:

1. Matched the measure-tracking information with the electric billing data. Billing data was received from January 2012 through October 2014.
2. Used ZIP code mapping for all weather stations in the United States to determine the nearest station for each ZIP code of the participants' billing addresses.
3. Obtained daily average temperature weather data from January 2011 through 2014 for ten National Oceanic and Atmospheric Administration (NOAA) weather stations, representing all ZIP codes of the participants' billing addresses.
4. Used daily temperatures to determine base 45–85 heating degree days (HDDs) and cooling degree days (CDDs) for each station.
5. Matched billing data periods with the CDDs and HDDs from the associated stations.

We removed 6.8% of the sites from our analysis because of these criteria:

- Any service account with a ground source heat pump
- Any service account with less than 300 days of data
- Some results with very low R-square
- Any results when the model overpredicted total consumption by more than 150% of actual and less than 50% of actual

For each participant service account, we estimated a heating and cooling PRISM model in the post-installation periods to weather-normalize raw billing data. Each model allowed the heating reference temperature to range from 45°F to 85°F and the cooling reference temperature to range from the heating reference temperature to 85°F.

The PRISM model used the following specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer 'i' and calendar month 't':

ADC_{it}	=	the average daily kWh consumption in the post program period.
α_i	=	the participant intercept; represents the average daily kWh base load.
β_1	=	the model space heating slope.
β_2	=	the model cooling slope.
$AVGHDD_{it}$	=	the base 45°F to 85°F average daily HDDs for the specific location.
$AVGCDD_{it}$	=	the base 45°F to 85°F average daily CDDs for the specific location.
ε_{it}	=	the error term.

Using this PRISM model, we computed weather-normalized annual consumption (NAC) for each heating and cooling reference temperature, as follows:

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$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_i + \beta_2 LRCDD_i + \varepsilon_i$$

Where for each customer ‘i’:

NAC_i	=	the normalized annual kWh consumption.
α_i	=	the intercept is the average daily or base load for each participant; it represents the average daily base load from the model.
$\alpha_i * 365$	=	the annual base load kWh usage (non-weather sensitive).
β_1	=	the heating slope; in effect, this is usage per heating degree day from the model above.
$LRHDD_i$	=	annual, long-term HDDs of a typical month year normal (TMY3) in the 1991–2005 series from NOAA, based on the home location.
$\beta_1 * LRHDD_i$	=	the weather-normalized annual weather sensitive heating usage, also known as HEATNAC.
β_2	=	the cooling slope; in effect, this is usage per CDD from the model above.
$LRCDD_i$	=	annual, long-term CDDs of a typical month year (TMY3) in the 1991–2005 series from NOAA, based on home location.
$\beta_2 * LRCDD_i$	=	the weather-normalized annual weather sensitive cooling usage, also known as COOLNAC.
ε_i	=	the error term.

If any heating and cooling model yielded negative intercepts, negative heating slopes, or negative cooling slopes, we estimated additional models that separated out only the cooling usage (cooling-only models) or the heating usage (heating-only models). From the models with correct signs on all parameters, the best model chosen for each participant for the post-installation periods was the one with the highest R-square. To obtain the HVAC use, we added up the heating and cooling NACs. We determined HVAC consumption separately for the following seven participant groups:

- Cooling: 1 cooling system; heating: 1 heat pump, no gas furnace
- Cooling: 1 cooling system; heating: 1 heat pump with gas furnace
- Cooling: 1 cooling system; heating: no electric heating
- Cooling: 2+ cooling systems; heating: 1 heat pump, no gas furnace
- Cooling: 2+ cooling systems; heating: 1 heat pump with gas furnace
- Cooling: 2+ cooling systems; heating: multiple electric heating systems
- Cooling: 2+ cooling systems; heating: no electric heating

We separated results in this way for several reasons, including:

- Heat pumps installed with gas furnaces are unlikely to have backup electric resistance heat, so all electric heating consumption is from the evaporator/condenser.
- To investigate consumption differences of homes with one system versus homes with multiple systems.

- To compare cooling consumption and savings of heat pumps to air conditioners.

Note that these observations cannot be confirmed because they are based only on reported data in the tracking database. For example, a home could have multiple air conditioners but only one may have been installed using a rebate. In this scenario, our analysis would overestimate consumption and savings for that type of HVAC system reported in the tracking database.

Method – ECM Savings Estimates

We used data collected from previous Cadmus metering studies to estimate savings from ECM fan in heating mode for air conditioners and in circulation mode for both air conditioners and heat pumps. ECMs typically save energy in three ways:

- Cooling mode savings
- Heating mode savings
- Circulation mode savings

Seasonal energy efficiency ratio (SEER) and heating seasonal performance factor (HSPF) ratings include the benefit of the ECM fan. ECM fan savings in cooling mode, therefore, are accounted for. Savings attributable to an ECM fan in heating mode are accounted for by the HSPF rating of a heat pump. An ECM fan does save energy for an air conditioner installed with a heating system, so we estimated heating mode savings for all air conditioners using a large-scale metering study performed by Cadmus in Wisconsin.[4] We adjusted the heating mode savings for run time by a ratio of HDD.

To determine savings in circulation mode, we used the same Wisconsin metering study and another large (160 HVAC units) fan metering study conducted by Cadmus for a Midwest utility in 2013.[5] We found that the average circulation mode run time of a typical HVAC system is approximately 8%. This results in a circulation mode savings for both air conditioners and heat pumps of 153 kWh.

Method – Heating and Cooling Savings Calculations

Cadmus developed savings models that use normal bin temperature data (typical meteorological year 3 [TMY3]) to estimate cooling savings for both air conditioners and heat pumps and to estimate the heating savings for heat pumps. The federal minimum efficiency of a heat pump and air conditioner through 2014 was 13 SEER (and 7.7 HSPF for heat pumps in heating mode). All savings are based on the

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4 Wisconsin Focus on Energy. *Technical Reference Manual.* Prepared by Cadmus. August 15, 2014. Available online: https://focusonenergy.com/sites/default/files/Wisconsin%20Focus%20on%20Energy%20Technical%20Reference%20Manual%20August%202014.pdf

5 Data from this study are not yet publicly available.

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assumption that an HVAC system of this efficiency with a standard permanent split capacitor (PSC) fan would have been installed even if the Smart $aver incentive was not available.

Our spreadsheet models estimated savings with the same general principle as DOE-2-based residential energy models.[6] The calculated savings are based on HVAC consumption estimated from billing analysis; with a spreadsheet model, we are able to quickly make adjustments and check the reasonableness of results. For example, we used the HDD and CDD base temperatures determined in the billing analysis to limit the HVAC consumption to a range of temperatures. If the HDD base temperature for a group was 58°F and the CDD base temperature was 65°F, we assumed cooling consumption occurs only above 65°F and heating consumption occurs only below 58°F.[7] To calibrate a model (such as BeOpt) to billing analysis results, the user must make changes to the building shell (change window size, increase/ decrease insulation values) that are unrealistic.

To determine savings by the SEER reported, we used the average HVAC consumption estimated by the groups defined in the Method – Billing Analysis section above and applied the simulated EER versus temperature curves developed from manufacturer's data. Figure 1 shows typical manufacturer data.

Figure 1. Example of HVAC Parameters used for Analysis

Single Stage

Rated Inputs
15.0 SEER
13 Rated EER
3.81 COP   COP = EER / 3.413
36,000 BTUH_3_t Total Capacity

SINGLE STAGE ODB	BTUH	kW	EER	EIR
65	37,351	1.98	18.85	0.181
75	35,986	2.17	16.58	0.206
85	34,529	2.43	14.20	0.240
95	32,980	2.75	11.99	0.285
105	31,340	3.11	10.08	0.339
115	29,609	3.49	8.49	0.402

	a	b	c
EER	0.000933	-0.37802	39.55868
Capacity	-0.4572	-72.5605	43999.58
kW	0.000242	-0.01298	1.796721

Dual Stage

Rated Inputs
17.0 SEER
14.4 Rated EER
4.22 COP   COP = EER / 3.413

LOW STAGE ODB	BTUH	kW	EER	EIR
65	27,576	1.18	23.31	0.146
75	26,473	1.29	20.47	0.167
85	25,297	1.50	16.82	0.203
95	24,050	1.80	13.39	0.255
105	22,731	2.15	10.58	0.323
115	21,339	2.54	8.41	0.406

	a	b	c
EER	0.001187831	-0.52122	52.43768
Capacity	-0.360288	-59.8779	32990.04
kW	0.000351894	-0.03581	2.014131

Rated Inputs
17.0 SEER
13.2 Rated EER
3.87 COP   COP = EER / 3.413

HIGH STAGE ODB	BTUH	kW	EER	EIR
65	36,676	1.98	18.54	0.184
75	35,333	2.23	15.82	0.216
85	33,923	2.53	13.43	0.254
95	32,447	2.85	11.40	0.299
105	30,905	3.18	9.71	0.352
115	29,297	3.53	8.31	0.411

	a	b	c
EER	0.001682	-0.50715	44.39718
Capacity	-0.33084	-88.0434	43796.87
kW	0.000109	0.011625	0.758049

Efficiency varies with both outdoor and indoor conditions. We assumed 40% relative humidity and 75°F to represent the indoor temperature setpoint during the cooling season. We assumed 37% relative humidity and 70°F to represent the indoor temperature setpoint during the heating season.

We used bin temperature data for each weather station to estimate the proportion of energy consumption (estimated through billing analysis) in 1°F temperature bins. We assumed cooling energy consumed was proportional to cooling degree days. This assumption has been validated by numerous residential metering studies and review of end-use metering conducted at a sample of 24 air conditioner

6 U.S. Department of Energy. DOE-2 software is available online at http://www.doe2.com/.

7 Group defined above as type of installation (e.g. air conditioner only, multiple HP systems).

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and 23 heat pump participant HVAC systems, metered from August to December 2013.[8] Figure 2 shows metered data from a participant with a central air conditioner. For this participant and most others, kWh consumption is relatively linear.

Figure 2. Example of Duke HVAC Metering Data (Central Air Conditioner)

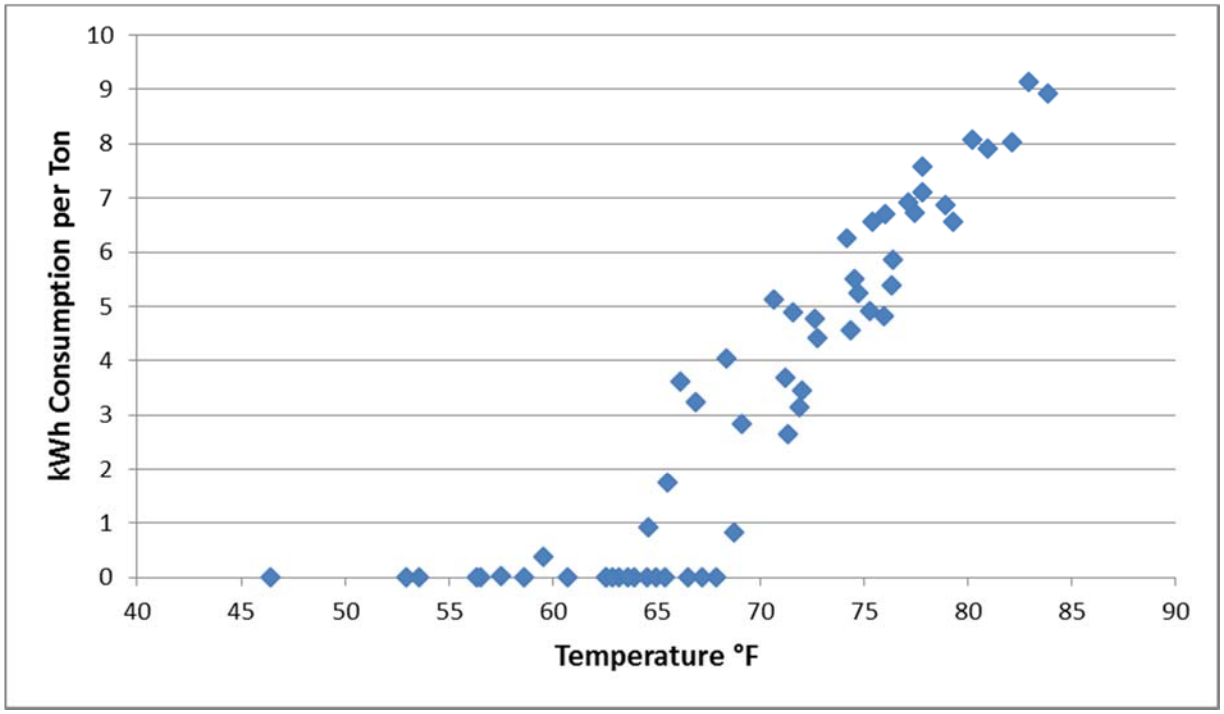

Figure 3 shows similar linearity in heating mode. We would expect some change in the curve to occur near the balance point (~20°F); however, only a small number of hours at or below this temperature were metered so the effect cannot be seen.

[8] The relationship between cooling kWh and CDD is typically linear, but we have seen that linearity may not uphold at extreme temperatures or during very hot years when utility customers experience billing fatigue.

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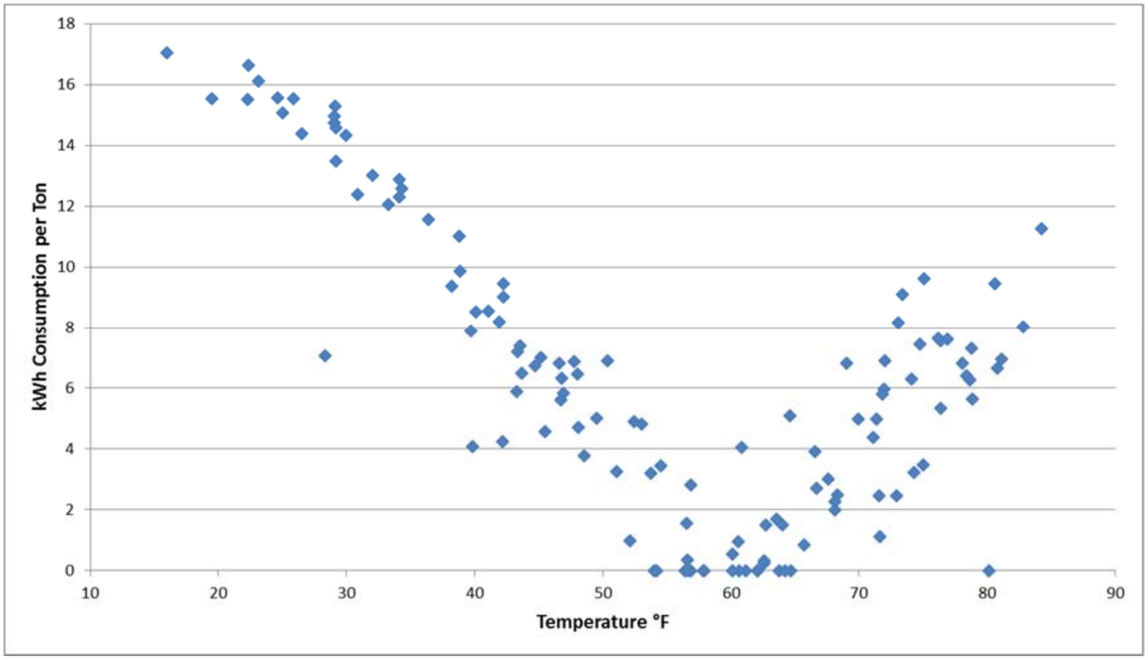
Figure 3. Example of Duke HVAC Metering Data (Central Heat Pump)



For multistage systems with higher proportional savings in the low stage, we estimated the temperature at which the system switched from low stage to high stage. We calculated a coincidence factor at each temperature bin using kWh consumed, estimated capacity (low stage), and estimated power. For temperatures when the coincidence factor was above 85%, we assumed that the system operated in high stage. The assumption that a unit operates in high stage when coincidence factor is above 85% is based on engineering judgment. Most of the systems we evaluated (approximately 94%) had only a single-stage operation, so even a large change to the assumption of 85% had minimal effect on calculated savings.

We estimated heat pump heating savings in 1°F temperature bins in the same way. We assumed a heat pump condenser sizing balance point of 20 degrees for all-electric heat pumps and 30 degrees for heat pumps with gas furnaces.[9] For heat pumps without gas furnaces, we assumed that energy consumption in each temperature bin below the balance point was a combination of backup electric resistance heat and heat pump energy consumption. We assumed a heat pump installed with a gas furnace does not operate below the balance point.

[9] These balance points worked for most groups. We made some changes by a few degrees if the calculated heat pump consumption did not match billing analysis results.

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Results

This section summarizes results based on the evaluation objectives listed above (net savings methods and results are provided in a subsequent chapter). Table 7 shows the results of the monthly billing data HVAC disaggregation analysis.

Table 7. Duke Energy Ohio Billing Analysis Summary

Grouping	Service Accounts	Heat Pumps	Air Conditioners	Heating (kWh)	Cooling (kWh)
Cooling: 1 cooling system Heating: 1 HP no gas furnace	1,668	1,668	-	6,796	2,639
Cooling: 1 cooling system Heating: 1 HP with gas furnace	191	191	-	3,162	2,902
Cooling: 1 cooling system Heating: No electric heating	3,813	0	3,813	-	2,861
Cooling: 2+ cooling systems Heating: 1 HP no gas furnace	7	7	7	3,475	3,606
Cooling: 2+ cooling systems Heating: 1 HP with gas furnace	4	4	5	7,550	3,167
Cooling: 2+ cooling systems Heating: Multiple electric heating systems	46	101	-	8,832	5,725
Cooling: 2+ cooling systems Heating: No electric heating	92	10	181	-	4,903
Grand Total	**5,821**	**1,981**	**4,006**	**6,505**	**2,874**

To provide context, we offer the following observations to help interpret the billing analysis results for each row in Table 7:

- ***Row 1.*** One system only, a heat pump. All heating and cooling energy consumption is used to estimate savings for one heat pump system.
- ***Row 2.*** One system only, a heat pump installed with a gas furnace. Heating energy consumption is much less than in row 1, as expected, because gas furnace provides some heat. This installation type has lower consumption but higher proportional savings because we assume the heat pump does not use any backup electric resistance (ER) heat, which has no savings potential.
- ***Row 3.*** One system only, an air conditioner. Billing analysis found some heating energy consumption but the estimates were unreliable, as expected. We set heating consumption to 0 kWh because we calculated heating savings from the ECM installation using secondary sources.
- ***Row 4.*** There was a low number of services accounts so the results have higher uncertainty. Seven services accounts had 14 total systems (seven air conditioners, seven heat pumps). The per-unit cooling consumption, therefore, is half of the consumption value estimated from the billing analysis.
- ***Row 5.*** See row 4.

- ***Row 6.*** This group includes participants with at least two and up to four heat pumps installed, none with gas furnaces. The heating and cooling consumption values per system, therefore, are lower than the values estimated by billing analysis.
- ***Row 7.*** Similar to row 6; however, the billing analysis found no heating energy consumption for the four heat pump systems (installed at two service accounts). Some possible explanations of this unexpected finding are:
  - Large number of heat pumps installed indicates a large home that may have low occupancy during the heating season.
  - Heat pumps could be installed with gas furnaces.
  - Issue or error in tracking database (systems installed actually air conditioners).

We used aggregate (average) HVAC energy consumption for each group defined in Table 7, rather than individual participant estimated HVAC consumption, to limit the uncertainty of the savings calculation estimates.[10]

Our review of all consumption values found that the billing analysis results were reasonable[11]. Because savings vary with temperature we also reviewed the amount of HVAC energy consumption estimated in each 8,760 hour temperature bin.

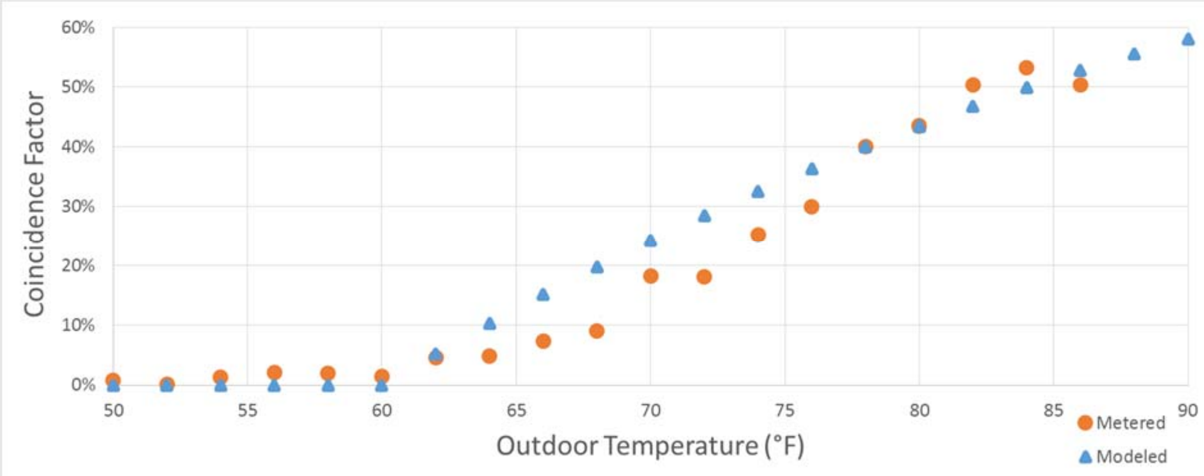
The section "Method – Heating and Cooling Savings Calculations" explains that we assumed cooling energy consumed is proportional to cooling degree days. We used this assumption to calculate the proportion of HVAC energy consumption[12] in each one-degree temperature bin. With known energy consumption (kWh) and known power (kW is a function of outdoor temperature) we estimate the hours of operation in each temperature bin to determine the ratio of hours of operation to total hours per year at each temperature. We compared estimated coincidence factors to end-use metering conducted at a sample of 24 air conditioner and 23 heat pump sites. Figure 4 shows an example of the average estimated coincidence factor of metered participants alongside the modeled coincidence factor.

[10] The analysis is based on energy consumption and physical limits of the HVAC equipment specification data. If the billing analysis overestimates HVAC consumption for one participant and underestimates consumption for another, the analysis has bias that underestimates savings. For example, as HVAC heating energy consumption increases we assume a larger portion of consumption is electric resistance heat, which has no savings. In cooling mode, we might assume more high-stage operation (low savings) than is realistic if HVAC consumption load is high. Conversely, there is no physical limit if HVAC consumption estimate is low. We mitigate bias by averaging HVAC consumption estimates.

[11] Cadmus has performed extensive residential HVAC metering across the country. In total we have performed long-term (full season) metering of more than 1,000 central HVAC systems.

[12] Energy consumption determined through billing analysis

Figure 4. Coincidence Factor Comparison: Estimated from Billing Analysis and End-Use Metering



To estimate heating and cooling consumption in normal temperature bins, we followed the methods described in the section above. Table 8 shows the average monthly and total yearly savings for central air conditioners and heat pumps for each mode of operation (cooling mode for ACs and HPs, heating mode for HPs, savings when the air conditioner furnace fan runs in heating mode, and circulation mode).

Table 8. Monthly Average kWh Savings by System Type and Mode of Operation

	Central Air Conditioner Savings			Central Heat Pump Savings			
	ECM (Heating and Circulation Mode)	Cooling	**Total**	ECM (Circulation Mode)	Heating	Cooling	**Total**
January	40	-	40.2	14.3	122.59	-	136.9
February	37	-	37.3	14.3	108.87	-	123.1
March	30	-	29.8	14.3	73.66	-	87.9
April	19	16	34.5	14.3	22.42	13	49.4
May	16	40	55.9	14.3	8.33	33	55.3
June	15	73	87.5	14.3	3.10	60	76.9
July	14	171	185.6	14.3	-	140	154.8
August	14	127	141.2	14.3	-	104	118.3
September	16	60	75.8	14.3	8.79	49	72.0
October	21	14	35.4	14.3	32.50	12	58.4
November	25	-	25.0	14.3	50.75	-	65.0
December	36	-	35.6	14.3	100.87	-	115.1
Total	**284**	**500**	**783.8**	**171**	**532**	**410.1**	**1113.2**

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Table 9 summarizes the average savings for the program by system type and mode of operation and shows total program gross energy (kWh) savings for central air conditioners and heat pumps evaluated by the Cadmus Team[13].

Table 9. Heating and Cooling Savings for Air Conditioners and Heat Pumps

	Average Savings per System (kWh)	Number of Units	Total Savings (kWh)
Air Conditioner Heat (ECM savings)	112	4,479	3,510,509
Air Conditioner Cool	500		
ECM Circulation Mode	171		
Air Conditioner Total Savings	**784**		
Heat Pump Heat	532	1,904	2,119,541
Heat Pump Cool	410		
ECM Circulation Mode	171		
Heat Pump Total Savings	**1,113**		
Total Savings	**948**	**6,383**	**5,630,050**

Table 10 shows the average demand savings values for central air conditioners and for central heat pumps. The demand savings values were estimated with DSMore using the monthly kWh savings values in Table 8. Demand savings values do not include transmission line losses.

Table 10. Per-Unit Demand Savings Estimated by DSMore Simulation Tool

Measure	Annual Non-Coincident kW	Summer Coincident kW	Winter Coincident kW
Smart $aver Central Air Conditioner	0.517	0.481	0.096
Smart $aver Central Heat Pump	0.427	0.393	0.373

[13] 6.8% of systems were precluded from analysis because billing analysis results were unreliable. The team used the average savings per system to determine savings for all 6,383 participants (see Table 1).

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Net-to-Gross

This section describes the method, analysis, and findings TecMarket Used in 2014[14] for determining the net to gross (NTG) for the Residential Smart $aver HVAC program, using the following formula:

$$NTG = (1 - Freeridership) + Customer\ Spillover$$

We calculated the freeridership and spillover estimates based on responses from participating customer surveys. Duke Energy reviewed the survey and algorithms and provided input, helping to ensure the approach accounted for important program design elements.

Freeridership

TecMarket Works fielded a short survey with HVAC vendor allies to estimate freeridership. Participant surveys are not used in this analysis because many customers did not know that their purchase price was reduced via the Duke Energy program because the incentive was applied through participating dealers.

Method

TecMarket Works established freeridership using a primary gateway question that could be directed, depending on the response, to a follow-up question about the influence of the Smart $aver rebate. The gateway question asked vendors what their customer's behavior would have been if the Smart $aver rebate had not been available.

Gateway Question (A): ***Of the Energy Efficient equipment that was rebated through the program, what percentage of those customers do you think would have still gone with an energy efficient model if the Duke Energy rebate were not available?***

To determine this gateway value, and to check consistency, we asked vendors to rate the level of influence the Smart $aver rebate may have had on choices made by the customers.

Follow-up Question (B): ***Using a scale of 1 to 10, where 1 means not at all influential and 10 means very influential, how important would you say the rebate is to your customers' decision when considering all the various factors that a customer typically contemplates prior to making a purchase from your company?***

We turned influence ratings on a 10-point scale into percentages for use in the NTG formula, based on the conversion values shown in Table 11.

[14] This report section was written in 2014 by TecMarket Works before TecMarket Works was acquired by Cadmus, and reviewed by Cadmus in 2015.

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Table 11. Percentages Used for Net Calculations Based on Vendor Influence Ratings

Influence Rating Score	Equivalent Percentage Value
10	100%
9	90%
8	80%
7	70%
6	60%
5	40%
4	30%
3	20%
2	10%
1	0%

Table 12 shows the mean and median responses to the gateway (column A) and follow-up (column B) questions; for each question, 60 out of 69 surveyed trade allies gave responses that could be scored for the first question. The follow-up question has been converted from 10-point ratings into percentage scores (as shown in Table 11). 64 out of 69 surveyed trade allies gave responses that could be scored for the follow-up question.

Table 12. Vendor Responses Used to Estimate Freeridership

	Gateway Question (A) (N=60)	Follow-Up Question (B) (N=64)
Mean percentage	82.1%	58.0%
Median percentage	90.0%	70.0%
Minimum	0%	0%
Maximum	100%	100%

Results

The formula for estimating freeridership is shown below, where A and B represent responses to the two survey questions and factor represents a coefficient that accounts for a level of uncertainty around the establishment of a NTG ratio.

Freeridership = A * (1 – (B * Factor))

Freeridership is calculated separately for every vendor who answered both questions,[15] and the average of these individual scores provides the overall freeridership estimate for the program. The value of factor is set to 1.0, assuming vendors are not overestimating or underestimating the effect of the program; to less than 1.0, depending on how much vendors overestimate the program's effect; and to

[15] Each of the freeridership questions was answered individually by 60 out of 69 surveyed trade allies in Ohio; however, only 58 out of 69 survey respondents answered both questions. Since both questions are required to compute a freeridership score, the twelve respondents who did not answer both questions are withheld from calculations and the valid N for freeridership computations is 58 respondents.

greater than 1.0 if vendors are underestimating the program's effect. In this case, however, we do not know the true value of the factor, so we calculated overall freeridership rates based on five different levels of factor influence (150%, 125%, 100%, 75% and 50%), which we then averaged to estimate freeridership for the residential Smart $aver HVAC program. Using this approach, we estimated a 37.7% NTG factor to account for freeridership, as shown in Table 13.

Table 13. Freeridership Estimates Based on Five Scenarios

Factor Value	Calculated Freeridership (N=58)
150%	21.6%
125%	25.8%
100%	35.2%
75%	47.0%
50%	58.8%
Average of 5 scenarios above	**37.7%**

Spillover

The Residential Smart $aver HVAC program involved large single-unit residential installations. For this reason, individual participant spillover for HVAC systems is assumed to be at or near zero. Although some customers installed more than one unit, in most cases these installations received a rebate from the program and were included in the program's energy savings calculations.

Calculated Net-To-Gross

The NTG ratio for this program is 0.623 and includes a downward adjustment in gross savings equal to the freeridership percentage, 37.7% of the gross savings. There is no adjustment for spillover savings for this program. Table 14 shows the gross and net heating and cooling savings for air conditioners and heat pumps evaluated by the Team. Table 15 shows the gross and net summer coincident demand savings for air conditioners and heat pumps evaluated by the Team.

CADMUS

Table 14. Duke Energy Ohio Net Heating and Cooling Savings for Air Conditioners and Heat Pumps

Program Component	Average Gross Savings per System (kWh)	Units	Total Gross Savings (kWh)	Total Net Savings (kWh)
Air Conditioner Heat (ECM savings)	112	4,479	3,510,509	2,187,047
Air Conditioner Cool	500			
ECM Circulation Mode	171			
Air Conditioner Total	**784**			
Heat Pump Heat	532	1,904	2,119,541	1,320,474
Heat Pump Cool	410			
ECM Circulation Mode	171			
Heat Pump Total	**1,113**			
Total Savings		**6,383**	**5,630,050**	**3,507,521**

Table 15. Duke Energy Ohio Net Heating and Cooling Summer Coincident Demand Savings for Air Conditioners and Heat Pumps

Measure	Average Gross Savings per System (kW)	Units	Total Gross Savings (kW)	Total Net Savings (kW)
Smart $aver Central Air Conditioner	0.481	4,479	2,152	1,341
Smart $aver Central Heat Pump	0.393	1,904	748	466
Total Savings		**6,383**	**2,901**	**1,807**

APPENDIX K-

Smart $aver Residential –
Specialty Bulbs Evaluation

Final Report

Process and Impact Evaluation of the Residential Energy Efficient Appliance and Devices: Lighting - Specialty Bulbs Program in Ohio

Prepared for
Duke Energy

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May 13, 2015

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Executive Summary

Duke Energy's Specialty Bulb Program sells discounted specialty CFLs and LEDs to qualifying residential customers in Ohio via an online store. These include three-way bulbs, dimmable bulbs, outdoor bulbs, reflectors (recessed), candelabras[1], capsules (A-Line) and globes in both CFL and LED varieties. Adoption is encouraged through discount pricing, the convenience of online ordering and home delivery. The online store also has lighting-associated educational elements.

Duke Energy effectively combines low cost marketing vehicles such as email, website promotions, and direct mail with sophisticated targeting techniques to ensure high conversion rates at low acquisition costs. Participants are very satisfied with their experience purchasing light bulbs at the Savings Store, giving an average overall program satisfaction rating of 9.18 on a ten-point scale where "10" is most satisfied. When asked to rate their satisfaction on a five-point Likert scale, 77.0% are "very satisfied" with the program and another 19.4% are "somewhat satisfied."

It is our finding based on this evaluation that program participants largely represent households who have already adopted energy efficient lighting technology for standard sockets in their home, and this program has allowed them to extend that decision to specialty bulbs that would not have been replaced with efficient bulbs without the program. Although program participants had an average of 12.6 efficient bulbs apiece installed in their homes before they purchased Savings Store specialty bulbs, most installations of the efficient bulbs provided by the Duke Energy store replaced inefficient bulbs. The key question for these customers when making light bulb purchase decisions is not "should I get efficient bulbs?", but "where can I get the efficient bulbs that will work in my fixtures at an acceptable price?" The participant survey shows that the over-riding reason customers bought energy efficient specialty light bulbs from the Savings Store is the availability of specialty bulbs at reduced prices offered by the store. The cost savings associated with less energy use is a distant secondary concern for these customers.

Reinforcing this hypothesis, participants overwhelmingly express that they would like to install efficient bulbs in their specialty sockets when their program bulbs burn out (at least 92% of installations), even though for 81% of these surveyed installations the efficient program bulb had replaced a previously-installed incandescent or halogen bulb. That is, they wanted to use efficient bulbs, but had not been able to make that switch in their specialty bulb fixtures without the availability of the program. Thus, participation in the Specialty Bulbs program seems to distill down to the customer being able to find the "right bulbs" for special non-standard uses and functions at the "right price." The Duke Energy store enabled these customers to make the switch in their specialty bulb sockets.

[1] Also known as decorative lamps, candles, flame tips, blunt tips, and torpedoes. Manufacturers are not consistent with how they label and group products. For this report, these bulbs are all referred to as candelabras for consistency.

These findings support our conclusion that this program is performing as intended: by delivering efficient light bulbs to customers who will use them, but who largely would not have done so in the absence of the program.

Key Findings and Recommendations

This section presents the key findings and recommendations identified through this evaluation.

Significant Process Evaluation Findings

Significant Process Evaluation Findings from the Management Section can be found in the section titled *Key Findings* on page 57.

Significant Process Evaluation Findings from the Participant Surveys can be found in the section titled *Key Findings* on page 142.

Significant Process Evaluation Findings from the Non-Participant Surveys can be found in the section titled *Key Findings* on page 190.

Significant Impact Evaluation Findings

- From the logger study, the average daily hours of use across all bulb and room types and adjusted for day length is estimated to be 2.53 hours/day.
  - See Table 118 on page 223.
- The average wattage of a bulb replaced by a program bulb is 50.05 watts.
  - See Table 120 on page 224.
- From the logger study, the coincidence factor for demand is estimated to be 9.14%.
  - See Figure 53 on page 221.
- The power fractions for estimating the average percent of maximum power used by dimmable and 3-way bulbs are 54.8% and 75.1% respectively.
  - See Table 117 on page 221.
- The average gross savings per bulb shipped are 25.4 kWh; the average coincident peak kW savings per bulb shipped are 0.0028 kW.
  - See Table 135 on page 215.
- Effective useful life of program savings is estimated to be eight years.
  - See *Effective Useful Life* on page 226.
- Freeridership is estimated at 23.1% and spillover is estimated at 1.1%, for a NTGR of 77.8%.
  - See *Net to Gross Ratio Calculation* on page 213.

Table 1 presents the gross unit kWh and kW savings per bulb associated with the Specialty Bulbs program in Ohio.

Table 1. Summary of Program Savings by Measure

Measure	Participation Count (Bulbs)	Ex Post (Adjusted) Per unit kWh impact	Ex Post (Adjusted) Per unit CP kW impact	Gross Ex Post (Adjusted) kWh Savings	Gross Ex Post (Adjusted) CP kW Savings
CFL Indoor Reflector (Recessed)	26,318	25.0	0.0030	656,739	77.7
CFL Dimmable Reflector (Recessed Dimmable)	3,010	41.9	0.0049	126,128	14.9
CFL Outdoor Reflector (Recessed Outdoor)	6,461	64.6	0.0039	417,099	25.4
LED Reflector (Recessed LED)	6,753	43.4	0.0039	293,280	26.6
CFL Globe	20,487	14.4	0.0022	295,684	44.9
CFL Candelabra	18,257	12.1	0.0014	220,687	25.9
CFL Three-Way Spiral	6,707	34.2	0.0040	229,086	26.8
CFL Dimmable Spiral	4,815	38.0	0.0045	182,830	21.7
CFL Capsule (A Line)	14,820	22.1	0.0026	327,530	38.9
LED Capsule (A Line LED)	13,918	24.5	0.0029	340,877	40.1

Table 2. Summary of Gross and Net Program Savings by Measure

Measure	Participation Count (Bulbs)	Gross Ex Post kWh Savings	Gross Ex Post NCP kW Savings	Gross Ex Post CP kW Savings	Net Ex Post kWh Savings	Net Ex Post NCP kW Savings	Net Ex Post CP kW Savings
CFL Indoor Reflector (Recessed)	26,318	656,739	850	77.7	510,646	661	60.4
CFL Dimmable Reflector (Recessed Dimmable)	3,010	126,128	163	14.9	98,071	127	11.6
CFL Outdoor Reflector (Recessed Outdoor)	6,461	417,099	278	25.4	324,314	216	19.7
LED Reflector (Recessed LED)	6,753	293,280	291	26.6	228,039	226	20.7
CFL Globe	20,487	295,684	491	44.9	229,908	382	34.9
CFL Candelabra	18,257	220,687	284	25.9	171,594	221	20.2
CFL Three-Way Spiral	6,707	229,086	293	26.8	178,125	228	20.9
CFL Dimmable Spiral	4,815	182,830	238	21.7	142,159	185	16.9
CFL Capsule (A Line)	14,820	327,530	426	38.9	254,670	331	30.3
LED Capsule (A Line LED)	13,918	340,877	439	40.1	265,048	341	31.2

Process Evaluation Recommendations

From the Management Section

Below is a brief list of top level recommendations for program improvement. For the complete set of recommendations see section titled *Recommendations* beginning on page 59.

- **Consider upgrading the energy savings calculator on the Duke Energy public website** at http://www.duke-energy.com/residential-savings-store/ so that the public version of the calculator features the same interactive functionality as the version installed on the Savings Store website. If this is feasible with Duke Energy website technology and policy, making this upgrade will enable more customers to see how much they can save with specialty bulbs prior to requiring them to log on to the Savings Store itself.

- **Test and improve the Savings Store's search features.** Because web search functionality yielded inconsistent results or failed to find items using key words commonly found on the website, the Savings Store's search features should be tested and improved to accurately reflect store inventories using the Savings Store's names for bulb types and application types, as well as for entries with singular and plural spelling and associated terms such as lighting, bulb, and other common words and phrases.
- **Test the suggested website usability improvements.** TecMarket Works recommends that, wherever feasible with EFI's online website platform, the various website usability improvements suggested on page 59 and throughout the management section be implemented and tested using what is known as split testing; that is a system whereby one portion of website visitors are presented one version of a web page, while another portion are presented an alternative version of the same page. Such a system will enable Duke Energy to determine whether more customers take action with or without the suggested changes. The Content Experiment feature of Google Analytics can be used for this purpose.
- **Consider curtailing customer ability to ship purchases to addresses located outside of Duke Energy's service territory**.
- **Consider expanding program offerings** to include additional specialty bulb types, as well as smart devices for home automation, and other efficiency measures.

From the Participant Surveys

- **Consider routinely monitoring competitors' pricing on bulbs and shipping.** Most customers are aware of the price of energy-efficient light bulbs at local retailers and through other online stores, and many of them are directly comparing Savings Store prices to the competition. Price is perhaps the most important driver of Savings Store purchases. This does not mean having the lowest price for every bulb (which may increase freeridership), however many customers will only pay a small premium for the convenience of online ordering if they can find equivalent bulbs available at a lower price elsewhere.
    - Shipping costs should also be noted when monitoring competitors' pricing. Most Savings Store customers are experienced online shoppers and have had their expectations for what shipping should cost set from their experience with other retailers (such as offering free shipping on orders over a certain amount).
    - Price comparisons can be an effective marketing tool. Duke Energy should consider including favorable comparisons to competitors' pricing in advertising for the Savings Store. These comparisons could also include shipping price and policy comparisons.
- **Consider the effects of multi-pack pricing.** Multi-packs of light bulbs that offer increased savings on the per-bulb price drive a significant number of customers to purchase additional bulbs so that they can get "the best deal"; this often results in the purchase of more bulbs than will be immediately installed, with the extra bulbs stored for future use. Duke Energy should consider the positive effects of multi-pack pricing (to drive additional sales), and also the effect this may have on program impacts (distributing bulbs that will not be installed immediately will dilute the savings per bulb, a corollary effect of selling additional "spare bulbs" that customers don't need immediately).

- **Explain the Savings Store limits are on price, not on quantity of bulbs**. Most customers who are aware of the limit on incented light bulbs did not realize that they could purchase more bulbs of the same type beyond these limits, albeit at a higher price without the incentive and from a different section of the site. Duke Energy should also consider streamlining the order process and/or the display of bulbs on the site in a way that doesn't involve customers having to go to a different page to order additional non-incented bulbs.
- **More prominently display information on bulb physical dimensions and threading.** One of the more common issues reported by customers regarding the bulb information presented at the Savings Store, and related requests for more information, involves the physical dimensions of bulbs and their socket threading; this is because some customers are seeking energy-efficient bulbs for unusual and difficult-to-fit sockets in their home. This information is included on the "product specifications" tab for each bulb, but some customers who are seeking this information are not finding it; perhaps a more prominent link labeled "product dimensions" or "socket size/type" could help. In addition to including this information for all bulbs sold at the Savings Store, Duke Energy should also consider the variety of bulb dimensions and threading available when deciding on additions to or subtractions from the Savings Store's offerings.
- **Continue efforts to market the Savings Store to customers who have already shopped at the Store.** Customers who purchased bulbs from the Savings Store still have a significant number of incandescent specialty bulbs in their homes, and a large majority of them say they intend to shop the Store again in the future.

From the Non-Participant Surveys

Duke Energy's non-participant customers made the following requests for program and website improvement. TecMarket Works concurs with these suggestions.

- Expand inventory to include brighter LEDs to enable displacement of higher wattage incandescent and halogen bulbs.
- Create an interactive way to compare CFLs and LEDs to incandescent equivalents, including wattage, brightness, color, price, energy savings, bulb life, etc.
- Enable Store visitors to search and sort by wattage equivalents. Such a feature would be helpful to those potential bulb buyers who are more familiar with buying bulbs based upon wattage numbers as they have done in years past.
- Increase customer confidence in purchases by expanding the product descriptions to more clearly denote bulb shapes and bases and to better explain which bulbs are best used for which applications.
- Review website language and simplify potentially confusing technical language to more layman's terms.
- Provide more prominent explanations regarding bulb warranties.
- Consider an option for customers to make payments via PayPal.
- Respondents offered a number of suggestions for expanding the Store's inventory of energy efficient items, including: a greater variety of LEDs and other kinds of CFL bulbs for currently unaddressed specialty applications such as bright/higher wattage equivalents and more outdoor and landscape lighting. They also suggested non-lighting energy

efficiency devices including "smart home" devices, weatherization items, and other devices to control lighting, such as timers and motion detectors.

Introduction and Purpose of Study

Summary Overview

This document presents the evaluation report for Duke Energy's Residential Specialty Bulb Program as it was administered in Ohio. The evaluation was conducted by TecMarket Works, Matthew Joyce, and BuildingMetrics, Inc.

Summary of the Evaluation

The findings presented in this report were calculated using survey data from program participants and non-participants as shown in Table 3.

Table 3. Evaluation Date Ranges

Evaluation Component	Sample Pull: Start Date of Participation	Sample Pull: End Date of EMV Sample	Dates of Analysis
Participant Surveys	May 17, 2013[2]	June 23, 2014	Surveys conducted from July 15, 2014 through October 5, 2014
Non-participant Surveys	May 1, 2013[3]	June 23, 2014	Surveys conducted from October 6, 2014 through November 20, 2014
Management Interviews	February 27, 2014	Dec 16, 2014	Interviews conducted and analyzed from February 27, 2014 to Dec 16, 2014
Engineering Estimates	May 17, 2013	June 23, 2014	October 2014 through January 2015
Lighting Logger Study	August 14, 2014	November 24, 2014	October 2014 through January 2015

Surveyed participants were asked how many program-provided CFLs and LEDs are currently installed in light fixtures. Additional, more specific information was collected for at least one installation from each specialty bulb category purchased (indoor reflector, outdoor reflector, globe, candelabra, three-way spiral, dimmable spiral, efficient capsule, and standard spiral bulbs) or a minimum of three installations if a customer purchased fewer than three types of specialty bulb (customers with fewer than three installations overall were asked about all of their program bulb installations). The information collected includes the location of the installed program bulbs, the type and wattage of the bulbs that they replaced, and the average hours per day that they are in use. The decision to limit the number of installations about which to collect detailed information to a maximum of three total or one per bulb category (whichever is greater) was

[2] These are the start and end purchase dates from EFI store data among the population of participants. Actual range of surveyed purchase dates is May 18 to June 23. Start dates are the earliest records of purchases after program launch.

[3] Start date for non-participants is the earliest "date established" in EFI customer data (i.e., date when someone first logged on to the Store website using their Duke Energy account). We also surveyed non-participants who were aware of the program but did not visit the Store; while these customers do not have specific "established" dates, they all received marketing messages at least once between June 15, 2013 and May 19, 2014.

made in the interest of time and evaluation cost, as the surveys are lengthy. The information gathered about program bulb installations covered a majority of the program bulbs installed by surveyed participants and provides sufficiently robust data about all of the incented specialty bulb categories. Data was also collected about non-program bulbs installed in specialty sockets and specialty bulbs in storage. Results of this survey of 192 customers in Ohio who purchased program bulbs during the evaluation period are presented in the *Participant Surveys* section of this report.

To assess barriers to, and interest in, program participation, TecMarket Works conducted phone surveys with a random sample of 80 non-participants, including 50 non-participants who visited the Savings Store website but did not make a purchase and 30 non-participants who received marketing materials from Duke Energy but did not visit the website or make a purchase. Results of the non-participant survey are presented in the *Non-Participant Surveys* section of this report, and some key differences and similarities between survey groups are highlighted in the *Participant and Non-Participant Survey Comparisons* section.

An impact analysis was performed for all specialty bulbs by room type and can be seen in Table 121. However, it should be noted that individual room type samples are of insignificant size to achieve statistical relevance and are presented as anecdotal evidence. The impacts are based on an engineering analysis of the impacts associated with the self-reported installs identified through the participant surveys. The hours of use were determined through a logger study and are adjusted to reflect yearly averages using the daylength algorithm developed via a larger logger study conducted in California that documented the monthly change in lighting usage due to seasonal variances in day length. This approach is explained in detail in the *Daylength Adjustment* section.

This report is structured to provide program impact estimations per bulb purchased from the online store as well as overall program savings based on an extrapolation of these results to the full participant population, which includes participants who purchased bulbs from May 17, 2013 (the earliest recorded purchase after program launch) through June 23, 2014 (n=7,719 customers).

Description of Program

Duke Energy's Specialty Bulb Program sells discounted CFLs and LEDs to qualifying residential customers in Ohio via an online store. The program website, called the Duke Energy Savings Store, was launched in April of 2013. The Specialty Bulb program is designed to extend the market penetration of energy efficient lighting beyond the replacement of conventional incandescent bulbs to specialty applications including: dimmables, three-ways, reflectors (recessed), capsules (A Line), candelabras, and globes. Adoption is encouraged through incentive pricing, the convenience of online ordering and home delivery, and educational elements that break down barriers by explaining the differences between buying lighting based upon lumens instead of watts, and by helping customers to choose the most appropriate bulbs for different applications. The educational aspects of the Savings Store are also intended to encourage spillover demand for energy efficient specialty bulbs that are sold through conventional retail channels.

The Duke Energy Savings Store website can only be accessed by verified Duke Energy customers whose bulb purchases are individually tracked so that personal incentive limits can be enforced. Customers who desire to buy more bulbs than allowed by the program's incentive limits can do so, but the additional bulbs must be purchased without Duke Energy discounts.

Program Eligibility

To be eligible for the program, participants must be customers with active residential electric accounts in Duke Energy's Ohio service territory. Both property owners and renters are eligible.

Program Participation

Program participation is primarily tracked based upon customer purchases of specialty bulbs. According to Duke Energy's tracking of unique account numbers associated with bulb purchases, 3,359 Ohio customers purchased a total of 50,695 specialty bulbs between program inception on April 26, 2013 and December 31, 2013 (Table 4). An additional 8,524 customers purchased 132,974 bulbs between January 1, 2014 and November 14, 2014. Combined program participation shows a total of 11,616 unique Ohio customers who purchased at total of 183,669 specialty bulbs over the 19 month period.

Table 4. Program Participation in Ohio

Time Period	Number of Unique Purchasing Customers	Number of Specialty Bulbs Purchased
Apr 26 to Dec 31, 2013	3,359	50,695
Jan 1 to Nov 15, 2014	8,524	132,974
Total	**11,616**[4]	**183,669**

Note that for the purposes of this evaluation, we present the above mentioned participation numbers as the most recently available data at the time of drafting this report. However, for the purposes of participant survey data collection and analysis, as well as for impact calculations, we

[4] The total number of customers shown here is 11,616 and not 11,883 because while each year's tally counts unique customers, some customers made purchases in both years. Those duplicates have been removed from the total shown.

necessarily used the data that was available through the start of those efforts which began on June 30, 2014. As a result, this shorter time period yields the following numbers as shown in Table 5.

Table 5. Program Participation through June 30, 2014

Time Period	Number of Unique Purchasing Customers	Number of Specialty Bulbs Purchased
Apr 26 to Dec 31, 2013	3,359	50,695
Jan 1 to June 30, 2014	4,484	68,480
Total	**7,719**[5]	119,175

[5] The total number of customers shown here is 7,719 and not 7,843 because while each year's tally counts unique customers, some customers made purchases in both years. Those duplicates have been removed from the total shown.

Methodology

Overview of the Evaluation Approach

This evaluation had four components: management interviews, participant surveys, non-participant surveys, and an impact analysis based on engineering algorithms and data collected from loggers in a sample of participants' homes.

Study Methodology

Management Interviews

TecMarket Works conducted interviews with Duke Energy's product manager, marketing communications manager, and senior market research analyst. We also spoke with four representatives from Energy Federation Incorporated (EFI), including the vice president of sales, vice president of strategic development, program manager, and call center manager.

The interviews considered program design, execution, operations, staff and customer interactions, data tracking and transfer methods, and personal experiences in order to identify any implementation issues and discuss opportunities for improvement. Interview guides were used to ensure a full and complete battery of questions were addressed to the interview subjects. Sample guides are shown in *Appendix B: Management Interview Instrument* and *Appendix C: Vendor Interview Instrument.*

Participant Surveys

TecMarket Works fielded a phone survey with randomly selected participants in order to measure satisfaction and to identify areas for program improvement. One hundred and ninety-two (192) interviews were completed with customers in Ohio who purchased bulbs from the Savings Store between April 26, 2013 and June 30, 2014 according to program records.

Non-Participant Surveys

TecMarket Works fielded a phone survey with randomly selected non-participants in order to identify barriers to program participation. Eighty (80) interviews were completed in Ohio with customers who received marketing materials and/or who visited the Savings Store website between May 1, 2013 and June 22, 2014, but who had not made any purchases as of that time. Of these 80 survey respondents, 50 visited the Savings Store website but did not make a purchase (visiting non-participants), while the other 30 received marketing materials about the program and are aware of the program's existence, but had not visited the website at the time of the survey (non-visiting non-participants).

Impact Analysis

Engineering algorithms taken from the Draft Ohio Technical Resource Manual (TRM) were used to estimate savings. Data inputs to the algorithm were determined through the logger study (hours of use, coincidence factor, power fractions), the participant survey (baseline wattage), program tracking data (energy efficient wattage), and an appliance saturation study (HVAC interaction factors). These unit energy savings values were applied to customers in the engineering analysis sample.

Data collection methods, sample sizes, and sampling methodology

Management Interviews

Interviews and follow up exchanges were conducted by phone with seven staff members from Duke Energy and EFI. Conversations ranged from half an hour to two and half hours. The interview instruments can be seen in *Appendix B: Management Interview Instrument* and *Appendix C: Vendor Interview Instrument*.

Participant Surveys

Duke Energy provided TecMarket Works with a list of 7,350 records of program participants in Ohio. After removing records with missing contact information, duplicate records, "do not contact" numbers and customers who have recently been surveyed about other programs, the sample list consisted of 5,713 contactable customers. The survey was conducted by telephone by TecMarket Works staff from the list of 5,713 participant customers, and 192 respondents completed the survey. The survey instrument can be found in *Appendix D: Participant Survey Instrument.*

Non-Participant Surveys

Duke Energy provided TecMarket Works with a list of 86,599 customer records from Ohio. After removing records with missing contact information, duplicate records, "do not contact" numbers and customers who have recently been surveyed about other programs, as well as removing customers who did not receive marketing communications about the program during the evaluation period and customers who have made purchases from the Savings Store, the sample list consisted of 70,991 contactable non-participants. The contact list was further subdivided into 8,302 customers who visited the Savings Store site without making a purchase and 62,689 customers who received marketing materials but who did not visit the Savings Store site. The survey was conducted by telephone by TecMarket Works staff from this list of non-participant customers and 80 respondents completed the survey. The survey instrument can be found in *Appendix E: Non-Participant Survey Instrument*.

Lighting Loggers

The impact analysis uses a combination of the participant survey (n= 192 respondents) and the lighting logger study (n= 192 loggers) to estimate program savings. Logger study participants were recruited as part of the participant survey.

Number of completes and sample disposition for each data collection effort

Management Interviews

Seven out of seven management representatives were contacted in 2014 for a 100% response rate.

Participant Surveys

From the sample list of 5,713 customers, 2,556 participants in Ohio were called between July 15, 2014 and October 5, 2014, and a total of 192 usable telephone surveys were completed yielding a response rate of 7.5% (192 out of 2,556).

Non-Participant Surveys

From the sample list of 70,991 customers, 1,356 non-participants in Ohio were called between October 6, 2014 and November 20, 2014, and a total of 80 usable telephone surveys were completed, yielding a response rate of 5.9% (80 out of 1,356).

Lighting Loggers

From the 192 participant survey respondents, 79 were recruited to participate in the logger study, a recruitment rate of 41.1%. Into these 79 households, 211 loggers were installed. Nineteen loggers were thrown out of the sample for bad or corrupted data, leaving a total of 192 loggers used to estimate impacts.

Table 6. Summary of Data Collection Efforts

Data Collection Effort	Size of Population in Sample	# of Successful Contacts	Sample Rate
Management Interviews	7	7	100%
Participant Surveys	5,713	192	3.4%
Non-Participant Surveys	70,991	80	0.1%
Lighting Loggers	192	79	41.1%

Expected and achieved precision

Participant Surveys

The survey sample methodology had an expected precision of 90% +/- 9.1% and an achieved precision of 90% +/- 5.8%.

Non-Participant Surveys

The survey sample methodology had an expected precision of 90% +/- 9.2% and an achieved precision of 90% +/- 9.2%.

Lighting Loggers

The expected precision of the average daily hours of use and coincidence factor was +/- 10% at 90% confidence. The achieved precision was +/-16.2% at 90% confidence for the hours of use and +/-20.8% at 90% confidence for the coincidence factor. This is based on the mean overall values and the standard deviation of the individual estimates compared to the mean. Achieved precision is less than planned as a result of the much wider than expected range of bulb hours of usage observed in the metering study. This is attributable to the numerous different bulb types included in the study, each with a different usage pattern, resulting in a higher than expected coefficient of variation.

Description of baseline assumptions, methods and data sources

Baseline assumptions were determined through a combination of phone surveys and onsite surveys with customers providing self-reported values of baseline lamp watts and operating hours. Lighting loggers were used to measure actual lamp operating hours. Robust data concerning HVAC system fuel and type was available from Duke Energy's Home Profile Database (appliance saturation survey type data) in Ohio. Interaction factors derived from this data were used in favor of deemed values from secondary sources as they recognize only Duke Energy customers and, therefore, more accurately represent the participant population. A breakdown of these factors by system and fuel type can be seen in *Appendix K: Impact Algorithms*.

Description of measures and selection of methods by measure(s) or market(s)

A mixture of CFL and LED bulbs of different types were offered through the online store:

- CFL - Indoor Reflector (Recessed)
- CFL - Outdoor Reflector (Recessed Outdoor)
- CFL - Dimmable Reflector (Recessed Dimmable)
- CFL - Globe
- CFL - Candelabra
- CFL - Three-way spiral
- CFL - Dimmable Spiral
- CFL - Capsule (A Line)
- LED - Indoor Reflector (Recessed LED)
- LED - Capsule (A Line LED)

The Draft Ohio TRM's impact algorithms were enhanced with primary data, specifically appropriate waste heat factors were used that are indicative of climate characteristics similar to those observed in Ohio and used to calculate energy savings along with the results of the participant survey and lighting logger study. All customers are in the residential market.

Threats to validity, sources of bias and how those were addressed

Bulb installations and baseline wattage were self-reported by the surveyed participants. There is a potential for social desirability bias[6] but the customer has no vested interest in their reported measure adoptions, therefore this bias is expected to be minimal. There is a potential for bias in the engineering algorithms, which was minimized through the use the lighting logger study to determine actual average daily hours of use values and of building energy simulation models, which are considered to be state of the art for building shell and HVAC system analysis.

[6] Social desirability bias occurs when a respondent gives a false answer due to perceived social pressure to "do the right thing."

Management Interviews

Program History and Development

The Specialty Bulb program is a recent addition to Duke Energy's Energy Efficiency Portfolio. The program was officially opened to qualifying residential customers in Ohio on April 26, 2013, but the concept was conceived two years prior in 2011. The impetus for the program arose from the success of Duke Energy's Residential Smart $aver Energy Efficiency Products Program, which bypasses the need for customers to visit brick and mortar stores by directly mailing up to 15 free CFLs to customer homes. As increasing numbers of customers ordered these standard 13 and 18 watt CFLs, Duke Energy recognized the opportunity to encourage their customers to adopt energy efficient specialty bulbs as well.

The procedures and platforms developed for the free CFL program—including marketing methods, account verification procedures, ordering tools, and a database for tracking how many free CFLs each customer received—served as foundational elements for building the Specialty Bulb program. However, because Duke Energy did not intend to fully subsidize the costs of the specialty bulbs, significant upgrades and entirely new systems were required; most notably an e-commerce platform for selling and distributing discounted specialty bulbs to qualifying customers.

Duke Energy requested proposals from third party vendors and in the spring of 2012 the utility selected Energy Federation Incorporated (EFI) of Southborough, Massachusetts. EFI is a non-profit organization that specializes in helping utilities to promote and deliver energy efficient lighting and other items via utility-branded e-commerce solutions.

Program Goals and Performance

The primary goal of the program is to increase household energy savings by advancing customer adoption of energy efficient lighting from the replacement of incandescent bulbs with standard spiral CFLs to also include specialty CFLs and LEDs, such as three-way bulbs, dimmable bulbs, outdoor bulbs, reflectors (recessed), candelabras, capsules (A-Line), and globes. The program achieves its goals through customer education and the use of financial incentives that reduce the final purchase price of the bulbs for the customer.

To set budgets and measure program performance, Duke Energy established overall goals for specialty bulb sales on the website, as well as for individual bulb types. During 2013, Duke Energy expected to sell 25,318 specialty bulbs. The program actually sold 50,695 bulbs, which represents 200% of the 2013 goal. For 2014 the goal was set for 68,561 bulbs. The program had sold 132,974 through November 15, 2014. This represents 194% of the 2014 goal with seven weeks remaining in the year. Table 7 presents bulb purchases sorted by bulb type and year. It shows that indoor CFL reflectors and LED A-Line capsules were the most popular bulb types, followed by CFL globes and candelabras.

Table 7. Program Goals vs. Actual Performance

Bulb Type	Number of Incented Bulb Purchases[7]								
	April 26 – Dec 31, 2013			Jan 1 – Nov 15, 2014			Combined		
	Goal	Actual	% Goal	Goal	Actual	% Goal	Goal	Actual	% Goal
CFL Three-Way Spiral	952	3,250	341%	2,571	5,486	213%	3,523	8,736	248%
CFL Capsule (A Line)	1,898	7,417	391%	5,143	12,879	250%	7,041	20,296	288%
CFL Dimmable Capsule (A Line)	1,265	1,941	153%	3,429	4,622	135%	4,694	6,563	140%
CFL Candelabra	3,797	7,555	199%	10,282	18,024	175%	14,079	25,579	182%
CFL Globe	5,063	9,463	187%	13,711	18,314	134%	18,774	27,777	148%
CFL Indoor Reflector (Recessed)	7,746	13,937	180%	20,983	21,863	104%	28,729	35,800	125%
CFL Dimmable Reflector (Recessed Dimmable)	861	1,446	168%	2,331	2,471	106%	3,192	3,917	123%
LED Reflector (Recessed LED)	253	274	108%	686	16,338	2383%	939	16,612	1770%
CFL Outdoor Reflector (Recessed Outdoor)	2,531	2,784	110%	6,855	6,541	95%	9,386	9,325	99%
LED Capsule (A Line LED)	952	2,628	276%	2,571	26,436	1028%	3,523	29,064	825%
Total	**25,318**	**50,695**	**200%**	**68,561**	**132,974**	**194%**	**93,879**	**183,669**	**196%**

EFI's online reporting tools also provided the following customer data regarding customer orders. Table 8 shows that between program launch on April 26, 2013 and November 15, 2014, the Duke Energy Savings Store for Ohio served 11,616 unique customers who placed a combined total of 12,854 orders for 183,669 bulbs. This equates to an average of 15.8 bulbs per customer, 14.3 bulbs per order, and an average of 22.6 orders per day. When year to year comparisons are made, the program's growth appears quite robust with a 254% increase in unique customers placing orders.

[7] As noted in Table 4 and Table 5 on page 12, although impact evaluation totals end during June of 2014, we have extended the time period for describing program performance to the latest date that data was available in November of 2014.

Table 8. Yearly Order Tracking

	Apr 26- Dec 31, 2013	Jan 1 – Nov 15, 2014	Total	Year to Year % Increase
Unique customers	3,359	8,524	11,616	254%
Unique orders	3,510	9,344	12,854	266%
Total bulbs	50,695	132,974	183,669	262%
Average bulbs per customer	15.1	15.6	15.8	103%
Average bulbs per order	14.4	14.2	14.3	99%
Average bulbs per day	202.8	416.8	322.8	206%
Average orders per day	14.0	29.3	22.6	209%
Average orders per customer	1.0	1.1	1.1	105%

Program Products and Incentive Levels

When it came to product selection, Duke Energy decided to offer its customers a variety of the most commonly used specialty bulbs to replace conventional incandescent bulbs. “There are thousands of bulbs on the market. We didn’t want to try to replicate the number of choices available in a big box store, but we did want to ensure that people have a positive experience,” said the Duke Energy Product Manager. “So we looked at types of bulbs, different technologies, efficiency levels, bulb life, and other lighting factors like lumens. Then we worked with EFI to select the brands and bulbs that would cover the most common applications and deliver the most value for the lowest price.” While the Energy Store’s product inventory has continued to evolve over time, for its initial 2013 offerings Duke Energy chose to provide: CFL and LED capsules (A Line), CFL and LED reflectors, CFL globes, CFL candelabras, and CFL standard, dimmable, and three-way spirals. Each of these bulb categories has been consistently represented since the program’s launch, but the mix of individual bulbs has shifted slightly over time as the Store’s inventory has evolved to adjust to changing prices, new technologies, and manufacturer capabilities. All bulbs sold via the program are Energy Star qualified and most are offered in a variety of wattages as shown in Table 9.

Table 9. 2014 Products and Incentive Levels

Product List			EFI Store Base Item Cost	Duke Energy Incentive Amount	Customer	
Bulb Type	Category	Watt			Final Purchase Price	Maximum Purchase Limit
CFL Reflector (Recessed)	Indoor Reflector	14	$3.00	$2.52	$0.48	15
		14	$3.35	$2.52	$0.83	
		23	$6.75	$2.52	$4.23	
	Outdoor Reflector	23	$4.95	$3.34	$1.61	6
	Dimmable Reflector	15	$12.95	$5.00	$7.95	12
LED Reflector (Recessed)	Reflector	7	$14.50	$7.00	$7.50	15
		8	$17.95	$7.00	$10.95	
		9.5	$36.25	$7.00	$29.25	
		9.5	$12.95	$7.00	$5.95	
		10	$12.75	$7.00	$5.75	
CFL Globe	Globe	9	$3.00	$1.70	$1.30	12
		14	$3.00	$1.70	$1.30	
CFL Candelabra	Candelabra	5	$4.50	$2.11	$2.39	12
		7	$3.95	$2.11	$1.84	
		9	$3.65	$2.11	$1.54	
CFL Spiral	Three-Way	12.22.33	$7.45	$3.67	$3.78	6
	Dimmable	23	$6.75	$4.40	$2.35	6
CFL (Capsule)	A Line	14	$3.35	$1.94	$1.41	15
		18	$4.95	$1.94	$3.01	
LED (Capsule)	A-Line	6	$9.97	$7.00	$2.97	15
		7	$11.95	$7.00	$4.95	
		9.5	$9.97	$7.00	$2.97	
		10	$10.95	$7.00	$3.95	
		11	$11.95	$7.00	$4.95	
CFL Spiral	Standard Spiral	13	$1.80	$0.00	$1.80	N/A
		20	$1.85	$0.00	$1.85	N/A

As shown in the table above, incentive levels are specific to each bulb type and wattage, so final purchase prices for the customer can vary for bulbs within the same product family. For instance, CFL reflectors have a common incentive amount of $2.52 per bulb, yet the bulbs' base item costs range from $3 each for a 12 watt reflector to $6.75 for a 23 watt reflector. As a result, after the incentive is applied, these bulbs will cost customers $0.48 for a 12 watt and $4.23 for a 23 watt, respectively.

Incentive levels were determined by assessing specialty bulb prices in the retail marketplace and then considering the full range of costs to customers who make online purchases from the Duke Energy Savings Store, including product cost, any applicable sales tax, plus shipping expenses.

These retail factors were weighed against program budget, wholesale costs and discounts obtained by EFI, and other factors such as retaining the ability for Duke Energy to offer its customers extra incentives to purchase larger quantities of bulbs or to reduce shipping costs.

When setting bulb incentive levels, Duke Energy also considered other issues such as the differences between shopping online and in stores. For example, in-store shopping allows customers to examine and compare physical products; it encourages impulse buying through product placements at registers and end caps; and it provides the opportunity for same day purchase and installation. But in retail stores product information is often scarce. So customers must depend on the knowledge of sales associates or do their research in advance. Online shopping allows customers to shop when it is convenient for them, including when stores are not typically open for business; it delivers products by mail directly to the home, and it can offer customers a variety of educational and product information in advance of their making the purchase decision. Because these non-financial attributes can have an influence on sales, Duke Energy factored them into its overall pricing calculus in order to ensure that the Duke Energy Savings Store fit appropriately in its e-commerce niche.

Operational Roles

Program operational roles are assigned as follows: Duke Energy provides overall program oversight and quality assurance, marketing, and customer authentication. EFI provides the e-commerce platform for the Duke Energy Savings store, including the online storefront, shopping cart, and secure credit card processing. EFI also manages purchase limits for each account, bulb inventory, fulfills orders, arranges shipping (through the U.S. Post Office and United Parcel Service), handles customer service, and deals with returns and warranty replacements. These roles are discussed in more detail under the relevant sections below.

Program Marketing

Duke Energy promotes awareness of its Specialty Bulb program through a combination of general and targeted marketing efforts. General marketing efforts began with program webpages and links on the Duke Energy website, bill inserts, and a press release to coincide with the public launch of the program. Electronic marketing began with pop-up messaging appearing on the Duke Energy My Account Online System (OLS) that encouraged customers to click through to visit the new store. These efforts were followed by a direct mail campaign that targeted three subsets of Duke Energy customers: 1) those who had previously purchased CFLs at retailers using Duke Energy's discount coupons, 2) those who had ordered free CFLs; and 3) OLS account users, since they are known to be savvy web users. An email campaign followed the direct mail campaign. Initially these efforts were rolled out in sequence in the months following the program launch to give Duke Energy and EFI time to fine tune the systems for customer authentication and data transfer (see *Customer Authentication* below). Then in the fall of 2013 the program team stepped up its efforts with a combined campaign that incorporated all of the above-mentioned elements in the same month, as well as mentions on the Duke Energy online employee portal to promote greater awareness of the program within the company. No paid advertising was used during 2013, but Duke Energy initiated paid advertising in newspapers during 2014. Otherwise, marketing efforts in 2014 continued in a comparable manner with a similar combination of tactics, including website banners, OLS pop-up messages, bill inserts, targeted direct mail, and email campaigns.

In addition to the marketing activities mentioned above, Duke Energy sends direct mail letters to new customers to prompt them to visit the Store. Those letters also mention Duke Energy's separate free CFL program, which provides free standard spiral CFLs via mail. Moreover, every customer who orders free CFLs automatically receives a printed flier advertising the Store in their shipment. As of July 2014 those fliers specifically included a toll free phone number that enables customers to place orders for specialty bulbs by phone rather than using the online web platform. This ability to take phone orders is discussed in more detail in the *Call Center* section of this evaluation on page 49.

As the Duke Energy Product Manager explained, "Marketing the free CFL program was fairly straightforward since 'free' is a no-brainer motivational tool for a lot of people. But now we're asking customers to actually pay for a portion of the bulbs." This presents more of a challenge in terms of refining the program's offer (including which bulbs get promoted in the marketing materials and the level of discounts for bulbs and shipping) and the creative (which messages resonate best with different customer groups). For this reason, Duke Energy has experimented with different marketing pieces. Some pieces feature selected bulbs, while others show the entire product line in the Savings Store. Still other marketing pieces have experimented with different discount offers to reduce the cost of shipping. Figure 1 below provides a sample excerpt from one such promotion. Other marketing samples can be found in *Appendix F: Marketing Examples*.

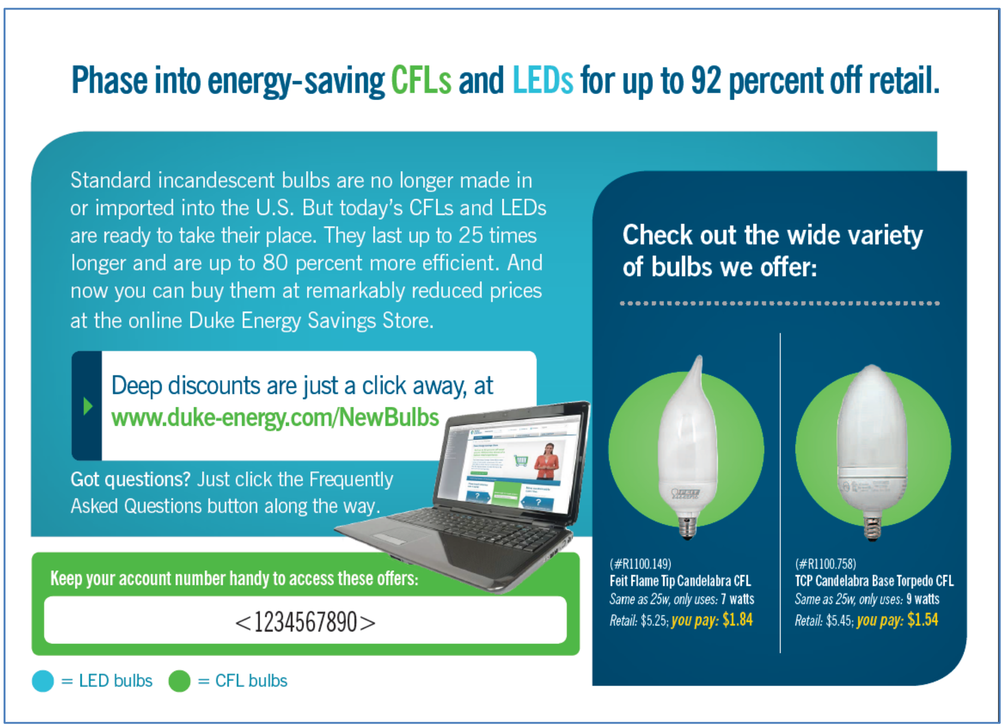


Figure 1. Sample Excerpt from a Direct Mail Promotion

The utility also employs an array of tools and techniques to track and improve the effectiveness of its marketing efforts: Mailing lists are compared against authentication records to determine which customers responded to direct mail campaigns. Separate and campaign-specific URLs are used for bill inserts, while click-through rates are tracked for email messages and OLS pop-up intercepts are tracked with weekly reports designed to capture response rates. Duke Energy's Google Analytics account is used to track web traffic on the public website, as well as follow through traffic to the EFI Duke Energy store landing page. EFI's Google Analytics and other e-commerce measurement systems track customer activities on the Savings Store itself.

To further enhance the program's marketing, the many digital data points collected from the various tracking systems are subsequently fed into propensity modeling tools from Duke Energy's Market Analytics group. These modules crunch external data such as Experian and PRIZM segmentation data and then combine it with Duke Energy program participation records to identify the common attributes shared by customers who have responded to previous efficiency offers. The most significant characteristics are then fed back into the models so that millions of Duke Energy customers can be sifted for those who are most likely to respond to the program's next marketing effort.

In 2014 Duke Energy also sought to scientifically test the effectiveness of different offers using A/B split testing. For the test, 400,000 customers were divided into two groups with half receiving an offer for $5 flat rate shipping and equal number of recipients seeing an offer for free shipping on orders over $25. Other elements of the offer remained identical so only the shipping options were being tested. The primary objective was to determine which shipping offer drew more responses. However, once respondents actually reached the online store, customers from both groups could participate in either offer. Results of the tests showed little difference in response rates between groups. Nonetheless, TecMarket Works applauds Duke Energy for using controlled testing to determine the most effective ways to reach customers and prompt them to take action.

TecMarket Works also notes techniques such as sequential and combined marketing campaigns, the use of unique URLs, customer-specific response tracking, propensity modeling, and split testing to constitute best practices in program marketing.

Customer Authentication

Numerous utilities employ online stores to sell their customers discounted light bulbs. The most common methods they use to confirm that online store visitors actually live within a utility's service territory are to either validate by checking the customer's residential address zip codes or for the vendor to compare account numbers entered by the website visitor with account numbers provided by the utility. While these methods suffice, neither method provides the online store vendor with up-to-date records regarding previous customer participation in energy efficiency programs. Duke Energy already possessed a more sophisticated system than this, and the utility wanted to use it for this program.

Duke Energy's previously established CFL distribution systems enable the utility to identify customers at the household level and track their participation down to the demand side management program that was responsible for providing a specific number of CFLs. "We wanted a vendor who would allow us to use our existing systems to authenticate customers before they accessed the vendor's e-commerce platform. That way we could confirm eligibility and track customer participation at the individual account level ourselves, and then redirect the customers to the vendor's online store to make their purchases," explained the Duke Energy Product Manager. With a data push from Duke Energy's computer system to the vendor's website, the vendor would have all the customer information needed to confirm eligibility for making purchases, as well as confirming the customer's account status as a residential customer (as opposed to being an eligible business customer who can buy discounted bulbs via a separate energy efficiency program for commercial customers).

This concept necessitated significant planning and technical adaption on the parts of Duke Energy and EFI. In the end, the complete process—from initially building the online website to finally testing that all data exchange procedures were working correctly—took the better part of a year before the Savings Store was ready to launch. However, once the system was ready, customers could access Duke Energy's authentication systems to verify their eligibility. Then the utility's computer systems would push the relevant customer data to EFI so that the vendor would have the customer's account information, including real-time eligibility for incentive discounts on light bulbs.

Because each of Duke Energy's state service territories are served by their own online storefront, one part of the authentication process also ensures that customers are automatically directed to their state-appropriate Store. As of the time of this evaluation, the Ohio website appears to be identical with those of other states, but by maintaining different online storefronts the system can readily accommodate state-specific changes as necessary.

Login Process

There are two ways to access the Duke Energy Savings Store: via the webpage for the program on the Duke Energy public website at http://www.duke-energy.com/residential-savings-store/ or via a link from within Duke Energy's OLS. If customers enter via the public website they must first enter either their account number or the phone number associated with the account (Figure 2). They must also enter the last four digits of the social security number associated with the account. If customers access the Savings Store via the OLS they will have been through the authentication and thus they can go directly to the Savings Store.

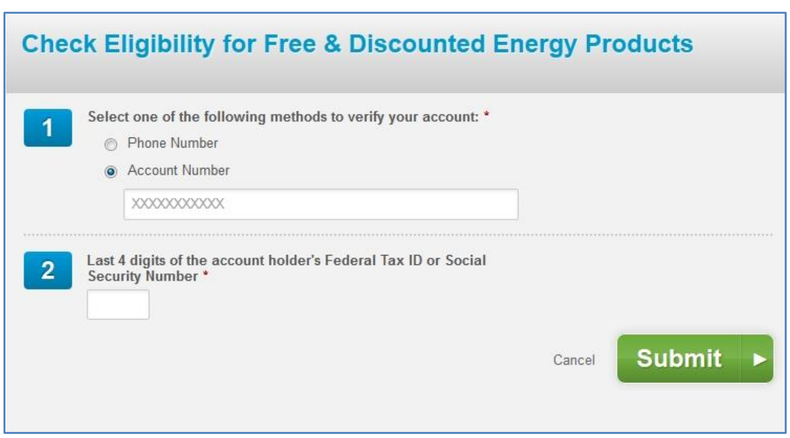
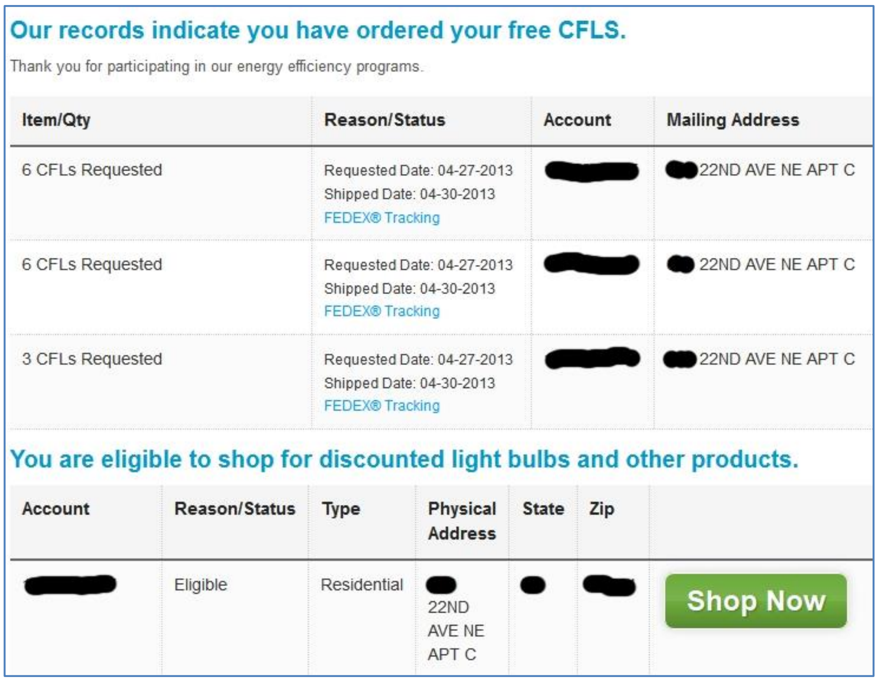


Figure 2. Login Screen for Authentication

By design, customers cannot access the Duke Energy Savings Store without first going through Duke Energy's authentication process. If someone tries to visit the site directly whether that's via a bookmark/favorite or via a link from another website, their web browser will display an error message that points them back to the public webpage for the program for verification.

After authentication, customers are shown a Bulb Order pop-up screen that displays the number of free CFLs that they have requested and allows the customer to obtain more free CFLs if they are still eligible. It also displays a section showing their eligibility to shop for discounted specialty bulbs (Figure 3). Clicking the "Shop Now" button on the Bulb Order pop-up screen automatically redirects customers to the Duke Energy Saving Store website, which is hosted by EFI.



Our records indicate you have ordered your free CFLS.

Thank you for participating in our energy efficiency programs.

Item/Qty	Reason/Status	Account	Mailing Address
6 CFLs Requested	Requested Date: 04-27-2013 Shipped Date: 04-30-2013 FEDEX® Tracking	[redacted]	[redacted] 22ND AVE NE APT C
6 CFLs Requested	Requested Date: 04-27-2013 Shipped Date: 04-30-2013 FEDEX® Tracking	[redacted]	[redacted] 22ND AVE NE APT C
3 CFLs Requested	Requested Date: 04-27-2013 Shipped Date: 04-30-2013 FEDEX® Tracking	[redacted]	[redacted] 22ND AVE NE APT C

You are eligible to shop for discounted light bulbs and other products.

Account	Reason/Status	Type	Physical Address	State	Zip	
[redacted]	Eligible	Residential	[redacted] 22ND AVE NE APT C	[redacted]	[redacted]	Shop Now

Figure 3. Bulb Count and Eligibility Screen

Prior to August of 2013, the login process involved an additional step after customers clicked the "Shop Now" button. Originally they were redirected to the pop-up screen that displayed their customer profile information, as well as the terms and conditions for website use. Customers were required to read the page and click the submit button before being transferred to the Savings Store (Figure 4).

Figure 4. Customer Profile Page

As the site went live and visitor traffic built up, it became apparent that customers were having difficulty moving beyond the profile page to the EFI store due to technical data handing issues. As a result, visitors received an error message indicating “token already in use.” This error caused confusion and at least temporarily hindered thousands of people from reaching the Savings Store. The problem was diagnosed and ultimately resolved, not by merely fixing the technical glitch, but rather by eliminating the entire step in the login process. Instead the profile page was removed and the terms and conditions were moved to the end of the shopping cart buying process. This move also addressed customer objections to the need to review and agree to terms and conditions before they knew what the program was offering. TecMarket Works commends Duke Energy on this decision since it eliminated a barrier to entry for customers, allowing more people to browse the Savings Store and ensuring that only those people who intended to make a purchase needed to review their address on file and agree to the terms and conditions.

Duke Energy Savings Store Website

Once the authentication process is completed, visitors are automatically redirected from the authentication pop-up windows to the Duke Energy Savings Store home page. The primary elements of the Savings Store website are all reviewed in this section, including navigation, customer education, products, and the shopping process. Numerous screen capture images from the website are shown in this section of the evaluation. Additional images can be seen in *Appendix G: Website Screen Images*.

Website Navigation

The Savings Store home page is arranged in a traditional grid layout with a large central column surrounded by smaller left and right columns to the sides and a footer below (Figure 5). In the central space a 50-second welcome video automatically launches when the page is first loaded. The video shows an actress who orients the visitor to the site’s shopping assistance tools and other helpful resources. She also mentions current special promotions, such as discounts on shipping. The left hand column of the home page is devoted to website navigation. The bottom of the page consists of a series of three boxes: a promotion for discounted shipping, featured bulbs for sale, and a special offer for energy efficient holiday lighting. The right hand column contains four boxes: 1) the Help Resources tool referenced in the welcome video; 2) a separate lighthearted video that shows CFLs installing themselves around the house; 3) a video explaining why Duke Energy wants its customers to save energy; and 4) a box showing the most popular bulb sold at the Savings Store. As visitors move beyond the home page and further into the Savings Store, the right hand column also displays products in the shopping cart and an itemized order history.

Figure 5. Duke Energy Savings Store Home Page

As a result of the well-considered layout and the various tools provided, website navigation is straightforward and self-explanatory. The left side navigation column remains constant for virtually all pages on the site. It provides visitors with a useful set of tools for finding what they are looking for, including: a search feature; a pull down menu listing bulb manufacturers; a list of quick access links for bulb types; and a separate set of links for support features, such as

FAQs, shipping and returns, privacy notice, contact us, and package tracking. Throughout the website, in-text links are colored blue, and they display an underline when visitors mouse over them.

In addition to these standard navigational elements, a thin horizontal navigation strip at the top of each page displays breadcrumbs to indicate where the visitor is within the website. For instance, when a visitor is looking at a MaxLite A21 bulb the breadcrumbs show the following: Home » Capsules » CFL Capsules » MaxLite A21. The navigation strip also permanently displays links for: Logoff | My Account | Cart | Checkout, making these features readily accessible at all times. TecMarket Works considers the addition of this navigation strip to be a best practice for utility web design.

Website Search Function

The Savings Store offers two levels of search functionality: basic and advanced (Figure 6). The basic feature searches for key words entered. The advanced search function allows visitors to refine their searches by bulb category (candelabra, capsule, etc.), manufacturer, price, and date. When we tested both the basic and advanced search functions the results were mixed. Some keyword searches yielded results consistent with the website inventory, while others did not. Specific findings are shown in the list below Figure 6.

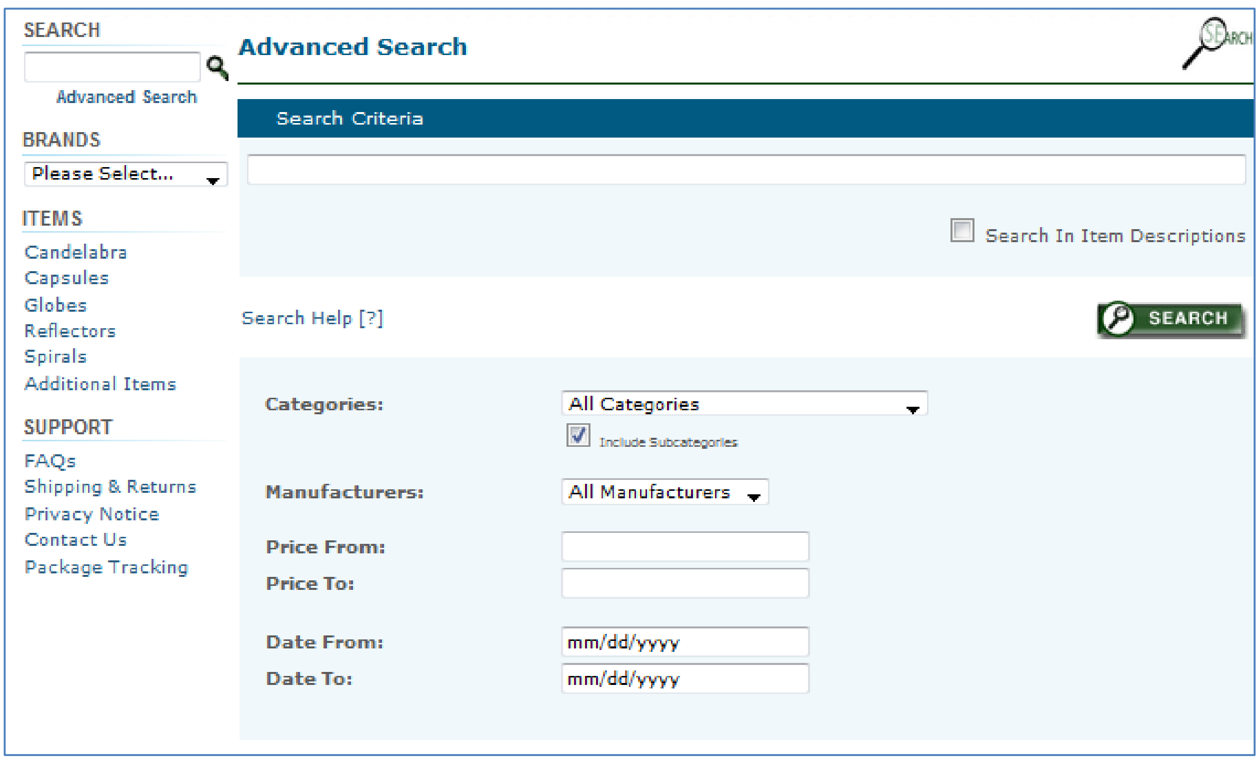


Figure 6. Website Search Function

Bulb Type Search Issues

- "Spiral" showed one result for a non-incented normal 13 W spiral and three results for three-way spirals (incented and non-incented), but it didn't find dimmable spirals, which are sold at the Savings Store.

- While "spiral" showed four results, "spirals" yielded zero items. Likewise "candelabra" resulted in 12 items, but "candelabras" resulted in zero. Since customers may enter singular or plural terms, both terms should be coded into the search function.
- "Capsule" and "capsules" both resulted in no items found. This prominent category of bulbs should be coded in.
- "Globe" and "globes" both showed eight items found. No issues were noted.
- "Reflector" resulted in 28 products, including both CFLs and LEDs. But when "CFL reflector" and "LED reflector" were searched they each returned just two items respectively. Search terms should be broadened to reveal all bulbs that fit these descriptions.
- "Three way" found four items, yet "3 way" resulted in eight items. Since customers may enter either phrase, the results should be coded so that all items are found with both terms.
- "Dimmable" resulted in 31 products found, but "dimmables" yielded none. "Dimmable lighting" yielded 16 hits. We recommend that search coding be extended to accommodate plurals and possible word combinations containing the bulb type name, as well as commonly associated words such as light, lighting, bulb, bulbs, and light bulb, and alternative spellings such as lightbulb.

Application Type Search Issues

- "Ceiling" yielded six candelabra products, but failed to list other bulb types such as spirals and capsules which may also be used in ceiling fixtures.
- "Table lamp" found 88 products, but "floor lamp," "pendant," "mounted ceiling," and "vanity" resulted in no bulbs, despite the fact that these words are prominently mentioned alongside table lamps as application types.
- "Recessed" and "recessed light" yielded 28 items, but "recessed lighting" found only 22.
- "Sconce" and "wall sconce" both found six items.
- "Track," "track light," and "track lighting" all yielded 14 results.

At the time of this evaluation TecMarket Works considers the Savings Store's search functionality to be in need of the changes noted above, as well as other improvements along the lines of the examples provided. However, we do note that some of these search issues may be resolved in the process of making currently planned website upgrades, since EFI indicates that product filtering will be considerably enhanced under its pending ecommerce platform replacement, which is scheduled for the first quarter of 2015.

Customer Education and Shopping Assistance

Perhaps one of the most distinguishing features of the Duke Energy Savings Store is its set of resources for providing visitors with shopping assistance. Duke Energy considers customer education to be a significant mission of the Savings Store. "One of the big advantages of buying from a retail store is that people can take their old bulb in with them and compare to the ones on the shelf so they get the right replacement. But that means they're likely to buy the same kind of inefficient bulb they used before," said the Duke Energy Product Manager. "We wanted to build tools that mimic looking at what's on the store shelf, but also go beyond that so that customers really understand their options and know they are buying the right thing. That way they will not have to worry about returning it because it was wrong."

Pop-Up Shopping Guides

To this end, Duke Energy hired a third-party firm, Capstrat, to help develop a series of online resource modules to help with customer education. Those educational resources are clustered in the upper right hand column of the website where an array of links lead to informative pop-up boxes designed to assist customers in identifying the kinds of bulbs they need by application (track lighting, recessed lights, table and floor lamps, pendant lights, wall sconces, mounted ceiling lights, and vanity light), and by bulb type (reflector, globe, candelabra, spiral, capsule). Each pop-up tab provides a brief text description, accompanying photograph, and quick access links to enable customers to shop for that type of bulb. Other pop-up boxes explain the benefits of energy efficient lighting and discuss how to recycle the bulbs safely. The resource modules also contain a section that clarifies the difference between watts and lumens. This includes a text explanation, an online video called *Energy 101: Lumens* made by the U.S. Department of Energy, and a comparison/conversion chart so customers can look up the old incandescent bulbs they are familiar with and find CFLs with similar lumen levels.

Savings Calculator

Another educational feature on the site is an interactive savings calculator that allows customers to see how much money and carbon they will save by replacing their old bulbs with more efficient CFLs (Figure 7). A drop-down menu enables the user to select the approximate square footage of their home. Then the number of bulbs of each type can be entered into the calculator. With each change the calculator displays the amount of money to be saved on the purchase, as well as the total financial savings on the customer's Duke Energy electric bill over the course of a year. Calculations are based upon bulb type, average hours of use, presumed wattage of the old bulbs, and the Duke Energy rate factor for that state. The calculator also shows the total number of pounds of carbon saved per year and the equivalent of how many trees would have to be planted in order to offset that same amount of carbon. Although the calculator shows these savings in aggregate, it is possible to enter one bulb at time to see the individual savings per bulb.

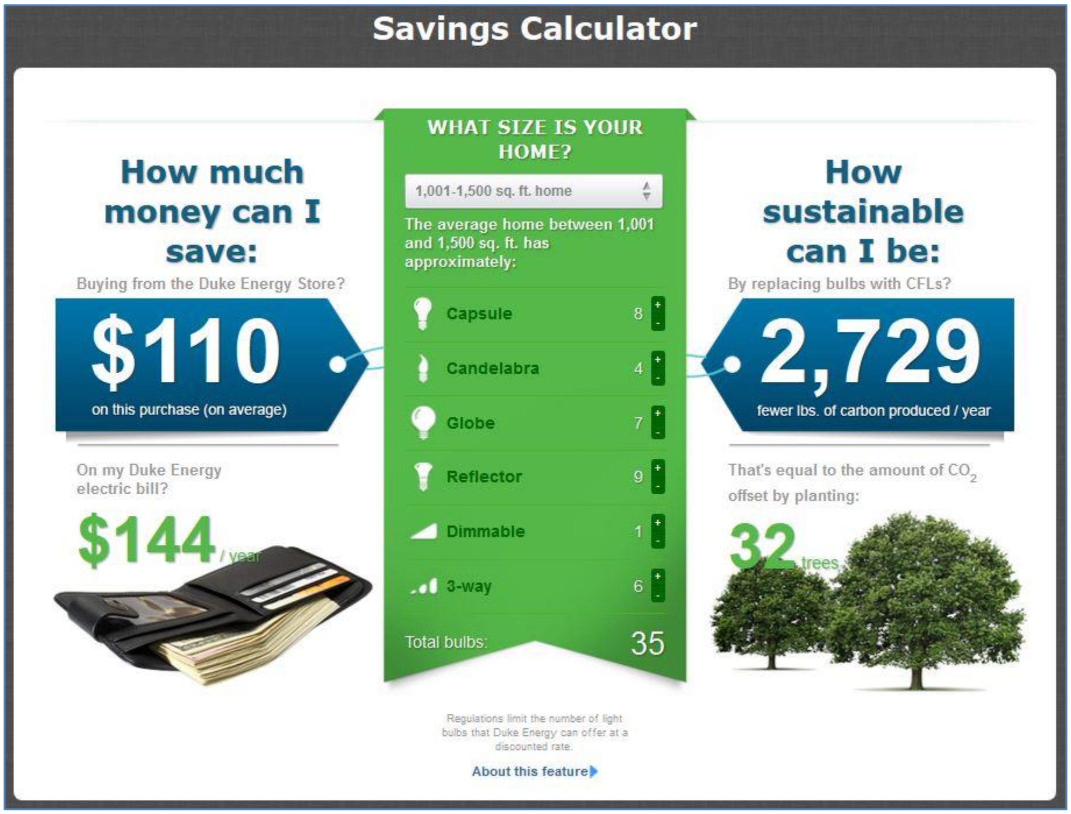


Figure 7. Savings Calculator

According to the "About this feature" link on the calculator, its programming uses inputs and assumptions from the 2010 U.S. Lighting Market Characterization report released by the U.S. Department of Energy; ENERGY STAR reports on lifetime savings in electricity costs of CFLs and savings in pounds of carbon dioxide per average CFL bulb; as well as the Environmental Protection Agency (EPA) Greenhouse Gas Equivalencies Calculator.

A similar looking savings calculator is shown on the program's public web page on the residential Duke Energy website. However, that version of the calculator does not have the interactive features that are available on the Savings Store version. Instead it displays pre-programmed bulb counts and their associated savings as a single fixed example. While interactive functionality may not be necessary on the public website, TecMarket Works suggests that Duke Energy investigate the feasibility of upgrading the public calculator since its interactive functionality would encourage more customers to see how much they can save before making the effort to log on to the Store.

TecMarket Works considers this interactive calculator to be a worthy feature at the Duke Energy Savings Store because the meaningful information provided by the calculator helps to shift customer buying decisions from a short-term focus on the immediate financial savings at the time of purchase to the broader considerations of the overall value obtained during the lifetime of bulb use. This additional context demonstrates one of the key benefits of online shopping given that retailers are unlikely to reproduce this feature in retail stores.

One minor change we recommend regarding the energy savings calculator is to ensure that it has continuous placement or mention on the Store's home page. We mention this because while prominent placement was the case for much of 2014, the savings calculator box had been supplanted by a promotion for holiday lighting during the time of our website evaluation visit in November of 2014.

Frequently Asked Questions
Answers to frequently asked questions can be found via the FAQ link on the left hand navigation column. Common questions and answers cover a wide range of topics including: why Duke Energy is providing energy saving products, incentive limits, shipping options and delivery times, payment and warranty information, and who and how to call for further assistance. Rather than being displayed as a traditional HTML webpage, the FAQs are shown as an online PDF so that they can be readily downloaded to the visitor's computer or mobile device.

Summary
While all of the above mentioned information, pop-up shopping guides, video, savings calculator, and FAQs can all be rightly called customer education tools, none appear to be presented as separate education components. Instead they are all well-integrated website elements to help Duke Energy's customers to make better purchasing decisions and have a more complete user experience. TecMarket Works commends Duke Energy for its exemplary efforts in creating a user-friendly online shopping experience.

Product Display and Pricing

As discussed above, customers can access individual product pages in a variety of ways, including direct search-term entry, search by brand, and navigation by following links for bulb types. This last method guides customers through a sequence of web pages that begin with photographs showing one or more common uses for a bulb type, such as floor and table lamps, and a paragraph-long description of the overall bulb category. For example, capsule bulbs are described as follows:

> *These bulbs, which are also known as "A" lamps, most closely resemble traditional incandescents although capsules are slightly larger in size. These encapsulated style light bulbs are especially suitable for use in open fixtures in which the bulb will be visible.*

After this brief description, customers see a sentence telling them the purchase limits for incented bulbs in that category. Links to CFL or LED bulb types are also shown. The next page in the sequence displays product summaries of the bulbs within the category (Figure 8). Summaries include an image of the bulb, bulb name and model number, wattage, lumens, bulb life, and a price breakdown showing the discounts offered. More details are available one level deeper by clicking on the bulb name link.

Figure 8. Initial Multiple Product Display

While these summary pages are adequate to the role they fill within the website, TecMarket Works offers several suggestions that may help to improve the customer experience. We mention these as suggestions rather than program recommendations. We do this in order to encourage Duke Energy and EFI to review the Savings Store's Google Analytics or other web traffic analysis software to assess website traffic flow and then to experiment and test the effectiveness of our suggestions. For instance, A/B Split Testing can be used to test each suggestion individually in order to determine if more customers take action without or with each change. Our suggestions are summarized in Figure 9 on page 40.

Website Links

CSS style sheets on the website denote in-text links with a subtle blue coloring. While many online shoppers can be assumed to be generally aware that colored text indicates a link to more information, not every site visitor may be aware of this. As a result, some percentage of online customers may not be clicking links to get additional information. This may cause customer confusion and lost sales. Changing link text to a more distinct color or adding underlines may make links more prominent. Another way to help customers to realize more information is available would be to include a "more information" button on the product summary page (see Figure 9 for example). We suggest that Duke Energy and EFI explore which options work best with the website platform.

Bulb Wattage and Brightness

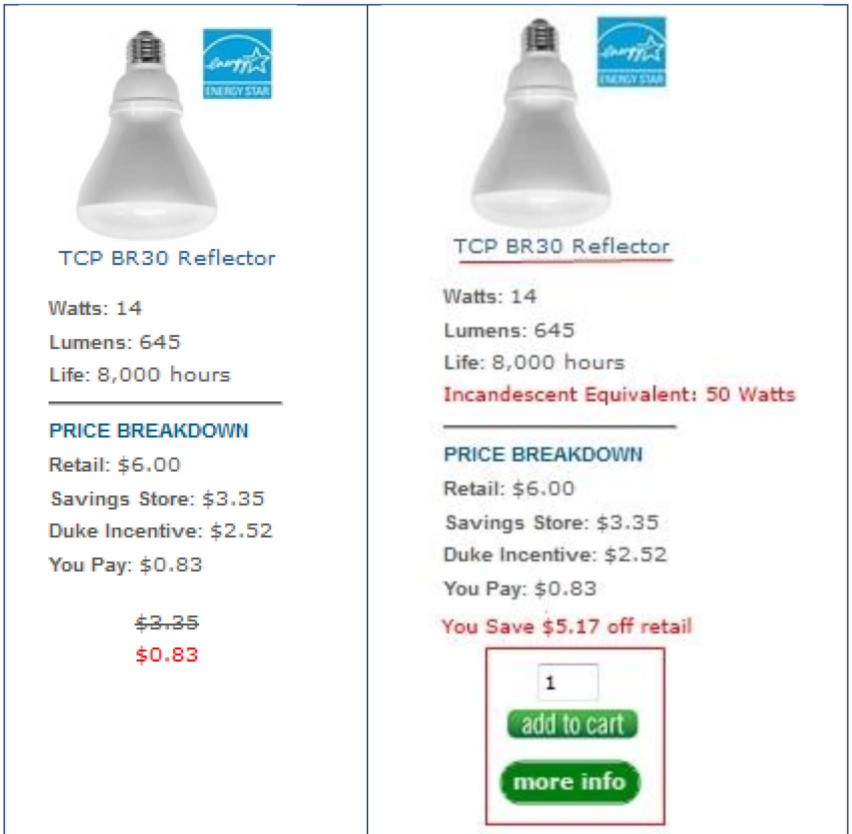
Although the customer education section of the website does an admirable job of explaining to customers the similarities and differences between traditional incandescent bulbs and newer CFLs and LEDs, those comparative features are not carried over to the product display pages. This can present challenges for customers who are accustomed to years of identifying light bulbs based upon their incandescent wattage. As a result, when site visitors view product descriptions listing watts, lumens, and bulb life they must either 1) draw upon prior knowledge of product comparisons; 2) find their way to the "About Brightness" table (this is two clicks away if they know where it is); or 3) continue without the extra information. This trio of choices can be improved by either including a line of text citing the most similar incandescent bulb in terms of wattage (see Figure 9 for an example), and/or by providing a link directly to the "About Brightness" table, which is already programmed to appear as a pop-up window on top of the existing page so customers do not lose their place on the product page. Improvements such as these will make mental comparisons easier for the customer and may increase sales since it will increase customer knowledge and comfort with idea of buying an "unknown" bulb online.

Bulb Pricing

In order for customers to appreciate the discount pricing that Duke Energy is providing, the website shows a breakdown of various incentives applied to each bulb. Pricing begins with a retail price that is set based on EFI market analysis. After this initial retail figure, price reductions are shown in sequence, including the base EFI store price, the Duke Energy incentive amount, and the final price. TecMarket Works considers showing customers the discounts to be a good idea because it reminds them of the prices they would likely be paying elsewhere and it reinforces the savings that the customer is receiving as a result of visiting the Savings Store. However, we also note the potential for customer confusion arising from the display of so many different amounts. The potential confusion seems possible given that the phrases "Savings Store" and "Duke Incentive" may not be clear to some people. One way to mitigate potential confusion and to further reinforce the amount savings being offered would be to present the math for customers so that they see the difference between the original and final prices. See Figure 9 for an example.

Add to Cart

Currently the initial bulb summary page does not include a button to add the item to the shopping cart. In order to actually purchase the bulb the customer must first access the detailed information page by clicking the blue text link associated with the bulb product name. This step, and any associated loss in the sales funnel, could be eliminated if an "add to cart" button is inserted below the item description as shown in the suggestion in Figure 9. TecMarket Works offers this suggestion while recognizing that such a change would be necessarily dependent upon a combination of web design and underlying web coding details that would still allow for customers to purchase quantities of bulbs at multi-pack discount prices.



Original	Suggested changes are shown here in red

Figure 9. Suggested Changes for Multiple Product Display

Once customers click beyond the product summary pages they are taken to product specific pages that contain a description and picture of the bulb (Figure 10). Below this basic information the visitor sees four tabs: program pricing, estimated savings, product specifications, and installation instructions. The page defaults to the pricing tab.

Above each tabbed page is a product image of the specialty bulb (Figure 10). In some cases there is a link directly below the picture of the bulb that reads "Click to Enlarge." Clicking on the link brings up a separate pop-up window with a larger image of the bulb. This feature is inconsistently implemented throughout the website. For instance, it is available for candelabras, globes, and capsules, but not available for spirals and reflectors. At a minimum, we recommend that the feature be consistently implemented throughout. For extra measure, we suggest adding more product images taken from different angles or, if possible, adding viewing software that allows the visitor to pivot and turn the image to see different points of view. This could help increase sales by increasing customer confidence that the new specialty bulb is similar to the bulb they already have.

Figure 10. Individual Product Display (webpage excerpt)

Program Pricing Tab

The Pricing tab shows a product table that includes part number, bulb image, item name, price, available, and an "Add to cart" button with a quantity box. The available column shows the number of bulbs in stock or the date of expected availability if the item is currently out of stock. Our suggestions for this tab are duplicative of those discussed for the price summary page.

Estimated Savings Tab

The Estimated Savings tab displays a tab that compares old technology with that of the new bulb. This includes: electric demand in watts, utilization (hours per day), and annual use (kWh). For the new bulb, the table also shows annual electricity savings (kWh), annual carbon savings (pounds), annual dollar savings, and expected product life. Units of measure are explained in a paragraph below the table. These comparison tables are well considered. However, they might be more helpful if they also included additional information such as lumens and color temperatures, given that these bulb characteristics determine the brightness and color of the light, which are often key criteria in customer decision making.

Product Specifications Tab

The Product Specification tab shows manufacturer specifications for their bulbs. Because this information is not standardized across manufacturers, the level of information provided and its order of presentation vary considerably, as shown in Table 10. This lack of standardization makes product comparisons difficult. Moreover, without a primer for clarification, some specification terms listed, such as "Color Rendering: 84 CRI" and "Base Type: E26" may be confusing to those customers who are unfamiliar with them.

Table 10. Non-Standard Product Specifications

Bulb 1	Bulb 2
• ***Dimensions:*** *Width 2.4 inches (61 mm), Length 4.4 inches (112 mm)* • ***Light Output:*** *700 lumens* • ***Color Temperature:*** *2,700 degrees Kelvin* • ***Color Rendering:*** *84 CRI* • ***Rated Lifetime:*** *8,000 hours* • ***Minimum Start Temperature:*** *-20 degrees Fahrenheit* • ***Maximum Operating Temperature:*** *160 degrees Fahrenheit* • ***Power Specifications:*** *120 volts AC, 60 Hz, 0.21A, 14w* • ***Base Type:*** *E26* • ***Manufacturer Warranty:*** *1 Year*	• ***Light Output:*** *1,100 lumens (60 to 75 watt incandescent equivalent)* • ***Electrical Specifications:*** *120 volts, 60 Hz, 18 watts* • ***Dimensions:*** *2.6 inch diameter, 5.1 inch length* • ***Color Temperature:*** *2,700 degrees Kelvin* • ***Rated Life:*** *8,000 hours* • ***Certifications:*** *UL* • ***Manufacturer Warranty:*** *Two Year*

While TecMarket Works is quick to point out that these same issues apply to all companies that sell light bulbs at wholesale or retail, we also note that the web pages on the Duke Energy Savings Store provide the opportunity to customize information in a way that is difficult for those who sell products on store shelves. Since Duke Energy indicates that it seeks to provide a web-based shopping experience that is above and beyond the retail experience, we suggest that the utility and EFI consider standardizing and explaining the product specifications for the 22 items listed for sale on the Duke Energy Savings Store.

Installation Tab

The Installation Instructions tab provides the same set of directions for every bulb.

> *Prior to installing this light bulb, turn power off to the socket at the switch. If it had previously been on allow the existing light bulb to cool. Unscrew the existing light bulb by turning counter clockwise. Install this new light bulb by turning it clockwise until it is secure in the socket. Do not over-tighten.*

While screwing in a light bulb is so basic that it is the subject of countless jokes, we commend Duke Energy and EFI for the thoroughness with which they have considered their customers' experiences. However, we note that while basic screw-in installation instructions apply to virtually all the bulbs, we found that installation directions had not been edited for bulbs that use a GU10 base such as MR16s. Because MR16 bulbs use metal pins instead of a screw-in base, they are the one type of bulb sold at the Savings Store that customers may be unsure how to install. We recommend a minor edit to the instructions for any bulbs lacking a screw in base in order to explain any differences.

New Feature Suggestions
Current website functionality allows visitors to simultaneously view bulbs of the same type, such as two different models of CFL capsules. This enables them to compare summary information including watts, lumens, bulb life, and price. But visitors cannot compare bulbs of different types, such as CFL vs LED capsules. This limitation requires visitors to click back and forth and thus hinders their ability to compare different technologies. Furthermore, the current website functionality also does not allow for detailed comparisons between bulbs, such as simultaneously viewing estimated savings and product specifications. TecMarket Works considers these functional limitations to be high priority improvements in order to enhance the customer experience. Duke Energy and EFI have already indicated that they agree with this assessment and report that they are in the process of making system upgrades that will enable these features by the first quarter of 2015.

One important website visitor challenge that did not yet appear to be planned is the ability for customers to compare their old bulbs with the new bulbs sold on the website. As mentioned earlier in this evaluation, one of the advantages of retail sales is that customers can bring their old bulbs into the store and look through the items on store shelves until they find a match for the bulb's shape and base. This visual confirmation generates confidence in the purchase. While making physical comparisons is impossible through a website, providing a collection of photographs or drawings to help identify old bulbs would be fairly easy. An excellent example with images of bulb shapes and base-types can be found on the light bulb buyers guide page of Amazon.com.[8] Furthermore, clicking on the image or shape for the old bulb could bring up a list of possible replacements. TecMarket Works offers this suggestion as an additional way to address Duke Energy's mission to encourage as many of its customers to swap out old bulbs as possible.

On a related note, we also offer the following suggestions. As discussed above, those customers who are new to CFLs and LEDs tend to associate the brightness of light bulbs based upon on their wattage. This lack of familiarity with lumens and light colors makes it challenging for them to find suitable replacements for their older technologies, and thus may be inhibiting purchase behaviors. For this reason, we suggest that Duke Energy consider adding a Brightness Comparison tab to its list of other product tabs. This tab could display light bulb fact boxes developed by Energy Star, as well as the lumen to watts comparison graphic shown in the Lumens 101 video or a bar chart similar to that on Amazon.com.[9] Examples are shown in Figure 11.

[8] http://www.amazon.com/gp/feature.html/ref=amb_link_356841462_1?ie=UTF8&docId=1002234061&pf_rd_m=ATVPDKIKX0DER&pf_rd_s=product-alert&pf_rd_r=1XK8CAY99M4TXE02YDH5&pf_rd_t=201&pf_rd_p=1740479022&pf_rd_i=B002NH5TTA

[9] http://www.amazon.com/gp/feature.html/ref=amb_link_356841462_1?ie=UTF8&docId=1002234061&pf_rd_m=ATVPDKIKX0DER&pf_rd_s=product-alert&pf_rd_r=1XK8CAY99M4TXE02YDH5&pf_rd_t=201&pf_rd_p=1740479022&pf_rd_i=B002NH5TTA

Figure 11. Light Bulb Facts

Lighting appearance is another area where many customers may require assistance. For this reason it may also be helpful to provide an information resources tab with explanations and visual images to educate customers about how light temperatures affect light color and influence mood. The Energy Star website provides a ready example at http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_color. TecMarket Works considers this particular suggestion to be of lesser importance given the limited number of bulb types offered through the Savings Store.

Shopping Cart and Purchase Process

Shopping Cart Functionality

The Duke Energy Savings Store's shopping cart functionality meets the conventional standards for e-commerce. Product descriptions include a field for entering item quantity and an "Add to Cart" button. The cart can be accessed at any time via the navigation ribbon along the top of the page. The cart displays part numbers, item descriptions and prices (Figure 12). If an item is out of stock, then an expected-available date is prominently displayed in red text. Items in the cart can be easily removed and quantities can be edited. Subtotals can be updated with a click of a button.

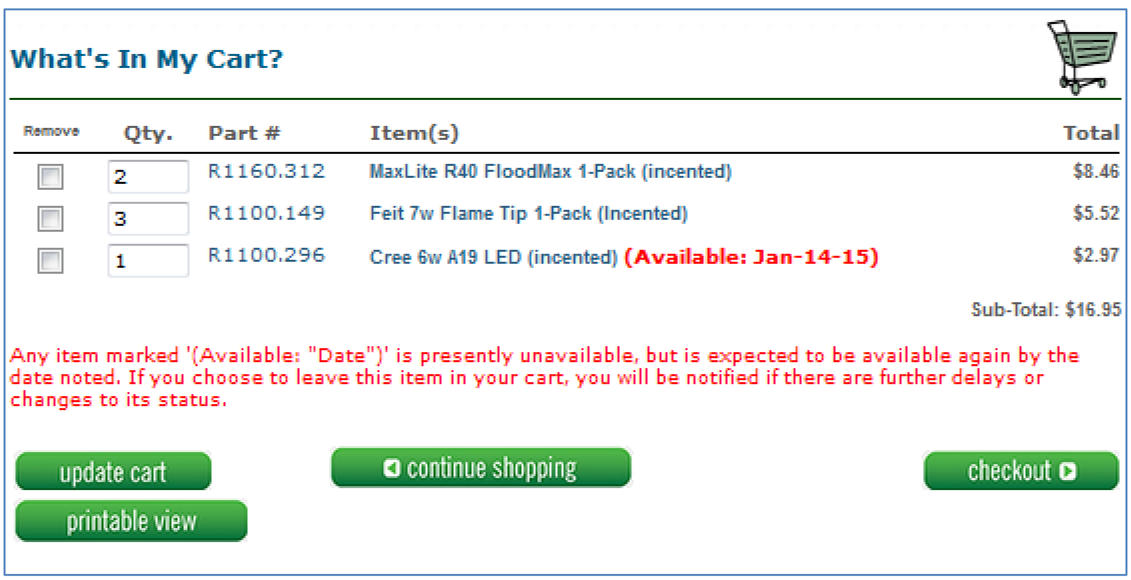


Figure 12. Shopping Cart

Visitors can print a record of items in their carts and save the cart contents so that their bulb selections will be available the next time they visit the site (Figure 13). While the save function is helpful, there is no link for the feature shown within the cart itself as there is for printing. Instead the save feature is displayed in the right-hand column of the website below the permanently displayed Resources and CFL video boxes, which means that on small screens it may not be noticeable since it will appear below the fold. This less than prominent placement makes the save feature less likely to be used. Because this feature is already available and useful for customers, TecMarket Works suggests that if feasible, Duke Energy add a "Save Cart" button to the list of buttons displayed in the cart, or otherwise move the display box to make the function more obvious for site visitors.

Special website functionality also allows customers to use more than one shopping cart at a time (Figure 13). While this feature was primarily designed to aid business customers who may have multiple departments making purchases, the feature is available to residential customers as well.

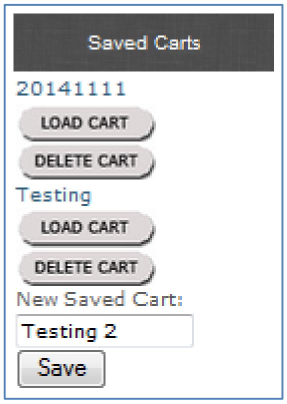


Figure 13. Saved Shopping Carts

Exceeding Incentive Limits and Buying Non-Incented Bulbs

The Duke Energy Savings Store permits customers to order more bulbs than are allowed by the incentive limits, but doing so triggers a message at the bottom of their shopping cart. A representative message is shown below:

> *The purchase limit for incented CFL capsules is 15 per account. Please adjust the quantity in your cart to proceed. Note that you may still order more of these products beyond the limit through the non-incented portion of this online store. Click here to purchase additional products without purchase limits.*

Customers cannot move further into the checkout process unless the quantity of bulbs is reduced to within limits. This must be done manually by deleting the original quantity and entering a lower number. Having done this, customers can click the link which redirects them to a different section of the website that stocks identical bulbs at higher costs since they are priced without the incentive amounts offered by Duke Energy. This approach makes it possible for customers to order as many bulbs as they want without exceeding Duke Energy's preset incentive limits. Duke Energy tracks these non-incented bulb purchases separately.

The Savings Store's non-incented bulb inventory can be accessed directly via the Additional Items link in the left side navigation list or via the website search function. While these additional methods of accessing non-incented bulbs are admirable from an ease of navigation point of view, TecMarket Works found them to be potentially problematic from a customer savings perspective, since visitors can mistakenly purchase non-incented bulbs when they are eligible to receive the incentive discount.

As shown in Figure 14 below, the first few items consistently shown in the search results are the non-incented bulbs. Incented items appear lower down on the list, although they are shown at a lower price. As presented, the search results require visitors to first notice that the same bulbs are offered at two different prices and then to select the lower price option. Unless visitors do so, they will end up purchasing non-incented bulbs when they are eligible for incented bulbs. In addition to causing a potential customer equity problem, this may also lead to lower customer satisfaction when customers discover their error.

Figure 14. Website Search Results

Presenting the incented bulbs first would seem to be a simple improvement to help reduce the likelihood of these potential problems. Other potential options could include not showing non-incented bulbs in the search results, or only allowing customers to see non-incented bulbs if they have reached their incentive limits. TecMarket Works recognizes that any such improvements may require significant programming changes. So rather than prescribing a specific solution we encourage Duke Energy and EFI to take necessary steps to make it explicit to website visitors that the same bulbs can be purchased at a lower price.

The Checkout Process

The checkout process occurs across four separate webpages. The first page provides customers the opportunity to enter a shipping address and select a delivery method. The second page collects credit card payment information and requires customers to accept the terms and conditions of the program, including that the bulbs cannot be resold and that they must be installed on a property associated with the Duke Energy account. The third page offers a final chance to confirm the order. The fourth page indicates the customer has successfully completed the transaction. TecMarket Works considers the addition of a confirmation page to be a best practice for web transactions, particularly for those of a financial nature.

Customers can also opt to pay by check or money order. If customers choose to pay by mail, they must complete the checkout process and then mail payment (payable to Energy Federation) along with a printed copy of their order to EFI. Orders are shipped upon receipt of payment. While this feature makes Duke Energy's discounted bulbs available to customers who may not possess credit cards, EFI representatives told us that very few customers availed themselves of the option.

Inventory Management

The Duke Energy Savings Store sells approximately two dozen different kinds of specialty bulbs. The number of bulb types continues to change slightly as the program team refines the product mix and adjusts to shifts in the marketplace, such as Energy Star specification changes, technology improvements, price reductions, and bulb adoption rates. Nevertheless, the program has consistently provided one or more product offerings in the following bulb types: dimmables, three-ways, reflectors, capsules, candelabras, and globes; in many cases in both CFL and LED varieties. In 2013 and 2014 the program stocked and sold far more CFLs than LEDs, but the planned 2015 product mix will more include greater numbers and types of LEDs, including LED outdoor reflectors, LED globes, and LED candelabras.

Although Duke Energy's relatively limited selection of bulbs represents a tiny fraction of the more than 1,500 different SKU items that EFI stocks for its various customers, the overall volume of bulbs sold each month by Duke Energy places the utility among EFI's largest clients. To help ensure that inventories for Duke Energy remain intact, EFI sets aside products stocked for the utility so that they aren't inadvertently pulled for other clients. EFI constantly monitors its inventories, while the Duke Energy Product Manager reviews inventory on a weekly basis.

EFI has a strong track record of maintaining inventories. However, they can run out of stock due to: 1) forecasting mistakes when marketing response rates are higher than expected; 2) manufacturing issues; or 3) shipping delays, such as those caused by weather. If an item is placed on back order, the Savings Store website is updated with an anticipated available date. The date shown is typically one week longer than the actual expected date, in order to better manage customer expectations.

EFI has a service level agreement that at least 95% of orders each month will ship complete. Only twice, in June of 2013 and January of 2014, did performance dip slightly below the mark due to manufacturer product discontinuations and weather-related inventory shipment delays, both of which were beyond EFI's control. In all other months performance for this metric has varied between 98% and 100%. If inventory issues do happen to cause EFI to send a partial shipment, there is no charge to the customer for the second delivery, which is sent via the same delivery method as originally selected.

Shipping and Delivery

Customer bulb purchases are typically fulfilled within two business days of the order being received, which represents a best practice in this field. Bulb delivery dates depend upon the type and speed of shipping selected by the customer. The program allows customers to choose between shipping via the U.S. Post Office or United Parcel Service. Application programming interfaces (API's) from these shippers allow shipping costs and times to be automatically calculated on the website based on delivery speed, zip code, and weight of the order. Discounted shipping rates are also shown during times when Duke Energy is offering additional customer incentives, such as $5 flat rate shipping or free shipping on orders of $25 or more.

A webpage on the Savings Store enables customers to track UPS packages using the order number or the UPS tracking number. Packages sent via the post office are not trackable from the Store website, but a phone number for the post office is provided.

During checkout customers can add new mail delivery addresses. While the majority of customers have the same service and delivery address, Duke Energy recognized that some customers may wish to have their bulbs delivered elsewhere, such as a place of business or a second home. Customers can enter delivery addresses anywhere in the United States, as well as any overseas U.S. military installation. TecMarket Works acknowledges this gesture toward customer convenience, but we also point out the potential to degrade energy savings by allowing incented bulbs to be shipped, and presumably installed, outside of Duke Energy's service territory. This has the potential to reduce the energy savings that Duke Energy can claim as a result of the programs' operations.

With this in mind, we reviewed the records of customer sales to determine the prevalence of out of state shipping. At the time this review was conducted on November 1, 2014, among the 12,240 unique customer orders (181,850 bulbs) for Ohio, only 67 orders (555 bulbs) were sent out of state between program inception on April 26, 2013 and October 31, 2014. This represents 0.5% of Ohio sales. The detail provided in the records did not allow us to conclusively determine if any out of state addresses were within Duke Energy service territories in other states. Nor was is it possible to determine if customers chose to have bulbs shipped to an out-of-state location such as a work address and then personally brought their purchased bulbs home to their residences within Ohio.

Call Center

EFI provides 17 customer service representatives (CSRs) who are trained to handle Duke Energy's program. Each state Store has its own unique phone number for residential customers, and the EFI phone system automatically indicates where the call is originating.

According to the Duke Energy and EFI spokespeople that we interviewed, overall call center operations have run smoothly. Between the program's inception in April 26, 2013 and October 31, 2014, the call center has met all of its service level requirements, including answering at least 70% of calls within 30 seconds. In most cases, greater than 85% of calls were answered within that time.

From the point of view of customer service, the primary challenge for the program had nothing to do with CSR performance or website functionality. Instead it revolved around the fact that for the first 15 months of the program CSRs could not take phone orders for Duke Energy customers. The limitation arose from the customized authentication process that requires all website visitors to enter their residential account number or phone number and the last four digits of their social security number into Duke Energy's system in order to verify eligibility.

Because orders can only be placed by authenticated customers, the CSRs were required to talk Duke Energy customers through the log in process and then coach them as they navigated the Store website to order bulbs. "Our people were very familiar with the website, but they couldn't access it themselves," explained EFI's call center manager. "So we built a mockup of the website so we could click along in parallel with the customers. But we couldn't actually see what customers were seeing. In most cases that was fine, but once in a while it could be a challenge if a customer wasn't particularly computer savvy."

The solution for serving customers who don't have computer access and customers who prefer not to use a computer was to enable the EFI CSRs to accept telephone orders for Duke Energy customers, just as they do for other utility clients. The challenge was to do so in a way that works with the authentication system. In other words, this meant that in order to place bulb orders on behalf of customers, the CSRs would need to log into the system as if they were the customers and then enter the customer's Duke Energy account number and the last four digits of the social security number associated with the account. Thus the issue—and the resulting 15 month timeframe for resolving it—was not due to technical limitations per se, but rather due to concerns about maintaining privacy regarding customer data.

Eventually the utility and EFI developed protocols and processes by which they could inform customers of the need to enter this information and allow customers to decide whether to provide that information or not. The solution involved adding a brief interactive call intercept system on each state's toll free phone line that informs customers about their option to order bulbs by phone and plays a recording that informs them of the terms and conditions to do so. Figure 15 shows a flowchart illustrating the new call handling process.

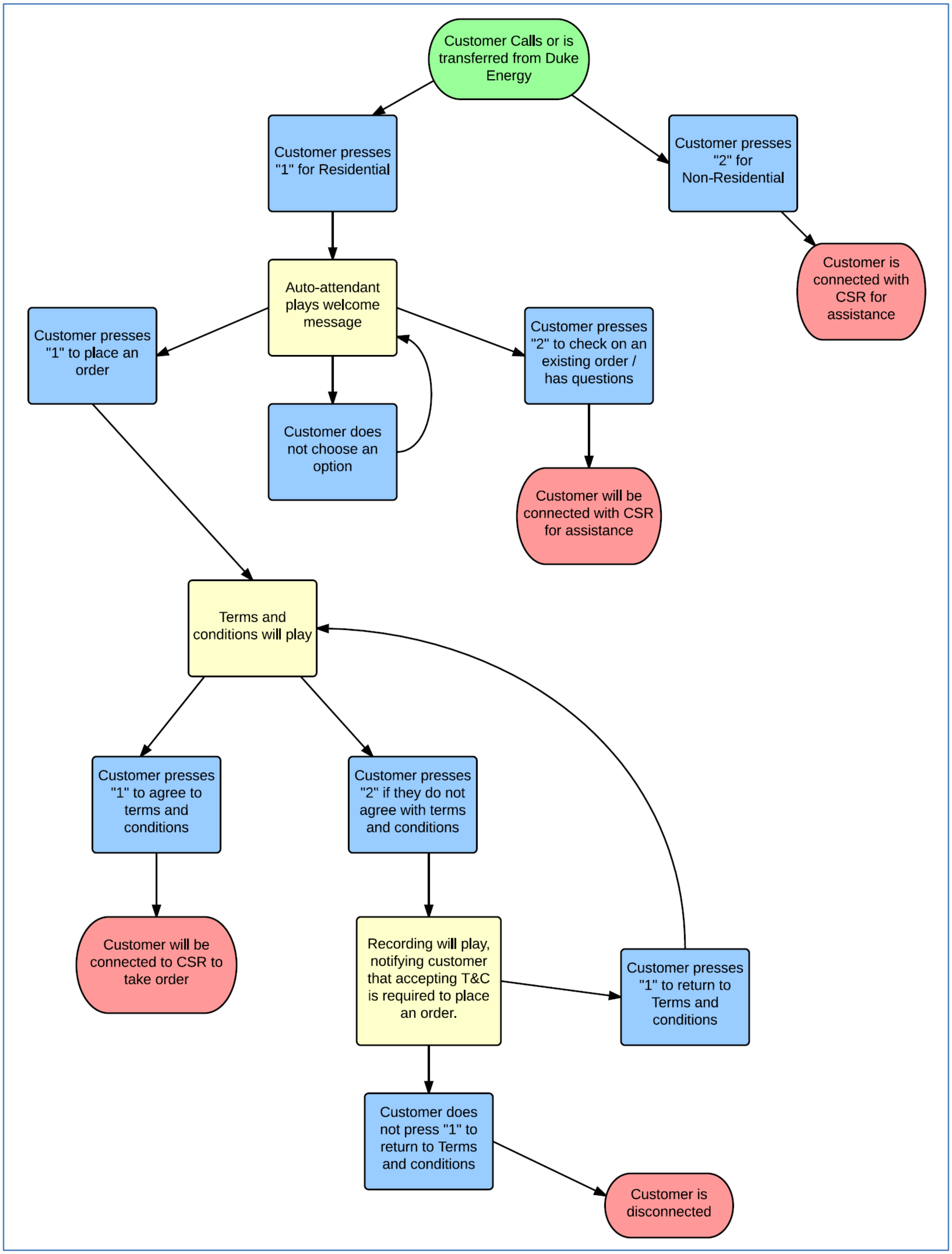


Figure 15. Process for Taking Phone Orders

To accompany the new call intercept system, Duke Energy developed an updated training manual for EFI's CSRs, providing specific instructions that describe how to log in to a customer's account and how to place an order on behalf of a customer, as well as information about how to respond to issues such as customers being ineligible for the program and not knowing the last four digits of the social security number on file.

To date the actual number of phone orders received from Ohio customers has been modest with 118 customers requesting phone purchases between July 31 and October 31, 2014. This represents 3.8% of the Ohio sales volume when compared to a total of 3,077 unique invoices generated during the same time period. Nonetheless, TecMarket Works commends Duke Energy on this improvement since enabling CSRs to take phone orders has specifically helped Duke Energy to broaden the program's ability to better serve customers who are unable or disinclined to shop online.

According to EFI's call center manager, when phone calls for all reasons are tallied, Duke Energy's Specialty Bulb Program received a combined average of 10 calls per day from customer callers in OH, KY, IN, NC and SC in 2013. In 2014 call volumes rose to an average of 15 calls per day. During the midst of a marketing campaign call, volume can rise to 40 calls per day. Ohio callers represent a modest percentage of this total volume, averaging 0.44 calls per day in 2013 and 1.18 calls per day in 2014. TecMarket Works considers this to be a low call volume given the number of sales generated. The low call volume is the direct result of a well-designed web platform and the self-service nature of purchasing the bulbs online.

During 2013 the average call lasted three minutes. In 2014 that average rose to five minutes, primarily as a result of the extra time it takes to handle phone order requests. Duke Energy and EFI consider this increased call handling time to be worth the effort since the new capability has improved customer service.

While customers can and do contact the call center directly, the call center manager indicated that a percentage of the calls received for the Savings Store also come as transfers from Duke Energy's customer service call center. Regardless of whether the call originates from Duke Energy or directly from the customer, EFI CSRs are trained to answer calls as official Duke Energy representatives in order to facilitate consistent customer service. This same warm transfer approach also applies in reverse. When EFI CSRs receive customer requests for their free CFLs, which are offered through a separate efficiency program, the CSRs transfer the callers back to Duke Energy rather than simply providing a phone number.

CSR training begins with classroom lessons and then progresses into side-by-side training with a trainer. Initially the trainee observes as the trainer handles the calls. Then the roles reverse with the trainer monitoring as the CSR handles the calls. On average it takes four to eight weeks before the CSR is working independently. Training topics include operational tasks such as using the phone system and software, soft skills such as customer service etiquette, and inventory familiarization. Then the CSRs begin to learn about utility specific programs. In Duke Energy's case, that specialized training includes such things as: basic guidelines for identifying the utility's program, incentive limits, and protocols for transferring calls back and forth with the Duke Energy customer service call center. The training also necessarily covered how to use the mockups to guide callers through the Duke Energy Store, and since July of 2014 it includes the new process for logging in to the Savings Store in order to place an order on a customer's behalf.

Whereas some call centers script virtually all possible customer interactions, EFI's approach favors informed conversation over canned answers. "Customers get turned off when somebody is reading off a script, so we don't use lot of that. Instead we hire people who can talk on the phone and generate rapport," explained EFI's call center manager. "We aggregate all the program information and put it in a program guide so our people can bring up a page with all the information they need to answer questions."

During 2013 the most commonly asked questions involved:

1. Assistance placing orders on the website
2. Product inquiries about bulbs and applications (such as the difference between directional bulbs versus spotlights)
3. Status of orders
4. Replacement requests for damaged or defective products
5. Requests for free CFLs (a separate Duke Energy program)
6. Other: including questions regarding billing, misdirected calls, etc.

As of November 2014, the most commonly asked raised topics were:

1. Requests to place phone orders
2. Assistance placing orders on the website
3. Product inquiries about bulbs and applications
4. Status of orders
5. Other: including questions regarding billing, misdirected calls, etc.
6. Replacement requests for damaged or defective products

All incoming calls are recorded and monitored for training and quality assurance. CSRs receive monthly coaching with a call center supervisor, during which time they review calls, discuss areas for improvement, and share best practices. Although Duke Energy retains the option to review the recordings, the EFI call center manager indicated that thus far the utility had not done so.

Quality Assurance

Quality assurance for the program is addressed on several levels. EFI's order assembly process maintains redundant systems that allow it to double check every customer order for accuracy. EFI also conducts regular inspections of all physical inventory and the vendor regularly audits its on-floor operational processes to ensure that its fulfillment processes operate as smoothly and as accurately as possible.

All specialty bulbs sold through the Duke Energy Savings Store are warranted by EFI for one year. Beyond that time, the manufacturers' warranties apply. If a bulb arrives damaged; if it burns out; or if it otherwise becomes defective within the first twelve months, customers can call EFI's call center to request a replacement. EFI provides new bulbs and covers the shipping costs with no proof required. Broken and defective bulb replacements are noted and coded into daily quality assurance tracking. Summary reports are provided monthly. Customers can also arrange to return working bulbs if they do not like them or if the wrong item was ordered. These returns and exchanges are also recorded daily and reported monthly.

According to program tracking reports, out of the 183,669 bulbs shipped to 8,524 Ohio customers between April 26, 2013 and November 15, 2014, only 142 customers reported a total of 433 broken or defective bulbs. Of these, 50 bulbs were defective and 383 arrived broken. This represents two tenths of one percent of bulbs sold.

EFI closely monitors all product QA reports for the Duke Energy program, as well as QA reporting for its other clients. EFI adjusts its suppliers and inventory as necessary to maintain consistently high quality for every item it sells. For instance, in one incident, a bulb manufacturer announced backorder delays of three weeks due to a plant closure in Southeast Asia. In response, EFI immediately removed the supplier's bulbs from the Store website to curtail new orders; insisted on delivery of bulbs to meet existing orders within seven days; and rapidly replaced the supplier's bulb item with one from a firm with a reputation for providing consistent supply. The plant closure caused some customer orders to ship as partial completes for a few days, but thanks to these fast actions it did not have lingering effect on customer orders.

EFI and Duke Energy cited no notable issues with service level agreements regarding product quality, shipping breakage, or returns. Nor have any quality assurances issues arisen with any other aspect of the program.

Data Tracking and Reporting

Duke Energy and EFI take full advantage of the tracking and reporting opportunities made possible through online metrics and customer tracking. That tracking begins with OLS intercept reports that indicate which customers saw promotions for the Savings Store when they accessed their accounts online. Reviewing which customers clicked through to the Store helps Duke Energy to further refine its targeting and marketing messaging. As shown in Table 11, since program launch Duke Energy has presented Ohio customers with more than three quarters of a million (751,412) OLS intercept messages while they accessed their online accounts. Four percent (4.2%) of customers who saw the OLS messages clicked through to shop at the Store, and of the customers who clicked through, 10.7% placed orders. TecMarket Works considers this to be a noteworthy and cost effective way for Duke Energy to be generating specialty bulb sales.

Table 11. OLS Tracking Data

Ohio	OLS Intercepts	Shop Now	Take Rate	Orders	Bulbs	Avg/Bulb	Conversion Rate
Apr 26 – Dec 31, 2013	303,853	16,545	5.4%	606	8,658	14.3	3.7%
Jan 1 – Nov 15, 2014	447,559	14,713	3.3%	2,728	29,235	10.7	18.5%
Total	751,412	31,258	4.2%	3,334	37,893	11.4	10.7%

The program team also tracks the success rate of customers who are authenticating and passing through to the Savings Store. Once on the Store itself, EFI systems track virtually every click the customer makes. Website traffic flow analysis reveals the most frequently followed links, the amount of time spent on each page, and the relative popularity of webpage elements such as images, videos, and online resources and tools. “These analytics are great for identifying trends and patterns, but web tracking also has its limitations,” explained EFI’s Vice President of Strategic Development, “So we’ve also created scorecards profiling the number of products sold, average order size, the most popular items being purchased, frequency, and other shopping details to give Duke greater richness around the web metrics.”

These and other details are made available for Duke Energy through a suite of online tools that can be used 24/7 to obtain daily updates for the following reports:

- Participation Upload
- Customer List
- Order Detail
- Order Summary (by Order Number)
- Order Summary (by Invoice Number)
- Invoice Summary by Measure ID
- Customer Cart
- Open Orders
- Shipped Summary
- Shipping Cost
- Returns
- Replacement Returns

These self-service reports are supplemented with EFI’s monthly reports that summarize program activities and measure performance against the program’s service level agreements. No concerns or issues were reported in regard to the reporting tools.

Management Coordination and Communication

Team members from Duke Energy and EFI report positive working relationships, with each side providing experiences and insights that complement and strengthen the other firm. For instance, the Savings Store represents Duke Energy’s first foray into the online retail arena. As such, the utility has drawn upon EFI’s expertise in e-commerce and product distribution. In turn, Duke Energy’s authentication and other technical requirements required a new level of sophistication from EFI’s web programmers.

Duke Energy representatives characterized the EFI team members as “knowledgeable,” “highly responsive and reliable,” and “cooperative and easy to work with.” In turn, the EFI team spoke highly of their Duke Energy colleagues, describing them as “our strongest e-commerce client,” “excellent marketers,” and “highly customer focused.” Interestingly, numerous representatives from both firms chose to describe the other business partner as “highly professional” and “a pleasure to work with.”

Team members from Duke Energy and EFI meet semi-monthly to discuss marketing strategy. They also meet monthly to reconcile accounting, review program performance, as well as to plan improvements and changes. In addition to these regular phone conferences, the team meets in person quarterly. These regularly scheduled meetings are supplemented by daily phone and email exchanges as necessary to address program operations and implement any upgrades and fixes.

No communication or relationship challenges or issues were reported by any party.

Planned Improvements and Desired Program Changes

The team responsible for Duke Energy Savings Store takes a proactive approach to program improvements. They have a steady list of planned feature upgrades to the Savings Store, as well as other enhancements intended to improve the customer experience and make program management easier. The most significant change will be a complete replacement of EFI's ecommerce system with a new platform called Magento, which is owned (and used) by eBay. The new platform will enable the following improvements.

- Native support for mobile devices
- Visitor-selectable product filtering
- Visitor-selectable product comparisons by feature or specification
- Dynamic presentation of associated savings information ($, kWh, etc.)
- Product review/rating functionality
- Customized shopping experience, allowing products to be recommended based on visitor behavior
- Dynamic price presentation based on program rules
- Additional promotion models (e.g. buy X and automatically get Y for free)
- Support for additional shipping calculation methodologies and discount options
- Support for additional payment methods (such as Google Wallet, PayPal)
- Integration with social media apps
- Embedded customer sales support
- More flexible site structure, allowing store elements to be easily repositioned and custom designed
- Improved video functionality
- More complete integration with Google Analytics

The transition to the Magento platform was expected to be completed sometime during the first quarter of 2015.

Another program improvement that is underway but as yet unfinished is the development of an automated customer survey system that sends email messages requesting feedback about the Store, its product offerings, and any issues needing correction. The initial plan for the survey is to include a feedback request and a web link along with the order-confirmation email that is automatically generated by EFI. This approach offers the advantage of requesting feedback from every customer, but the timing makes it less useful for collecting customer thoughts regarding shipping, physical products, and post-sale follow up support. For this reason, Duke Energy indicated that it is considering the possibility of changing the timing or sending a separate request after product delivery.

Evaluation and Recommendations

Key Findings

- The program website, called the Duke Energy Savings Store, was launched in April of 2013. It can only be accessed by Duke Energy customers (verified via account number) whose bulb purchases are individually tracked so that personal incentive limits can be enforced.
    - See section titled *Program History and Development* on page 21.

- The program sells three-way bulbs, dimmable bulbs, outdoor bulbs, reflectors (recessed), candelabras, capsules (A-Line) and globes in both CFL and LED varieties. CFL indoor reflectors and LED capsules were the most popular bulb types, followed by CFL candelabras and CFL globes.
    - See section titled *Program Goals and Performance* on page 21.

- Between program inception on April 26, 2013 and December 31, 2013, a total of 3,359 Ohio customers purchased 50,695 specialty bulbs. Between January 1, 2014 and November 15, 2014, an additional unique 8,524 customers purchased 132,974 bulbs. Combined program participation shows a total of 11,616 unique Ohio customers who purchased at total of 183,669 specialty bulbs over the 19 month period.
    - See section titled *Program Goals and Performance* on page 21.

- Duke Energy effectively combines low cost marketing vehicles such as email, website promotions and intercepts, and direct mail with sophisticated targeting techniques to ensure high conversion rates at low acquisition costs.
    - See section titled *Program Marketing* on page 25.

- Overall, the website functions well and is deliberately designed for visitor usability, but it still presents opportunities for improvement, which are detailed in this report.
    - See section titled *Duke Energy Savings Store Website* on page 30.

- The program has no significant issues with quality assurance. Nor does it have any notable customer service issues or challenges.
    - See section titled *Quality Assurance* on page 53.

- All members of the Duke Energy and EFI teams report positive working relations.
    - See section titled *Management Coordination and Communication* on page 55.

Evaluation

- Overall Duke Energy's Specialty Bulb program is well-designed and well-run. The Duke Energy Savings Store website is successfully educating customers and encouraging them to save energy by making it fast and easy to replace their old, inefficient specialty bulbs with new, affordable energy efficient models.

- Program participation is strong. Between program launch on April 26, 2013 and November 15, 2014, the Duke Energy Savings Store for Ohio served 11,616 unique customers who placed a combined total of 12,854 orders for 183,669 bulbs. This equates to averages of 15.8 bulbs per customer, 14.3 bulbs per order, and 22.6 orders per day. When year to year comparisons are made, the program's growth appears quite robust with a 254% increase in unique customers placing orders.

- Duke Energy approaches marketing for the Specialty Bulb Program in a systematic manner that reaches out to its residential customers with free and low cost vehicles, such as online promotions and bill inserts, while simultaneously deploying sophisticated segmentation techniques that target those customers who are most likely to make purchases online and take advantage of the program's incentives. Conversion rates are tracked step-by-step for every customer for every campaign, starting with initial responses for each marketing vehicle, through authentication and website visits, to the final individual items purchased at the Savings Store. This combination of low cost yet highly sophisticated approaches helps to ensure healthy participation rates while keeping the program's overall customer acquisition costs down.

- The Duke Energy Savings Store website is well designed for easy visitor usability, although the site still presents some opportunities for continued fine-tuning, as discussed in the recommendations section below. The planned upgrade of the website's entire e-commerce platform in the first quarter of 2015 should bring significantly increased functionality.

- In terms of the variety of specialty bulbs offered by the program, the product inventory appears to be well chosen and deliberately limited so that a wide range of bulb applications are met with a small number of bulb types. This stocking strategy facilitates easier decision making for customers, and it helps to simplify inventory management. EFI demonstrates consistently strong performance with its inventory maintenance, as well as with shipping and delivery. The program also has no significant issues with quality assurance.

- The program has no customer service issues or challenges.

- When phone calls for all reasons are tallied, Duke Energy's Specialty Bulb Program received a combined average of 10 calls per day from customer callers in OH, KY, IN, NC and SC in 2013. In 2014 call volumes rose to an average of 15 calls per day, both as a result of increasing numbers of customers served and due to the addition of new capability to take phone orders. Ohio callers represent a modest percentage of this total volume, averaging 0.44 calls per day in 2013 and 1.18 calls per day in 2014.

- All parties agree that the Duke Energy and EFI teams work well together, sharing common goals and working collaboratively to ensure the program is as effective as possible.

- In summary, TecMarket Works considers this to be a robust energy efficiency program that well serves the customers in Duke Energy's Ohio service territory. Moreover, the success of the program promises well for the potential expansion of inventory to include non-lighting energy savings devices as well.

Recommendations

1. **If feasible, consider upgrading the energy savings calculator on the Duke Energy public website** at http://www.duke-energy.com/residential-savings-store so that the public version of the calculator features the same interactive functionality as the version installed on the Savings Store website. Doing so will enable more customers to see how much they can save with specialty bulbs prior to requiring them to log on to the Store itself.

2. **Test and improve the Savings Store's search features.** Because web search functionality yielded inconsistent results or failed to find items using key words commonly found on the website, the Savings Store's search features should be tested and improved to accurately reflect store inventories using the Store's names for bulb types and application types. The search function should also yield accurate results when visitors include associated terms such as lighting, bulb, and other common words and phrases. Likewise the search feature should yield accurate results for entries with singular and plural spelling, such as spiral and spirals.

3. **Test the suggested website usability improvements.** Although the program team plans to update the Savings Store's e-commerce platform during the first quarter of 2015, the Store's overall website design should be continually refined and optimized as well. With that mind, we offer the following suggestions to help improve customer education, streamline site visitor usability, and increase sales.

    - Changing link text to a more distinct color or adding underlines may make links more prominent.
    - Adding a "more information" button on the product summary page may help customers to realize additional information is available.
    - Customer bulb comparison with older incandescent bulbs may be eased by including text citing the most similar incandescent bulb in terms of wattage and lumens, or by inserting a link to the "About Brightness" table.
    - Including an "Add to Cart" button on the initial bulb summary page will eliminate the need for customers to make additional clicks before buying the item they want.

- Creating a Brightness comparison tab or otherwise providing additional information such as lumens and color temperature with the other information in the Estimated Savings tab area may facilitate easier customer decision making. Including an Energy Star-style light bulb facts and lumen comparison chart will also be helpful to customers. The Energy Star website[10] provides an example.
- Provide the consistent ability for visitors to see larger images of the bulbs they want to buy and show the bulbs from multiple points of view. This will make it easier for customers to assure themselves they are buying a bulb comparable to the old one they currently have.
- Consider standardizing and explaining the product specifications provided for the items listed for sale on the Duke Energy Savings Store.
- Make a minor edit to the installation instructions for MR16 bulbs and other bulb types that do not comply with the standard “screw-in” instructions.
- Enable a feature that allows customers to select and compare CFL and LED bulbs at a detailed level, including watts, lumens, bulb life, price, estimated savings and product specifications.
- Showing photographs or drawings of bulb types and shapes will make it easier for customers to compare their old bulbs with the new bulbs offered for sale on the website. An excellent example of this approach can be found on the light bulb buyers guide page of Amazon.com.[11] Furthermore, clicking on the image or shape for the old bulb could bring up a list of possible replacements.
- Insert a “Save Cart” button into the list of buttons displayed in the shopping cart, or otherwise move the display box to make the save function more obvious for site visitors.

4. TecMarket Works considers the above mentioned bullet list of ideas to be suggestions rather than formal recommendations. We do however formally recommend that Duke Energy and EFI use some form of systematic testing measures, such as A/B Split Testing, to determine if more customers take action with or without the above mentioned suggestions. For example, split testing can be measured using the Content Experiment feature of Google Analytics, which enables simultaneous testing of two or more versions of the same web page to see which versions of page content and designs are most effective. We recognize that other testing techniques may be more applicable to the program’s website platform and encourage Duke Energy and EFI to explore the most appropriate options.

5. Despite the fact that the number of out of state bulb shipments is low, **we encourage Duke Energy to consider limiting the customer’s ability to purchase and ship specialty bulbs to addresses located outside its service territory.** While the ability to do so represents proactive customer service and may therefore help to increase customer satisfaction, it also fosters the opportunity for incented bulbs to be installed in locations

[10] http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_color
[11] http://www.amazon.com/gp/feature.html/ref=amb_link_356841462_1?ie=UTF8&docId=1002234061&pf_rd_m=ATVPDKIKX0DER&pf_rd_s=product-alert&pf_rd_r=1XK8CAY99M4TXE02YDH5&pf_rd_t=201&pf_rd_p=1740479022&pf_rd_i=B002NH5TTA

where Duke Energy cannot appropriately claim savings while adding costs to Duke Energy's customers.

6. Because this program involves incentives paid to customers for items sold elsewhere at retail prices, we encourage Duke Energy to **carefully watch the marketplace for technology and pricing changes and to adjust incentive levels accordingly**, particularly as LED prices continue to drop. As retail store pricing becomes more competitive with Savings Store pricing, the need for incentives will shift or diminish.

7. Finally, we suggest that Duke Energy **consider the possibility of expanding the program to promote the adoption of additional specialty bulb types**, as well as smart devices for home automation, and other efficiency measures, such as those for saving water or tightening building envelopes.

Participant Surveys

Awareness and Participation in the Program

All surveyed participants are aware of their participation in this program (100% of 192), and 99.0% confirmed that they purchased the same type and quantity of bulbs as shown in program records (only two customers reported purchasing a different number or type of bulbs than program records).

A majority of surveyed program participants in Ohio (63.0%) first learned about the Savings Store from letters and brochures they received in the mail, as seen in Figure 16. More than one participant in four mentioned learning about the Savings Store from messaging at the Duke Energy website (27.6%) and roughly one participant in ten mentioned emails from Duke Energy (11.5%).

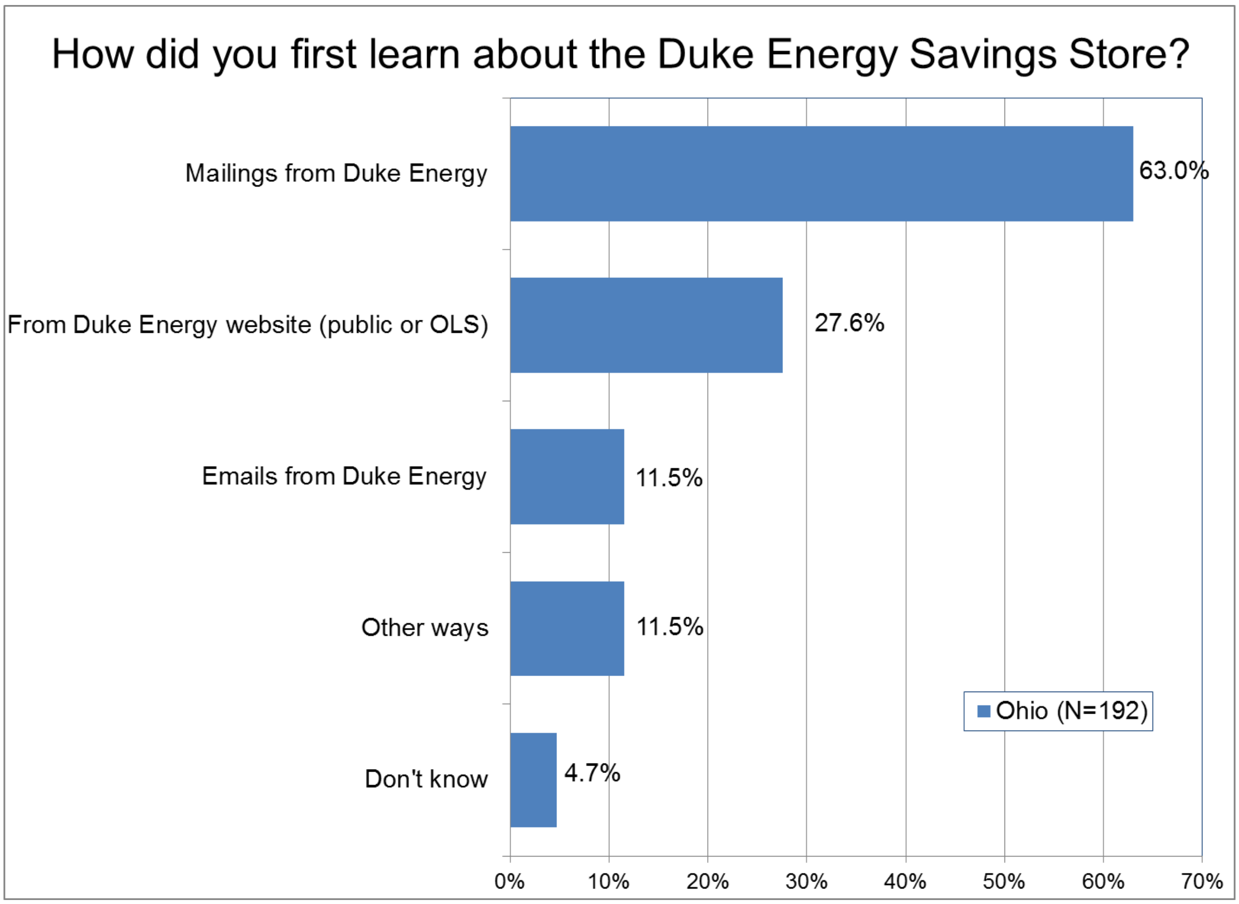


Figure 16. Source of Awareness for Duke Energy's Savings Store (N=192)
Percentages total to more than 100% because participants could name multiple sources of awareness.

Breaking these results down further, among participants who recalled mailings from Duke Energy 40.5% (49 out of 121) mentioned bill inserts, 48.8% mentioned mailings that did not come with bills and 10.7% say they received both types of mailings. Among participants who mentioned messaging from the Duke Energy website 81.1% (43 out of 53) said they saw a message while accessing their account online, 15.1% saw a message on the public section of the site and 3.8% mentioned seeing both of these types of online messaging. Among customers who first became aware through emails, 36.4% (8 out of 22) specified a paperless billing email while 59.1% described this contact as "an email from Duke Energy or a Duke Energy employee" and 4.5% received both of these types of email contact.

Twenty-two surveyed participants named "other" sources of awareness of the program, which are summarized below (these responses add to more than 22 because participants could mention multiple sources).

- Recommendation of a friend / family / neighbor / co-worker (n=9)
- Flyer in box with free CFLs from Duke Energy (n=5)
- Through participation in other Duke Energy programs (n=4)
    - My Home Energy Report (n=2)
    - Home Energy House Call
    - "*In the past, Duke offered the free CFLs so I was able to get used to them.*"
- Media reports: TV, radio, newspaper (n=3)
- Through school / children in school (n=2)

Factors Motivating Participation

Participants were asked to list all of the reasons that they purchased light bulbs from the Savings Store, including the main reason for their participation; these results are shown in Figure 17. The most frequently mentioned reason is to save money on light bulb purchases, which is the main reason for participation for a majority of customers (58.9%) and a secondary reason for another 22.9%, and is thus mentioned as a reason for participation by 81.8% of surveyed participants overall. The second most-mentioned reason for buying bulbs from the Savings Store is to save energy, mentioned by about a third of surveyed customers overall (30.2%), while a quarter of participants mention the ease and convenience of purchasing bulbs from the Savings Store (25.0%).

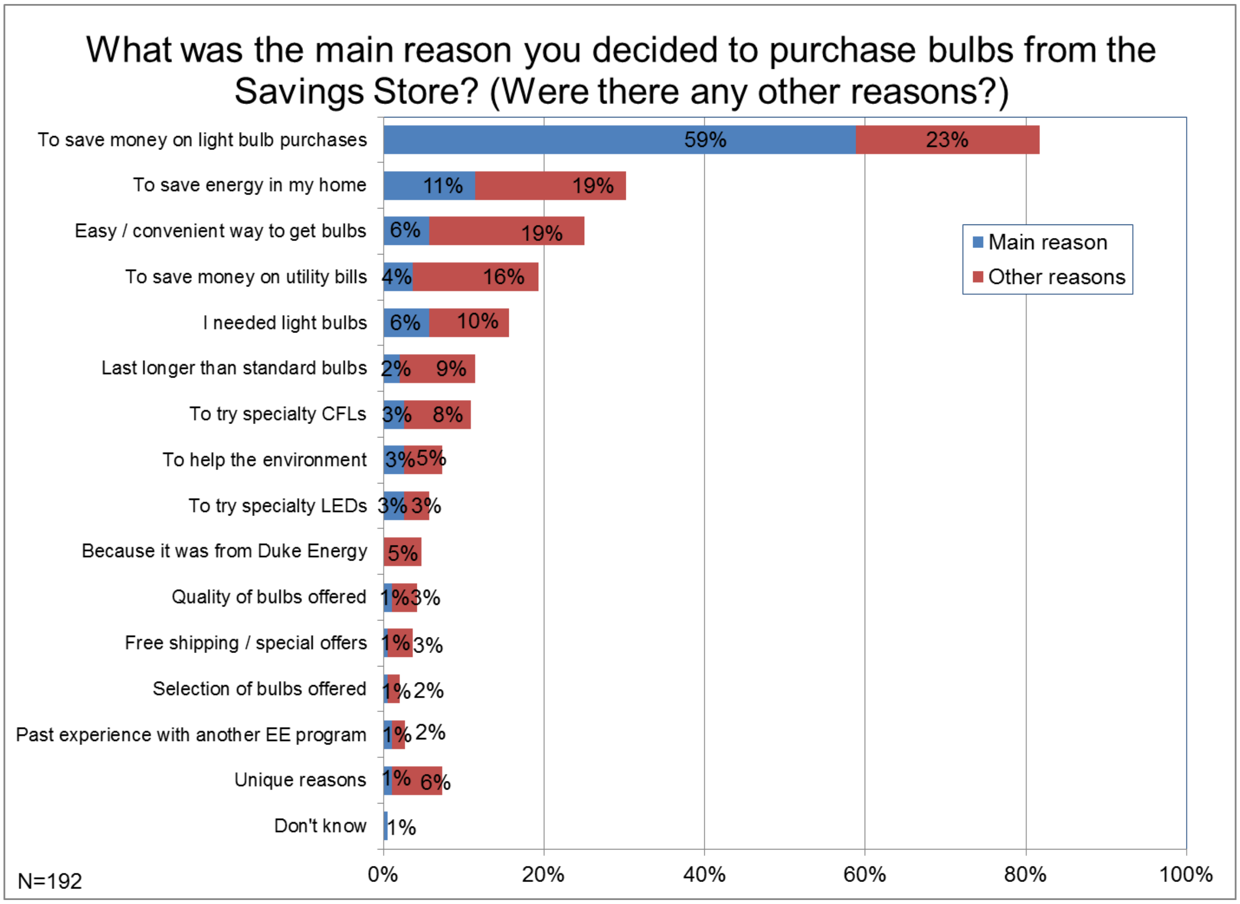


Figure 17. Factors Motivating Light Bulb Purchases from the Savings Store (N=192)
"Other reason" percentages total to more than 100% because participants could name multiple "other" reasons. "Main reason" percentages total to 100% because participants could only name one "main" reason.

Fourteen participants gave unique reasons for purchasing bulbs from the Savings Store; these include wanting efficient bulbs in high-usage sockets, wanting to replace "ugly" CFLs, wanting lighting that generates less heat, wanting consistent lighting (all the same brands and colors in a room), a desire for a specific brand, and a general preference for purchasing items in large quantities.

Five participants mentioned their experience with other energy efficiency programs: two specified past participation in free CFL programs and one mentioned Duke Energy's My Home Energy Report (the other two respondents did not specify which programs).

Participants were also asked "*Why do you think that Duke Energy is providing discounted specialty bulbs to their customers?*" Figure 18 shows that the top explanations given by customers are that Duke Energy wants to save energy for economic reasons (33.9%), for environmental reasons (32.8%) and because Duke Energy wants to save their customers money (21.4%). Only 10.9% of participants surveyed could not offer an explanation for Duke Energy's motives ("don't know.")

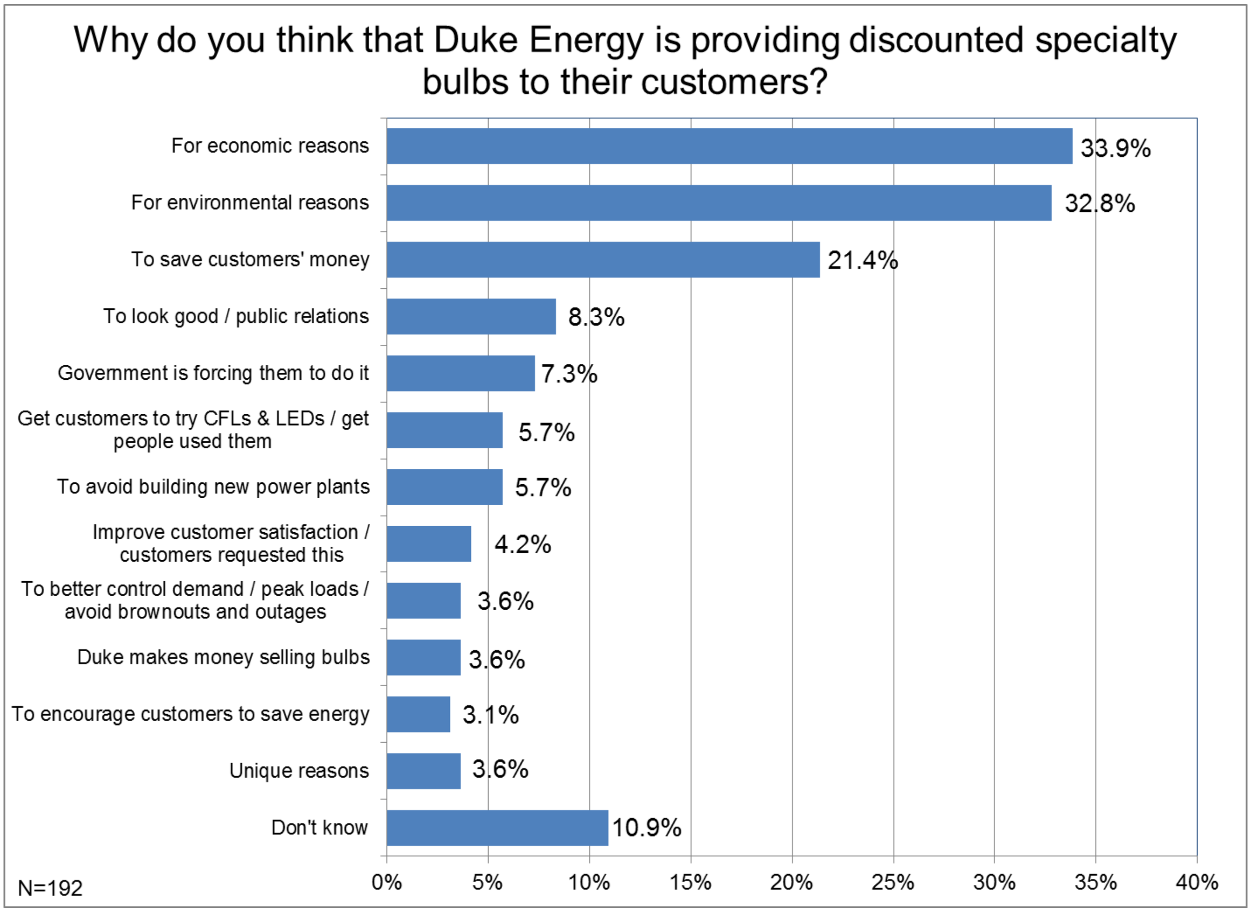


Figure 18. Why Participants Believe Duke Energy is Offering the Program (N=192)
Percentages total to more than 100% because participants can give multiple responses.

Seven surveyed customers gave unique explanations as to why they think Duke Energy is offering this program: two suggested that this program will allow Duke Energy to increase the rates they charge customers, while other explanations include that Duke Energy wants to increase the number of services they offer, to increase the number of customers they serve, to take advantage of a "*government grant*" and to encourage the use of light bulbs with greater longevity.

Savings Store Website Information and Tools

As seen in Table 12, only about a quarter (25.5%) of surveyed customers recalled the information resources at the Savings Store website, and only about one in six customers (16.7%) recalled something that stood out as useful or important to them.

Table 12. Recalling Useful and Important Information from the Savings Store Site (N=192)

	Ohio (count)	Ohio (percent)
The website provides a number of resources designed to provide additional information, including written explanations and videos about bulb types and uses, brightness, and bulb recycling and safety. Do you recall any of these informational resources?		
Yes, recall information resources and something specific stood out as useful or important	32	16.7%
Yes, recall information resources but nothing stood out as useful or important (including can't recall anything that stood out)	17	8.9%
No, do not recall information resources	127	66.1%
Don't know / can't recall	16	8.3%

The 32 customers who recalled something useful or important were asked what it was; these responses are categorized below (more than 32 responses are listed because respondents could recall more than one category of information).

- Comparative information about light bulbs: dimensions, shapes, features, wattages and common uses for different bulb types (n=13)
- Watched informational videos (n=6)
- Information about lumens and brightness (n=5)
- Information about light colors (soft white, daylight, etc.) (n=4)
- Energy savings for efficient bulbs versus incandescent bulbs (n=3)
- Recycling, disposal and safety (n=2)

As seen in Table 13, less than a third of surveyed customers (29.2%) recall that there is an Energy Savings Calculator tool at the Savings Store website, and only about one in seven customers (14.0%) actually recall viewing this tool. However among customers who viewed the tool, most (74.1% of 27) were aware that it is an interactive feature.

Table 13. Recalling the Energy Savings Calculator Tool from the Savings Store Site (N=192)

	Ohio (count)	Ohio (percent)
The Duke Energy Savings Store features an Energy Savings Calculator that you can use to calculate the amount of money you'll save on bulb purchases and on your Duke Energy bill. It also shows how much CO2 you'll offset by using more energy efficient bulbs. Do you recall the Energy Savings Calculator?		
Yes, recall calculator tool: viewed it, and was aware that the tool is interactive	20	10.4%
Yes, recall calculator tool: viewed it, but was not aware that the tool is interactive	7	3.6%
Yes, recall calculator tool but did not view it (including can't recall if tool was viewed)	29	15.1%
No, do not recall calculator tool	121	63.0%
Don't know / can't recall	15	7.8%

Number of Visits to the Savings Store and Number of Purchases

Participants were asked how they accessed the Savings Store website. As seen in Table 14, about a third (34.4%) entered the URL directly into their browser and nearly as many (30.7%) used a link from their Online Services (OLS) accounts; another 15.1% visited the store via the public portion of the Duke Energy website and about one participant in six (16.1%) could not recall the method they used to visit the Savings Store. Three participants (1.6%) placed their orders by telephone.[12]

Table 14. Accessing the Savings Store Website (N=192)

	Ohio (count)	Ohio (percent)
Entered URL directly into browser	66	34.4%
Via a link in my Online Services account (OLS)	59	30.7%
Via a link on the Duke Energy public website	29	15.1%
Used an online link received via email, social media, etc.	9	4.7%
Used a web browser favorite / bookmark	4	2.1%
Ordered by telephone (not online)	3	1.6%
Friend or relative placed the order online for me	2	1.0%
Internet search engine (Google)	1	0.5%
Don't know / can't recall	31	16.1%

Responses total to more than 100% because respondents could give multiple responses.

Participants were asked how many times they visited the Savings Store website before they made a purchase. Table 15 indicates that five out of six participants (83.9%) purchased light bulbs on their first or second visit to the Savings Store, though 14.1% visited three or more times before

[12] EFI began placing orders on behalf of customer via telephone on July 31, 2014. Prior to that time customers who phoned in were guided through the buying process by customer service representatives as the customer placed their own orders via the Store website.

purchasing. The largest reported number of visits before making a purchase is "*four or five times*."

Table 15. Number of Visits to Savings Store Before Purchasing Light Bulbs (N=192)

	Ohio (count)	Ohio (percent)
Made purchase during first visit to the Savings Store	76	39.6%
Made purchase during second visit	85	44.3%
Made purchase during third visit	23	12.0%
Made purchase on fourth visit or later	4	2.1%
Don't know / can't recall	4	2.1%

Participants were also asked how many times they have visited the Store in total, and how many times they have made purchases in total. On average, surveyed participants visited the Savings Store site 2.3 times apiece (with 62.4% visiting two or more times); the median number of visits per participant is two, and the maximum reported number of times visiting the site is twelve. Most survey participants (85.4%) have only purchased bulbs from the Savings Store one time, though 13.5% of participants report having made two purchases and 1.0% report three purchases (none report more than three purchases). Overall, most participants (55.7%) have visited the Savings Store more times than they have made purchases from the Store, while a minority of 42.2% have made a purchase every time they visited the Store and the other 2.1% of participants either were not sure or did not answer all of the questions.

Participants who visited the Savings Store website more times than they made purchases from the site were asked for the reasons why they visited the Savings Store without making a purchase. Table 16 shows that more than half of these participants (56.1%) said they were "just looking to see what was there" while another 38.3% were "just checking the prices." However, nearly a quarter of participants (22.4%) were making comparisons between Savings Store offerings and those of other retailers.

Table 16. Reasons for Visiting the Savings Store without Making a Purchase (N=107)

Base: 107 customers who visited the Savings Store more times than they have made purchases from the Savings Store	Ohio (count)	Ohio (percent)
Just looking to see what was there	60	56.1%
Just checking the prices	41	38.3%
Making comparisons with other retailers	24	22.4%
Looking for specific information about bulbs	10	9.3%
Could not decide which bulbs to buy	10	9.3%
Was not ready to make a purchase	7	6.5%
Too busy to complete order / ran out of time	6	5.6%
Had to determine the number and type of bulbs I needed	5	4.7%
Wanted to see physical products instead of images online	4	3.7%
Had unanswered questions	2	1.9%
Could not complete transaction due to technical issues	2	1.9%
Unique reasons, listed below	10	9.3%
Don't know / can't recall	3	2.8%

Responses total to more than 100% because respondents could give multiple responses.

Twenty-four participants reported that they visited the Savings Store to make comparisons with other retailers; these retailers are listed below (this list totals to more than 24 because respondents could mention multiple retailers).

- Home Depot (n=14)
- Lowe's (n=10)
- Walmart (n=5)
- Target (n=3)
- Amazon.com (n=3)
- Menards (n=2)
- Kroger (n=2)
- One mention apiece: Sam's Club, Dollar General, Meijer, "*online lighting stores*"

Ten participants reported that they were looking for specific information about the bulbs available at the Store; most of the information sought had to do with ensuring that the bulbs they were considering would function and fit in their intended sockets. Many of these participants seem to know what they were looking for (a dimmable bulb or bulb of a particular wattage) and were verifying that the store bulbs met their needs, though a few participants were "*looking at new products*" or "*becoming familiar with what's available*."

Ten participants reported that they visited the Savings Store without making a purchase because they "could not decide which bulbs to buy"; virtually all of these participants explained that there was something they needed to verify about the bulbs they needed (size, shape, quantity, etc.) One participant specified that they were seeking LED outdoor reflector bulbs and could not find these at the Savings Store, while another participant said they were trying to decide between purchasing CFLs and LEDs.

Seven participants reported that they visited the Savings Store without making a purchase because they "were not ready" to do so; most of these customers reported that they had to verify something about their order (bulb size, type or quantity needed) or else consult with another member of their household before making a final purchase decision.

Two participants reported that they visited the Savings Store without making a purchase because they "had unanswered questions"; their questions are listed below.

- *I didn't know whether the bulbs fit in my fixtures, what color of light it was: whether it was blue, white, or yellow. I didn't know whether the bulbs would stick out above the lampshade or whether they'd fit in my fixtures.*
- *I wanted to see how the bulbs available from the website would be used in their intended lighting setting. I wanted to see the bulbs installed in the fixtures they were most likely intended for, like how the candelabra bulbs would look in a fixture.*

Two participants reported that they visited the Savings Store without making a purchase because of "technical issues"; their issues are described below.

- *I got all the way to the last page and I could not complete my purchase. After the third attempt at putting everything in again, I called Duke and they said they were having technical difficulty with the website. I tried for a fourth time the following month and was successful.*
- *I visited the website but became confused between the Savings Store and the free CFL Program.*

Ten participants reported unique reasons for visiting the Savings Store without making a purchase; these include not having credit card information ready, wanting to call the customer service number for more information, wanting to do more research, altering an order and returning an item. One participant believed they were not eligible for the program during one of their visits to the Savings Store, though this customer confirms purchasing bulbs from the Store.

Ordering and Shipping Light Bulbs from the Savings Store

Table 17 shows that customers overwhelmingly used credit cards (95.8%) to pay for their orders from the Savings Store; only two customers (1.0%) reported paying by check or money order. However, more than one customer in ten (13.5%) would have preferred another method of buying their light bulbs other than ordering them online from the Savings Store; the largest number of these customers stated a preference for shopping in stores to ordering online (5.2%) or would have preferred to order over the telephone (3.6%).

Table 17. Methods of Paying for Savings Store Purchases (N=192)

	Ohio (count)	Ohio (percent)
Paid for Savings Store order by credit card	184	95.8%
Paid for Savings Store order by check / money order	2	1.0%
Don’t recall how Savings Store order was paid for	6	3.1%
Would have preferred another method for purchasing bulbs:		
Prefer purchasing bulbs at a local store	10	5.2%
Would prefer to order by telephone	7	3.6%
Would prefer mail order	3	1.6%
Prefer using coupons at local stores	2	1.0%
Would prefer having bulb charges added to utility bill	2	1.0%
Would prefer unique methods, listed below	3	1.6%
Would not have preferred using another method	166	86.5%

Responses to preferred methods for purchasing bulbs total to more than 100% because respondents could suggest multiple alternate methods.

Three participants offered unique suggestions when asked how they would have preferred to purchase their Savings Store bulbs: one participant would have preferred “*receiving these bulbs for free*”, one would prefer not to use a computer at all “*because I am not good with them*,” and the third suggested that Duke Energy could schedule a truck to visit different neighborhoods so that customers could see the bulbs in person.

The two customers who paid for their light bulbs by check or money order were asked how long they waited from the day they mailed their payment to the day they received their bulbs: one customer reported "*less than two weeks*" and the other said "*I'm not sure but they arrived quickly*."

As seen in Table 18, a little more than half of surveyed customers could not recall what method they used for shipping (55.2% "don't know"). Among those who could recall, the most common shipping methods are U.S. Post (28.1%) and UPS (18.2%). Most customers (57.3%) are aware that there is a feature for tracking the shipping status of their orders, though less than one participant in ten (8.9%) actually used the tracking feature. There are no statistically significant differences in awareness or use of the order tracking feature between customers who shipped by UPS and U.S. Post.

Table 18. Shipping and Tracking Orders from the Savings Store (N=192)

	Ohio (count)	Ohio (percent)
Order shipped by U.S. Postal Service	54	28.1%
Order shipped by UPS	35	18.2%
"*Whatever was cheapest*" or "*standard shipping*"	6	3.1%
Can't recall how order was shipped	106	55.2%
Aware of order tracking feature and used it	17	8.9%
Aware of order tracking feature and did not use it	90	46.9%
Aware of order tracking feature and can't recall if used it	3	1.6%
Not aware of order tracking feature	82	42.7%

The seventeen customers who used the order tracking feature were asked how they accessed this feature. According to Table 19, the most common method was using the package tracking links at the Savings Store website (52.9%) followed by logging on through Duke Energy online accounts (23.5%).

Table 19. Accessing Order Tracking (N=17)

Base: 17 customers who used the order tracking feature	Ohio (count)	Ohio (percent)
Savings Store package tracking links	9	52.9%
Through "My Account" at Duke Energy website	4	23.5%
UPS web tracking feature	1	5.9%
Link in confirmation email	1	5.9%
Calling the phone number to check on post office delivery	0	0.0%
Don't know / can't recall	2	11.8%

Defective Bulbs and Return Policies

Although 6.7% of surveyed participants reported that they received at least one damaged or defective bulb, only 3.6% have actually returned light bulbs that they ordered from the Savings Store, as seen in Table 20. All seven of the customers who returned merchandise received new light bulbs and none took a refund. Another one in six participants (17.2%) reports that they have had Savings Store bulbs burn out or become defective since installation.

Table 20. Damaged and Defective Bulbs and Returning Bulbs (N=192)

	Ohio (count)	Ohio (percent)
Bulbs arrived damaged or defective	13	6.8%
Bulbs became defective or burned out since installation	33	17.2%
Returned bulbs for any reason	7	3.6%
Returned bulbs and received a replacement	7	3.6%
Returned bulbs and received a refund	0	0.0%

The seven customers who returned light bulbs were asked how many bulbs of what types were returned and why they returned them; these responses are listed below (one participant received the wrong bulbs, four participants received obviously defective bulbs, and two participants had bulbs burn out very quickly after installation). These customers were also asked to rate their satisfaction with the return process on a ten-point scale where "10" is highest: six gave their experience with returning merchandise the highest possible "10 out of 10" rating while the seventh participant did not provide a rating.

- *I returned six reflector bulbs; I was sent the wrong bulbs. I sent them back and the correct ones were sent.*
- *I had a capsule bulb replaced, though Duke did not ask me to return the bad one. The bulb arrived rattling and obviously broken.*
- *I sent back two globe bulbs that rattled when I shook them. I was given replacements.*
- *I received one defective outdoor reflector that wouldn't light up.*
- *I returned three dimmable spirals that were flickering and not dimming properly.*
- *Two candelabras burned out right away.*
- *I returned three indoor reflector LEDs that burned out within minutes of installation.*

Participants who returned bulbs were also asked if they had tried installing these bulbs before returning them and if so what type of bulb is currently installed in the socket where they had intended to put the returned bulbs. Four of these seven participants (57.1%) did try installing their returned Savings Store bulbs, and all four of these participants currently have efficient bulbs in these sockets (three installed CFLs and one installed an LED).

Customer Support

Table 21 shows that customers who need assistance are more likely to use telephone support (6.8%) than the *Contact Us* feature at the Savings Store website (1.6%). Large majorities of participants are aware of these contact methods but did not need to contact customer support (79.7% for telephone and 84.4% for web support).