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Duke Energy Progress & Duke Energy Carolinas Neighborhood Energy Saver Program

2021 Evaluation Report - FINAL

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1. Evaluation Summary

1.1 Program Summary

The Duke Energy Progress (DEP) and Duke Energy Carolinas' (DEC) Neighborhood Energy Saver (NES) program provides one-on-one energy education, on-site energy assessments, and energy conservation measures to customers in selected low-income neighborhoods. These services are offered free of charge to all active DEP/DEC account holders who are individually metered homeowners or tenants living in predetermined income-qualified communities. Qualifying neighborhoods have at least 50% of households with incomes equal to or less than 200% of the federal poverty level.

The program employs a neighborhood canvas approach to drive participation, while working with existing organizations in each community to maximize the number of customers benefitting from the program. Each year the program team has a goal of serving at least 70% of the households in each of the neighborhoods with which they engage. Based on the number of eligible households in the targeted neighborhoods, this amounts to approximately 4,500 customers in the DEP service territory and 8,900 customers in the DEC service territory throughout North and South Carolina.[1]

The program period under evaluation is July 1, 2018, through June 30, 2019.[2]

1.2 Evaluation Objectives

The objectives of the 2018–2019 NES program evaluation are below:

- Review and update, as necessary, deemed savings estimates through a review of measure assumptions and calculations.
- Verify measure installation and persistence.
- Estimate program energy (kWh) and summer and winter demand (kW) savings.
- Explore potential for participant free ridership for LEDs.
- Identify and characterize program strengths, which may include customer engagement and other non-energy benefits.
- Identify barriers to participation in the program and recommend strategies for addressing those barriers.
- Identify ways the Duke Energy program teams may be able to improve the NES program in the future.

To achieve these objectives, Opinion Dynamics completed several data collection and analytic activities, including interviews with program staff, a participant telephone survey, an analysis of survey results, an analysis of program tracking data, a deemed savings review, a consumption analysis, and an engineering analysis.

[1] The goals of jurisdiction-specific number of customers served are based on the 2019 program goals expressed by the Duke NES Program Manager during an interview conducted by our evaluation team on March 13, 2021.
[2] The evaluation period was selected to ensure that sufficient post-installation usage data was available for these customers before the COVID-19 pandemic.

1.3 High Level Findings

Overall, the NES program teams in DEP and DEC territories implemented the program effectively and achieved a high penetration rate in target neighborhoods. Program participation was strong in both service territories. Between July 1, 2018, and June 30, 2019, a total of 5,619 DEP and 10,277 DEC customers participated in the NES program. The neighborhood penetration rates are equal to 71% for the DEP jurisdiction and 75% for the DEC jurisdiction, exceeding program goal of serving at least 70% of households in targeted neighborhoods (which amounts to 4,500 DEP households and 8,900 DEC households).[3]

Impact Findings

Based on results of the consumption analysis, we estimated average annual net energy savings per household to be 539 kWh for DEP participants and 221 kWh for DEC participants. At the program level, estimated net energy savings for the evaluation period (July 1, 2018 through June 30, 2019) are 3,031 MWh for DEP and 2,276 MWh for DEC. The estimates include savings from equipment installed by program representatives, as well as savings from any additional behavioral changes and participant spillover attributable to the program. Table 1 presents these results and also shows demand savings, which are calculated by applying the ratios of engineering analysis kW to kWh savings (see Table 3 below) to the consumption analysis net energy savings.

Table 1. Net Impact Results

Service Territory	Per Household			Program Level		
	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy Savings (MWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
DEP	539	0.0865	0.0901	3,030.8	488.0	508.1
DEC	221	0.0402	0.0406	2,276.2	413.1	418.1

As part of the impact evaluation, we also conducted an engineering analysis to (1) provide insight into how each measure contributes to overall program savings and (2) develop kW to kWh savings ratios to determine ex-post demand savings for the program.

Table 2 presents the total ex-post gross impacts for each measure installed through the program and the estimated individual measure contribution to the overall energy (kWh) savings from the engineering analysis. Based on this information, lighting is responsible for the largest proportion of savings in the DEP jurisdiction (33%), while infiltration reduction generates the largest share of energy savings in the DEC jurisdiction (39%).

Table 2. Total Measure-Level Gross Energy Savings Results from Engineering Analysis

Measures	DEP		DEC	
	Energy (MWh)	Percent of Total MWh	Energy (MWh)	Percent of Total MWh
Lighting	1,614.7	33%	2,017.4	26%
Infiltration Reduction	1,432.0	29%	3,056.5	39%
Low Flow Showerheads	1,030.1	21%	1,349.3	17%
Efficient Aerators	361.5	7%	513.7	7%
HVAC Filters	209.0	4%	364.0	5%

[3] To determine the program penetration rates for DEP and DEC, Duke Energy provided the evaluation team with the number of eligible households in the targeted neighborhoods for the denominators, while the numerators are based on the numbers of participant account numbers shown in the tracking data.

Measures	DEP		DEC	
	Energy (MWh)	Percent of Total MWh	Energy (MWh)	Percent of Total MWh
Pipe Insulation (five-foot sections)	162.4	3%	248.8	3%
Water Heater Insulation Wrap	121.2	2%	230.0	3%
Total	**4,930.9**	**100%**	**7,779.6**	**100%**

Table 3 shows the jurisdiction-level energy and demand savings, based on the engineering analysis, and the resulting kW to kWh savings ratios. As mentioned above, these ratios were multiplied by the consumption analysis-derived energy savings to arrive at summer and winter coincident demand savings.

Table 3. Gross Annual Program Impact Results from Engineering Analysis

Jurisdiction	Energy Savings (MWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Summer Demand Ratio (kW/kWh)	Winter Demand Ratio (kW/kWh)
DEP	4,930.9	791.0	823.6	0.0001604	0.0001670
DEC	7,779.6	1,410.5	1,427.7	0.0001813	0.0001835

Process Evaluation

The research team focused the process evaluation on several questions related to energy education, non-energy impacts, NES participant satisfaction, and the overall effectiveness of the program. The full results are available in Section 5 and key findings are summarized below.

Customer satisfaction was high in both service territories; 96% of DEP and 88% of DEC respondents reported they were either completely satisfied or mostly satisfied with the program. In addition, nearly all DEP and DEC respondents were also either completely or mostly satisfied with the energy-efficient equipment they received (95% in both jurisdictions) and the NES program representatives who visited their households (96% and 97%, respectively). Most participants were also satisfied with their communication with Duke Energy staff (94% in both jurisdictions).

Overall, the educational component of the program was successful and reached most participants. Over 85% of NES respondents (87% of DEP and 86% of DEC) received in-person education during their assessments and 93% of DEP and 89% of DEC respondents thought that the information they received was either useful or very useful. Additionally, participants reported that they were more knowledgeable about ways to save energy in their homes after their NES program participation than they were beforehand.

Participants reported experiencing a variety of energy and non-energy benefits after participating in the NES program. More than one-third of NES respondents reported that their electric bills in summer (33% of DEP and 41% of DEC participants) were lower after participating in the program. Results were generally similar when participants were asked about their electric bills in the winter (30% of DEP and 42% of DEC participants). Additionally, a majority of both DEP and DEC participants felt that their home was less drafty and had better lighting after they participated in the program.

Most customers said they did not have any recommendations to improve the program, but a few did offer suggestions. The suggestions provided included increasing program outreach and communication and improve assessment scheduling and follow-up (6% of DEP participants for both suggestions and 6% for DEC participants for both suggestions).

Exploration of LED Free-Ridership

For low-income programs, it is customary to assume a net-to-gross (NTG) ratio of 1, i.e., zero free-ridership. An alternative way to frame this is that low-income program participants would not purchase and install energy-efficient equipment without receiving it for free through the NES Program. Since use of a consumption analysis with a comparison group, as employed in this evaluation, produces *net* savings, any existing free-ridership is already embedded in the savings, i.e., it is not possible to verify the zero free-ridership hypothesis using this method.

As part of this evaluation, Duke Energy was interested in exploring the potential for free-ridership for LEDs among the program's low-income customers. Based on responses to exploratory free-ridership questions included in the participant survey, we found moderate levels of LED free-ridership of 49% for DEP and 35% for DEC. We therefore do see evidence of some free-ridership, although at lower levels than what is commonly observed for lighting programs that are not targeted at low-income populations.

1.4 Evaluation Recommendations

Opinion Dynamics has the following recommendations for maintaining and improving program performance and overall savings.

- **At the time of the energy assessment, NES program teams should consider offering coupons for additional quantities of the energy-saving products to program participants.** While most participants were satisfied with the NES program, a small number offered recommendations to improve how it is implemented. Of the 39 participants who provided recommendations, 54% commented on how additional quantities would be beneficial. To meet this need, NES program teams could provide "deep discount" coupons for energy saving products that customers can redeem through Duke Energy's Online Savings Store, where the coupon could provide NES participants with discounts that are larger than what they would have received without the coupon. This could help to ensure continued energy savings in homes that have been treated through the program. Furthermore, offering coupons could increase participant satisfaction with the program and can serve to direct customers to another Duke program.
- **NES program staff should emphasize air infiltration measures, as they provide both energy and non-energy benefits**. While infiltration measures make an important contribution to overall program energy savings (29% for DEP and 39% DEC participants), NES participants who receive these measures also report other valuable non-energy benefits. Of those who received infiltration measures, 66% of DEP and 59% of DEC participants reported that their home was less drafty and about one-third reported noticing a change in the comfort of their home in both the summer and winter in both jurisdictions.
- **Duke Energy should consider lengthening the amount of time before it archives customer billing data, particularly for those who participate in programs where consumption analysis is used to estimate program savings, such as NES.** For consumption analysis purposes, the evaluation team requires at least two years of data—one year of pre-participation and one year of post-participation data. Duke's consumption data archiving practices in the DEC and DEP jurisdictions conflict with the need for an extensive period of time to accumulate a sufficient number of participants to complete a consumption analysis (for treatment and comparison groups). To ensure successful evaluation, we recommend that Duke Energy work with the evaluation team prior to starting impact evaluation activities to consider what data will be required and determine whether Duke can extend the length of time before it archives its billing data. This is especially important when evaluating programs that, due to slower participation accumulation, need to rely on a longer evaluation period to ensure sufficient numbers of participants. This is particularly true for the pre-period consumption data.

2. Program Description

2.1 Program Design

Duke Energy's NES program provides one-on-one energy education, on-site energy assessments, and appropriate packages of no-cost energy conservation measures to customers in income-qualified neighborhoods. The program is available to active DEP and DEC account holders who are individually metered homeowners or tenants living in pre-determined neighborhoods. Neighborhoods targeted for this program are eligible to participate if at least 50% of the households within the community have incomes less than or equal to 200% of the federal poverty guidelines. Participants are limited to a one-time receipt of energy efficiency measures through the NES program. The overall goal of the NES program is to offer persistent energy and demand savings to Duke Energy customers through the direct installation of energy savings measures and by providing education on other ways to reduce household energy use. The program offers equipment and education at no cost to customers, and, when possible, works with community leaders to maximize the number of customers receiving benefit from the program.

In targeted neighborhoods, the NES implementation team recruits customers via door-to-door canvassing and community events. Program staff work with community leaders and organizations to maximize the number of customers benefiting from the program. Each engaged neighborhood consists of approximately 500 to 1,500 households, and program staff aim to serve at least 70% of the households in each of the neighborhoods they engage.

2.2 Program Implementation

Honeywell Building Solutions implemented the 2018–2019 DEP/DEC NES program in partnership with Duke Energy program staff. The implementer performs all assessments and installations. DEP and DEC program staff are heavily involved in selecting specific neighborhoods based on program eligibility criteria.

Prior to participating in the program, residents in selected neighborhoods receive targeted mailings that provide introductory information about how to participate, the benefits of participation, and a notice that additional information from program staff will be circulated throughout their community, including additional mailings and a community launch event. The implementation team organizes at least one community launch event in each targeted neighborhood, both to make residents aware of the program and to provide demonstrations of the measures that the NES program offers.

The implementation team records measure installation information at each premise, which Duke Energy tracks in its program tracking database. Program representatives also record the location in which they installed lighting measures and faucet aerators (i.e., kitchen or bathroom), along with household characteristics, such as primary heating fuel type and the type of heating and cooling equipment present in each participating household. Finally, implementation teams leave behind educational materials that explain the measures they install in each home, additional recommendations for how participants could save energy through behavioral changes, and information about other Duke Energy programs that may be of interest.

2.3 Program Performance

The program period under evaluation is July 1, 2018, through June 30, 2019. Over this period, the program teams served 5,619 DEC households and 10,277 DEP households in 25 neighborhoods. The program exceeded its goal to serve at least 70% of the households in each of the neighborhoods with which they

engaged, which amounts to approximately 4,500 customers in the DEP service territory and 8,900 customers in the DEC service territory throughout North and South Carolina.[4] We calculated the ratio of households served to the number of eligible households and found penetration rates of 71% and 75% for DEP and DEC territories, respectively.[5] Figure 1 shows the breakdown of NES participants by jurisdiction and state. A majority of the program's participants reside in North Carolina for both DEP and DEC jurisdictions.

Figure 1.Breakdown of Participants by Jurisdiction and State

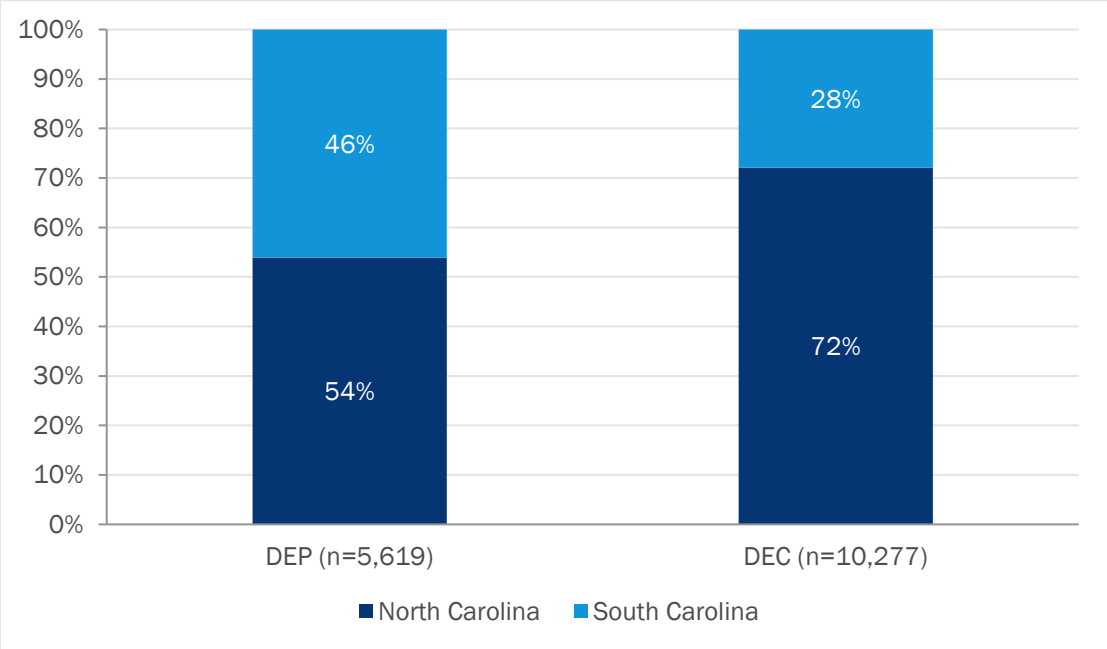


Table 4 shows a comprehensive breakdown of both DEP and DEC participants' home types by jurisdiction, state, and city based on information present in the program tracking data. A majority of the participants consist of single family households (79% of DEC and 65% of DEP participants). For both DEP and DEC, most single family and multifamily households come from North Carolina, whereas the manufactured homes are in South Carolina. Greenville in South Carolina's DEC jurisdiction has the most overall households that participated in the program, totaling 1,922. Duke served customers in 25 cities, 17 in the DEC jurisdiction and 8 in the DEP jurisdiction.

[4] The goals of jurisdiction-specific number of customers served are based on the 2019 program goals expressed by the Duke NES Program Manager during an interview conducted by our evaluation team on March 13, 2021.
[5] To determine the program penetration rates for DEP and DEC, Duke Energy provided the evaluation team with the number of eligible households in the targeted neighborhoods for the denominators, while the numerators are based on the numbers of participant account numbers shown in the tracking data.

Table 4. Breakdown of Participant Home Types by Location

Location	Single Family	Multifamily	Manufactured Home	Total Treated
Duke Energy Progress (North Carolina)				
Dunn	569	44	7	620
Spring Lake	677	271	202	1,150
Clinton	1	0	0	1
Jacksonville	813	369	15	1,197
Asheville	35	1	26	62
Total	**2,095**	**685**	**250**	**3,030**
Duke Energy Progress (South Carolina)				
Lake City	845	365	177	1,387
Sumter	649	12	490	1,151
Manning	47	0	4	51
Total	**1,541**	**377**	**671**	**2,589**
Duke Energy Carolina (North Carolina)				
Hickory	587	158	5	750
Sylva	125	22	20	167
Durham	520	7	0	527
Greensboro	896	675	0	1,571
Winston Salem	708	103	8	819
Bessemer City	408	71	4	483
Kannapolis	715	44	6	765
Spencer	1	0	0	1
Charlotte	1,054	87	1	1,142
Graham	769	247	7	1,023
Burlington	49	6	51	106
Chapel Hill	6	23	0	29
Carrboro	10	10	1	21
Total	**5,848**	**1,453**	**103**	**7,404**
Duke Energy Carolina (South Carolina)				
Greenville	1,432	304	186	1,922
Walhalla	0	1	0	1
Kershaw	728	9	49	786
Spartanburg	109	51	4	164
Total	**2,269**	**365**	**239**	**2,873**
Duke Energy Progress Total	**3,636**	**1,062**	**921**	**5,619**
Duke Energy Carolinas Total	**8,117**	**1,818**	**342**	**10,277**
Total	**11,753**	**2,880**	**1,263**	**15,896**

Based on the results from the consumption analysis, participants saved an average of 539 kWh per household per year in the DEP jurisdiction and 221 kWh per household per year in the DEC jurisdiction. Energy and demand savings by service territory are displayed in Table 5.

Table 5. Annual Energy Savings and Summer and Winter Peak Demand Reductions per Household

Jurisdiction	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
DEP	539	0.0865	0.0901
DEC	221	0.0402	0.0406

Note: Demand savings are calculated by applying the kW-to-kWh savings ratio from the engineering analysis to net energy savings from the consumption analysis.

3. Overview of Evaluation Activities

To answer the research objectives outlined in Section 1.2, Opinion Dynamics performed a range of data collection and analytic activities, including:

- Interviews with DEP and DEC program staff
- A review of program materials and program tracking data
- A participant telephone survey
- An engineering analysis of deemed savings
- A consumption analysis
- An exploratory LED free-ridership analysis

In Sections 4 and 5 we provide more details on the methods and results of the impact and process analyses, respectively. Below, we summarize the scope and approach for the staff interviews, program materials and data review, participant survey, engineering analysis, and consumption analysis. Each of these components supported either the impact or the process evaluations. In addition to the impact and process analysis, this year we also analyzed participant free-ridership for LEDs, which is expanded upon in Section 6.

3.1 Program Staff Interviews

Opinion Dynamics conducted an in-depth interview with program staff responsible for program administration in 2018/2019. The in-depth interview allowed the evaluation team to discuss implementation of the NES program in DEP and DEC territories, including differences between the DEP/DEC NES programs and program implementation in other Duke Energy territories. We also used this interview to identify program successes, to discuss any difficulties in administering the program, and to determine any risks for the program achieving its goals.

3.2 Program Materials and Data Review

DEP and DEC program administration staff provided Opinion Dynamics with information on the program, including marketing materials and program tracking databases. Review of these materials informed development of the participant survey instrument and the engineering analysis.

- **Marketing Materials**. Opinion Dynamics reviewed the leave-behind brochure, the customer survey booklet, the pre-participation program informational brochure, the leave-behind door hanger, the energy efficiency brochure about other Duke Energy programs, the introduction letter to the NES program, and postcards sent to participants with information about how to participate.
- **Program Database**. The program staff provided Opinion Dynamics with tracking data covering the evaluation period of July 1, 2018, to June 30, 2019. The database provided us with information on the quantities, location, and types of measures installed in each treated household.

3.3 Participant Survey

The purpose of the participant survey was to collect information to support the process evaluation, the development of in-service rates, and an exploratory analysis of LED free-ridership. Opinion Dynamics

implemented the survey as a computer-assisted telephone interviewing (CATI) survey in August 2021. Note that we fielded the participant survey with customers who participated in the program between July 1, 2019 and March 31, 2020 (i.e., a "future" comparison group of customers who also served as the comparison group of customers in the consumption analysis) as their recollection of their participation details is likely stronger than those who participated in the program during the evaluation period.

Sample Design

The survey sample was designed to allow for the development of statistically significant in-service rate (ISR) estimates and process results (targeting 10% relative precision at 90% confidence) by jurisdiction.

To develop the survey sample, 700 participants from each of the DEP and DEC territories (1,400 participants in total) were randomly extracted from the 6,164 DEP/DEC participants who were part of the "future comparison" group. In order to achieve 144 survey completes (74 from DEP and 70 from DEC), the survey team had to increase the initial survey sample from 1,400 to 1,939 NES participants. When conducting the survey, our team removed a total of 233 records due to not-in-service phone numbers, ineligible participants, or the survey quota being reached, which left the total sample with 1,706 participants, excluding ineligibles.

We completed a total of 144 interviews and achieved a response rate of 13%; the average length of the interviews was 15 minutes.

3.4 Consumption Analysis

Opinion Dynamics conducted a consumption analysis to determine the net energy savings attributable to the NES program during the evaluation period. We specified linear fixed effects regression (LFER) models to estimate the overall net ex-post program savings for DEC North Carolina, DEC South Carolina, DEP North Carolina, and DEP South Carolina. The fixed effect in our models is the customer, allowing us to control for all household factors that do not vary over time. Treatment customers included those who participated in the program during the evaluation period (between July 1, 2018 and June 30, 2019). For the DEC jurisdiction, we leveraged a comparison group comprised of future participants—customers who participated in the program between July 2019 and June 2020. We were unable to construct a similar comparison group for the DEP jurisdiction due to differences in treatment and comparison group composition and instead constructed a matched comparison group from similar non-participants. Section 4.1.1 provides a summary of the consumption analysis approach; Appendix A contains the detailed methodology description.

3.5 Engineering Analysis

The engineering analysis was used to (1) provide a ratio of kW demand to kWh energy savings which we applied to the consumption analysis energy savings to estimate demand savings and (2) to better understand the relative contribution of each measure to overall energy savings.

The engineering analysis consisted of two components:

- **Measure verification and development of measure-specific ISRs:** We verified measures and developed measure-specific ISRs based on responses to the participant survey.
- **A deemed savings review of all program measures:** We reviewed measure-level savings algorithms and parameters and revised input assumptions, as needed. To develop ex post deemed energy and demand savings for each measure, we leveraged, in order of preference, program tracking data, participant survey results, and Technical Reference Manuals (TRMs). The *DEP and DEC NES Deemed*

Savings Review Final Memorandum developed for Duke Energy provides more detail on the sources and inputs used in the deemed savings review.[6] This document is available as part of Appendix B.

We calculated program-level savings, by jurisdiction, by applying ISRs and ex post deemed savings values to the measure quantities tracked in the program tracking database.

[6] Memorandum from Opinion Dynamics to Duke Energy's EM&V Team. February 22, 2022.

4. Impact Evaluation

4.1 Methodology

The impact analysis for the 2018–2019 NES program included a consumption analysis as well as an engineering analysis. The consumption analysis determined the net evaluated energy (kWh) impacts for the program. The engineering analysis supplemented the consumption analysis by providing (1) a kW-to-kWh savings ratio, which we applied to the consumption analysis energy savings to estimate demand savings and (2) insights into the relative contribution of each measure to overall savings.

4.1.1 Consumption Analysis

Opinion Dynamics conducted a consumption analysis to determine evaluated program savings for DEC and DEP territories. Consumption analysis is a statistical analysis of energy consumption recorded in utility billing records.[7] Because billing records reflect whole-building energy use, the method is well suited for studying the combined impact of the NES program's mix of energy efficiency measures (and any behavioral changes) per home. Total program savings from each territory are estimated by examining variation among participants' monthly electricity consumption in the pre- and post-program periods, relative to the variation in a comparison group's electricity consumption during those times. The consumption analysis was conducted by jurisdiction and state (i.e., North and South Carolina). The results were then aggregated to the jurisdiction level.

Data Cleaning and Preparation

Prior to specifying the models, we performed a thorough cleaning of the consumption and participation data. We checked data for gaps and inconsistencies as well as for sufficiency. Among other checks, we ensured the participants retained in the analysis had sufficient pre- and post-participation consumption data, participation dates were accurate, and the consumption data was free of outliers, such as bill periods with unreasonably small or unreasonably large consumption.

Comparison Group Selection

Incorporating a comparison group into the consumption analysis allows evaluators to control for changes in economic conditions and other non-program factors that might affect energy use during the study period. Like many other energy efficiency programs, the NES program was not designed as an experiment. As such, we leveraged a quasi-experimental approach to the evaluation by developing a comparison group of participants. There are multiple approaches to selecting a comparison group, including the use of future participants, past participants, or similar non-participants. When possible, it is preferable to use future program participants as a comparison group. The use of future participants—who are similar to the evaluated participants—as the comparison group allows us to effectively control for self-selection biases.

For this evaluation, we constructed a comparison group from customers who participated in the NES program between July 1, 2019, and March 31, 2020.[8] We performed equivalency checks to assess the similarity of treatment and comparison groups in terms of energy consumption, weather, and housing characteristics in

[7] Due to AMI deployment schedules, the evaluation team relied on monthly billing data to conduct the consumption analyses for the DEC and DEP NES program. We will assess the feasibility of using AMI data for future evaluations of this program.
[8] Typically, we construct a comparison group from customers who participated in the subject program sometime during the full 12 months after the evaluation period. In this case, we limited the timeframe to 9 months to avoid any confounding effects from COVID-19.

order to ensure that the comparison group could serve as a valid baseline. We performed this equivalency analysis by territory. For the DEC jurisdiction, participants in the comparison group were reasonably similar to the treatment participants across key characteristics, and we therefore proceeded with the future participant comparison group approach. The evaluation team felt confident that any differences between the treatment and comparison groups could be overcome by including additional independent variables in the consumption analysis models. For the DEP jurisdiction, however, we were unable to construct a viable comparison group from future participants due to pronounced differences in location, energy consumption, and observable housing characteristics. Upon discussion with Duke Energy, we recommended to construct a comparison group from similar non-participants using a two-stage matching approach. As part of the first stage, we obtained income, demographic, and housing U.S. Census data at the census block group level for the DEP jurisdiction and selected comparison neighborhoods for each of the participating neighborhoods using geography, income, housing type, and home ownership as key matching variables. As part of the second stage, we matched customers in the comparison neighborhoods based on their pre-participation consumption patterns using statistical distance matching techniques. Matched customers formed the comparison group for DEP.

Controlling for Participation in Other Programs

Some customers participated in other Duke Energy programs after participating in the NES program. Including those customers in the consumption analysis would result in double counting of savings from other programs and artificially inflating the estimate of savings from the NES program. To obtain the most accurate estimate of the effects of the NES program, we dropped those customers who cross-participated in the following programs from the analysis: Residential Energy Efficient Products & Services, Smart Saver Residential, Residential Energy Assessments, Save Energy & Water Kit, and Home Energy Improvement.

Table 6 summarizes final participant counts used to develop the consumption analysis models.

Table 6. Accounts Included in the Consumption Analysis Model

Territory	Treatment Group	Comparison Group	Total
DEP North Carolina	1,191	217	1,408
DEP South Carolina	1,413	211	1,624
DEC North Carolina	3,967	3,196	7,163
DEC South Carolina	1,510	1,315	2,825

Modeling

We used a Linear Fixed Effects Regression (LFER) model for this analysis. Fixed effects models capture the effect of time invariant household-specific characteristics and are the best practice approach to modeling program savings in the industry. We specified a variety of models ranging from simple pre-post models to more complex models incorporating a variety of terms to control for known sources of variation. We specified distinct models for each jurisdiction and state with consideration of unique characteristics of participant populations and integration of additional terms in the models to control for variation. Consumption analyses typically include a series of additional variables to explain non-program variation in monthly energy use pre- and post-participation. Our final model specifications across all jurisdictions and states included weather (heating degree days and cooling degree days) in the model as well as monthly dummies to further control for seasonal differences in energy consumption. All models also contained a control for electricity usage, which was interacted with the weather term so as not to be absorbed by the fixed effect. The final models produced savings associated with installed measures and any behavioral changes from energy efficiency knowledge gained during their participation process.

Appendix A contains a detailed discussion of the consumption analysis methodology, including data cleaning steps, comparison group selection and assessment of equivalency, modeling process, and the final model specification and outputs.

4.1.2 Engineering Analysis

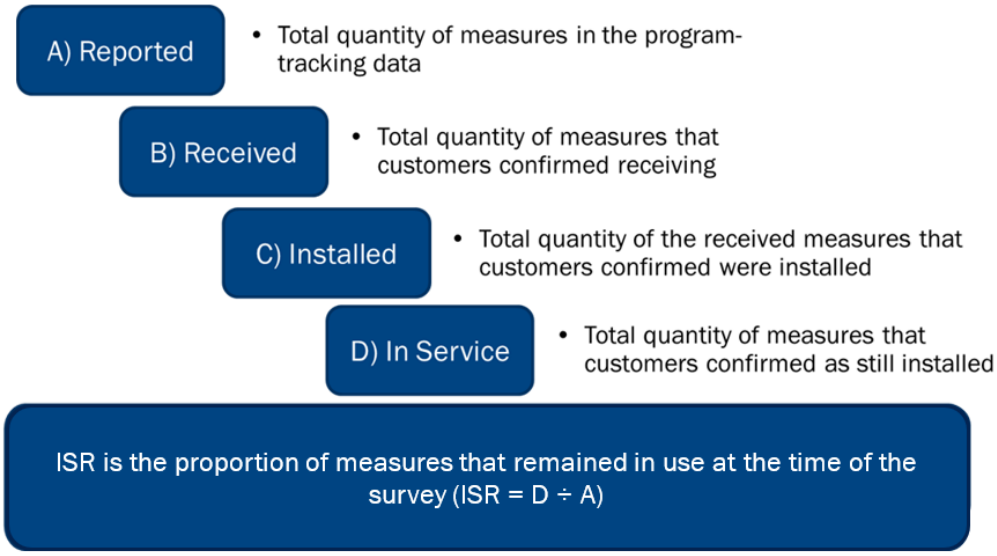
The engineering analysis consisted of two distinct steps: (1) verification of measure installation and continued operation and (2) review of per-unit deemed savings values for program measures.

Measure Verification Methodology

The participant survey included questions designed to verify that participants received and installed program measures and that those measures remained in place and operational. The ISR for each measure represents the share of measures in the program tracking data that were still in service at the time of the survey, based on responses from surveyed participants who were able to complete the ISR survey battery.

Figure 2 outlines the method for deriving the ISR for each measure. During the survey, we asked participants to confirm that they received the quantity of measures recorded in Duke Energy's program tracking data and, when necessary, to provide the correct quantity. We also asked participants to confirm the quantity of measures that were installed and remained in service at the time of the survey.

Figure 2. In-Service Rate Components



Based on the survey responses, we calculated the verification, installation, and persistence rates, as well as the resulting ISR—using the equations shown below—for each participant and each measure they received. We then developed jurisdiction-specific averages of all four rates for each measure group.

$$Verification\ Rate = \frac{(B)Received\ Quantity}{(A)Reported\ Quantity}$$

$$Installation\ Rate = \frac{(C)Installed\ Quantity}{(B)Received\ Quantity}$$

$$Persistence\ Rate = \frac{(D)In\ Service\ Quantity}{(C)Installed\ Quanhtity}$$

$$ISR = In\ Service\ Measures\ (D) \div Reported\ Measures\ (A)$$

In previous evaluations of the NES program, Opinion Dynamics found that participants were unable to verify certain measures (e.g., water heater tank wraps and pipe wraps). For these measures, we assumed 100% for all four rates. Additionally, for some air infiltration measures, such as caulking or glass patch tape, participants were unable to verify installation and persistence of individual measures. As such, we asked participants to verify installation of the entire package of air infiltration measures and assumed that 100% of those treatments remain installed. As NES measures are installed directly by program staff and infiltration measures specifically are difficult to remove, we feel these assumptions are reasonable for this type of program.

Deemed Savings Review

To develop ex post per-unit savings for each program measure, we reviewed measure-level savings algorithms and parameters and revised input assumptions, as needed. We leveraged the following sources in our review:

- **Program tracking data:** Where available, we used program tracking data to update household characteristics such as the percentage of homes with electric heat, central cooling, and electric water

heating. Since program tracking data is available for the population, it is the most reliable and evaluation-specific source of information.

- **Participant survey data:** Where not available from program tracking data, we used survey data to update household characteristics such as the number of people per household. Since survey data is specific to the program's participants, it is preferable over deemed assumptions from TRMs.
- **Technical Reference Manual (TRM) assumptions:** We used algorithms and parameters from various TRMs. The preferred TRM was version 9.0 of the Mid-Atlantic TRM. We leveraged other TRM, including the Illinois TRM and the Indiana TRM, if a parameter was not available from the Mid-Atlantic TRM or if other TRMs were deemed to have more recent or more rigorous parameters.

The previously mentioned *DEP and DEC NES Deemed Savings Review Final Memorandum* developed for Duke Energy (see Appendix B) provides more detail on the methods used in the deemed savings review and engineering analysis.

Total Program Gross Savings

We developed total program gross savings, by jurisdiction, by applying the measure-specific ISRs and the ex post deemed values to the measure quantities provided in the program tracking database, using the following formula:

Equation 1

$$Sav = \sum_{i=1}^{n} Q_{dbi} \times ISR_i \times EST_i$$

Where:

i	=	Program measures 1…n, where n = 14
Sav	=	Total program savings
Q_{dbi}	=	Database quantity of measure i
ISR_i	=	In-service rate for measure i
EST_i	=	Per unit deemed savings estimate for measure i (KW or kWh)

Where savings for certain measures rely on electric heating equipment, electric water heating equipment, or the presence of cooling equipment, our engineering team developed fuel-specific deemed values and applied them based on the HVAC equipment specified within the program tracking database. For example, NES implementation teams provide domestic hot water measures to all participants, regardless of the fuel they use to heat water in their homes. However, as Duke Energy only provides electricity to DEP and DEC customers, when developing total program savings, our team only applied savings for domestic hot water measures to participants that received them and heated their water with electricity.

We then calculated per household savings by dividing total program savings by the number of participating households, by jurisdiction.

4.2 Results

4.2.1 Consumption Analysis

This section provides average per-participant consumption analysis results. Appendix A contains the complete results of the models. Table 7 summarizes modeling results and presents key model fit metrics. Final models for all jurisdictions incorporated the use of a comparison group.[9] All models showed positive statistically significant participation coefficients, indicating that the models established a statistically significant relationship between participation in the program and energy consumption. Furthermore, savings estimates from the final models that leverage comparison groups were similar to alternative model specifications, including ones without the use of the comparison group, indicating stability of the savings signal and limited effect on the final savings estimates of incorporating comparison groups.

Table 7. Summary of Modeling Results

Model Output Component	DEP North Carolina	DEP South Carolina	DEC North Carolina	DEC South Carolina
Modeled customers (treatment and comparison)	1,408	1,624	7,163	2,825
Modeled baseline (kwh/day)	37.77	45.15	33.95	34.94
Modeled savings (kwh/day)	1.33	1.65	0.69	0.39
Standard error	0.29	0.29	0.06	0.10
Statistically significant participation coefficient	Yes	Yes	Yes	Yes
Akaike Information Criterion	444,267	513,633	2,688,050	1,096,543
Bayesian Information Criterion	456,972	528,498	2,765,157	1,124,442
Adjusted R Squared	0.68	0.71	0.64	0.63

Table 8 contains annual savings with associated confidence bounds for each jurisdiction and state. Savings vary from 1.1% to 3.7% of the baseline consumption.

Table 8. Results of Consumption Analysis Models

Jurisdiction and State	Modeled Treatment Participants	Average Annual Baseline Energy Consumption per Participant (kWh)	Average Per Participant Ex Post Net Annual Savings (kWh)	Average Per Participant Savings Percentage	90% Confidence Interval	
					Lower	Upper
DEP North Carolina	1,191	13,786	485	3.5%	310	661
DEP South Carolina	1,413	16,481	603	3.7%	430	775
DEC North Carolina	3,967	12,390	252	2.0%	219	286
DEC South Carolina	1,510	12,753	142	1.1%	82	201

Based on these results, we developed average per participant ex-post net annual savings at the jurisdiction level by weighting the state-level estimates for each jurisdiction by the number of participants in each state. Table 9 presents the net savings results of the consumption analysis for both the household and program levels. We developed summer and winter peak demand savings by multiplying the consumption analysis-derived energy savings by the ratio of kW to kWh from the engineering analysis. These too are shown below. Multiplying the per household values by the number of households that participated in DEP and DEC jurisdictions provided the program level energy and demand savings as well.

[9] As described in the methodology section, the comparison groups consisted of future NES program participants for DEC and of matched non-participants for DEP.

Table 9. Net Impact Results from Consumption Analysis

Service Territory	Per Household			Program Level		
	Energy Savings (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy Savings (MWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
DEP	539	0.0865	0.0901	3,030.8	488.0	508.1
DEC	221	0.0402	0.0406	2,276.2	413.1	418.1

One of the key drivers of savings differences by jurisdiction is lower baseline energy consumption of DEC participants, which limits the opportunity for savings. DEP participants also have a higher share of electric water heating systems in their homes as compared to DEC participants, which can help achieve higher electric savings resulting from program measures. Finally, based on our analysis of program participation data, more DEP participants received LEDs and showerheads than DEC participants. On the other hand, DEC participants have a higher share of infiltration measures (see Table 10).

Table 10. Drivers of Savings Differences

Characteristic	DEP North Carolina	DEP South Carolina	DEC North Carolina	DEC South Carolina
Average Annual Baseline Energy Consumption/Participant (kWh)	13,786	16,481	12,390	12,753
Percent of participants with electric water heating system	96%	94%	70%	77%
Percent of participants receiving LED measures	94%	92%	87%	87%
Percent of participants receiving faucet aerators	88%	92%	89%	88%
Percent of participants receiving showerheads	72%	81%	74%	59%
Percent of participants receiving infiltration measures	78%	58%	82%	81%

4.2.2 Engineering Analysis

Measure Verification Results

The results of the measure verification analysis showed high ISRs for measures in both DEP and DEC service territories, as shown in Table 11. Overall, both DEP and DEC participants reported that most measures were still in service at the time of the participant survey. Except for the DEC ISRs for faucet aerators and low flow showerheads, all results are significant at the 90% confidence level with +/-10% relative precision.[10]

The evaluation team calculated overall ISRs by computing a savings-weighted value for each jurisdiction. We found an overall ISR of 88% for DEP and 85% for DEC.

[10] The relative precision of the DEC ISRs for faucet aerators and low flow showerheads were 11.5% and 11.7%, respectively.

Table 11. Measure In-Service Rates

Measure Category	DEP				DEC			
	Verification Rate	Installation Rate	Persistence Rate	ISR	Verification Rate	Installation Rate	Persistence Rate	ISR
LEDs	97%	99%	93%	88%	100%	90%	96%	87%
Faucet Aerators	94%	100%	88%	83%	92%	100%	87%	80%
Low Flow Showerheads	92%	100%	96%	88%	96%	100%	87%	84%
HVAC Filters	100%	96%	N/A	96%	96%	94%	N/A	91%
Infiltration Measures	93%	N/A	N/A	93%	92%	N/A	N/A	92%
Pipe Insulation Wrap	100%	100%	100%	100%	100%	100%	100%	100%
Tank Insulation Wrap	100%	100%	100%	100%	100%	100%	100%	100%

Note: We assume 100% for the verification, installation, persistence, and in-service rates for pipe and tank insulation wrap for the engineering analysis.

Ex-Post Deemed Savings Estimates

Table 12 provides the estimated gross per-unit energy and demand savings for all measures installed through the NES program. As described in Section 4.1.2, we based the measure-level savings on program tracking data, survey results, and TRMs. The estimates shown below are for households with the appropriate mix of heating and cooling equipment, and electric heat or hot water. For example, savings from kitchen faucet aerators would only be realized by households with an electric water heater.

Table 12. Ex Post Per-Unit Deemed Savings Estimates

Measure	Energy Savings (kWh)		Summer Peak Demand (kW)		Winter Peak Demand (kW)	
	DEP	DEC	DEP	DEC	DEP	DEC
Lighting						
LEDs (75W equivalent)	42	42	0.0061	0.0061	0.0030	0.0030
LEDs (60W equivalent)	33	33	0.0049	0.0049	0.0024	0.0024
LEDs 5 W or similar - Candelabra Bulbs	36	36	0.0054	0.0054	0.0026	0.0026
LED 5 W or similar - Globes	36	36	0.0053	0.0053	0.0026	0.0026
LEDs (40W equivalent)	24	24	0.0035	0.0035	0.0017	0.0017
Domestic Hot Water						
Low Flow Showerhead	226	248	0.0106	0.0108	0.0212	0.0216
Water Heater Insulation Wrap	105	104	0.0120	0.0119	0.0120	0.0119
Pipe Insulation (5 feet sections)	90	90	0.0103	0.0103	0.0103	0.0103
Kitchen Faucet Aerator	84	90	0.0044	0.0045	0.0088	0.0090
Bathroom Faucet Aerator	13	14	0.0013	0.0013	0.0026	0.0027
Air Sealing						
Infiltration Reduction	118	122	0.0365	0.0359	0.0424	0.0415
HVAC						

Measure	Energy Savings (kWh)		Summer Peak Demand (kW)		Winter Peak Demand (kW)	
	DEP	DEC	DEP	DEC	DEP	DEC
HVAC Filters	54	55	0.0226	0.0240	0.0125	0.0115

Total Program Savings

Our team calculated total program savings by applying the per-unit estimates shown in Table 12 to each participant who received the corresponding measure.[11] We then applied the ISRs shown in Table 11 and, where applicable, multiplied the per-unit estimate by the measure quantity installed in each participating household. Table 13 summarizes total gross program energy and demand savings, by jurisdiction and measure, for the 2018–2019 evaluation period.

Table 13. Total Gross Program Savings

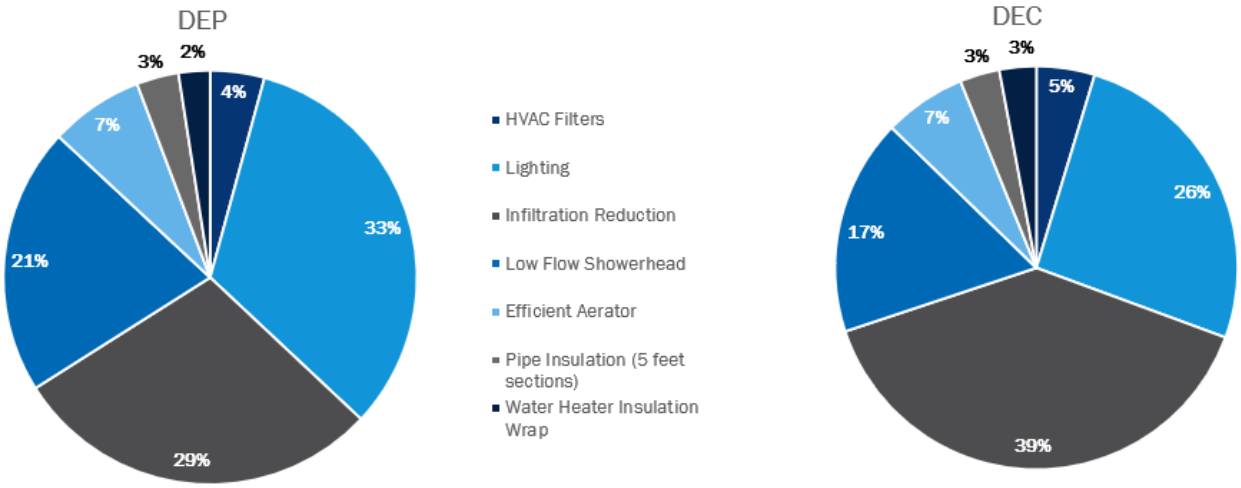
Measure	Energy Savings (MWh)		Summer Peak Demand (kW)		Winter Peak Demand (kW)	
	DEP	DEC	DEP	DEC	DEP	DEC
Lighting						
LEDs (75W equivalent)	37.5	21.9	5.6	3.2	2.7	1.6
LEDs (60W equivalent)	1,196.0	1,310.2	176.9	193.8	85.6	93.8
LEDs 5W or similar - Candelabra Bulbs	294.8	504.1	43.6	74.6	21.1	36.1
LEDs 5W or similar - Globes	79.6	163.5	11.8	24.2	5.7	11.7
LEDs (40W equivalent)	6.8	17.7	1.0	2.6	0.5	1.3
Domestic Hot Water						
Low Flow Showerhead	1,030.1	1,349.2	48.3	58.7	96.6	117.4
Water Heater Insulation Wrap	121.2	230.0	13.8	26.2	13.8	26.2
Pipe Insulation (five-foot sections)	162.4	248.8	18.5	28.4	18.5	28.4
Kitchen Faucet Aerator	308.4	441.0	16.2	22.1	32.3	44.3
Bathroom Faucet Aerator	53.0	72.6	5.4	7.1	10.9	14.3
Air Sealing						
Infiltration Reduction	1,432.0	3,056.5	364.7	811.7	492.9	983.8
HVAC						
HVAC Filters	209.0	364.0	85.2	157.9	43.0	69.0
Total Program Savings	**4,930.9**	**7,779.6**	**791.0**	**1,410.5**	**823.6**	**1,427.7**
Savings per Household	**877.5**	**757.0**	**0.141**	**0.137**	**0.147**	**0.139**

Using the total gross savings values from Table 13 and the total number of participants, we calculated per household energy savings of 878 kWh for DEP and 757 kWh for DEC neighborhoods. The majority of these savings are attributable to infiltration reduction and lighting. As shown in Figure 3, infiltration reduction accounted for 1,432 MWh (29%) and 3,056 MWh (39%) of savings in DEP and DEC territories, respectively.

[11] Certain measures only generate electric savings in households with electric space or water heating, or central cooling (i.e., domestic hot water, infiltration reduction, and HVAC filters). For these measures, we only applied savings to those households with the appropriate mix of electric heating, hot water, or cooling equipment. In cases where individual participants did not have space or water heating fuel type information in the program tracking data, we weighted per-unit savings by the share of participating households with the appropriate fuel type.

Lighting accounted for 1,615 MWh (33%) of overall savings in DEP territory and 2,017 MWh (26%) of savings in DEC territory.

Figure 3. Measure Contribution to Total Energy (kWh) Savings



5. Process Evaluation

5.1 Researchable Questions

Based on prior evaluations of this program and discussions with DEP and DEC program staff, Opinion Dynamics developed the following process-related research questions:

- What are the major strengths of the program? Are there specific ways the program could be improved to be more effective in the future?
- What are the barriers to implementing this program—that is, are there limiting factors to achieving greater participation and realizing additional program attributable savings?
- Is there potential participant free ridership for LEDs?[12]
- Do NES participants realize other non-energy benefits as a result of their participation, and, if so, which are most common?

5.2 Methodology

The process evaluation relied on the following tasks:

- An in-depth interview with DEP and DEC NES program staff
- A review of secondary materials (i.e., NES marketing materials, data associated with neighborhood populations, and program evaluations from previous years)
- A telephone survey of program participants
- An analysis of program tracking data

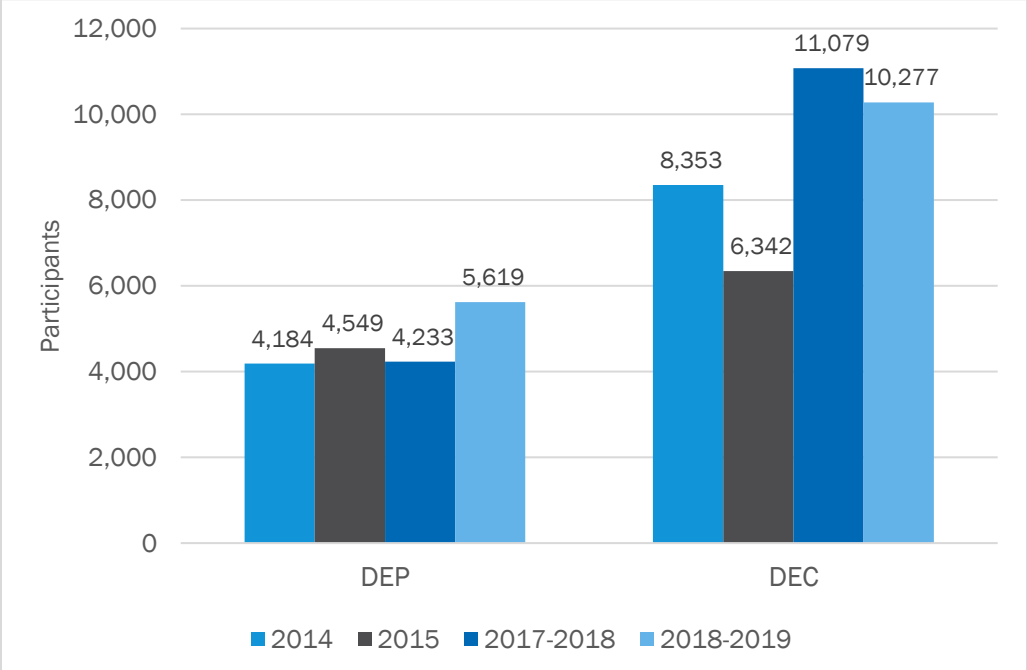
5.3 Key Findings

5.3.1 Program Participation

The NES program has operated for numerous years in both the DEC and DEP jurisdictions. Between July 1, 2018, and June 30, 2019, the NES program teams reached customers that reside in 25 cities in total, 8 in DEP territory and 17 in DEC territory (see Table 4). The NES program team served 5,619 DEP and 10,277 DEC customers, 15,896 in total. Figure 4 provides a comparison of program participation over the past five years, which shows a general increase in the number of participants. Overall, staff reached 74% of customers across all neighborhoods served during the 2018–2019 evaluation period (71% for the DEP jurisdiction and 75% for the DEC jurisdiction).

[12] This research question is addressed in Section 6. Free-Ridership Analysis.

Figure 4. NES Program Participation 2014–2019



Note: The evaluation periods for 2014 and 2015 were from January 1 to December 31, whereas the evaluation periods for the 2017–2018 and 2018–2019 years were from July 1 to June 30 of the following year.

Measure Provided to NES Participants

To evaluate the success of the program in providing energy-saving measures to participants, and to determine if there were missed savings opportunities or measures that were being provided less frequently than in past years, Opinion Dynamics examined the number of measures provided to each home. Table 14 shows the share of homes that received at least one of each measure and the average quantity provided per home (including homes that did not receive the measure). DEP and DEC territories had similar measure mixes overall, although homes in DEC territory had fewer LEDs installed on average than homes in DEP territory (9.5 compared to 6.6).

Table 14. Measure Installation Rates from Program Tracking Data

Measure Category	Measure	DEP		DEC	
		Percent of Projects with Measure	Average Qty Per HH	Percent of Projects with Measure	Average Qty Per HH
Lighting	LEDs (60W equivalent)	88%	7.2	78%	4.4
	LEDs 5W or similar - Globes	10%	0.4	12%	0.5
	LEDs 5W or similar - Candelabra Bulbs	33%	1.6	32%	1.6
	LEDs (75W equivalent)	3%	0.2	2%	0.1
	LEDs (40W equivalent)	2%	0.1	3%	0.1
Hot Water	Kitchen Faucet Aerator	82%	0.8	77%	0.8
	Bathroom Faucet Aerator	70%	0.9	68%	0.9
	Low Flow Showerhead	76%	1.0	70%	0.8

Measure Category	Measure	DEP		DEC	
		Percent of Projects with Measure	Average Qty Per HH	Percent of Projects with Measure	Average Qty Per HH
	Pipe Insulation (five-foot sections)	19%	0.3	21%	0.3
	Water Heater Insulation Wrap	99%	0.2	96%	0.2
Infiltration Reduction	Door Sweep	39%	0.6	38%	0.5
	Caulking	64%	0.6	77%	0.8
	Weatherstripping per door	61%	0.9	74%	1.1
	Foam Insulation	59%	0.6	54%	0.5
	Cover for A/C Installed	31%	0.6	21%	0.3
	Poly Tape	0%	<0.1	1%	<0.1
HVAC	HVAC Filters	74%	0.7	73%	0.7
Education/Other	Refrigerator thermometer	98%	2.3	95%	2.2
	Water Heater Temperature Check	96%	1.0	96%	1.0
	Switch Plate Wall Thermometer	97%	1.0	96%	1.0

Cross Participation

There were high levels of cross participation in other Duke Energy programs after customers had participated in the NES program during the evaluation period. As shown in Table 15, 526 of DEP and 3,448 of DEC participants also participated in another Duke Energy program. Note that participants are non-unique in these counts since a single customer can participate in multiple programs. The largest number of DEP cross participants also enrolled in the Save Energy and Water Kit program, while the largest number of DEC participants also enrolled in the Smart Saver Residential program. The difference in the number of cross participants across the jurisdictions may partially be due to the difference in the total number of NES participants in the two jurisdictions (5,619 in DEP and 10,227 in DEC).

Table 15. Count of NES Cross Participants by Program

Program	DEP	DEC
Save Energy and Water Kit	350	0
Home Energy Improvement	10	0
Residential Energy Assessment	176	107
Smart Saver Residential	48	2,903
Residential EE Products & Services	0	438
Total Cross Participants	**526**	**3,448**

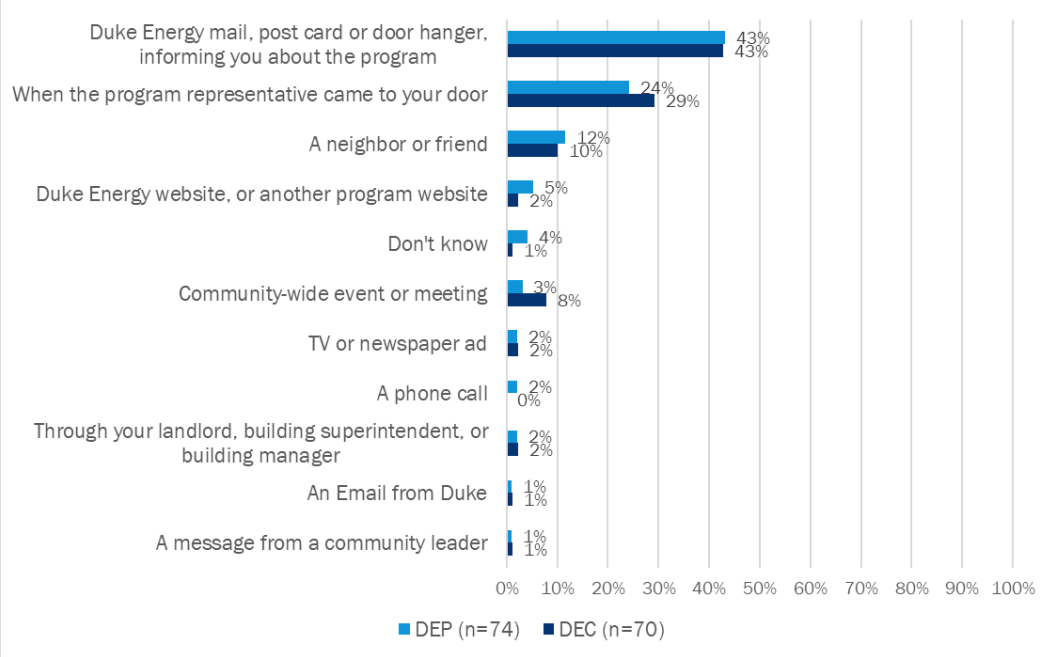
Note: Participants can be counted more than once if they cross-participating. in more than one additional Duke program.

5.3.2 Marketing and Outreach

For each neighborhood, Duke program staff and implementation teams conducted both broad and targeted outreach aimed at encouraging program participation and educating communities about energy efficiency. Program teams first sent customized introductory letters to neighborhood residents, providing information on the measures the program offers, the monetary savings that participants can achieve by enrolling, and information about how to participate. The introductory letter also noted any local community organizations program teams had partnered with and provided information about the community launch event for their neighborhood. In coordination with the implementation teams, program staff conducted a community launch event for each neighborhood, introducing the NES program, the implementation teams, and showing residents the types of energy efficiency measures offered through the NES program. Program teams also sent follow-up postcards reminding residents about the NES program and, for those not home when an implementation team knocked on their door, crews left behind door hangers that provided an option to schedule an appointment to have measures installed.

Figure 5 shows participant survey responses about how they first heard about the NES program. In both service territories, the most common way that participants heard about the program was though a direct mailer, post card, or door hanger (43% for both DEP and DEC). The second most common method was from a program representative who visited the home (24% for DEP and 29% for DEC). These responses indicate that the initial contacts made by program teams are an effective form of outreach and contribute to how a majority of NES participants were introduced to the program. Duke Energy should continue to rely on these outreach methods. Additionally, Duke Energy could consider using additional methods of communication, such as opt-out text messages if mobile phone numbers are available for customers.

Figure 5. How Participants First Heard About the NES Program

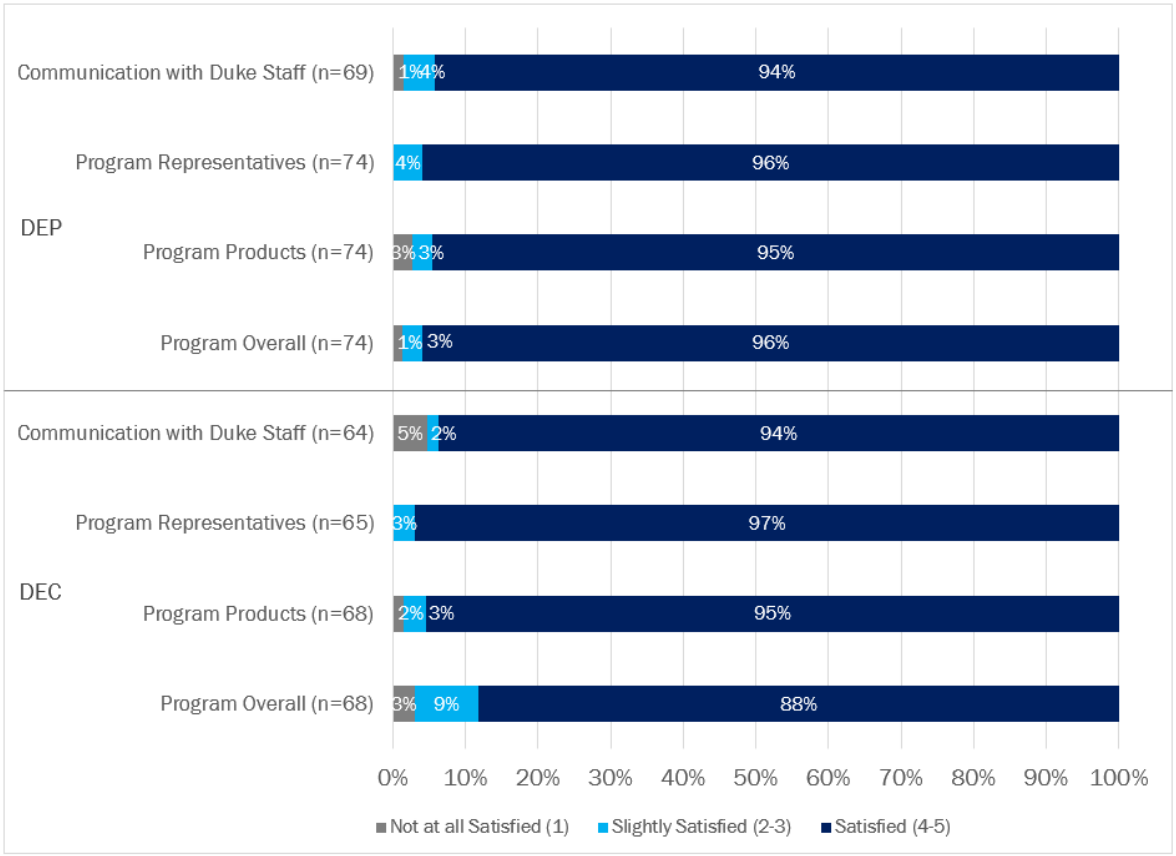


5.3.3 Program Satisfaction

Participants from both territories were generally satisfied with all components of the program. As shown in Figure 6, on a five-point scale where 5 is “completely satisfied” and 1 is “not at all satisfied,” 96% of DEP and

88% of DEC participants reported that they were either "completely satisfied" or "mostly satisfied" with the program overall. Participants were also very satisfied with program representatives who installed energy-efficient equipment. Ninety-six percent of DEP and 97% of DEC participants reported they were either "completely satisfied" or "mostly satisfied" with their NES program representatives and their performance. Ninety-five percent of DEP and DEC participants reported that they either "completely satisfied" or "mostly satisfied" with the products they received through the program. Very few participants expressed any dissatisfaction with program elements. In fact, no participants expressed any dissatisfaction with their program representatives. Only 1% of DEP and 5% of DEC participants reported being "not at all satisfied" with their communications with Duke Energy or program staff, which can be a potential avenue for program process improvement. When asked why these customers were dissatisfied, a couple respondents noted that it was difficult to get in touch with a representative. Another mentioned that he only received mailed communications.

Figure 6. Satisfaction with NES Program Overall and Program Components



5.3.4 Additional Benefits

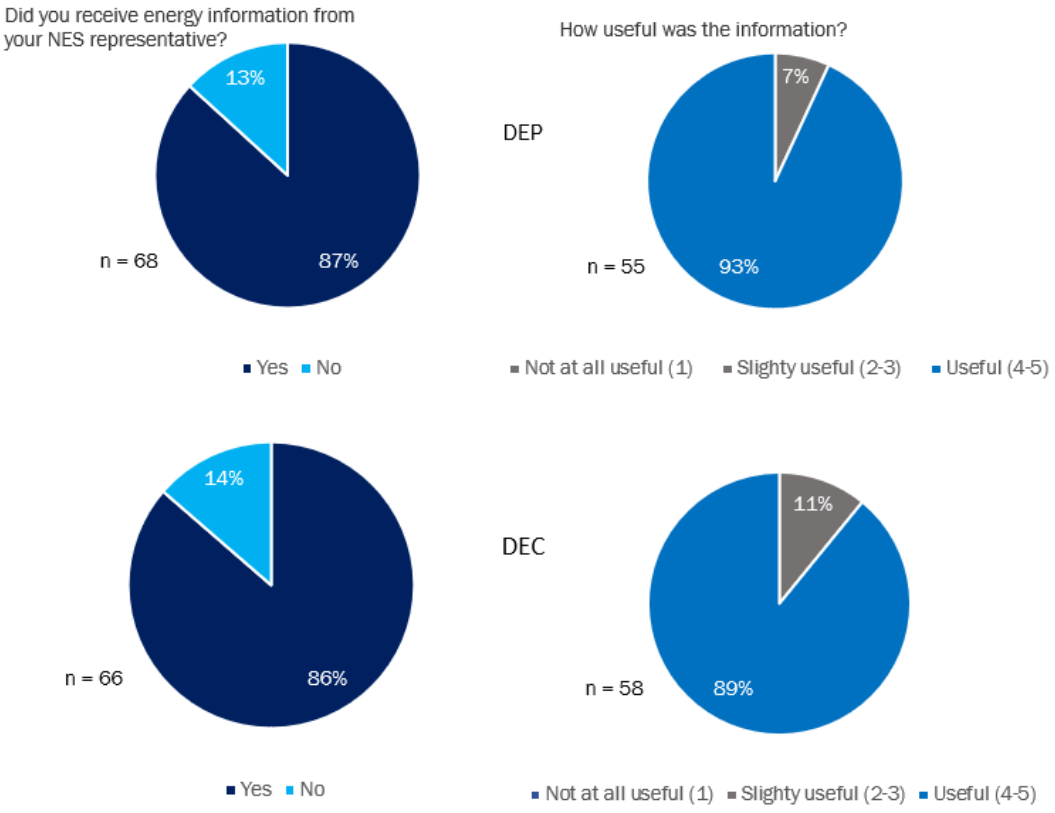
Energy Education

An important customer benefit of the NES program is the energy education that customers receive during home visits. Prior to scheduling visits by program representatives to install energy-efficient equipment, customers receive some information about ways to save energy through mailings and flyers either left at their

home or provided at community launch events. Additionally, program staff discuss the energy-saving measures offered through the NES program and how each measure saves energy in participants' homes when Duke Energy hosts neighborhood launch events. Implementation teams also provide important education to participants while on-site. During measure installation, implementation teams provide more detail on energy-saving measures, discuss other ways participants might change their behavior to save more energy, and answer participant questions. Implementation teams then leave behind information to reinforce the energy education, provide other tips for saving energy in their homes and information about other Duke Energy programs for which participants may be eligible.

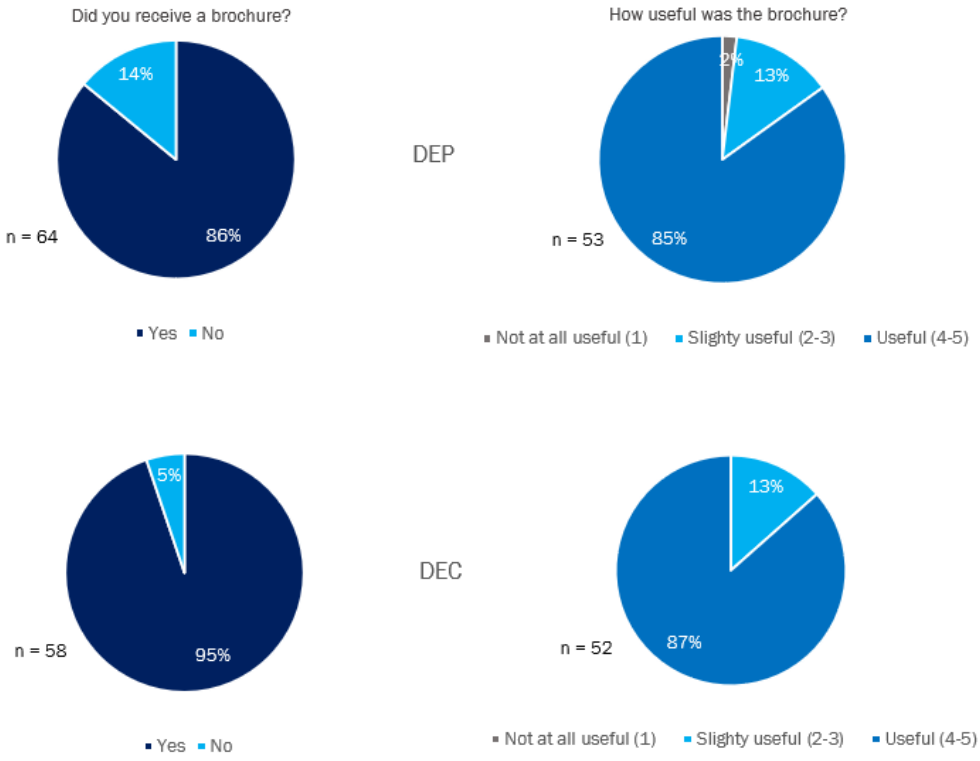
As shown in the pie charts on the left in Figure 7, 87% percent of DEP and 86% of DEC participants reported receiving energy saving tips from the implementation teams. Every participant found this information at least slightly useful, and the vast majority of these participants found the information either "useful" or "very useful" in helping them save energy (93% for DEP and 89% for DEC,). The pie charts on the right of Figure 7 show how useful participants felt the information provided by the implementation teams were. In addition, 86% of DEP participants and 95% of DEC participants said that they received educational materials during their home visit (see Figure 8). Of those who received these educational materials, most found them either "useful" or "very useful" in helping save energy in their homes (85% for DEP and 87% for DEC).

Figure 7. Energy Information from Program Representatives Received and Its Usefulness



Note: Zero percent of participants said that the energy information that they received was "not at all useful"

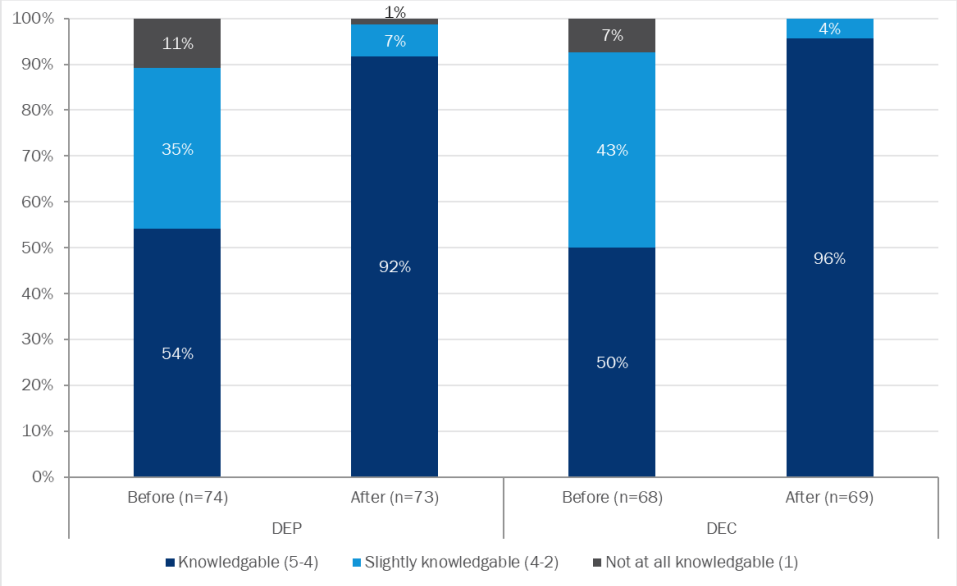
Figure 8. Receipt of Energy Efficiency Brochure and Its Usefulness



Participants across both service territories reported their knowledge increased after their enrollment in the NES program. Prior to participation, 54% of DEP participants and 50% of DEC participants reported that they were either "very knowledgeable" or "knowledgeable" about ways to reduce energy usage in their homes.[13] After participation, however, these numbers jumped up to 92% of DEP participants and 96% of DEC participants being at least "knowledgeable," showing the influence the NES program has on participants' energy usage knowledge (see Figure 9).

[13] Asked on a scale from 1 to 5, where 1 means "not at all knowledgeable" and 5 means "very knowledgeable,"

Figure 9. Participant Knowledge of Ways to Save Energy



Non-Energy Impacts

A large body of research, dating back decades, supports the existence of non-energy impacts from energy efficiency programs, particularly those offering low-income weatherization services.[14] In fact, according to the Department of Energy's Office of Energy Efficiency and Renewable Energy, "weatherization returns $2.78 in non-energy benefits for every $1.00 invested in the program.[15] NEIs include a range of occupant health, safety, and economic outcomes that participants may realize beyond the energy and cost savings of energy-efficient upgrades. NEIs can provide significant additional benefits to participants and can be a powerful motivator for program participation. The participant survey included questions about changes in electricity bills and in different aspects of the home's comfort following program participation. As seen in the summary of non-energy benefits (Table 16), a larger proportion of participants from both DEP and DEC jurisdictions experienced a positive change rather than a negative change for all the non-energy benefits that were attributed to the NES program.

Specifically, more NES program participants reported that their summer home comfort was improved for a larger percentage of participants (DEP 40% and DEC 41%) than for those who said they were less comfortable for both jurisdictions (DEP 5% and DEC 3%). Similarly, more participants reported being more comfortable in the winter after participation than those who noted being less comfortable. While we do see positive changes for a larger share of DEP and DEC customers than those who reported negative changes, for some of the non-energy impacts, the proportion of customers who reported no change was larger (for example, home comfort in the summer and winter, amount of noise heard from outside when windows are closed, and home maintenance costs).

[14] Oak Ridge National Laboratory (2014). *Health and Household-Related Benefits Attributable to the Weatherization Assistance Program*. https://weatherization.ornl.gov/wp-content/uploads/pdf/WAPRetroEvalFinalReports/ORNL_TM-2014_345.pdf
[15] US Department of Energy, Office of Energy Efficiency and Renewable Energy, *Weatherization Works! Weatherization Assistance Program Fact Sheet*. Accessed on April 5, 2022. https://www.energy.gov/sites/prod/files/2019/07/f64/WAP-Fact-Sheet-2019.pdf.

Additionally, we found that home draftiness improved for a larger percentage of participants (DEP 66% and DEC 59%) than those who reported that their homes had become draftier (DEP 10% and DEC 2%) and 59% of DEP and 68% of DEC participants noticed better lighting in their households.

Table 16. Summary of Non-Energy Benefits

Impact Category	Positive Change		No Change		Negative Change	
Energy Impacts	**DEP**	**DEC**	**DEP**	**DEC**	**DEP**	**DEC**
Summer electricity bills (DEP n=61, DEC n =58)[a]	33%	41%	41%	41%	26%	17%
	Bills are lower				Bills are higher	
Winter electricity bills (DEP n=64, DEC n=57) [a]	30%	42%	44%	49%	27%	9%
	Bills are lower				Bills are higher	
Non-Energy Impacts						
Home comfort in the summer (DEP n=73, DEC n = 69)	40%	41%	55%	56%	5%	3%
	More comfortable				Less comfortable	
Home comfort in the winter (DEP n = 74, DEC n = 69)	35%	38%	59%	61%	5%	1%
	More comfortable				Less comfortable	
Home draftiness (DEP n = 61, DEC n = 56)	66%	59%	25%	39%	10%	2%
	Less drafty				More drafty	
Lighting (DEP n = 61, DEC n = 53)[b]	59%	68%	39%	28%	2%	4%
	Better				Worse	
Amount of outdoor noise heard when all windows are closed (DEP n = 60, DEC n = 54)	30%	30%	67%	69%	3%	2%
	Less noise				More noise	
Home maintenance costs (DEP n = 71, DEC n = 66)	18%	20%	73%	79%	8%	2%
	Lower costs				Higher costs	

[a]Asked only of those who pay their own electric bill.
[b]Asked only of those who received LEDs.

Recommendations to Improve the NES Program

Most customers did not offer any recommendations to improve the program when asked, though a few did provide suggestions. The suggestions included increasing program outreach and communication (6% for DEP and 6% for DEC) and improve assessment scheduling and follow-up (5% for DEP and 6% for DEC) (see Figure 10). Additionally, 7% of DEP participants recommended that Duke provide higher quality products.

Participants were also asked about products they would like to see offered through the NES program. Most respondents did not provide any feedback about other products, but of those who did (n=39), the most common response was to provide additional quantities of the free energy efficiency products received during their assessments (see Figure 11). We recognize that customers may reach their cap on the quantities of free products they receive through Duke Energy programs, so we recommend providing NES participants with coupons to purchase energy efficiency products through the Online Savings Store. These coupons would result in discounts on top of the already discounted prices of products available through the store.

Figure 10. Recommendations to Improve the NES Program

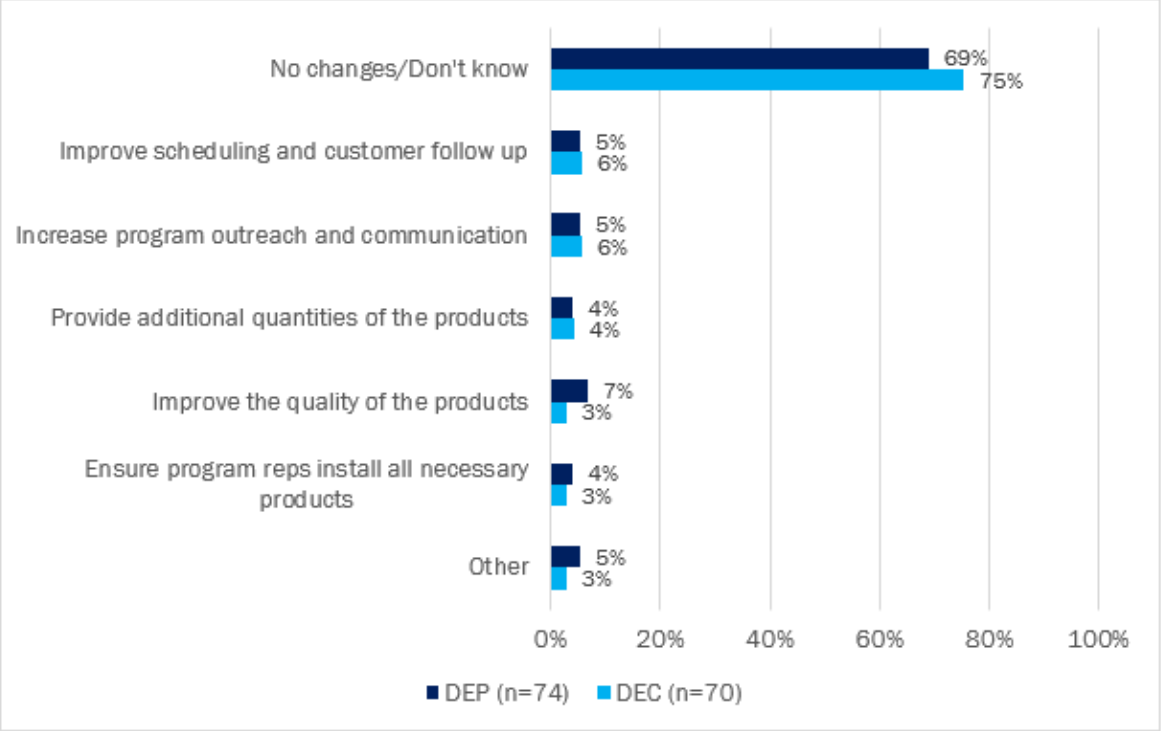
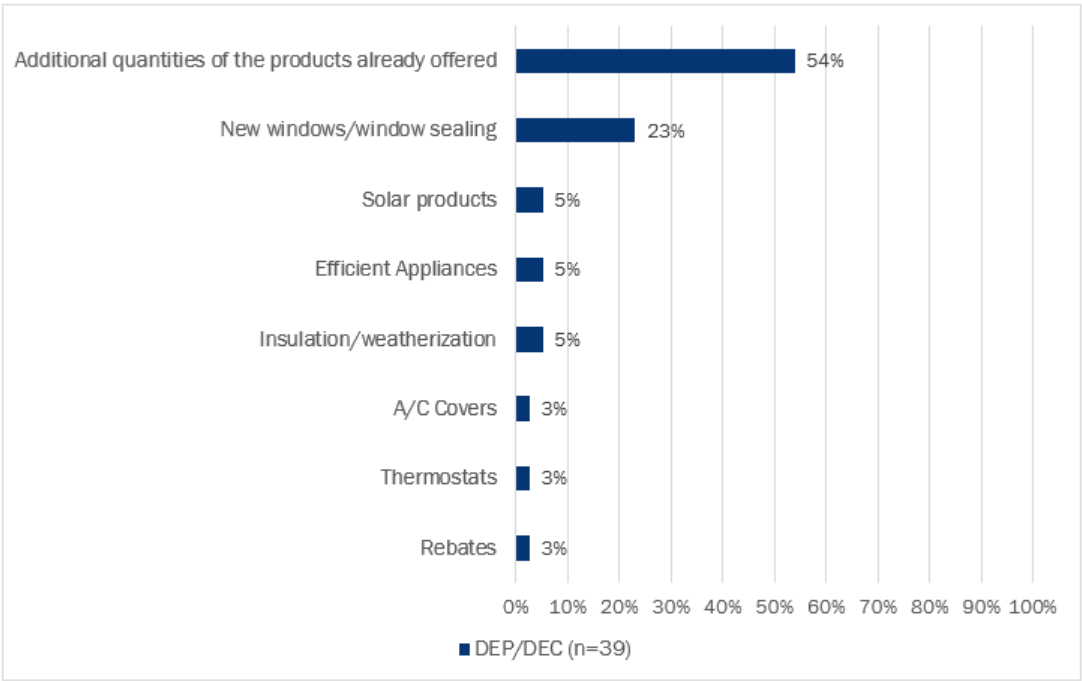


Figure 11. Products Customers Would Like Offered Through the NES Program



6. Free-Ridership Analysis

For low-income programs, it is customary to assume a net-to-gross (NTG) ratio of 1, i.e., zero free-ridership. An alternative way to frame this is that low-income program participants would not purchase and install energy-efficient equipment without receiving it for free through the NES Program. Since use of a consumption analysis with a comparison group, as employed in this evaluation, produces *net* savings, any existing free-ridership is already embedded in the savings, i.e., it is not possible to verify the zero free-ridership hypothesis using this method.

As part of this evaluation, Duke Energy was interested in exploring the potential for free-ridership for LEDs. This section describes the methodology and results of this exploration.

6.1 Free-Ridership Methodology

Program participants who would have paid for energy efficiency products on their own, (i.e., without the program) yet still received the program's free products are called program free-riders. Participants who would not have purchased LEDs in the absence of the program are 0% free-riders whereas participants who would have purchased LEDs without the program are 100% free-riders. Customers who would have waited to replace their bulbs with LED light bulbs are partial free-riders, because while they would have eventually purchased LEDs in the absence of the program, the program caused them to do so sooner.

The participant survey included questions to assess two aspects of program influence:

- **Influence on efficiency**: Knowing the price of LED bulbs, what type of light bulb would participants have purchased the next time they buy bulbs?
- **Influence on timing**: If participants had not received free LED bulbs from the program, would they have still replaced their working light bulbs with LED bulbs or would they have waited until the working bulbs burnt out?

We checked survey data for item non-responses and calculated respondent-level FR values per the algorithm presented below. We included in the analysis respondents who were able to verify receiving LEDs through the NES program and knew whether the bulbs they replaced with the free LEDs were still working or had all burnt out.[16] FR scores represent the percentage of savings that would have been achieved in the absence of the program.

Equation 2. Free Ridership Value

$$FR\,Value_{measure} = FR\,Efficiency_{measure} * TimingAdjustment_{measure}$$

We then aggregated respondent-level FR values to the program-level, by jurisdiction, weighting by measure quantities.

6.2 Free-Ridership Results

As shown in Table 17, the overall LED free-ridership was 44%, while the territory specific free-ridership for DEP and DEC was 51% and 38%, respectively. While the exploratory analysis of LED free-ridership shows that it is not zero for either jurisdiction, the free-ridership results from comparable non-low income programs is generally the same or higher. For example, LED free-ridership rates for the DEP and DEC Residential Energy Assessments program

[16] Participant survey responses were considered for the LED free-ridership percentage if the respondent verified receiving at least one or more LEDs and was able to offer a valid response to the entire free-ridership survey battery of questions.

evaluation are 47% and 50%.[17] For the Online Savings Store, the rates are 70% and 78% for DEP and DEC, respectively.[18] It should also be noted that the timing of the survey (fielded in August of 2021) relative to receipt of the LEDs through the program (between mid-2019 and mid-2020) might have affected participant perceptions of their likely actions without the program and thus their responses to the FR questions.

Table 17. LEDs Free-Ridership

Territory	FR
DEP (n=57)	51%
DEC (n=48)	38%
Overall	**44%**

Table 18 shows a breakdown of the percentage of respondents who received a 0%, 50%, or 100% free-rider score. The 46% of DEP respondents that are considered 100% free-riders (they would have bought the LEDs they received without the program) compared to the 23% of DEC respondents, contributes to its higher free-ridership score.

Table 18. Percentage of Respondents Free-Ridership

Percentage of Respondents who were:			
Territory	0% Free Rider	50% Free Rider	100% Free Rider
DEP (n=57)	37%	18%	46%
DEC (n=48)	40%	38%	23%

[17] *Duke Energy Progress Residential Energy Assessments Program Evaluation Report – Final*. October 18, 2018. Prepared by Opinion Dynamics for Duke Energy. Duke Energy Carolinas Residential Energy Assessments Program Evaluation Report – Final. October 12, 2018. Prepared by Opinion Dynamics for Duke Energy.
[18] Duke Energy Carolinas & Duke Energy Progress Online Savings Store Program 2021 Evaluation Report – Final. November 30, 2021. Prepared by Opinion Dynamics for Duke Energy.

7. Conclusions and Recommendations

7.1 Conclusions

Overall, the NES program teams in DEP and DEC territories implemented the program effectively and achieved a high penetration rate in target neighborhoods. The program team served 15,896 participants across both territories and achieved a 74% overall penetration rate. Based upon unique account numbers in the program tracking data, 5,619 participants were DEP customers while 10,277 were DEC customers.

Using consumption analysis, the evaluation team found annual ex-post net program savings of 3,031 kWh for the DEP jurisdiction and 2,276 kWh for the DEC jurisdiction, despite the NES program serving fewer customers in the DEP jurisdiction. The annual household energy savings were 539 kWh for the DEP jurisdiction and 221 for the DEC jurisdiction. The estimates include savings from equipment installed by program representatives, as well as savings from any additional behavioral changes and participant spillover attributable to the program.

Based on engineering analysis, which explains the relative contribution of each measure type to program savings, lighting is responsible for the largest proportion of savings in the DEP jurisdiction (33%), while infiltration reduction generates the largest share of energy savings in the DEC jurisdiction (39%).

The evaluation team found high levels of program satisfaction; 96% of DEP and 88% of DEC participants reported they were either "mostly satisfied" or "completely satisfied" with the program overall. In addition, a majority of both DEP and DEC respondents were also either "completely" or "mostly satisfied" with the energy-efficient equipment they received (95% in both territories) and the NES program representatives who visited their households (96% and 97%, respectively).

For this evaluation, Duke Energy asked us to explore whether there was free-ridership for LEDs. Based on responses to free-ridership questions included in the participant survey, we estimated LED free-ridership at 51% for DEP and 38% for DEC. The overall free-ridership estimate is 44%. We therefore do see evidence of some free-ridership; however, the consumption analysis generates an ex-post net energy savings value that accounts for free-ridership.

Participants reported experiencing a variety of additional energy benefits after participating in the NES program. A fraction of NES respondents reported that their electric bills in summer (33% of DEP and 41% of DEC) and winter (30% of DEP and 42% of DEC) were lower after participating in the program. Additionally, a majority of both DEP and DEC participants felt that their home was less drafty and had better lighting after they participated in the program.

Overall, the educational component of the program was successful. Most NES respondents (87% of DEP and 86% of DEC) received in-person education and 93% of DEP and 89% of DEC respondents thought that the information they received was either useful or very useful. Additionally, participants reported that they were more knowledgeable about ways to save energy in their homes after their NES program participation than they were beforehand.

7.2 Recommendations

Based upon the evaluation of the NES program and our above conclusions, we provide the following recommendations to potentially enhance the program's performance and energy savings in the future.

- **At the time of the energy assessment, NES program teams should consider offering coupons for additional quantities of the energy-saving products to program participants.** While most participants were satisfied with the NES program, a small number offered recommendations to improve how it is implemented. Of the 39 participants who provided recommendations, 54% commented on how additional quantities would be

beneficial. To meet this need, NES program teams could provide "deep discount" coupons for energy saving products that customers can redeem through Duke Energy's Online Savings Store, where the coupon could provide NES participants with discounts that are larger than what they would have received without the coupon. This could help to ensure continued energy savings in homes that have been treated through the program. Furthermore, offering coupons could increase participant satisfaction with the program and can serve to direct customers to another Duke program.

- **NES program staff should emphasize air infiltration measures, as they provide both energy and non-energy benefits**. While infiltration measures make an important contribution to overall program energy savings (29% for DEP and 39% DEC participants), NES participants who receive these measures also report other valuable non-energy benefits. Of those who received infiltration measures, 66% of DEP and 59% of DEC participants reported that their home was less drafty and about one-third reported noticing a change in the comfort of their home in both the summer and winter in both jurisdictions.
- **Duke Energy should consider lengthening the amount of time before it archives customer billing data, particularly for those who participate in programs where consumption analysis is used to estimate program savings, such as NES.** For consumption analysis purposes, the evaluation team requires at least two years of data—one year of pre-participation and one year of post-participation data. Duke's consumption data archiving practices in the DEC and DEP jurisdictions conflict with the need for an extensive period of time to accumulate a sufficient number of participants to complete a consumption analysis (for treatment and comparison groups). To ensure successful evaluation, we recommend that Duke Energy work with the evaluation team prior to starting impact evaluation activities to consider what data will be required and determine whether Duke can extend the length of time before it archives its billing data. This is especially important when evaluating programs that, due to slower participation accumulation, need to rely on a longer evaluation period to ensure sufficient numbers of participants. This is particularly true for the pre-period consumption data.

8. Summary Forms

DUKE ENERGY PROGRESS
NEIGHBORHOOD ENERGY SAVER PROGRAM
COMPLETED EM&V FACT SHEET

PROGRAM DESCRIPTION

The DEP Neighborhood Energy Saver (NES) program provides one-on-one energy education, on-site energy assessments, and energy conservation measures to customers in selected low-income neighborhoods. These services are offered free of charge to all active DEP account holders who are individually metered homeowners and tenants living in predetermined income-qualified communities.

Date:	May 11, 2022
Region(s):	Duke Energy Progress
Evaluation Period:	July 1, 2018 – June 30, 2019
Annual MWh Savings (ex post net):	3,031 MWh
Coincident MW Impact (ex post net):	0.488 MW (Summer), 0.508 MW (Winter)
Measure Life:	Not Evaluated
Net-to-Gross Ratio:	N/A
Process Evaluation:	Yes
Previous Evaluation(s):	Duke Energy Progress Neighborhood Energy Saver Program, November 30, 2019

EVALUATION METHODOLOGY

To evaluate the strengths, barriers, and non-energy related benefits of the program, the evaluation team performed a range of data collection and analytic activities, including (1) interviews with DEP program staff, (2) a review of program materials and program tracking data, (3) participant telephone survey, (4) an engineering analysis of deemed savings, (5) a consumption analysis, (6) an LED free-ridership analysis.

EVALUATION FINDINGS

- A total of 96% of DEP participants reported that they were either completely satisfied or mostly satisfied with the program overall.
- DEP participants reported that most measures were still in service at the time of the participant survey, with an overall ISR of 88%.
- For the consumption analysis, a Linear Fixed Effects Regression (LFER) model was used which established a statistically significant relationship between participation in the program and energy consumption.
- NES participants reported several non-energy benefits including less drafty homes, increased comfort in summertime, and better home lighting. Additionally, 33% of DEP participants reported that their summer electric bill had gone down after participating in the NES program.

DUKE ENERGY CAROLINAS
NEIGHBORHOOD ENERGY SAVER PROGRAM
COMPLETED EM&V FACT SHEET

PROGRAM DESCRIPTION

The DEC Neighborhood Energy Saver (NES) program provides one-on-one energy education, on-site energy assessments, and energy conservation measures to customers in selected low-income neighborhoods. These services are offered free of charge to all active DEP account holders who are individually metered homeowners and tenants living in predetermined income-qualified communities.

Date:	May 11, 2022
Region(s):	Duke Energy Carolinas
Evaluation Period:	July 1, 2018 – June 30, 2019
Annual MWh Savings (ex post net):	2,276 MWh
Coincident MW Impact (ex post net):	0.413 MW (Summer), 0.418 MW (Winter)
Measure Life:	Not Evaluated
Net-to-Gross Ratio:	N/A
Process Evaluation:	Yes
Previous Evaluation(s):	Duke Energy Progress Neighborhood Energy Saver Program, November 30, 2019

EVALUATION METHODOLOGY

To evaluate the strengths, barriers, and non-energy related benefits of the program, the evaluation team performed a range of data collection and analytic activities, including (1) interviews with DEP program staff, (2) a review of program materials and program tracking data, (3) participant telephone survey, (4) an engineering analysis of deemed savings, (5) a consumption analysis, (6) an LED free-ridership analysis.

EVALUATION FINDINGS

- A total of 88% of DEC participants reported that they were either completely satisfied or mostly satisfied with the program overall.
- DEP participants reported that most measures were still in service at the time of the participant survey, with an overall ISR of 85%.
- For the consumption analysis, a Linear Fixed Effects Regression (LFER) model was used which established a statistically significant relationship between participation in the program and energy consumption.
- NES participants reported several non-energy benefits including less drafty homes, increased comfort in summertime, and better home lighting. Additionally, 41% of DEP participants reported that their summer electric bill had gone down after participating in the NES program.

9. DS More Table

An Excel spreadsheet containing measure-level inputs for Duke Energy Analytics is provided as a separate file. Per-measure savings values in the spreadsheet are based on the net impact analyses reported above. The evaluation scope did not include updates to measure life assumptions.

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