



Opinion **Dynamics**

Fields Exhibit I
1 of 48

Boston | Headquarters

617 492 1400 tel
617 497 7944 fax
800 966 1254 toll free

1000 Winter St
Waltham, MA 02451

OFFICIAL COPY

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Duke Energy Carolinas

Low Income Weatherization Program (2019–2020)

Evaluation Report – Draft

December 13, 2022

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1. Executive Summary

This report presents findings from our impact and process evaluation of the Duke Energy Carolinas (DEC) Low Income Weatherization Program (hereafter referred to as the Weatherization Program or the program), covering the period of January 1, 2019 to December 31, 2020. The impact evaluation results are based on a combination of consumption analysis and engineering analysis. Process evaluation results are based on a program materials review, interviews with program staff and participating providers, and a telephone survey of program participants.

This report includes a high-level description of the evaluation methodologies as well as results, findings, and recommendations. The associated appendix includes additional detail on the impact methodology and results.

1.1 Program Summary

The Weatherization Program aims to improve the health, safety, and energy efficiency of income-qualified Duke Energy customer households. Duke Energy funds a comprehensive package of electric conservation measures that increase energy efficiency and lower household energy costs. These weatherization, health, and safety benefits are provided at no cost to Duke Energy's customers. The program's secondary goal is to provide customer education on energy efficiency actions, measures, and other available Duke Energy programs. Duke Energy's implementation partners consist of the program administrator (the North Carolina Community Action Association, or NCCAA),¹ the database administrator (TRC), and a network of local implementing providers that enroll customers and complete weatherization projects (including community action providers, local governments, and other non-profit organizations).

Implementing providers can obtain Duke Energy funds in two ways: as a reimbursement for qualifying work completed under their state's federally funded state weatherization assistance program (State WAP)² or as a payment for new weatherization, HVAC, or refrigerator replacement projects. To be eligible, projects must be completed for Duke Energy customers who live in individually metered homes or apartments and whose household income is less than or equal to 200% of the federal poverty guideline. Providers who participate using the reimbursement model are required to apply the funds to future weatherization-related work. Duke Energy funds three types of projects through this program:

- **Tier 1:** For owner-occupied, single-family homes using less than 7 kWh per square foot annually; up to \$600 for air sealing and low-cost energy efficiency upgrades such as domestic water heater tank insulation, low-flow shower heads, faucet aerators, LED bulbs, and others.
- **Tier 2:** For owner-occupied, single-family homes using at least 7 kWh per square foot annually; up to \$4,000 for Tier 2 weatherization measures. Tier 2 projects can qualify for additional funds (up to

¹ The South Carolina Association of Community Action Partnerships, or SCACAP, is also an administrator in the program. However, SCACAP did not administer any projects during the evaluation period. NCCAA administered all South Carolina projects completed during the evaluation period.

² The State WAP programs treat this transaction as a "purchase" of savings by Duke Energy. WAP programs and Duke Energy agree that Duke Energy can claim 100% of the savings at each home for which it credits a provider, including those where Duke Energy funds cover all or part of the original project cost. US Department of Energy rulings about how providers can spend the received DEC funds differ by state. Since 2016, North Carolina does not restrict when providers can apply DEC funds, and providers do not have to spend them during the fiscal year received. South Carolina has and continues to treat DEC funds as "program income," requiring South Carolina community action providers to spend the money by the end of the fiscal year received. Historically, this has limited South Carolina provider participation.

\$6,000 in total) for qualifying electric HVAC system replacements, heat pump upgrades, or heat pump system replacements.

- **Refrigerator Replacement:** For owner-occupied homes and tenants with landlord approval; replaces existing refrigerators as a standalone offering or in combination with a Tier 1 or Tier 2 project. Incentive levels depend on the old refrigerator's size and a two-hour metering test.

Duke Energy launched the Weatherization Program in January 2015. This evaluation covers implementation processes and impacts achieved from projects completed between January 1, 2019, to December 31, 2020.

1.2 Evaluation Objectives

We established the following objectives for this evaluation:

- 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 peak demand (kW) savings;
- Identify program strengths and potential ways that the program can increase average savings per household;
- Determine participants' level of satisfaction with the program and measures received;
- Identify non-energy benefits realized by participants; and
- Identify barriers to provider participation in the program and recommend strategies for addressing those barriers.

To achieve these objectives, we completed a number of data collection and analytic activities:

- Impact evaluation activities included a review of program-tracking data, a deemed savings review, development of in-service rates (ISRs), an engineering analysis, and a consumption analysis.
- Process evaluation activities included a review of program materials; interviews with Duke Energy program staff, implementing provider staff, NCCAA and TRC staff; and a survey of participating customers.

1.3 Key Findings

During the evaluation period, 1,167 households participated in the Weatherization Program, completing 1,394 projects. The majority of participants (76%) completed a Tier 2 project; only 11% of participants completed a Tier 1 project. In addition, 27% received a replacement refrigerator, either as a stand-alone measure (13%) or in combination with Tier 1 or Tier 2 services (14%).

Impact Findings

Based on our impact analysis, we estimate that the projects completed during the evaluation period generated 1,627 MWh of net annual energy savings, 217 kW of annual summer coincident demand savings, and 517 kW of annual winter coincident demand savings. Tier 2 participants accounted for the largest share of

program-level savings (83%) while Tier 1 participants and refrigerator replacements accounted for 2% and 15%, respectively, of total program energy savings.

Table 1 presents annual per-household and program-level net ex post savings for the evaluation period.

Table 1. Summary of Impact Results

Project Type	Number of Participants	Net Annual Savings Per Household			Net Annual Program Savings		
		Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy (MWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Tier 1	130	235	0.0773	0.0274	31	10.0	3.6
Tier 2 ^a	885	1,519	0.2012	0.5479	1,344	178.0	484.9
<i>Tier 2 Weatherization Measures</i>	566	1,311	0.2469	0.3801	742	139.7	215.1
<i>HVAC Replacement/Upgrade</i>	382	1,577	0.1002	0.7062	603	38.3	269.8
Refrigerator Replacement	315	800	0.0912	0.0912	252	28.7	28.7
Total ^b	1,167				1,627	216.8	517.2

^a The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both types of upgrade.

^b The total number of unique participants is smaller than the sum of project types because some households received a replacement refrigerator in addition to completing a Tier 1 or Tier 2 project.

Based on program-tracking data, most Tier 1 and Tier 2 participants (98% and 61%, respectively) received air sealing, as shown in Table 2. Approximately half of Tier 2 participants also received insulation (57%) and/or duct system sealing (46%); these are measures not offered to Tier 1 participants. Larger shares of Tier 2 participants than Tier 1 participants received water heating measures,³ weatherstripping, lighting, and heating system tune-ups. Overall, 27% of participants received a new refrigerator and 33% received an HVAC replacement or upgrade. Notably, 13% of participants only received a new refrigerator and 27% only received an HVAC replacement/upgrade.

³ Water heating measures include water heater tank and pipe insulation, water heater temperature adjustment, low flow aerators, and low flow showerheads.

Table 2. Measure Mix

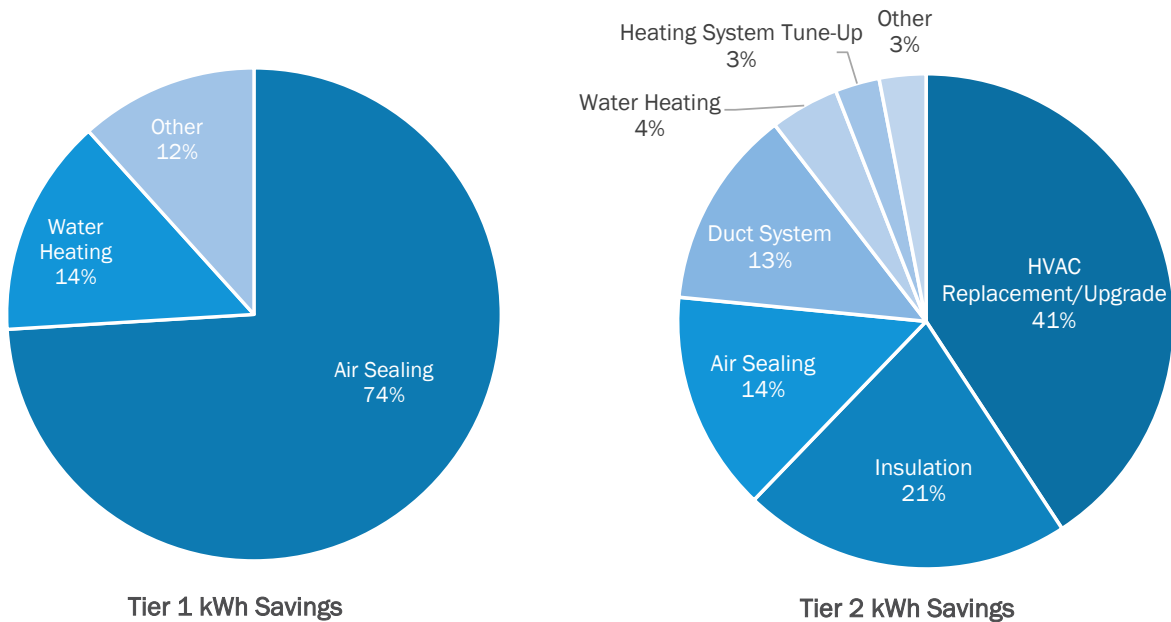
Measure Category	% of Participating Households Receiving Measure Category ^a		
	All Participants ^b (N=1,167)	Tier 1 Participants (N=130)	Tier 2 Participants (N=885)
Air Sealing	57%	98%	61%
Insulation	43%	n/a	57%
Duct System	35%	n/a	46%
Water Heating	29%	30%	34%
Weatherstripping	27%	20%	33%
Lighting	19%	18%	22%
Heating System Tune-Up	11%	7%	14%
HVAC Replacement/Upgrade	33%	n/a	43%
Refrigerator Replacement	27%	12%	17%

^a Values are based on program-tracking data and do not incorporate ISRs.

^b The overall N for All Participants is not the same as the sum of Tier 1 Participants and Tier 2 Participants because the overall N also includes those participants who only received refrigerator replacements.

Based on the engineering analysis, Tier 1 savings during the evaluation period came primarily from air sealing (74%). Another 14% came from water heating measures and 12% came from other Tier 1 measures (including heating system tune-ups, weatherstripping, and lighting measures). Tier 2 savings, on the other hand, were dominated by HVAC replacements/upgrades (41%) followed by insulation (21%), air sealing (14%), and duct sealing and insulation (13%). Water heating measures (such as faucet aerators and low-flow showerheads) accounted for 4% of engineering-based Tier 2 savings during the evaluation period, while heating system tune-ups and other Tier 2 measures (including lighting and weatherstripping) each contributed 3% (Figure 1).

Figure 1. Measure Contribution to Total Tier 1 and Tier 2 Energy Savings



Process Findings

The process evaluation found that the Weatherization Program continues to benefit from previously established relationships, implementation processes, and program-tracking systems. Program and implementation staff reported high satisfaction with the program. Participating providers also reported minimal changes to how they implement and participate in the Weatherization Program compared to the previous evaluation period, and many stated that the DEC funds allow them to complete more weatherization jobs than they would otherwise.

Key process findings include:

- **Program Participation & Processes.** Participation in the Weatherization Program has been increasing steadily since the program began in 2015. Although there was a decrease in projects in the spring and summer of 2020, due to barriers associated with the global COVID-19 pandemic, provider staff have since reported a return to normal participation levels. Providers continue to work hard to inform clients about the program through multiple advertising channels (newspaper ads, in-person events, agency websites, etc.) and most interviewed providers indicated the number of projects they complete each year either stayed the same or increased since they have resumed normal business operations following COVID-19 pandemic related shutdowns.
- **Satisfaction.** The process evaluation shows high satisfaction with the Weatherization Program. Interviewed provider staff often provided unprompted praise for the program and underscored the importance of the program to their clients. Providers also reported finding the logistical elements of the program—including the ease of participating—to be another key program strength. Sources of dissatisfaction included difficulty determining customer eligibility and the inability to apply program funds to all equipment. Participating customers are also highly satisfied with the program overall. A key driver of participation is to make the home more comfortable. Survey results suggest the program is helping participants in this respect, with 54% and 49% of respondents reporting higher comfort levels in the home during the summer and winter seasons, respectively, following participation in the program.
- **Non-Energy Impacts (NEIs).** In addition to lowering energy bills, the Weatherization Program provided substantial non-energy benefits to participants during the evaluation period, including improved home comfort in the summer and winter, reduced draftiness, and better lighting. To a lesser extent, survey respondents also reported lower noise levels from outdoors and reduced home maintenance costs. Almost three-fourths (72%) of participants reported experiencing at least one beneficial NEI since participating in the program.
- **South Carolina Policy Barriers.** The new participation channel, introduced in 2018, allows non-profit and other organizations to provide program services to customers who may not have been able to receive them otherwise using Weatherization Program funds. One objective of this channel is to overcome barriers in South Carolina, as state policies around funding prevent community action agencies (CAAs) from participating in the program. The Weatherization Program has made progress in serving customers in South Carolina, but there is room for improvement. Based on program-tracking data, there were three program providers in South Carolina actively completing projects during the evaluation period; all three providers are community-based organizations and they completed 10% of projects. However, the vast majority of South Carolina projects were refrigerator replacements, with a small number of HVAC upgrades/replacements and only one weatherization project submitted in South Carolina during the evaluation period.

1.4 Evaluation Recommendations

- **Increase support to providers in program marketing and outreach.** Providers note that communication and organization of the program are key strengths and frequently provide unprompted praise for staff at Duke Energy and NCCAA. One area identified for potential additional Duke Energy assistance is marketing and outreach to help increase customer awareness of the program. The program should continue to explore ways to promote participation while supporting existing providers by including information about the program alongside customer bills. This may be particularly important in South Carolina where the program has not had time to cultivate a large base of previous participants who can support word-of-mouth recruiting. Another area identified for potential additional Duke Energy assistance is supporting program providers in identifying eligible participants or confirming eligibility of customers they have identified. The program should consider providing additional data (individual or aggregated) for targeted outreach.
- **Evaluate funding required to align with changes in measure and labor costs following the COVID-19 pandemic and consider increasing per-project funding.** Program administration staff noted that during the evaluation period, they struggled to spend all program funds. At the same time, providers reported supply chain and labor shortages, and corresponding increased measure and labor costs, following the COVID-19 pandemic, with all interviewed providers indicating that they supplemented Weatherization Program funds with funding from other sources in order to meet participant needs. At the time of this evaluation, many providers cited high labor and material costs as an ongoing challenge. In fact, program-tracking data indicates fewer than half of participating households received most program measures. In addition, compared to the last evaluation period,⁴ a significantly smaller share of Tier 2 households received the various program measures – the only exception are HVAC upgrades/replacements (which were a new measure in the last evaluation period and not widely provided) and refrigerator replacements (which were provided to 17% of participants in both evaluation periods). Increasing per-project funding to align with current measure and labor costs can support spending of all available program funds, help ensure providers are able to install all measures appropriate for a given project, increase per-participant savings, and maintain or increase NEIs and participant satisfaction.
- **Expand efforts to recruit and support organizations that do not face funding barriers in South Carolina, with a focus on providers that offer weatherization services.** The program should continue to explore ways to promote participation in South Carolina by recruiting more organizations that do not face funding barriers in South Carolina. The providers from South Carolina have achieved more success completing projects compared to the previous evaluation period given their non-profit status, but have focused primarily on refrigerator and HVAC replacements. Duke Energy should continue to recruit organizations that do not face barriers due to state policies around weatherization funding, with a focus on those organizations that can provide weatherization services in addition to equipment replacement.
- **Consider tracking several additional parameters within the program-tracking system to enhance the accuracy of future deemed savings estimates.** Our deemed savings review (Appendix B) identified a few parameters not currently tracked in program data: (1) pre- and post-project blower door results in units of reduced cubic feet per minute (CFM); (2) presence or type of cooling at participating homes; (3) water heating fuel of participating homes; and (4) the installed location (e.g., bathroom, kitchen) for each low-flow faucet aerator. In addition, the cooling efficiencies of existing equipment for heat pump upgrades and replacements was tracked less than 7% of the time and appeared to be incorrect.

⁴ The last evaluation included participants between April 1, 2016 and December 31, 2018.

Some of this information was collected in the participant survey but including it in the program-tracking data would enhance the accuracy of future deemed savings estimates. We therefore recommend asking providers to enter this information, if already collected and available, into the program's tracking system.

2. Program Description

This section describes key elements of program design, implementation, and performance. The evaluation period addressed in this report is January 1, 2019, to December 31, 2020.

2.1 Program Design

The Weatherization Program aims to improve the health, safety, and energy efficiency of income-qualified Duke Energy customer households. The program does so by providing customers with comprehensive home weatherization services and repairs that reduce electric energy consumption. The program distributes funding through a network of CAAs, local and regional government agencies, and other non-profit organizations (collectively referred to as “providers”), which serve Duke Energy’s residential electric customers. The program reimburses providers for work completed at eligible homes.

The Weatherization Program offers two tiers of funding for weatherization upgrades to owner-occupied homes, as well as refrigerator replacements to both homeowners and renters (with landlord approval). Tier 1 covers eligible projects at homes using less than 7 kWh per square foot annually and provides up to \$600 for air sealing and low-cost energy efficiency upgrades like LEDs, domestic water heater tank insulation, low-flow shower heads, faucet aerators, and others. Tier 2 covers eligible projects at homes using at least 7 kWh per square foot annually and provides up to \$4,000 for Tier 1 measures plus insulation improvements. Tier 2 projects can qualify for a higher funding cap of \$6,000 if they include a qualifying heat pump upgrade or a heat pump system replacement. Refrigerator replacement is available even if the home did not receive any Tier 1 or Tier 2 measures. Refrigerator replacement eligibility and incentive levels are dependent on the old refrigerator’s size and a two-hour metering test.

2.2 Program Implementation

During the evaluation period, DEC contracted with NCCAA and their subcontractor TRC to implement the Weatherization Program. In total, 18 local providers participated in the program. These providers also implement a variety of poverty relief activities, including the State Weatherization Assistance Program (WAP). NCCAA and TRC oversee provider submittals, invoicing, and program-tracking, train providers on the program and requirements, support participating providers in making the most of program funding, and conduct outreach to potential new providers.

2.3 Program Performance

During the evaluation period, the program served 1,167 unique households. Only 11% of participants completed a Tier 1 project and 76% completed a Tier 2 project. About one-quarter of participants (27%) received a replacement refrigerator, either alone or in combination with a Tier 1 or Tier 2 project. Based on the impact analysis, the program achieved average annual savings of 234 kWh per Tier 1 participant and 834 kWh per Tier 2 participant. Refrigerator recipients saved an additional 800 kWh per year. Table 3 summarizes program participation as well as per household energy and demand savings, by project type.

Table 3. Annual Per Household Savings

Project Type	Number of Participants	Net Annual Savings Per Household		
		Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Tier 1	130	235	0.0773	0.0274
Tier 2 ^a	885	1,519	0.2012	0.5479
<i>Tier 2 Weatherization Measures</i>	566	1,311	0.2469	0.3801
<i>HVAC Replacement/Upgrade</i>	382	1,577	0.1002	0.7062
Refrigerator Replacement	315	800	0.0912	0.0912
Total ^b	1,167			

^a The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both types of upgrade.

^b The total number of unique participants is smaller than the sum of project types because some households received a replacement refrigerator in addition to completing a Tier 1 or Tier 2 project.

3. Overview of Evaluation Activities

3.1 Program Staff Interviews

We conducted in-depth interviews with Duke Energy program staff and the Weatherization Program administrator. The main purpose of each interview was to gain insight into program implementation processes and to develop research objectives for the evaluation. In particular, the interviews allowed us to identify implementation consistencies and inconsistencies across providers and between North Carolina and South Carolina, to identify processes that changed within the evaluation period or compared to the previous evaluation period, processes that are working well, and processes that could be improved moving forward.

3.1.1 Duke Energy Program Staff Interview

Opinion Dynamics conducted an in-depth interview with the Weatherization Program manager in September 2021. The purpose of the interview was to gauge changes in program design and implementation since the last evaluation, Duke Energy's expectations for the Weatherization Program, and the successes and challenges the program encountered over the evaluation period. The interview also covered changes to the program's measure mix, provider participation, and barriers to program participation.

3.1.2 Program Administrator Staff Interview

We conducted one in-depth interview with NCCAA (the program administrator) and its subcontractor TRC. TRC maintains the program tracking database and serves as the day-to-day contact for providers, providing them with training and implementation support. This interview explored program-wide coordination, delivery, and enrollment processes. It provided insight into the program's reimbursement process and gauged the administrators' satisfaction with program elements. The interview also helped identify key similarities and differences across implementing providers and any barriers to provider participation.

3.2 Program Materials Review

Opinion Dynamics reviewed program guidance documentation to support our understanding of program processes and resources available to providers. We also reviewed the program's tracking database and found the program-tracking data to be complete and of high quality.

While the program-tracking data for the evaluation period was complete and of high quality, we also reviewed 2021 participant data when identifying comparison group participants for the consumption analysis. South Carolina Association of Community Action Partnerships (SCACAP), which did not have any projects during the current evaluation period, submitted projects for 2021. Based on our review, SCACAP's program tracking database lacks key participation details. To support future evaluations, we recommend that SCACAP tracks the same program participation data as NCCAA and TRC.

3.3 Implementing Provider Staff Interviews

Participating providers located in North Carolina (n=15) and in South Carolina (n=3), submitted projects to the Weatherization Program during the evaluation period. These providers each received funding for an average of 77 projects.⁵ We conducted semi-structured in-depth interviews with a sample of ten of the 18 participating

⁵ The number of projects per provider during the evaluation period ranged from 2 to 492.

providers selected to represent varied types of organizations and levels of program participation. We explored changes to the program since the last evaluation, feedback on implementation processes and funding structure, as well as providers' satisfaction with the program and views about successes and barriers to participation.

We completed these interviews between January and March 2022. Responding providers completed 77% of the 2019–2020 projects. Table 4 summarizes the sample and outcome.

Table 4. Provider Interview Sample

Participating Providers	Providers in Sample	Completed Interviews	Cooperation Rate
18	15	10	67%

In addition to the interviews with participating providers, we interviewed two of the three additional providers that were associated with the program but did not complete any projects during the evaluation period. We conducted semi-structured in-depth interviews with these providers and explored reasons for the lack of participation.

3.4 Participant Survey

Opinion Dynamics implemented a computer-assisted telephone interviewing (CATI) survey in February 2022. The survey gathered data to verify participation in the program, develop measure-level estimates of installation, persistence, and ISRs, and support our process evaluation.

The survey sample design and sample size were based on customers who participated during the evaluation period. Of the 1,026 participants in the database,⁶ we drew a sample of 758 valid telephone numbers. We used this sample to complete 100 participant telephone interviews. The average interview length was approximately 11 minutes, and the response rate was 20%.

3.5 Consumption Analysis

Opinion Dynamics conducted a consumption analysis to determine the net energy savings attributable to the Weatherization Program during the evaluation period. We used separate linear fixed effects regression (LFE) models to estimate the overall net ex post program savings for Tier 1 and Tier 2 participants. The fixed effect in our models is the participant, which allows us to control for all household factors that do not vary over time. The consumption analysis used customers who participated from January 1, 2019, through December 31, 2020, as the treatment group and those who participated from January 1, 2021, through December 31, 2021, as the comparison group.

While we conducted consumption analysis for both Tier 1 and Tier 2 participants, this evaluation only relies on consumption analysis results for Tier 2 participants. For Tier 1 participants, we leveraged a combination of engineering analysis results and impact results from the prior evaluation to assess program savings. We were

⁶ The number of participants in the survey population is slightly lower than the total referenced elsewhere in the report. Following fielding of the participant survey, 141 participants were added to the evaluation and included in the impact analysis. This was due to a change in how program participation dates were recorded between the previous and current evaluation periods.

not able to estimate Tier 1 savings via consumption analysis because the results were not statistically significant.⁷

Section 4.1.1 provides a summary of the consumption analysis approach; Appendix A contains a detailed description of methods.

3.6 Engineering Analysis

The engineering analysis served several purposes: (1) to develop demand-to-energy savings ratios for Tier 1 and Tier 2 projects; (2) to develop ex post energy and demand savings for refrigerator replacements; (3) to understand the relative contribution of different measures to Tier 1 and Tier 2 savings; and (4) to develop inputs into Tier 1 energy savings.

The engineering analysis consisted of two components:

- Measure verification and development of measure specific ISRs; and
- A deemed savings review of all program measures.

We verified measures and developed measure-specific ISRs based on responses to the participant survey. As part of the deemed savings review, we reviewed measure-level savings and revised input assumptions, as needed, to be consistent with standard industry practice and other Duke Energy Carolinas program assumptions and to align with applicable versions of reviewed TRMs (mainly the Mid-Atlantic TRM V10.0). When available, the evaluation team leveraged program tracking data as well as results from the participant survey to update certain assumptions (e.g., the share of participating households with electric domestic water heating).

Appendix B provides more detail on the methods and input assumptions used in the deemed savings review.

⁷ Two factors likely contributed to the inability of the model to detect statistically significant savings: (1) the small number of Tier 1 participants and (2) the small expected savings of Tier 1 measures, relative to baseline household electricity usage.

4. Gross Impact Evaluation

4.1 Methodology

The gross impact analysis for the Weatherization Program included a consumption analysis as well as an engineering analysis. The consumption analysis determined the net evaluated energy (kWh) impacts for Tier 2. The engineering analysis supplemented the consumption analysis by:

- Providing a ratio of demand savings (kW) to energy savings (kWh), which was then applied to the consumption analysis net energy savings to calculate net evaluated demand savings;
- Developing ex post energy and demand savings for refrigerator replacements;
- Providing insight into the relative contribution of different measures to Tier 1 and Tier 2 savings; and
- Developing inputs into Tier 1 energy savings.

While we conducted consumption analysis for both Tier 1 and Tier 2 participants, this evaluation only relies on consumption analysis results for Tier 2 participants. For Tier 1 participants, we used a combination of engineering analysis results and impact results from the prior evaluation to assess program savings. We were not able to use consumption analysis to estimate Tier 1 savings because the model results were not statistically significant.

4.1.1 Consumption Analysis

Opinion Dynamics conducted a consumption analysis to determine the overall evaluated program savings from Tier 1 and Tier 2 projects. Consumption analysis is a statistical analysis of energy consumption recorded in utility billing records. Because billing records reflect whole-building energy use, the method is well suited for studying the combined impact of the Weatherization Program's mix of energy efficiency measures per home. Total program savings from Tier 1 and Tier 2 projects are estimated by examining the variation in participants' monthly electricity consumption pre- and post-program participation, relative to the variation in a comparison group's electricity consumption during those times.

Data Cleaning and Preparation

Prior to specifying the models, we performed 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 were free of outliers, such as bill periods with unreasonably small or 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 Weatherization Program was not designed as an experiment. As such, we leveraged a quasi-experimental approach to the evaluation by developing a comparison group. There are multiple approaches to selecting a comparison group, including the use of future participants, past participants, or similar non-participants. When possible, using future program participants as a comparison

group is the preferred method. The use of future participants as the comparison group allows us to effectively control for self-selection biases. We relied on a comparison group of customers who participated in the Weatherization Program between January 1 and December 31, 2021, for the Tier 2 consumption analysis.

We performed equivalency checks to assess the similarity of the treatment and comparison groups in terms of energy consumption, weather, and housing characteristics to validate that the comparison group could serve as a valid baseline. We performed equivalency analysis by tier as well as among Tier 2 HVAC replacement/upgrade recipients specifically to ensure balanced consumption among key Tier 2 subpopulations. Tier 1 treatment group participants had lower pre-period energy consumption levels than the comparison group in the pre-period, which prevented us from leveraging the comparison group for Tier 1. Pre-period consumption levels and patterns were similar between Tier 2 treatment and comparison group participants. Analysis of weather patterns indicated nearly perfect equivalency between the treatment and comparison group participants. Treatment and comparison group participants were also similar across key housing characteristics, such as home vintage, size, and type, although a slightly higher proportion of Tier 2 comparison than treatment group participants heated with electric fuel (77% vs. 70%). This slight discrepancy is controlled for in the model.

Accounting for Participation in Other Programs

Some customers participated in other Duke Energy programs after participating in the Weatherization Program. Including those customers in the consumption analysis would result in double counting of savings from other programs and artificially inflate the estimate of savings from the Weatherization Program. We dropped those customers from the analysis in order to obtain the most accurate estimate of the effects of the Weatherization Program. As part of the analysis, we reviewed Weatherization Program participants for cross participation in the following programs: the Residential Energy Efficient Products & Services Program, the Smart Savers Residential Program, the Residential Energy Assessments/Home Energy House Call Program, the My Home Energy Report Program, and the Residential Demand response Program.⁸ Overall, we dropped 4.7% of Tier 1 and 2.2% of Tier 2 treatment participants due to participation in other programs.

Table 5 summarizes final participant counts used to develop consumption analysis models.

Table 5. Accounts Included in the Consumption Analysis Model

Program Component	Treatment Group	Comparison Group	Total
Tier 1 ^a	105	60	165
Tier 2 ^b	679	311	990
<i>Tier 2 Weatherization Measures</i>	450	258	708
<i>HVAC Replacement/Upgrade</i>	275	163	438

^a The Tier 1 consumption analysis was completed using treatment participants only due to inequivalence observed between the treatment and comparison groups.

^b The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both types of upgrade.

⁸ Notably, we only dropped cross participants who participated in other programs during the 12-month post-period. We retained participants who participated either prior to their Weatherization Program participation or more than a year after participating in the Weatherization Program.

Modeling

We used an LFER model for this analysis. Each tier was analyzed in a separate regression model because the tiers are expected to provide different levels of per-home savings due to differing measures, features, and customer eligibility criteria.⁹ In addition, we used a pre-post model for Tier 1 treatment participants while the model for Tier 2 participants leveraged a future comparison group.

LFER models for Tier 1 included a series of explanatory variables designed to improve our estimate of savings relative to the baseline (i.e., what participants' consumption might have been during the post-program period, had they not received program services). The relationship of interest is between the dependent variable (monthly energy use) and a "dummy" variable that indicates whether an individual participated in the Weatherization Program. In alignment with Duke Energy's requests to isolate savings from refrigerator replacements separately from the package of measures provided for each tier, we included an indicator variable to capture the effect of a refrigerator replacement. In addition to excluding savings from the refrigerator measure, Duke Energy was interested in understanding savings from the HVAC replacement/upgrade measure within the Tier 2 program component as well as savings from the weatherization component. To accommodate that request, we estimated a Tier 2 model that included an indicator variable for HVAC replacement/upgrade that enabled us to separate the impact of that measure.

Consumption analyses typically include a series of additional variables to explain non-program variation in monthly energy use pre- and post-participation. Following best practice, we used a fixed-effects model, which captures the effect of household-specific characteristics that do not vary over time (as participant-specific intercepts).¹⁰ We included weather (heating degree days and cooling degree days) in the model and monthly dummy variables to further control for seasonal differences in energy consumption. For Tier 2, we also included an interaction term for weather and heating fuel type to account for the different electricity usage that customers with electric heating fuel have in the winter. After controlling for these outside influences, the final model results for the Weatherization Program reflect savings associated with installed measures and any behavioral changes from energy efficiency knowledge gained as part of the participation process.

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

4.1.2 Engineering Analysis

As part of the impact evaluation, Opinion Dynamics conducted an engineering analysis for each Weatherization Program measure installed during the evaluation period. The engineering analysis consisted of two distinct steps: (1) measure verification and development of measure specific ISRs; and (2) a deemed savings review of all program measures. Both are described below.

⁹ Note that participants who only received a refrigerator replacement were excluded from the consumption analysis.

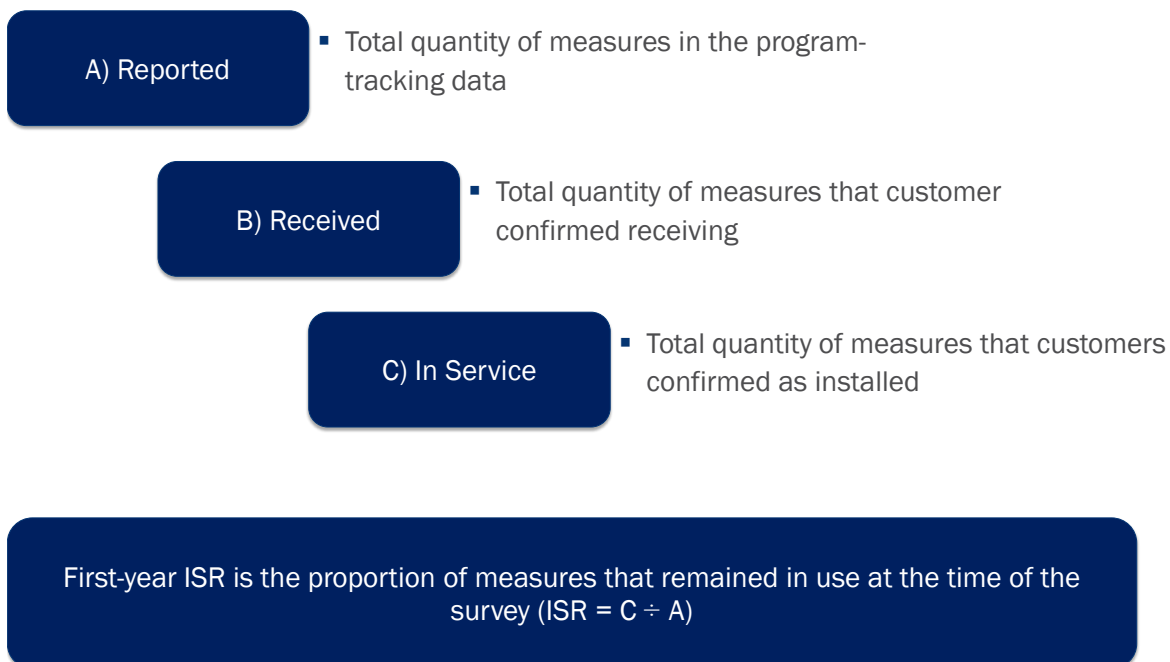
¹⁰ This includes factors such as building square footage, appliance stock, habitual behaviors and preferences, household size, and others.

Measure Verification

The participant survey included questions designed to verify that participants received program measures and that those measures are in place and operational. The measure-level ISRs represent the share of measures in the program-tracking data in service at the time of the survey, based on 100 completed telephone interviews. Our engineering analysis applied the ISRs to ex post deemed savings to develop total engineering savings.

Figure 2 outlines the method for deriving the ISR for each measure. During the survey, we asked participants to confirm 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 in service at the time of the survey.

Figure 2. In-Service Rate Components



Based on the survey responses, we calculated the verification rate, the persistence rate, and the resulting ISR, using the equations shown below, for each participant and each measure they received. We then developed averages of each rate by measure group.

$$1) \text{ Verification Rate} = \frac{(B)\text{Received Quantity}}{(A)\text{Reported Quantity}}$$

$$2) \text{ Persistence Rate} = \frac{(C)\text{In Service Quantity}}{(B)\text{Received Quantity}}$$

$$3) \text{ First Year In Service Rate} = \frac{(C)\text{In Service Quantity}}{(A)\text{Reported Quantity}}$$

In previous evaluations of the Weatherization Program and other DEC direct install programs, Opinion Dynamics found that participants had difficulty verifying certain measures, and that the nature of certain measures made verification of persistence unnecessary. As such, we made the following assumptions:

- **Water heater tank wrap, pipe wrap, duct sealing/insulation, water heater adjustments, and heating system tune-ups:** For these measures, we assumed 100% for both rates as participants are often not aware of the installation of these measures, but once installed, they are unlikely to be removed/undone.
- **HVAC upgrades/replacements, air sealing, and insulation:** We assumed that 100% of received measures remained installed as they are unlikely to be removed.

Ex Post Deemed Savings

We used several resources and assumptions to conduct our deemed savings review, including previous DEC low income program evaluations, relevant TRMs,¹¹ and other secondary sources (such as ASHRAE Fundamentals and the US EPA air source heat pump calculator) to examine algorithms and assumptions. Where possible, we used DEC-specific assumptions to estimate measure-specific deemed savings including program-tracking data, participant survey data, and supplemental refrigerator test data. For more information on the algorithms and inputs used to develop deemed savings estimates for each measure, see Appendix B.

Total Program Gross Savings

We developed total program gross savings, by tier, by applying the measure-specific ISRs to the ex post deemed values. We then multiplied the ex post deemed savings by the measure quantity provided in the program tracking database to arrive at total program savings. Where savings for certain measures rely on electric heating equipment or the presence of cooling equipment, we developed fuel-specific deemed values and applied them based on the HVAC equipment specified within the program tracking database. For water conservation measures, we developed weighted savings based on participant survey responses since the database does not provide water heating fuel type.

We then estimated per household savings for each tier by dividing total tier savings by the number of households participating in that tier.

4.1.3 Tier 1 Savings

Because the consumption analysis did not generate statistically significant results for Tier 1 participants, we developed per household Tier 1 savings using a combination of engineering analysis results and results from a prior evaluation. Specifically, the analysis consisted of the following steps:

- **Step 1:** Develop a ratio of per household Tier 1 savings based on (1) engineering estimates from this evaluation and (2) normalized engineering estimates from the 2015–2016 evaluation; and
- **Step 2:** Apply the Tier 1 savings ratio from Step 1 to Tier 1 consumption analysis results from the 2015–2016 evaluation.

¹¹ Per recent guidance from Duke Energy, this review used the Mid-Atlantic TRM v10.0 for all possible TRM-based inputs and only leveraged other TRMs when the Mid-Atlantic TRM did not have the needed information or when we judged another data source to be substantially superior to the Mid-Atlantic TRM.

The goal of this analysis was to develop a measure of Tier 1 activity during this evaluation period relative to Tier 1 activity during the 2015–2016 evaluation period that could then be applied to Tier 1 consumption analysis results from the prior evaluation.¹² The following subsections provide more detail on the two steps.

Ratio of Tier 1 Engineering-Based Savings

We developed the Tier 1 savings ratio using the following equation:

$$\begin{aligned}\text{Tier 1 Savings Ratio} &= \text{Per HH Tier 1 Savings}_{2019-2020} / \text{Normalized per HH Tier 1 Savings}_{2015-2016} \\ &= 864 \text{ kWh} / 963 \text{ kWh} \\ &= 0.90\end{aligned}$$

The numerator in this equation (864 kWh) is the per household Tier 1 savings as estimated in the engineering analysis for this evaluation (Section 4.2.3).

The denominator (963 kWh) is estimated by multiplying, for each Tier 1 measure, the 2015–2016 ISR-adjusted quantity by the 2019–2020 average Tier 1 savings value. We “normalized” the 2015–2016 Tier 1 engineering analysis results with deemed savings values from this evaluation to isolate changes in program activity (i.e., changes in the measure mix and the average quantity of measures received by each Tier 1 participant) between the two evaluation periods. This normalization step was important because updates to deemed savings assumptions resulted in changes to deemed savings values between the two evaluations. These changes were made, in part, to develop more consistent assumptions between various Duke Energy program evaluations (as requested by regulatory staff) and are not necessarily reflective of changes in the operation or outcomes of the Weatherization Program.

Final Tier 1 Savings

We estimated the final per household Tier 1 savings for the 2019–2020 evaluation period as follows:

$$\begin{aligned}\text{Final Per HH 2019–2020 Tier 1 Savings} &= \text{Tier 1 Savings Ratio} * \text{2015–2016 Tier 1 Savings}_{\text{Consumption Analysis}} \\ &= 0.90 * 262 \text{ kWh} \\ &= 235 \text{ kWh}\end{aligned}$$

The final Tier 1 per household savings thus leverage the Tier 1 consumption analysis results from the prior consumption analysis (262 kWh) but adjust those results by the change in Tier 1 activity (on a per household basis) between the two evaluation periods (90%).

¹² We selected this approach since the previous evaluation of this program found that engineering analysis results alone do not provide a good proxy for the consumption analysis. However, engineering analysis results from this evaluation, relative to those from a prior evaluation, provide a good indication of changes in program activity that can be used to adjust the consumption analysis results from a prior evaluation. We used the 2015–2016 evaluation results as a base because the 2016–2018 consumption analysis also did not generate statistically significant results for Tier 1 participants, and this approach relies on the relationship between engineering and consumption analysis values.

4.2 Gross Impact Results

4.2.1 Consumption Analysis

This section provides per-participant consumption analysis results. Appendix A contains the complete results of the models. Table 6 summarizes the results of the consumption analysis models for Tier 1 and Tier 2. The variable “Post Weatherization” represents the main effect of the treatment (i.e., the change in average daily consumption [ADC] attributable to participation in the Weatherization Program) controlling for whether the participant also received a refrigerator replacement and/or an HVAC replacement/upgrade (applicable to Tier 2 only). Local weather (expressed as cooling degree days [CDD] and heating degree days [HDD]) and having electric heating fuel also significantly impacted consumption.

As can be seen in the table, the participation coefficient for Tier 1 is not statistically significant, indicating that the model did not establish a statistically significant relationship between participation in the program and energy consumption. For Tier 2, all program-related coefficients are statistically significant and negative, indicating a negative relationship between participation and energy consumption (i.e., the presence of savings).

Table 6. Results of Tier 1 and Tier 2 Consumption Analysis Models¹³

Variable	Tier 1 Coefficients ^a	Tier 2 Coefficients
Post Weatherization (Participation Date)	-0.129	Summer: -0.502*** Winter: -0.321***
HDD (Heating Degree Days)	0.319***	0.025
CDD (Cooling Degree Days)	2.356***	1.995***
Refrigerator Replacement Indicator	-1.886**	-3.455***
HVAC Replacement Indicator	---	Summer: -0.893*** Winter: -0.334***
Electric Heating Fuel Indicator	---	1.316***
Constant (Average Intercept)	15.042	30.618
Observations (Number of Customer Bills)	2,629	24,644
Adjusted R-Squared	0.594	0.649

^a Tier 1 consumption analysis results are shown for reference only and were not used to calculate impacts as the results were not statistically significant.

* p<0.1, ** p<0.05, *** p<0.01.

Table 7 shows the estimated annual per-home savings for the program. As noted above, the results in the Tier 1 and Tier 2 rows reflect the effect of the Weatherization Program alone (any changes in energy use due to other programs are not included) and exclude impacts of the program refrigerator installations. For Tier 2, the table isolates estimated savings for Tier 2 weatherization measures and HVAC replacement/upgrades, respectively.¹⁴ It should be noted that the estimates of percent savings per home are based on the modeled baseline usage, including the pre-period usage of both treatment and control group participants, controlling for weather. As such, Table 7 presents a single baseline usage estimate for overall Tier 2 savings as well as savings for Tier 2 weatherization measures and the HVAC replacement/upgrade measure.

¹³ The coefficients for the monthly dummies are presented in Appendix A.

¹⁴ The category “Tier 2 weatherization measures” includes all Tier 2 measures other than HVAC Replacement/Upgrade, (i.e., it includes measures such as lighting and water heating measures installed as part of a Tier 2 project).

The savings estimate for Tier 1 participants is not statistically significant at 90% confidence, indicating that the model could not detect a savings signal. The small sample size relative to the variability in the consumption data as well as the nature and depth of Tier 1 improvements (smaller expected savings) are likely the key drivers of the model performance. Savings for Tier 2 participants, on the other hand, are meaningful and statistically significant. Tier 2 participants saved an average of 1,519 kWh per year, equivalent to 10.1% of their baseline usage. Savings from Tier 2 weatherization measures were 1,311 kWh per year, while savings from HVAC replacements/upgrades were 1,577 kWh per year.

Table 7. Annual Per-Participant Energy Savings from Consumption Analysis

Program Component	Modeled Treatment Participants	Per-Participant Baseline Energy Use (kWh/yr)	Ex Post Annual Savings per Participant (kWh)	90% Confidence Interval	
				Lower	Upper
Tier 1 ^a	105	7,848	47	(133)	228
Tier 2 ^b	679	15,100	1,519	1,349	1,689
Tier 2 Weatherization Measures	450		1,311	1,166	1,455
HVAC Replacement/Upgrade	275		1,577	1,398	1,757

^a Savings for Tier 1 participants are not statistically significant at 90% confidence.

^b The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both types of upgrade. Tier 2 savings and associated confidence intervals were calculated as a weighted average of the sum of Tier 2 Weatherization and HVAC replacement measures.

4.2.2 Engineering Analysis

This section provides the results of the engineering analysis, including ISRs and ex post deemed energy and demand savings estimates for each measure offered by the Weatherization Program. In addition, it summarizes total program and per household savings estimates for the 2019–2020 evaluation period (by project type), provides insight into the contribution of various measures to Tier 1 and Tier 2 savings, and presents the Tier 1 and Tier 2 demand-to-energy ratios (used to develop Tier 1 and Tier 2 demand savings).

Measure Verification Results

Our measure verification analysis showed moderate to high ISRs for all measures, as shown in Table 8. DEC Weatherization Program participants reported that 98% of insulation, 92% of refrigerators, and 97% of heating systems remained in service at the time of the survey. Additionally, 91% of air sealing and 91% of door weatherstripping remained in service at the time of the survey. ISRs were slightly lower for the smaller measures: 85% of efficient showerheads, 72% of LEDs, and 63% of efficient faucet aerators remained in service at the time of the survey.

The lower ISRs for LEDs and faucet aerators were due to a combination of low verification and persistence, while the showerhead ISR was driven primarily by low persistence. Verification rates for these measures may be lower because customers do not realize the equipment has been installed. The program directly installs equipment that would help achieve energy savings, but the customer may lack awareness of just what equipment has been installed. The few participants who reported removing these measures stated either that the measure stopped working or that the measure did not meet their needs.

Table 8. First Year Measure In-Service Rates

Measure Category	Verification Rate	Persistence Rate	First-Year ISR ^a
Air Sealing , Weather Stripping, and Insulation			
Air Sealing	91%		91%
Door Weatherstripping	93%	99%	91%
Insulation	98%		98%
Water Heating			
Faucet Aerators	71%	88%	63%
Pipe Insulation ^b			100%
Showerheads	95%	89%	85%
Water Heater Insulation Wrap ^b			100%
Water Heater Temp Adjustment ^b			100%
Heating System			
Duct Sealing/Insulation ^b			100%
Heating System	97%		97%
Heating System Tune-Up ^b			100%
Other Measures			
LEDs	84%	85%	72%
Refrigerator	96%	96%	92%

^a Note that each rate is developed as the average of respondent-level rates.

^b Not verified through the participant survey and assumed 100% ISR.

Note: Responses of “I don’t know” were removed from the analysis.

Ex Post Deemed Savings Results

Table 9 provides the estimated gross per-unit energy and demand savings for all measures installed through the Weatherization Program. As described in Section 4.1.2, we based the measure-level savings on secondary research. We then applied Weatherization Program-specific assumptions on household characteristics, where applicable per-unit savings for all measures except lighting, refrigerator replacements, and HVAC upgrades/replacements represent the fuel-weighted average based on the participant mix of heating fuel and cooling equipment during the evaluation period.

Table 9. Ex Post Per-Unit Deemed Savings Estimates

Measure	Tier	Per-Unit Energy Savings (kWh)	Per-Unit Summer peak demand (kW)	Per-Unit Winter peak demand (kW)
Water Heating				
DWH Pipe Insulation (2'-5' sections)	Tier 1	312.00	0.0356	0.0356
DWH Tank Insulation	Tier 1	165.87	0.0189	0.0189
Water Heater Temp Adjustment	Tier 1	53.49	0.0061	0.0061
Low-Flow Showerhead	Tier 1	159.61	0.0177	0.0354
Low-Flow Aerator	Tier 1	55.20	0.0037	0.0073
Lighting				
5W LED	Tier 1	20.26	0.0030	0.0015
9W LED	Tier 1	34.44	0.0051	0.0025
Air Sealing and Weatherstripping				
Air Sealing (per home)	Tier 1	861.79	0.2819	0.1617
Door Weatherstripping (per door)	Tier 1	88.14	0.0288	0.0165
Insulation				
Attic Insulation – Cellulose, Blown – R-30	Tier 2	0.98	0.0001	0.0004
Attic Insulation – Cellulose, Blown – R-38	Tier 2	1.02	0.0001	0.0004
Attic Insulation – Fiberglass, Blown – R-30	Tier 2	0.98	0.0001	0.0004
Attic Insulation – Fiberglass, Blown – R-38	Tier 2	1.02	0.0001	0.0004
Belly Fiberglass Loose	Tier 2	0.86	0.0001	0.0003
Floor Insulation – Fiberglass, Batts – R-19	Tier 2	0.86	0.0001	0.0003
Knee Wall Insulation	Tier 2	0.86	0.0001	0.0003
Wall Insulation – Fiberglass, Blown – R-13	Tier 2	0.72	0.0001	0.0003
Wall Insulation – Cellulose, Blown – R-13	Tier 2	0.72	0.0001	0.0003
Manufactured Home Roof Cavity	Tier 2	0.86	0.0001	0.0003
Heating System				
Heating System Tune-up (per system)	Tier 1	745.83	0.0223	0.1387
Duct Insulation (per system)	Tier 2	232.49	0.0313	0.0906
Duct Sealing (per system)	Tier 2	1,172.35	0.1579	0.4566
HVAC Upgrade/Replacement				
Heat Pump Upgrade (per heat pump)	Tier 2	959.51	0.0970	0.3790
Heat Pump Replacement (per heat pump)	Tier 2	6,541.72	0.3674	2.9969
Refrigerator				
ENERGY STAR® Refrigerator (15 cu. Ft.) ^a	Tier 1	679.33	0.0775	0.0775
ENERGY STAR® Refrigerator (18 cu. Ft.)	Tier 1	894.78	0.1021	0.1021
ENERGY STAR® Refrigerator (21 cu. Ft.)	Tier 1	930.66	0.1062	0.1062

^a The ENERGY STAR® name and mark are registered trademarks owned by the US EPA.

Total Program and Per-Household Savings

We calculated engineering-based gross program savings for the evaluation period by applying the ISRs shown in Table 8 to the per-unit estimates shown in Table 9. We then multiplied these ISR-adjusted per-unit estimates by the respective measure quantities in the program tracking database.

Table 10 summarizes total engineering-based gross program energy and demand savings, by measure, for the 2019–2020 evaluation period. It also includes the average measure quantity per participating household.

Table 10. Engineering Analysis Total Gross Savings by Measure

Measure	Unit	Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Average Qty per Household
Water Heating					
DWH Pipe Insulation	Water heaters	77,688	8.86	8.86	0.2
DWH Tank Insulation	Water heaters	37,155	4.24	4.24	0.2
Water Heater Temp Adjustment	Water heaters	1,444	0.16	0.16	< 0.1
Low-Flow Showerhead	Showerheads	26,591	2.95	5.89	0.1
Low-Flow Aerator	Aerators	9,993	0.66	1.32	0.2
Lighting					
5W LED	Lamps	1,162	0.17	0.08	< 0.1
9W LED	Lamps	40,694	6.02	2.91	1.0
Air Sealing and Weatherstripping					
Air Sealing	Households	520,682	179.05	88.52	0.5
Door Weatherstripping	Households	56,202	20.63	8.19	0.6
Insulation					
Attic Insulation	Sq. Feet	405,795	52.50	160.33	348.9
Belly Fiberglass Loose	Sq. Feet	63,373	8.20	25.04	62.8
Floor Insulation	Sq. Feet	152,832	19.77	60.38	151.5
Wall Insulation	Sq. Feet	13,671	1.77	5.40	15.5
Manufactured Home Roof Cavity	Sq. Feet	15,350	1.99	6.06	15.2
Heating System					
Heating System Tune-up	Households	95,337	3.13	17.48	0.1
Duct Insulation	Households	1,487	0.17	0.61	< 0.1
Duct Sealing	Households	394,768	66.11	140.19	0.3
HVAC Upgrade/Replacement					
Heat Pump Upgrade	Households	204,296	20.65	80.70	0.2
Heat Pump Replacement	Households	1,036,681	58.22	474.92	0.1
Refrigerator					
ENERGY STAR Refrigerator (15 cu. Ft.)	Refrigerators	38,251	4.36	4.36	< 0.1
ENERGY STAR Refrigerator (18 cu. Ft.)	Refrigerators	114,807	13.10	13.10	0.1
ENERGY STAR Refrigerator (21 cu. Ft.)	Refrigerators	98,793	11.27	11.27	0.1

Table 11 summarizes total and per household gross program energy and demand savings by project type.

Table 11. Engineering Analysis Gross Program Savings

Project Type	Unique Participating Households	Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)
Total Program Savings				
Tier 1	130	112,350	36.9	13.1
Tier 2 ^a	885	3,042,853	418.3	1,078.2
<i>Tier 2 Weatherization Measures</i>	566	1,801,875	339.5	522.6
<i>HVAC Replacement/Upgrade</i>	382	1,240,977	78.9	555.6
Refrigerator Replacement	315	251,851	28.7	28.7
Total ^b	1,167	3,407,053	484.0	1,120.1
Average Savings per Household				
Tier 1	130	864	0.284	0.101
Tier 2 ^a	885	3,438	0.473	1.218
<i>Tier 2 Weatherization Measures</i>	566	3,184	0.600	0.923
<i>HVAC Replacement/Upgrade</i>	382	3,249	0.206	1.455
Refrigerator Replacement	315	800	0.091	0.091

^a The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both weatherization measures and an HVAC replacement/upgrade.

^b The total number of unique participants is smaller than the sum of project types because some households received a replacement refrigerator in addition to completing a Tier 1 or Tier 2 project.

Measure Mix and Contribution to Tier 1 and Tier 2 Savings

Based on program-tracking data, the majority of Tier 1 and Tier 2 participants (98% and 61%, respectively) received air sealing. About half of Tier 2 participants also received insulation (57%) and/or duct system sealing (46%), measures not offered to Tier 1 participants. Slightly larger shares of Tier 2 participants than Tier 1 participants received water heating measures, weatherstripping, lighting, and heating system tune-ups. Overall, 27% of participants received a new refrigerator and 33% an HVAC replacement or upgrade. Notably, 13% of participants only received a new refrigerator and 27% only received an HVAC replacement/upgrade.

Table 12. Measure Mix

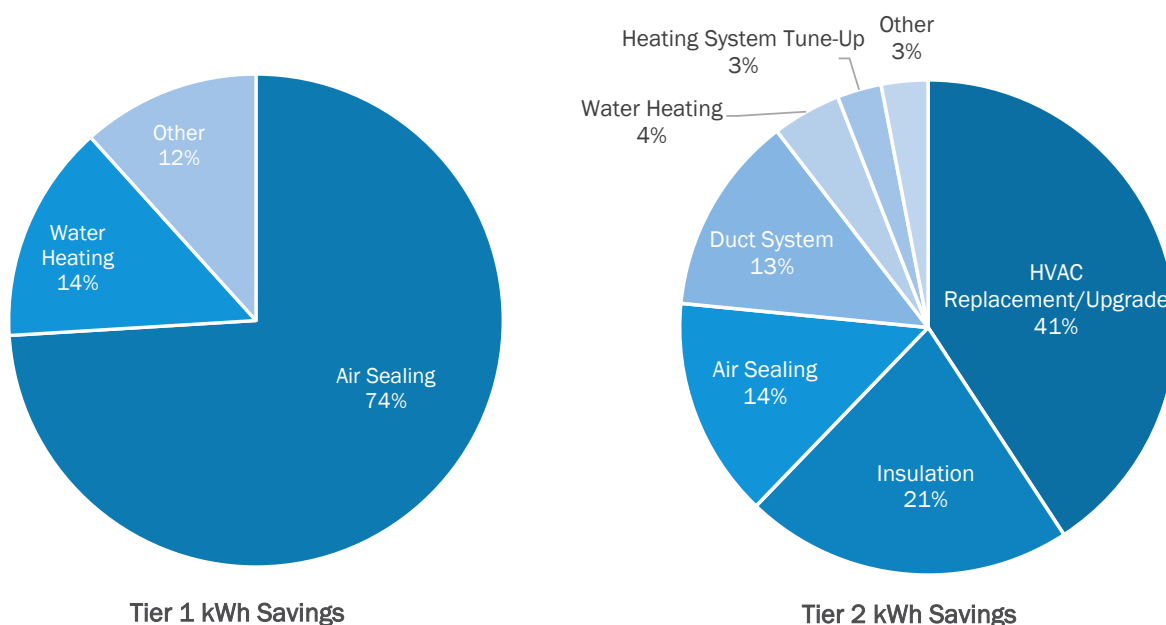
Measure Category	% of Participating Households Receiving Measure Category ^a		
	All Participants (N=1,167) ^b	Tier 1 Participants (N=130)	Tier 2 Participants (N=885)
Air Sealing	57%	98%	61%
Insulation	43%	n/a	57%
Duct System	35%	n/a	46%
Water Heating	29%	30%	34%
Weatherstripping	27%	20%	33%
Lighting	19%	18%	22%
Heating System Tune-Up	11%	7%	14%
HVAC Replacement/Upgrade	33%	n/a	43%
Refrigerator Replacement	27%	12%	17%

^a Values are based on program-tracking data and do not incorporate ISRs.

^b The overall N for All Participants is not the same as the sum of Tier 1 Participants and Tier 2 Participants because the overall N also includes those participants who only received refrigerator replacements.

Based on the engineering analysis, Tier 1 savings during the evaluation period came primarily from air sealing (74%). Another 14% of Tier 1 savings came from water heating measures and 12% came from other Tier 1 measures (including heating system tune-ups, weatherstripping, and lighting measures). Tier 2 savings, on the other hand, were dominated by HVAC replacements/upgrades (41%) followed by insulation (21%), air sealing (14%), and duct sealing and insulation (13%). Water heating measures (such as faucet aerators or low-flow showerheads) accounted for 4% of engineering-based Tier 2 savings during the evaluation period, while heating system tune-ups and other Tier 2 measures (including lighting, and weatherstripping) each contributed 3% (Figure 3).

Figure 3. Measure Contribution to Total Tier 1 and Tier 2 Energy Savings



4.2.3 Tier 1 Savings

A comparison of installed units (inclusive of evaluation-specific ISRs) between the two evaluation periods shows that participants during the 2019–2020 evaluation period were less likely to receive door weatherstripping, faucet aerators, and showerheads than participants during the 2015–2016 evaluation period. Similarly, the participants during the 2019–2020 evaluation period did not install any CFLs.

Applying 2019–2020 per unit savings for Tier 1 participants to installed units results in annual per household Tier 1 savings of 864 kWh during the current evaluation period, compared with 963 kWh for the prior evaluation period. The resulting Tier 1 Savings Ratio is 0.90 (864 kWh / 963 kWh), meaning that based on the measure mix and installed measure quantities, per household Tier 1 savings for the 2019–2020 evaluation period could be expected to be 90% of Tier 1 savings for the 2015–2016 evaluation period.

Table 13 summarizes the comparison between Tier 1 participants in the two evaluation periods.

Table 13. Tier 1 Savings Comparison with Participants from Prior Evaluation

Measure	Savings Unit	Installed Units / Participant ^a		2019–2020 per Unit kWh Savings ^b	Per Participant kWh Savings	
		2015–2016	2019–2020		2015– 2016	2019– 2020
Air Sealing and Weatherstripping						
Air Sealing	Home	0.90	0.90	710.3	637	640
Door Weatherstripping	Door	0.56	0.34	65.8	37	23
Lighting						
LED 5W	Lamp	-	0.02	20.3	-	0.4
LED 9W	Lamp	-	0.60	34.4	-	21
Heating System						
Heating System Tune Up	System	0.11	0.07	827.7	88	57
Water Heating						
DWH Pipe Insulation	10’ Section	0.28	0.20	312.0	87	62
DWH Tank Insulation	System	0.26	0.25	165.9	43	42
Water Heater Temp Adjustment	System	0.10	0.04	53.5	5	2
Low-Flow Showerheads	Showerhead	0.23	0.07	159.6	37	11
Low-Flow Aerators	Aerator	0.50	0.10	55.2	28	6
Total Tier 1 Savings					963	864

^a Inclusive of evaluation-specific ISRs^b Savings represent averages for Tier 1 participants only and are exclusive of ISRs

Applying the Tier 1 Savings Ratio of 0.90 to the Tier 1 consumption analysis result from the prior evaluation (262 kWh per household) results in estimated per household Tier 1 savings of 235 kWh for the 2019–2020 evaluation period:

$$\text{Final Per Household Tier 1 Savings} = 0.90 * 262 \text{ kWh} = 235 \text{ kWh}$$

4.2.4 Demand-to-Energy Ratios

Using the estimated energy and demand savings from the engineering analysis (Table 11), we calculated overall kW-per-kWh savings ratios, by tier (Table 14).

Table 14. Engineering Demand-to-Energy Ratios

Project Type	Total Gross Energy Savings (kWh)	Summer Coincident Peak Savings (kW)	Winter Coincident Peak Savings (kW)	Summer Ratio Multiplier (summer demand/energy savings)	Winter Ratio Multiplier (winter demand/energy savings)
Tier 1	112,350	36.91	13.10	0.0003285	0.0001166
Tier 2-Wx	1,801,875	339.48	522.60	0.0001884	0.0002900
Tier 2-HVAC	1,240,977	78.86	555.62	0.0000636	0.0004477

We multiplied these ratios by the Tier 1 and Tier 2 per-household energy savings to estimate per household net demand savings per tier (Table 15).

Table 15. Net Annual Energy and Demand Savings by Project Tier

Project Type	Number of Participants	Net Annual Savings Per Household			Net Annual Program Savings		
		Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy (MWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Tier 1	130	235	0.0773	0.0274	31	10.0	3.6
Tier 2 ^a	885	1,519	0.2012	0.5479	1,344	178.0	484.9
<i>Tier 2 Weatherization Measures</i>	566	1,311	0.2469	0.3801	742	139.7	215.1
<i>HVAC Replacement/Upgrade</i>	382	1,577	0.1002	0.7062	603	38.3	269.8

^a The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both weatherization measures and an HVAC replacement/upgrade.

4.3 References

The following sources were used in the engineering analysis:

- ASHRAE Fundamentals. Appendix: Design Conditions for Selected Locations. June 1, 2021.
- ENERGY STAR Air Source Heat Pump Calculator. Full-load cooling and heating hours cite EPA 2002 in calculator.
- Illinois Technical Reference Manual. Version 10.0. September 25, 2020.
- Indiana Technical Reference Manual. Version 2.2. July 28, 2015.
- Michigan Evaluation Working Group Showerhead and Faucet Aerator Meter Study Memorandum. June 2013.
- Mid-Atlantic Technical Reference Manual. Version 10.0.
- Baseline refrigerator energy consumption based on test measurement data provided by Duke Energy for 60 refrigerators.
- 2019–2020 DEC LI Weatherization program tracking database.
- 2019–2020 DEC LI Weatherization participant survey conducted by Opinion Dynamics in 2022.

5. Process Evaluation

5.1 Researchable Questions

Based on discussions with DEC program staff, Opinion Dynamics developed the following process-related research questions:

- Have there been any major changes since the last evaluation, and what effects have they had on implementing provider participation levels, measure mix, and per-household savings?
- What are the major strengths of the program? Are there specific ways that the program could be improved to be more effective in the future?
- Are participating implementing providers satisfied with the program? What are their barriers to program participation (i.e., are there limiting factors to achieving greater participation)?
- What policy barriers to implementing provider participation still exist in the South Carolina portion of DEC's service area? What, if any, program process improvements can DEC make to enhance its impact in that state?
- Are participants satisfied with the program and measures received?
- What types of non-energy benefits have participants experienced since participating?

5.2 Methodology

Our process evaluation relied on (1) interviews with program staff, the program coordinators (NCCAA and TRC), and ten participating providers; (2) review of program materials and program-tracking data; and (3) analysis of the participant survey.

The full survey instrument can be found in Appendix C.

5.3 Key Findings

5.3.1 Program Participation

The 2019–2020 program comprised the fifth and sixth years of the Weatherization Program. Between January 1, 2019, and December 31, 2020, 15 participating providers in North Carolina served 1,036 households (89%) while three participating providers in South Carolina served 131 households (11%). The majority of projects (68%) were classified as Tier 2 projects while 23% of projects were refrigerator replacements and 9% of projects were classified as Tier 1 projects.

Of the 18 participating providers, 14 were already active during the prior evaluation period and four were new to the program; three of the new participating providers were from South Carolina. The 18 providers submitted between 2 and 492 weatherization projects, for an average of 77 projects per provider (Table 16).

Table 16. 2019–2020 Provider Projects by Tier

Provider	Type	Tier 1	Tier 2	Refrigerator Replacement	Total
Blue Ridge Community Action, Inc.	CAA	82	317	93	492
Piedmont Triad Regional Council	Government	0	317	39	356
Yadkin Valley Economic Development District Inc.	CAA	14	128	15	157
Community Action Opportunities	CAA	11	63	18	92
Kershaw Area Resource Exchange ^a	Non-Profit	0	15	45	60
Anderson Interfaith Ministries ^a	Non-Profit	0	7	33	40
United Way of Lancaster County Inc ^a	Non-Profit	0	0	39	39
Cabarrus County Planning & Development Services	Government	3	22	6	31
Resources for Seniors	Non-Profit	10	12	4	26
Blue Ridge Opportunity Commission	CAA	3	18	0	21
Macon County Government	Government	3	15	0	18
Charlotte Area Fund Inc	CAA	0	0	17	17
Mountain Projects Inc.	CAA	1	9	5	15
Habitat for Humanity of Charlotte ^a	Non-Profit	0	9	0	9
Four Square Community Action Inc.	CAA	1	7	1	9
Central Piedmont Community Action Inc	CAA	1	5	0	6
Rebuilding Together of the Triangle	Non-Profit	0	4	0	4
I CARE Inc.	CAA	1	1	0	2
Total Projects		130	949	315	1,394

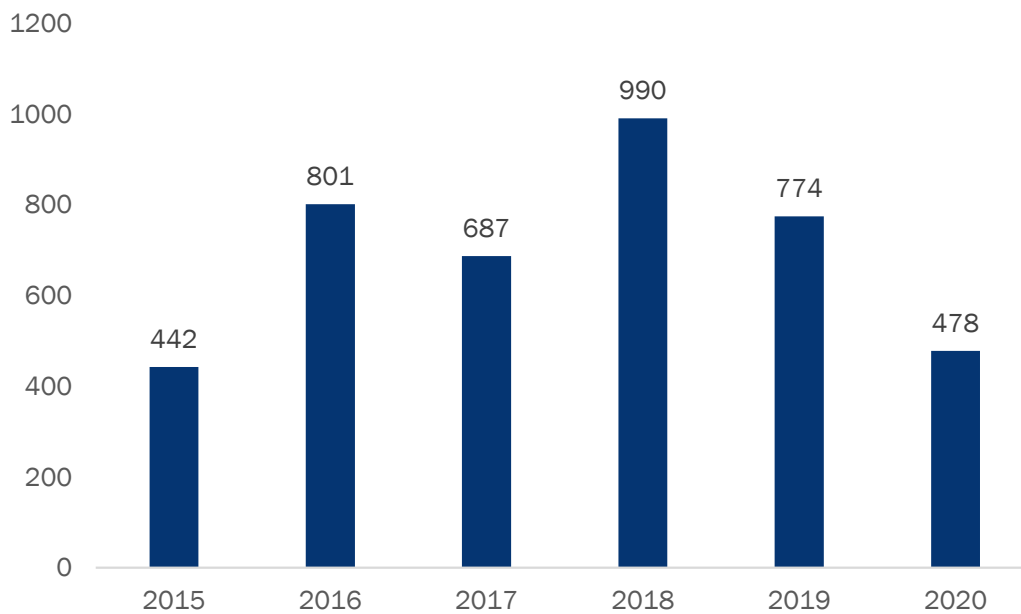
^a Denotes providers new to the Weatherization Program in the 2019–2020 evaluation period, based on a review of participating providers in the 2016–2018 evaluation period.

During the evaluation period, the program provided incentives for 1,394 projects at 1,167 homes across North and South Carolina.¹⁵ On an annual basis, 2018 represented the largest number of projects (990) since program initiation in 2015. While the years 2017 and 2019 saw slight dips in project completions (687 and 774, respectively) compared to 2016 and 2018 (801 and 990, respectively), the overall trend of project completions was increasing until 2019. The program, however, experienced a substantial reduction in participation in 2020 (478), corresponding to the global pandemic during that year. In interviews, many providers noted that they paused services in spring of 2020 due to the COVID-19 pandemic, and that supply chain and staffing challenges affected their ability to complete projects at their pre-pandemic rate once services resumed. Figure 4 shows the total number of projects completed each year, from 2015 through 2020.¹⁶

¹⁵ Projects are defined by project numbers found in the tracking database, which denotes HVAC and refrigerator replacements as separate projects when a participant also receives Tier 1 or Tier 2 measures.

¹⁶ (1) 2016 includes projects from two different evaluation periods (2015–2016 and 2016–2018) and (2) 2018 includes 142 projects from the current evaluation period because the date used to define participation in the program-tracking data changed between the current and prior evaluation.

Figure 4. DEC Weatherization Projects Per Year 2015–2020

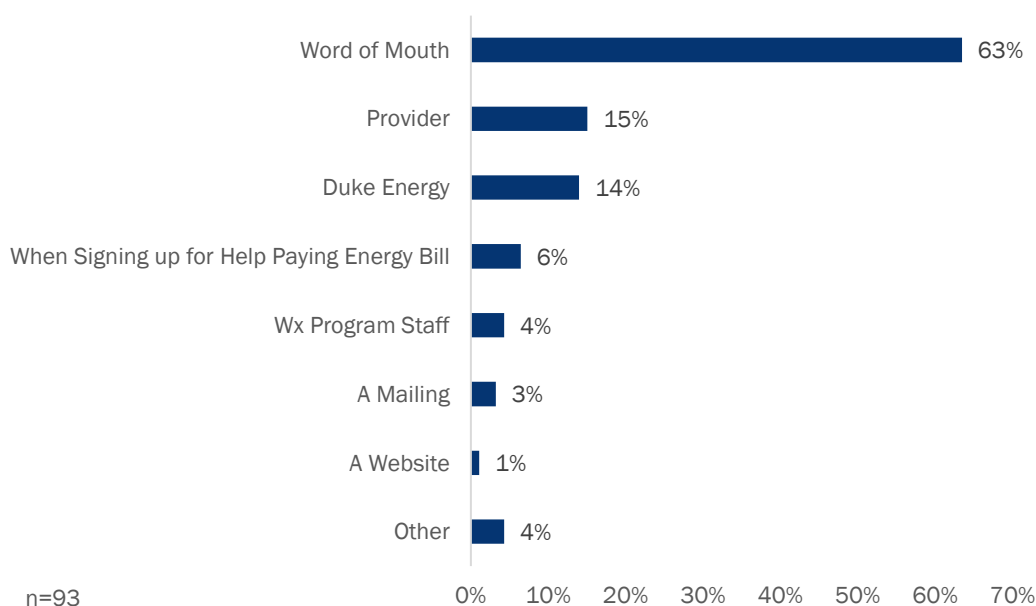


5.3.2 Program Outreach

Providers complete their own marketing and outreach to generate a local pipeline of state and DOE weatherization projects, and Duke Energy does not conduct any additional marketing. Interviewed providers (n=10) most often reported marketing the program with targeted print advertisements (7/10) and/or through a website or social media campaign (6/10). Only a few of the interviewed providers market the program through a social service provider or senior citizen center (3/10) or through newspaper ads (3/10). None of the participating providers reported much collaboration with Duke on marketing materials for the Weatherization Program, though the majority (6/10) specifically noted that they would like to see more Duke support in advertising the program, for example through the use of “bill inserts.”

According to responses to the participant survey, a majority of participants (63%) learn about the Weatherization Program through word of mouth; smaller shares of participants learn about the program through social services or another provider (15%), or directly from Duke Energy (14%; Figure 5).

Figure 5. How Participants Learn About the Weatherization Program



Note: Respondent could indicate more than one source of awareness.

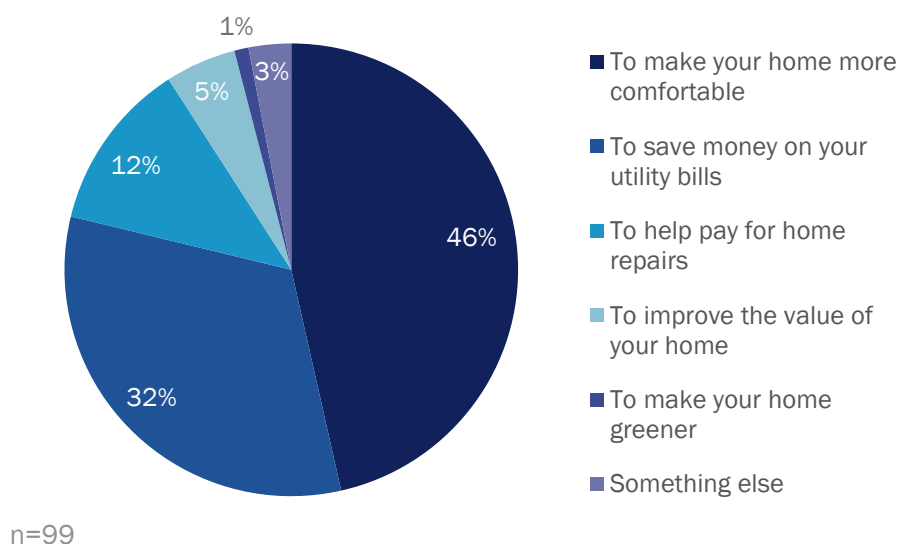
Note: Responses of "I don't know" were removed from the analysis.

While the majority of participants first hear about the program by word of mouth (63%), it is worth noting that there are stark differences between participants in North and South Carolina: Word-of-mouth is a much more common information source for participants in North Carolina (69%) compared to participants in South Carolina (31%) who more often hear about the program from Duke directly (69%) either when they sign up for help paying their energy bill (38%) or through other communications (38%).

5.3.3 Motivators of Participation

The main drivers of customer participation are to make the home more comfortable (46%) and to save money on utility bills (32%; Figure 6). This is a change from the previous evaluation cycle, in which the main drivers of customer participation were to save money on utility bills (42%) and to help pay for home repairs (22%), with only 1% of customers who reported participating to make the home more comfortable. Notably, however, the 2016–2018 evaluation showed that the Weatherization Program provided a substantial non-energy benefit of improved home comfort. Since word of mouth is the primary channel through which customers become aware of the program, more customers may participate to achieve the goal of home comfort over time.

Figure 6. Participants' Main Motivation in Signing Up for Weatherization



Note: Responses of "I don't know" were removed from the analysis.

5.3.4 Participating Providers' Program Experience

In general, provider staff express great appreciation for the Weatherization Program and emphasize the high level of need for weatherization services among their clients.

Provider Participation Summary

All but two of the providers we interviewed (8/10) had been involved with the Weatherization Program prior to the current evaluation period; the new providers we interviewed reported joining the program in 2019. All of the interviewed providers had completed Tier 2 weatherization projects while seven were also associated with refrigerator replacements and six with Tier 1 projects. The proportions of projects that were completed by interviewed providers were comparable to that of the provider population.

DEC Weatherization projects represent a large portion of weatherization jobs completed by the providers and all providers report submitting 100% of eligible Duke projects for reimbursement. However, all providers also report supplementing Duke funds with funds from other sources on the same project, either because the participant needs more measures than the Weatherization Program funding can cover or because they need measures not covered under the Weatherization Program.

Key Services and Client Concerns

All interviewed providers offer services to their clients in addition to weatherization. Some of these services include financial assistance, nutrition programs, day care, and educational offerings. Eight of the ten interviewed providers provide health or safety upgrades to weatherized homes, either through DOE WAP or another program.

Despite the variety of additional services offered by providers, all providers report that their clients struggle with weatherization needs. The clients, according to the providers, often have the most difficulties with

insulation and roofing (8/10). Their homes are often in need of repairs or upgrades, most commonly having gaps in doors and roofs, using broken heating equipment, or missing insulation. Five providers reported that their clients have trouble maintaining adequate indoor temperatures and need upgraded heating and cooling systems, while two providers reported their clients need refrigerators.

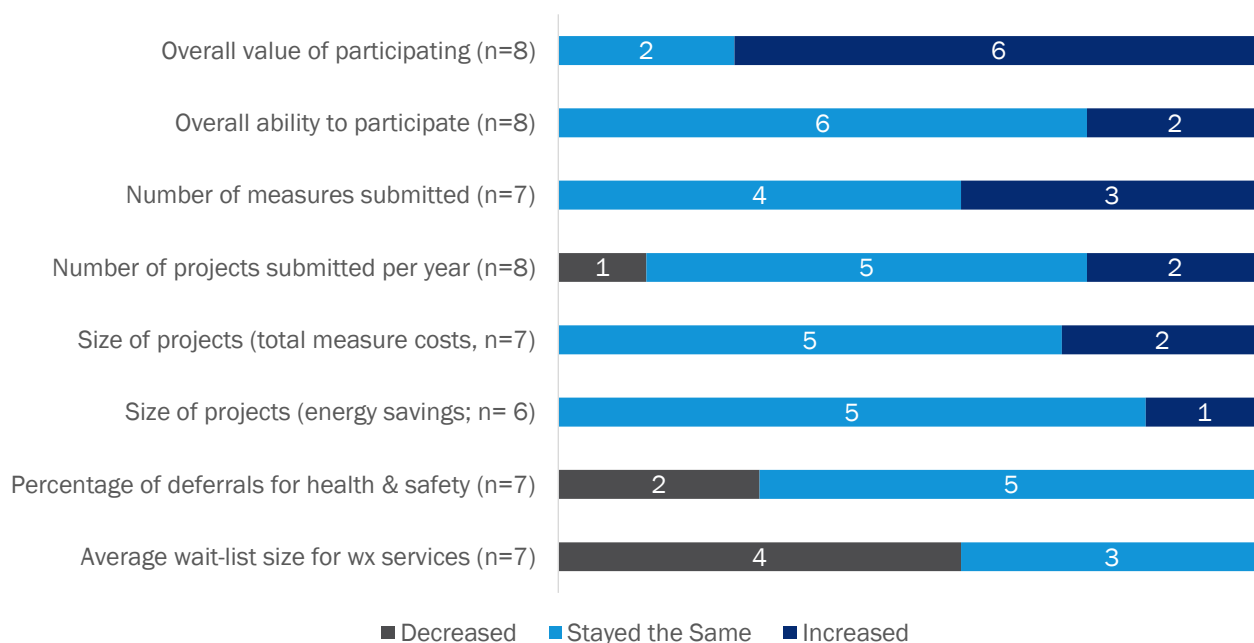
Program Changes

In 2019–2020, the Weatherization Program remained largely unchanged compared to the previous evaluation period, and all of the providers reported that they did not significantly change how they implemented or participated in the program. However, most providers reported pandemic-driven shifts in activities including a slowdown of work (such as pausing activities for a period of time or limiting the type of work that could be done, 7/10), the loss of workers (3/10), supply chain challenges (3/10), and a decrease in advertising capabilities (2/10). A couple of providers also mentioned receiving more funds from their state during the evaluation period (2/8) compared to the previous period.

The previous evaluation found that the new participation channel for the program, which was designed to overcome policy barriers preventing South Carolina agencies to participate in the Weatherization Program, had yet to encourage participation in the state. Both of the providers from South Carolina interviewed for the current evaluation were non-profit organizations and did not report policy barriers. However, program-tracking data indicates that these providers offered refrigerator replacements and HVAC upgrades/replacements rather than weatherization services, suggesting that while the new channel is making progress in South Carolina, existing program providers in the state are still unable to offer weatherization services to Duke Energy customers. Both of the newer providers expressed that participation throughout the evaluation period went smoothly, despite pandemic-related slowdowns.

To further understand specific changes to program implementation, we asked the provider staff who worked with the program prior to the current evaluation period to comment on a series of potential changes that may have occurred in a variety of program areas over the past four years. The most frequently reported changes were an increase in the overall value of the program to the providers (6/8), a decrease in the size of the waitlist providers have for their weatherization services (4/8), and an increase in the number of measures submitted for reimbursement (3/8). Figure 7 summarizes provider responses.

Figure 7. Changes to Provider Participation



Note: Responses of "I don't know" were removed from the analysis.

Inactive Providers

In addition to the interviews with participating providers, we interviewed two providers that were included in Duke Energy's list of approved providers but were not associated with any completed projects during the evaluation period. One of these providers was from North Carolina while the other was from South Carolina.

The provider from North Carolina that did not complete any projects noted being involved with the Weatherization Program since 2015. They have had very few clients apply for projects qualifying for this program during that time. They currently advertise the offering at social events in the area and at senior centers, and they also rely on a word of mouth network. The provider feels there has not been much growth in program demand because they only serve a small number of eligible customers. Similar to the active providers requesting program outreach support from Duke, this provider also inquired if (1) DEC would be able to advertise the program in bill inserts, and (2) if they could have more support identifying eligible customers.

The provider from South Carolina that did not complete any projects was much newer to the program than the North Carolina provider mentioned above but echoed many similar sentiments. For example, they also expressed needing more support from DEC in advertising the program and identifying what measures clients would be eligible to receive from the program. The support they received from DEC thus far, in terms of the webinars and DEC's availability to take questions, however, was considered very helpful. This provider mentioned they started work on several qualifying projects during the evaluation period and expect to be more active in the future.

5.3.5 Non-Energy Impacts

Non-energy impacts (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. One-third of Weatherization Program participants, for example, reported that their summer or winter electricity bills were lower compared to before they participated in the program (34% and 33%, respectively; Table 17), although 26% of participants reported an increase in their bills in the winter months. Beyond bill savings, many participants said their home is more comfortable in the summer (54%) and in the winter (49%) months than it was prior to program participation. These benefits align with customers' original motivations for participation, which included making their home more comfortable (46%) and saving money on their utility bills (32%; Figure 6). Several survey respondents mentioned additional benefits they have experienced since participating in the program, including feeling more secure and noticing the air in the home is cleaner. Almost three-fourths (72%) of participants report experiencing at least one beneficial NEI since participating in the program.

Table 17. Impacts Reported by Participants

Impact Category	Positive Change	No Change/ About the Same	Negative Change
Energy Impacts ^a			
Summer Electricity Bills (n= 96)	34% <i>Bills are lower</i>	57%	8% <i>Bills are higher</i>
Winter Electricity Bills (n= 98)	33% <i>Bills are lower</i>	42%	26% <i>Bills are higher</i>
Non-Energy Impacts			
Home Comfort in the Summer (n= 84) ^b	54% <i>More comfortable</i>	46%	0% <i>Less comfortable</i>
Home Comfort in the Winter (n=85) ^b	49% <i>More comfortable</i>	42%	8% <i>Less comfortable</i>
Home Draftiness (n= 86) ^b	56% <i>Less drafty</i>	35%	9% <i>Draftier</i>
Lighting (n=15) ^c	53% <i>Better</i>	40%	7% <i>Worse</i>
Amount of Outdoor Noise Heard When All Windows are Closed (n= 85) ^b	25% <i>Less noise</i>	71%	5% <i>More noise</i>
Home Maintenance Costs (n= 96)	25% <i>Lower costs</i>	66%	9% <i>Higher costs</i>

^a The evaluation period coincided with the global COVID-19 pandemic; it is possible that some changes in energy bills were impacted by shifts in energy usage and other habits associated with the pandemic. In addition, residential rate increases that took effect in 2019 (SC) and 2021 (NC) may impact customer bills and therefore responses to questions surrounding bill impacts.

^b Those who only received refrigerator replacements were excluded from the analysis.

^c Asked only of those who received LEDs.

Note: Responses of "I don't know" were removed from the analysis.

These findings suggest the Weatherization Program provides value to participants beyond energy savings. Increased home comfort and reduced draftiness could be beneficial for customer health and safety, especially

as climate change alters temperature patterns. Improved lighting provides a greater sense of safety in and around the home. Lower energy bills and home maintenance costs help alleviate energy burden and allow customers to spend their money on other essential items, such as food and medicine.

DEC should consider providing information regarding improved home comfort, draftiness, and lighting quality to providers to help them market the program. Duke Energy could also use this information to recruit new providers to the program whose clients face high energy bills or uncomfortable homes in the winter and summer.

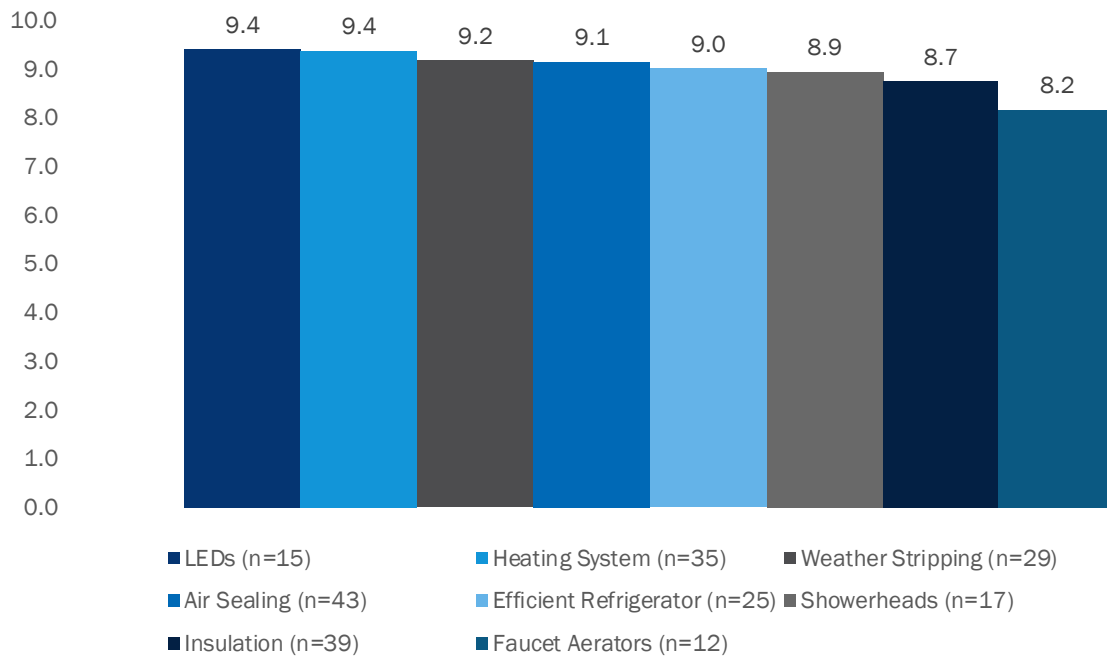
5.3.6 Program Satisfaction and Strengths

Overall, program administration staff, implementing provider staff, and participants all report being highly satisfied with the Weatherization Program:

- **NCCAA and TRC program administration staff give the program a satisfaction score of 4.5 out of 5,** saying they are very satisfied. The main areas of dissatisfaction cited relate to high administrative costs and the lack of alternate avenues to ensure that all available program funds are used. Two quotes that summarize possible areas of improvements follow:
 - *"I'd love to see us have some avenues to spend the money. I don't want to compete with agencies that are doing [this work or take anything away from community action], but [have] a way to take the money that's not being spent and go out and design a parallel program that allows that annual budget to be spent by a contractor network."*
 - *"From my understanding, there has not been an any increase in terms of administrative fees since this program launched. So I would say revisiting [the possibility of an increase annually of administrative fees] in some way [would] be helpful."*
- **Provider staff are very satisfied with the program as well, giving it an average rating of 4.4 out of 5 (n=10).** Provider staff reported few issues with implementation and underscored the value of the program to their communities. Providers are particularly satisfied with logistical elements of the program, the ease of participating (6/10), and the funding itself, which allows for the work to be done (4/10). Several respondents noted that funds cannot be applied to all equipment (5/10), they are sometimes unable to determine customer eligibility (2/10), and have encountered difficulties with billing (1/10). Still, provider staff frequently offered unprompted praise for the program, noting sentiments such as:
 - *"We are so grateful for the money; without it, a lot of this work would go undone".*
- **Half of the provider staff requested additional measures and program features to encourage deeper savings.** Several provider staff noted that they see more opportunity for increasing program savings if they were able to use program funds for measures such as roofs, windows, and floors (3/10). Other suggested program features included being able to offer more appliances (1/10), and/or duct work for gas systems (1/10).
- **Provider staff faced several difficulties due to the global COVID-19 pandemic.** Provider staff reported several pandemic-related barriers that were faced during the evaluation period including a slowdown of work (such as pausing activities for a period of time or limiting the type of work that could be done, 7/10), the loss of workers (3/10), supply chain challenges (3/10), and a decrease in advertising capabilities (2/10).

- **Participants are satisfied with all components of the program.** Overall, participants reported high satisfaction with the program, the program’s staff, and the equipment they received from the program. Respondents rated their overall satisfaction with the program a 9.1 out of 10 and rated their satisfaction with the weatherization representative who installed the equipment a 9.0 out of 10.
- **Across the measures we verified, participants are highly satisfied with the equipment they received,** ranging from an 8.2 for those who received faucet aerators to a 9.4 for participants who received LEDs (Figure 8). Common reasons for dissatisfaction with equipment included participants not satisfied with the performance of the equipment and not noticing a difference in their home following installation.¹⁷
 - Regarding the faucet aerator: *“It gets to the point where you can’t pull it down.”*
 - Regarding the weatherstripping: *“One door won’t open.”*
 - Regarding the air sealing: *“I am still getting air coming into my home.”*

Figure 8. Participant Satisfaction with DEC Weatherization Equipment



¹⁷ For all measure satisfaction questions, participants were asked to rate their satisfaction on a scale from 0 to 10, where 0 is “extremely dissatisfied” and 10 is “extremely satisfied.”

6. Key Findings and Recommendations

6.1 Key Impact Findings

Based on our impact analysis, we estimate that the projects completed during the evaluation period generated 1,627 MWh of net annual energy savings, 217 kW of annual summer coincident demand savings, and 517 kW of annual winter coincident demand savings. Tier 2 participants accounted for the largest share of program-level savings (83%) while Tier 1 participants and refrigerator replacements accounted for 2% and 15%, respectively, of total program energy savings.

Table 18 presents annual per-household and program-level net ex post savings for the evaluation period.

Table 18. Summary of Impact Results

Project Type	Number of Participants	Net Annual Savings Per Household			Net Annual Program Savings		
		Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy (MWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Tier 1	130	235	0.0773	0.0274	31	10.0	3.6
Tier 2 ^a	885	1,519	0.2012	0.5479	1,344	178.0	484.9
<i>Tier 2 Weatherization Measures</i>	566	1,311	0.2469	0.3801	742	139.7	215.1
<i>HVAC Replacement/Upgrade</i>	382	1,577	0.1002	0.7062	603	38.3	269.8
Refrigerator Replacement	315	800	0.0912	0.0912	252	28.7	28.7
Total ^b	1,167				1,627	216.8	517.2

^a The total number of Tier 2 participants is smaller than the sum of weatherization and HVAC replacement/upgrade participants because some participants received both types of upgrade.

^b The total number of unique participants is smaller than the sum of project types because some households received a replacement refrigerator in addition to completing a Tier 1 or Tier 2 project.

6.2 Key Process Findings

- **Program Participation & Processes.** Participation in the Weatherization Program has been increasing steadily since the program began in 2015. Although there was a decrease in projects in the spring and summer of 2020, due to barriers associated with the global COVID-19 pandemic, provider staff have since reported a return to normal participation levels. Providers continue to work hard to inform clients about the program through multiple advertising channels (newspaper ads, in-person events, agency websites, etc.) and most interviewed providers indicated the number of projects they complete each year either stayed the same or increased since they have resumed normal business operations following COVID-19 pandemic related shutdowns.
- **Satisfaction.** The process evaluation shows high satisfaction with the Weatherization Program. Interviewed provider staff often provided unprompted praise for the program and underscored the importance of the program to their clients. Providers also reported finding the logistical elements of the program—including the ease of participating—to be another key program strength. Sources of dissatisfaction included difficulty determining customer eligibility and the inability to apply program funds to all equipment. Participating customers are also highly satisfied with the program overall. A

key driver of participation is to make the home more comfortable. Survey results suggest the program is helping participants in this respect, with 54% and 49% of respondents reporting higher comfort levels in the home during the summer and winter seasons, respectively, following participation in the program.

- **Non-Energy Impacts (NEIs).** In addition to lowering energy bills, the Weatherization Program provided substantial non-energy benefits to participants during the evaluation period, including improved home comfort in the summer and winter, reduced draftiness, and better lighting. To a lesser extent, survey respondents also reported lower noise levels from outdoors and reduced home maintenance costs. Almost three-fourths (72%) of participants reported experiencing at least one beneficial NEI since participating in the program.
- **South Carolina Policy Barriers.** The new participation channel, introduced in 2018, allows non-profit and other organizations to provide program services to customers who may not have been able to receive them otherwise using Weatherization Program funds. One objective of this channel is to overcome barriers in South Carolina, as state policies around funding prevent community action agencies (CAAs) from participating in the program. The Weatherization Program has made progress in serving customers in South Carolina, but there is room for improvement. Based on program-tracking data, there were three program providers in South Carolina actively completing projects during the evaluation period; all three providers are community-based organizations and they completed 10% of projects. However, the vast majority of South Carolina projects were refrigerator replacements, with a small number of HVAC upgrades/replacements and only one weatherization project submitted in South Carolina during the evaluation period.

6.3 Evaluation Recommendations

- **Increase support to providers in program marketing and outreach.** Providers note that communication and organization of the program are key strengths and frequently provide unprompted praise for staff at Duke Energy and NCCAA. One area identified for potential additional Duke Energy assistance is marketing and outreach to help increase customer awareness of the program. The program should continue to explore ways to promote participation while supporting existing providers by including information about the program alongside customer bills. This may be particularly important in South Carolina where the program has not had time to cultivate a large base of previous participants who can support word-of-mouth recruiting. Another area identified for potential additional Duke Energy assistance is supporting program providers in identifying eligible participants or confirming eligibility of customers they have identified. The program should consider providing additional data (individual or aggregated) for targeted outreach.
- **Evaluate funding required to align with changes in measure and labor costs following the COVID-19 pandemic and consider increasing per-project funding.** Program administration staff noted that during the evaluation period, they struggled to spend all program funds. At the same time, providers reported supply chain and labor shortages, and corresponding increased measure and labor costs, following the COVID-19 pandemic, with all interviewed providers indicating that they supplemented Weatherization Program funds with funding from other sources in order to meet participant needs. At the time of this evaluation, many providers cited high labor and material costs as an ongoing challenge. In fact, program-tracking data indicates fewer than half of participating households received most program measures. In addition, compared to the last evaluation period,¹⁸ a significantly smaller share of Tier 2 households received the various program measures – the only exception are HVAC

¹⁸ The last evaluation included participants between April 1, 2016 and December 31, 2018.

upgrades/replacements (which were a new measure in the last evaluation period and not widely provided) and refrigerator replacements (which were provided to 17% of participants in both evaluation periods). Increasing per-project funding to align with current measure and labor costs can support spending of all available program funds, help ensure providers are able to install all measures appropriate for a given project, increase per-participant savings, and maintain or increase NEIs and participant satisfaction.

- **Expand efforts to recruit and support organizations that do not face funding barriers in South Carolina, with a focus on providers that offer weatherization services.** The program should continue to explore ways to promote participation in South Carolina by recruiting more organizations that do not face funding barriers in South Carolina. The providers from South Carolina have achieved more success completing projects compared to the previous evaluation period given their non-profit status, but have focused primarily on refrigerator and HVAC replacements. Duke Energy should continue to recruit organizations that do not face barriers due to state policies around weatherization funding, with a focus on those organizations that can provide weatherization services in addition to equipment replacement.
- **Consider tracking several additional parameters within the program-tracking system to enhance the accuracy of future deemed savings estimates.** Our deemed savings review (Appendix B) identified a few parameters not currently tracked in program data: (1) pre- and post-project blower door results in units of reduced cubic feet per minute (CFM); (2) presence or type of cooling at participating homes; (3) water heating fuel of participating homes; and (4) the installed location (e.g., bathroom, kitchen) for each low-flow faucet aerator. In addition, the cooling efficiencies of existing equipment for heat pump upgrades and replacements was tracked less than 7% of the time and appeared to be incorrect. Some of this information was collected in the participant survey but including it in the program-tracking data would enhance the accuracy of future deemed savings estimates. We therefore recommend asking providers to enter this information, if already collected and available, into the program's tracking system.

7. Summary Form



DUKE ENERGY CAROLINAS LOW INCOME WEATHERIZATION PROGRAM COMPLETED EM&V FACT SHEET

PROGRAM DESCRIPTION

The DEC Weatherization Program reimburses local implementing agencies that have recently completed qualifying weatherization projects at Duke Energy customer homes. Electric conservation measures are provided at no cost to the customer. A tiered project structure is used to allocate reimbursements to agencies: Tier 1 applies to low usage homes and offers air sealing and low-cost energy efficiency upgrades (including lighting and low-flow aerators and showerheads); Tier 2 applies to higher usage homes and offers more comprehensive energy efficiency measures (including insulation and HVAC upgrades/ replacements) in addition to Tier 1 measures. Refrigerator replacements are also provided to qualifying households as a standalone project or in addition to Tier 1 or Tier 2 measures.

Date:	December 13, 2022
Region(s):	Duke Energy Carolinas
Evaluation Period:	January 1, 2019 – December 31, 2020
Annual kWh Savings (ex post net):	1,626,724 kWh
Coincident kW Impact (ex post net):	216.8 kW (Summer) 517.2 kW (Winter)
Measure Life:	Not Evaluated
Net-to-Gross Ratio:	N/A
Process Evaluation:	Yes
Previous Evaluation(s):	Duke Energy Carolinas Low Income Weatherization Program, April 2021 and June 2018

EVALUATION METHODOLOGY

The evaluation team performed a process and gross impact evaluation.

The process evaluation included a participant survey and interviews with implementing providers.

The gross impact evaluation included an engineering analysis and a consumption analysis and leveraged results from a prior evaluation.

IMPACT EVALUATION DETAILS

- We determined annual per household energy savings for Tier 2 participants using consumption analysis.
- We determined annual per household energy savings for Tier 1 participants based on a combination of engineering analysis results and results from a prior evaluation.
- We estimated demand savings for Tier 1 and Tier 2 participants based on engineering analysis-based demand-to-energy ratios, applied to energy savings.
- We developed savings for refrigerator replacements through engineering analysis.
- The engineering analysis applied deemed savings values to measures distributed and in service. In-service rates were calculated based on information collected in the participant survey.

8. DSMore Table

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



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Program 2022-12-13

For more information, please contact:

Danielle Fulmer
Principal Consultant

617-301-4614 tel
dfulmer@opiniondynamics.com

1000 Winter Street
Waltham, MA 02451



Boston | Headquarters

617 492 1400 tel
617 492 7944 fax
800 966 1254 toll free

1000 Winter Street
Waltham, MA 02451

San Francisco Bay

510 444 5050 tel
510 444 5222 fax

1 Kaiser Plaza
Suite 445
Oakland, CA 94612

San Diego

858 270 5010 tel
858 270 5211 fax

1200 Prospect Street
Suite #G-100
La Jolla, CA 92037

Portland

503 287 9136 tel
503-281-7375 fax

1500 NE Irving Street
Suite #370
Portland, OR 97232