Final Report

# Process and Impact Evaluation of the 2013-2014 Residential Neighborhood Program in the Carolina System

**Prepared for**
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# Executive Summary

## Significant Impact Evaluation Findings

This section presents the key findings and recommendations identified through the evaluation of Duke Energy's Residential Neighborhood Program in the Carolina System. This evaluation covers program participation from March, 2013 through July, 2014 (n= 8,147 participants). A billing analysis was conducted to estimate the net energy savings by participants in the program. The billing analysis employs a statistical analysis of actual customer-billed monthly electricity usage of customers participating in the program. The statistical model used for the billing analysis produces estimates of the monthly electricity savings resulting from participation in the program, and Table 1 presents the estimated overall ex post energy impacts from the billing analysis. The billing analysis approach used to assess energy savings provides a direct net (net of short-term freeridership, short-term participant spillover, and participation in other Duke Energy programs) energy impact estimate[1] by employing a quasi-experimental analysis design.

**Table 1. Estimated Overall Impacts**

| | Net Savings |
|---|---|
| Annual Savings Per Participant Per Year | |
| kWh | 350 |
| kW | 0.0944 |

The billing analysis gives the estimated overall net kWh savings per participant, but is incapable of estimating coincident kW reduction. As a result, kW is determined using the results of the billing analysis in DSMore. Additionally, program per participant savings as reported in Table 1 includes an adjustment made to CFL savings over the effective useful life of a bulb. The adjustment factor is computed in the course of the engineering analysis. The purpose of the adjustment factor is to account for the decrease in baseline wattage over time due to the phase out of standard wattage incandescent bulbs as stipulated in the Energy Independence and Security Act (EISA) of 2007. See *Appendix K: EISA Schedule and CFL Baseline* for a detailed description of baseline adjustments by year. See *Billing Analysis EISA Effects* for the calculation of the adjustment factor.

## Significant Process Evaluation Findings

### From the Participant Surveys

- A plurality of 36.3% (29 out of 80) of participants first learned about this program from letters and postcards received in the mail. Home visits from the enrollment team (23.8% or 19 out of 80) were the next most-mentioned source of awareness, followed by door hangers (12.5% or 10 out of 80).

[1] The net long-term spillover or short and long-term market effects savings were not documented in this evaluation. These savings are in addition to those identified in this report, but are beyond the researchable issues associated with this evaluation.

- When participants were asked what they understood this program was about, 57.5% (46 out of 80) mentioned the installation of energy-saving measures, 43.8% (35 out of 80) mentioned a home audit, 35.0% (28 out of 80) mentioned saving energy, 26.3% (21 out of 80) mentioned saving money on energy bills, and 26.3% (21 out of 80) mentioned home weatherization.
- When asked for reasons they chose to participate in this program, the most common answers are "saving money on utility bills" (by 55.0% or 44 out of 80) and "saving energy" (42.5% or 34 out of 80). About one participant in four also mentioned "receiving efficiency measures" (25.0% or 20 out of 80) and "home weatherization and repairs" (22.5% or 18 out of 80).
- About half of participants (45.0% or 36 out of 80) had to wait less than a week from enrollment to audit, including 12.5% (10 out of 80) who reported that they enrolled on the same day of their audit or that "I did not enroll, the auditor just showed up." Only 3.8% (3 out of 80) thought the length of time between enrollment and audit was too long, and only 5.0% (4 out of 80) thought that the length of time the auditor was in their home should have been longer or shorter than it was.
- About a third of surveyed participants (32.5% or 36 out of 80) attending the community meeting kick-off event in their neighborhood. These customers were very satisfied with the staff and presenters at the meeting (mean satisfaction rating 9.8 on a 10-point scale) and the information presented at the meeting (mean satisfaction rating 9.5 out of 10).
- Participants are generally quite satisfied with the measures they received during the audit: among the most highly-rated items are the door sweeps (mean satisfaction rating 9.6 out of 10), years' supply of HVAC filters (9.5 out of 10), filter change calendar (9.4 out of 10), water tank insulation wrap (9.7 out of 10) and water heater temperature adjustment (9.5 out of 10). The lowest-rated measures are vinyl weather stripping for doors (8.1 out of 10) and the window HVAC winter kit (8.4 out of 10), which are the only items to receive mean satisfaction ratings of less than 8.5 out of 10; these are not low satisfaction scores, but there is room for improvement relative to customer satisfaction with some of the other measures.
- Program satisfaction is quite high, with the program receiving a mean satisfaction rating of 9.35 out of 10 overall. The program also receives high scores for convenience of enrollment (9.5 out of 10), the knowledge of the auditors (9.4 out of 10) and the helpfulness of the auditors (9.3 out of 10). Relative to the Residential Neighborhoods program, participants' satisfaction with Duke Energy is somewhat lower at 8.7 out of 10.
- A majority of 58.8% (47 out of 80) of surveyed participants report that this program has made their attitude towards Duke Energy more positive, while only 2.5% (2 out of 80) say it has made their attitude towards Duke Energy more negative. Two-thirds (67.5% or 54 out of 80) also report that the program has increased their knowledge of how to save energy.
- Nearly half of surveyed participants (43.8% or 35 out of 80) report that their utility bills have decreased since they participated in this program, though another 10.0% (8 out of 80) report that their bills have increased. Overall, customers estimate that their utility bills have decreased by an average of about $8 per month since the program.
- According to auditor records, the percentage of participating customers receiving measures ranges from 97.5% (78 out of 80) for CFLs down to 7.5% (6 out of 80) for both the clear glass patch tape and vinyl weather stripping for HVAC window units. Surveyed

customers received between five and thirteen types of measure during their home audits, with the average and median number of measures received being about nine.

- Surveyed participants were asked to confirm the installation of measures from auditor records. Some measure installations were confirmed at high rates (such as 96.1% or 75 out of 78 customers confirming that they received CFLs as reported in auditor records), while other measures were confirmed at much lower rates (only 9.1% or 1 out of 11 customers receiving window caulk according to auditor records was able to confirm this installation).
- Some participants report that auditors have left measures behind for the customer to install themselves; in particular, 41.0% (32 out of 78) of customers who received program CFLs report that the auditor left some uninstalled bulbs behind (most of these bulbs have since been installed by the customers themselves, although 50 CFLs out of 765 confirmed received by participants remained uninstalled at the time of this survey). The winter kits for window HVAC units were also mostly installed by customers (61.5% or 16 out of 26 confirmed installations), because this measure is meant for wintertime use and the audits were performed in the spring and summer.
- Customers who received the switch plate thermometer and who did not previously have any thermometers in their home are twice as likely to report turning the temperature down during the winter (36.7% or 11 out of 30) compared to those who received this measure but who already had a thermometer in their home before the program (16.7% or 6 out of 36; this difference is significant at $p<.05$ using Student's t-test). However, there is no significant difference in temperature settings during the summer (overall only 4.5% or 3 out of 66 participants who received thermometers report using less cooling in the summer).
- When asked what they learned from participating in this program, most customers (86.2% or 69 out of 80) were able to name something that they learned. The most-mentioned lessons include the importance of weatherization and plugging drafts (mentioned by 17.5% or 14 out of 80), that energy efficiency measures save money over time through lower bills (15.0% or 12 out of 80) and about efficient lighting (13.8% or 11 out of 80).
- Sixty percent (48 out of 80) surveyed participants report taking additional actions to save energy since participating in the program: the most commonly reported actions are turning off lights and electronic items and using less heat in the winter.
- Survey participants' favorite things about this program include the home audit and assistance from the auditor (32.5% or 26 out of 80), the fact that participation and the measures are cost-free for customers (27.5% or 22 out of 80), the information and education gained (17.5% or 14 out of 80) and saving money through lower bills (17.5% or 14 out of 80).
- Two-thirds of participants (67.5% or 54 out of 80) could not name a least favorite aspect of the program. The most frequently-mentioned complaints about the program are about problems with specific measures (13.8% or 11 out of 80) and not receiving measures (6.3% or 5 out of 80, with four of these cases involving undelivered HVAC filters).
- When asked for their suggestions to improve the program, the top suggestions are that the auditor should provide more information during the audit (13.8% or 11 out of 80) and that the program could include additional measures and services (12.5% or 10 out of 80).

### From the Non-Participant Surveys

- Two-thirds of non-participants contacted (82 out of 123) are aware of this program's existence, while the other third (33.3% or 41 out of 123) had not heard anything about it. Non-participants were only invited to complete the remaining parts of the survey if they were aware of the Residential Neighborhoods program.
- Non-participants who are aware of the program learned about it through the same channels as participants: mailings are the most-mentioned (47.5% or 38 out of 80), followed by door hangers (31.3% or 25 out of 80) and visits from the enrollment team (20.0% or 16 out of 80).
- When asked what they understood the Residential Neighborhoods program to be about, non-participants are most likely to mention "receiving free measures" (31.3% or 25 out of 80) and the home audit (30.0% or 24 out of 80). Only 16.3% (13 out of 80) of non-participants who are aware of the program were unable to answer this question.
- Only 55.0% (44 out of 80) of surveyed non-participants are certain that they would have been eligible to participate in the program, while 35.0% (28 out of 80) are not sure and 10.0% (8 out of 80) believe that they would not have been eligible. Among those who believe they are not eligible, most (5 out of 8) mentioned that their status as renters rather than owners played a part in their non-participation.
- When asked for their suggestions for improving program participation, non-participants' top responses are giving customers more information about the program (13.8% or 11 out of 80), improving communications about the program (12.5% or 10 out of 80) and making more weekend and evening hours available for audits (10.0% or 8 out of 80).
- Four-fifths of surveyed non-participants (81.3% or 65 out of 80) report that they have taken steps to save energy on their own in the past year. The most common action is using efficient light bulbs such as CFLs (37.5% or 30 out of 80), while another 15.0% (12 out of 80) mention that they sealed leaks around windows and doors.
- Non-participants' mean satisfaction rating with Duke Energy overall is 8.0 on a 10-point scale, which is lower than the 8.7 mean rating given by program participants. Though this difference is not quite statistically significant, it could indicate that having a lower opinion of Duke Energy is a barrier to participation in Duke Energy programs, even when they are free to all customers.
- In spite of not having participated in this program, 60.0% (48 out of 80) of non-participants report that their opinion of Duke Energy has become more positive based on what they know about the Residential Neighborhoods program, compared to 6.3% (5 out of 80) who say their attitude towards Duke Energy has become more negative.

## Recommendations

- Suggestions for improving program participation:
  - Make mailings more personalized if possible (a personal invitation rather than "advertising")
  - Work with local housing authority to pre-arrange permission for tenants living in properties with fewer than eight units to participate

# Introduction and Purpose of Study

## Summary Overview

This document presents the process and impact evaluation report for Duke Energy's Residential Neighborhood program as it was administered in North Carolina and South Carolina. The evaluation was conducted by TecMarket Works, BuildingMetrics, and Integral Analytics.

### Summary of the Evaluation

TecMarket Works performed a process evaluation comprised of management interviews to review program operations and administration, and a participant and non-participant survey to determine satisfaction levels and identify any program implementation issues.

Impact was evaluated using a billing analysis together with engineering estimates for the purpose of determining individual measure contributions to savings as well as coincident peak demand reduction.

**Table 2. Evaluation Date Ranges**

| Evaluation Component | Dates of Analysis |
|---|---|
| Participant Surveys | Surveyed from April 4, 2014 to May 9, 2014 |
| Non-Participant Surveys | Surveyed from February 22, 2014 to March 8, 2014 |
| Management Interviews | Conducted in February and May of 2014 |
| Engineering Estimates | September through October 2014 |
| Billing Analysis | September through October 2014 |

### Evaluation Objectives

The objective of this evaluation is to determine the effectiveness of and customer satisfaction with Duke Energy's Residential Neighborhood program as it was administered in the Carolina System.

# Description of Program

The program assists customers in reducing energy costs through energy education and by installing or providing energy conservation measures for each customer's residence. Areas targeted for participation in this program have approximately 50% of the households with income equal to or less than 200% of the federal poverty level. Once a neighborhood is identified, all participants within the boundaries will qualify for the program, regardless of income status. Under this program, participating customers will receive an energy assessment to identify energy efficiency opportunities in the customer's home, one-on-one education on energy efficiency techniques and measures, and a package of energy conservations measures installed or provided to the extent the measure is identified as an energy efficiency opportunity (based on the results of the energy assessment). Energy conservation measures, up to $210, may include the following energy efficiency starter items:

- AC/Heat Filters
- Change Filter Reminder
- Aerators
- Caulking
- Weatherstripping
- Clear Glass Patch Tape
- 13W CFLs
- 18W CFLs
- Door Sweeps
- Foam Insulation Spray
- HVAC Winterization Kit
- Low Flow Showerhead
- Water Heater Tank Insulation
- Water Heater Pipe Wrap
- Water Heater Temp Adjustment
- Switch Plate Wall thermometer

# Methodology

## Overview of the Evaluation Approach

The process evaluation has three components: management interviews, participant surveys and non-participant surveys. The impact evaluation has engineering and billing analysis components.

### Study Methodology

#### Management Interviews

Interviews were conducted with the Duke Energy product managers and with the program vendor (GoodCents) manager.

#### Participant Surveys

TecMarket Works fielded a phone survey with randomly selected participants in order to measure satisfaction and to identify areas for program improvement. Eighty (80) surveys were completed with Residential Neighborhoods participants in the Carolina System whose home audits were completed between March 6, 2013 and August 23, 2013 according to auditor records.[2] Roughly half of the participants surveyed live in North Carolina (55.0% or 44 out of 80) and roughly half live in South Carolina (45.0% or 36 out of 80).

#### Non-Participant Surveys

TecMarket Works fielded a phone survey with randomly selected non-participants in order to identify barriers to program participation. Eighty (80) surveys were completed with Residential Neighborhood participants in the Carolina System. Thirty-one surveys (38.8% of 80) were completed with non-participants in North Carolina and 49 surveys (61.3% of 80) were completed with non-participants in South Carolina.

#### Engineering Estimates

Engineering algorithms taken from the Draft Ohio and New York Technical Reference Manuals (TRMs) along with DOE-2 simulations were used to estimate savings. These unit energy savings values were applied to customers in the engineering analysis sample.

#### Billing Analysis

For this analysis, billing data were obtained for all participants in the program between March 2013 and July 2014. There were a total of 8,147 usable accounts after processing. A panel model specification was used that analyzed the monthly billed energy use across time and participants. The model included terms to control for the effect of weather on usage, the effect of impact from other Duke Energy offers, the effect of normal non-program induced energy use changes, as well as a complete set of monthly indicator variables to capture the effects of non-measureable factors that vary over time (such as economic conditions and season loads).

[2] One surveyed participant had December 27, 2013 listed as the date their work was completed. However since all other participants have completion dates between March and August, the December date is probably the result of this participant's record being updated or modified months after their audit.

## Data collection methods, sample sizes, and sampling methodology

### Management Interviews

All contacts provided by Duke Energy for the management interviews were contacted and interviewed for this evaluation.

### Participant Surveys

Duke Energy provided TecMarket Works with a list of 941 records of program participants in the Carolina System (439 from North Carolina and 502 from South Carolina). After removing records with missing contact information, duplicate records, "do not contact" numbers and customers who have recently been surveyed about other programs, the sample list consisted of 510 contactable customers. The survey was conducted by telephone by TecMarket Works staff from the list of 510 participant customers in the Carolina System, and 80 respondents completed the survey (44 from North Carolina and 36 from South Carolina). The survey instrument can be found in *Appendix F: Participant Survey Instrument.*

### Non-Participant Surveys

Duke Energy provided TecMarket Works with a list of 3,482 records of non-participants in the Carolina System (1670 from North Carolina and 1812 from South Carolina) that lived in targeted neighborhoods but did not participate in the program. After removing records with missing contact information, duplicate records, "do not contact" numbers and customers who have recently been surveyed about other programs, the sample list consisted of 2,341 contactable customers. The survey was conducted by telephone by TecMarket Works staff from the list of 2,341 non-participant customers in the Carolina System, and 80 respondents completed the survey (31 from North Carolina and 49 from South Carolina).

### Engineering Estimates

The engineering analysis relied on primary data collected through the participant phone survey, which was conducted with a random sample of 80 participants.

### Billing Analysis

The billing analysis used consumption data from all complete data provided for the participants in North and South Carolina that participated between March, 2013 and July 2014. The billing analysis used data of all participation homes with reliable data.

## Number of completes and sample disposition for each data collection effort

### Management Interviews

All contacts provided by Duke Energy for the management interviews were contacted and interviewed for this evaluation.

### Participant Surveys

From the sample list of 510 customers, 501 participants were called between April 4, 2014 and May 9, 2014, and a total of 80 usable telephone surveys were completed yielding a response rate of 16.0% (80 out of 501).

### Non-Participant Surveys

From the sample list of customers, 718 non-participants in the Carolina System (306 in North Carolina and 412 in South Carolina) were called between February 22 and March 8, 2014, and a total of 80 usable telephone surveys were completed (31 from North Carolina and 49 from South Carolina) yielding a response rate of 11.1% (80 out of 718).

### Engineering Estimates

The engineering analysis relied on primary data collected through the participant phone survey, which was conducted with a random sample of 80 participants.

### Billing Analysis

The billing analysis used consumption data from all complete data provided for the participants in North and South Carolina that participated between March, 2013 and July 2014. There were a total of 8,147 usable accounts after processing.

**Table 3. Summary of Data Collection Efforts**

| Residential Neighborhoods Program | | | |
|---|---|---|---|
| **Data Collection Effort** | **Size of Population in Sample for Surveys** | **# of Successful Contacts** | **Sample Rate** |
| Management Interviews | 3 | 3 | 100% |
| Participant Surveys | 510 | 80 | 15.7% |
| Non-Participant Surveys | 2341 | 80 | 3.4% |
| Engineering Estimates | 510 | 80 | 15.7% |
| Billing Analysis | 8,147 participants | | |

## Expected and achieved precision

### Participant Surveys

The survey sample methodology had an expected precision of 90% +/- 8.5% and an achieved precision of 90% +/- 8.5%.

### Non-Participant Surveys

The survey sample methodology had an expected precision of 90% +/- 9.0% and an achieved precision of 90% +/- 9.0%.

### Billing Analysis

The savings estimates for this program that were estimated from the billing analysis and presented in this report are statistically significant at the 95% confidence level unless otherwise noted.

## Description of baseline assumptions, methods and data sources

Baseline assumptions for CFLs were determined through phone surveys with customers providing self-reported values of baseline lamp watts and operating hours. Baseline assumptions for other measures were taken from the Draft Ohio TRM.

The HVAC system interaction factors are the result of a series DOE-2 of simulations and represent the weighted average value across all HVAC system types according to their prevalence in the Carolinas.

## Description of measures and selection of methods by measure(s) or market(s)

The audits may provide the following measures, depending on customer needs:

- Up to fifteen 18-watt CFL
- Up to fifteen 13 watt CFLs
- Up to two low flow showerheads
- Up to three faucet aerators
- One switch plate wall thermometer
- One year's supply of HVAC filters and filter change calendar
- Door sweeps for up to two doors
- Vinyl weatherstripping for up to two doors
- Caulking for up to two doors
- Caulking for up to three windows
- Clear glass patch tape for up to two windows
- Vinyl weatherstripping for window HVAC units
- Winterization kits for window HVAC units
- Spray foam insulation
- Water heater pipe wrap
- Water heater tank wrap
- Water heater temperature check and adjustment

## Use of TRM values

Algorithms were selected from the Draft Ohio and New York TRMs to make the best use of primary data collected through the participant survey. DOE-2 simulations of prototypical building models were used to estimate savings for infiltration measures. The HVAC interaction factors were developed from prototypical building simulations conducted across several HVAC system types. The results were weighted according to HVAC system type weights developed from Duke Energy's appliance saturation survey.

## Threats to validity, sources of bias and how those were addressed

### Engineering Analysis

The participant responses are self-reported and therefore may be affected by self-selection bias, false response bias or positive result bias. If these biases are present, the savings achieved can be expected to be higher than those reported in the impact evaluation. The effects of any bias in the participant responses is expected to be minimal as all measures distributed and installed were recorded by an auditor at the premise.

### Billing Analysis

The specification of the model used in the billing analysis was designed specifically to avoid the potential of omitted variable bias by including monthly variables that capture any non-program effects that affect energy usage, as well as other Duke Energy offers. Moreover, the interaction of temperature (cooling degree days and heating degree days) and monthly variables were also taken consideration to further control for differences in how consumption responds to weather in different months. The model did not correct for self-selection bias because there is no need as long as the program remains voluntary.

# Impact Evaluation: Engineering Analysis

Measure and program impacts were calculated using a combination of engineering and billing analysis. The engineering analysis was based on a combination of standard engineering assumptions and self-reported information from a sample of participants. Overall program savings are based on a pre/post billing data analysis results conducted on a near-census of participants. The engineering estimates were developed to provide insight into individual measure contributions to overall savings as well as a way to measure the effects of the Federal EISA standards on lifecycle program savings.

Table 4 shows the estimated energy savings per unit distributed adjusted downward for the ISR computed from participants' survey responses. The savings per unit distributed are shown for each energy saving item offered through the program and, in the final row, savings resulting from the all measures together.

**Table 4. Gross Program kWh and Coincident kW Savings by Measure**

| Measure | Quantity | Units | ISR | Gross kWh/unit | Gross kW/unit | Gross kWh | Gross kW |
|---|---|---|---|---|---|---|---|
| CFL | 715 | Bulb | 95.0% | 32.98 | 0.0029 | 23,579 | 2.0560 |
| Low-Flow Showerhead | 74 | showerhead | 98.7% | 127.6 | 0.0100 | 9,440 | 0.7381 |
| Faucet Aerator | 149 | Aerator | 98.7% | 8.80 | 0.0011 | 1,311 | 0.1639 |
| Weather Stripping | 1508 | linear foot | 86.0% | 0.36 | 0.0002 | 545 | 0.2656 |
| Caulking | 2112 | linear foot | 100.0% | 0.22 | 0.0001 | 468 | 0.2282 |
| Door Sweep | 113 | Each | 95.8% | 1.36 | 0.0007 | 153 | 0.0747 |
| Foam Insulation Spray | 196 | Sink | 100.0% | 2.83 | 0.0014 | 556 | 0.2707 |
| DHW Pipe Insulation | 225 | linear foot | 100.0% | 24.64 | 0.0028 | 5,544 | 0.6329 |
| DHW Tank Wrap | 19 | tank wrap | 100.0% | 125.8 | 0.0144 | 2,389 | 0.2727 |
| DHW Temp Adjust | 43 | adjustment | 97.7% | 86.08 | 0.0098 | 3,701 | 0.4225 |
| AC Filters/Calendar | 56 | participant | 87.5% | 23.01 | 0.0017 | 1,289 | 0.0924 |
| **Overall Savings** | **80** | **Survey participant** | | **612** | **0.0652** | **48,976** | **5.2177** |

# Effective Useful Life (EUL) Calculation

The EUL of program savings is a weighted average derived from the effective useful lives of the individual measures weighted based on their contribution to overall gross kWh savings. The overall EUL for the program is seven years as seen in Table 5.

**Table 5. Effective Useful life of Program Measures**

| Measure | Weight | EUL |
|---|---|---|
| CFL | 48.1% | 5 |
| Low-Flow Showerhead | 19.3% | 10 |
| Faucet Aerator | 2.7% | 10 |
| Weather Stripping | 1.1% | 5 |
| Caulking | 1.0% | 15 |
| Door Sweep | 0.3% | 5 |
| Foam Insulation Spray | 1.1% | 15 |
| DHW Pipe Insulation | 11.3% | 15 |
| DHW Tank Wrap | 4.9% | 5 |
| DHW Temp Adjust | 7.6% | 4 |
| AC Filters/Calendar | 2.6% | 1 |
| **Overall Effective Useful Life** | | 7 |

# In Service Rate (ISR) Calculation

Survey respondents were asked to report whether or not any of the energy saving measures installed through the program had been subsequently removed. As Residential Neighborhood program measures are directly installed by auditors, rather than afterward by participants, auditors' accounts of measure installations are considered to be the most accurate. Baseline ISR was set to 100% for each measure with reductions made for subsequently uninstalled units. The ISR for the furnace filters that were left behind for customer installation is determined through the participant survey, where respondents were asked if they had been installing the filters monthly as suggested by the calendar.

For CFLs, an allowance is made for program bulbs that are left behind by the auditor, placed into storage, and subsequently used to replace an incandescent bulb, thereby yielding energy savings. At the time of the phone survey, 96.9% of 13-Watt and 89.4% of 18-Watt bulbs distributed to respondents were installed and operable; this is the first year ISR.

The final ISR value is calculated, using 18-Watt CFLs as an example, with the following formula as presented in the Draft Ohio TRM:

ISR = first year ISR + (43% * remainder) = **89.4% + (43% * 7.6%) = 92.7%**

The remainder is the percentage of bulbs that are not installed in the first year (100% - 89.4% = 10.6%) less 3% for the 97% lifetime ISR[3]. In this case, the remainder is 7.6%. The 43% represents the percentage of the remainder that will replace an incandescent bulb rather than a CFL[4]. The ISR for each wattage of CFL is assigned a weight that represents its prevalence in the participant population and a weighted average ISR is calculated (95%).

[3] As established in the Nexus Market Research, RLW Analytics, and GDS Associates study, dated January 20, 2009: "New England Residential Lighting Markdown Impact Evaluation".
[4] As established in the Nexus Market Research, RLW Analytics, dated October 2004: "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs", table 6-4 where 24 out of 56 respondents indicated that they did not purchase the CFLs as spares.

The ISR for the other program measures were taken from the customer survey responses regarding the fraction of initially installed measures that were subsequently removed. The ISR assumptions for each program measure can be seen in Table 4.

## CFL Impact Calculation and EISA Application

Average daily hours of use, replaced wattage, and the room in which the bulb was installed were included in data collected from survey participants. Customers were asked if they had increased or decreased their lighting usage since installing the CFLs they received through the program. This enabled the detection of a slight decrease in hours of use going from an incandescent bulb to a CFL.

Table 6 shows the unadjusted weighted average daily hours of use values along with the updated values after the self-reporting bias is applied. Previous studies that have included both customer surveys and lighting loggers have shown that, comparing customers' self-reported hours of operation to the actual hours of operation, customers responding to the survey overestimated their lighting usage by about 27%[5]. As this study did not employ lighting loggers, there is no data with which to make a comparison for this program specifically. Consequently, the self-reported hours of use obtained from the survey were reduced by the 27% shown in Table 6.

**Table 6. Adjusted Average Daily Hours of Use**

| Adjustment | Magnitude of Adjustment | Average Daily Hours of Use (Incandescent) | Average Daily Hours of Use (CFL) |
|---|---|---|---|
| Unadjusted | N/A | 4.17 | 4.06 |
| Self-Reporting Bias | 27% | 3.05 | 2.96 |

The adjusted average daily hours of use by room type are shown in Table 7. The row labelled "Overall" represents the weighted average across all room types.

**Table 7. Adjusted Average Daily Hours of Use by Room Type**

| Room Type | Number of Installations | Mean Daily Hours of Use (Old) | Mean Daily Hours of Use (New) |
|---|---|---|---|
| Bathroom | 38 | 2.34 | 2.47 |
| Kitchen | 51 | 3.65 | 3.73 |
| Living/Family Room | 49 | 3.40 | 3.40 |
| Dining Room | 12 | 1.70 | 1.70 |
| Master Bedroom | 34 | 2.38 | 2.47 |
| Other Bedroom | 13 | 2.22 | 2.25 |
| Closet | 1 | 2.56 | 2.56 |
| Hall | 4 | 1.10 | 1.19 |
| Other | 16 | 4.15 | 4.52 |
| **Overall** | **218** | **2.96** | **3.05** |

[5] The adjustment for the self-reporting bias used in this study was determined using paired lighting logger and customer self-reported data from Kentucky, Ohio, Indiana, North Carolina, and South Carolina.

As described in *Appendix K: EISA Schedule and CFL Baseline*, it is assumed that a baseline incandescent lamp will be replaced several times during the life of a CFL. Due to EISA legislation which limits the wattage of an incandescent lamp, the baseline lamp wattage decreases during each replacement. The baseline wattage by room type and by year is shown in Table 8 with the average in the final column and the overall weighted average in the highlighted cell in the bottom right, the numbers used for the savings calculations. Baseline estimates for each room type are based on small sample sizes and have limited statistical reliability at the individual room type level. Gross savings for the program are presented in the same manner in Table 9 and Table 10.

**Table 8. Baseline Wattage by Room Type and Year**

| Room Type | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|
| Bathroom | 57 | 47 | 46 | 44 | 43 | 47 |
| Kitchen | 52 | 43 | 42 | 41 | 40 | 44 |
| Living/Family Room | 61 | 50 | 48 | 47 | 45 | 50 |
| Dining Room | 63 | 51 | 49 | 47 | 46 | 51 |
| Master Bedroom | 55 | 45 | 43 | 42 | 41 | 45 |
| Other Bedroom | 61 | 51 | 50 | 48 | 46 | 51 |
| Closet | 18 | 18 | 18 | 18 | 18 | 18 |
| Hall | 60 | 51 | 50 | 48 | 46 | 51 |
| Other | 69 | 56 | 54 | 52 | 51 | 56 |
| **Overall** | **58** | **48** | **46** | **45** | **43** | **48** |

Applying these adjustments to each individual room type shows estimated bulb savings by room type. As described above, calculations by room type have limited statistical reliability. Only the weighted mean across all room types, in the bottom rows of these tables, were used in the calculations. The overall averages in the bottom right corners of Table 9 below are the numbers reported as per unit savings for the engineering analysis seen in Table 4.

**Table 9. Gross kWh Savings by Room Type and Year**

| Room Type | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|
| Bathroom | 34.2 | 26.5 | 25.3 | 23.9 | 22.9 | 26.6 |
| Kitchen | 45.9 | 34.9 | 33.0 | 31.4 | 30.2 | 35.1 |
| Living/Family Room | 50.7 | 38.5 | 36.7 | 35.1 | 33.7 | 38.9 |
| Dining Room | 26.9 | 20.3 | 19.0 | 17.9 | 17.3 | 20.3 |
| Master Bedroom | 32.5 | 24.7 | 23.3 | 22.2 | 21.5 | 24.8 |
| Other Bedroom | 34.2 | 26.6 | 25.6 | 24.3 | 23.0 | 26.7 |
| Closet | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| Hall | 18.0 | 14.3 | 13.9 | 13.3 | 12.6 | 14.4 |
| Other | 81.4 | 62.1 | 58.9 | 56.9 | 54.9 | 62.8 |
| **Overall** | **42.9** | **32.7** | **31.1** | **29.6** | **28.5** | **33.0** |

Coincident peak demand savings were calculated based on the lamp wattage difference across each room and parameters from *Appendix C: Engineering Algorithms*. The results are shown in Table 10 below.

**Table 10. Gross Coincident kW by Room Type and Year**

| Room Type | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|
| Bathroom | 0.0037 | 0.0028 | 0.0027 | 0.0025 | 0.0024 | 0.0028 |
| Kitchen | 0.0033 | 0.0025 | 0.0024 | 0.0022 | 0.0021 | 0.0025 |
| Living/Family Room | 0.0040 | 0.0031 | 0.0029 | 0.0028 | 0.0027 | 0.0031 |
| Dining Room | 0.0043 | 0.0032 | 0.0030 | 0.0028 | 0.0027 | 0.0032 |
| Master Bedroom | 0.0035 | 0.0026 | 0.0025 | 0.0024 | 0.0023 | 0.0026 |
| Other Bedroom | 0.0041 | 0.0032 | 0.0031 | 0.0029 | 0.0027 | 0.0032 |
| Closet | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| Hall | 0.0040 | 0.0031 | 0.0031 | 0.0029 | 0.0027 | 0.0032 |
| Other | 0.0047 | 0.0036 | 0.0034 | 0.0033 | 0.0032 | 0.0036 |
| **Overall** | **0.0038** | **0.0029** | **0.0027** | **0.0026** | **0.0025** | **0.0029** |

# Low-Flow Showerheads and Faucet Aerators

A total of 74 low-flow showerheads and 149 faucet aerators were installed in the homes of survey respondents. According to customer self-reported data, nearly all of these units (98.7%) remain installed.

To determine impacts for low-flow showerheads, survey respondents were asked how many showers per week on average were taken using the showerhead provided by the program, which is rated at 1.75 GPM. Faucet aerators provided by the program are rated at 1.5 GPM. The baseline showerhead flow rate is assumed to be 2.87 GPM and the baseline faucet flow rate is assumed to be 2.2 GPM per the Draft Ohio TRM. This reduction in hot water usage was converted into kWh savings using the algorithm shown in *Appendix C: Engineering Algorithms*. This measure produces zero kW or kWh savings in households that use gas water heaters. Approximately 41% of households in the Carolinas have electric water heaters per Duke Energy's appliance saturation survey data. This is reflected in the unit savings values in Table 11.

**Table 11. Unit Savings Estimation for Low-Flow Showerheads and Faucet Aerators**

| Measure | Quantity | ISR | Base Flow Rate (GPM) | EE Flow Rate (GPM) | Gross kWh/unit | Gross Coincident kW/unit |
|---|---|---|---|---|---|---|
| Low-Flow Showerhead | 74 | 98.7% | 2.87 | 1.75 | 127.6 | 0.0100 |
| Faucet Aerator | 149 | 98.7% | 2.20 | 1.50 | 8.80 | 0.0011 |

## Air Sealing – Reduce Infiltration Measures

Program measures aimed at infiltration reduction include weather stripping, caulking, foam insulation spray, and door sweeps. Savings are calculated using kWh and kW per unit cfm reduction factors. These values were based on DOE-2 simulations of a set of prototypical residential buildings. The unit infiltration airflow rate reduction for each measure were determined using the ASHRAE tables, equations, and calculation methods described in the 2005 ASHRAE Fundamentals Handbook, Chapter 27, "Ventilation and Infiltration." Tables S3.1, S3.2, S3.3, and S3.4. The equation used can be seen in *Appendix C: Engineering Algorithms*. Unit savings estimates described above were applied to installed measure quantities from the installing contractors. Note, according to Duke Energy program staff, the foam insulation spray was used to seal pipe penetrations under sinks.

**Table 12. Unit Savings Estimation for Infiltration Reduction Measures**

| Measure | Quantity | Units | ISR | cfm Reduction per unit | Gross kWh/unit | Gross kW/unit |
|---|---|---|---|---|---|---|
| Weather Stripping | 1508 | linear foot | 86.0% | 0.0583 | 0.36 | 0.0002 |
| Caulking | 2112 | linear foot | 100.0% | 0.0308 | 0.22 | 0.0001 |
| Door Sweep | 113 | each | 95.8% | 0.3932 | 1.36 | 0.0007 |
| Foam Insulation Spray | 196 | sink | 100.0% | 0.1966 | 2.83 | 0.0014 |

## Water Heater Measures

Water heater measures available through the program include hot water pipe insulation, water heater tank wrap, and a tank temperature turn-down. The pipe insulation and tank wraps were only available to participants with electric water heaters. As such, no adjustment to unit savings, similar to that made for low-flow showerheads and faucet aerators to exclude gas water heater participants, is necessary.

Algorithms for calculating impacts are shown in *Appendix C: Engineering Algorithms*. The equation and parameters used for pipe insulation were taken from the Draft Ohio TRM. Tank wrap calculations use the New York TRM as the Draft Ohio TRM offers only deemed savings for this measure. This same algorithm was used for the tank temperature adjustment, holding tank insulation constant and varying the temperature difference assuming a 20 degree turn-down from 140 to 120 degrees Fahrenheit.

**Table 13. Unit Savings Estimation for Water Heater Measures**

| Measure | Quantity | Units | ISR | Gross kWh/unit | Gross kW/unit |
|---|---|---|---|---|---|
| DHW Pipe Insulation | 225 | linear foot | 100.0% | 24.64 | 0.0028 |
| DHW Tank Wrap | 19 | tank wrap | 100.0% | 125.8 | 0.0144 |
| DHW Temp Adjust | 43 | adjustment | 97.7% | 86.08 | 0.0098 |

## Furnace Filters and Calendar

Participants were left with a year supply of furnace filters and a calendar instructing them to replace their filter monthly. As dirt accumulates on the air filter, more energy is required to move air through the filter. Changing the filter monthly reduces the amount of time the unit is operated with a dirty filter, and therefore, lowers fan energy consumption for both the heating and cooling seasons.

**Table 14. Increased Power Use Over Time**

| Month | Percent Increase in Power due to Dirty Filter |
|---|---|
| 0 | 0.00% |
| 1 | 0.33% |
| 2 | 0.66% |
| 3 | 0.98% |
| 4 | 1.31% |
| 5 | 1.64% |
| 6 | 1.97% |
| 7 | 2.30% |
| 8 | 2.63% |
| 9 | 2.95% |
| 10 | 3.28% |
| 11 | 3.61% |
| 12 | 3.94% |

Table 14, taken from Southern California Edison Company's work paper on air filter alarms dated April 27, 2012, summarizes the linear increase over a 12 month average air filter replacement interval. Savings is estimated using a yearly changeout as a baseline. Annual fan energy consumption was estimated at 644 kWh/yr, based on the prototypical building simulations. The maximum percentage increase in power due to a dirty air filter was estimated as 3.94%, compared to 0.33% after one month.

| Measure | Quantity | Units | ISR | Gross kWh/unit | Gross kW/unit |
|---|---|---|---|---|---|
| AC Filters/Calendar | 56 | Participant | 87.5% | 23.01 | 0.0017 |

# Net to Gross Analysis

Typically, net to gross ratio (NTGR) for low income programs is simply deemed at 1.0. This is common practice in the industry, and discussed in the memo presented in *Appendix D: Memo: Low Income Programs and Freeridership*. Since this program operates at the neighborhood level, low income and standard income households are free to participate once the neighborhood as a whole has qualified. Freeridership for the program is thus calculated based only on phone survey responses given by standard income respondents (those over 200% of the Federal Poverty Level). Low income participants are assumed to have 0% freeridership and assigned a NTGR of 1.0. The overall program NTGR is the weighted average of both populations.

Using the participant survey responses, we have found that:

- 8.75% (7 out of 80) of the surveyed participant households are above the 200% Federal Poverty Level,
- 52.5% (42 out of 80) of the surveyed participant households are below the 200% Federal Poverty Level, and
- 38.75% (31 out of 80) are unknown (refused to answer, etc.).

Freeridership and spillover are calculated based on survey responses for households that are identified as standard income according to the participant's description of their household income and the number of residents in the home. Standard income household freeridership is calculated for each measure and then weighted by the percentage of standard income households identified among surveyed participants to calculate the freeridership level for all program participants. The methods used to calculate freeridership in standard income households are all based on survey responses, but the specific questions and calculations differ by measure.[6]

Of the 80 program participants surveyed in the Carolinas, 49 participants gave responses to the income and household composition questions which allowed them to be categorized as low-income or standard income (defined as being at or below 200% of the federal poverty income level). The other 31 participants could not be definitively categorized, including 16 participants who did not answer the question about household income. Thus the ratio of standard-income households in the program population is estimated at 14.3% (7 out of 49 customers whose survey responses allowed their income category to be determined). Table 15 shows the freeridership levels for measures confirmed to be installed in the seven households identified as standard income (over 200% of federal poverty level), and the estimated freeridership level for the measure among all program participants based on weighting standard income freeridership (14.3% of program population) with low income freeridership (85.7% of the program population who are assigned zero freeridership).

[6] Examples of freeridership calculations for measures such as those in the Residential Neighborhood program can be found in *Process and Impact Evaluation of the Residential Energy Assessments Program in the Carolina System*, TecMarket Works on behalf of Duke Energy, March 29, 2013.

**Table 15. Freeridership for Measures Installed in Standard Income Households**

| | Homes with Measures Installed, Standard Income households (valid N = # households) | Standard Income Freeridership | Population-weighted Freeridership |
|---|---|---|---|
| CFLs | 6 | 24.9% | 3.6% |
| Low-flow showerheads | 6 | 8.3% | 1.2% |
| Faucet aerators | 5 | 20.0% | 2.9% |
| Foam insulation spray | 1 | 0.0% | 0.0% |
| Weather stripping | 4 | 25.0% | 3.6% |
| Window AC kit | 2 | 50.0% | 7.1% |
| Caulking doors | 1 | 0.0% | 0.0% |
| Caulking windows | 0 | NA[7] | 0.0% |
| Door sweeps | 5 | 30.0% | 4.3% |
| Glass patch tape | 1 | 0% | 0.0% |
| Water pipe wrap | 3 | 0% | 0.0% |
| Water tank wrap | 2 | 0% | 0.0% |
| Water temp adjustment* | N/A | 0% | 0.0% |
| Filter changes/calendar* | N/A | 0% | 0.0% |

*Freeridership for these measures is assumed to be 0%.

None of the seven survey participants who are identified as standard income households gave responses indicating program spillover. Thus program-level spillover is zero, based on low income spillover being assigned zero percent and standard income household spillover being estimated at zero percent.

**Table 16. Gross and Net Program Savings by Measure**

| Measure | Gross kWh | Gross kW | Net kWh | Net kW |
|---|---|---|---|---|
| CFL | 23,579 | 2.0560 | 22,731 | 1.9820 |
| Low-Flow Showerhead | 9,440 | 0.7381 | 9,326 | 0.7293 |
| Faucet Aerator | 1,311 | 0.1639 | 1,273 | 0.1592 |
| Weather Stripping | 545 | 0.2656 | 526 | 0.2560 |
| Caulking | 468 | 0.2282 | 468 | 0.2282 |
| Door Sweep | 153 | 0.0747 | 147 | 0.0715 |
| Foam Insulation Spray | 556 | 0.2707 | 556 | 0.2707 |
| DHW Pipe Insulation | 5,544 | 0.6329 | 5,544 | 0.6329 |
| DHW Tank Wrap | 2,389 | 0.2727 | 2,389 | 0.2727 |
| DHW Temp Adjust | 3,701 | 0.4225 | 3,701 | 0.4225 |
| AC Filters/Calendar | 1,289 | 0.0924 | 1,289 | 0.0924 |
| **Overall Savings** | **48,976** | **5.2177** | **47,950** | **5.1173** |

The final overall freeridership for the program is set at 2.1% (47,950/48,976) for a program NTGR of 0.979.

[7] Since no surveyed standard income households received this measure, the program-level freeridership is based on low income households only (zero percent freeridership).

# Impact Evaluation: Billing Analysis

This section of the report presents the results of a billing analysis conducted among the participants in the Residential Neighborhood Program in the Carolina System. Billing data were obtained for all participants in the program between March, 2013 and July, 2014 that had accounts with Duke Energy (after processing, there were a total of 8,147 accounts from Carolinas)[8]. A panel model was used to determine program impacts, where the dependent variable was monthly electricity consumption from November 2010 to August 2014.

The estimated savings obtained from the billing data analysis are presented below.

**Table 17. Estimated Impacts: Billing Analysis**

| | 95% Confidence Interval | | |
|---|---|---|---|
| | Lower Bound | Mean Estimate, Unadjusted for EISA | Upper Bound |
| **Per Participant Annual Savings kWh** | 309 | 393 | 477 |

This table shows that the Residential Neighborhood Program produced statistically significant savings for participants.

Note that the billing data analysis includes variables to capture effect of participation in other Duke Programs. This is to explicitly control for any impact from other program participation.

For this analysis, data are available both across households (i.e., cross-sectional) and over time (i.e., time-series). With this type of data, known as "panel" data, it becomes possible to control, simultaneously, for differences across households as well as differences across periods in time through the use of a "fixed-effects" panel model specification that provides net savings estimates that are already adjusted for freeridership and participant spillover that occurs during the analysis period. The approach does not include the program induced savings that are associated with short and longer term non-participant spillover or market effects. As a result, these savings should be considered conservative for an estimate actual achieved savings. The fixed-effect refers to the model specification aspect that differences across homes that do not vary over the estimation period (such as square footage, heating system, etc.) can be explained, in large part, by customer-specific intercept terms that capture the net change in consumption due to the program, controlling for other factors that do change with time (e.g., the weather). That is to say, the fixed effects model can be viewed as a type of differencing model in which all characteristics of the home, which (1) are independent of time and (2) determine the level of energy consumption, are captured within the customer-specific constant terms. Differences in customer characteristics that cause variation in the level of energy consumption, such as building size and structure, are captured by constant terms representing each unique household. The model does control for what would have been done without the program within the participants' homes.

[8] Useable accounts are those accounts which have billing data for at least a year of the pre- and a portion of the post-participation period, as well as monthly kWh greater than 10 and less than 10,000 kWh. It was not required that the data covers the complete evaluation period, only that there is at least one observation in each period.

Because the consumption data in the panel model includes months before and after the installation of measures through the program, the period of program participation (or the participation window) may be defined specifically for each customer. This feature of the panel model allows for the pre-installation months of consumption to effectively act as the comparison group for post-participation months. In addition, this model specification, unlike annual pre/post-participation models such as annual change models, does not require a full year of post-participation data. Effectively, the participant becomes their own comparison group, thus eliminating the need for a non-participant comparison or control group. We know the exact month of participation in the program for each participant, and are able to construct customer specific models that measure the change in usage consumption immediately before and after the date of program participation, controlling for weather and customer characteristics.

In essence, because the model is analyzing the impacts at a monthly level, the model requires an adequate sample of monthly data to estimate the savings for each month. As a result, there is no need to have a full year of post-participant data for all participants. With past methods, the impact evaluations used annual data which required a full year of post-participation data to account for seasonal variations. With the monthly model, this is no longer required since each month is treated independently.

Algebraically, the fixed-effect panel data model is described as follows:

$$y_{it} = \alpha_i + ß(x_{it} * T) + \varphi P_t + \delta\, DP_{it} + \varepsilon_{it}$$

where:

$y_{it}$ = energy consumption for home $i$ during month $t$
$\alpha_i$ = constant term for site $i$ (the fixed-effect)
$T$ = indicator variables for each month in the analysis
$P$ = indicator for the treatment for the program in question
$DP$ = indicators for other utility-sponsored programs
$\beta, \varphi, \delta$ = vectors of estimated coefficients
$x$ = vector of non-program variables that represent factors causing changes in energy consumption for home $i$ during month $t$ (i.e., weather)
$x*T$ = *interaction of temperature and monthly indicator*
$\varepsilon$ = error term for home $i$ during month $t$.

With this specification, the only information necessary for estimation is those factors that vary month to month for each customer, and that will affect energy use, which effectively are weather conditions and program participation. Other non-measurable factors can be captured through the use of monthly indicator variables (e.g., to capture the effect of potentially seasonal energy loads).

The effect of the Residential Neighborhood program are captured by including a variable which is equal to one for all months after the household participated in the program. The coefficient on this variable is the savings associated with the program. In order to account for differences in billing days, the usage was normalized by days in the billing cycle. The estimated electric model for the Residential Neighborhood program is presented in Table 18.

**Table 18. Estimated Savings Model – dependent variable is daily kWh usage, November 2010 through August 2014 (savings are negative).**

| Independent Variable | Coefficient (Daily kWh Savings) | t-value |
|---|---|---|
| Participation | -1.08 | -9.17 |
| Sample Size | 281,382 observations (8,147 homes) | |
| R-Squared | 66% | |

The complete estimate model, showing the weather and time factors, is presented in *Appendix B: Estimated Model.*

## Billing Analysis EISA Effects

As the billing analysis does not span the entire EUL of a CFL, it does not take into account the future effects of EISA (See *Appendix K: EISA Schedule and CFL Baseline*). From Table 9, first year annual CFL savings is 42.9 kWh per bulb. As this is the first year of counted savings, no adjustment is made to the baseline wattage. The average annual CFL savings is 33.0 kWh per bulb, a reduction of 23.1%. [(42.9-33.0)/42.9].

From Table 20, engineering estimates show that CFLs contribute 47.4% of net program kWh savings. In terms of the raw billing analysis savings of 393 kWh per participant, from Table 17, this represents 186 kWh (0.474 * 393). This portion of the billing savings is adjusted downward 23.1% to account for EISA, resulting in the overall net savings from the billing analysis of 350 kWh per participant seen in Table 20 (393 – 0.231 * 186).

**Table 19. EISA Adjustments to Billing Analysis by year**

| Billing Analysis | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|
| Adjustment | 0.0% | 11.2% | 13.0% | 14.7% | 15.9% | 11.0% |
| kWh | 393 | 349 | 342 | 335 | 330 | 350 |

**Table 20. Breakdown of Per Participant Savings Contributions by Measure from Engineering Estimates Extrapolated to Billing Analysis**

| Measure | Net kWh Contribution from Engineering | Net kW Contribution from Engineering | Billing Analysis Average kWh Allocation | Billing Analysis kW Allocation |
|---|---|---|---|---|
| CFLs | 47.4% | 38.7% | 166 | 0.0365 |
| Low-Flow Showerhead | 19.5% | 14.3% | 68 | 0.0135 |
| Faucet Aerator | 2.7% | 3.1% | 9 | 0.0029 |
| Weather Stripping | 1.1% | 5.0% | 4 | 0.0047 |
| Caulking | 1.0% | 4.5% | 3 | 0.0042 |
| Door Sweep | 0.3% | 1.4% | 1 | 0.0013 |
| Foam Insulation Spray | 1.2% | 5.3% | 4 | 0.0050 |
| DHW Pipe Insulation | 11.6% | 12.4% | 40 | 0.0117 |
| DHW Tank Wrap | 5.0% | 5.3% | 17 | 0.0050 |
| DHW Temp Adjust | 7.7% | 8.3% | 27 | 0.0078 |
| AC Filters/Calendar | 2.7% | 1.8% | 9 | 0.0017 |
| **Overall Savings** | | | **350** | **0.0944** |

The billing analysis approach used to assess energy savings provides a direct net (net of short-term freeridership, short-term participant spillover, and participation in other Duke Energy programs) energy impact estimate by employing a quasi-experimental design. Therefore, it is necessary to apply a net to gross ratio to the engineering estimates for comparison to the billing analysis.

# Management Interviews

## Program Operations

Duke Energy's Residential Neighborhood Program supplies eligible Duke Energy customers with home energy audits, one-on-one education during the audit, and the installation of energy efficiency measures as appropriate[9]. Duke Energy provides administrative oversight for the program, including vendor management, confirmation of eligible neighborhoods. GoodCents handles day-to-day program activities including marketing, customer enrollment, measure ordering, oversight of installations and timelines, data collection and database management, and reporting.

The neighborhoods are served one at a time and selected using U.S. Census Tract data showing the percent of residents that live at or below 200% of the federal poverty level (FPL). If at least 50% of the residents are at or below 200% of the FPL, the neighborhood is considered. The program managers conduct additional research on the area to determine if it is a good selection for the program. For example, they consider safety issues (inquiring with the local police department), the size of the area (number of homes), and other factors. After a neighborhood is selected, the boundaries are set to include approximately 500-800 homes, however some neighborhoods have been as large as 2,000 homes.

### Marketing and Outreach

After the neighborhood and the 6-8 week period of time the program will operate are selected and confirmed, the program managers and GoodCents initiate more detailed planning for that neighborhood. The first outreach effort is targeted to all homes by mail two weeks prior to the neighborhood kick-off event. The purpose of the mailing is to inform the residents about the program, encourage them to learn more about it, and invite them to the program's kick-off event. The kick-off event provides more information about the program and how it operates and provides an opportunity for residents to meet the auditors. The event serves a catered dinner for the household to encourage participation and attendance. About a week before the kick-off event, postcards are sent as reminders to attend and learn more. Door hangers are also left on the doors of residents in the neighborhood throughout the 6-8 week period in which auditors are in the area. Residents are encouraged to RSVP for the event to help the managers order the correct amount of food for the dinner, however a response is not required to attend. Currently GoodCents and Duke Energy are reaching out to the residents six or seven times over the 6-8 week period they are in the neighborhood to encourage participation.

### Kick-off Event

The kick-off event is held at a place familiar to the neighborhood such as a school or community center. There are signs directing residents to the event on major streets close to the event (see Figure 1). During the first hour, residents are encouraged to sign up for an audit, informed of the program and its benefits to their homes, their utility bills, and to Duke Energy. GoodCents staff including all of the auditors that will be working in the neighborhood attend so that residents can

[9] Not all items are installed during the audit. For instance, a year's supply of furnace filters are left at the residence for future filter changes.

meet the people that will be entering their home and conducting the audit. All GoodCents and Duke Energy staff are wearing the same blue colored shirt that matches the program marketing materials and the vehicles that will be in the neighborhood. In addition, Duke Energy program managers invite trusted community members to attend and speak, encouraging residents to participate. TecMarket Works attended one of these events which included the mayor, a community center director, the Duke Energy liaison for the area, and a church leader. Attendees are provided with a catered dinner, and everyone is entered to win one of four $25 Visa gift cards which are awarded after the presentation. The events are very well organized and effective. Many residents sign up for their audit before they leave the event. A flyer that is displayed at the entrance of the kick-off event is shown in *Appendix J: Flyer at Kick-off Event*.


**Figure 1. Sign for the Kick-off Event**

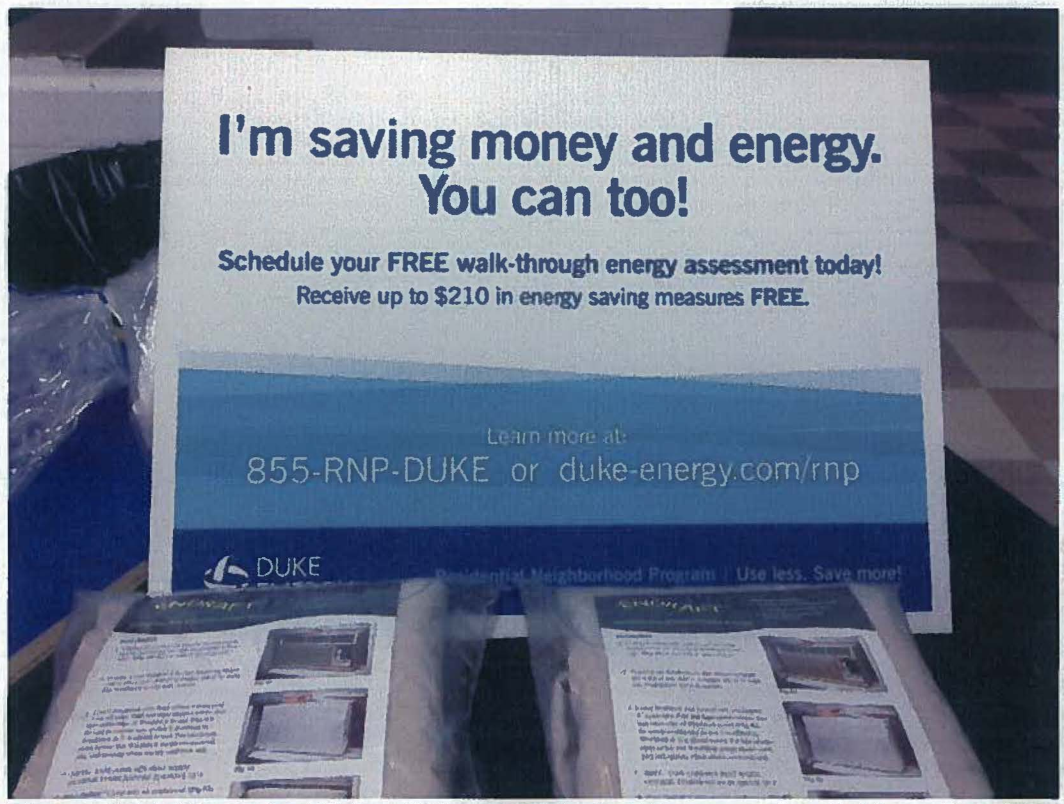


**Figure 2. Table at the Kick-off Event with the Measures Available to Participants**

## Post-Event Activities

After the event, the auditors are in the neighborhood for eight to ten weeks conducting audits and approaching residents encouraging them to participate. The trucks, shown in Figure 3, are parked in conspicuous areas so that the residents are aware of and reminded of their presence and the services they are offering. Audits generally take from one to two hours to complete and the auditors are available from 8am to 7pm Monday through Friday, and from 10am to 3pm on Saturdays. The auditors are available to make appointments at any time for the following week (past a week they have found that some appointments are not held by the customer).


**Figure 3. Residential Neighborhood Vehicle**

During the audit, participants are provided with one-on-one education about what the auditor is doing, and what measures they are installing. Each of the GoodCents auditors are provided with training specific to this program (see training guide in *Appendix I: Auditor Training Guide*). GoodCents hires auditors that have carpentry, weatherization, or some HVAC-related job history. Then they attend an internal training for this program, followed by one week of supervised on-site work. GoodCents also conducts safety training for carbon monoxide so that they can discuss carbon monoxide levels with the customers and its effects on health. Auditors also undergo quality assurance training which includes driving safety, in-home safety, and are required to review all training materials regularly (weekly, monthly or quarterly, depending on measure).

## Eligibility

This program is available to Duke Energy customers that live in the defined neighborhood. The neighborhood is selected as described above. However, residents from outside of the neighborhood borders have attended events and tried to participate. None are turned away from the event, however, customers from outside the targeted neighborhood are informed that when the auditors will be in their area, that they will be in contact to enroll them in the program.

While the eligibility rules are clearly defined and explained, non-participant surveys reveal some confusion about the hours that audits are available (believing the audits would conflict with their work hours), that their income is too high to participate, or since they have CFLs they believe their home is already efficient. This is discussed in more detail the section *Non-Participants' Understanding of the Program.*

## Management Communication and Coordination

All parties interviewed for this evaluation reported positive working relationships between Duke Energy and GoodCents. Representatives from the two entities meet to review progress toward goals, discuss challenges or discrepancies, adjust strategies, and coordinate marketing and field activities. All communications are reported to be effective and timely.

## Key Findings and Conclusions from Management Interviews

Duke Energy and its key vendor, GoodCents, work well together with no issues in communications or operational effectiveness.

All parties agree that all of the managers are open to discussing and trying out new marketing ideas, hoping to improve program participation.

# Participant Surveys Results

## Awareness and Understanding of the Program

A plurality of surveyed program participants in the Carolina System first learned about the Residential Neighborhoods program from letters and postcards in the mail (mentioned by 31.8% or 14 out of 44 North Carolina customers and 41.7% or 15 out of 36 South Carolina customers), as seen in Figure 4. People visiting the customers' homes were the second-most mentioned source of awareness (22.7% or 10 out of 44 North Carolinians and 25.0% or 9 out of 36 South Carolinians). Door hangers were the only other source of awareness mentioned by more than 10% of customers in South Carolina, however in North Carolina customers attending the community event, word of mouth, and spotting auditors and their trucks in the neighborhood were also mentioned by more than 10% of participants.

None of these customers learned about the program online (0% in both states), and very few mentioned traditional media sources (2.3% or 1 out of 44 for North Carolina and 2.8% or 1 out of 36 in South Carolina). The only statistically significant difference between North and South Carolina customers in terms of their initial source of awareness of the program is that North Carolinians are more likely to mention spotting auditors and their trucks in the neighborhood (13.6% or 6 out of 44, versus 2.8% or 1 out of 36 in South Carolina; this difference is significant at $p<.05$ using Student's t-test).

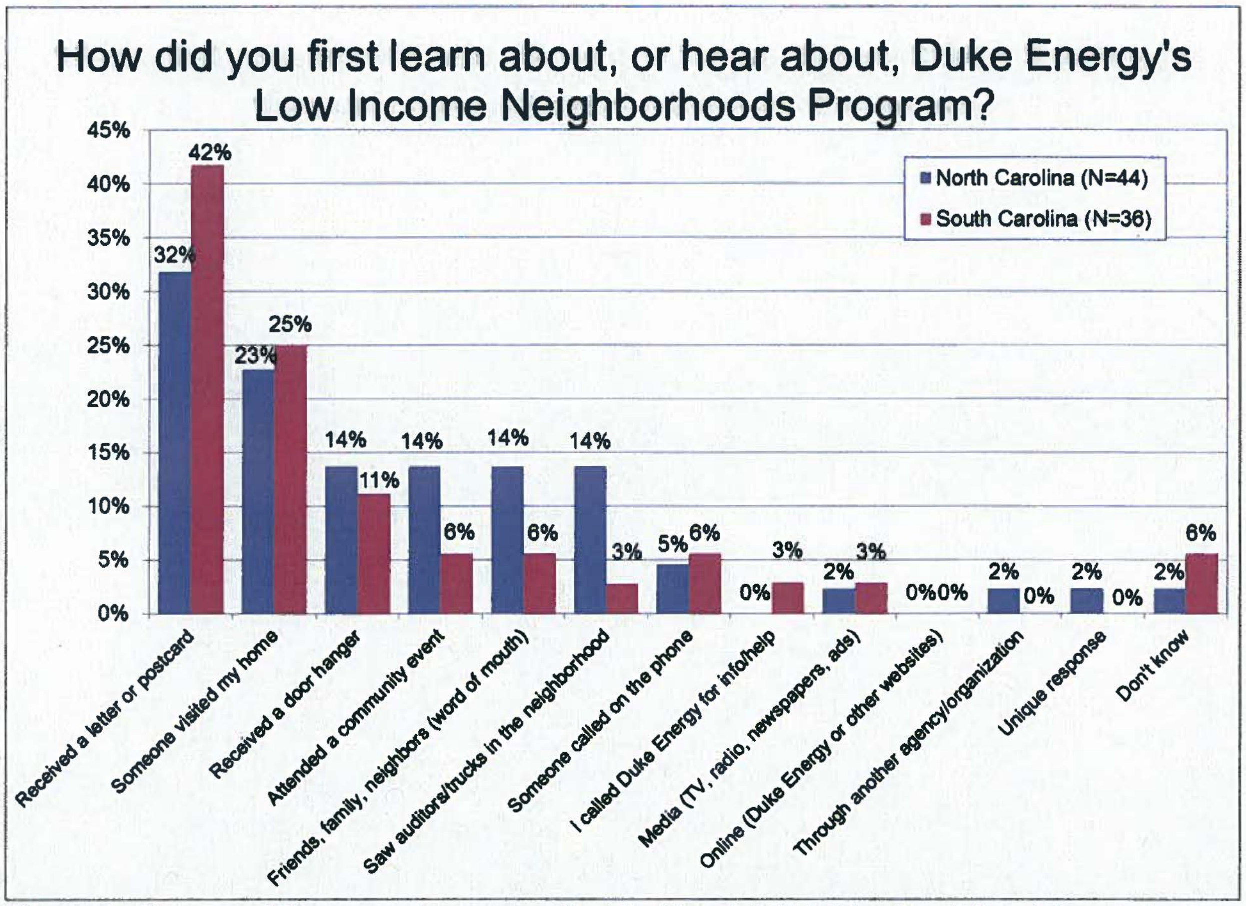


**Figure 4. Source of Program Awareness for Residential Neighborhood Participants in the Carolina System (N=80)**
*Percentages total to more than 100% because participants could name multiple sources of awareness.*

Among the 29 customers in the Carolina System who mentioned finding about the program through the mail, 93.1% (27 out of 29) identified Duke Energy as the organization that sent the mailings (including two customers who said they received a notice with their bill[10]). One South Carolina customer said their mailing came from "*one of the neighborhood centers: Northwest? C.C. Woodson?*", and one North Carolina customer could not recall the source of the mailing they received.

Among the 19 customers who learned about this program when someone visited their home, 73.7% (14 out of 19) identified Duke Energy as the organization that sent the representatives to their home, while the rest did not know or did not specify. All ten customers who learned about the program from door hangers (100% of 10) identified Duke Energy as the source of these communications.

Among the four customers who received phone calls about the program, three (75%) identified Duke Energy as the organization calling, while one customer from North Carolina stated that

[10] The program did not conduct a marketing effort via bill inserts.