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2017 EM&V Report for the Duke Energy Progress Commercial, Industrial, and Governmental Demand Response Automation (DRA) Program

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Attached as separate documents:
Appendix A: Event Day Load Profile and Baseline Plots (.pdf document)
Appendix B: Analysis Data Tables & Graphics (.xlsx document)

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EXECUTIVE SUMMARY

The Commercial, Industrial, and Governmental Demand Response Automation (DRA) program is part of the portfolio of demand-side management and energy efficiency (DSM/EE) programs initiated by Duke Energy Progress (DEP) in 2009. DRA offers participating companies and agencies a financial incentive to reduce their electricity consumption when called upon by DEP. This report covers evaluation, measurement, and verification (EM&V) activities for Program Year 2017 (PY2017).

This EM&V report is intended to verify program impacts as per the requirements established by the North Carolina Utilities Commission and the Public Service Commission of South Carolina. Major objectives of the evaluation were as follows:

- Verify the demand reduction calculated by DEP's method of baseline estimation as described in the *Demand Response Automation Rider DRA-7 (North Carolina) and DRA-8 (South Carolina)* filed by DEP [1]
- Produce a set of verified program impacts by customer and for the program as a whole using the most accurate baseline method identified in PY2010 and PY2011. Specifically, per Navigant's SOW and the approved evaluation plan, Navigant was required to:
    - Estimate verified impacts using a regression-based approach with a day-of load adjustment (as appropriate[2]);
    - Estimate average kW event load shed per meter, by sector, and for the program as a whole; and,
    - Provide a detailed baseline approach and explanation of the kW impact calculations.

Program Summary

The DRA program offers participating companies and agencies a financial incentive to reduce their electricity consumption for up to 8 hours at a time on only a few system peak days in either the summer or winter months. As in PY2016, no winter events were called in PY2017. Under the program, DEP's technology vendor (Comverge) installs two-way communications equipment to remotely monitor and record interval loads at 15-minute intervals. Customer load curtailments are commonly provided through the use of onsite generation or from shutting down manufacturing processes. Curtailments might also include modifications in the use of heating, ventilation, and air conditioning (HVAC) systems, lighting, and other building loads.

In PY2017, 20 customers were registered as participants in DEP's DRA program, representing 45 unique sites and 69 meters. Of the 69 meters that were registered as participants in PY2017, 31 are at commercial sites and three are at governmental sites. Thirty-five meters are at industrial sites, 16 of which belong to a single manufacturing company. For brevity, the very large industrial participant (with 16 meters) is referred to in this report as the "VLIP."

[1] North Carolina Rider, DRA-7: https://www.duke-energy.com/_/media/pdfs/rates/gp2ncriderdradep.pdf?la=en
South Carolina Rider, DRA-8: https://www.duke-energy.com/_/media/pdfs/for-your-home/rates/electric-sc/gp1scriderdra.pdf?la=en

[2] Day-of load adjustments are not appropriate when event notification is not provided on the same day as the event.

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An overview of the participating customers and average reported DR impacts for summer events is presented in Table 1.

Table 1. Summary of Participating Companies and Agencies

Sector	Customer Type	Number of Customers	Number of Sites	Number of Meters	Avg. Reported Reduction per Meter (kW)
Commercial	Warehouse/ Distribution	1	1	1	614
Industrial	Manufacturing	8	15	35	271
Governmental	Government Institution	1	1	1	2,766
Governmental	Water Treatment	2	2	2	640
Commercial	Grocery	4	22	24	246
Commercial	Office	3	3	3	271
Commercial	Hospital/Medical	1	1	3	363
	Total Program	**20**	**45**	**69**	**N/A**[3]

Source: DEP DRA program database

Evaluation Methods

The PY2017 evaluation consisted of an impact evaluation only. The methods used for the evaluation are summarized below.

1. **Replication of DEP-Reported Impacts**

   The evaluation team used interval data for all participant meters and event schedule data to calculate a baseline for each event and each participant meter. These baselines were all calculated using the algorithm Duke Energy uses to report program impacts and calculate participant incentives for settlement purposes.

2. **Verification of Program Impacts**

   Navigant estimated verified impacts by comparing a regression-estimated baseline to actual event day demands. The team estimated baselines using individual customer regressions. This approach is the result of a set of tests conducted as part of the PY2011 and PY2012 evaluation to determine the most accurate approach for estimating impacts.

Key Findings

Three DRA events were called during the summer of PY2017, involving 69 unique customer meters.

This section outlines the key findings of this impact evaluation.

[3] An average by meter is not provided here to avoid undue confusion in comparison with aggregated impacts. Average impacts per participating meter across multiple events ignore “impacts” of events in which the meter did not participate, reporting an average per meter value here could appear to inflate program-level impacts inappropriately.

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Key Impact Findings

The key impact evaluation findings are:

- **Verified impacts were slightly less than reported impacts.** The realization rate for the summer DR impacts for PY2017 was 96%, with an average of approximately 19.3 MW of DR contributed by the program.
- **Participation[4] remains inconsistent between events.** The average total event impacts for the summer of PY2017 were highest for the second two events (20 and 20.8 MW), but substantially lower for the first event (17 MW). Only 55 meters participated in the first event.
- **Total program impact increased in PY2017 compared to PY2016, but is still lower than PY2015 result.** The average event impact increased from about 17.6 MW in PY2016 to about 19.3 MW in PY2017. The average impact across all three PY2015 events was approximately 20.1 MW. Duke Energy staff indicate that changes in US Environmental Protection Agency (EPA) regulations regarding onsite generators were a major contributor to the decline in impacts since 2015 and that changes in these regulations resulted in the loss to the program (after 2015) of participants, accounting for 5 MW of contracted DR.

The EM&V analysis found average load reductions of approximately 19.3 MW per summer event, or about 300 kW per meter, on average[5], or 96% of the figure reported[6] by Duke Energy in its DRA program database (Table 2). On average, the relative precision associated with the baselines used to develop estimated impacts, during event periods, was +/- 1.2% at the 90% confidence level.

Table 2. Verified Load Reductions and EM&V Verification Rate – Summer

Load Reduction Category	Event kW			Avg. Total Reduction Over Summer Events
	2017-07-13	2017-07-21	2017-08-18	
Reported (Duke Energy Database)	17,974	20,088	22,262	20,108
Verified	16,992	20,020	20,767	19,260
Relative Precision (Verified Impacts +/-)	2.2%	2.0%	2.1%	1.2%
Verified Realization Rate (Verified Reductions/Reported Reductions	95%	100%	93%	96%

Sources: DEP DRA program database and Navigant analysis

The evaluation team found that, as in previous years' evaluations, the VLIP's demand was highly variable across many of its meters in the summer of 2017. On many non-holiday weekdays, demand for a given meter was close to zero and on others in the range of hundreds of kilowatts. These volatile patterns of

[4] Event-specific participation refers to enrolled participants delivering more than 0 kW of DR for a given event. An enrolled customer meter has participated in only two of three events if that meter has contributed more than 0 kW on only two of the three events.

[5] Average impact per meter is calculated as the average across events of the average across participating meters by event. This value will not correspond to the total number of meters that participated at some point in the summer (69) divided by the average impact across events (19.2 MW), since not all meters participated in all events.

[6] Reported impacts are those impacts calculated by DEP using the DRA baseline algorithm.

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use cause the estimated baselines and impacts for each of the individual meters to be less reliable than for other meters with a more consistent pattern of demand.

Navigant successfully replicated the DEP settlement baseline and reported impacts for every meter/event pair.

As in previous program year evaluations, a set of plots of event day load profiles—by meter—is included in Appendix A (separate document). These plots provide the average hourly demand, the load-adjusted regression baseline, and a non-load-adjusted regression baseline for each event and for each participating meter. These plots also highlight the evaluated event period. The evaluation team has found this set of plots to be extremely useful for its analysis and would recommend examining them after (or while) reading the report below.

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1. PROGRAM DESCRIPTION AND RESEARCH OBJECTIVES

The Commercial, Industrial, and Governmental (CIG) Demand Response Automation (DRA) program is part of the portfolio of demand-side management and energy efficiency (DSM/EE) programs initiated by Duke Energy Progress (DEP) in 2009. DRA offers participating companies and agencies a financial incentive to reduce their electricity consumption for up to 8 hours at a time on a few peak days. DEP's program literature specifies that a minimum of three summer events will be called, and the maximum number of curtailment events is 10. Typical event duration is 6-8 hours.

This report covers evaluation, measurement, and verification (EM&V) activities for the seventh year of the DRA program, Program Year 2017 (PY2017). EM&V is a term adopted by DEP and refers generally to the assessment and quantification of the energy and peak demand impacts of an EE or DR program. For DR, estimating reductions in peak demand is the primary objective, as energy impacts are generally negligible.

1.1 Objectives of the Evaluation

This EM&V report is intended to verify program impacts as per the requirements established by the North Carolina Utilities Commission and the Public Service Commission of South Carolina. Major objectives of the evaluation were as follows:

- Verify the demand reduction calculated by DEP's method of baseline estimation as described in the *Demand Response Automation Rider DRA-7 (North Carolina) and DRA-8 (South Carolina)* filed by DEP [7]
- Produce a set of verified program impacts by customer and for the program as a whole using the most accurate baseline method identified in PY2010 and PY2011. Specifically, per Navigant's SOW and the approved evaluation plan, Navigant was required to:
    - Estimate verified impacts using a regression-based approach with a day-of load adjustment (as appropriate[8]);
    - Estimate average kW event load shed per meter, by sector, and for the program as a whole; and,
    - Provide a detailed baseline approach and explanation of the kW impact calculations.

1.2 Program Overview

The DRA program was developed in response to DEP's determination that a curtailable load program would be a valuable resource for the company and an additional service offering for customers that would complement DEP's existing load curtailment riders. The program seeks to increase DEP's DR resources by improving customer receptiveness to curtailment programs through increased awareness of load

[7] North Carolina Rider, DRA-7: https://www.duke-energy.com/_/media/pdfs/rates/gp2ncriderdradep.pdf?la=en
South Carolina Rider, DRA-8: https://www.duke-energy.com/_/media/pdfs/for-your-home/rates/electric-sc/gp1scriderdra.pdf?la=en

[8] Day-of load adjustments are not appropriate when event notification is not provided on the same day as the event.

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reduction potential and restructuring of the incentives and non-compliance charges used for current DR programs.

The DRA program offers participating companies and agencies a financial incentive to reduce their electricity consumption for up to 8 hours at a time on only a few system peak days annually. Under the program, DEP's technology vendor (Comverge) installs two-way communications equipment to remotely monitor and record interval loads at 15-minute intervals. Participants are guaranteed at least 30 minutes of advanced notice before a curtailment event, but often are given several hours of notice for summer events and day-ahead notice for winter events. For the summer of PY2017, all participants received notice day-ahead of all events.

Eligibility. To qualify for the program, DEP commercial and industrial customers must be able to curtail 75 kW. Importantly, all industrial customers and any commercial customers that use more than 1 million kWh per year must also elect to forego the opportunity to opt out of the rider that funds DEP's DSM/EE programs. By opting in, customers become eligible for DSM/EE incentives and commit to pay the rider for a period of 3 years.[9]

Incentives. The program provides three types of participant incentives:

- **A one-time participation incentive of $50 per demonstrated kW.** Intended to enhance customer acquisition and to support customer investment related to program participation, including purchase and installation of automated controls
- **A monthly availability credit of $3.25 per contracted kW.** Intended to provide steady payment streams and ensure readiness
- **An event performance credit of $6 per curtailed kW.** Intended to increase resource reliability through an emphasis on event compliance

This three-part incentive structure was selected to benefit customers for responding to more events and to ensure that DEP pays for performance but limits its costs when few events are called. As a pay-for-play program, it ensures that customers will receive more incentives when the need for peak reduction is high.

Performance and Compliance. DEP provides customers with information about complying with program requirements based on curtailment levels during pre-defined seasonal peak periods. Participants are also provided information about the method for estimating baseline to determine curtailment impacts.

- Summer peak period: defined as 1 p.m. – 9 p.m. on weekdays in June through September
- Winter peak period: defined as 5 a.m. – 10 a.m., and 5 p.m. – 11 p.m. on weekdays in December through February

1.3 Reported Program Participation and Savings

In PY2017, 20 customers were registered as participants in DEP's DRA program, representing 45 unique sites and 69 meters. Of the 69 meters, 31 are at commercial sites and three are at governmental sites.

[9] Prior to January 1, 2016, the required commitment was 10 years.

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Thirty-five meters are at industrial sites, 16 of which belong to a single manufacturing company. For brevity, the very large industrial participant (with 16 meters) is referred to in this report as the VLIP.

An overview of the participating customers is presented in Table 3, including number of meters and sites by customer type and the average demand reduction reported by DEP over the three summer events by customer type.

Table 3. Summary of Participating Customers

Sector	Customer Type	Number of Customers	Number of Sites	Number of Meters	Avg. Reported Reduction per Meter (kW)[10]
Commercial	Warehouse/ Distribution	1	1	1	614
Industrial	Manufacturing	8	15	35	271
Governmental	Government Institution	1	1	1	2,766
Governmental	Water Treatment	2	2	2	640
Commercial	Grocery	4	22	24	246
Commercial	Office	3	3	3	271
Commercial	Hospital/Medical	1	1	3	363
	Total Program	**20**	**45**	**69**	**N/A[11]**

Source: DEP DRA program database

The average reported impacts shown above are the average only of the impacts for event/participant pairs where DEP reported a non-zero impact (sometimes referred to as “participation” in this report). DEP reported a total impact of approximately 20.1 MW on average, per event.

PY2017 average reported[12] event curtailments at individual meters ranged from the trivial to nearly 2,800 kW, as shown in Figure 1. In this chart, meters are segregated by sector: commercial/governmental and industrial.

[10] Average reported demand by customer type is calculated as the average by customer type of the average individual meter impacts across events in which participants achieved some DR. Because these values are based only on compliant reported DR achievement, a total calculated based on the values in this table will overstate the total reported average DR achieved across the three events. This value is reported in Table 2 and Table 4.

[11] An average by meter is not provided here to avoid undue confusion in comparison with aggregated impacts. Average impacts per participating meter across multiple events ignore “impacts” of events in which the meter did not participate, reporting an average per meter value here could appear to inflate program-level impacts inappropriately.

[12] Note that as per the convention of this report, reported impacts refer to the settlement impacts estimated using the DEP baseline algorithm and not the regression-estimated verified impacts.

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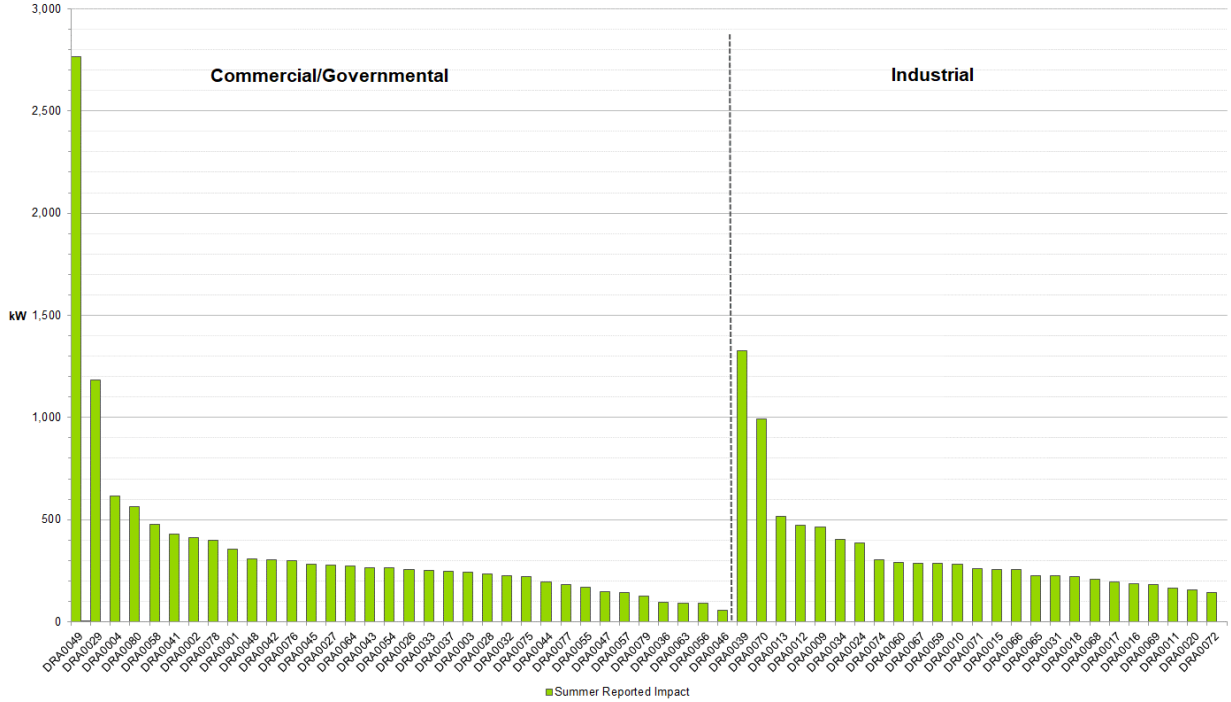
Figure 1. Reported Load Reductions (kW) by Meter



Source: DEP DRA program database

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2. EVALUATION METHODS

This section describes the methods and data used by the evaluation team to conduct the PY2017 impact evaluation of the CIG DRA program.

Estimating impacts of DR events is generally a matter of first estimating a counter-factual baseline of what a customer's load would have been during the hours of the curtailment event had the event not been called. Actual measured loads are then subtracted from this baseline to estimate load reductions. The baseline estimation methods used by DEP and by the evaluation team are discussed below. The regression approach applied by Navigant implicitly applies this arithmetic through the use of indicator or "dummy" variables included on the right-hand-side of the regression equation.

The evaluation team used the following data in its analysis:

- Quarter-hourly interval data for 69 DRA program participating meters between May 1, and October 31, 2017
- Hourly observations of temperature data from National Oceanic and Atmospheric Administration (NOAA) weather stations
- Event logs supplied by DEP indicating the date, and start and end time of each event, as well as the time at which participants were notified of an imminent event.

Using this data, the evaluation team conducted three principal sets of analyses:

1. **Replication of the savings calculations provided by DEP**, which estimated baselines using the three qualifying non-excluded days immediately prior to an event.
2. **Estimation of the impact of events for all meters** using a regression-derived baseline. Unlike in some previous program years, day-of-load adjustments could not be applied to the baselines. Day-of-load adjustments are possible when participants are notified on the date of the event. Notification was provided day-ahead for all three events in 2017.

Evaluations of DSM/EE programs commonly estimate a net-to-gross (NTG) ratio based on the evaluated percentage of demand reductions that may be ascribed either to free ridership (which reduces the NTG ratio) or program spillover (which increases the NTG ratio). Free ridership is typically defined as the percentage of demand reductions that would have occurred anyway, absent the presence of the program. Participant spillover is typically defined as incremental demand reductions undertaken by a program's participants though not directly incented or promoted by the program administrator.

In the case of DR programs such as DRA, there is no reason to expect that a customer would curtail loads during the event periods (the timing of which would be unknown to the customer absent participation in the program) without being enrolled in the program. Furthermore, because demand reductions are estimated relative to an estimated baseline that captures expected participant behavior absent an event, the analysis inherently accounts for free ridership and participant spillover; that is, absent the DRA program, none of the observed demand reductions would have taken place. Based on the above considerations, the evaluation team considers the NTG ratio for the impact analysis of the DRA program to be 1.0.

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2.1 Replication of the DEP Savings Calculations

DEP estimated load reductions using a baseline calculation method developed internally by DEP and described in *Demand Response Automation Rider DRA-7 (North Carolina) and DRA-8 (South Carolina)* filed by DEP. The evaluation team replicated DEP's algorithm to confirm the results reported by DEP.

The DEP algorithm[13] generates a baseline for calculating program impacts on event days based on the three non-excluded (holidays, weekends, and curtailment days) and qualifying days immediately prior to an event day. A day is deemed as qualifying if average demand during curtailment event hours on that day is at least 50% of the average of the three non-excluded days. If one of the first three non-excluded days prior to the event is deemed to be non-qualifying, the next prior non-excluded day is used. If there are not three qualifying days out of the 10 non-excluded days prior to the event, the algorithm reverts to using the three most immediate non-excluded days prior to the event.

The average demand over the three selected days during the hours corresponding to those in which the event was called is the baseline used to calculate impacts and participant incentive payments. The reported impact is calculated as the difference between the average baseline over the event period and the average actual demand over that period, excluding the first 15 minutes of the event.[14]

2.2 Estimation of Regression-Based Baseline for Calculating Verified Impacts

The evaluation team estimated verified impacts as the difference between actual average demand over the time span of the event (excluding the first 15 minutes) and the regression-estimated average baseline demand.

To estimate the baseline, the team estimated the following regression for each meter in the summer, including only non-holiday and non-event weekdays:

Equation 1. Individual Meter Regression Specification

$$y_t = \sum_{i=0}^{96} \beta_{1,i} Quarterhour_{i,t} + \sum_{i=0}^{96} \beta_{2,i} Quarterhour_{i,t} CDH_t + \sum_{c=1}^{69} \gamma_c C_{i,t} + errors_t$$

Where:

y_t	=	The average demand (kW) observed at the given meter in the quarter hour of sample *t*.
$Quarterhour_{i,t}$	=	96 dummy variables, each one equal to 1 if quarter hour *t* is *i*-th quarter hour of the day (for example, if quarter hour t is between midnight and 12:15 a.m., $Quarterhour_0$ is equal to 1 and 0 otherwise or if quarter hour t is between 1:00 p.m. and 1:15 p.m. then $Quarterhour_{52}$ is equal to 1 and 0 otherwise).
CDH_t	=	The cooling degree hours in quarter hour of sample *t*.

[13] The details of the DEP algorithm are described in more detail in Appendix A of the PY2010 report.

[14] Note, however, that the baseline is calculated using all event quarter-hours.

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$C_{i,t}$ = A set of 69 dummy variables, intended to control for program impacts in every event quarter hour of the evaluation period (three events, six hours each, less the first quarter hour of each). Each variable takes a value of 1 when the *t*-th hour of the sample is also the *c*-th event quarter hour for which impacts are being evaluated.[15]

Navigant applied the estimated coefficients from the regression above. The estimated impact in each quarter hour is delivered by the relevant parameters $\sum_{c=1}^{69} \gamma_c$.

[15] Using a set of dummy variables in this manner is analytically equivalent to simply excluding the event quarter-hours, estimating the model and subtracting the actual from the baseline. The key difference is that it makes estimating impact uncertainty (through the standard errors) much more convenient.

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3. PROGRAM IMPACTS

This chapter describes the findings from the evaluation team's analysis of load reduction impacts for the DRA program for PY2017.

DEP called three events during the summer of 2017, involving 69 unique customer meters. The EM&V analysis found average load reductions[16] of approximately 19.3 MW per summer event—approximately 300 kW per meter[17], or slightly less than the 20.1 MW figure reported[18] by DEP in its DRA program database (Table 4).[19]

Table 4: Verified Load Reductions and EM&V Verification Rate

Load Reduction Category	Event kW			Avg. Total Reduction Over Summer Events
	2017-07-13	2017-07-21	2017-08-18	
Reported (Duke Energy Database)	17,974	20,088	22,262	20,108
Verified	16,992	20,020	20,767	19,260
Relative Precision (Verified Impacts +/-)	2.2%	2.0%	2.1%	1.2%
Verified Realization Rate (Verified Reductions/Reported Reductions	95%	100%	93%	96%

Sources: DEP DRA program database and Navigant analysis

Other significant findings of the impact evaluation, by topic areas, are as follows:

Approved Baseline Methodology

- **Finding 1:** Navigant successfully replicated the DEP settlement baseline and reported impacts for every meter/event pair.

Verified Impacts

- **Finding 2:** Using the regression-derived baseline, the evaluation team verified that participants as a whole achieved an average of 19.3 MW of demand reduction during summer events, approximately 96% of that reported and 100% of that contracted.

[16] Note that the average load reduction per event is the average of only non-zero load reductions achieved. For example, if two meters contributed 100 kW each and a third meter did not achieve any DR (i.e., actuals were above baseline) the average verified impact for this event would be reported as 100 kW.

[17] Average impact per meter is calculated as the average across events of the average across participating meters by event. This value will not correspond to the total number of meters that participated at some point in the summer (69) divided by the average impact across events (19.2 MW), since not all meters participated in all events.

[18] Reported impacts are those impacts calculated by DEP using the DRA baseline algorithm.

[19] As noted previously, reported impacts are those impacts calculated by DEP using the DRA baseline algorithm. Verified impacts are based on a regression baseline. Both sets of impacts are net values, implicitly assuming an NTG ratio of 1.0. See Section 2 for further discussion.

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- **Finding 3:** Total program impacts increased in PY2017 compared to PY2016, but were still somewhat lower than in PY2015. DEP staff indicate that changes in US Environmental Protection Agency (EPA) regulations regarding onsite generators is a major contributor to this reduction in DR impacts from PY2015.

The remainder of this chapter is divided into two sections:

- **Section 3.1 – Replication of DEP-Reported Impacts.** Replication of the DEP settlement algorithm.
- **Section 3.2 – Verified Impacts .** Impacts estimated using the regression baseline method described above.

3.1 Replication of DEP-Reported Impacts

As noted above, part of the task assigned to the evaluation team was to replicate the DEP algorithm to confirm the validity of the results reported by DEP.

Navigant successfully replicated the DEP settlement baseline and reported impacts for every meter/event.

3.2 Verified Impacts

All verified impacts discussed below are based on the regression model without a symmetric day-of load adjustment. The evaluation team found that baselines with day-of-load adjustments delivered the most accurate estimated impacts, on average, in the PY2010 and PY2011 evaluations; however, these are not possible when participants are notified the day prior to an event date.

DEP called three events during the summer of 2017, involving 69 unique customer meters. The EM&V analysis found average load reductions of 19.3 MW per event—approximately 300 kW per meter, or approximately 96% of the 20.1 MW figure reported by DEP in its DRA program database (Table 5).[20]

[20] As noted previously, reported impacts are those impacts calculated by DEP using the DRA baseline algorithm. Verified impacts are net values, implicitly assuming an NTG ratio of 1.0. See Section 2 for further discussion.

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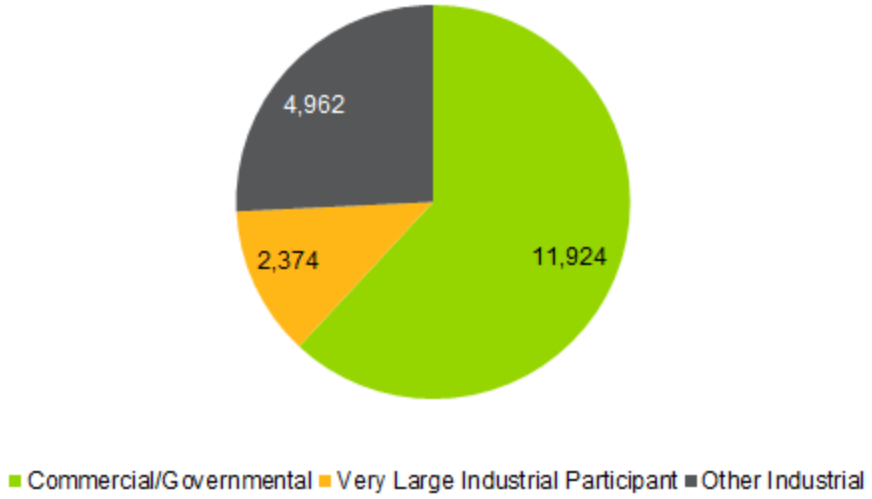
Table 5. Verified Load Reductions and EM&V Verification Rate (By Customer Type)

Load Reduction Category	Event kW			Avg. Total Reduction Over Summer Events
	2017-07-13	2017-07-21	2017-08-18	
Reported (Duke Energy Database)	17,974	20,088	22,262	20,108
Verified				
Com/Gov't	11,857	11,512	12,402	11,924
VLIP	833	3,312	2,977	2,374
Other Ind.	4,302	5,196	5,388	4,962
Verified – Total	**16,992**	**20,020**	**20,767**	**19,260**
Verified Realization Rate (Verified Reductions/Reported Reductions	**95%**	**100%**	**93%**	**96%**

Sources: DEP DRA program database and Navigant analysis

For summer 2017, the EM&V team verified that the 34 commercial/governmental meters realized an average total of 11,924 kW of load reductions, accounting for approximately 62% of the total kW reduction; the 16 industrial meters belonging to the VLIP realized an average total of 2,374 kW of load reductions, which accounts for approximately 12% of the total kW reduction. The balance of load reductions—4,962 kW or 25% of the total—were made up by meters located at industrial sites not belonging to the VLIP. This distribution is shown in Figure 2.

Figure 2. Share of Total Verified kW Reduction: Commercial/Governmental vs. Industrial



Sources: DEP DRA program database and Navigant analysis

The following discussion provides a summary of load impact findings based on a linear-regression baseline method identified by the evaluation team as the most accurate for predicting customers' loads

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(see PY2011 and PY2012 evaluation reports for more detail). The team estimated load reductions for individual participants for each event. Average verified program savings were then calculated as the average across each of the three summer events across all 69 participants' meters.

DEP had reported summer program impacts to be approximately 104% of the aggregate contracted load reductions, or 20.1 MW. The EM&V analysis verified 96% of these reported reductions (or 100% of the contracted reductions). The average contracted, DEP-reported, and verified load curtailment for each participant meter is shown in Table 6.

This table includes a count of the number of events for which each meter contributed non-zero DR impacts. The average contracted, reported, and verified impacts shown in Table 6 are the averages only of events for which the given participant was contracted and in which that participant participated. This means that the sum of the average impacts in this table will not match the average of the total impacts reported in Table 5, which are the average of the total impacts across all participants for each event.

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Table 6. Average Contracted, Reported, and Verified Loads by Meter

Commercial/Governmental					Industrial				
Participant Site	Contracted kW	DEP Reported kW	Verified kW	# Events Participated	Participant Site	Contracted kW	DEP Reported kW	Verified kW	# Events Participated
DRA0001	362	357	359	3	DRA0009	450	462	424	2
DRA0002	383	413	442	2	DRA0010	75	282	217	2
DRA0003	150	243	246	3	DRA0011	75	164	118	2
DRA0004	490	614	632	3	DRA0012	300	475	292	2
DRA0026	209	257	270	3	DRA0013	75	517	368	3
DRA0027	220	277	291	3	DRA0014	75	98	77	3
DRA0028	183	234	241	3	DRA0015	150	257	145	2
DRA0029	900	1181	1571	3	DRA0016	200	188	153	3
DRA0032	200	228	226	3	DRA0017	200	196	148	3
DRA0033	204	253	254	3	DRA0018	180	220	173	3
DRA0036	75	98	85	3	DRA0019	100	107	95	3
DRA0037	203	249	258	3	DRA0020	75	155	149	2
DRA0041	415	429	445	3	DRA0021	200	32	173	3
DRA0042	249	303	315	3	DRA0022	75	74	41	1
DRA0043	240	265	271	3	DRA0023	75	0	52	1
DRA0044	163	197	205	3	DRA0024	300	386	391	2
DRA0045	209	284	285	3	DRA0030	75	104	123	3
DRA0046	207	56	62	1	DRA0031	225	224	225	3
DRA0047	177	146	149	3	DRA0034	920	405	250	3
DRA0048	328	307	318	3	DRA0039	1,050	1328	1270	3
DRA0049	2500	2766	2828	3	DRA0051	135	130	91	3
DRA0054	275	263	281	3	DRA0052	75	57	57	3
DRA0055	275	171	184	3	DRA0059	209	285	260	2
DRA0056	143	89	95	3	DRA0060	413	292	268	3
DRA0057	198	143	146	2	DRA0061	75	44	33	3
DRA0058	500	477	505	3	DRA0065	130	228	232	3
DRA0063	250	92	95	3	DRA0066	200	255	253	3
DRA0064	209	273	276	3	DRA0067	190	288	304	3
DRA0075	258	221	232	3	DRA0068	140	207	218	3
DRA0076	303	298	307	3	DRA0069	150	184	180	3
DRA0077	185	180	179	3	DRA0070	761	993	731	3
DRA0078	500	398	96	1	DRA0071	180	262	202	3
DRA0079	700	125	0	1	DRA0072	125	144	104	3
DRA0080	500	565	224	1	DRA0073	105	132	82	3
					DRA0074	225	302	165	3

Sources: DEP DRA program database and Navigant analysis

Verification rates at the portfolio level are driven by findings for individual meters. Three of the 69 participating meters in 2017[21] account for a little less than one-third of all summer reductions and thus drive overall summer findings. Figure 3 ranks the meters by the amount of verified kW reduction in

[21] The three meters that are driving overall results include two governmental sites and one industrial (manufacturing) site.

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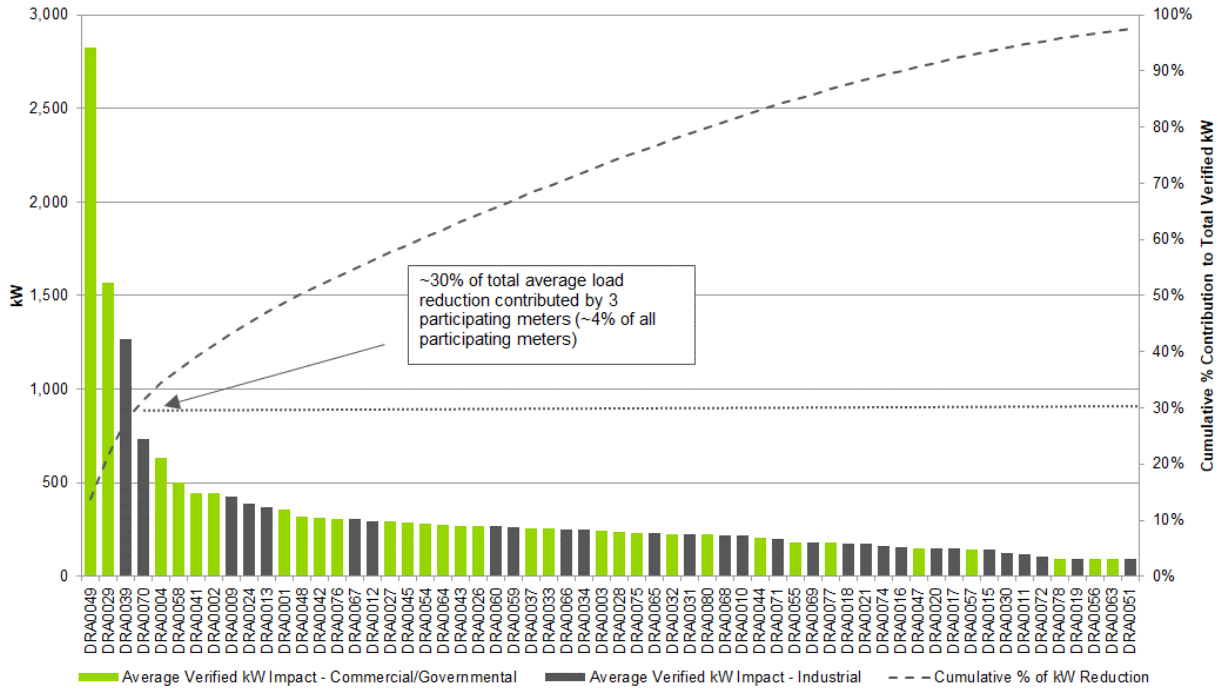
descending order, illustrating the decrease in load reductions between the largest and smallest contributors in the program.

Figure 3. Cumulative Percentage of Total Verified kW Reduction



Sources: DEP DRA program database and Navigant analysis

These results can be re-examined by plotting the reported and verified demand reductions and verified realization rate (average verified kW across three events divided by average reported kW across three events) once they have been sorted by verified realization rate (see Figure 4). In this figure, the black diamonds represent commercial/governmental realization rates, the gray diamonds represent the VLIP's realization rates, and the white diamonds represent the non-VLIP industrial realization rates.

As may be seen in Figure 4, the average verified summer realization rate for all but five of the commercial and governmental meter sites is at or above 90%. In contrast, the average verified summer realization rate of three-quarters of the VLIP meters is below 90%.

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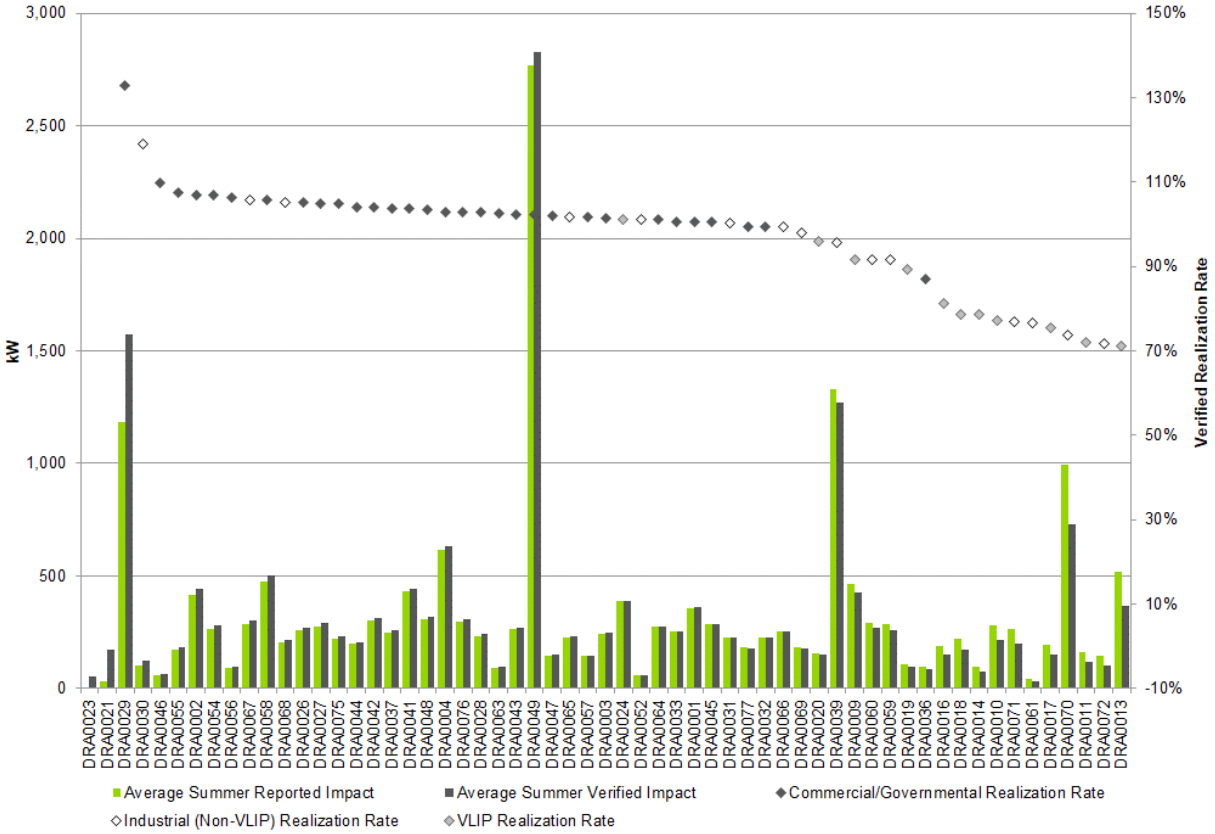
Figure 4. Reported and Verified DR and Verified Realization Rate



Sources: DEP DRA program database and Navigant analysis

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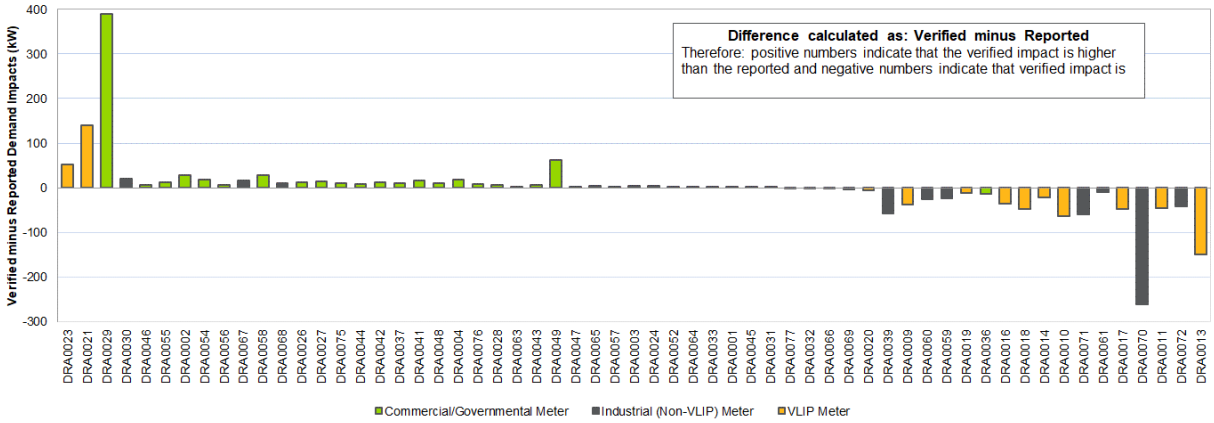
Recall that the verified realization rate is the (regression-estimated) verified impact divided by the (DEP algorithm calculated) reported impact. The regression approach estimates a baseline using average seasonal relationships whereas the DEP approach relies entirely on the three most recent non-excluded qualifying days to calculate a baseline.

To better understand the results implied by the realization rates presented above, it is important to also observe the magnitude of the difference (in kW instead of as a percentage) between the DEP-reported impacts and the verified impacts. For this reason, the evaluation team presents the average difference (across the seasonal events) between the verified summer impact and the reported summer impact for each meter in Figure 5. For example, the evaluation team found that Duke Energy's reported impacts for meter DRA 0029 were nearly 400 kW less than those verified by Navigant, and that the Duke Energy's reported impacts for meter DRA0070 were 250 kW higher than those verified by Navigant. To aid understanding, these have been sorted in this figure by realization rate in the same manner as in Figure 4.

Figure 5. Differences in Impact Estimates: Regression vs. DEP Settlement Method



Sources: DEP DRA program database and Navigant analysis

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4. SUMMARY FORM

Commercial, Industrial, and Governmental Demand Response Automation Program

Completed EMV Fact Sheet

Description of program

DEP's CIG DRA program is a demand response program where customers are incentivized by DEP to curtail their loads during "events" as requested by DEP.

Participants must have the capability to curtail at least 75 kW of load when called upon by DEP. Most events last for 3-6 hours, and participants are guaranteed at least 30 minutes of notice before an event starts, but are often notified the day before.

DEP called three events in 2017. The program included 20 customers, spanning 45 site locations and 69 electric meters.

Evaluation Methods

The evaluation team estimated impacts from the demand response events by replicating DEP's settlement baseline and applying a regression-based approach.

Impact Evaluation Details

- The program achieved a verified average of 19.3 MW per event, which is about 4% less than DEP's reported value of 20.1 MW.
- The average impact per meter was about 300 kW, with impacts as low as about 33 kW and as high as over 2,800 kW for individual meters.
- The evaluation team found the verified impacts to be between 90% and 110% of DEP's reported impacts for the majority of participants.
- The Net to Gross ratio is estimated to be 1.0 for this program. This is because the regression approach accounts for the counterfactual baseline and it is highly unlikely that any participants would curtail their load in the absence of the program during the same time that events are being called by Duke Energy (since only participants are notified of events).

Date:	March 21, 2018
Region:	Duke Energy Progress
Evaluation Period	January 1, 2017 through December 31, 2017
Annual MWh Savings	N/A
Net-to-Gross Ratio	1.0

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5. CONCLUSIONS & RECOMMENDATIONS

This section of the evaluation report presents the evaluation team's principal findings, conclusions, and recommendations.

The key impact evaluation findings are:

- **Verified impacts were slightly less than reported impacts.** The realization rate for the summer DR impacts for PY2017 was 96%, with an average of approximately 19.3 MW of DR contributed by the program.
- **Participation[22] was inconsistent between events.** The average total event impacts for the summer of PY2017 were highest for the second and third events (20.0 and 20.8 MW, respectively), but substantially lower for the first event (17.0 MW).
- **Total program impact increased in PY2017 compared to PY2016, but has yet to recover to PY2015 levels.** The average event impact increased from 17.6 MW in PY2016 to 19.3 MW in PY2017, but is still lower than the 20.1 MW achieved in 2015. DEP staff indicate that changes in US EPA regulations regarding onsite generators are a major contributor to this.

Navigant has one recommendation for the PY2018 evaluation, regarding a possible re-examination of the evaluation approach. In PY2010 and PY2011, Navigant tested a large number of potential baseline estimation techniques and tested these "out-of-sample" to select the approach that was, on average, the most accurate for all participants. Since that time, the group of enrolled participants has changed materially, with some participants leaving the program and others joining. Likewise, there appears to be a trend to shifting away from day-of notification to day-prior notification. This is doubtless very helpful for engaging customer response, but does materially impact the accuracy of the impact estimation: recall that the most accurate approach tested in the previous evaluation cycles was one which made use of a symmetric day-of adjustment, an adjustment that cannot be reasonably applied when notification is day-prior.

Navigant would therefore recommend that DEP consider allowing Navigant, for the PY2018 evaluation, to re-test a large set of potential regression model specifications, as it did in 2010 and 2011..

[22] Event-specific participation refers to enrolled participants delivering more than 0 kW of DR for a given event. An enrolled customer meter has participated in only two of three events if that meter has contributed more than 0 kW on only two of the three events.

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EM&V Report for the Residential New Construction Program

Program Years: 2015 – 2016

Prepared for:

Duke Energy Progress

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DISCLAIMER

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1. EVALUATION SUMMARY

The Duke Energy Progress (DEP) Residential New Construction (RNC) program[1] offers incentives to both single family and multi-family builders involved in new construction projects for the installation of energy efficient equipment or the development of high efficiency homes. The RNC program is designed to encourage energy efficiency during the planning and construction process, when energy efficiency upgrades have lower incremental costs. Participating builders can elect to follow either the whole-house or equipment paths to receive program incentives.

The RNC program allows DEP to be actively engaged in the efficiency considerations of the new construction market within its service territory. DEP closely coordinates with builders to maintain a productive relationship and a pathway for newly constructed homes to exceed the energy efficiency standards set by established building codes.

In 2016, DEP implemented considerable changes to the program design, incentive structure, and implementation contractor for the RNC program. This is the first Evaluation, Measurement, and Verification (EM&V) cycle to assess the program after those changes.

1.1 Evaluation Objectives

DEP selected Navigant to perform EM&V for the RNC program. The primary purpose of the EM&V assessment is to estimate the gross and net annual energy and demand impacts associated with participation for the 2016 Program Year (PY2016). Projects defined as being completed in the PY2016 encompass whole building projects that were submitted to the program between July 1, 2016 and December 31, 2016 and equipment only building projects that were submitted between January 1, 2016 and December 31, 2016.[2] This EM&V effort also includes a process evaluation to assess the program delivery structure, barriers to participation, and strengths or shortcomings of the program.

Navigant performed a comprehensive assessment of the RNC program to accomplish these objectives. The evaluation activities included:

- Interviews with DEP program staff, and ICF implementation staff
- Interviews with participant and nonparticipant builders
- Interviews with Home Energy Rating System (HERS) Raters
- Detailed review and analysis of program tracking data and program materials
- Onsite field verification at 40 program homes
- Calibrated energy simulation modeling based on participant billing data
- Market research

[1] http://www.duke-energyrncinfo.com/

[2] The 2016 program year was defined separately for Whole Building and Equipment Only projects, as the RNC program underwent a transition at the beginning of 2016 that redefined incentives for Whole Building projects, but did not affect the equipment only incentives.

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1.2 Program Level Findings

The evaluation team found DEP's RNC program to be highly effective at reaching the new construction housing market and achieving energy and demand savings that exceed established building codes. The program is well-managed and properly structured to engage with builders and achieve program objectives.

Navigant found that participating builders and HERS Raters generally speak favorably about the RNC program. A small number of builders indicate dissatisfaction directly related to the program redesign, either because they are receiving a smaller incentive than they had in the past, or because of the clarified focus on electric savings which penalizes them for installing gas appliances.[3] That said, the most significant complaint about the RNC program, from both builders and HERS Raters, is that it is only offered in DEP territory. Across the board, builders would like to see the geography of the program offering extended, so that they can use the incentive to encourage greater uptake of energy efficient practices from all the homebuyers they work with.

The evaluation team found that the new program implementation contractor is effectively bringing this program to the market, and adequately tracking participation and program activity. The evaluation team does recommend that DEP and the implementation contractor consider exploring the possibility of using a different software platform to estimate ex ante impacts.

1.2.1 Gross Impact Findings

Navigant found the overall, program-level verified gross energy impacts to be about 6% less than the amount reported in the tracking data from DEP. Verified summer demand impacts were about 2% less than the reported tracking data from DEP, and verified winter demand impacts were about 4% greater than the tracking data. The calculation of gross impact findings is discussed in detail in Section 4 of this report. Table 1 presents the program-level gross savings results.

Table 1. PY2016 Reported & Verified Gross Program-Level Impacts

	PY2016 Energy Savings (MWh)	PY2016 Summer Demand Savings (MW)	PY2016 Winter Demand Savings (MW)
Reported Gross Program Savings (A)	3,743	1.59	1.51
Verified Gross Program Savings (B)	3,503	1.56	1.57
Gross Realization Rate (B/A)	94%	98%	104%

Source: Navigant analysis, totals subject to rounding

[3] The focus of the RNC program was always electric savings, but under the previous program design builders were incentivized for their HERS score through a tiered incentive structure. This incentive structure masked the electric focus and gave builders the impression that the program incentivized all energy efficiency – so the program adjustment was a surprise to some.

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1.2.2 Net Impact Findings

The evaluation team found a net-to-gross (NTG) ratio of 1.051, meaning that the RNC impacts extend beyond the reach of program measures. The NTG analysis is discussed in extensive detail in Section 5 of this report, and the NTG ratio includes adjustments made for free ridership, spillover, and market effects. Table 2 shows program-level net energy and demand impacts.

Table 2. Verified Net Energy and Demand Impacts

	PY 2016 Energy Savings (MWh)	PY 2016 Summer Demand Savings (MW)	PY 2016 Winter Demand Savings (MW)
Verified Gross Program Savings (A)	3,503	1.56	1.57
Net-to-Gross Ratio (B)	1.051	1.051	1.051
Verified Net Program Savings (AxB)	3,681	1.64	1.65

Source: Navigant analysis, totals subject to rounding

1.3 Evaluation Parameters and Sample Period

To accomplish the evaluation objectives, Navigant completed an engineering review, calibrated building energy modeling, and field verification to assess installed quantities and characteristics. The whole house calibrated modeling process served as the basis for the gross savings calculations for all measures. This modeling process achieved a relative precision of 5.6% at a 90% confidence level, as illustrated in Table 3.

Table 3: Whole House Simulation Model Sample Statistics

Strata	2016 Strata Population Size (N)	Average Savings (kWh)	Coefficient of Variation	Single Family Electric Sample Size (N)	Relative Precision (90% CI)
2016 HERO + HERS Homes	1,049	2,891*	0.7	427	5.6%

** Average savings includes gas-heated homes*
Source: Navigant analysis

The RNC program underwent a significant program redesign at the beginning of 2016, therefore most efforts focused on activities completed during 2016. For the impact evaluation, PY2016 is defined as whole building projects that were submitted to the program between July 1, 2016 and December 31, 2016 and equipment only building projects that were submitted between January 1, 2016 and December 31, 2016. The process evaluation included participants from both the 2015 and 2016 program years, but preference was given to program participants who had participated in the RNC program since the redesign. Table 4 displays the start and end dates of Navigant's sample period for evaluation activities.

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Table 4. Sample Period Dates

Activity	Evaluation Period Start Date	Evaluation Period End Date
Program staff and implementer interviews	Throughout	
Participant builder interviews	May 29, 2017	July 7, 2017
Nonparticipant builder interviews	July 10, 2017	August 11, 2017
HERS Rater interviews	July 10, 2017	August 17, 2017
Field verification of equipment-only measures	June 1, 2017	July 28, 2017

Source: Summary of Navigant analysis

1.4 Evaluation Recommendations

Navigant developed a series of recommendations during the EM&V effort. These recommendations are intended to assist Duke Energy with enhancing the program delivery, customer experience, support future EM&V activities, and possibly increase program impacts. Further explanation for each recommendation can be found later in this report.

- Navigant recommends that Duke Energy adopt the per-unit energy and demand impacts for the deemed measures (equipment only and HERO) from this evaluation and use them going forward.
- Duke Energy should consider increasing the deemed measure life for HVAC equipment from 15 years to 18 years.
- Navigant recommends Duke Energy adjust the User Defined Reference Home (UDRH) heating system thermostat setpoint to 70°F.
- Duke Energy should consider expanding the RNC program offering to territories beyond the DEP territory.
- Navigant recommends that Duke Energy consider whether software modeling platforms other than REM/Rate could be used to confirm program requirements.
- Duke Energy should consider whether there is an opportunity to partner with a gas utility to provide value to gas savings, or consider program education around the goal of the program being electric savings.

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2. PROGRAM DESCRIPTION

The DEP RNC program offers incentives to both single family and multi-family builders for the installation of energy efficient equipment in new construction projects or the construction of high efficiency homes.

2.1 Design

The RNC program is designed to encourage energy efficiency during the planning and construction process, when energy efficiency upgrades have lower incremental costs. Participating builders can elect to follow either the whole-house or equipment paths to receive program incentives. The RNC program incentives were redesigned at the end of the PY2015 program year. The incentives presented below reflect the current program incentives, those that have been applied starting in PY2016.

2.1.1 Whole-House Incentives

Participating builders can receive up to $9,000 per dwelling unit (classified by Premise number) for building more efficiently, or above energy code specifications. Projects receive a minimum incentive of $750 for meeting the requirements of the 2012 North Carolina Energy Conservation Code's High Efficiency Residential Option (HERO) or the equivalent in South Carolina. If building project teams elect to exceed the efficiency requirements of the HERO code, project specific incentives are calculated per kWh saved as estimated through Home Energy Rating System (HERS) modeling as illustrated in Table 5.

Table 5. Whole House Measures and Eligibility Requirements

	Whole-House Eligibility Requirement	Incentive
HERO	Meet 2012 NCECC HERO standards.[4]	$750
HERO plus HERS Score	Meet HERO standards and submit confirmed annual kWh savings from the Energy Summary Report.	$0.90/kWh

Source: Duke Energy Progress, Residential New Construction Program Materials

In addition to the whole-house incentives outlined in Table 5, the whole-house incentive program offers the following benefits:

1. An optional three-year Heating and Cooling Energy Usage Limited Guarantee that participating builders can offer to home buyers.
2. Onsite subcontractor training.
3. Marketing support, including advertising and promotional campaigns, signage, and collateral.

2.1.2 Equipment Incentives

Participating builders that choose the equipment upgrade path can receive up to $725 for installing high-efficiency HVAC equipment, as described in Table 6.

.

[4] Homes must be a minimum of 699 heated square feet when meeting HERO standard but not submitting a HERS score.

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Table 6. Equipment Measures and Eligibility Requirements

	Equipment Incentive Description	Incentive
Tier 1	AC or heat pump with SEER (Seasonal Energy Efficiency Ratio) of 14 or greater but less than 15. The HVAC system must meet the Quality Installation Standard of 90%. High Efficiency Heat Pumps: The unit(s) shall be a minimum SEER of 14 with ECM. High Efficiency Central AC: The unit(s) shall be a minimum SEER of 14 with ECM.	$250
Tier 2	AC or heat pump with SEER of 15 or greater.	$300
	Quality Installation Standard (Option for Tier 2).	$75
HPWH Installation	ENERGY STAR qualified HPWH(s) with minimum Energy Factor of 2.0.	$350/unit

Source: Duke Energy Progress, Residential New Construction Program Materials

2.2 Implementation

The RNC program is currently implemented by ICF International. Prior to 2016, the RNC program was implemented by MASCO. DEP provides ICF with goals and directions for the program and collaborates around how those goals will be met. ICF manages all day-to-day interactions with builders and HERS Raters including, assisting builders and raters with administrative and technical issues, i.e. modeling issues; providing information about projects that are in the incentive process; and QC's raters' work in the field to ensure program compliance.

Recruiting new builders into the RNC program is primarily the responsibility of the ICF team, but this is done in close collaboration with the DEP RNC program team. The process of recruiting a new builder usually starts with an in-person meeting to walk them through the details of the program. ICF then reviews a full set of plans for a builder's typical home and shows them the adjustments that would be needed to get to program standards, and what they would be able to achieve in terms of rebates.

Once a builder has been recruited to participate in the RNC program, most of the work to ensure compliance with program requirements results from the work between the builder and HERS Rater. The HERS Rater completes the HERS score for each individual home and submits through the program for the builder to receive the incentive. For equipment or HERO only whole-house projects, the builder may manage the submittal process themselves. ICF completes in-field QA/QC throughout the building process to ensure that quality standards are met and to educate builders in the field. QA/QC findings are provided back to builders to support this education process.

RNC program rebates are processed twice per month. ICF pulls final documentation for projects that have final, confirmed REM/Rate files including blower door testing and sends invoices to DEP. Tracking data supporting all completed projects is provided to DEP and subsequently to Navigant for EM&V.

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3. KEY RESEARCH OBJECTIVES

The key research objectives of the RNC evaluation included conducting impact, process, and NTG research. The primary purpose of the EM&V assessment was to estimate the gross and net annual energy and demand impacts associated with participation for the 2016 Program Year. Projects defined as being completed in the 2016 Program Year encompass whole building projects that were submitted to the program between July 1, 2016 and December 31, 2016 and equipment only building projects that were submitted between January 1, 2016 and December 31, 2016.[5]

The detailed key research objectives included the following:

- Calculate verified net and gross energy and demand savings for all incentives offered after the 2016 incentive redesign (i.e. after July 1, 2016) and explain any differences between the verified kWh and kW savings and the reported values.
- Quantify RNC program attributable net savings through interviews with participant builders, nonparticipant builders, and HERS Raters, with consideration of the market effects quantification completed for the PY2013-14 evaluation.
- Evaluate the strengths and weaknesses of current program processes, including any barriers that might prevent participation.
- Review closeout of previous program design and transition to new program design.
- Provide updated deemed savings estimates by measure.
- Recommend improvements to program rules and processes that support greater savings, enhanced cost-effectiveness, and improved customer satisfaction.

[5] The 2016 program year was defined separately for Whole Building and Equipment Only projects, as the RNC program underwent a transition at the beginning of 2016 that redefined incentives for Whole Building projects.

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4. IMPACT EVALUATION

Navigant estimates program-level gross realization rates of 94%, 98%, and 104% for energy, summer peak demand, and winter peak demand, respectively. These results are presented in Table 7. The differences between reported and verified impacts are largely a result of energy simulation model calibration. Unlike the REM/Rate models used to calculate reported savings, the BEopt models used by the evaluation team for savings verification were calibrated to ensure that resulting energy consumption matches actual participant billing data.[6] More details are provided throughout this report.

Table 7. PY 2016 Reported & Verified Program-Level Impacts

	PY 2016 Energy Savings (MWh)	PY 2016 Summer Demand Savings (MW)	PY 2016 Winter Demand Savings (MW)
Reported Gross Program Savings (A)	3,743	1.59	1.51
Verified Gross Program Savings (B)	3,503	1.56	1.57
Gross Realization Rate (B/A)	94%	98%	104%

Source: Navigant analysis, totals subject to rounding

4.1 Summary of Reported Program Savings

Table 8 outlines the reported measure level savings for each of the RNC program measures. As indicated, the HERO and equipment only measures rely on deemed savings estimates, while the HERO+HERS measure is a custom measure, where energy savings are derived from the HERS building model report and a savings factor is applied to determine summer and winter demand savings.

Table 8. Summary of 2016 Reported Savings, by Measure

Measure Category	Measure	Reported Energy Savings (kWh)	Reported Summer Demand Savings (kW)	Reported Winter Demand Savings (kW)
Whole House	HERO	1,195	0.48	0.64
	HERO + HERS	Varies	0.000435423 per kWh	0.00038392 per kWh
Equipment Only	Heat Pump (SEER ≥ 15)	510	0.17	0.23
	Central AC (SEER ≥ 15)	293	0.429	0.0
	Heat Pump Water Heater (EF ≥ 2.0)	2,164	0.29	0.43

[6] BEopt is an advanced energy simulation modeling software package developed by the National Renewable Energy Laboratory. https://beopt.nrel.gov/

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Quality Install Standard	379	0.12	0.09

Source: RNC program staff

The 2016 program year was somewhat unique for the RNC program as program changes affecting the whole house measures went into effect partway through the year. As the purpose of this evaluation was to determine the impact and effectiveness of the program after the change, it was important to only review those projects that were completed under the new incentive system. Therefore, the evaluation captured only those projects that had been submitted to the program after July 1, 2016. Equipment measures were included starting on January 1, 2016, as there were no changes to the equipment-only measures. The total number of measures and associated savings evaluated through the 2016 RNC program evaluation are presented in Table 9.[7]

Table 9. Summary of 2016 Reported RNC Program Savings

Measure	Number of Projects	Reported Energy Savings (kWh)	Reported Summer Demand Savings (kW)	Reported Winter Demand Savings (kW)	Rebate Amount
Whole House	**1,358**	**3,402,834**	**1,469**	**1,363**	**$2,949,078**
HERO	309	369,255	148	198	$231,750
HERO+HERS	1,049	3,033,579	1,321	1,165	$2,717,328
Equipment Only	**681**	**339,715**	**125**	**149**	**$207,900**
Heat Pump (SEER ≥ 15)	646	329,460	110	149	$196,800
Central AC (SEER ≥ 15)	35	10,255	15	0	$11,100
TOTAL	**2,039**	**3,742,549**	**1,594**	**1,512**	**$3,156,978**

Source: Navigant analysis of 2016 RNC tracking data

4.2 Impact Evaluation Methodology

This section presents the impact evaluation methodology for the RNC Program. DEP's program tracking database provided savings values for energy and peak demand (reported gross savings) based on program participation data and deemed or calculated savings estimates for each measure. The evaluation team verified the accuracy of the reported savings values for each measure category through deemed savings review, onsite field verification, and calibrated energy simulation modeling.

[7] The program tracking data indicated that there was zero participation for the heat pump water heater and quality installation measures during the period covered by this evaluation.

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4.2.1 Deemed Savings Review

The evaluation team performed a detailed, engineering review of the deemed savings assumptions and algorithms for the prescriptive equipment measures offered through the RNC program. The program offers prescriptive incentives for heat pump water heaters (HPWHs), high-efficiency air source heat pumps (ASHPs) and high-efficiency central air conditioners (CACs), and quality installation. The incentives for ASHPs and CACs are further segmented into two incentive tiers based on SEER value. Table 10 presents the deemed savings values reviewed for this evaluation.

Table 10: Deemed Savings Review

Measure	Unit Basis for Tracking	Source	Annual Gross Energy Savings (kWh)	Summer Coincident Demand Impacts (kW)	Winter Coincident Demand Impacts (kW)
HERO[8]	Per home	2013 & 2014 EM&V Report for RNC program, by Navigant	1,195	0.48	0.64
Heat Pump (SEER $\geq$ 15)	Per home	HEIP Program Savings: high efficiency HVAC with ECM	510	0.17	0.23
Central AC (SEER $\geq$ 15)	Per home	HEIP Program Savings: high efficiency HVAC with ECM	293	0.43	0.00
Quality Installation	Per home	HEIP Program Savings	379	0.12	0.09
Heat Pump Water Heater (EF $\geq$ 2.0)	Per home	2013 & 2014 EM&V Report for RNC program, by Navigant	2,164	0.29	0.43

Source: Navigant review of RNC program data

For the equipment only portion of the program, the evaluation team's review was focused on the ASHP and CAC measures. The reported savings for the HERO and heat pump water heater measures referenced values from the most recent RNC evaluation completed by Navigant. Furthermore, the program tracking data showed zero participation for heat pump water heaters and the quality installation measure during the period covered by this evaluation so the evaluation team did not make any adjustments to deemed savings for these measures.

The reported savings for the 2016 ASHP and CAC measures reference values from the Home Energy Improvement Program (HEIP), which offers rebates for energy efficiency measures in existing homes.

[8] HERO references the High Efficiency Residential Option, which is a voluntary, stretch code detailed in Appendix 4 of the 2012 North Carolina Energy Conservation Code. The HERO code was launched on January 1, 2012 and is comprised of measures that achieve 15-20 percent greater energy savings than minimum state code requirements.

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The evaluation team reviewed the HEIP savings assumptions[9] for the DEP territory to better through understand the underlying references for the RNC Equipment claimed savings. No *ex ante* calculations were available for review, as the HEIP savings were developed using an energy model and only outputs were referenced in the provided workbook.

The program also uses a deemed savings value for the HERO homes. This value (1,195 kWh) was developed using calibrated simulation modeling through the most recent RNC evaluation (PY2013-14). The evaluation team confirmed that the 2016 reported HERO savings referenced the correct values from the 2013 & 2014 EM&V Report. The evaluation team also verified the deemed savings values in 2016 using calibrated simulation modeling as described in Section 4.2.3.

4.2.2 Onsite Field Verification

Navigant conducted 40 site visits to verify the installation of prescriptive HVAC measures reported in the measure tracking database. The field-work sample was stratified by builder volume, focusing on the top five, who represented 90% of prescriptive HVAC measure participation. Navigant compared the results of the field data collection activity with the reported installations to check for both quantitative and qualitative differences.

4.2.3 Energy Model Development and Calibration

Reported participant savings were calculated for each HERO+HERS project using REM/Rate modeling software. The baseline home characteristics were defined by prescriptive code specifications in the 2012 North Carolina Energy Conservation Code. Similar to the EM&V methodology used for the 2013-2014 RNC program evaluation, the evaluation team used calibrated simulation modeling to assess the degree to which un-calibrated REM/Rate models for program homes accurately reflect actual participant consumption and weather patterns. This model calibration process was only used to development of a realization rate for electric heated homes. The development of a realization rate for gas homes, for which only partial consumption data was available, is discussed in the next section.

For electric homes, the evaluation team used BEopt hourly building simulation software for calibrated simulation: modelling a sample of electric program participant homes based on average home specifications extracted from the REM/Rate files used for program verification. DEP provided Navigant with monthly electricity consumption data for PY2016 program participants. Model results were weather-normalized using 2016 historical weather data. The baseline home was modeled in BEopt using the same prescriptive code specifications used in the reported savings models.

The verified gross energy and demand savings were calculated as the difference between the program baseline and simulation results. Peak demand savings were extracted directly from the BEopt hourly simulation results during DEP's peak period.[10] Appendix A provides more detail about the model development and calibration process.

[9] The HEIP savings assumptions were used for Navigant's PY2013 EM&V report for the HEIP Program. See *2013 EM&V Report for the Home Energy Improvement Program, Prepared for Duke Energy Progress, July 6, 2015.*

[10] The winter peak period was defined as weekdays during the month of January for the hour ending 8. The summer peak period was defined as weekdays during the month of July for the hour ending 17.

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4.2.4 Calculating Realization Rates

Realization rates are calculated as the ratio of verified savings to reported savings. For whole house measures, the realization rate calculated for the sample of single family electric homes was applied to the remainder of electrically heated projects when calculating a program-level realization rate. While conducting further analysis around the discrepancy between reported and verified savings, the evaluation team compared the estimated annual consumption from REM/Rate models to the actual annual consumption from the participant billing data, for the sample of electrically heated homes. This analysis found that the REM/Rate files over-estimated total annual consumption by 15%. Since the BEopt models were calibrated to this same billing data, the REM/Rate models overestimate the BEopt models by that same 15% when the BEopt models were run with actual weather data from the same period as the billing data. However, when the BEopt models were run using TMY weather data, the results were very similar, suggesting that the actual weather conditions for the sampled period were not all that different from average weather conditions.

The evaluation team repeated this comparison of REM/Rate estimates and billing data for the gas-heated homes. In this case, the REM/Rate models were found to underestimate electric consumption by 5% compared to billing data (effectively a 105% realization rate). Rather than applying the realization rate from electrically-heated homes to the gas-heated homes to develop the program-level realization rate, the evaluation team applied the 105% realization rate found from this analysis to the gas homes in the population. This approach is justified because the difference between the REM/Rate estimates and the billing data for electrically-heated homes is approximately equal to the difference between the REM/Rate estimates and the BEOpt estimates for electrically-heated homes. It is reasonable to assume that the same is true for gas-heated homes.

4.3 Impact Evaluation Findings

This section presents the verified gross savings results for the RNC program, including data collected during field verification and developed through energy model calibration.

4.3.1 Whole House Measures

Table 11 shows the results of the modeling procedures discussed in Section 4.1, which were used to develop the verified gross energy savings for each whole house measure. Unit realization rates were calculated from the modeling results for an average single family home with electric heat representing each whole house measure. The resulting realization rates were then applied to all the electric-heated homes. A realization rate for gas heated homes was developed through a comparison of the REM/Rate model estimates and the billing data, as described in Section 4.2.4. The gas-home realization rate was applied to all gas-heated homes and the resulting saving were rolled-up to a program level total. This process resulted in a 137% realization rate for the HERO measure, an 94% realization rate for the HERO+HERS measure, and an 95% realization rate for the whole home measures in total.

Table 11: Whole House Measure Gross Energy Savings and Realization Rates

Incentive Level	Count	Unit Energy Savings		Program Total Energy Savings		
		Reported (kWh)	Verified (kWh)	Reported (MWh)	Verified (MWh)	RR%
HERO	309	1,195	1,639	369	507	137%

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HERO + HERS	1,049	2,891	2,707	3,034	2,730	94%
Whole Home Total	**1,358**	**-**	**-**	**3,403**	**3,237**	**95%**

Source: Navigant analysis, totals subject to rounding

Table 12 shows the whole house model results for summer peak demand savings. Navigant's evaluation found an overall realization rate of 88% for whole house summer demand savings.

Table 12: Whole House Measure Gross Summer Demand Savings and Realization Rates

Incentive Level	Count	Unit Summer Demand Savings		Program Total Summer Demand Savings		
		Reported (kW)	Verified (kW)	Reported (MW)	Verified (MW)	RR%
HERO	309	0.48	0.98	0.15	0.30	203%
HERO + HERS	1,049	1.26	1.05	1.32	1.00	83%
Whole Home Total	**1,358**	**-**	**-**	**1.47**	**1.30**	**88%**

Source: Navigant analysis, totals subject to rounding

Table 13 shows the whole house model results for winter peak demand savings. Navigant's evaluation found an overall realization rate of 103% for whole house winter demand savings.

Table 13: Whole House Measure Gross Winter Demand Savings and Realization Rates

Incentive Level	Count	Unit Winter Demand Savings		Program Total Winter Demand Savings		
		Reported (kW)	Verified (kW)	Reported (MW)	Verified (MW)	RR%
HERO	309	0.64	0.97	0.20	0.30	151%
HERO + HERS	1,049	1.11	1.10	1.16	1.11	99%
Whole Home Total	**1,358**	-	-	**1.36**	**1.41**	**103%**

Source: Navigant analysis, totals subject to rounding

The difference between the reported and verified savings is attributed primarily to the difference between calibrated and uncalibrated simulation models for the HERO+HERS measure. The REM/Rate models used for reported savings cannot be calibrated to actual billing consumption and weather data, due to limitations of the REM/Rate software. However, the BEopt models used for savings verification were calibrated to ensure that resulting energy consumption matches billing data to within five percent. To illustrate this effect, the evaluation team compared the annual energy consumption estimates from PY2016 REM/Rate project files to the actual billing consumption for a sample of 250 projects. This analysis found that on average REM/Rate models overestimated annual energy consumption by 16 percent, compared to actual billing records.

Navigant also conducted a review of other evaluation studies that compared REM/Rate results to other modeling software. Appendix B presents a summary of the findings from each study. Nearly all studies found discrepancies between REM/Rate and other models. More than half of these studies attributed

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those discrepancies to REM/Rate's overestimation of energy consumption (especially heating consumption).

This evaluation found higher realization rates for HERO homes. Both the reported and verified savings estimates were calculated using the same calibrated simulation methodology. However, the program home and baseline home characteristics were updated since the previous evaluation, based on market forces and program design changes. The result was an increase in average energy savings for PY 2016 homes.

4.3.2 Prescriptive Equipment Measures

Navigant conducted an onsite field verification of prescriptive HVAC measures reported in the measure tracking database for PY2016. Navigant completed 40 site visits and found an installation rate of 100%, as shown in Table 14. The field-work sample was stratified by the top five program builders, who represented 90% of prescriptive HVAC measure participation. Differences between the sample target and actual completed site visits are due to scheduling issues.

Table 14: Onsite Sample Targets

Builder	Projects	Sample Target	Completed Site Visits	Verified Installation Rate
1	221	11	13	100%
2	110	8	8	100%
3	109	8	8	100%
4	71	6	11	100%
5	64	6	0	N/A
Total	**575**	**39**	**40**	**100%**

Source: Navigant analysis

Verified gross energy savings, summer demand savings, and winter demand savings for the prescriptive equipment measures are presented in Table 15,
Table **16**, and Table 17, respectively. These results were developed following the modeling procedures discussed in Section 4.2.3. The evaluation team modified the calibrated simulation models developed for the Whole House measures to match the specifications for equipment measures. In other words, the prescriptive heat pump and air conditioner were modeled with a 15 SEER unit in BEopt, per program specifications. A baseline model was then created with a 14 SEER unit and savings were calculated as the difference in consumption between the two models. Unit-level realization rates were calculated from the modeling results. These values were then applied to the 2016 program total reported energy savings to calculate the total verified savings. This resulted in an overall prescriptive measure gross energy savings realization rate of 78%, 205% for summer demand, and 108% for winter demand savings.

Table 15: Prescriptive Measure Gross Energy Savings and Realization Rates

Incentive Level	Count	Unit Energy Savings		Program Total Energy Savings		
		Reported (kWh)	Verified (kWh)	Reported (MWh)	Verified (MWh)	RR%

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Heat Pump (SEER 15)	646	510	401	329	259	79%
Central AC (SEER 15)	35	293	207	10	7	71%
Prescriptive Total	681	-	-	**340**	**267**	**78%**

Source: Navigant analysis, totals subject to rounding

Table 16: Prescriptive Measure Gross Summer Demand Savings and Realization Rates

Incentive Level	Count	Unit Summer Demand Savings		Program Total Summer Demand Savings		
		Reported (kW)	Verified (kW)	Reported (MW)	Verified (MW)	RR%
Heat Pump (SEER 15)	646	0.17	0.38	0.11	0.25	226%
Central AC (SEER 15)	35	0.43	0.24	0.02	0.01	57%
Prescriptive Total	681	**-**	**-**	**0.13**	**0.26**	**205%**

Source: Navigant analysis, totals subject to rounding

Table 17: Prescriptive Measure Gross Winter Demand Savings and Realization Rates

Incentive Level	Count	Unit Winter Demand Savings		Program Total Winter Demand Savings		
		Ex-Ante (kW)	Ex-Post (kW)	Ex-Ante (MW)	Ex-Post (MW)	RR%
Heat Pump (SEER 15)	646	0.23	0.25	0.15	0.16	108%
Central AC (SEER 15)	35	0.00	0.00	-	-	-
Prescriptive Total	681	-	-	**0.15**	**0.16**	**108%**

Source: Navigant analysis, totals subject to rounding

4.3.3 Summary of Impact Evaluation Findings

Figure 1 through Figure 3 show the total gross RNC program energy and demand savings, for both the whole house and prescriptive measures. The program's total verified gross energy savings for PY2016 were 3,503 MWh, summer peak demand savings were 1.56 MW and winter peak demand savings were 1.57 MW.

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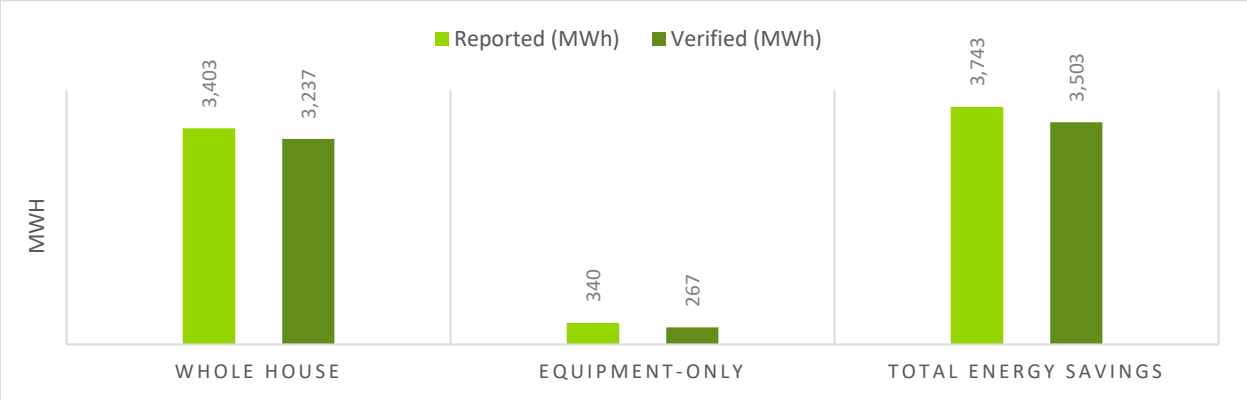
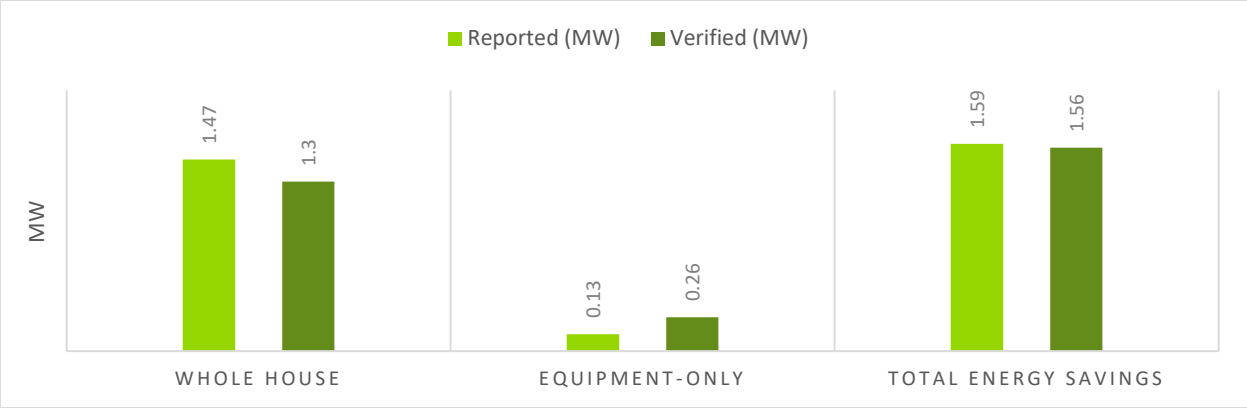
Figure 1. Reported & Verified Gross Energy Savings



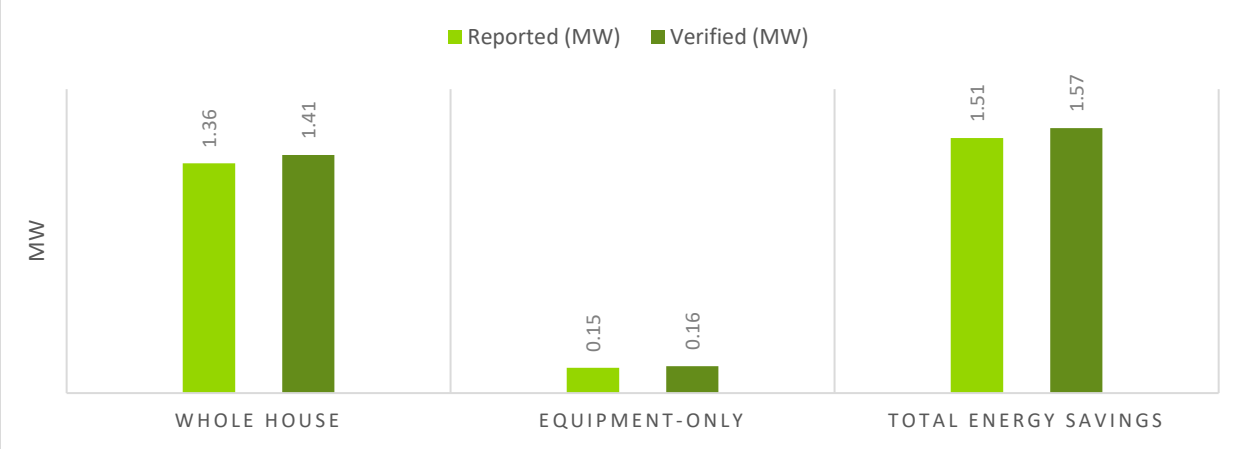
Source: Navigant Analysis

Figure 2. Reported & Verified Summer Demand Savings



Source: Navigant Analysis

Figure 3. Reported & Verified Winter Demand Savings



Source: Navigant Analysis

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5. NET-TO-GROSS ANALYSIS

Navigant conducted a NTG analysis to estimate the share of program savings that can be attributed to participation in or influence from the program. Table 18 shows the results of Navigant's NTG analysis.

Table 18. Summary of NTG Findings

NTG Category	Ratio
Estimated Free Ridership Ratio	0.054
Estimated Spillover Ratio	0.000
Estimated Market Effects Ratio	0.105
Estimated NTG Ratio	1.051

Source: Navigant analysis

5.1 Net-to-Gross Methodology

As indicated in the evaluation plan, the goal of the NTG work was to quantify free ridership, spillover, market effects for the RNC program. Together these three inputs would result in an updated NTG ratio for the program. Navigant used a survey-based, self-report method to estimate free ridership and spillover for this evaluation. A self-report approach is outlined in the Uniform Methods Protocol,[11] and Navigant has previously used this method to estimate a NTG ratio for several other Duke Energy programs. Navigant engaged with HERS Raters, participant builders, and nonparticipant builders for the NTG surveys. Specific involvement of each of these market actor groups is identified in the following specific methodology sections. To estimate market effects for the RNC program, Navigant updated the evaluation methodology developed through the PY2013-2014 evaluation. The previous methodology was developed using a Delphi Panel, which is outlined in the Uniform Methods Protocol as a standard method for determining market effects.[12]

The outcome of the net savings assessment for the RNC program were defined by Equations 1-3, all referenced from the Uniform Methods Protocol.[13]

Equation 1. Net Savings Including Free Ridership, Spillover, and Market Effects

Net Savings = Gross Savings - FR + SO + ME (not already captured by SO)

Where: Net Savings includes free ridership, spillover, and market effects savings
FR = free ridership savings
SO = spillover savings
ME = market effects savings not already captured by SO

[11] National Renewable Energy Laboratory, *Chapter 23: Estimating Net Savings: Common Practices*, 2014. https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

[12] Ibid.

[13] Ibid.

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Equation 2. Net-to-Gross Ratio

NTG Ratio = 1 - FR ratio + SO ratio + ME ratio

Where: NTG Ratio = Net-to-Gross ratio
The denominator in each ratio is the gross savings

Equation 3. Net Savings Calculation Using the Net-to-Gross Ratio

Net Savings = NTG Ratio x Gross Savings

The determination of net savings for new construction programs is often difficult due to the complexity and subjectivity in quantifying and attributing changes in baseline practices. It can be difficult to identify why a program participating builder made the choice to build an energy efficient home and what they would have done in the absence of the program influence. To add to the complexity of this evaluation, the evaluation team determined two program participant subsets: custom and production builders. Whether builders were self-defined as custom or production was a significant predictor of how builders would answer questions around program attribution. As a result, the evaluation team developed net savings estimates separately for the two groups before rolling the results up to a program level finding.

To ground this conversation, custom and production builders must be clearly defined. For this evaluation, a custom home was defined as a home built from a unique set of plans – these are most often developed with an architect, but in some cases may be developed as part of a design/build process. Conversely, a production home was defined as a home where the plan comes from a library, in some cases these are semi-custom in that the homeowner specifies equipment and portions of the plan, but even if the home is semi-custom the home is still considered to be built by production methods if the plan comes from a library.

Table 19 summarizes the results from the program participating builder interviews as they relate to understanding the RNC program's effects on these builders. It is important to note that none of the three questions outlined within this table were asked directly, instead these responses represent a composite of responses from multiple open-ended questions. Using multiple questions to compile a result was seen by the evaluation team as more accurate, because it limited the ability for a builder to say that they absolutely build energy efficient homes and would have done so without the RNC program, which always brings up questions in terms of the legitimacy of the self-reported answers. In some cases, the builder's statement clearly placed them in one category, and is identified by an "X". However, in other cases, the placement in a specific category is inferred by the builder's responses, and is identified by an "/."

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Table 19. Program Participating Builder Interview Summary

			Would have built energy efficient homes without the RNC program		*Would have followed other green building program without the RNC program*		*Standard building practices have been affected by program participation*		
Builder	*Custom*	*Production*	*Yes*	*No*	*Yes*	*No*	*Definitely*	*Some*	*No*
1	-	100%		X		X	X		
2	-	100%		X		X	X		
3	-	100%	/		/			/	
4	-	100%		/	/			X	
5	-	100%		X	/		X		
6	5%	95%		X	/		X		
7	5%	95%	X		X			/	
8	20%	80%		X		X	X		
9	50%	50%		X		X	X		
10	50%	50%	X		X			/	
11	60%	40%	X		X			X	
12	70%	30%	X		X			/	
13	75%	25%	X			X		/	
14	75%	25%	X		/			X	
15	90%	10%	X		X				X
16	100%	-	/			X		X	
17	100%	-	X		/			X	
18	100%	-	X		X			/	

KEY: **X = Clear Response**
/ = Inferred Response

Source: Navigant analysis

Table 19 indicates a clear difference in baseline and energy efficient practices as well as RNC program influence for custom and production builders. Builders that define more than half of their building as production[14] would not have built energy efficient homes without the influence of the RNC program, and their standard building practices have significantly changed because of their program participation. The evaluation team also heard from these production builders that their decision to build efficient homes was a financial one. They didn't necessarily use energy efficiency as a selling point or a differentiator, but they were willing to make the changes because they could produce a better house by leveraging the program incentive.

Because of the vast differences in the participant motivations around program participation and the resulting program effects on building practices, the evaluation team determined that it was appropriate to consider RNC program net savings separately for production and custom builders.

[14] For simplification, production builders will be defined as those builders who define more than half of their building as production and custom builders will be defined as those who define more than half of their building as custom.

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In contrast to the production builders, most of the custom builders indicated that they would leverage other energy efficiency programs like ENERGY STAR to build energy efficient homes in absence of the RNC program. These custom builders indicated that they had made changes to their building practices because of their participation in the RNC program, like a greater focus on air sealing or the inclusion of a heat pump water heater, but they were in most cases already building above-code buildings. This finding was echoed by the HERS Raters who work with these builders. Custom builders use energy efficient practices as a differentiator in the marketplace; the incentive is nice, but they would continue to build energy efficient homes because the financials penciled out before the RNC incentive.

Because of the vast differences in the participant motivations around program participation and the resulting program effects on building practices, the evaluation team determined that it was appropriate to consider RNC program net savings separately for production and custom builders, which will be seen in the specific methodologies used to calculate free ridership and spillover. The separate results are combined to a full program result using a weighted average that relies on the proportion of production and custom homes within the RNC program for the 2016 Program Year.

5.1.1 Free Ridership

Free ridership is a measure of "program savings attributable to free riders (program participants who would have implemented a program measure or practice in the absence of the program)."[15] Free riders can be further segmented into total free riders, partial free riders, and deferred free riders. An example of an RNC program free rider is a participant who would have built to another above-code standard, such as ENERGY STAR, even if DEP did not offer a program incentive.

The evaluation team used inputs from the builder and HERS Rater interviews to calculate free ridership for the RNC program. Additionally, because the differences identified between custom and production builders were expected to significantly impact the calculation of RNC program free ridership, the evaluation team considered free ridership separately across within these two program actor groups. The results for each group were combined through a weighted average accounting for the percent of homes completed in the 2016 RNC program that could be defined as production and custom, as illustrated in Equation 4. The free ridership results for the RNC program, as calculated using the methodology described in this section, are presented in Section 5.2.1.

Equation 4. RNC Program Free Ridership

Total FR = (Custom FR x 2016 % Custom Homes) + (Production FR x 2016 % Production Homes)

Where: Custom FR = Percent of custom homes meeting RNC requirements without intervention
Production FR = Percent of production homes meeting RNC requirements without intervention
2016 % Custom Homes = Percent of 2016 RNC homes built using custom practices
2016 % Production Homes = Percent of 2016 RNC homes built using production practices

[15] National Renewable Energy Laboratory, *Chapter 23: Estimating Net Savings: Common Practices*, 2014. https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

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5.1.1.1 Calculation of Custom and Production Free Ridership

The evaluation team used results from the HERS Rater interviews to understand the percent free ridership for the custom and production builder categories.[16] The evaluation team asked HERS Raters to quantify the percentage of home plans that would achieve program-qualifying levels of efficiency upon initial review (i.e. before intervention by the rater). A senior member of the evaluation team teased out the answers to this question, to identify differences for custom and production builders and whether the builder would be able to achieve the proposed level of efficiency.

The HERS Rater answers to the question of what percent of homes would meet program qualifying levels without intervention, were rolled up using a weighted average based on the number of homes each HERS Rater reviewed in 2016. Therefore, answers from HERS Raters who reviewed hundreds of homes will carry more value than those from HERS Raters who only reviewed a few homes, which should result in a more accurate result for the RNC program. This exercise resulted in a separate free ridership ratio for custom and production builders, as illustrated in Figure 4.

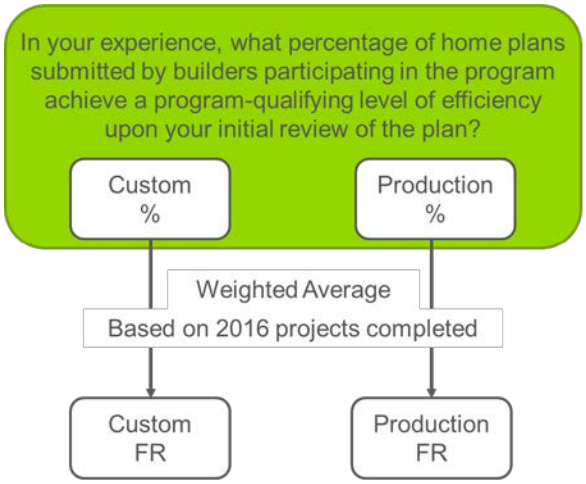

Figure 4. Free Ridership Calculation

Source: Navigant analysis

The evaluation team reviewed the results of the HERS Rater determination of free ridership against results from the participant builder interviews. While no quantitative process was developed for this comparison, the evaluation team did not identify a qualitative difference between the free ridership understanding for the HERS Raters and the participant builders. Answers from two specific questions in the program participating builder interview were considered in this corroboration process.

1. What are the most significant factors that have caused you to make the decision to build energy efficient homes? Using the scale of 1 to 5, where 1 is “not at all influential” and 5 means “very influential,” tell us how influential the following were on your decision to build energy efficient homes?

[16] The HERS Rater interviews were considered a better source of information for determining free ridership than the participant builder interviews, because of the concern of builders overestimating the energy efficient practices that they would employee without program intervention.

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a. The Duke Energy RNC Program
b. Another energy efficient building standard, i.e. ESTAR or LEED
c. Corporate decisions/purchasing
d. Homebuyer preference
e. Other market influences [specify]

2. Using a scale of 1 to 5, where 1 is "not at all influential" and 5 means "very influential," tell us how influential the following elements were on your decision to build homes to the RNC program standards:
    a. Program incentive
    b. Program information/training from Duke Energy/ICF program staff
    c. Program marketing materials
    d. Program information provided by your HERS Rater

5.1.1.2 Calculation of Custom and Production Home Percentage

The evaluation team used results from the participant builder interviews to understand the percent of program homes that could be defined as production and custom. During the participant builder interviews, the evaluation team asked builders to describe what percent of the homes they build could be defined as production or custom, using the definitions identified in Section 5.1 Net-to-Gross Methodology. These answers were rolled up, using a weighted average based on the number of homes that each builder submitted to the program in 2016 within each of the predefined builder size categories: small, medium, and large as defined in Table 20.[17] A program level ratio production and custom homes was developed through a weighted average based on the total number of homes within each of the size categories. The entire process of developing the program level custom and production percentages is illustrated in Figure 5.

Table 20. Builder Size Definitions

Builder Strata	Strata Definition [Projects Completed in the RNC Program during PY2016]	Builders in Strata
Large	> 50	7
Medium	10-50	21
Small	< 10	285

Source: Navigant analysis

[17] Because different proportional quotas were set for completed interviews in each of the size categories, the builder responses cannot be considered representative across the entire program, but only representative within each category.

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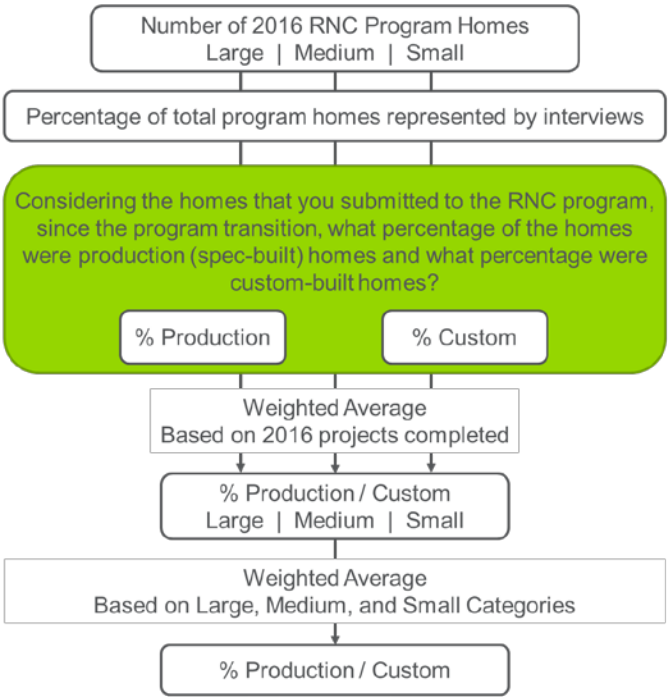
Figure 5. Program Level Production

Calculation of Custom and Percentages



Source: Navigant analysis

5.1.2 Spillover

Spillover describes "additional reductions in energy consumption or demand that are due to program influences beyond those directly associated with program participation."[18] Because these savings are beyond standard program participation, they may not be tracked by or credited to the program. Spillover can include participant spillover, where program participants install energy efficient practices outside the program due to program influence, or nonparticipant spillover, where nonparticipants implement energy efficient practices not through the program, but resulting from the program's influence—i.e., through exposure to the program.

An example of participant spillover within the RNC program is a builder that uses insulation practices learned through the program in a home that is not incentivized through the program. An example of nonparticipant spillover is a nonparticipant builder installing an above-code HVAC system after walking through an RNC program home. The evaluation team considered both participant and nonparticipant spillover within the 2016 RNC program evaluation.

5.1.2.1 Participant Spillover

Because the majority of RNC program participation is through comprehensive, whole house rebates, which rewards participants for all electric savings, there is very little opportunity for participant spillover

[18] National Renewable Energy Laboratory, *Chapter 23: Estimating Net Savings: Common Practices*, 2014. https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

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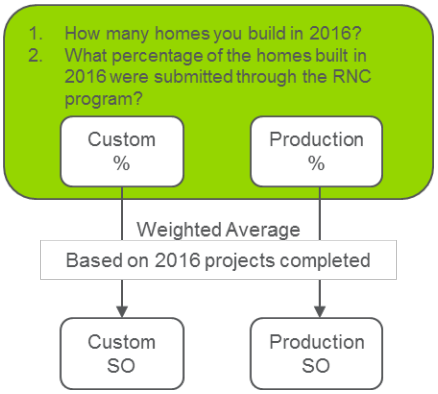
within program participating homes. The evaluation team identified the largest opportunity for participant spillover as program participating builders using practices learned in the program to build homes within DEP territory that don't get submitted to the program and incentivized with program dollars. The hypothesis was that builders may decide to not submit either an individual home or neighborhood to the program because of timing or financial reasons, but would still use some of the energy efficiency practices developed through the program.

The evaluation team attempted to identify and quantify participant spillover by asking questions during the participant builder interviews to understand how many homes are built within the DEP territory, but not submitted to the RNC program, as illustrated in Figure 5. If builders identified homes that fit in this category, the evaluation team would assess the construction practices used within these homes and how these align with building practices used by the builder for program participation.

Figure 6. Spillover Calculation



Source: Navigant analysis

The evaluation team expected the spillover ratio to be different for custom and production homes, resulting in separate results, like the free ridership calculation. The evaluation team would then use the same custom and production percentages developed for the free ridership calculation (described in Section 5.1.1.2) to roll-up the results to the program. The results of the participant builder interviews in relation to spillover are discussed in Section 5.2.2.1.

5.1.2.2 Nonparticipant Spillover

The evaluation team completed interviews with nonparticipant builders to look for nonparticipant spillover. These interviews included a series of questions about familiarity with the DEP RNC program, to understand if these builders had any connection to the program, such that program induced spillover could be a possibility. The interviews also included a detailed review of building practices to understand if the nonparticipant builders were building to minimum code prescriptive levels or above. If the builders indicated that they were both aware of the RNC program and were building above prescriptive code minimums in any capacity, the evaluation team asked questions about why, i.e. what were the influences driving decisions above code.

If the RNC program was identified as an influence in the decision to build above code, the evaluation team would quantify the potential savings from the identified above code building measures. The resulting savings would be combined in a weighted average based on the number of homes built by each of the non-participating builders. The evaluation team would then scale the number resulting from the interviews

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to the entire market of non-participating homes built within DEP Progress territory using the results of the 2016 census, which collects data on the number of new homes by county.[19] The results of the nonparticipant builder interviews in relation to spillover are discussed in Section 5.2.2.2.

5.1.3 Market Effects

Market effects savings are separate from spillover savings in that they reflect "significant program-induced changes in the structure or functioning of energy efficiency markets."[20] So, market effects savings are savings induced by the program that are beyond standard program savings and that are different from spillover savings because they are representative of a change in the structure of the market reflecting an increase in the adoption of energy efficient products, services, or practices. An example of market effects for the RNC program is a nonparticipant builder being induced to build a more energy efficient home than they otherwise would because homebuyers in the North Carolina market only buy energy efficient homes because of program intervention in the market.

The PY2013-2014 evaluation attributed significant market effects savings to the RNC program, resulting from the findings of a Delphi Panel, which was convened to determine market effects. The evaluation team determined the market effects ratio for PY2013 to be 1.72 and 0.30 for PY2014. The significant difference in the market effects ratios between the two years is a result of a significant difference in program participation and savings between the two years, given that 2013 was a program transition year with very low participation. The conclusion of the PY2013-2014 evaluation was that market effects would continue to exist for the DEP RNC program, but they would degrade over time, as more time passed since there was significant RNC program investment in educational activities.[21] After review of the current program activities, the evaluation team determined that the conclusion from the PY2013-2014 was still relevant; market effects savings resulting from past program activities should continue to be quantified, but current program activities would not contribute to additional market effects savings.

The PY2013-2014 evaluation identified separate market effects factors for participant and nonparticipant homes. This resulted from the realization that energy efficient builders were self-selecting into the RNC program following the PY2013 program redesign, which meant that the quantification framework had to account for a separate baseline for participant and nonparticipant builders, as indicated in Figure 7.

[19] Census data on the number of new homes built was used in the previous evaluation to identify the number of hon-participating homes built within DEP territory. While the census data does not match directly with the Duke Energy Progress boundaries, it does provide the best estimate of home construction activity that the evaluation team could develop.

[20] National Renewable Energy Laboratory, *Chapter 23: Estimating Net Savings: Common Practices*, 2014. https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

[21] The market effects quantification framework developed through the PY2013-2014 evaluation would continue to be relevant until the adoption of a new residential energy code in DEP territory. When a new residential energy code is adopted, the quantification framework would need to be adjusted to account for an updated baseline.

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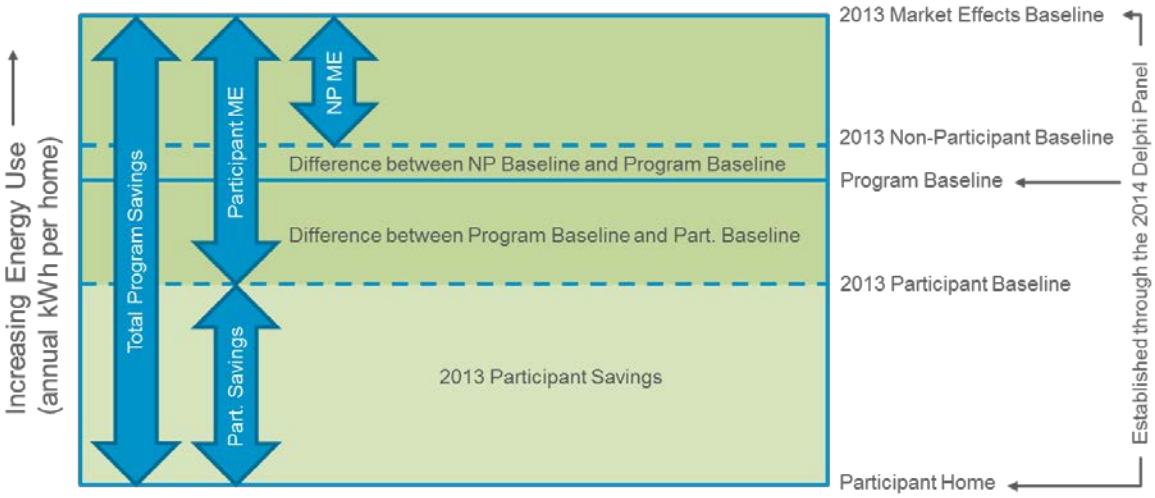
Figure 7. PY2013 Market Effects Model (From PY2013-2014 Evaluation)



Source: Navigant analysis

The PY2013-14 evaluation also indicated that the variation in the participant and nonparticipant baseline would reduce over time, as the program matured and a wider range of builders participated. This was seen in the PY2014 participant mix, which saw the participant and nonparticipant builder baselines migrating towards an average, what was named the *Program Baseline*, as indicated in Figure 8. The market effects evaluated for PY2014 were smaller than the market effects in PY2013, because more time had passed since the program activities that had induced market effects resulting in the market effects baseline moving closer to the program baseline (Figure 8).

Figure 8. PY2014 Market Effects Model (From PY2013-2014 Evaluation)

Source: Navigant analysis

The PY2016 market effects calculation was expected to explore two opportunities: (1) do any current program activities result in the need to quantify additional market effects savings and (2) what are the remaining residual market effects from past program activities using the PY2013-2014 market effects model. The evaluation team planned to explore the opportunity for additional market effects savings first through the interviews with the program managers and implementers, where the team would determine if any current program activities should be explored through the builder and HERS Rater interviews to

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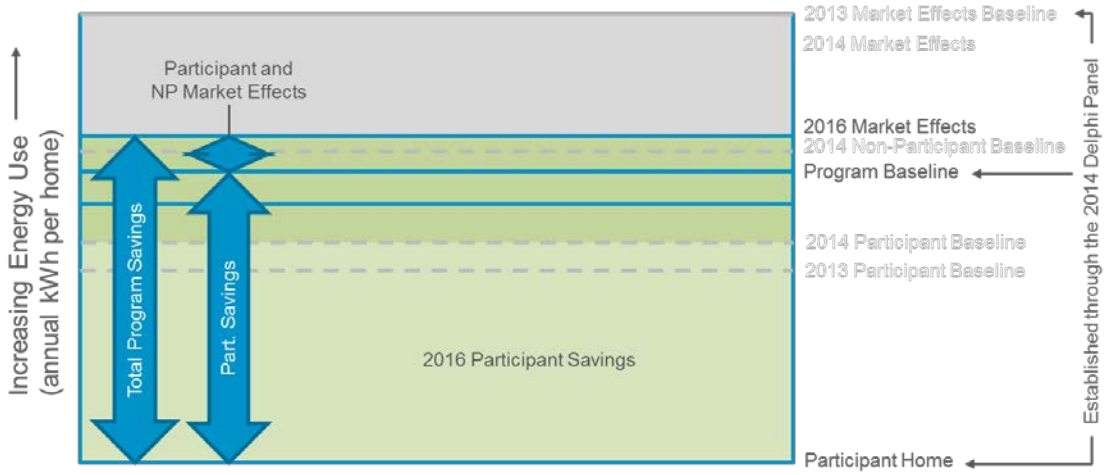
quantify additional market effects. To quantify residual market effects from past program activities, required the evaluation team to adjust the PY2014 market effects model to reflect the PY2016 program activities. The model was expected to be adjusted in two ways: (1) the market effects baseline was adjusted closer to the program baseline to account for the additional passage of time and (2) the individual nonparticipant and participant baselines disappeared into a single program baseline, as illustrated in Figure 9. The details of these adjustments are discussed in the Market Effects Results Section (5.2.3).

Figure 9. PY2016 Market Effects Model



Source: Navigant analysis

The evaluation team did not recommend updating the Delphi panel, used to develop the primary market effects model in the PY2016 evaluation, because the overall North Carolina residential building market had not changed significantly. Instead, the evaluation team recommended using the prior model as it existed and pulling from it a market effects ratio that could be applied to the specific participant population who participated in the RNC program in PY2016. The market effects results for the PY2016 RNC program are presented in Section 5.2.3.

5.1.4 Net-to-Gross Ratio

The NTG portion of the 2016 RNC program evaluation will result in program level estimates for free ridership, spillover, and market effects savings. The free ridership and spillover calculations will identify impacts resulting from PY2016 activities, while the market effects calculation will identify residual impacts from prior program activities that are realized in PY2016. The individual savings estimates will together be rolled into a calculation of the NTG ratio. In the end, equation 2 (presented above) will be adjusted to account for the specifics of the 2016 RNC program net savings as follows:

Equation 2a. Net-to-Gross Ratio for the 2016 RNC Program

NTG Ratio = 1 – FR ratio + SO ratio + ME ratio

Where: FR ratio = Custom FR x % Custom + Production FR x % Production
SO ratio = Custom SO x % Custom + Production SO x % Production
ME ratio = [(Prog. Baseline – ME Baseline) * Total Homes Constructed in DEP Territory

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5.2 Net-to-Gross Findings

As identified in Table 21, Navigant completed interviews with 18 participant builders, nine HERS Raters, and nine nonparticipant builders to inform the calculation of RNC program net savings.

Table 21. Participant / Nonparticipant Builder and HERS Rater Interviews

Market Actor Category	Targeted Interviews	Completed Interviews
Participant Builders	**15-20**	**18**
Large (>50)*	6-8	5
Medium (10-50)	6-8	7
Small (<10)	4-6	6
HERS Raters	**6-8**	**9**
Nonparticipant Builders	**8-10**	**9**

**Values in parenthesis indicate the number of participating homes built by each builder*
Source: Navigant analysis

5.2.1 Free Ridership

The evaluation team determined the free ridership ratio for the RNC program overall to be 0.054. Through this section, we describe the findings from participant builder and HERS Rater interviews that lead to that overall result for the program.

The interviews completed with participant builders and HERS Raters indicated some degree of free ridership in the RNC program. As expected the interview results pointed to significantly different free ridership results for custom and production builders. As illustrated in Table 19 and discussed previously, custom builders were identified as already meeting many of the program requirements, already building above-code prior to their participation, and would have continued to make these choices in the absence of RNC program intervention. On the other hand, production builders indicated that RNC program participation has shaped their company policies around energy efficiency and they would most likely revert to code minimum building policies if they weren't participating in the program. These findings were identified through the HERS Rater interviews and corroborated through the participant builder interviews.

The evaluation team identified free ridership at 17% for custom builders and 1% for production builders. The program-level result was calculated through a weighted average, based on number of homes evaluated in the 2016 program, of the HERS Raters answers to the question: what percent of builders were already meeting program requirements prior to program intervention? These separate free ridership results for custom and production builders were combined to a program level result by weighting by the number of custom and production homes incentivized through the RNC program in PY2016, using the methodology described in Section 5.1.1.2, and illustrated in Table 22.

The evaluation team made one adjustment to the planned methodology after reviewing the results of the participant builder interviews. One large builder (Builder 3) indicated that 40% of the homes they built were custom homes. Through interviews with other builders and the program team, the evaluation team identified that this finding was not representative of other builders in the large strata and it would not be appropriate to apply the findings for this one builder across the rest of the large strata. Instead, the

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evaluation team made the decision to isolate the findings for this one large builder, as described in Table 22.

Table 22. Calculation of Custom and Production Home Percentage

Builder	Size	Custom	Production	2016 Total Program Homes	% of Total Homes Represented in Interviews	% Production	% Custom
1	Large	-	100%	456	25%	100%	0%
2	Large	-	100%				
3	Large	40%	60%	66	100%	40%	60%
4	Medium	-	100%	466	36%	68%	32%
5	Medium	-	100%				
6	Medium	-	100%				
7	Medium	5%	95%				
8	Medium	70%	30%				
9	Medium	75%	25%				
10	Medium	100%	-				
11	Small	5%	95%	370	9%	57%	43%
12	Small	20%	80%				
13	Small	50%	50%				
14	Small	50%	50%				
15	Small	75%	25%				
16	Small	90%	10%				
17	Small	100%	-				
18	Small	100%	-				
TOTAL				1,358	28%	74%	26%

Source: Navigant analysis, totals subject to rounding.

The overall free ridership result for the RNC program was calculated to be 0.054, through Calculation 4, identified in Section 5.1.1, and as follows:

Total FR = (Custom FR x 2016 % Custom Homes) + (Production FR x 2016 % Production Homes)
Total FR = (0.171 x 0.26) + (0.013 x 0.74) = 0.054

5.2.2 Spillover

Through interviews with participant builders, HERS Raters, and nonparticipant builders, the evaluation team found no substantive evidence for spillover from the RNC program, resulting in an overall spillover ratio of 0.00. Through this section we describe the specific findings leading to that result.

5.2.2.1 Participant Spillover

Identification of participant spillover was based on the results of the participant builder and HERS Rater interviews. Like free ridership, the avenues for spillover are different for production and custom builders, so the evaluation team considered these groups separately.

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Every production builders interviewed by the evaluation team indicated that all the homes they build within the DEP territory are submitted to the RNC program, meaning that there is no opportunity for spillover within this participant group. Custom builders indicated that not every home that they build within the DEP territory meets RNC program standards, and for these builders and their clients it is really a home-by-home decision. The evaluation team found no clear indication that RNC program practices are being applied to non-program homes. In fact, HERS Raters reported that custom builders and subcontractors know which homes will be submitted to the program and improve their building practices in these homes knowing that they will be subject to additional testing.[22]

5.2.2.2 Nonparticipant Spillover

The evaluation team was not able to identify evidence for nonparticipant builder spillover, as summarized in the interview results presented in Table 23. Though some of the interviewed nonparticipant builders were aware of the DEP RNC program, there are no indications that the program has had any direct influence on their building practices. In addition, a significant number of builders that are not aware of the DEP RNC program are typically building above code homes and using the services of a HERS Rater.

Table 23. Nonparticipant Builder Interview Summary

Builder	Homes per Year	Familiar with RNC Program	Other Green Standards/Work with HERS Rater
1	1-2	No	• Have built to LEED standards, does not certify • Not aware of/does not use NC HERO code • No HERS Raters, don't like billing practices or attitudes
2	2	No	• Client driven efficiency decisions, do build above code • Issues with Duke Energy, no interest in program
3	Varies	Yes	• Standard practice is to use ENERGY STAR, because they receive credit through HUD • Above code decisions for durability not efficiency • Work with a HERS Rater
4	5-10	Yes	• Efficiency decisions are client by client, not many clients looking for above code homes
5	50-60	Yes	• Have built through ENERGY STAR and LEED when requested by clients • HERS Rater on some homes, client request
6	5	No	• Built a few homes to HERO code • All homes are certified by a HERS Rater
7	3-5	No	• Have built some homes to ENERGY STAR • All homes are certified by a HERS Rater

[22] It is possible that participant spillover may exist for custom builders, but it is likely very small and almost impossible to quantify without inspections of non-program homes. The evaluation team was not able to collect enough evidence through the participant builder interviews to clearly recommend a claim of spillover for the production builder category.

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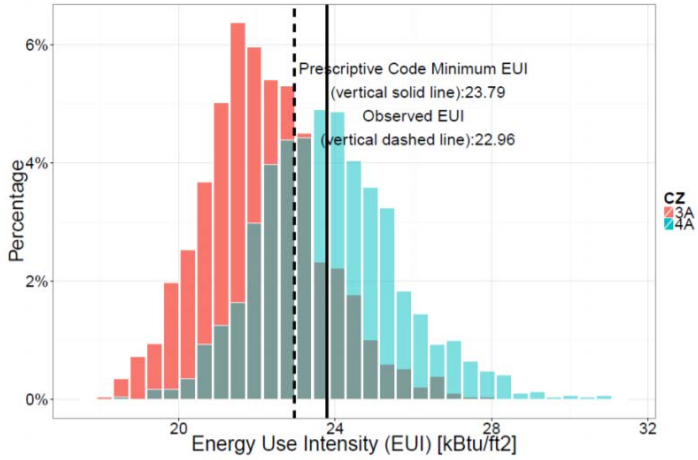
Table 24. Nonparticipant Builder Interview Summary (continued)

Builder	Homes per Year	Familiar with RNC Program	Other Green Standards/Work with HERS Rater
8	6-8	Yes	• Built a few homes to HERO code • May have previously participated in DEP RNC program • HERS Rater on some homes, client request
9	500-600	Yes	• Have built some homes to ENERGY STAR • Efficiency decision made by price point, higher price homes receive more efficiency measures • Compete with very efficient builders, in other parts of the country efficiency is a bigger selling point

Source: Navigant analysis of Nonparticipant Builder Interviews

The finding of no nonparticipant builder spillover is additionally supported by the recently completed North Carolina Residential Energy Field Code Study.[23] The study found that on average, homes in North Carolina are 3.5% more energy efficient than would be expected based solely on prescriptive code requirements (Figure 10).

Figure 10. Statewide EUI Analysis for North Carolina



Source: North Carolina Residential Energy Code Field Study, August 2017.

This finding in and of itself does not necessarily lead to a finding that nonparticipant spillover is non-existent for the RNC program. However, when combined with the results of the overall code study that found that the average energy consumption for new single family homes in five of the six states analyzed was less than what would be expected in comparison to the prescriptive code requirements, it makes a strong statement for the lack of nonparticipant spillover.[24] This result was consistent even across states

[23] Bartlett, R., M Halverson, V Mendon, et al. *North Carolina Residential Energy Code Field Study: Baseline Report.* August 2017. Pacific Northwest National Laboratory (PNNL-26752). https://www.energycodes.gov/sites/default/files/documents/North_Carolina_Residential_Field_Study.pdf

[24] U.S. DOE. *Building Energy Codes Program Single Family Residential Energy Code Field Study.* December 2015. https://www.energycodes.gov/sites/default/files/documents/Field_Study_120715_Final.pdf

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without, of with less active, residential new construction incentive programs. Based on this finding, it would be hard to argue for the presence of nonparticipant spillover connected to the DEP RNC program.

5.2.3 Market Effects

The evaluation team determined the market effects ratio for the RNC program to be 0.105. Through this section we describe the findings from interviews with the program managers, implementers, builders, and HERS Raters that lead to this overall program result.

To quantify market effects, the evaluation team first interviewed program managers and implementers to determine if new sources of market effects needed to be considered in the quantification approach, beyond those resulting from past program activities identified through the prior market effects model. The identification of significant market effects savings through the PY2013-2014 evaluation was a result of a strong legacy of engaging and teaching the local building community within the RNC program. Through the interviews with DEP program managers and the implementer, the evaluation team determined that current training activities are limited to one-on-one builder mentoring, to support builders meeting specific program requirements. Broader, building science trainings are available to builders and Home Energy Rating System (HERS) raters on the program website, but these are voluntary and not as significant as the program trainings previously offered by Advanced Energy.

> The current RNC program is more heavily focused on encouraging a higher level of program participation, both in the number of builders as well as the depth of participation by each builder, than on developing an overall market that supports greater uptake of energy efficient practices.

The evaluation team identified that the RNC program is currently more focused on encouraging a higher level of program participation—both in the number of builders as well as the depth of participation by each builder—than on developing an overall market that supports greater uptake of energy efficient practices. Additionally, the program incentive structure has changed such that builders are rewarded for each incremental change in kilowatt-hour savings, with all energy efficiency increases being captured and rewarded equally. Thus, little participant builder behavior in relation to program homes is expected to occur outside of what is captured through program savings. As a result, the evaluation team did not expect to find evidence to support new sources of market effects savings, and instead focused on quantifying residual market effects savings from past program activities.

The Market Effects Methodology Section (5.1.3) describes the process of updating the market effects model developed through the PY2013-2014 evaluation to reflect the PY2016 program activities and NC residential new construction market. Because the PY2013-2014 market effects model was developed based on a different set of program homes, and there was no reason for the PY2016 evaluation to update the costly Delphi panel, the evaluation team used the PY2013-2014 model to extract a market effects savings ratio that could be applied to the PY2016 gross savings to determine market effects savings.

The evaluation team determined that the 2016 participant builder population no longer reflected the self-selection that had caused the program baseline to be split into a participant and nonparticipant builder population. With a single program baseline, participant and nonparticipant market effects converged to a single value (Figure 11).

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Figure 11. PY2016 Market Effects Model

Source: Navigant analysis

Additionally, the nonparticipant builder interviews conducted as part of this evaluation and summarized in Table 23 illustrate that the market effects baseline has moved towards higher efficiency since the previous evaluation, as the evaluation team had expected. Likely, the new baseline sits somewhere between the 2014 market effects baseline and the 2014 nonparticipant baseline, but the evaluation team opted for a conservative approach, using the 2014 nonparticipant baseline as the new baseline for calculating market effects. These baseline definitions were applied to the 2014 program savings using the 2014 market effects model, resulting in a market effects ratio of 0.105, which the evaluation team applied to the 2016 program savings.

5.2.4 Net-to-Gross Results

The NTG ratio, combining free ridership, spillover, and market effects, was calculated as written in Equation 5:

Equation 5. NTG Ratio

NTG Ratio = 1 - FR ratio + SO ratio + ME ratio[25] = 1 – 0.054 +0.000 + 0.105 = 1.051

This suggests that for every 1 kWh reduced from program measures, about 1.043 kWh of savings can be directly attributed to the program.

Applying the NTG ratio to the PY2016 verified gross savings values results in verified net energy savings of 3,469 MWh, verified net summer peak demand savings of 1.44 MW and verified net winter peak demand savings of 1.69 MW as shown in Table 25.

[25] National Renewable Energy Laboratory, *Chapter 23: Estimating Net Savings: Common Practices*, 2014. https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

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Table 25. Impact Evaluation Results (Net)

	Reported Savings	*Verified Net Savings*	Net Realization Rate
Energy Savings (MWh)	3,743	3,681	98%
Summer Peak Demand Savings (MW)	1.59	1.64	103%
Winter Peak Demand Savings (MW)	1.51	1.65	109%

Source: Navigant analysis

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6. PROCESS EVALUATION

Navigant completed a process evaluation of the RNC program to assess the success of current program activities and explore opportunities available to address program participation gaps, identified in the PY2013-14 evaluation cycle. In addition, the process evaluation supported the NTG methodology, presented in section 5.1. The process findings are based on detailed interviews with program and market actors, a roundtable discussion with RNC program and ICF staff, and a high-level review of program documentation including the website. In total, 18 interviews were completed with participant builders, nine with HERS Raters, and nine with nonparticipant builders, as indicated in Table 26

Table 26. Participant / Nonparticipant Builder and HERS Rater Interviews

Market Actor Category	Targeted Interviews	Completed Interviews
Participant Builders	**15-20**	**18**
Large (>50)	6-8	5
Medium (10-50)	6-8	7
Small (<10)	4-6	6
HERS Raters	**6-8**	**9**
Nonparticipant Builders	**8-10**	**9**

Source: Navigant analysis

6.1 Process Evaluation Results

Through Navigant's process evaluation, the RNC program was generally determined to be a strong program that was well liked by builders and HERS Raters. In fact, the most significant complaint about the RNC program, from both builders and HERS Raters, is that it is only offered in DEP territory. Across the board, builders would like to see the geography of the program offering extended, so that the program incentive is available for all homes that they build. Additional detailed findings resulting from the process evaluation are discussed throughout this chapter.

6.1.1 Builder & HERS Rater Relationship

The RNC program is designed such that once builders are active participants in the program, HERS Raters serve as the main connection between RNC program staff and participating builders. Participating builders work with HERS Raters to file the necessary program documentation and HERS Raters often work with RNC program and implementer staff to deal with modeling or documentation issues. In addition, most HERS Raters identify RNC program participation as a significant piece of their building model, because the financial incentives for builders drive their interest in the HERS Rater's services.

The interviews completed with program participating builders indicated that HERS Raters serve as a critical program recruitment avenue. In fact, 11 out of the 18 builders interviewed indicated that they first learned about the RNC program through a HERS Rater, or a HERS Rater in association with another source (Figure 12).

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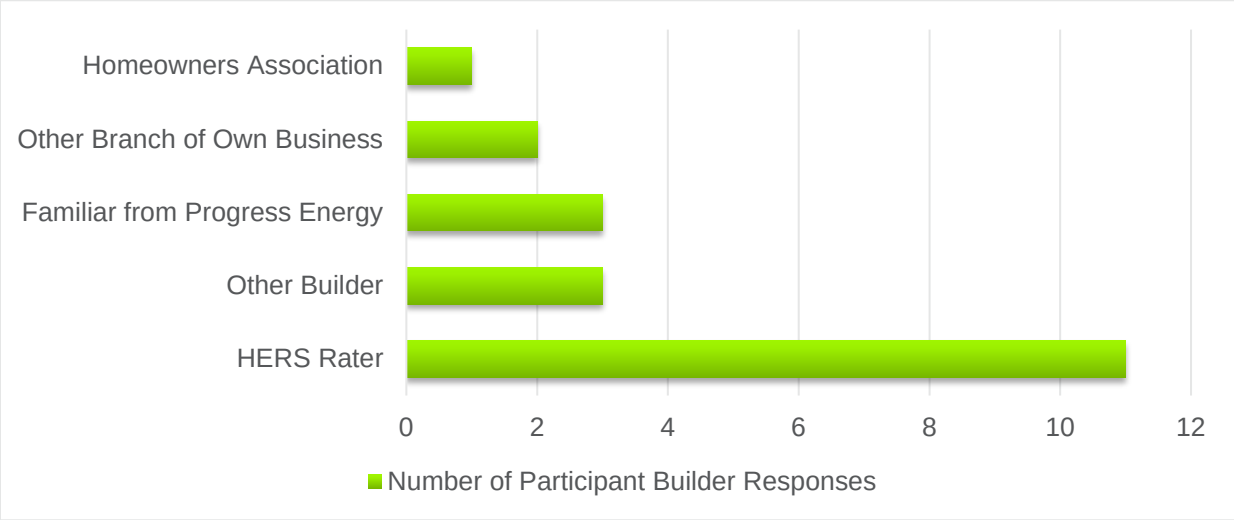
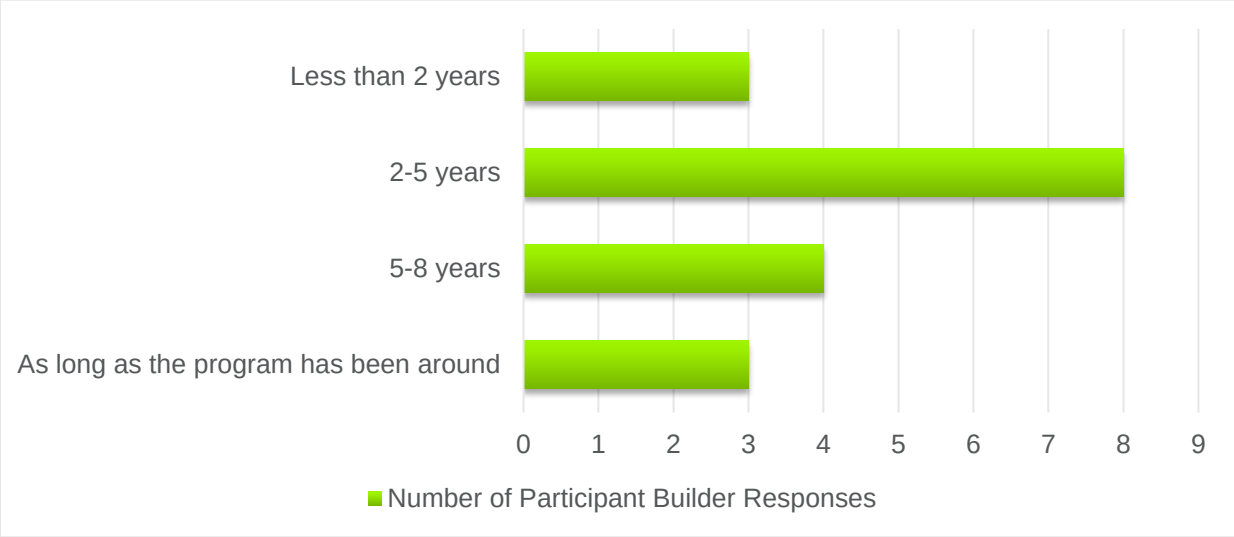
Figure 12. How Participant Builders Reported First Hearing about the RNC Program



Source: Navigant analysis of participant builder interview responses (Total number of responses adds up to more than 18, because 2 builders provided multiple responses.)

While most builders learned about the RNC program through their HERS Rater, most of the builders that were interviewed as part of the process evaluation had been participating in the RNC program for many years. So, for most builders, significant time had passed since they first learned about the RNC program, as indicated in Figure 13.

Figure 13. How Long Builders Have Received Incentives through the DEP RNC Program



Source: Navigant analysis of participant builder interview responses

For most builders, the relationship with their HERS Rater is the most successful aspect of the RNC program, beyond the incentive. Through the interviews, participant builders volunteered the following about the relationship with their HERS Rater.

- HERS Rater has been a consultant for eight years (have not used anyone else). They rely on their HERS Rater to determine where their money is best spent.

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- Rater tells them when a problem may exist and pinpoints the exact measure requirements to get to compliance.
- Rater is a “good go-between.” Has been very helpful in talking to and educating his tradesman.
- Likes the HERS Rater’s suggestions on how to make energy-related improvements that make whole building packages work better.

6.1.2 Program Implementer & Tracking Software

At the start of PY2016, ICF International serves as the program implementer for the RNC program. The change in implementer was both recognized and appreciated by program participants. Of the builders and HERS Raters who were interviewed who had worked with the previous implementer, multiple participants indicated high-levels of satisfaction with ICF’s services. The general sentiment is summarized by one of the interviewed HERS Raters as follows, “ICF has done a phenomenal job. Seems like a tighter ship, more professional. I have appreciated the way they have tackled complicated issues – I don’t feel like the resource was there before.”

The change in program implementer also resulted in a change in the program tracking software, by which HERS Raters upload projects for review and incentives are tracked. When this tracking software change was discussed it was well received by all. The only potential complaint mentioned by a couple of the HERS Raters was that the RNC program continues to require REM/Rate as the base modeling system for claiming savings. A few of the HERS Raters have switched their standard software to Ekotrope and are having to build a second model in REM/Rate to submit homes to the RNC program.

6.1.3 Program Satisfaction - Builders

The overall sentiment from the process interviews was that program satisfaction was a bit mixed for PY2016. Some program participants reported high program satisfaction, even providing compliments, such as the following, “It's a user friendly, simple program that benefits the builder, homeowner and the environment. A win/win. I find it hard to believe that a huge corporate like Duke Progress could keep it simple, and that's a compliment.” On the other hand, some program participants indicated very low program satisfaction. What stands out to the evaluation team is that at least for this year, program satisfaction seemed to be quite contingent on whether builders were receiving a smaller or larger incentive under the new program design. For example, when one builder was asked how satisfied they were with the RNC program they responded, “In the current form it’s a 6 out of 10, previously I would have said 8 or 9.” And another builder responded, “not nearly as satisfied as before the incentive change,” in response to the same question.

To better understand the relationship between reported program satisfaction and program incentive levels, Navigant performed an analysis of the incentive levels between the incentives offered under the previous program design and those offered in PY2016. On average, builders received a 15% smaller incentive under the new program design as compared to the incentives received under the previous program design. However, for individual builders, the difference between the incentives received under the two program designs varied more significantly, with some builders receiving incentives that were almost 200% greater and as much as 75% smaller when compared to the incentives received prior to 2016 (Figure 14).

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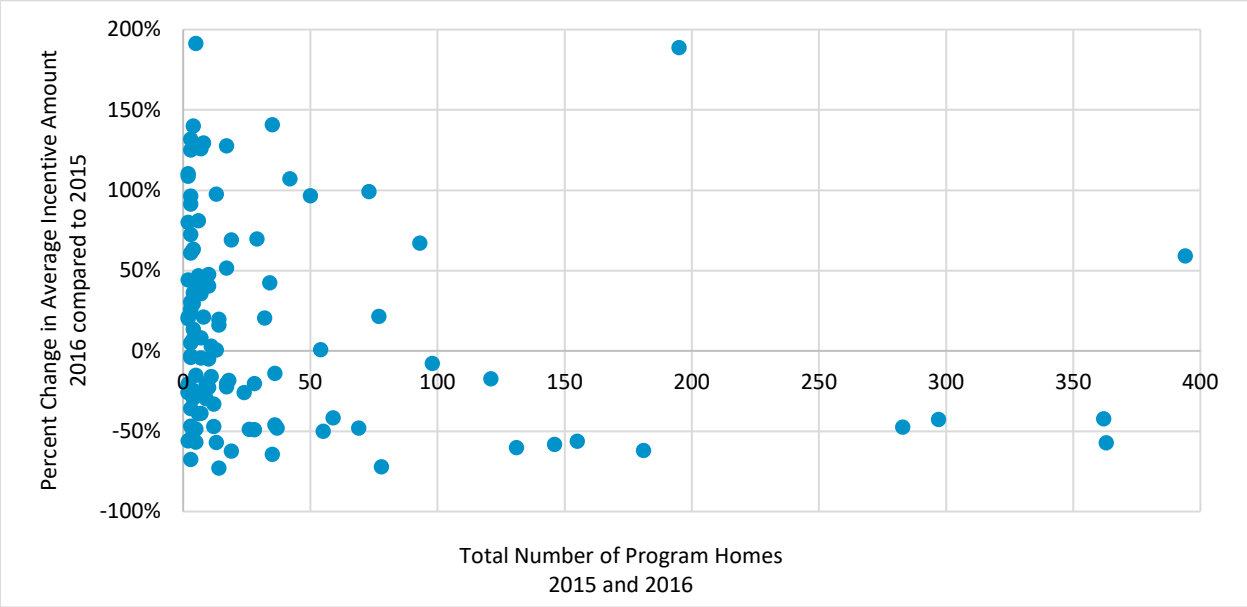
Figure 14. Percent Change in Incentives (2015 to 2016), by Builder



Source: Navigant Analysis

In general, the Navigant team found that builders who were receiving higher incentives under the new program structure were much more likely to indicate satisfaction with the RNC program than the builders who were receiving smaller incentives under the new program structure. For most builders, the Navigant evaluation team expects that the volatile program satisfaction will even out as time extends from the program transition, but for a few builders, specifically larger production builders, the incentive change may affect long-term program participation if they cannot determine how to make the new financials work across their business plan.

Through the process interviews, the Navigant evaluation team found one other trend around program satisfaction. A few of the program builders indicated confusion about the program structure, indicating that it was counter-intuitive that the program rewarded electric savings over gas/all fuel savings. This subset of builders indicated that it was easier to get higher rebates for their entry-level homes, because these homeowners are willing to accept electric appliances over gas appliances. In fact, the builders indicated that to receive higher incentives, they needed to push their homes to use a higher percentage of electricity, which seemed counter-intuitive from a holistic environmental perspective.

6.2 Program Gap Research

As part of the PY2016 process evaluation, the Navigant team explored three potential program gaps that were identified in the PY2013 & PY2014 RNC Evaluation report. Though the previous report indicated that the RNC program performed adequately in terms of the program focus: single family, new homes built by production builders, the report indicated that, “The program falls short in supporting energy efficiency improvements in very small or low-income homes; multi-family buildings; and high dollar value homes.” All builders who participated in the process interviews were asked whether they built homes in each of the three categories of interest, and if so, were asked a few questions about the specific challenges facing these market categories.

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6.2.1 Affordable Homes

Affordable/small homes have always been a challenge for residential new construction programs. The margin for builders on affordable homes is smaller, meaning that the builder must turn over many homes to make the numbers work – which means they are focused primarily on what will make homes sell the fastest. Additionally, at this price point, builders don't have the option to pass along any energy efficiency costs to the homeowner.

The process interviews indicated two potential solutions to serve greater numbers of affordable/small homes within the RNC program. First, the program could consider a higher incentive for smaller, affordable homes. Second, builders indicated that providing a homeowner incentive, such as a percentage off their energy bill could encourage participation, but this may not be possible for Duke Energy to implement in line with regulatory requirements.[26]

6.2.2 High Dollar Value Homes

The high dollar value segment is one of particular interests for many of programs, because these homes are often larger and influencing energy efficient decisions in this market segment results in more kWh savings per home, even if on a percentage basis, the savings are similar to other segments. Builders indicate that in this market, client choice becomes a bigger issue, as these clients often know what they want and help to specify products within the home; homebuyers in this market segment want gas appliances. In addition, because homes in this segment are larger, efficiency measures become proportionally more expensive.

Two opportunities were presented in the process interviews to close the gap in the high dollar value home category. First, Duke Energy may want to partner with a gas utility e.g. Piedmont to offer incentives for comprehensive energy efficiency, because the electric only focus may be significantly more limiting to this group. Second, homeowner education around the financial benefits of energy efficiency is likely not as compelling. In this market, the three-year heating and cooling guarantee is not going to drive as much interest as appliances that meet more of the *want to haves*.

6.2.3 Multi-family Buildings

Within the RNC program, multi-family buildings[27] have historically participated in the equipment-only track at a high percentage. In general, multi-family projects have encountered challenges participating in the whole building track of the RNC program. Builders interviewed in the process interviews indicated two reasons why multi-family buildings have been underrepresented in the whole building track:

1. Builders, even large builders, rarely specialize in both single family and multi-family buildings. This means that multi-family builders are often outside the recruiting paths for the RNC program

[26] It should be noted that the Duke Energy RNC program does encourage builders participating in the RNC program to offer homebuyers a three-year Heating and Cooling Energy Usage Limited Guarantee. This program covers only the energy used to heat and cool the home and provides homeowners a guarantee that their heating/cooling energy usage will not exceed the expected value over the three-year period. However, not all builders in the RNC program take advantage of this offer.

[27] Within the RNC program multi-family refers to any attached dwelling unit, which could include townhouses, condos, or traditional apartments. Note that not all condos are necessarily attached dwelling units and could be considered single family homes. To qualify for the RNC program, multi-family buildings must be three or fewer stories to qualify for the Whole-House incentives; multi-family buildings over three stories only qualify for the Equipment incentives.

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and in general are often less aware of whole building efficiency programs, making it harder for them to get on board with the whole building track.

2. Builders have issues with the foundation insulation requirement for multi-family projects, because multi-family projects are commonly built on slab foundations. This issue is also seen for single family builders in more coastal regions of the DEP territory, where slab foundations are also common. The use of slab foundations require builders to locate foundation insulation at the slab edge which raises questions around potential termite damage.

Through the process interviews, two opportunities were identified to encourage greater program participation for multi-family builders. First, the program could consider targeted marketing for multi-family builders, because the primary builders in this category don't often overlap with the single family builders that are targeted by the program. Second, the program could consider whether the program technical requirements, that were designed more directly for single family homes are all applicable to the multi-family home segment.

6.2.4 Conclusion

In general, participating builders and HERS Raters are happy with the RNC program including the changes in the structure and the implementer. There are some discontented builders, specifically those who have received smaller incentives because of the program transition, but in most cases builders are happy enough with the RNC program that their biggest complaint is that the program is only offered within DEP territory. Specific recommendations resulting from the process evaluation are presented in Section 8.

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7. CONCLUSIONS AND RECOMMENDATIONS

Navigant's evaluation suggests that Duke Energy's RNC program effectively drives a more energy efficient residential new construction market within DEP territory. In fact, the greatest complaint from program participants is that the program offering is limited to DEP territory, which limits the homes that can take advantage of the program. Navigant presents the following conclusions and recommendations to help improve program delivery and impacts.

7.1 Key Impact Findings & Recommendations

- **Navigant recommends that Duke Energy adopt the per-unit energy and demand impacts for the deemed measures (equipment only and HERO) from this evaluation and use them going forward.** The current equipment-only deemed savings values reference HEIP deemed savings values developed from models that represent existing buildings, which are not representative of the new homes in which these measures are installed. The engineering analysis and data collection described in this report provide support for updating the estimated impacts for the RNC program deemed savings measures, including the equipment-only and HERO measures.
- **Duke Energy should consider increasing the deemed measure life for HVAC equipment from 15 years to 18 years.** The current deemed measure life for HVAC equipment through the RNC program is 15 years. The Mid Atlantic TRM v6 2016 cites a 2016 study identifying an EUL / ML of 18 years. The evaluation team believes that this measure life increase is appropriate to use for the equipment-only measures in the RNC program
- **Navigant recommends Duke Energy adjust the User Defined Reference Home (UDRH) heating system thermostat setpoint to 70°F.** The evaluation team attributes the difference between reported and verified savings primarily to the calibration of energy models used to calculate savings. Unlike the REM/Rate models used to calculate ex-ante savings, the BEopt models used for savings verification were calibrated to ensure that resulting energy consumption matches billing data to within 5%. The evaluation team conducted additional research and analysis that indicate the REM/Rate software tends to overestimate energy consumption and savings.

  To address this issue, the evaluation team recommends a minor adjustment to the UDRH specifications. The UDRH specifications define the baseline home conditions for REM/Rate's savings calculations. The UDRH currently specifies a heating system thermostat setpoint of 72°F. However, to calibrate the BEopt models to participant billing data, the evaluation team had to reduce the thermostat setpoint to 70°F. By reducing the UDRH setpoint accordingly, the REM/Rate models will produce a savings estimate much closer to billing data and calibrated model results.

7.2 Key Process Findings & Recommendations

- **Duke Energy should consider expanding the RNC program offering to territories beyond the DEP territory.** The most consistent complaint of program builders was that not all of their homes could participate in the program because the RNC program is only offered within Progress

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territory. Offering the program beyond the current DEP territory would encourage a greater uptake of energy efficient practices at the most cost-effective time within a home's lifecycle.

- **Navigant recommends that Duke Energy consider, if feasible, whether software modeling platforms other than REM/Rate could be used to confirm program requirements.** Some of the HERS Raters who actively participate with the RNC program indicated that they use Ekotrope for residential home modeling with their clients and that they build a separate REM/Rate model to conform to program requirements.
- **Duke Energy should consider whether there is an opportunity to partner with a gas utility to provide value to gas savings, or consider program education around the goal of the program being electric savings.** After the program change, builders indicate greater confusion around the program focus on electric savings only. While this was always the program focus, it was less clear to builders when the incentive was based on the HERS score and not just the associated electricity savings.

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8. INPUTS FOR DUKE ENERGY ANALYTICS

Navigant used the findings from field verification, modeling, and review of Duke Energy's deemed savings to estimate an updated set of deemed savings for Duke Energy to use for tracking program activity. Table 27 provides the measure-level inputs that can be used by Duke Energy Analytics for estimates of future program savings.

Table 27. Gross Measure-Level Impacts

Measure	Average Verified Energy Savings Per-Unit (kWh)	Summer Coincident Demand Savings Per-Unit (kW)	Winter Coincident Demand Savings Per-Unit (kW)
HERO	1,639	0.98	0.97
HERO + HERS[28]	2,707	1.05	1.10
Heat Pump (SEER ≥ 15)	401	0.38	0.25
Central AC (SEER ≥ 15)	207	0.24	0.00

Source: Navigant Analysis

DSMore table template -DEP RNC -c

[28] The average savings values for the HERO + HERS measure are not meant to be used prescriptively as deemed values. The reported savings for this measure are calculated using the REM/Rate software and verified through calibrated simulation modeling. These average savings values are intended for application in program planning and cost-effectiveness purposes.

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9. SUMMARY FORM

Residential New Construction Program

Completed EMV Fact Sheet

Description of program

DEP's Residential New Construction Program provides incentives to participating home builders for incorporating energy efficient practices into the construction of new homes.

Participating builders can choose from two program incentive paths.

- **Whole Home:** Incentives are awarded on a per-kWh basis for homes that submit a HERS score and exceed the efficiency standards established by the 2012 North Carolina Energy Conservation Code's High Efficiency Residential Option (HERO) or the equivalent in South Carolina. A minimum deemed incentive is available for homes that only meet HERO or equivalent.
- **Equipment Only:** Prescriptive incentives are awarded for installation of high-efficiency HVAC equipment

Date:	May 25, 2018
Region:	Duke Energy Progress
Evaluation Period	Whole Home: July 1, 2016 through December 31, 2016 Equipment Only: January 1, 2016 through December 31, 2016
Annual MWh Savings	3,503
Net-to-Gross Ratio	1.051

Evaluation Methods

The evaluation team used engineering analysis, onsite field inspections, and calibrated energy simulation modeling as the basis for estimating verified program impacts. Additionally, the evaluation team performed in-depth interviews with the following groups to assess program delivery and Net-to Gross considerations:

- DEP program staff
- Implementation contractor staff
- HERS Raters
- Participant builders
- Nonparticipant builders

Impact Evaluation Details

- **Field inspections were conducted at 40 program homes.** The evaluation team inspected program equipment at 40 participating homes to inspect the high-efficiency HVAC equipment and compare the field-verified quantities and characteristics with the program tracking database. Navigant found the equipment in the field to be exactly as reported in the tracking data.
- **Calibrated energy simulation modeling.** The evaluation team developed energy simulation models in the BEopt platform. The team used participant billing data to calibrate the energy simulation models, and the final calibrated models were used to estimate verified impacts.
- **The average annual gross energy savings achieved by each participating home depends on the measures pursued.**

  Heat pump – 401 kWh

  Central air conditioner – 207 kWh

  HERO – 1,639 kWh

  HERO + HERS – 2,707 kWh
- The Net to Gross ratio is estimated to be 1.051. Free ridership was generally offset by the program market effects. The evaluation team found zero spillover.

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APPENDIX A. PY2016 BUILDING SIMULATION MODELS

For the PY2016 evaluation, Navigant developed a new set of energy simulation models to estimate energy and demand savings for RNC program homes. This appendix includes a detailed discussion of the energy simulation model development process.

Sample

The evaluation team conducted a review of program tracking data and REM/Rate file extracts for all 2016 HERO+HERS program homes to look for variances in building characteristics. This analysis was used to understand the effect of these variations on actual billing consumption and to determine the most appropriate sample of projects for use in model calibration. The most important factors effecting billing consumption were the HVAC system type and home type (single family vs multi-family). Single family electrically-heated homes were selected as the representative sample to calibrate the building simulation models as the majority of 2016 participant homes were single family all-electric homes and gas billing data was not available to calibrate gas-heated home models. Table 28 shows the relative precision (+/- 5 percent) achieved by this sample at a 90 percent level of confidence.

Table 28: Whole House Simulation Model Sample Statistics

Strata	2016 Strata Population Size (N)	Average Savings (kWh)	Coefficient of Variation	Single-Family Electric Sample Size (N)	Relative Precision (90% CI)
2016 HERO + HERS Homes	1,049	2,891	0.7	427	5.6%

Source: Navigant analysis

Billing Data Analysis

Duke Energy provided electric consumption billing data for PY2016 program participants. The evaluation team cleaned and aggregated the billing data to create a load shape for the sampled single family electric homes. Figure 15 shows the aggregated participant billing data load shape used for model calibration (discussed below).

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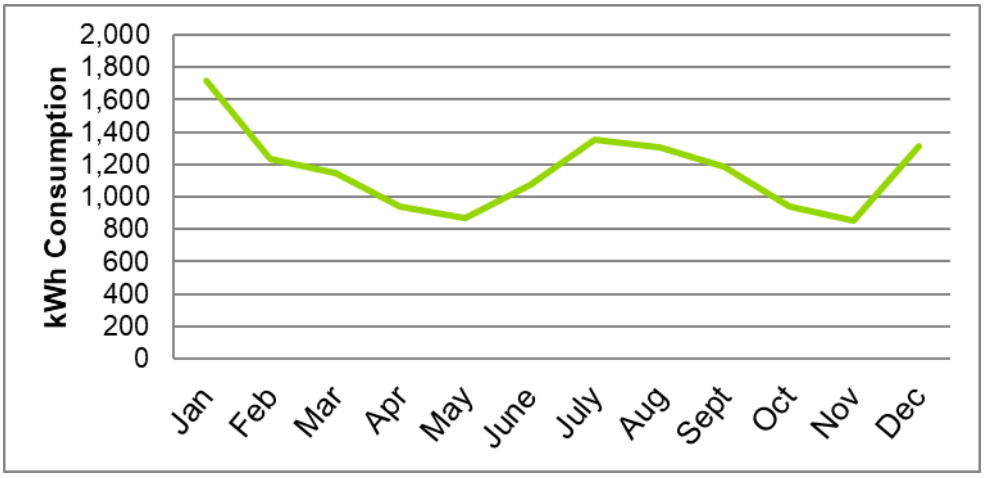
Figure 15. Single-Family Electric Load Shape



Source: Navigant analysis

Model Construction

The evaluation team constructed the energy simulation models using the Building Energy Optimization (BEopt) software package. BEopt is a residential software modeling platform developed by the National Renewable Energy Laboratory (NREL). It utilizes the industry-trusted EnergyPlus or DOE-2.2 simulation engines and contains built-in assumptions that are based on the U.S. Department of Energy's (DOE's) Building America House Simulation Protocols. The evaluation team based the model specifications on average building characteristics extracted from REM/Rate files for the sample of 427 projects, as shown in Table 29.

Table 29: Whole House Simulation Model Sample Statistics

Parameter	Average 2016 Sample Characteristics
Home Characteristics	
Conditioned Floor Area (sf)	2,700
Stories	2
Bedrooms	4
Envelope Characteristics	
Ceiling R-Value	34.1
Above Grade Wall R-Value	16.1
Slab Floor R-Value	10.0
Window Area	356.9
Window U Value	0.33
Window SHGC	0.25
Infiltration (ACH @ 50 Pascals)	2.9

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Mechanical Equipment	
Air Source Heat Pump (HSPF)	8.7
Air Source Heat Pump (SEER)	14.8
Air Source Heat Pump (EER)	12.2
Duct Insulation R-Value	8.3
Duct Leakage (CFM@25Pa/100 sq. ft.)	1.8
Water Heater Energy Factor (EF)	1.54

Source: Navigant analysis of 2016 REM/Rate files

Load Disaggregation and Model Calibration

Proper calibration of energy simulation models requires that the billing data load shape be disaggregated to estimate the individual contribution from primary end uses.[29]

Once the billing load shape was disaggregated, the evaluation team conducted a rigorous calibration procedure to adjust model simulation parameters so that the modeled energy consumption output was within 5% of participants' annual electric consumption for lighting, appliance, plug, heating, and cooling loads. The calibration parameters were kept within reasonable ranges to ensure that simulation inputs were representative of realistic home and customer behaviors.

During the calibration process, the evaluation team used 2016 actual meteorological year (AMY) weather data to ensure that models were properly calibrated to the consumption that occurred as a result of the weather during the same time period. Once the models were calibrated, measure savings estimates were generated using typical meteorological year (TMY3) weather data so that the savings reflect what would be observed during a typical weather year rather than a specific weather year.[30]

Establishing Measure Baselines

To model the baseline home, the evaluation team used the baseline specifications found in the program's User-Defined Reference Home (UDRH) file. The UDRH specifies baseline conditions for use in REM/Rate models, to generate an energy savings report. Navigant used these values to ensure direct comparison with the reported savings estimates from REM/Rate files for each program home.

Measure Savings Estimates

After creating a complete set of modeling input parameters, Navigant performed a number of model simulation runs to estimate energy savings for the whole house option and the prescriptive HVAC measures. The evaluation team adjusted the efficiency parameters in order to simulate the baseline condition versus the efficient condition. The evaluation team chose criteria for the efficient categories that

[29] Navigant has developed a rigorous approach for load disaggregation, which has been used as an accepted approach for several evaluations among various utility clients, including several previous evaluations for DEP.

[30] Navigant chose to use TMY3 weather data for model savings because it provides the best estimate of the typical savings that a customer would experience. Furthermore, Duke Energy generally uses the evaluated savings from one program year as the deemed savings for the next program year, which makes TMY3 data the most appropriate choice.

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were consistent with actual RNC program activity to simulate the most appropriate measure combinations.

Estimating Prescriptive HVAC Measure Savings

Using the calibrated models developed for the whole house option, Navigant performed a series of model runs to estimate energy savings for the prescriptive HVAC measures. The evaluation team adjusted the efficiency parameters to simulate the baseline condition versus the efficient condition. The evaluation team chose criteria for the efficient categories that were consistent with actual RNC program activity to simulate the most appropriate measure combinations.

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APPENDIX B. REM/RATE LITERATURE REVIEW

Source	Study	Findings
ACEEE	Accuracy of Home Energy Saver Energy Calculation Methodology	A comparison across three tools (Home Energy Saver, REM/Rate, and SIMPLE) resulted in REM/Rate systematically over predicting annual energy use; approximations used in translating REM/Rate inputs to HES inputs unavoidably introduced error compared to cases where audits gathered inputs expressly for HES. NREL's BEopt is generally accurate, though is also prone to over-predicting heating energy.
Advanced Energy	Houston Home Energy Efficiency Study	Analysis found no systematic bias of REM/rate, though there was a large amount of variability in data; vintage and square footage of home were as good predictors of energy use as REM/Rate projections. REM projected average cooling loads about 3% higher than actual, but given the likely positive bias in billing data, these figures should be considered in excellent agreement.
Energy Center of Wisconsin	Energy and Housing in Wisconsin	Overall error statistics when comparing PRISM to REM/Rate indicates that REM/Rate overestimates heating energy use by a median of 20% when compared to utility billing records. For most houses, the difference is moderate, but the REM/Rate predictions of heating use are much higher for houses that are predicted by REM/Rate to have a high heating energy intensity. Plots and regression results point to a systematic difference between REM/Rate and billing data that is a function of the predicted heating energy intensity.
ACEEE	Energy Analysis Beyond Benchmarking for Multi-family Buildings: Results from Wisconsin's 30 Multi-family Buildings Study	A simple analysis of the mean difference between the REM/Rate and PRISM estimates of heating use per square foot of multi-family buildings suggest a flight positive bias to the REM/Rate estimates (vs PRISM estimates), though small study size affects ability to defend this statement. REM/Rate and PRISM are noticeably congruent and there is a lack of evidence that their estimates differ systematically in this study. Lack of ability of REM/Rate to accurately predict space heating for individual buildings greatly limits utility of tool in new construction programs geared toward apartments and condominiums. However, REM/Rate will still accurately demonstrate acceptable energy upgrades, and would not recommend measures that might be incorrect in multi-family settings. REM/Rate is a reasonable tool to use for retrofit planning in smaller apartment buildings, and the use of REM/Rate in new construction could be effective where analysis is performed at unit level, or in garden apartments and row houses.

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Source	Study	Findings
NREL	Assessing and Improving the Accuracy of Energy Analysis for Residential Buildings	A general perception is that software-based energy analysis of inefficient existing homes tends to overpredict pre-retrofit energy use and retrofit energy savings. Energy Trust of Oregon performed study to evaluate programs, including SIMPLE, REM/Rate, HES, and on average REM/Rate and HES predicted energy use higher than utility bill (especially in older homes).
DOE	Review of Selected Home Energy Auditing Tools	2008 Energy Performance Score report compared REM/Rate against two versions of HES and SIMPLE, and found all tools have issues with accurate prediction of actual energy use across a broad range of house types. Conclusion from Energy Trust of Oregon study was that none of the software reviewed was extremely accurate, but SIMPLE performed the best across an entire population of houses.
DOE	Validating Savings Claims of Cold Climate Zero Energy Ready Homes	REM/RATE models aligned with BEopt baseline models on the total consumption level, but a more detailed analysis showed major discrepancies at end-use level. Only trend consistent in all three sites was REM/Rate higher prediction of LAMELs, but heating, cooling, water heating consumption alignment varied site to site. At site, heating was overpredicted by REM/Rate, but underpredicted by BEopt. Modeling methods need improvement to increase whole-building electricity consumption estimates in cold climates. To accurately model these systems in BEopt it may be appropriate to use a slightly reduced heating season performance factor input. REM/Rate currently uses data collected from the 1970s to the 1990s, thus modeling predictions are not entirely reflective of today's inverter-driven technology. Also, cold climate heating energy consumption is significantly overpredicted.
Energy Trust of Oregon	2009-2011 New Homes Billing Analysis: Comparison of Modeled vs. Actual Energy Usage	For gas heated homes, average differences between normalized and modeled gas use were less than 10% and individual differences were within 25% of modeled usages for 2/3 of homes. Average differences for electric base load usage were also less than 10%, although variability was much higher. For electric heated homes, sample sizes were too small to provide reliable results. Analysis of energy use over time showed that the energy models consistently underestimated average annual gas and electric use by a small amount. Energy models used by the program appear to be relatively accurate particularly for gas use, though they may underestimate usages. However, there are substantial deviations from modeled usage in individual homes.

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APPENDIX C. PARTICIPANT BUILDER INTERVIEW GUIDE

The following document outlines the participant builder interviews that will be completed as part of the 2015/2016 Duke Energy Residential New Construction (RNC) program evaluation. The participant builder interviews will meet objectives for *Task I1 – Participant Builder Interviews to Understand Program Freeridership, P2 – Market Research to Address Program Gaps,* and *Task P3 – Participant Builder Process Interviews.*

Goals of the Participant Builder Interviews

- Measure key indicators of market progress.
- Identify areas and recommendations for program improvement.
- Identify challenges and benefits of the transition to the new program design.
- Quantify free-ridership, separate from market effects.
- Identify barriers and possible solutions to reaching categories of lower program participation, including affordable housing, multi-family development, and high value homes.

Interview Targets

Table 30 outlines the interview targets for the Duke Energy Residential New Construction participant builder interviews. Targets for individual categories are relatively loose and do require that some builders will meet the requirements of multiple categories.

Table 30. Interview Targets

Builder Program Participation		Target Markets		TOTAL INTERVIEWS
	Interviews		Interviews	
Large (>50)*	4-6	Affordable Housing	3-4	15 - 20 Interviews
Medium (10-50)	4-6	Multi-family	3-4	
Small (<10)	3-4	High Dollar Value	3-4	

**Values in parenthesis indicate the number of participating homes built by each builder*

NOTE: Priority will be placed on builders who have completed homes under the new program structure.

Incentives

The interview guide outlines a pretty substantial/long interview. In response to the fact that we expect that builders will be on the phone with us for ~45 minutes, we will be offering a $50 incentive for their participation.

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Participant Builder Interview Guide

INTRODUCTION

Hi, my name is _____ and I'm calling from Navigant on behalf of Duke Energy, specifically the Residential New Construction program. We are talking to builders who participated in the Residential New Construction program to gather feedback for a program evaluation we are completing. I would like to talk with you for about 30-45 minutes, where we are hoping that you can give us insights into your experience that will help to identify improvements in the program and its support of you as a participating builder. In recognition of your time we are happy to offer a $50 incentive in the form of a Visa gift card.

BUILDER BACKGROUND

1. What is your current position?
2. How long have you been with your company in this current position?
3. How long has your company received incentives through the Duke Energy Residential New Construction, or RNC program?
4. How did you first hear about the Duke Energy RNC program?
5. What was the main reason that you got involved with the Duke Energy RNC program?
6. Do you see your company continuing to participate with the RNC program in future years?

CURRENT PROGRAM/TRANSITION

[NOTE FOR INTERVIEWER: In 2016, the Duke Energy RNC program underwent a transition, specifically related to the incentive structure. The new program was fully in effect as of June 1, 2016.]

1. [If builder participated in the Duke Energy RNC program prior to the program transition]. What changes have you seen as a result of the recent transition in the Duke Energy RNC program? The new version of the program was fully in effect as of June 1, 2016. [Allow time for open-ended response before moving into prompts.]
    a. Building practices [have you made changes to your homes as a result of the program changes?]
    b. Incentives [have you received greater or smaller incentives per home?]
    c. Implementer [have you seen differences in approaches or your interaction with the program?]
    d. Technical Assistance [have you received different levels of technical assistance?]
    e. Overall Satisfaction [has your overall satisfaction with the program changed?]

For the remainder of this interview, please focus your responses on your interaction with the Duke Energy RNC program following the program transition, since June 1, 2016.

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PROGRAM REQUIREMENTS

1. What do you think of the Duke Energy RNC program's eligibility requirements for construction standards and quality assurance? Do you have any major concerns or insights? Please explain.

2. Specifically focusing on the program requirements following the program transition, do you feel that the program has clearly communicated participation requirements?
    a. [If no] How could the program better communicate participation requirements?

3. Are there any areas in which the program could improve that would make it more compelling for you and other builders to participate?

BUILDING PRACTICES

1. Considering the homes that you submitted to the Duke Energy RNC program, since the program transition, what percentage of the homes were production (spec-built) homes and what percentage were custom-built homes?
    a. [Note for interviewer, the two percentages should sum to 100%]

2. Since the program transition, what percentage of the homes that you built in Duke Energy territory were submitted to the Duke Energy RNC program?
    a. [If not 100%] Why have you not submitted 100% of your homes through the program?
    b. [If not 100%] What would it take to build 100% of your homes to program standards?

3. What measures have you employed to meet the HERO/RNC program requirements? Please also note any places where these building practices differ from your standard building practices? (check as appropriate)? [Note for interviewer: please read this list of building characteristics]
    a. R-19 wall insulation (either 2x6 framing or R-3 external sheathing)
    b. R-38 or greater attic insulation to meet performance specification
    c. Radiant barrier
    d. Window U-Factor, 0.32 upgrade
    e. Window SHGC, 0.25 upgrade
    f. Enclosed crawl space
    g. R-5/10 slab insulation
    h. ACH50 less than 4 to meet performance specification
    i. HVAC duct leakage less than 4% to meet performance specification
    j. Any procedures/measures initiated for the purpose of meeting RNC program requirements not listed above? Please list _____.

4. Have you submitted homes that have been rejected from the program because they did not meet program requirements?
    a. [If yes] What have you done to either resubmit or make sure that this doesn't happen for other projects?
    b. [If yes] For these projects that didn't quite meet program standards, what were the reason(s) that the homes did not meet program requirements?

HERS RATERS/TECHNICAL SUPPORT

1. Please describe your relationship with the HERS Rater(s) who you work with for the program?

2. In what areas do you find HERS Rater(s) to be most helpful? In what areas have you learned the most from them?

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3. Have you been offered any training through the Duke Energy RNC program? Did you participate?
    a. [If yes] How satisfied were you with that training? Was it at the right level for you?

4. Are there areas where you would like additional technical support or training, either from HERS Raters or program staff?

FREE-RIDERSHIP

1. What were your company's policies regarding green building and energy efficiency prior to your participation in the Duke Energy RNC program?
2. How would your building practices be different if Duke Energy had never provided the RNC program incentive and training?
    a. Would you be building to different specifications or purchasing different products/materials?
    b. Would you employ different subcontractors or work with them differently onsite?
    c. Would your company consider a different green/energy efficient certification system for your homes, i.e. HERO (without incentive), ENERGY STAR, or LEED?
3. [If participant indicates that they would not have made any changes to building practices as a result of the Duke Energy program never having existed] You indicate that your building practices would have been the same, even if the Duke Energy program would not have existed. Would you have also made the changes to build more energy efficient homes at the same time, or would it have taken you longer to make that change?
4. What are the most significant factors that have caused you to make the decision to build energy efficient homes? [Leave this open ended first, then ask the following to clarify] Using the scale of 1 to 5, where 1 is "not at all influential" and 5 means "very influential," tell us how influential the following were on your decision to build energy efficient homes?
    a. The Duke Energy RNC Program
    b. Another energy efficient building standard, i.e. ESTAR or LEED
    c. Corporate decisions/purchasing
    d. Homebuyer preference
    e. Other market influences [Ask to clarify, if they indicate "other" was influential]
5. Using a scale of 1 to 5, where 1 is "not at all influential" and 5 means "very influential," tell us how influential the following elements were on your decision to build homes to the RNC program standards:
    a. Program incentive
    b. Program information/training from Duke Energy/ICF program staff
    c. Program marketing materials
    d. Program information provided by your HERS Rater

LOWER PARTICIPATION TARGETS

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1. Does your company build within any of the following market segments: affordable housing, multi-family, and/or high dollar value homes? To clarify, we are looking at both program and non-program homes here, but please limit your answers to building that you are doing in North Carolina. [Note to interviewer: High dollar value homes should be homes over $500,00]

[If yes to affordable housing]

2. Does your company submit any affordable housing projects through the Duke Energy RNC program?
3. It is our understanding that there may be significant challenges with program participation for affordable housing projects. Can you elaborate on any of the specific barriers to program participation that may be experienced by builders of affordable housing?
4. How could the Duke Energy RNC program better encourage participation by the affordable housing sector?

[If yes to multi-family]

5. Does your company submit any multifamily projects through the Duke Energy RNC program?
6. It is our understanding that there may be significant challenges with program participation for multi-family housing projects. Can you elaborate on any of the specific barriers to program participation that may be experienced by builders of multi-family projects?
7. How could the Duke Energy RNC program better encourage participation by the multi-family sector?

[If yes to high dollar value homes, ~$500,000 or greater]

8. Does your company submit any high dollar value homes through the Duke Energy RNC program?
9. It is our understanding that there may be significant challenges with program participation for high dollar value homes. Can you elaborate on any of the specific barriers to program participation that may be experienced by builders of high dollar value homes?
10. How could the Duke Energy RNC program better encourage program participation for high dollar value homes?

CONCLUSION:

1. Overall, how satisfied are you with the Duke Energy RNC program?
2. In closing, do you have any last insights on how the program can improve or ideas that would make participation in the program more compelling for you and other builders?

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APPENDIX D. NONPARTICIPANT BUILDER INTERVIEW GUIDE

The following document outlines the nonparticipant builder interviews that will be completed as part of the 2015/2016 Duke Energy Residential New Construction (RNC) program evaluation. The nonparticipant builder interviews will meet objectives for *Task I2 – Calculation of Net Program Savings.*

Goals of the Non-Participant Builder Interviews

- Measure key indicators of market progress.
- Quantify spillover and free-ridership.

Interview Targets

Nonparticipant builders are relatively challenging to recruit for interviews. However, their responses are significantly important to this study. As such, the evaluation team sets a target of 8-10 completed interviews. These nonparticipant builder interviews, will be focused as much as possible on builders focused on the Greater Raleigh Area, as this area comprises the majority of program activity.

Incentives

Nonparticipant builders will be offered a $50 incentive for their participation. Though the interview should be relatively short (~20 min), this incentive is offered in hopes that it supports recruiting a larger and more diverse sample.

INTRODUCTION

Hi, my name is _____ and I'm calling from Navigant on behalf of Duke Energy, specifically the Residential New Construction program. We are reaching out to builders who have not participated in the Residential New Construction program to better understand the residential construction market in North Carolina. I would like to talk with you for about 20 minutes and am hoping that your insight can help me to better understand the North Carolina residential building market as a whole. In recognition of your time we are happy to offer a $50 incentive in the form of a Visa gift card.

BUILDER BACKGROUND

1. What is your current position?
2. How long have you been with your company in this current position?
3. Annually, how many homes does your company build in North Carolina?
4. Where are these homes generally built? [i.e. Raleigh area, Ashville area, coastal, or across the state – collect as much detail as we can]

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5. How would you generally describe the standard homes that you build? [i.e. production vs. custom, low-cost, general market, or high dollar value]

DEP RNC PROGRAM

1. Are you familiar with the Duke Energy Progress (DEP) Residential New Construction program, which provides incentives to builders for building homes that meet or exceed the requirements of the NC HERO code? [The North Carolina High Efficiency Residential Option (HERO) code is an additional **voluntary** criteria of the North Carolina Energy Conservation Code for increasing energy efficiency.]

    a. **[If no]** Would knowing that Duke Energy offers incentives to builders for building homes that meet or exceed the requirements of the NC HERO code, cause you to consider building above code?
    b. **[If yes]** Why have you chosen not to participate in the program?
    c. **[If yes]** Are you considering participating in the program in the future?
    d. **[If yes]** Are you familiar with the two separate paths for participation in the DEP program? [If needed, the whole house path and the equipment path]
        i. Would you be more likely to consider participating in one or the other?
    b. **[If yes]** Are there any changes that could be made to the program to make it more compelling for you or other builders to participate?

ENERGY EFFICIENCY DECISIONS

1. Do you regularly build to any specific energy efficient building standards?
    a. **[If yes]** Why? What drives your decision to build to these standards?
    b. **[If no]** Why not?
2. What portion of your homes are verified to meet the NC HERO code?

3. Do any of your equipment or building envelope systems exceed minimum energy code levels? [i.e. specifying equipment above code, including additional insulation, etc.]

BUILDING PRACTICES

Now I would like to discuss specific building practices with you. For these questions, please focus your answers on the homes that you have built in North Carolina during 2017.

Framing Practices

1. In what percentage of the homes you constructed in 2017 was the **attic/ceiling interface** framed such that all attic penetrations include a full interior air barrier aligned with insulation, and that any gaps in the air barrier are fully gasketed and/or sealed with caulk, foam, or mastic?

    [Openings in the attic ceiling interface include for example: the attic access panel, attic drop-down stair, recessed lighting fixtures, and whole house fan applications.]

2. In what percentage of the homes you constructed in 2017 were the **chases and soffits capped**, such that all openings to unconditioned spaces, including dropped ceiling soffits, shafts, and chases are sealed with a rigid air barrier and air sealed?

    [Where drop ceilings or soffits occur at exterior walls, air barriers shall be included at the wall as well as the attic floor.]

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3. In what percentage of the homes you constructed in 2017 were the **thermal bypass paths eliminated** through the proper alignment of insulation and the air barrier at the garage ceiling and cantilevered floor assemblies and that all seams, gaps, and holes in the air barrier are sealed caulk or foam?

   [For a garage with conditioned space above, a continuous rigid air barrier or other supporting material separates the garage from conditioned space. For cantilevered floors, a continuous rigid air barrier or other supporting blocking separates the cantilever from the conditioned space. This air barrier can be the exterior finished material if it is airtight.]

4. In what percentage of the homes you constructed in 2017 were the **knee walls backed**, such that a continuous top and bottom plate or blocking is installed at the top and bottom or all knee walls including exposed edges of insulation at the joists and rafters?

   [Attic knee walls are backed with a rigid air barrier or other supporting material to prevent insulation from sagging. Where truss framing is used, the top and bottom of each framing bay is blocked.]

Insulation Practices

5. In what percentage of the homes you constructed in 2017 was the insulation installed in cavities framed on all six sides, in **full contact with the air barrier**, and had no gaps, voids, compressions, or misalignments with the air barrier?

   [Insulation is cut and split around any wiring, pipes, or blocking and is correctly sized for wall width and height.]

6. In what percentage of the homes you constructed in 2017 was **the insulation maintaining permanent contact with the sub-floor** above, including necessary supports (e.g. staves for blankets and netting for blown-in)?

   [Insulation has no gaps, voids, compression, or misalignment with the air barrier. Blown-in insulation has proper density with firm packing.]

7. In what percentage of the homes you constructed in 2017 were **rough openings around windows and exterior doors air sealed** using a backer rod, caulk, or low expansion foam?

   [Fibrous insulation is not used for sealing gaps, typical expansion foam is not used for sealing around windows and doors as it might interfere with the proper functioning of the window or door.]

8. In what percentage of the homes you constructed in 2017 were **all openings or penetrations** between conditioned and unconditioned spaces, such as penetrations in framing made by plumbers, electricians, or HVAC contractors are **sealed** with solid backing and caulk or foam, as needed.

9. In what percentage of the homes you constructed in 2017 were the **roof trusses constructed** so that the **full value of attic insulation** can be installed over the exterior top-plates?

   [This is typically 10" for R38 insulation.]

HVAC Practices

10. In what percentage of the homes you constructed in 2017 were the installed **heating and cooling equipment sized** based on the ACCA Manual J or 2009 ASHRAE?

11. In what percentage of the homes you constructed in 2017 were all HVAC components at all seams, gaps, and holes **sealed with mastic** before installing insulation?

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[Additionally, insulation is installed without misalignments, compressions, gaps, or voids around all connections and exposed ductwork. Duct insulation is sealed in place with mastic.]

12. In what percentage of the homes you constructed in 2017 were the **room pressures balanced and air flow volumes optimized**?

    [Jump ducts, dedicated returns in each room, or under-cut doors are used to provide proper air flow for pressure balancing. Connections and routing of duct work do not have kinks or sharp bends and usually take the path of least resistance.]

General

13. Do you have an internal quality assurance process for verifying that the measures referenced above were effectively implemented? If yes, can you describe briefly?

ENERGY EFFICIENCY IN THE MARKET

1. Are you familiar with HERS Raters as home building subcontractors?
    a. **[If yes]** Ask question #2
    b. **[If no]** Move to question #3

2. Do you work with a HERS Rater?
    a. **[If yes]** What services do they provide for you?
    b. **[If no]** Is there any reason in particular why you do not?

3. Do you see any benefit in building high efficiency homes? What do you see as the advantages or disadvantages of advertising a home as energy efficient?

4. How would you describe the level of customer demand for higher efficiency new homes? [high, moderate, low]

5. From your perspective, are realtors and appraisers willing/able to add a price premium to energy efficient homes?

6. How would you describe builder competition in the North Carolina market in relation to energy efficiency? Are all builders generally building to the same level of efficiency, or is there a large range between different builders?

CONCLUSION

1. In conclusion, do you have anything else that you would like to tell us about your building practices in terms of energy efficiency or the North Carolina market as a whole?

2. Before we hang up, I need to capture your current contact information so that we can mail you the $25 Visa gift card.
    a. Name:
    b. Street Address:
    c. City/State:
    d. Zip Code:

    The gift card will be mailed once all interviews are complete and are expected to arrive within 4-6 weeks.

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Thank you for your time today. Please feel free to reach out if you have any questions or additional thoughts you'd like to share.

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APPENDIX E. HERS RATER INTERVIEW GUIDE

The following document outlines the HERS Rater interviews that will be completed as part of the 2015/2016 Duke Energy Residential New Construction (RNC) program evaluation. The HERS Rater interviews will meet objectives for *Task I2 – Calculation of Net Program Savings.*

Goals of the HERS Rater Interviews

- Measure key indicators of market progress.
- Quantify spillover and free-ridership.

Interview Targets

The evaluation team targets completing with 6-8 HERS Raters interviews from the population described in Table 31. These interviews will prioritize discussions with the most active HERS Raters, but will supplement as necessary with some of the smaller/less active HERS Raters.

Table 31. Characteristics of DEP RNC Program HERS Raters

Registered with DEP RNC Program	Completed Projects in PY2016	Completed >50 Projects in PY2016	Completed <50 Projects in PY2016
23	20	8	12

Incentives

HERS Raters will be offered a $50 incentive for their participation. Though the interview should be relatively short (20-30 min), this incentive is offered in hopes that it supports recruiting efforts.

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HERS Rater Interview Guide

INTRODUCTION

Hi, my name is _____ and I'm calling from Navigant on behalf of Duke Energy, specifically the Residential New Construction program. We are reaching out to HERS Raters who have participated in the Residential New Construction program to better understand the residential construction market in North Carolina. I would like to talk with you for about 20-30 minutes and am hoping that your insight can help me to better understand the North Carolina residential building market as a whole. In recognition of your time we are happy to offer a $50 incentive in the form of a Visa gift card.

RATER BACKGROUND

1. What is your current position?
2. How long have you been with your company in this current position?
3. How long have you worked with the Duke Energy (DEP) Residential New Construction program [previously Home Advantage, prior to 2014]?
4. How did you first learn about the RNC program?
5. What was the main reason you got involved with the RNC program?

DEP RNC PROGRAM EXPERIENCE

1. Annually how many homes does your company rate in North Carolina?
2. How much of your current work is through the DEP RNC program? [Prompt for a percentage]
3. How many builders do you work with in the RNC program [one or multiple]?
4. At what point in the plan development process do you typically begin interacting with builders for each home? [During the initial design phase; during the design review phase, prior to design completion; after the design is finalized]
5. In your experience, what percentage of home plans submitted by builders participating in the program achieve a program-qualifying level of efficiency upon your initial review of the plan?
6. In the cases where a home plan does not achieve a qualifying level of efficiency upon your initial review, how would you characterize the extent to which plans require revisions? [Significant revisions required, moderate revisions required, minor revisions required]
    a. What are the most common reasons that a home plan does not qualify? [Thermal bypass checklist issues, window to wall ratio, insulation levels, HVAC system]
    b. How many iterations of the plan are typically needed?
7. For the builders you work with who are not currently involved in the DEP RNC program, what improvements would be necessary to meet the program requirements?
8. For these builders that are not currently involved in the DEP RNC program, are there other energy efficiency certifications that these builders are pursuing?

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BUILDING PRACTICES

Now I would like to discuss specific building practices with you. For these questions, please focus your answers on your work completed on homes built within Duke Energy Progress territory during 2017. **[Specifically focus on North Carolina.]** For each of these questions about specific building practices, I would like you to provide three percentages: (1) total percentage of homes constructed in DEP territory that exhibit this building practice, (2) percentage of program homes exhibiting this building practice, and (3) percentage of non-program homes exhibiting this practice.

Framing Practices

14. In what percentage of the homes constructed in DEP territory in 2017 was the **attic/ceiling interface** framed such that all attic penetrations include a full interior air barrier aligned with insulation, and that any gaps in the air barrier are fully gasketed and/or sealed with caulk, foam, or mastic?

    [Openings in the attic ceiling interface include for example: the attic access panel, attic drop-down stair, recessed lighting fixtures, and whole house fan applications.]

15. In what percentage of the homes constructed in DEP territory in 2017 were the **chases and soffits capped**, such that all openings to unconditioned spaces, including dropped ceiling soffits, shafts, and chases are sealed with a rigid air barrier and air sealed?

    [Where drop ceilings or soffits occur at exterior walls, air barriers shall be included at the wall as well as the attic floor.]

16. In what percentage of the homes constructed in DEP territory in 2017 were the **thermal bypass paths eliminated** through the proper alignment of insulation and the air barrier at the garage ceiling and cantilevered floor assemblies and that all seams, gaps, and holes in the air barrier are sealed caulk or foam?

    [For a garage with conditioned space above, a continuous rigid air barrier or other supporting material separates the garage from conditioned space. For cantilevered floors, a continuous rigid air barrier or other supporting blocking separates the cantilever from the conditioned space. This air barrier can be the exterior finished material if it is airtight.]

17. In what percentage of the homes constructed in DEP territory in 2017 were the **knee walls backed**, such that a continuous top and bottom plate or blocking is installed at the top and bottom or all knee walls including exposed edges of insulation at the joists and rafters?

    [Attic knee walls are backed with a rigid air barrier or other supporting material to prevent insulation from sagging. Where truss framing is used, the top and bottom of each framing bay is blocked.]

Insulation Practices

18. In what percentage of the homes constructed in DEP territory in 2017 was the insulation installed in cavities framed on all six sides, in **full contact with the air barrier**, and had no gaps, voids, compressions, or misalignments with the air barrier?

    [Insulation is cut and split around any wiring, pipes, or blocking and is correctly sized for wall width and height.]

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19. In what percentage of the homes constructed in DEP territory in 2017 was **the insulation maintaining permanent contact with the sub-floor** above, including necessary supports (e.g. staves for blankets and netting for blown-in)?

    [Insulation has no gaps, voids, compression, or misalignment with the air barrier. Blown-in insulation has proper density with firm packing.]

20. In what percentage of the homes constructed in DEP territory in 2017 were **rough openings around windows and exterior doors air sealed** using a backer rod, caulk, or low expansion foam?

    [Fibrous insulation is not used for sealing gaps, typical expansion foam is not used for sealing around windows and doors as it might interfere with the proper functioning of the window or door.]

21. In what percentage of the homes constructed in DEP territory in 2017 were **all openings or penetrations** between conditioned and unconditioned spaces, such as penetrations in framing made by plumbers, electricians, or HVAC contractors are **sealed** with solid backing and caulk or foam, as needed.

22. In what percentage of the homes constructed in DEP territory in 2017 were the **roof trusses constructed** so that the **full value of attic insulation** can be installed over the exterior top-plates?

    [This is typically 10" for R38 insulation.]

HVAC Practices

23. In what percentage of the homes constructed in DEP territory in 2017 were the installed **heating and cooling equipment sized** based on the ACCA Manual J or 2009 ASHRAE?

24. In what percentage of the homes constructed in DEP territory in 2017 were all HVAC components at all seams, gaps, and holes **sealed with mastic** before installing insulation?

    [Additionally, insulation is installed without misalignments, compressions, gaps, or voids around all connections and exposed ductwork. Duct insulation is sealed in place with mastic.]

25. In what percentage of the homes constructed in DEP territory in 2017 were the **room pressures balanced and air flow volumes optimized**?

    [Jump ducts, dedicated returns in each room, or under-cut doors are used to provide proper air flow for pressure balancing. Connections and routing of duct work do not have kinks or sharp bends and usually take the path of least resistance.]

ENERGY EFFICIENCY DECISIONS

1. What do you see as the benefit of building high efficiency homes? What do you see as the advantages or disadvantages of advertising a home as energy efficient?

2. From your perspective, how receptive are realtors and appraisers to attribute added value to energy efficient homes?

3. How would you describe builder competition in the North Carolina market in relation to energy efficiency? Are all builders generally building to the same level of efficiency, or is there a large range between different builders?

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4. How would you describe the builders who participate in the DEP RNC program? Do program participating builders represent a general cross-section of all builders in terms of efficiency, or do they tend to be the most efficient builders?

5. How would you describe the builders who choose not to participate in the DEP RNC program? What are the most common reasons why builders choose not to participate?

CONCLUSION

3. In conclusion, do you have anything else that you would like to tell us about your building practices in terms of energy efficiency or the North Carolina market as a whole?

4. Before we hang up, I need to capture your current contact information so that we can mail you the $50 Visa gift card.
    a. Name:
    b. Street Address:
    c. City/State:
    d. Zip Code:

    The gift card will be mailed once all interviews are complete and are expected to arrive within 4-6 weeks.

    Thank you for your time today. Please feel free to reach out if you have any questions or additional thoughts you'd like to share.

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APPENDIX F. ONSITE DATA COLLECTION PLAN

This document presents a summary of Navigant's plan to conduct onsite field verification as part of the evaluation efforts for the Residential New Construction Program. This field verification will occur during June and July of 2017 in Duke Energy Progress jurisdictions. The Duke Energy Call Center has been notified of these efforts and the date ranges. During field site visits, Navigant technicians will assess the quantities and efficiency characteristics of the prescriptive, equipment only program measures (HVAC and water heating) and will compare field findings to the reported measure tracking database. The field technicians have received safety training, and each is categorized into a field tier level by Navigant's Field Operations Group based on experience and training. The field work for this program does not consist of any metering or measurements of live electrical equipment.

Navigant will contact homeowners of Residential New Construction prescriptive measure participants to schedule site visits, and will request access to HVAC and water heating equipment for verification. Navigant will send postcards to customers identified for potential verification before scheduling. Field technicians will leave an informational letter behind with each homeowner describing the reason for the inspection and providing them with contact information should they have any follow-up questions.

Sampling

As identified in the evaluation plan, Navigant will visit 40 prescriptive measure sites. Based on the experience from the HVAC study during the PY2013-14 evaluation, 40 sites should be adequate to meet the precision and confidence levels necessary for this evaluation. Navigant plans to stratify the sample based on equipment incentivized, region, and home type (i.e. single family vs. multi-family) such that the sample is representative of the population of participants for these equipment only measures. We are still analyzing the tracking data to determine the example sample quota for each strata, however this final stratification will be shared with the Duke Energy team prior commencing recruitment for this study.

Data Collection

Measure Specific
Navigant will verify prescriptive HVAC and Heat Pump Water Heaters installed through the program. Verification will include equipment specifics such as equipment type, make, and model. The collected data will be compared to values in the tracking database and previous deemed savings assumptions to assess the accuracy of program reporting and evaluate other customer-initiated efficiency changes. Navigant will collect basic home characteristics such as square footage, year built and conditioned stores of homes verified.

Field Equipment
Navigant will use the following equipment for this evaluation: flashlight, camera, and field collection form loaded onto an iPad. All data collected during these sit visits will be collected through Fulcrum, an online data entry system, which allows the field tech to combine notes and pictures from each site. The data from each site visit will be uploaded to a secure server for QC and storage.

HVAC

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Field technicians will record the type, make and model of the HVAC system. Prescriptive Air Source Heat Pump system information will be collected. Navigant will collect both heating and cooling equipment information if an Air Source Heat Pump is not identified onsite.

Water Heaters
Field technicians will record the type, make and model of water heating equipment. Prescriptive Heat Pump Water Heater information will be collected. Navigant will also collect water heating equipment information if a Heat Pump Water Heater is not identified onsite.

Customer Survey

In the event that the field technicians have an opportunity to speak with the resident, they will ask a brief list of questions to collect additional information about measures unrelated to the verification for the Residential New Construction program, but of interest to Duke Energy Progress.[31] Table 32 identifies the four additional measures and associated characteristics to be collected.

Table 32. Secondary Measures for Field Data Collection

	Lighting (non-hard wired)	Smart Strips	Smart Thermostats	Home Automation
Installed quantity	x	x	x	x
Installed type	x			
Installed wattage	x			
Attached equipment		x		x

Lighting
Navigant will verify non-hard wired lighting with the customer should time permit. Lighting types, quantity and installed wattages will be collected. Wattage will be collected, but only total quantities will be collected and not broken out by wattage.

Smart Strips
Smart strip use will be collected in addition to total quantity in use. Attached equipment controlled by smart strips will be collected. Attached equipment could include: TV, DVR, set-top-box, video game systems, computer, printer, scanner, modem, router, and all-in-one unit.

Smart Thermostat
In addition to smart thermostat type, Navigant will verify if programmable thermostats have been programmed properly.

Home Automation
Navigant will verify if the customer was offered home automation products by their homebuilder, or whether they are interested in installing any home automation products. Additionally, Navigant will verify automation products currently in use by the customer such as: Amazon Echo, Google Home, connected music system, lighting automation, connected locks, connected security and smart meters.

[31] A request to collect this additional data was transmitted to the Navigant team by Marc Faircloth on April 28, through email.

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EM&V Report for the EnergyWise Home Program

Winter 2017/2018

Presented for:
Duke Energy Progress

Prepared by:
Navigant Consulting, Inc.

August 6, 2018

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EXECUTIVE SUMMARY

The EnergyWise Home (EnergyWise) demand response (DR) program offers Duke Energy Progress (DEP) residential customers the opportunity to earn credit on their electricity bill by allowing DEP to remotely control the following appliances during times of seasonal peak consumption:

- Summer: Air conditioning
- Winter: Water heater and heat pump auxiliary heating strips

This report covers evaluation, measurement, and verification (EM&V) activities conducted by Navigant for this program during the winter of 2017/2018. The total program population in this period included approximately 10,000 water heater participants and approximately 5,000 heat strip participants.

Navigant estimated impacts using logger data from a sample of 70 participating households.[1] Participating households were split randomly into two separate EM&V samples and curtailed in alternating order throughout the winter. These groupings are referred to as EM&V Group A and EM&V Group B (or Group A and Group B) throughout this report.

Each EM&V group was subject to nine DR events (18 events[2] in total across both groups) during which both heat strips and water heaters were curtailed and four additional events each (eight across both groups) during which only water heaters were curtailed. Altogether the EM&V sample was subject to 26 curtailment events over the analysis period. The overall program population was subject to six of these 26 events, all occurring in January. Both appliances were controlled for all population events.

At the program level, Navigant has estimated the DR capability delivered by heat strips to be approximately 7.2 MW and the DR capability of water heaters to be approximately 5.6 MW. These values, the average capability of an appliance that is responsive to DEP's control signal, and a series of adjustment factors that account for non-responsive devices, devices not in use, and devices not connected are summarized in Table ES-1. This table also provides the same metrics, on average, across the six events to which the entire program population was subject.

Table ES-1. Estimated Program Impacts

	Appliance Type	Impact per Appliance (kW)*	Relative Precision (+/- %)	% Non-Responsive	% Not in Use	% Not Connected	Pop. Avg. Impact per Appliance (kW)	Total Program Impact (MW)
Projected Capability (Ex Ante)	Heat Strips	**3.11**	20%	41%	13%	4%	**1.39**	**7.2**
	Water Heaters	**0.57**	21%	5%	0%	0%	**0.54**	**5.6**
Population Impact - Winter 2017/2018 (Ex Post)	Heat Strips	**2.77**	8%	32%	19%	4%	**1.30**	**6.7**
	Water Heaters	**0.41**	9%	4%	0%	0%	**0.40**	**4.1**

*Includes only partially or fully responsive appliances.
Relative precision is estimated at the 90% confidence level.

[1] Navigant deployed loggers to 78 homes as an intentional over-sample; data of sufficient quality to include in the regression analysis was recovered from 70 of these homes.

[2] Thirteen of these events were EM&V events, and six were the January general population events.

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Source: Navigant analysis

The principal factors driving the differences between the projected capability and population historical impacts are summarized in Table ES-2.

Table ES-2. Differences Between Projected Capability and Historical Population Impact

Metric/Assumption	Projected Capability (Ex Ante)	Population Impact – Winter 2017/2018 (Ex Post)
Average event temperature for heat strip events (°F)	10[3]	15.8
Timing of water heater event	8:00-9:00[4]	Mixed Events started as early as 6:00 and as late as 6:30 Events ended as early as 7:30 and as late as 10:00
Non-responsive rate (all appliances)	Average across all EM&V events, grouped by temperature band	Event-specific non-responsiveness rate
Device not in use rate (heat strips only)	Average across all EM&V events, grouped by temperature band[5]	Event-specific device not in use rate

Sources: DEP program staff, Navigant analysis

Navigant conducted its analysis at the appliance level, rather than the customer level. Although the impact per customer and the impact per appliance are very close, there are, on average, slightly more than one appliances controlled per household. The table immediately below provides the average number of appliances controlled per participating customer household[6] and the average impact per customer for responsive (fully or partially) devices and for the population average as a whole (i.e., accounting for non-responsive, non-connected, and not in use devices).

Table ES-3. Per Customer Impacts

	Appliance Type	Impact per Appliance (kW)*	Avg. # of Appliances per Customer	Impact per Customer (kW)*	Pop. Avg. Impact per Customer (kW)**
Projected Capability (Ex Ante)	Heat Strips	**3.11**	1.083	3.37	1.51
	Water Heaters	**0.57**	1.021	0.58	0.55
Population Impact - Winter 2017/2018 (Ex Post)	Heat Strips	**2.77**	1.083	3.00	1.40
	Water Heaters	**0.41**	1.021	0.42	0.40

[3] Specified by DEP staff as the appropriate temperature for evaluating system peak capability.

[4] Specified by DEP staff as the appropriate period of time for evaluating system peak capability. Note that unless stated otherwise all times provided in this report are in the 24-hour format—e.g., 8:00 a.m. is represented as 8:00 and 8:00 p.m. is represented as 20:00.

[5] See Section 4.2.1 for additional details.

[6] Derived from the population program tracking database.

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**Includes only partially or fully responsive appliances*
***Accounts for devices not in use or not responsive to curtailment signal.*

Source: Navigant analysis and DEP program tracking data.

Evaluation Objectives

The key objectives for the impact analysis conducted as part of this evaluation were identified in Navigant's evaluation plan; they include the following:

1. **Estimating hourly kilowatt (kW) DR impacts by device type (i.e., water heaters and auxiliary heat strips).** Navigant estimated the average kW DR impact for all EM&V events[7] and population-wide events by quarter-hour or hour. Quarter-hourly impacts for EM&V and population-wide events are provided in Appendix D, an Excel spreadsheet attached as a separate document.
2. **Estimating the program-level DR impact per population-wide event.** Based on regression-estimated relationships, observed temperatures, and the findings of the field work and switch responsiveness analysis, Navigant has estimated the average demand impact of the program for each event to which the entire program population (i.e., not just the EM&V sample) was subject.
3. **Estimating hourly kW snapback impacts.** Navigant has estimated the average kW snapback[8] impact for all EM&V events and population-wide events by quarter-hour. Quarter-hourly impacts for EM&V and population-wide events are provided in Appendix D, an Excel spreadsheet attached as a separate document.
4. **Estimating average event load shed capability.** Navigant has applied the regression-estimated parameters to a series of assumed average event temperatures to deliver a projected load shed under a variety of weather conditions. As in previous years' evaluations, this is presented graphically, showing average event temperature/event impact pairs for actual 2017/2018 events as data points and the estimated average event temperature/event impacts relationship as a line extending through the range of temperatures presented on the plot. The values underlying this plot are provided in Appendix D, an Excel spreadsheet attached as a separate document.
5. **Quantifying switch responsiveness and operability.** Navigant's analysis reports the percentage of switches found to be inoperative when inspected as part of the field metering study and the proportion of devices that appeared to be:
    - Fully responsive to the curtailment signal
    - Partially responsive to the curtailment signal (heat strips only)[9]
    - Totally unresponsive to the curtailment signal
    - Not in use at the time of the DR event (heat strips only)

[7] To improve precision, EM&V participants are subjected to substantially more curtailment events than the program population as a whole.

[8] Snapback refers to the manner in which demand from water heaters or HVAC systems tends to rise considerably above normal levels in the period immediately following a DR event as the equipment works to restore water or air temperature to its setpoint level.

[9] "Partial response" refers to the apparent curtailment of the load punctuated with short load spikes throughout the curtailment period. An explanation for this behavior is provided below.

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6. **Providing a clear technical description of the analytic approach.** A detailed description of the approach Navigant used may be found in Appendix B. This is most suitable for technical reviewers or those interested in reproducing the analysis. A higher-level description of the evaluation team's approach may be found in Chapter 2 of this report.

The key objectives for the process analysis conducted as part of this evaluation were identified in Navigant's evaluation plan; these include the following:

1. **Assessing participant satisfaction with DEP and the EnergyWise programs.** Responses to general questions about program and utility satisfaction have been compared to responses recorded in prior years.
2. **Assessing the degree to which customer comfort is affected by curtailment.** Navigant deployed post-event surveys and one placebo[10] post-event survey to determine how severe participant discomfort is during winter DR events.

Evaluation Methods

For the evaluation of the winter 2017/2018, Navigant undertook both process and impact analyses.

Impacts were estimated using appliance load data collected from data loggers deployed and in place over the winter season. These data were combined with weather and event schedule data to allow the evaluation team to estimate a fixed effects regression that delivered an estimated relationship between heat strip DR impacts and outdoor temperature and water heater impacts and the time of day. A significant difference from prior winter EnergyWise evaluations is the use of a randomized control trial (RCT) style experimental design.

For the RCT design, all EM&V participants were randomly assigned to two Groups: Group A and Group B. When Group A was curtailed, Group B was not, and vice versa. This means that there are available contemporaneous observations of non-curtailed appliance demand on event days to help develop the baseline (also referred to as counterfactual) demand. This differs significantly from previous winters in which all EM&V participants were curtailed for all events, and baseline estimation was driven by the use of similar weather non-event days.

The RCT approach's principal benefit is making the analysis much less sensitive to model specification bias: the baseline estimation relies much less on the accuracy of analyst assumptions about demand-driving relationships because of the availability of a contemporaneous control group not subject to curtailment.

The process analysis is driven by data collected from a series of phone surveys fielded to a sample of EnergyWise participants immediately following DR events and a placebo event where no real event was called. Navigant's process findings were driven by an analysis of these survey responses.

Impacts

The principal EM&V findings regarding winter 2017/2018 event demand impacts are as follows:

[10] A "placebo" event (in the context of the survey analysis) refers to a survey deployed in which participants were allowed to believe that an event had recently occurred when in fact none had. This provides a valuable control for assessing participant survey responses to actual events.

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- **The current DR capability of DEP's EnergyWise program in the winter is approximately 13 MW.** This is the sum of the projected program capability of 7.2 MW from heat strip curtailment when the average temperature is 10°F and 5.6 MW from water heater curtailment deployed between 8:00 and 9:00 on winter mornings.
- **The estimated average program impact of the six population events deployed in the winter of 2017/2018 was approximately 11 MW.** This is the sum of the estimated average impact of 6.7 MW from heat strips where the average event temperature was slightly less than 16°F and an estimated average impact of 4.1 MW from water heaters where events began as early as 6:00 and ended as late as 10:00 in the morning.
- **The estimated impact per set of heat strips (that responded in some way to DEP's curtailment signal) controlled during the population events was 2.77 kW, and the estimated impact per responsive water heater during the same events was 0.41 kW.** On the coldest event (January 7, 2018) the average impact per responsive, including both fully and partially responsive, set of heat strips was 3.1 kW. The reason why the average water heater population event impact was lower than the projected capability is due to the differing time-spans – population events could start as early as 6:00 and end as late as 10:00, whereas the population capability was calculated assuming an event from 8:00 to 9:00.
- **Navigant's investigation into the cause of why some heat strips were only partially responsive during curtailment events concluded that this behavior was driven by a heat pump's auto-defrost cycle.** Navigant logged heat pump compressors as well as heat strips to test the hypothesis that partial response was a result of a heat pump's defrost cycle periodically overriding the control signal. If this were the cause of the partial response, the expectation would be that the demand spikes characteristic of partial response would be coincident with a shutdown of the compressor fan to thaw the compressor coils. The evaluation team confirmed that this was the case, and that partial response (as defined here) was a result of the defrost cycle.
- **On average, of heat strips in use on the event day, approximately 40% were fully responsive to the curtailment signal and approximately 20% were partially responsive.** The percentage of devices not in use varied significantly across events and was correlated with outdoor temperature. During the four events in which the average event temperature was less than 15°F, 13% of heat strips expected to curtail were not in use, on average. In contrast, for the six events in which the average temperature was between 30°F and 40°F, 41% of heat strips were not in use, on average.

Participant Perceptions

The evaluation team conducted post-event phone surveys with 401 EnergyWise participants during this study. The surveys were conducted after three real DR events and one placebo event. For the placebo event, respondents were told that an event had been called when in fact one had not. All surveyed participants were from the general program population, as those involved in Groups A and B for the field study were removed from the survey sample.

Of the 401 survey respondents, 301 were surveyed after real DR events; the remaining 100 were surveyed after the placebo event. The surveys achieved a relative precision of ±3% at the 90% confidence level for key quantitative outcomes.

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Analysis of these participant perception surveys was intended to determine the degree to which participants were aware of curtailment events, and if aware, what changes participants noticed during the event, including perceptions of comfort.

The principal EM&V findings from the analysis of participant perception were as follows:

- **Participants were generally unaware of curtailment events when they happened.** Most (>90%) survey respondents indicated that they had not been aware that an event had occurred recently.
- **The program has little impact on the comfort of its participants.** Only 23 respondents (out of 301 event participants) were aware that an event had been called during the period in question. For that subgroup, comfort levels reported during the event varied widely, ranging from a rating of a 0 to a 10 on the 0-10 comfort scale, with only two rating their comfort less than 5. Most survey respondents indicated that they were “very comfortable” during the event.
- **The program does not appear to be a key driver of supplemental heating use.** A similar portion of placebo survey respondents reported using supplemental methods for heating their homes during “event” periods as those respondents who were subject to actual events.
- **Participants were generally satisfied with the EnergyWise program.** Over half of the respondents indicated that they were very satisfied, while only 4% of all survey respondents (18 people) indicated that they were “dissatisfied” with the program. Satisfaction with the program did not differ significantly between respondents who responded to actual events versus those who responded to placebo events.
- **Fewer than half of participants were aware of the bill credits they receive as part of their program participation.** Every customer enrolled in the program receives a hardcopy brochure explaining the bill credits details (when the are received, amounts, etc.). It is important to note that many of the particpants received their bill credits outside the EM&V study calendar.

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1. PROGRAM DESCRIPTION AND RESEARCH OBJECTIVES

The EnergyWise Home (EnergyWise) demand response (DR) program offers Duke Energy Progress (DEP) residential customers the opportunity to earn credit on their electricity bill by allowing DEP to remotely control the following appliances during times of seasonal peak consumption:

- Summer: Air conditioning
- Winter: Water heater and heat pump auxiliary heating strips

This report covers evaluation, measurement, and verification (EM&V) activities conducted by Navigant for this program during the winter of 2017/2018. The total program population in this period included approximately 10,000 water heater participants and approximately 5,000 heat strip participants.

Navigant estimated impacts using logger data from a sample of 70 participating households. Participating households were split randomly into two separate EM&V samples and curtailed in alternating order throughout the winter. These groupings are referred to as EM&V Group A and EM&V Group B (or Group A and Group B) throughout this report.

Each EM&V group was subject to nine DR events (18 events in total across both groups) during which both heat strips and water heaters were curtailed and four additional events each (eight across both groups) during which only water heaters were curtailed. Altogether the EM&V sample was subject to 26 curtailment events over the analysis period.

EM&V is a term adopted by DEP and refers generally to the assessment and quantification of the energy and peak demand impacts of an energy efficiency or DR program. For DR, estimating peak demand reductions is the primary objective, as energy impacts are generally negligible. EM&V also encompasses an evaluation of program processes and customer feedback, typically conducted through participant surveys.

1.1 Evaluation Objectives

This EM&V report is intended to support program improvements and to verify program impacts as per the requirements established by the North Carolina Utilities Commission and the Public Service Commission of South Carolina.

The key objectives for the impact analysis conducted as part of this evaluation were identified in Navigant's evaluation plan; these include the following:

1. **Estimating hourly kilowatt (kW) DR impacts by device type (i.e., water heaters and auxiliary heat strips).** Navigant estimated the average kW DR impact for all EM&V events[11] and population-wide events by quarter-hour or hour. Quarter-hourly impacts for EM&V and population-wide events are provided in Appendix D, an Excel spreadsheet attached as a separate document.
2. **Estimating the program-level DR impact per population-wide event.** Based on regression-estimated relationships, observed temperatures, and the findings of the field work and switch responsiveness analysis, Navigant has estimated the average demand impact of the program for each event to which the entire program population (i.e., not just the EM&V sample) was subject.

[11] To improve precision, EM&V participants are subjected to substantially more curtailment events than the program population as a whole.

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3. **Estimating hourly kW snapback impacts.** Navigant has estimated the average kW snapback[12] impact for all EM&V events and population-wide events by quarter-hour. Quarter-hourly impacts for EM&V and population-wide events are provided in Appendix D, an Excel spreadsheet attached as a separate document.
4. **Estimating average event load shed capability.** Navigant has applied the regression-estimated parameters to a series of assumed average event temperatures to deliver a projected load shed under a variety of weather conditions. As in previous years' evaluations, this is presented graphically, showing average event temperature/event impact pairs for actual 2017/2018 events as data points and the estimated average event temperature/event impacts relationship as a line extending through the range of temperatures presented on the plot. The values underlying this plot are provided in Appendix D, an Excel spreadsheet attached as a separate document.
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1. **Assessing participant satisfaction with DEP and the EnergyWise programs.** Responses to general questions about program and utility satisfaction have been compared to responses recorded in prior years.
2. **Assessing the degree to which customer comfort is affected by curtailment.** Navigant deployed post-event surveys and one placebo[13] post-event survey to determine how severe participant discomfort is during winter DR events.

1.2 Program Overview

The EnergyWise program was developed in response to DEP's determination that a curtailable load program would be a valuable resource for the company and would provide an opportunity to engage directly with customers to help reduce costly seasonal peak demand. The program seeks to attract DR

[12] Snapback refers to the manner in which demand from water heaters or HVAC systems tends to rise considerably above normal levels in the period immediately following a DR event as the equipment works to restore water or air temperature to its setpoint level.

[13] A "placebo" event (in the context of the survey analysis) refers to a survey deployed in which participants were allowed to believe that an event had recently occurred when in fact none had. This provides a valuable control for assessing participant survey responses to actual events.

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resources by incenting residential customers to allow DEP to remotely control water heater and heat pump auxiliary heating strips in the winter months.

The winter program offers an annual bill credit of $25 for each enrolled appliance type. Electric water heaters and heat pumps with auxiliary heat strips may be enrolled in the program, allowing DEP to control those appliances during EnergyWise DR events.

Eligibility. To be eligible to participate in the EnergyWise program, a household must meet the following criteria:

- The participant's heat pump must be a central unit with a ducted system. Wall, window, and ductless units are not eligible for participation.
- All central heat pump units in the home must be controlled by DEP as part of the EnergyWise program.
- Residential electricity service must be in the name of the participant.

Incentives. Each participant receives a one-time bill credit of $25 upon joining the program and then an additional $25 bill credit annually per appliance type controlled to encourage continued participation.

Marketing. DEP is responsible for all marketing of the EnergyWise program. Participation leads are generated through a mix of direct mailings, email, outbound calling, and canvassing door to door.

1.3 Reported Program Participation

The overall program participation for the EnergyWise program is discussed in this section. The sample sizes for the EM&V analysis may be found in Section 2.1.1.

Six population-wide DR events were called in the winter of 2017/2018 for the EnergyWise program, all in January. The total program population (subject to winter curtailment) in this period included approximately 10,000 water heater participants and approximately 5,000 heat strip participants.[14]

The date, time,[15] and length of each event are provided in Table 1-1. For each event, both heat strips and water heaters were controlled.

[14] The precise values provided to Navigant by DEP to calculate program impacts were 5,154 sets of heat strips controlled (4,777 participants) and 10,316 water heaters controlled (10,107 participants).

[15] Note that unless stated otherwise all times provided in this report are in the 24-hour format—e.g., 8:00 a.m. is represented as 8:00 and 8:00 p.m. is represented as 20:00.

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Table 1-1. Overall Winter PY2017/2018 Program Participation by Event

Date	Start Time	End Time	Length of Event (Hours)	Average Event Temperature (°F)[16]
2018-01-02	6:30	9:30	3	10
2018-01-05	6:30	9:30	3	13
2018-01-07	6:00	9:00	3	9
2018-01-08	6:00	7:30	1.5	27
2018-01-15	6:00	10:00	4	22
2018-01-18	6:00	9:00	3	14

Source: DEP DR control event tracking report

[16] Average event temperature shown here is the average event temperature to which all heat strip participants included in the analysis were subject during the event.

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2. EVALUATION METHODS

This chapter of the evaluation report provides a description of the approaches used to conduct both the impact and process evaluations. Additional technical details of the approach used for the impact analysis may be found in Appendix B.

2.1 Impact Evaluation

Navigant estimated demand reduction, snapback, and event-level energy impacts using a fixed effects regression analysis applied to participant interval data, weather data, and data flags indicating the intervals in which events took place. The remainder of this subsection details the data and the econometric method used in the analysis. Appendix B provides further discussion of the regression models used.

2.1.1 EM&V Participants and Events

The estimated impacts presented in this evaluation report are based on a sample of participants from the overall population that agreed to have data loggers installed so that each curtailed device's consumption could be monitored in isolation of the rest of the household's demand. This sample of participants was also subjected to more events than the overall sample to provide the evaluation team with more data points from which impacts could be estimated.

Altogether, Navigant obtained useable logger data from the following:

- 60 participating homes with controlled heat strips (out of 69 homes in which heat strip loggers were installed)
- 36 participating homes with controlled water heaters (out of 40 homes in which water heater loggers were installed)

For the 2017/2018 evaluation, Navigant randomly allocated each EM&V participant site to one of two groups: Group A and Group B. This enabled a randomized control trial (RCT) experimental design, where when one group is subject to curtailment, the other is not. This means that only event days needed to be included in the analysis. Participants were assigned randomly by winter energy usage strata to one group or the other by the evaluation team. The purpose of this approach (discussed in greater detail below) was to improve estimation accuracy.

A key concern of DR evaluations when all participants are subject to the same events is that there remain some non-event days that sufficiently resemble (in terms of temperature and other factors) the event days. This is required to allow for the estimation of a robust baseline. One problem with this approach is that often events are highly correlated with extreme weather events, meaning that baselines are often projected out of sample (i.e., baselines are predicted over temperature conditions that may not actually have been observed on non-event days).

Subjecting only half of all EM&V participants to each event ensures the existence of event-like, non-event days in the sample and provides additional information (from the non-curtailed devices) that helps estimate the counterfactual event demand (the baseline). These factors improve model accuracy by

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substantially reducing the likelihood of model specification bias compared to a purely within-subject approach (as used in prior years).[17]

EM&V participants were subjected to 26 events, 13 for each group. Six of these events (all in January) were also population-wide events (i.e., the program population and the selected EM&V group were both controlled). The date, time, event length, EM&V group controlled, appliances controlled, and mean event temperature (in °F) are shown in Table 2-1.

Table 2-1. Water Heater EM&V Sample Participation

Date	Start Time	End Time	Length of Event (Hours)	Average Event Temperature (°F)[18]	Appliance(s) Controlled	Population Event	Group
2017-12-07	6:30	9:00	2.5	39	WH and HS[19]	No	A
2017-12-08	6:30	9:00	2.5	35	WH and HS	No	B
2017-12-13	6:30	8:30	2	24	WH and HS	No	A
2017-12-15	6:30	8:30	2	30	WH and HS	No	B
2017-12-20	6:30	8:30	2	53	WH Only	No	B
2017-12-21	6:30	8:30	2	49	WH Only	No	A
2017-12-27	6:30	8:30	2	31	WH and HS	No	A
2017-12-28	6:30	8:30	2	23	WH and HS	No	B
2018-01-02	6:30	9:30	3	10	WH and HS	Yes	A
2018-01-05	6:30	9:30	3	13	WH and HS	Yes	B
2018-01-07	6:00	9:00	3	10	WH and HS	Yes	A
2018-01-08	6:00	7:30	1.5	28	WH and HS	Yes	B
2018-01-15	6:00	10:00	4	22	WH and HS	Yes	A
2018-01-18	6:00	9:00	3	13	WH and HS	Yes	B
2018-01-24	6:00	9:00	3	31	WH and HS	No	B
2018-01-25	6:00	9:00	3	28	WH and HS	No	A
2018-01-30	6:00	9:00	3	29	WH and HS	No	B
2018-01-31	6:00	9:00	3	22	WH and HS	No	A
2018-02-07	6:00	9:00	3	47	WH and HS	No	B
2018-02-08	6:00	9:00	3	34	WH and HS	No	A
2018-02-12	6:00	9:00	3	56	WH Only	No	B
2018-02-16	6:00	9:00	3	63	WH Only	No	A
2018-02-19	6:00	9:00	3	50	WH Only	No	A
2018-02-20	6:00	9:00	3	57	WH Only	No	B
2018-02-27	6:00	9:00	3	34	WH Only	No	B
2018-03-02	6:00	9:00	3	43	WH Only	No	A

[17] Navigant used this RCT-style evaluation approach to evaluate DEP's EnergyWise Home program for the summer of 2016.

[18] Average event temperature shown here is the average event temperature to which all heat strip participants included in the analysis were subject during the event on days in which heat strips were controlled. On event days in which heat strip participants were not curtailed, the average temperature is the average event temperature to which water heater participants included in the analysis were subject.

[19] WH = water heater, HS = heat strips

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Sources: Navigant logger data, DEP event schedule data, and National Oceanic and Atmospheric Administration (NOAA) temperature data

2.1.2 Data Used for Impact Evaluation

The impact evaluation made use of three sources of data:

- **Logger data.** Five-minute interval logger data from loggers connected to each participating unit in an EM&V participant's home. These data were aggregated to quarter-hourly frequency for the analysis.
- **Event scheduling data.** The schedule of events deployed to the program population and the EM&V groups.
- **NOAA weather data.** Outdoor temperature data were drawn from 15 NOAA weather stations in the DEP service territory. Each participant's ZIP code was used to locate the eight most proximate NOAA stations to that ZIP code. Values from these stations were averaged on an hourly basis to deliver a complete and consistent series[20] of weather values. These values were then interpolated across the quarter-hourly intervals to deliver a separate quarter-hourly weather series for each participant ZIP code. The complete list of weather stations used may be found in Appendix D (attached as a separate Excel spreadsheet).

2.1.3 Data Collection

In November 2017, the evaluation team installed data loggers at a sample of homes in the service territory. Of the 121 data loggers deployed, 79 logged auxiliary heat strips and 42 logged water heaters. The data loggers were set to log at 5-minute intervals. Navigant reset the EnergyWise switch event counter and curtailment timer during the logger installation visit using the IntelliPORT device and readout the event counter and curtailment tier during the retrieval visit.

The evaluation team visited a total of 100 residences during the deployment of the data loggers. Of these:

- There were six sites at which data logger installation was not possible due to the customer not being at home, poor access, impending heat pump replacement planned, etc.
- There were fourteen sites at which the switch that controls equipment cycling was either non-functional or disconnected. Because the switch did not appear to be functional, logging was not conducted at these sites.

Navigant selected the EM&V sample size to target a relative precision of ±10% at the 90% confidence level based on the previous evaluations in PY2011 and PY2014.

2.1.4 Data Quality Control

Upon retrieval, Navigant downloaded and batch-processed the data loggers. The quality control (QC) process involved three steps: visual inspection of each logger file, visual inspection of field photographs and notes, and discarding of bad data. First, the evaluation team plotted all logger interval data for inspection. If data appeared suspect, the team reviewed the field photographs and notes to determine

[20] Weather stations often include many missing values in their weather series, particularly for values such as dewpoint and windspeed.

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the cause for the bad data. In all cases where the team identified a problem with the data, it was discarded.

2.2 Method for Estimating Device Responsiveness to Curtailment Signal

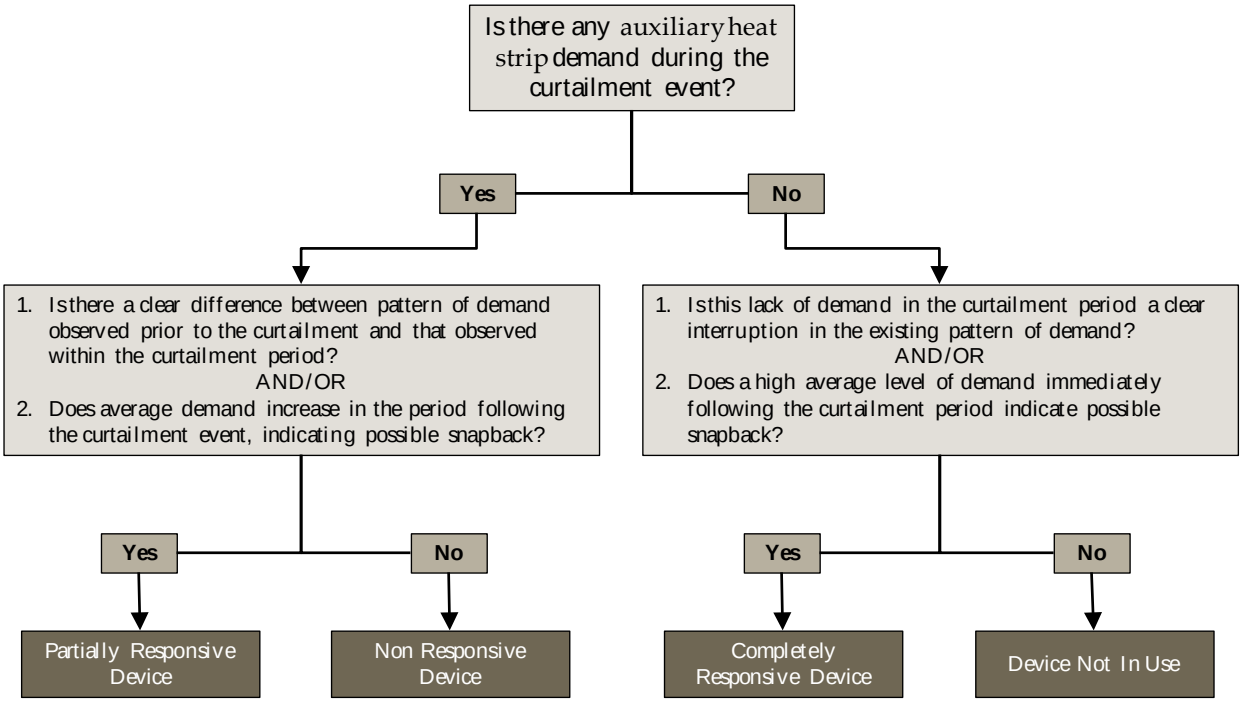
As part of its evaluation of the EnergyWise program, Navigant estimated the share of auxiliary heat strips that failed to respond to DEP's control signal. The evaluation team also estimated the share of water heaters that failed to respond to the control signal. This section provides the details of how this was carried out.

The team assigned heat strips to one of the four dispositions defined below:

1. **Responsive:** During the given event, the device was completely responsive to the signal to curtail.
2. **Partially Responsive:** During the given event, the device showed evidence of response to the curtailment signal but also showed evidence of some demand occurring during the event.
3. **Non-Responsive:** During the given event, the device showed no evidence of response to the curtailment signal.
4. **Device Not in Use (DNU):** During the given event (and across the whole day), the device showed no evidence of being in use, meaning that even if it were to be responsive, it would not deliver any DR.

Navigant assigned the heat strips to each of these categories by examining a data plot of the raw 1-minute interval logger data for each device/curtailment event pair. The team determined assignment for each pair using the decision tree shown in Figure 2-1.

Figure 2-1. Decision Tree for Responsiveness Analysis



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To determine the disposition of water heaters, the evaluation team employed a simpler method: any water heater with an average event demand of more than 0.5 kW was determined to be non-responsive to the curtailment signal for the given event and was used in the control group for that event.

2.3 Method for Estimating Impacts

The evaluation team used an econometric technique known as a fixed effects regression to estimate the impacts of the devices curtailed. Fixed effects regression is a form of linear regression commonly used to estimate the impact of DR programs. The technique is applied to a set of observations of some variable of interest (in this case electricity demand) from several different individuals (i.e., program participants)—also known as longitudinal or panel data—over time.

Fixed effects regression assigns each individual appliance its own dummy variable. In this way, the evaluation team may control for each individual's time-invariant characteristics such as the size of a participant's home, its orientation, etc. The fixed effects regressions were applied to quarter-hourly data.

Heat strip impacts were estimated as a function of the 3-hour exponential moving average of heating degree quarter-hours and the relative hour of the event (e.g., the first quarter-hour of the event, the second quarter-hour of the event, etc.). Water heater impacts were estimated as a function of the time of day (e.g., the quarter-hour between 8:15 and 8:30, the quarter-hour between 8:30 and 8:45, etc.)

Impacts were only estimated for fully or partially responsive heat strips and for fully responsive water heaters.[21] Non-responsive devices were included in the regression and augmented the control group. Heat strips determined to DNU were excluded entirely from the regression. Note that this means the regression parameters deliver an estimated impact only for responsive devices and that these impacts must be adjusted to reflect the percentage of devices that were non-responsive, DNU,[22] or not connected.[23]

Formal model specifications with additional input variable detail may be found in Appendix B of this report.

2.4 Participant Perceptions Evaluation Method

In parallel with the impact evaluation activities discussed earlier in this report, Navigant also conducted a process evaluation of the program to understand the participant experience. The primary source of data for the process portion of this evaluation was a series of phone surveys that were fielded to a sample of EnergyWise participants immediately following DR events and a placebo event where no real event was called but participants were asked similar questions. Surveys were administered to a sample of participants from the broader program population, and those in the EM&V group for the impact evaluation were excluded. The survey was designed to:

- Assess participant understanding, satisfaction, and attitudes about the program

[21] No water heaters were classified as partially responsive.

[22] Note that the proportion of devices not in use for any given day is a function of temperature. This is reflected in the proportion of devices assumed to not be in use to predict capability.

[23] As part of the field work, when technicians were deploying data loggers they confirmed whether a physical wired connection existed between the appliance being controlled and the direct load control (DLC) switch. Where no connection was present, the information was collected, but no data logger was deployed. Of heat strips, 4% were not connected. All water heaters were connected.

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- Assess participant awareness and comfort during DR events

The survey was fielded by telephone directly following the first, second, and fourth program-wide DR events of the winter 2017/2018 season, as well as one placebo day—a day when the weather was cold but no DR event was called. Fielding was completed within 48 hours of the end of the event.

An evaluation team completed 401 telephone surveys. Table 2-2 provides a summary of the completed surveys by date and event status.

Table 2-2. Summary of Telephone Survey Completes

	Event: January 2, 2018	Event: January 5, 2018	Event: January 8, 2018	Placebo: January 31, 2018
Survey completes	100	100	101	100
Mean temperature[24] (°F) between 7:00 and 9:00	9	12	28	22

Source: Navigant analysis

A more comprehensive disposition of the survey attempts is shown in Table 2-3.

Table 2-3. Complete Disposition Report of Telephone Surveys

Survey Disposition	Total
Saved callback (mid-survey)	225
No answer	857
Busy	66
Disconnect/wrong #/blocked #	330
Business/government	29
Deaf/language barrier	25
Answering machine	2,505
Initial refusal (Opted Out)	45
Respondent refused	406
Callback for correct person	122
Changed number	1
Complete	**401**
Total	**5,012**

The survey achieved a relative precision ±3% at the 90% confidence level for key quantitative outcomes.

[24] Average across all EM&V participant ZIP codes.

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3. IMPACT FINDINGS

The discussion of program impacts on winter demand is divided into the following sections:

1. **Historical Estimated Impacts.** This section provides the estimated impacts of heat strip and water heater curtailment during both population and EM&V events.
2. **Forecast Curtailment Capability.** This section provides the estimated DR capability of heat strips and water heaters across a variety of different temperatures (heat strips) and times of day (water heaters).
3. **Partially Responsive Heat Strips: Defrost Cycling.** The section reports on Navigant's findings with respect to the probable cause of some heat strips only partially responding to DEP's curtailment signal.
4. **Net-to-Gross.** This section outlines why the appropriate net-to-gross factor for this program should be 1.

The evaluation team's principal findings regarding winter event demand impacts are as follows:

- **The current DR capability of DEP's EnergyWise program in the winter is approximately 13 MW.** This is the sum of the projected program capability of 7.2 MW from heat strip curtailment when the average temperature is 10°F and 5.6 MW from water heater curtailment deployed between 8:00 and 9:00 on winter mornings.
- **The estimated average program impact of the six population events deployed in the winter of 2017/2018 was approximately 11 MW.** This is the sum of the estimated average impact of 6.7 MW from heat strips where the average event temperature was slightly less than 16°F and an estimated average impact of 4.1 MW from water heaters where events began as early as 6:00 and ended as late as 10:00 in the morning.
- **The estimated impact per set of heat strips (that responded in some way to DEP's curtailment signal) controlled during the population events was 2.77 kW, and the estimated impact per responsive water heater during the same events was 0.41 kW.** On the coldest event (January 7, 2018) the average impact per responsive, including both fully and partially responsive, set of heat strips was 3.1 kW. The reason why the average water heater population event impact was lower than the projected capability is due to the differing time-spans – population events could start as early as 6:00 and end as late as 10:00, whereas the population capability was calculated assuming an event from 8:00 to 9:00.
- **Navigant's investigation into the cause of why some heat strips were only partially responsive during curtailment events concluded that this behavior was driven by a heat pump's auto-defrost cycle.** Navigant logged heat pump compressors as well as heat strips to test the hypothesis that partial response was a result of a heat pump's defrost cycle periodically overriding the control signal. If this were the cause of the partial response, the expectation would be that the demand spikes characteristic of partial response would be coincident with a shutdown of the compressor fan to thaw the compressor coils. The evaluation team confirmed that this was the case, and that partial response (as defined here) was a result of the defrost cycle.
- **On average, of heat strips in use on the event day, approximately 40% were fully responsive to the curtailment signal and approximately 20% were partially responsive.** The percentage of devices not in use varied significantly across events and was correlated with outdoor temperature. During the four events in which the average event temperature was less

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than 15°F, 13% of heat strips expected to curtail were not in use, on average. In contrast, for the six events in which the average temperature was between 30°F and 40°F, 41% of heat strips were not in use, on average.

The key outputs—estimated capability (sometimes referred to as ex ante impacts) and the historical actual program population impacts (also referred to as ex post)—are summarized in Table 3-1.

This table provides the average per appliance impact for appliances that were in some way responsive to DEP's curtailment signal (left-most numeric column) and the overall program average and totals (right-most columns). The difference between these two values is captured by the factors shown in the columns between those two estimated sets of impacts:

- The percentage of appliances that were **non-responsive** to the curtailment signal (determined as described above using the appliance logger data)
- The percentage of appliances that were **not in use** at the time of the event (determined as described above using the appliance logger data)
- The percentage of appliances observed by the field deployment team that were **not physically connected** to the direct load control (DLC) switch.[25]

Table 3-1. Summary of Capability and Historical Population Impacts

	Appliance Type	Impact per Appliance (kW)*	Relative Precision (+/- %)	% Non-Responsive	% Not in Use	% Not Connected	Pop. Avg. Impact per Appliance (kW)	Total Program Impact (MW)
Projected Capability (Ex Ante)	Heat Strips	**3.11**	20%	26%	13%	4%	**1.39**	**7.2**
	Water Heaters	**0.57**	21%	5%	0%	0%	**0.54**	**5.6**
Population Impact - Winter 2017/2018 (Ex Post)	Heat Strips	**2.77**	8%	32%	19%	4%	**1.30**	**6.7**
	Water Heaters	**0.41**	9%	4%	0%	0%	**0.40**	**4.1**

*Includes only partially or fully responsive appliances.
Relative precision is estimated at the 90% confidence level.
Source: Navigant analysis

The principal differences between the projected capability and population historical impacts are summarized in Table 3-2.

[25] Appliances not connected to a DLC switch were not logged.

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Table 3-2. Differences Between Projected Capability and Historical Population Impact

Metric/Assumption	Projected Capability (Ex Ante)	Population Impact – Winter 2017/2018 (Ex Post)
Average event temperature for heat strip events (°F)	10[26]	15.8
Timing of water heater event	8:00-9:00[27]	Mixed Events started as early as 6:00 and as late as 6:30 Events ended as early as 7:30 and as late as 10:00
Non-responsive rate (all appliances)	Average across all EM&V events, grouped by temperature band	Event-specific non-responsiveness rate
DNU rate (heat strips only)	Average across all EM&V events, grouped by temperature band[28]	Event-specific DNU rate

Sources: DEP program staff, Navigant analysis

Navigant conducted its analysis at the appliance level, rather than the customer level. Although the impact per customer and the impact per appliance are very close, there are, on average, slightly more than one appliances controlled per household. The table immediately below provides the average number of appliances controlled per participating customer household[29] and the average impact per customer for responsive (fully or partially) devices and for the population average as a whole (i.e., accounting for non-responsive, non-connected, and not in use devices).

Table 3-3. Per Customer Impacts

	Appliance Type	Impact per Appliance (kW)*	Avg. # of Appliances per Customer	Impact per Customer (kW)*	Pop. Avg. Impact per Customer (kW)**
Projected Capability (Ex Ante)	Heat Strips	**3.11**	1.083	3.37	1.51
	Water Heaters	**0.57**	1.021	0.58	0.55
Population Impact - Winter 2017/2018 (Ex Post)	Heat Strips	**2.77**	1.083	3.00	1.40
	Water Heaters	**0.41**	1.021	0.42	0.40

**Includes only partially or fully responsive appliances*
***Accounts for devices not in use or not responsive to curtailment signal.*

Source: Navigant analysis and DEP program tracking data.

[26] Specified by DEP staff as the appropriate temperature for evaluating system peak capability.

[27] Specified by DEP staff as the appropriate period of time for evaluating system peak capability.

[28] See Section 4.2.1for additional details.

[29] Derived from the population program tracking database.

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3.1 Historical Estimated Impacts

Historical demand impacts are the impacts estimated by the evaluation team for the actual events that were called in the winter of PY2017/2018. This section is divided into three subsections:

- **Population Event Impacts.** This subsection summarizes the estimated program-level impacts of the six events called for the entire program population.
- **EM&V Event Impacts.** This subsection summarizes the average event impacts by event and EM&V group.
- **Load Profile Comparisons.** This subsection provides an illustration of EM&V participant load profiles during events, showing both actual demand and the counterfactual (i.e., the estimated baseline).

3.1.1 Population Event Impacts

This subsection (split into two parts) provides detail regarding the average event impacts for the six events to which the entire program population was subject. The first part presents the program-level impacts for curtailed heat strips and the second presents the program-level impacts for curtailed water heaters.

3.1.1.1 Heat Strip Program-Level Impacts

The full population of EnergyWise participants was subject to six events in the winter of PY2017/2018. The estimated program total (in MW) and average per appliance (in kW) event demand impact for all six heat strip curtailment events is provided in Table 3-4. This table includes the event-specific factors used to adjust the regression-estimated impacts (non-responsive rate, etc.) and the average event temperature.

Table 3-4. Heat Strip Population Event Impacts

Event Date	Avg. Event Temperature (°F)	Impact per Appliance (kW)*	Relative Precision (+/- %)	% Non-Responsive	% Not in Use	% Not Connected	Pop. Avg. Impact per Appliance (kW)	Total Program Impact (MW)
2018-01-02	10	**3.15**	20%	41%	9%	4%	**1.51**	**7.8**
2018-01-05	13	**3.05**	20%	44%	13%	4%	**1.27**	**6.6**
2018-01-07	9	**3.10**	20%	38%	19%	4%	**1.30**	**6.7**
2018-01-08	27	**2.34**	20%	6%	28%	4%	**1.47**	**7.6**
2018-01-15	22	**2.13**	22%	25%	34%	4%	**0.83**	**4.3**
2018-01-18	14	**2.85**	20%	41%	9%	4%	**1.36**	**7.0**

*Impact per responsive/partially responsive appliance.
Sources: Navigant logger data and analysis, NOAA weather data

3.1.1.2 Water Heater Program-Level Impacts

The estimated program total (in MW) and average per appliance (in kW) event demand impact for all six water heater curtailment events is provided in Table 3-5. This table includes the event-specific factors

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used to adjust the regression-estimated impacts (non-responsive rate, etc.) and the event start and end times.

Table 3-5. Water Heater Population Event Impacts

Event Date	Event Start Time	Event End Time	Impact per Appliance (kW)*	Relative Precision (+/- %)	% Non-Responsive	Pop. Avg. Impact per Appliance (kW)	Total Program Impact (MW)
2018-01-02	6:30	9:30	**0.50**	21%	6%	**0.46**	**4.8**
2018-01-05	6:30	9:30	**0.50**	21%	10%	**0.45**	**4.6**
2018-01-07	6:00	9:00	**0.38**	25%	6%	**0.36**	**3.7**
2018-01-08	6:00	7:30	**0.23**	32%	0%	**0.23**	**2.4**
2018-01-15	6:00	10:00	**0.47**	20%	0%	**0.47**	**4.8**
2018-01-18	6:00	9:00	**0.38**	25%	0%	**0.38**	**4.0**

*Impact per responsive appliance.
Sources: Navigant logger data and analysis

3.1.2 EM&V Event Impacts

This subsection details the average event impacts for all events (26 for water heaters, 18 for heat strips) to which the EM&V participants were subject. These estimated impacts reflect the characteristics of the entire sample included in the regression equation—e.g., the average weather affecting all EM&V participants, the average relationship across all EM&V participants between DR impacts and the time of day, etc.[30]

This subsection is divided into two parts. The first presents the impacts for curtailed heat strips during the 18 heat strip EM&V events; the second part presents the impacts for curtailed water heaters during the 26 water heater EM&V events.

3.1.2.1 Heat Strip Curtailment Impacts

Figure 3-1 provides a graphical summary of the estimated DR impact of heat strip curtailment for all 18 heat strip curtailment events. Each vertical bar represents the average event DR impact of the following:

- Fully responsive heat strips (grey)
- Partially responsive heat strips (yellow)
- The weighted (reflecting the distribution of partially and fully responsive appliances) average impact (red)

Event average temperatures are captured by the blue diamonds, scaled to the right-hand vertical axis. The whiskers attached to the columns capture the 90% confidence interval of the estimated impacts.

[30] Put another way, the estimated impacts presented in this sub-section are the estimated impact had all EM&V participants (representative of the program population) been subject to each curtailment event as opposed to only the proportion represented by Group A or Group B. This is to ensure that EM&V event impacts are presented in a manner that is consistent with the population impacts.

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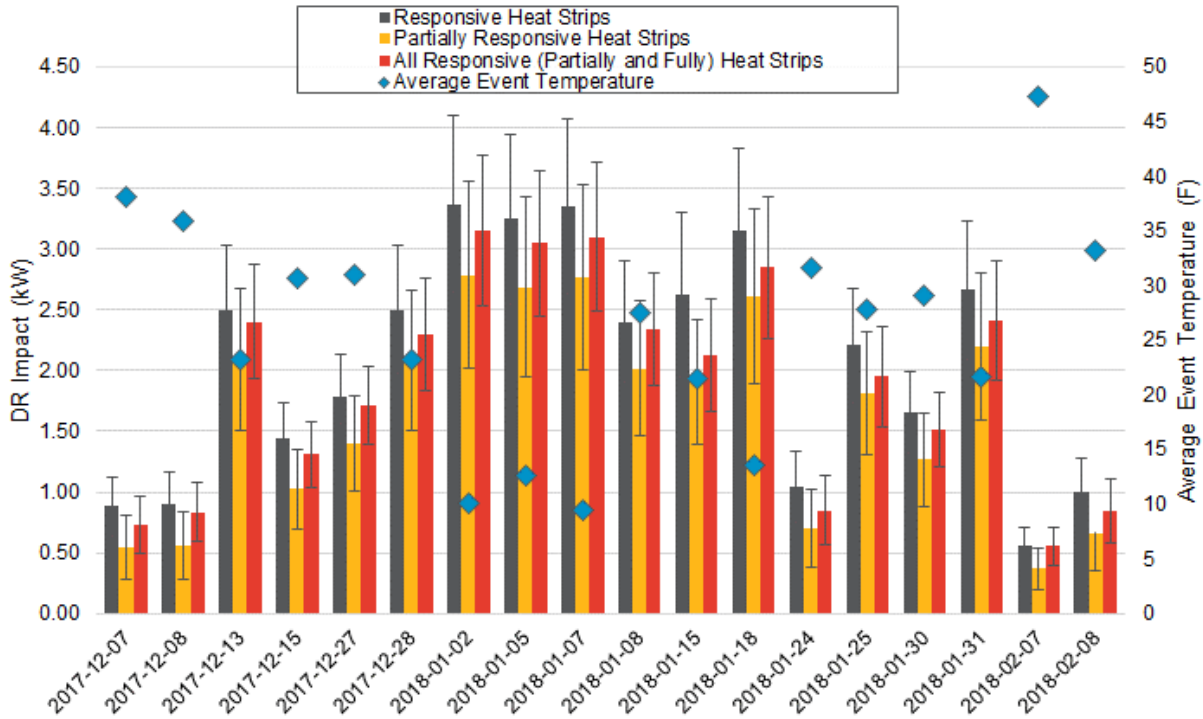
Figure 3-1. Average Heat Strip Event Impacts by Disposition



Source: Navigant analysis, and NOAA data

Impacts are substantially higher at the lowest observed temperatures than they are at higher temperatures. These estimated impacts are only for those heat strips that responded to the curtailment signal and do not account for the percentage of heat strips that were non-responsive, not in use, or not connected. The average population impact per controlled set of heat strips that accounts for these effects is presented in Table 3-6.

Table 3-6. Average Heat Strip Impacts by EM&V Curtailment Event

Event Date	DR Impacts (kW)			Avg. Event Temperature (°F)	% Non-Responsive	% Not in Use	% Not Connected	Avg. Impact per Appliance (kW)
	Responsive Heat Strips	Partially Responsive Heat Strips	All Responsive (Partially and Fully) Heat Strips					
	A	B	C	D	E	F	G	H = C*(1-(E+F))*(1-G)
2017-12-07	0.88	0.54	0.73	38	13%	59%	4%	**0.20**
2017-12-08	0.91	0.56	0.83	36	22%	34%	4%	**0.35**
2017-12-13	2.50	2.09	2.40	23	13%	34%	4%	**1.22**
2017-12-15	1.45	1.03	1.31	31	38%	25%	4%	**0.47**
2017-12-27	1.78	1.40	1.71	31	9%	38%	4%	**0.87**
2017-12-28	2.50	2.09	2.29	23	31%	25%	4%	**0.96**
2018-01-02	3.37	2.79	3.15	10	41%	9%	4%	**1.51**
2018-01-05	3.25	2.68	3.05	13	44%	13%	4%	**1.27**
2018-01-07	3.35	2.77	3.10	9	38%	19%	4%	**1.30**

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2018-01-08	2.40	2.02	2.34	27	6%	28%	4%	**1.47**
2018-01-15	2.63	1.91	2.13	22	25%	34%	4%	**0.83**
2018-01-18	3.16	2.61	2.85	14	41%	9%	4%	**1.36**
2018-01-24	1.05	0.70	0.85	32	31%	47%	4%	**0.18**
2018-01-25	2.21	1.81	1.95	28	19%	47%	4%	**0.64**
2018-01-30	1.66	1.27	1.51	29	31%	44%	4%	**0.36**
2018-01-31	2.66	2.20	2.41	22	31%	34%	4%	**0.79**
2018-02-07	0.56	0.37	0.56	47	3%	94%	4%	**0.02**
2018-02-08	1.00	0.66	0.85	33	28%	44%	4%	**0.23**

Source: Navigant analysis

A key feature of DLC DR programs is the phenomenon known as “snapback”. This refers to the period of elevated appliance demand that immediately follows a DR event. This reflects the additional load placed on the appliance to return the home to the thermostat setpoint temperature in the period following the event (in which many homes would have cooled below the setpoint due to heat strip curtailment).

Figure 3-2 shows the average DR impact of each heat strip event (for partially and fully responsive heat strips, grey column) as well as the following:

- The average snapback in the first hour beginning 15 minutes after the end of the DR event (yellow column).
- The average snapback in the 3.5 hours beginning 15 minutes after the end of the DR event (red column).

The 15-minute gap between the end of the event and the beginning of the period in which snapback is reported is to accommodate appliance ramping (some appliances may still be curtailing during this period).

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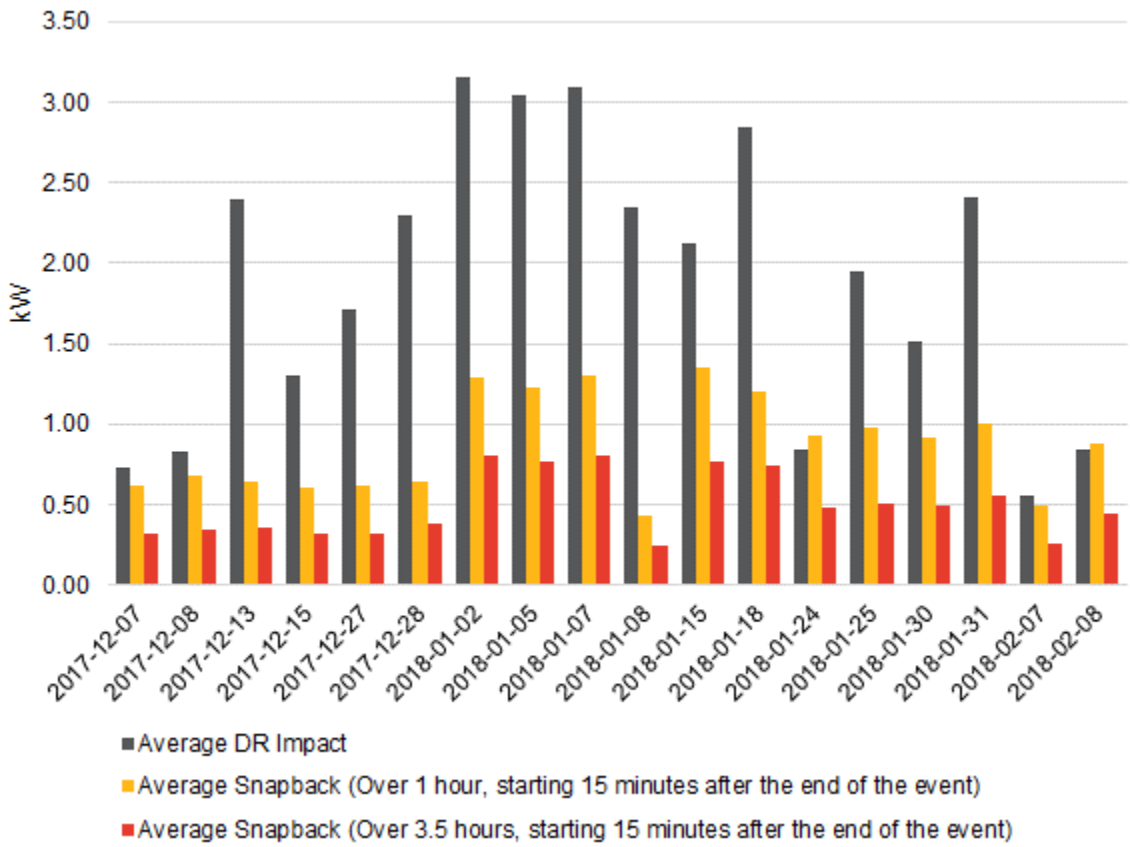
Figure 3-2. Heat Strip DR and Snapback Impacts



Quarter-hourly snapback and DR impacts are not presented above for reasons of concision but may be found as tables in Appendix D, the Excel spreadsheet document attached to this report.

3.1.2.2 Water Heater Curtailment Impacts

Figure 3-3 provides a graphical summary of the estimated DR impact of water heater curtailment for all 26 water heater curtailment events. Each vertical bar represents the average event DR impact of fully responsive water heaters. The whiskers attached to the columns capture the 90% confidence interval of the estimated impacts.

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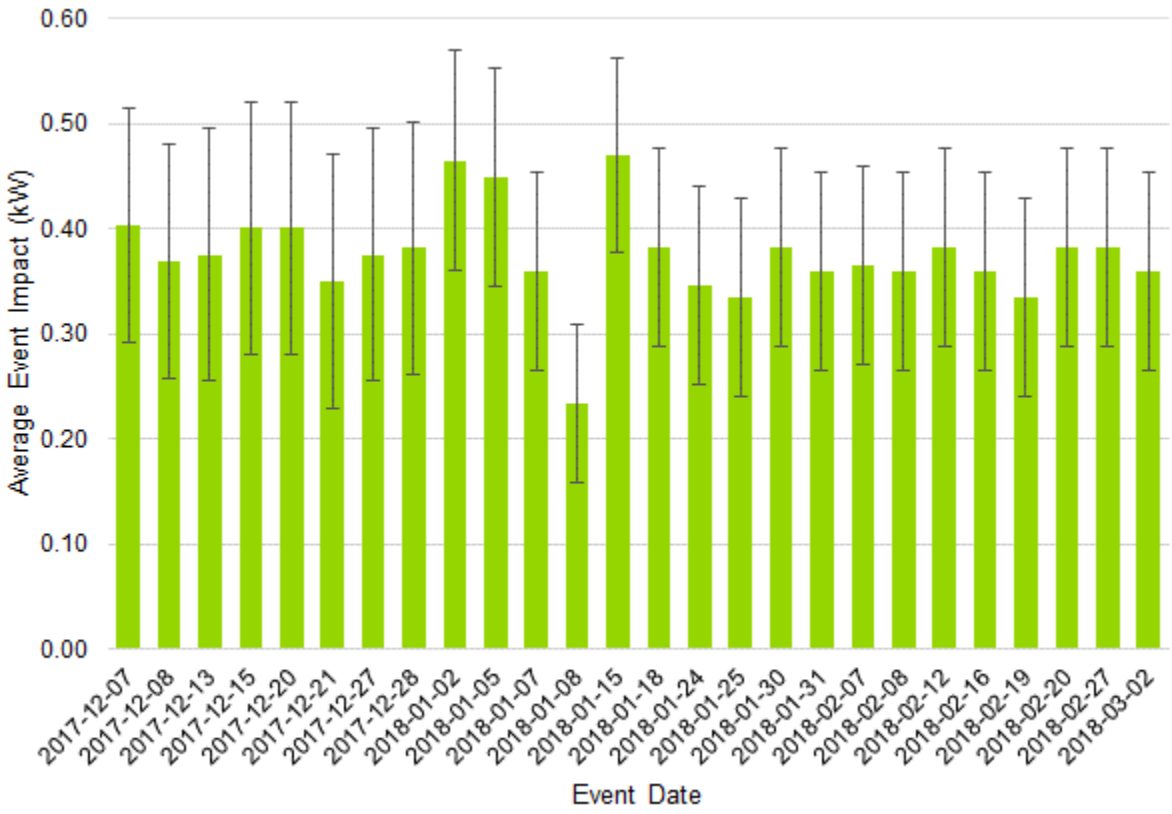
Figure 3-3. Average Water Heater Impacts



These estimated impacts are only for those water heaters that responded to the curtailment signal and do not account for the percentage of water heaters that were non-responsive. The average population impact per controlled water heater that accounts for these effects is presented in the right-most column of Table 3-7.

Table 3-7. Average Water Heater Impacts by EM&V Curtailment Event

Event Date	Event Start Time	Event End Time	Avg. Impact per Responsive Appliance (kW)	% Non-Responsive	Avg. Impact per Appliance (kW)
2017-12-07	6:30	9:00	0.43	6%	0.40
2017-12-08	6:30	9:00	0.43	14%	0.37
2017-12-13	6:30	8:30	0.40	6%	0.38
2017-12-15	6:30	8:30	0.40	0%	0.40
2017-12-20	6:30	8:30	0.40	0%	0.40
2017-12-21	6:30	8:30	0.40	13%	0.35
2017-12-27	6:30	8:30	0.40	6%	0.38
2017-12-28	6:30	8:30	0.40	5%	0.38
2018-01-02	6:30	9:30	0.50	6%	0.46
2018-01-05	6:30	9:30	0.50	10%	0.45
2018-01-07	6:00	9:00	0.38	6%	0.36

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Event Date	Event Start Time	Event End Time	Avg. Impact per Responsive Appliance (kW)	% Non-Responsive	Avg. Impact per Appliance (kW)
2018-01-08	6:00	7:30	0.23	0%	0.23
2018-01-15	6:00	10:00	0.47	0%	0.47
2018-01-18	6:00	9:00	0.38	0%	0.38
2018-01-24	6:00	9:00	0.38	10%	0.35
2018-01-25	6:00	9:00	0.38	13%	0.34
2018-01-30	6:00	9:00	0.38	0%	0.38
2018-01-31	6:00	9:00	0.38	6%	0.36
2018-02-07	6:00	9:00	0.38	5%	0.36
2018-02-08	6:00	9:00	0.38	6%	0.36
2018-02-12	6:00	9:00	0.38	0%	0.38
2018-02-16	6:00	9:00	0.38	6%	0.36
2018-02-19	6:00	9:00	0.38	13%	0.34
2018-02-20	6:00	9:00	0.38	0%	0.38
2018-02-27	6:00	9:00	0.38	0%	0.38
2018-03-02	6:00	9:00	0.38	6%	0.36

Source: Navigant analysis

A key feature of DLC DR programs is the phenomenon known as “snapback”. This refers to the period of elevated appliance demand that immediately follows a DR event. This is especially pronounced in water heaters and is characterized by a very short spike in demand immediately following the end of the curtailment period.

This demand spike, although quite short in length, will exceed the average DR impact. This reflects the mechanics of the heating system, which works to restore tank setpoint temperature as quickly as possible. Often doing so requires using a second heating element that is not normally required. This spike is evident in the example load profile provided below in sub-section 3.1.3 and is reflected in the average snapback impact in the period following curtailment (see Figure 3-4).

Figure 3-4 shows the average DR impact of each water heater event (grey column) as well as the following:

- The average snapback in the first hour beginning 15 minutes after the end of the DR event (yellow column).
- The average snapback covering the length of the DR event itself, beginning 15 minutes after the end of the DR event (e.g., if the event was 3 hours long, then this is the average DR impact across 3 hours) (red column).

The 15-minute gap between the end of the event and the beginning of the period in which snapback is reported is to accommodate appliance ramping (some appliances may still be curtailing during this period).

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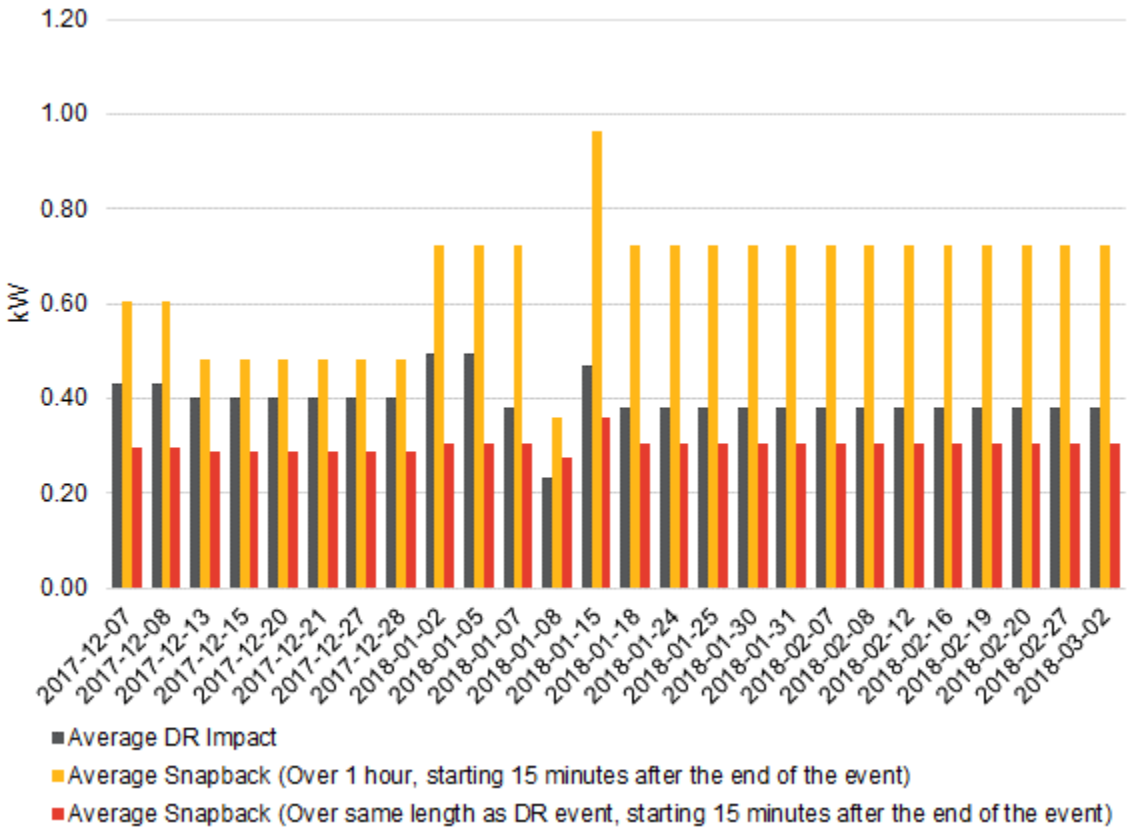
Figure 3-4. Water Heater DR and Snapback Impacts



3.1.3 Load Profile Comparisons

It is Navigant's standard practice in DR evaluations to provide one or more plots of average actual and counterfactual (i.e., model-predicted baseline) participant demand during DR events. These plots are particularly useful in providing a more intuitive understanding of the processes driving the results presented above. This subsection is divided into two parts. The first part provides the load profile comparison for heat strips, while the second provides the load profile comparison for water heaters.

3.1.3.1 Heat Strip Load Profile Comparison

Two examples of event load profile plots for heat strips are provided below. The first, Figure 3-5, shows load profiles associated with the coldest event observed as part of this study, occurring on Sunday, January 7.

- The **solid black line** indicates average heat strip demand for those heat strips that were partially or fully responsive to DEP's signal to curtail (note the deep trough during the event period).
- The **blue line** is what the model predicted demand would have been had no event been called. This is baseline, or counterfactual, heat strip demand.
- The **dashed black line** shows the actual average heat strip load of the control group (in this case Group B heat strips and those Group A heat strips that did not respond to the signal to curtail).

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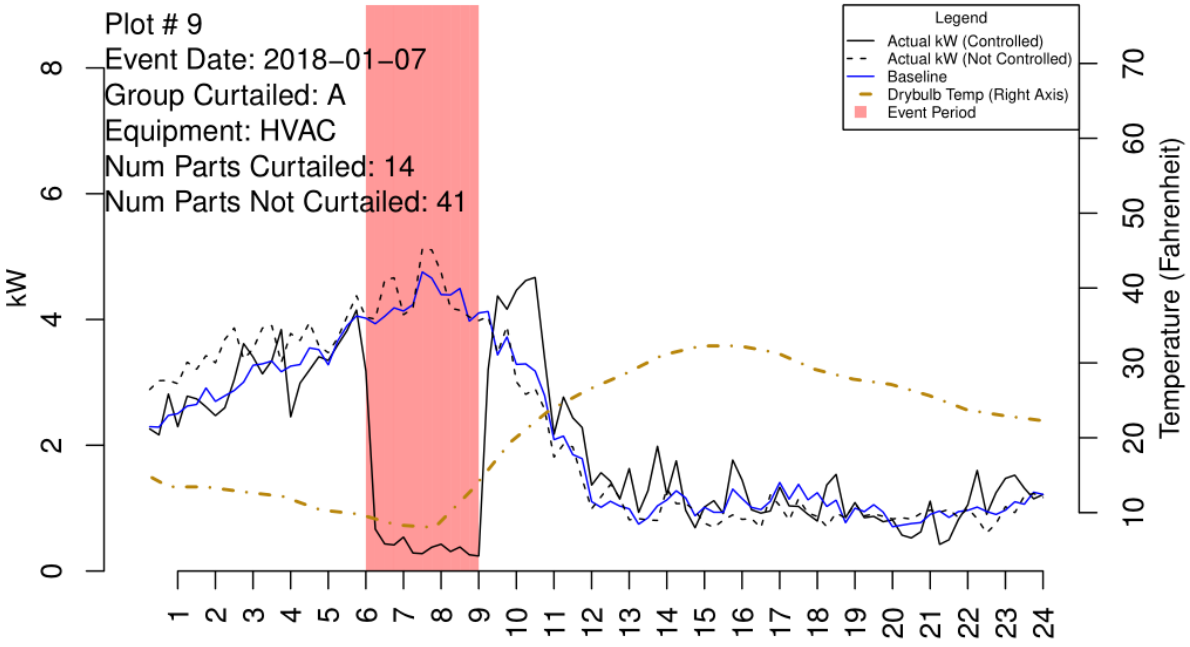
- The **dash-dotted yellow line** shows the average outdoor temperature (right axis).

Figure 3-5. Heat Strip Load Shape Comparison: January 7, 2018



Source: Navigant logger data and analysis

Note how closely the dashed blue line tracks the solid black line prior to the curtailment period. This is a strong indication that the model is doing a good job of estimating the average heat strip baseline and thus the true average impact that the curtailment event is having across the group of EM&V participants during the DR event period.

The second example provided in Figure 3-6 is for the EM&V event that occurred on December 7, 2017. In contrast to the previous example (the coldest event), this is the second warmest of the EM&V events.[31] All of the data series represented in this plot follow the definitions of Figure 3-5. Like the plot above, the baseline closely tracks the participant actuals in the period immediately prior to the curtailment event and in the hours following the end of the snapback period.

[31] The warmest event, on February 7, 2018, is a poor example load profile to present for the purposes of assessing the average event impact graphically because the proportion of devices not in use was so high that only a single heat strip expected to curtail fell into either the responsive or partially responsive" category.

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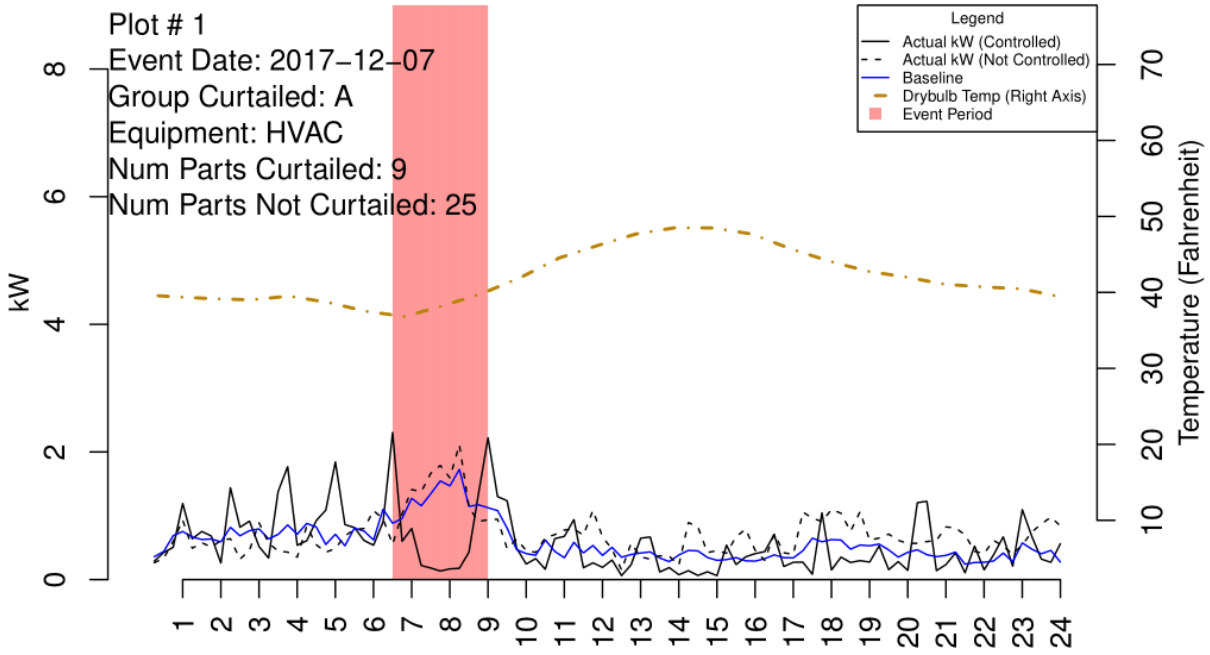
Figure 3-6. Heat Strip Load Shape Comparison: December 7, 2017



Source: Navigant logger data and analysis

3.1.3.2 Water Heater Load Profile Comparison

Figure 3-7 shows the water heater load profile on January 7, 2018 an event that lasted from 6:00 to 9:00. One key characteristic of water heater loads evident from this plot is the more volatile nature of their loads. These appliances tend to have either very high loads or very low loads; while an average demand of 0.4 kW is quite common, median loads tend to be very low, well below 0.1 kW (a function of the manner in which they operate). This characteristic may be observed in the very spiky loads shown in the plot below. Note, however, that the baseline (the blue line) traces smoothly through these loads with actuals (outside of periods affected by the event) being higher than the baseline as often as they are lower.

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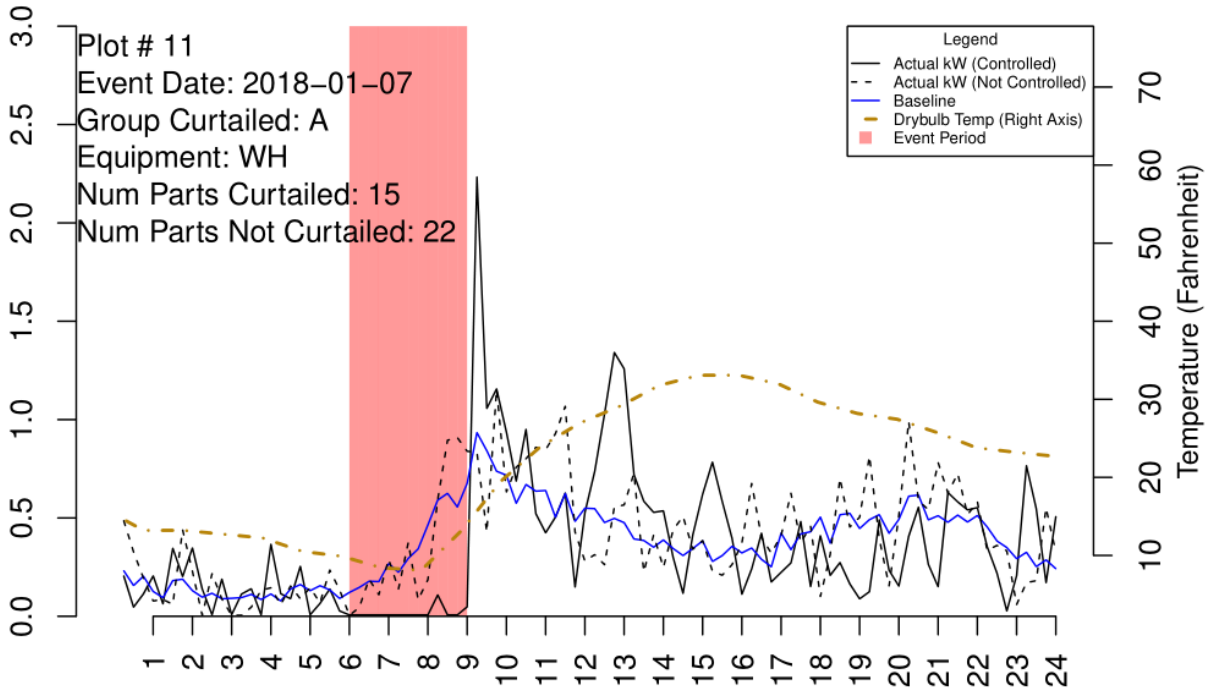
Figure 3-7. Water Heater Load Shape Comparison: January 7, 2018



Source: Navigant analysis, and NOAA weather data

A few other key characteristics of water heater DR are evident from this comparison: the double-peaked nature of the load, morning loads peak at about the time (or shortly after) many residents would be expected to have completed their morning showers, and a sudden spike in demand immediately following the end of the event (snapback).

A second example load comparison plot, for January 15, 2018, is provided in Figure 3-8.

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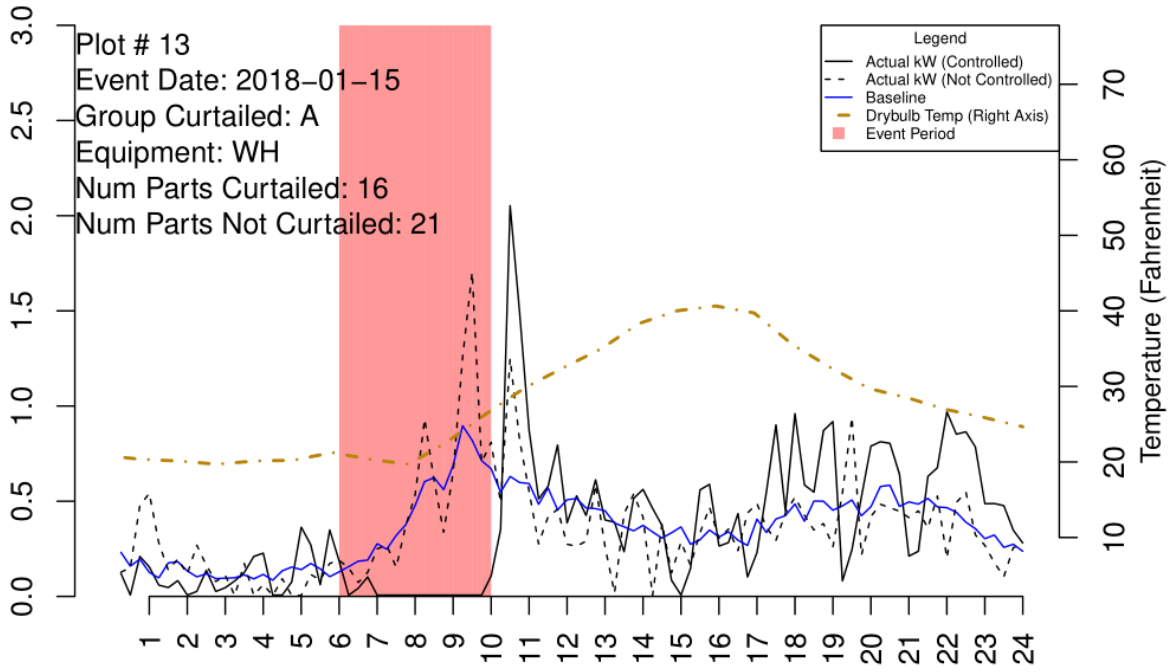
Figure 3-8. Water Heater Load Shape Comparison: January 15, 2018



Source: Navigant analysis, and NOAA weather data

3.2 Forecast Curtailment Capability

This section provides the estimated EnergyWise DR capability (sometimes referred to as the ex ante impacts), Navigant's projection of how much DR appliances and the program could offer at system peak conditions. This estimate of capability is based on the relationships between DR impacts and outdoor temperature (for heat strips) or time of day (water heaters).

It is this forecast of capability that provides the truest estimate of a given DR program's value as a system resource because it provides DEP staff with an understanding of how much of a demand reduction the program may be counted on to deliver in future system peak conditions. This is also why it is the forecast DR capability that should be used to calculate the benefits for any cost-benefit ratio test (e.g., total resource cost test, or TRC).

This section is divided into two subsections: the first details the projected DR capability of heat strips under different weather conditions, and the second details the projected DR capability of water heaters at different times of day.

3.2.1 Heat Strip DR Capability

This subsection provides the projected capability of heat strips. This capability is projected by applying a series of temperature values to the estimated model parameters. Navigant's projected capability (shown in Figure 3-9) assumes that the temperature at which the capability is estimated: lasts the entire length of the event and is the same as the temperature in the 3 hours leading up to the event.

This second assumption is required due to the manner in which impacts are estimated. Because homes have thermal mass, a sudden swing in outdoor temperature does not immediately provoke a concomitant

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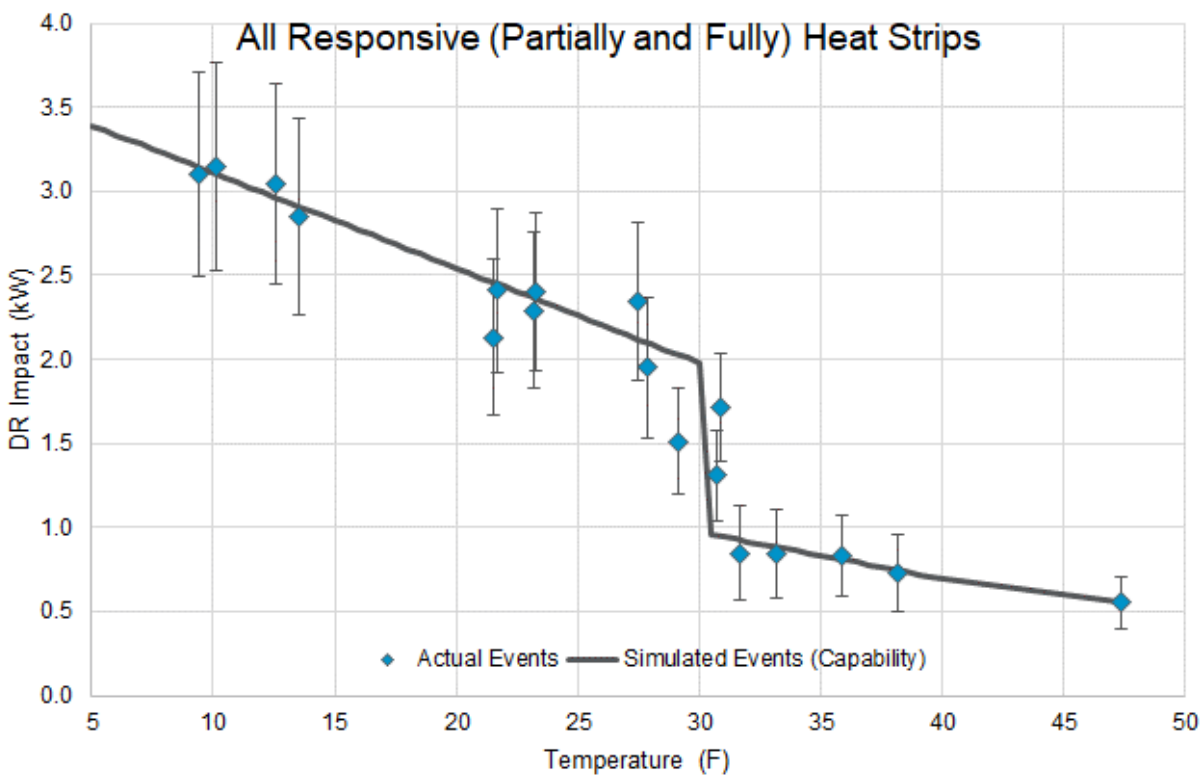
swing in heat strip load—it takes time for the building's indoor temperature to fall below the setpoint temperature because of that outdoor temperature swing. This is reflected in Navigant's estimation approach (see Appendix B for more details), where impacts are modeled as a function of a 3-hour exponential moving average of outdoor temperature. Therefore, projecting capability requires an assumption of what the temperature is in the 3 hours leading up to the event.

Figure 3-9 provides the average projected capability of all responsive devices[32] (partially and fully) from 5°F to 50°F (grey line). Actual estimated EM&V event impacts are represented on this chart as blue diamonds, with the 90% confidence interval around each estimate represented by the whiskers. The values underlying this plot may be found in Appendix D, the Excel spreadsheet that accompanies this report.

The capability of heat strips shows a significant discontinuity at 30°F. This reflects the highly nonlinear nature of heat strip demand and is captured in the model by two temperature splines (for more details, please refer to Appendix B).

Figure 3-9. Projected Average DR Capability per Responsive Heat Strip Installation



Source: Navigant analysis

As noted above, the projected capability shown in Figure 3-9 is the average capability per responsive appliance. To obtain the average population capability, values from the chart above must be adjusted by three factors:

1. **Percentage of non-responsive devices.** On average, 26% of heat strips expected to curtail during the EM&V events failed to respond to DEP's signal to curtail.

[32] This represents the weighted average impact of partially and fully responsive devices based on the proportion of devices by disposition and event. Capability by disposition is provided in Appendix D, the Excel spreadsheet that accompanies this report.

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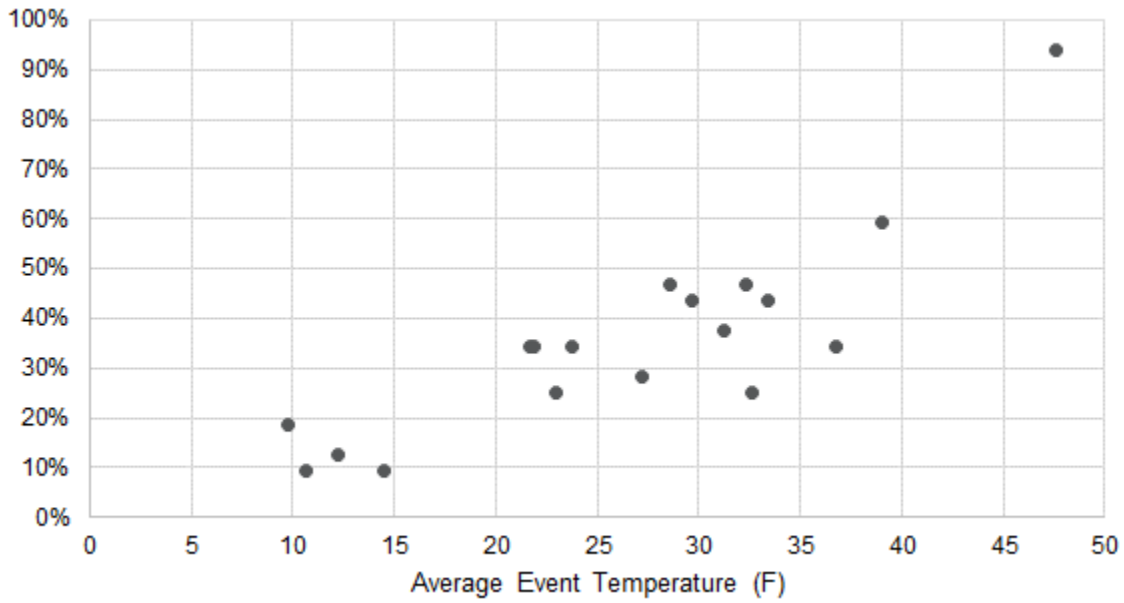
2. **Percentage of devices not in use (DNU).** A material proportion of heat strips were not in use on EM&V event days. As would be expected, this proportion varies by temperature. The details of this adjustment are presented below.
3. **Percentage of devices not connected.** As part of Navigant's field work, all switch/appliance physical connections were inspected. As a result of this exercise, it was found that 4% of heat strips observed had no physical (wired) connection to the DLC switches.

Devices not in use on event days were excluded from the regression analysis to improve the precision of estimated impacts. This proportion of appliances must be accounted for in determining average population capability. The proportion of devices not in use on event days is a function of average temperature. This is shown in Figure 3-10, which plots the percentage of devices not in use for any given event against the average event temperature.

Figure 3-10. Scatterplot of Event-Specific Percentage of DNU and Average Event Temperature



Given this, Navigant developed the following four values to apply against the responsive capability estimate to obtain the population capability estimate. Each factor is the average of the proportion of heat strips not in use for the events encompassed by the range of average event temperatures shown in Table 3-8. Applying the DNU adjustment factor by temperature band necessitates a consistent treatment of the non-responsive factor as well. Although the proportion of devices in use that are non-responsive is not correlated with weather, the overall proportion of non-responsive devices *is* since it is implicitly a function of the percentage DNU, which, as demonstrated above, is correlated with outdoor temperature.

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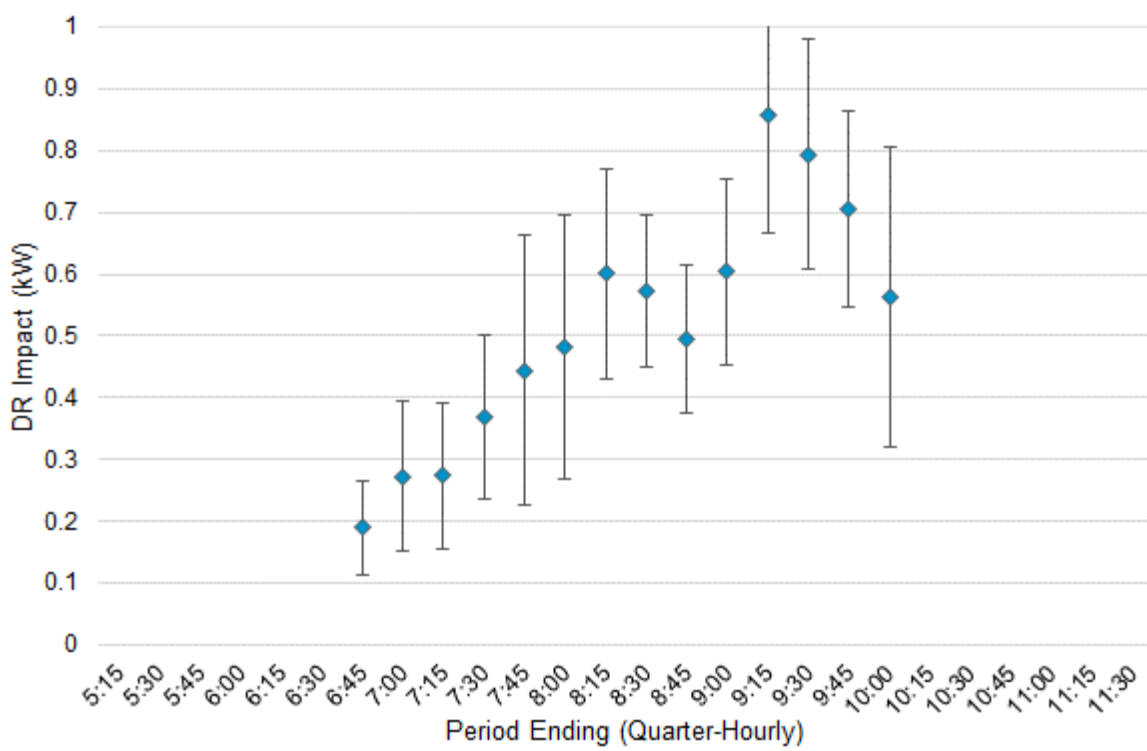
Table 3-8. DNU Adjustment Factors

Temperature Thresholds (°F)		Group	Average DNU %	Average NR %
Less Than	Equal to or Greater			
15	0	1	**13%**	**41%**
30	15	2	**35%**	**22%**
40	30	3	**41%**	**23%**
60	40	4	**94%**	**3%**

3.2.2 Water Heater DR Capability

This subsection provides the projected capability of water heaters. Unlike heat strips, water heater impacts are modeled as a function of the time of day in which curtailment occurs rather than the outdoor temperature.[33] Figure 3-11 provides the average estimated impact of responsive water heater curtailment by quarter-hour of the day. The blue diamonds represent the average estimated impact at each quarter-hour of the day and correspond to the values used to calculate the impacts of each of the EM&V events. The whiskers capture the 90% confidence interval. Note that the quite wide confidence interval for the impacts between 9:00 and 10:00 is because only a single event lasted until 10:00 and only three events lasted later than 9:00 (including the one event that lasted until 10:00).

Figure 3-11. Projected Average DR Capability per Responsive Water Heater



[33] See Appendix B for the rationale for modeling water heater capability as a function of time of day instead of outdoor temperature..

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As noted above, the projected capability shown in Figure 3-11 is the average capability per responsive appliance. To obtain the average population capability, values from the figure above must be adjusted by the average non-response rate observed across the 26 water heater EM&V events, which was 5%. All water heaters inspected by Navigant field staff were found to be connected to the DLC switch.

3.3 Partially Responsive Heat Strips: Defrost Cycling

To determine the cause of "partially responsive" heat strips as described in previous EnergyWise Home winter impact evaluation reports, Navigant worked with DEP program staff and the program implementer's technical lead to design a data collection strategy to determine the cause. The hypothesis put forward by the DEP program staff was that the heat pump compressor defrost cycle was causing heat strips to turn on intermittently during a control event (i.e. override the control action). In addition to logging heat strips, EM&V field technicians logged outdoor heat pump compressors. During a defrost cycle, the heat pump compressor reversing valve engages and the compressor fan shuts off, allowing the coils to thaw. The result is a drop in total compressor power draw during the defrost cycle.

The results of this research effort were conclusive: partial response of a heat strip during a control event is most likely caused by defrost cycling and can be seen by visually inspecting the compressor and heat strip data together. The phenomenon is a normal and necessary part of heat pump system operation and is not a shortcoming of the switch control. Furthermore, the evaluation team was able to differentiate between systems that were controlled with defrost cycling and systems that were completely non-responsive to curtailment signals. Example plots are shown below for reference (Figure 3-12 and Figure 3-13). Note how in Figure 3-12 the blue line showing the heat pump load dips as the compressor fan cycles off while the heat strips (in green) momentarily cycle on to counteract the cold air that would blow while the compressor coils defrost.

Figure 3-12. Example of Defrost Cycling During a Partial Response Event

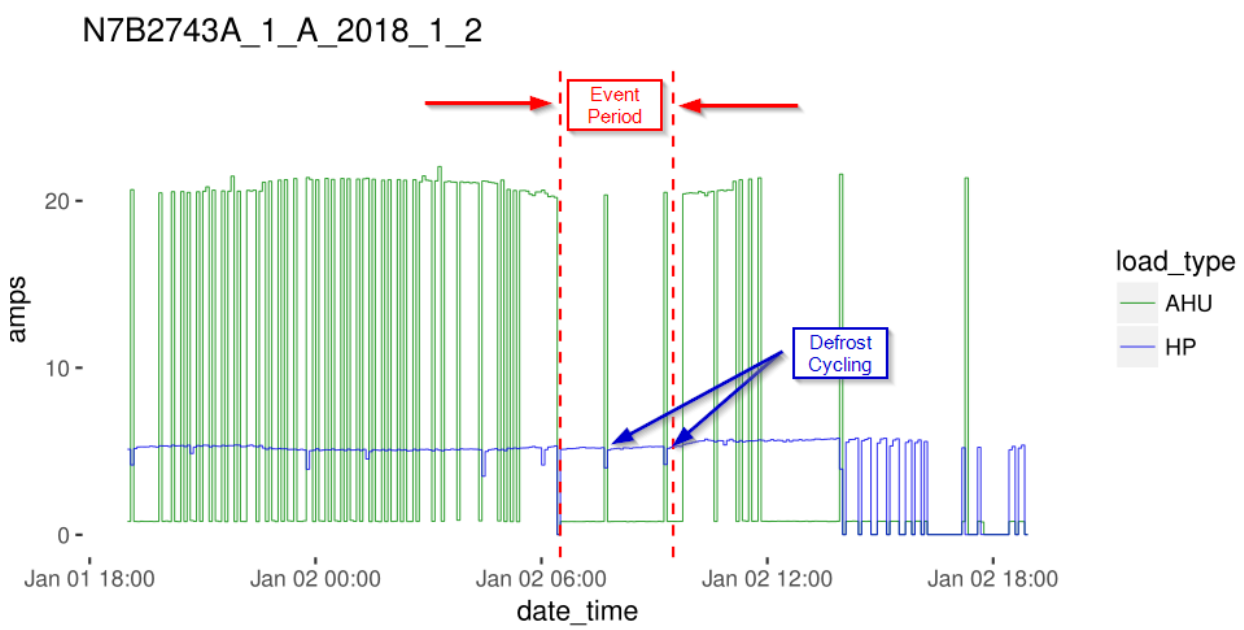

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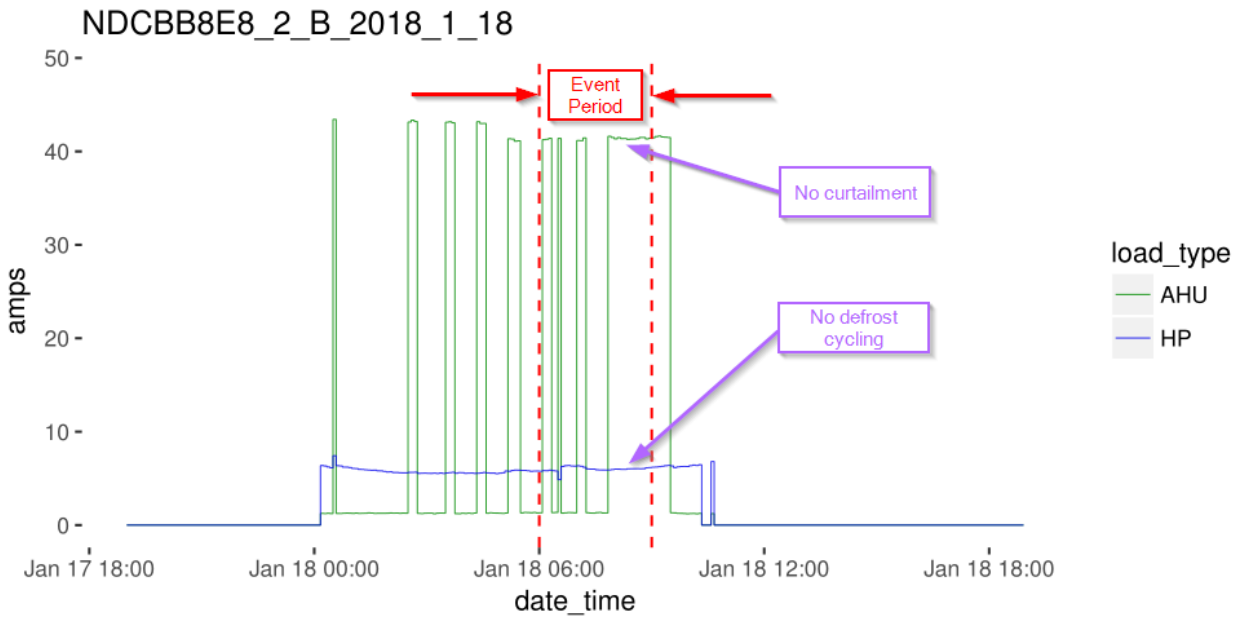
Figure 3-13. Example of a Non-Responsive Heat Strip



3.4 Net-to-Gross Ratio

Evaluations of demand-side management programs typically estimate a net-to-gross (NTG) ratio based on the evaluated percentage of demand reductions that may be ascribed either to free ridership (which increases the NTG ratio) or to program spillover (which reduces it). Free ridership is typically defined as the percentage of demand reductions that would have occurred anyway, absent the presence of the program. Spillover is typically defined as incremental demand reductions undertaken by a program's participants not directly incented or promoted by the program administrator. In this case, because demand reductions are estimated in contrast to an implied estimated baseline[34] that captures expected participant behavior absent an event, the evaluation team can confidently state that the free ridership is 0: absent the EnergyWise program, none of the observed demand reductions would have taken place. It is possible that there may have been some spillover resulting from the program (from participants becoming more aware of their sites' consumption profiles, for example). However, it is likely impossible to estimate such an effect in a sufficiently robust manner and the assessment of such impacts is beyond the scope of this report.

Since spillover cannot be robustly estimated and because free ridership must, by program design, be considered 0, the evaluation team considers the EnergyWise program to have a NTG ratio of 1.

34 That is, the average level of behavior implied by the estimated parameter values of the regressions used.

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4. PROCESS EVALUATION FINDINGS

A detailed presentation of the process evaluation survey findings can be found in 0, and the final version of the survey guide can be found in Appendix C.

The principal EM&V findings from the analysis of participant perception were as follows:

- **Participants were generally unaware of curtailment events when they happened.** Most (>90%) survey respondents indicated that they had not been aware that an event had occurred recently.
- **The program has little impact on the comfort of its participants.** Only 23 respondents (out of 301 event participants) were aware that an event had been called during the period in question. For that subgroup, comfort levels reported during the event varied widely, ranging from a rating of a 0 to a 10 on the 0-10 comfort scale, with only two rating their comfort less than 5. Most survey respondents indicated that they were “very comfortable” during the event.
- **The program does not appear to be a key driver of supplemental heating use.** A similar portion of placebo survey respondents reported using supplemental methods for heating their homes during “event” periods as those respondents who were subject to actual events.
- **Participants were generally satisfied with the EnergyWise program.** Over half of the respondents indicated that they were very satisfied, while only 4% of all survey respondents (18 people) indicated that they were “dissatisfied” with the program. Satisfaction with the program did not differ significantly between respondents who responded to actual events versus those who responded to placebo events.
- **Fewer than half of participants were aware of the bill credits they receive as part of their program participation.** Every customer enrolled in the program receives a hardcopy brochure explaining the bill credits details (when the are received, amounts, etc.). It is important to note that many of the particpants received their bill credits outside the EM&V study calendar.

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5. SUMMARY FORM

EnergyWise Home
Winter PY2017/2018
Completed EM&V Fact Sheet

Description of Program

Duke Energy's EnergyWise Home program is a demand response (DR) program offered to residential customers in the Duke Energy Progress (DEP) territory.

EnergyWise is a direct load control (DLC) program. Participants receive an incentive to allow Duke Energy to control their air conditioners (in the summer) their heat pump auxiliary heat strips (in the winter) or their electric water heaters (winter or summer). Only participants in the Western region are curtailed in the winter.

This report evaluates the impact of the program in the summer of 2016. Two program-wide events were called in the summer of 2016. Ten events were called for a sample of 78 participants to whom data loggers had been deployed.

Date	July 20, 2018	
Region	Duke Energy Progress	
Evaluation Period	Winter 2017/2018	
DR Event Capability (kW)	**per Appliance**	**per Customer**
Heat Strips	1.39	1.51[35]
Water Heaters	0.54	0.55[36]
DR Event Capability Impact (MW)		
Heat Strips	7.2	
Water Heaters	5.6	
Net-to-Gross Ratio	1	

Evaluation Methods

Navigant estimated DR impacts for heat strip and water heater DLC through the use of two fixed effects regressions applied to logger data collected from a representative sample of 70 EnergyWise participants. EM&V appliances were divided into two sub-samples and curtailed on alternating events. This experimental design approach is superior to the previously used within-subject design because it avoids the possibility that all very cold winter days are used up for events, leaving no observed cold temperatures with which to properly estimate the implicit baseline (impacts are measured against the baseline). This design reduces the possibility of model specification bias.

Impact Evaluation Details

- **The current DR capability of DEP's EnergyWise program in the winter is approximately 13 MW.** This is the sum of the projected program capability of 7.2 MW from heat strip curtailment when the average temperature is 10°F and 5.6 MW from water heater curtailment deployed between 8:00 and 9:00 on winter mornings.
- **The estimated average program impact of the six population events deployed in the winter of 2017/2018 is approximately 11 MW.** This is the sum of the estimated average impact of 6.7 MW from heat strips where the average event temperature was slightly less than 16°F and an estimated average impact of 4.1 MW from water heaters where events began as early as 6:00 and ended as late as 10:00.
- **The estimated impact per responsive set of heat strips controlled during the population events was 2.77 kW, and the estimated impact per responsive water heater during the same events was 0.4 kW.** On the coldest event (January 7, 2018) the average impact per responsive, including both fully and partially responsive, set of heat strips was 3.1 kW.

[35] Based on 1.083 appliances per customer.

[36] Based pm 1.021 appliances per customer.

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6. PROGRAM FINDINGS AND CONCLUSIONS

The following are the principal findings of the impact evaluation:

- **The current DR capability of DEP's EnergyWise program in the winter is approximately 13 MW.** This is the sum of the projected program capability of 7.2 MW from heat strip curtailment when the average temperature is 10°F and 5.6 MW from water heater curtailment deployed between 8:00 and 9:00 on winter mornings.
- **The estimated average program impact of the six population events deployed in the winter of 2017/2018 was approximately 11 MW.** This is the sum of the estimated average impact of 6.7 MW from heat strips where the average event temperature was slightly less than 16°F and an estimated average impact of 4.1 MW from water heaters where events began as early as 6:00 and ended as late as 10:00 in the morning.
- **The estimated impact per set of heat strips (that responded in some way to DEP's curtailment signal) controlled during the population events was 2.77 kW, and the estimated impact per responsive water heater during the same events was 0.41 kW.** On the coldest event (January 7, 2018) the average impact per responsive, including both fully and partially responsive, set of heat strips was 3.1 kW. The reason why the average water heater population event impact was lower than the projected capability is due to the differing time-spans – population events could start as early as 6:00 and end as late as 10:00, whereas the population capability was calculated assuming an event from 8:00 to 9:00.
- **Navigant's investigation into the cause of why some heat strips were only partially responsive during curtailment events concluded that this behavior was driven by a heat pump's auto-defrost cycle.** Navigant logged heat pump compressors as well as heat strips to test the hypothesis that partial response was a result of a heat pump's defrost cycle periodically overriding the control signal. If this were the cause of the partial response, the expectation would be that the demand spikes characteristic of partial response would be coincident with a shutdown of the compressor fan to thaw the compressor coils. The evaluation team confirmed that this was the case, and that partial response (as defined here) was a result of the defrost cycle.
- **On average, of heat strips in use on the event day, approximately 40% were fully responsive to the curtailment signal and approximately 20% were partially responsive.** The percentage of devices not in use varied significantly across events and was correlated with outdoor temperature. During the four events in which the average event temperature was less than 15°F, 13% of heat strips expected to curtail were not in use, on average. In contrast, for the six events in which the average temperature was between 30°F and 40°F, 41% of heat strips were not in use, on average.

The principal EM&V findings from the analysis of participant perception were as follows:

- **Participants were generally unaware of curtailment events when they happened.** Most (>90%) survey respondents indicated that they had not been aware that an event had occurred recently.
- **The program has little impact on the comfort of its participants.** Only 23 respondents (out of 301 event participants) were aware that an event had been called during the period in question. For that subgroup, comfort levels reported during the event varied widely, ranging from a rating

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of a 0 to a 10 on the 0-10 comfort scale, with only two rating their comfort less than 5. Most survey respondents indicated that they were “very comfortable” during the event.

- **The program does not appear to be a key driver of supplemental heating use.** A similar portion of placebo survey respondents reported using supplemental methods for heating their homes during “event” periods as those respondents who were subject to actual events.
- **Participants were generally satisfied with the EnergyWise program.** Over half of the respondents indicated that they were very satisfied, while only 4% of all survey respondents (18 people) indicated that they were “dissatisfied” with the program. Satisfaction with the program did not differ significantly between respondents who responded to actual events versus those who responded to placebo events.
- **Fewer than half of participants were aware of the bill credits they receive as part of their program participation.** Every customer enrolled in the program receives a hardcopy brochure explaining the bill credits details (when the are received, amounts, etc.). It is important to note that many of the particpants received their bill credits outside the EM&V study calendar.

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APPENDIX A. PARTICIPANT PERCEPTIONS ANALYSIS

This appendix presents the findings of Navigant's analysis of four phone surveys conducted in the winter of 2017/2018 of EnergyWise participants. Participants from the EM&V group who received data loggers for the impact evaluation were excluded from the survey effort.

The evaluation team conducted 401 phone surveys with EnergyWise participants during this study. The surveys were conducted after three real DR events and one placebo event. For the placebo event, respondents were told that an event had been called when in fact one had not.

Of the 401 total survey respondents, 301 were surveyed after real DR events; the remaining 100 were surveyed after the placebo event. The survey achieved a relative precision ±3% at the 90% confidence level for key quantitative outcomes.

A summary of the survey disposition by group is shown in Table A-1. For event surveys, respondents were surveyed 1-2 days following an actual curtailment event and asked questions related to their perception and comfort specifically during the event. The placebo event survey respondents were asked the same set of questions, although the event in question was a placebo because no curtailment event was called that day for the group in question.

Table A-1. Survey Status by Event

	Event: January 2, 2018	Event: January 5, 2018	Event: January 8, 2018	Placebo: January 31, 2018
Survey completes	100	100	101	100
Participant minimum temperature during survey event period	9	12	28	22

The principal EM&V findings from the analysis of participant perceptions were as follows:

- **Participants were generally unaware of curtailment events when they happened.** Most (>90%) survey respondents indicated that they had not been aware that an event had occurred recently.
- **The program has little impact on the comfort of its participants.** Only 23 respondents (out of 301 event participants) were aware that an event had been called during the period in question. For that subgroup, comfort levels reported during the event varied widely, ranging from a rating of a 0 to a 10 on the 0-10 comfort scale, with only two rating their comfort less than 5. Most survey respondents indicated that they were "very comfortable" during the event.
- **The program does not appear to be a key driver of supplemental heating use.** A similar portion of placebo survey respondents reported using supplemental methods for heating their homes during "event" periods as those respondents who were subject to actual events.
- **Participants were generally satisfied with the EnergyWise program.** Over half of the respondents indicated that they were very satisfied, while only 4% of all survey respondents (18 people) indicated that they were "dissatisfied" with the program. Satisfaction with the program

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did not differ significantly between respondents who responded to actual events versus those who responded to placebo events.

- **Fewer than half of participants were aware of the bill credits they receive as part of their program participation.** Every customer enrolled in the program receives a hardcopy brochure explaining the bill credits details (when the are received, amounts, etc.). It is important to note that many of the particpants received their bill credits outside the EM&V study calendar.
-

Table A-2 provides a summary of the number of surveys completed in each category.

Table A-2. Simplified Survey Disposition Report

Survey Disposition	Total
Saved callback (mid-survey)	225
No answer	857
Busy	66
Disconnect/wrong #/blocked #	330
Business/government	29
Deaf/language barrier	25
Answering machine	2,505
Initial refusal (Opted Out)	45
Respondent refused	406
Callback for correct person	122
Changed number	1
Complete	**401**
Total	**5,012**

This section of the report is divided into four subsections, the first three of which analyze a distinct aspect of participant perspectives. These are:

1. **Awareness of Event:** To what degree were participants aware that an event had taken place?
2. **Comfort During Event:** How comfortable were participants who were aware an event had taken place?
3. **General Program Satisfaction:** How happy or unhappy are participants with the program?

The fourth section presents participant responses to questions about typical HVAC usage, familiarity with electricity billing, and other topics covered by the survey.

A.1 Awareness of Event

The principal objective of the survey was to determine the degree to which participants took notice of and were affected by curtailment events. While the surveys included a series of more nuanced questions, one of the most important questions was whether or not the respondents took note of their device activation.

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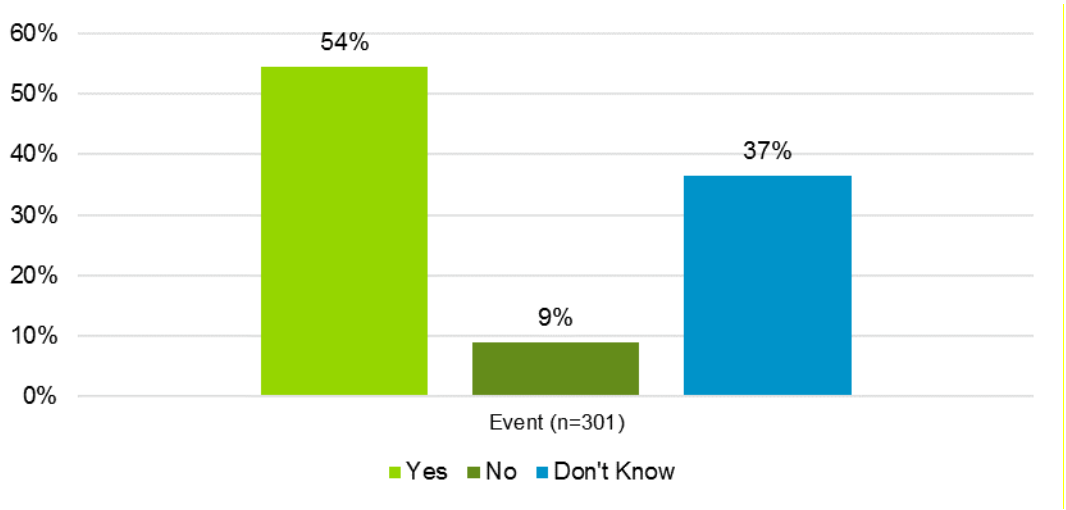
The survey assessed whether participants believed that DEP had activated their EnergyWise device, and 54% of all participants said yes, as shown in Figure A-1.

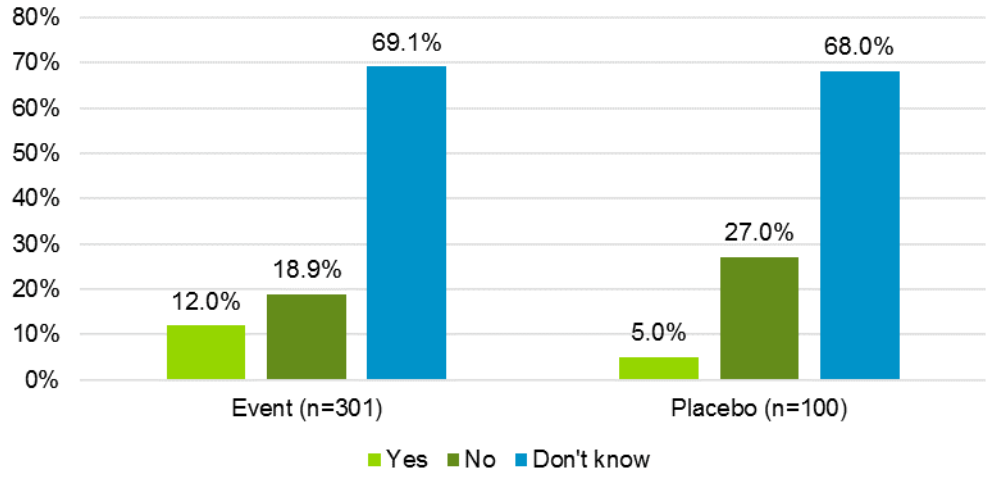
Figure A-1. Has Duke Energy Progress activated your EnergyWise device?



Source: Navigant analysis of post-event survey data, 2018

While a majority of participants believed their EnergyWise device was activated, they were unsure as to whether it had been called in the past 7 days. Figure A-2 shows that nearly 70% of participants did not know. While the results are slightly different between the event and placebo survey groups, the differences between the two are not statistically significant.

Figure A-2. Has your device been activated in the last 7 days?



Source: Navigant analysis of post-event survey data, 2018

A.2 Comfort During Event

Awareness of a curtailment event is the most important indicator of the event's impact on customer comfort. If a participant did not notice an event, then its perceived impact on their comfort must be trivial. Event awareness is not, however, the only measure of the impact on the participant. Each respondent

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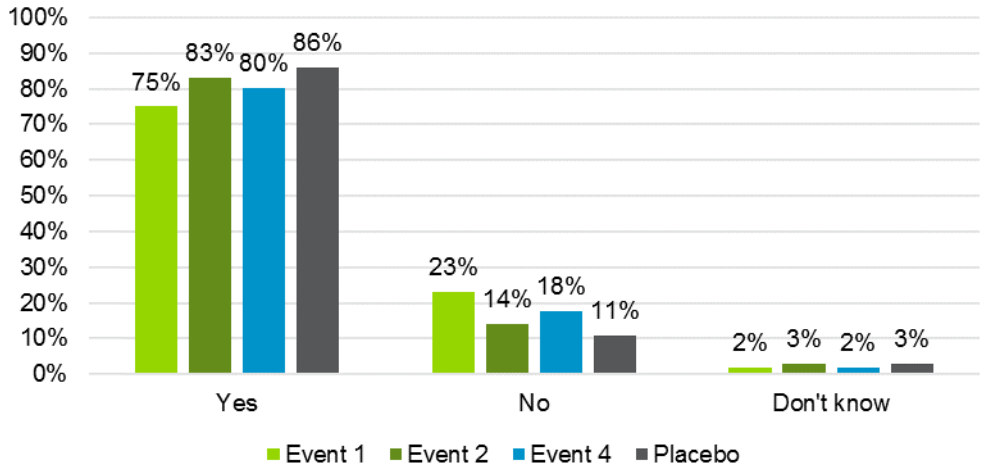
that was home during an event, regardless of whether they were aware of the event, was asked to characterize their level of comfort both immediately before and during the event. Prior to asking about levels of comfort, the survey screened for respondents who were home at the time of the event, as shown in Figure A-3. The majority of participants were home during the event hours, with a slightly higher percentage of participants reporting that they were not home during the first event (January 2, 2018). This is likely because January 2 is the day after a national holiday.

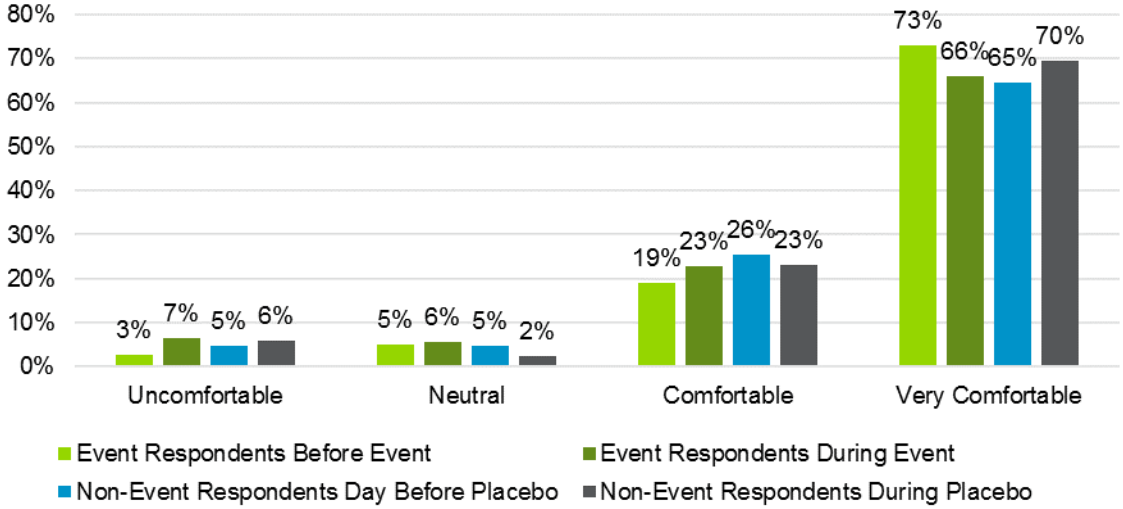
Figure A-3. Respondents Who Were Home During the Time of the Event



Source: Navigant analysis of post-event survey data, 2018

Most survey respondents reported high levels of comfort during both the actual and placebo events. Figure A-4 shows comfort levels both before and during the events for each group. The percentage of event respondents who rated themselves as very comfortable decreased during the event, going from 73% to 66%. Similarly, the percentage of event respondents who rated themselves as uncomfortable increased from 3% to 7% during the event. For the non-event respondents, the data revealed no discernible pattern in comfort level change.

Figure A-4. Change in Comfort Level During Curtailment and Placebo Events
(n_{event} = 214, $n_{placebo}$ = 82)



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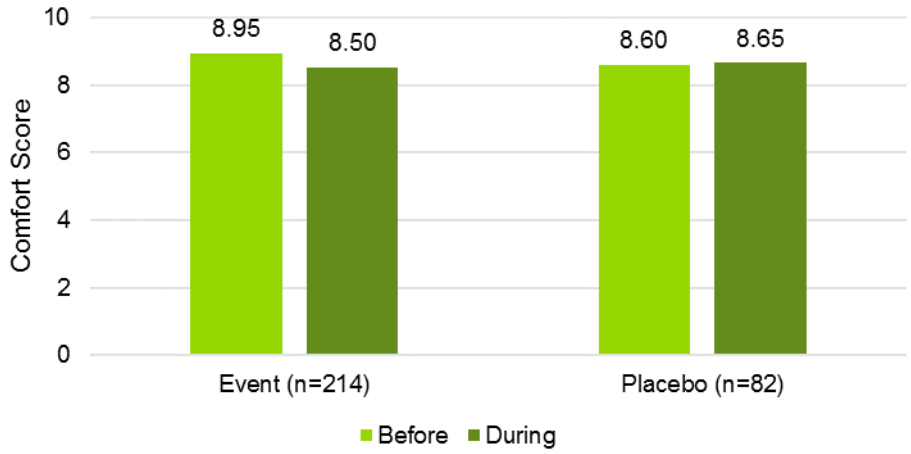
Note: Comfort levels assigned based on 0-10 rating scale: 0-4 = Uncomfortable, 5 = Neutral, 6-8 = Comfortable, 9-10 = Very Comfortable. Results exclude Don't know responses.

Source: Navigant analysis of post-event survey data, 2018

Participants who reported being home during the event period were then asked to rate their comfort with the air temperature and/or water temperature in their home before and during the event, dependent upon the types of equipment they have enrolled in the EnergyWise program. Figure A-5 shows that the comfort scores were high, with the lowest average score at 8.5 on a scale of 0-10. It is interesting to observe that the event day scores go down slightly during the event compared to before, but the difference is not statistically significant. This indicates that most participants' comfort is not being negatively affected by their participation in the EnergyWise program.

Figure A-5. Mean Comfort Score Before and During Control Event by Event Status



Source: Navigant analysis of post-event survey data, 2018

Figure A-6 shows that there is a difference between comfort scores given during the events that were surveyed, as Event 2 did have statistically lower scores. However, it is important to note that the reported comfort scores before the event started were lower than any other day surveyed.

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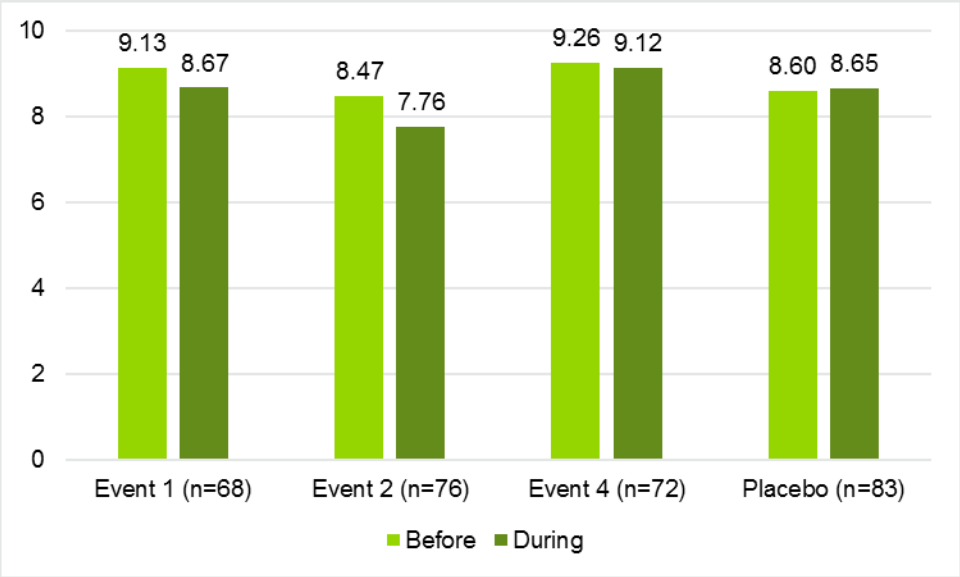
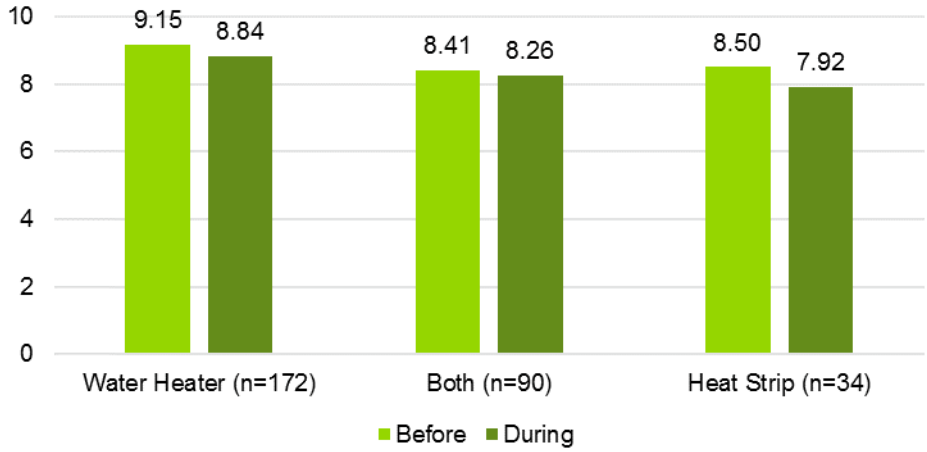
Figure A-6. Mean Comfort Score Before and During Control Event by Date



Source: Navigant analysis of post-event survey data, 2018

Figure A-7 shows the comfort scores before and during events separated by equipment type. Some participants have only a water heater or only heat strip device enrolled in the program, while others have both. Respondents were only asked about the devices they have enrolled in the program. Navigant's analysis of this data indicates that the water heater group is statistically higher than the other two equipment groups both before and during events, but the other groups are not statistically different from one another nor are the differences between before and during the event different for any given equipment type.

Figure A-7. Mean Comfort Score Before and During Control Event by Equipment Type



Source: Navigant analysis of post-event survey data, 2018

The participants who rated their comfort lower than 7 were asked to elaborate on their scores, and verbatim responses from the survey indicate that some of these participants observed lower air or water temperatures during the event. However, as Figure A-8 shows, most water heater participants who reported low comfort did not notice any changes in their hot water.

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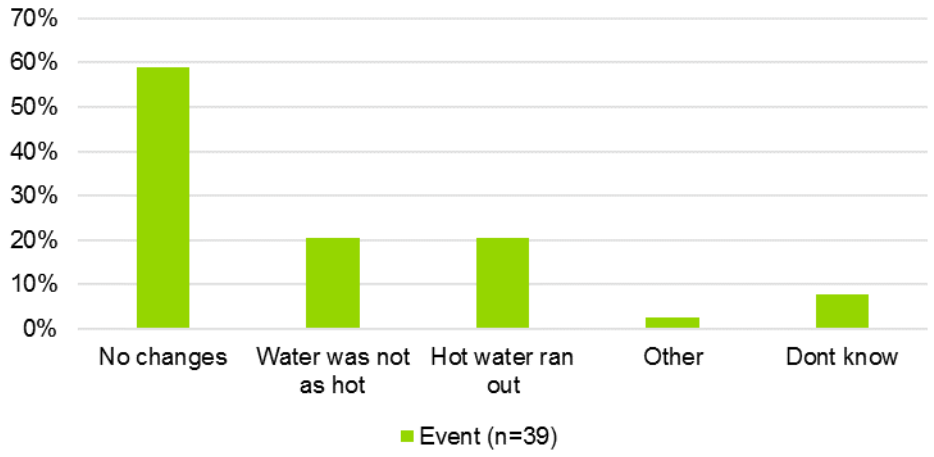
Figure A-8. Describe Changes You Noticed with Your Hot Water

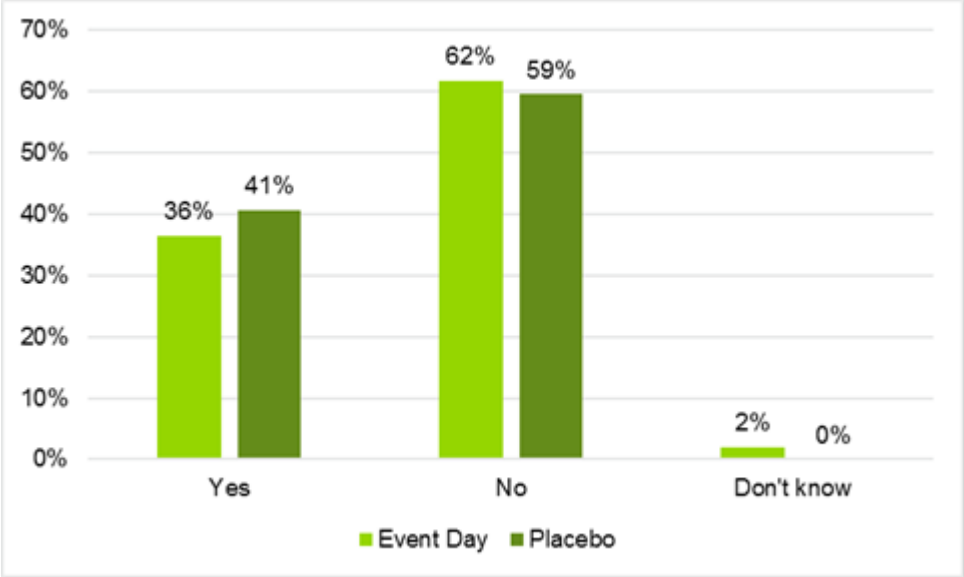


Source: Navigant analysis of post-event survey data, 2018

There is limited suggestion that the comfort of program participants decreased during the event, and coupled with low levels of awareness of device activation, it can be safely concluded that the program is having a minimal effect on the comfort of its participants.

Participants who have heat strips enrolled in the program were asked whether they used additional sources of heat to stay warm during the event and placebo periods. As shown in Figure A-9, Fewer than half of respondents reported using additional heat sources, and a similar portion of placebo and actual event respondents reported using alternate heat. These findings seem to indicate that actual DR events are not a key driver in customer use of alternate heating sources.

Figure A-9. Respondent Use of Additional Heat Sources During Event or Placebo Period



Of those respondents who reported using additional heat sources, Figure A-10 shows that most used an electric space heater (19), a gas fireplace or stove (16), or a wood-burning fireplace or stove (10). Ten respondents reported using other heat sources not listed in the survey, which included pellet stove, gas furnace, and propane heaters.

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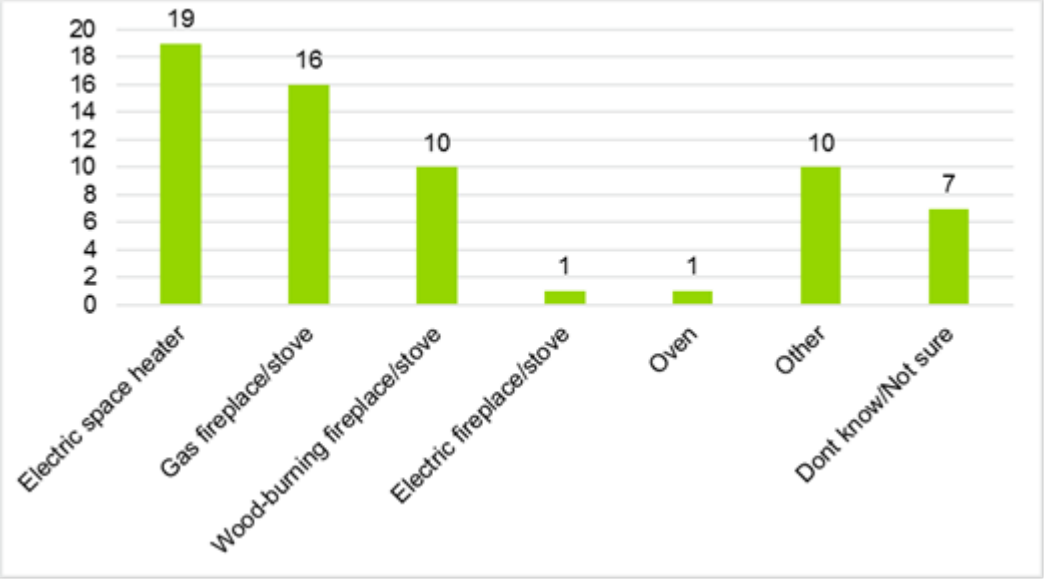
Figure A-10. Types of Additional Heat Sources Used

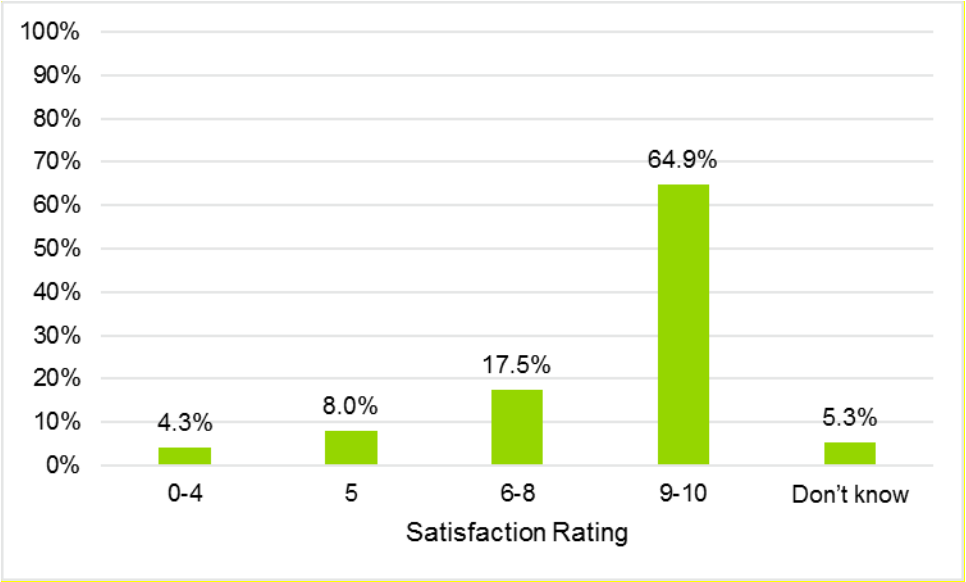


A.3 General Program Satisfaction

In addition to testing participant awareness of events and comfort during events, an important component of the post-event survey effort was to determine the general level of satisfaction participants had with the program. The evaluation team asked respondents to rate their satisfaction with the program overall on a scale from 0 to 10, where 10 is extremely satisfied.

Most survey respondents reported high levels of satisfaction with the program, with 65% of participants highly satisfied (9-10). Only 4% of survey participants rated themselves as dissatisfied with the program (4 or below). Figure A-11 shows a breakdown of these findings.

Figure A-11. Program Satisfaction of Survey Respondents (n = 399)



Source: Navigant analysis of post-event survey data, 2018

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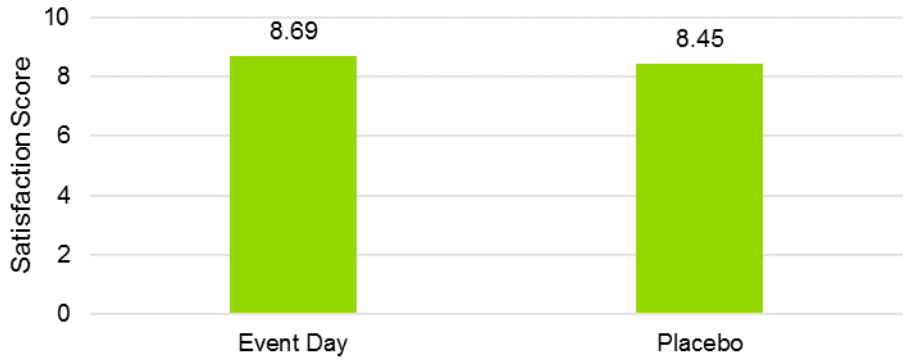
The survey also investigated satisfaction. Satisfaction was assessed using a scale of 0-10, with 1 being very unsatisfied and 10 being very satisfied. Navigant found that the average satisfaction scores were around 8.5 for participants surveyed after event days and the placebo day, indicating high satisfaction with the program. Note that while Figure A-12 shows a difference between the two groups, that difference is not statistically significant.

Figure A-12. Reported Satisfaction with the EnergyWise Program by Event Status



Source: Navigant analysis of post-event survey data, 2018

Similarly, the reported satisfaction did not differ significantly between event days, indicating that the frequency in events did not impact participants' overall satisfaction with the program. Figure A-13 shows these results.

Figure A-13. Reported Satisfaction with the EnergyWise Program by Event

Source: Navigant analysis of post-event survey data, 2018

Building on their reported satisfaction, 83% of survey respondents indicated that they would recommend the program to a friend or colleague, characterized by a rating of 6 or higher on a likelihood scale from 0 to 10.

The evaluation team asked respondents who expressed lower satisfaction with the program (a rating of a 7 or below) to expand on their reasoning. The most common reason for dissatisfaction was a lack of

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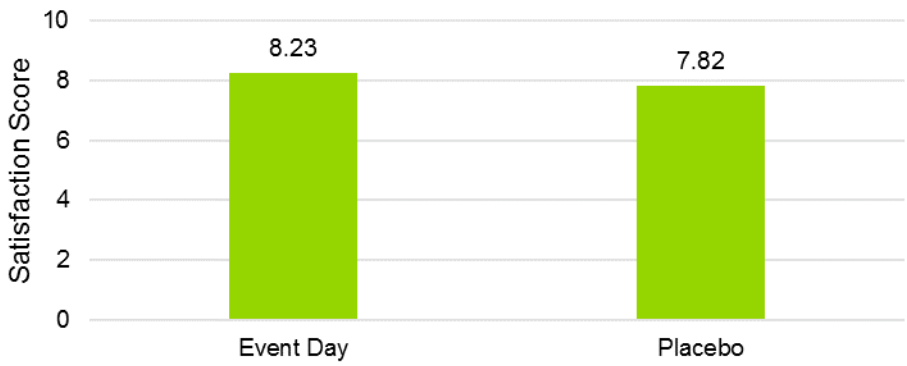
notification when DEP activates their device or lack of information about the program in general. Five participants mentioned that they either ran out of hot water or their water was not hot enough.

Compared to their satisfaction with the EnergyWise program, participants rated their satisfaction with DEP as a utility slightly lower, though most participants were still satisfied, as shown in Figure A-14. As above, while there is a slight difference in the scores given after an event day versus a placebo day, the difference is not statistically significant.

Figure A-14. Satisfaction with DEP

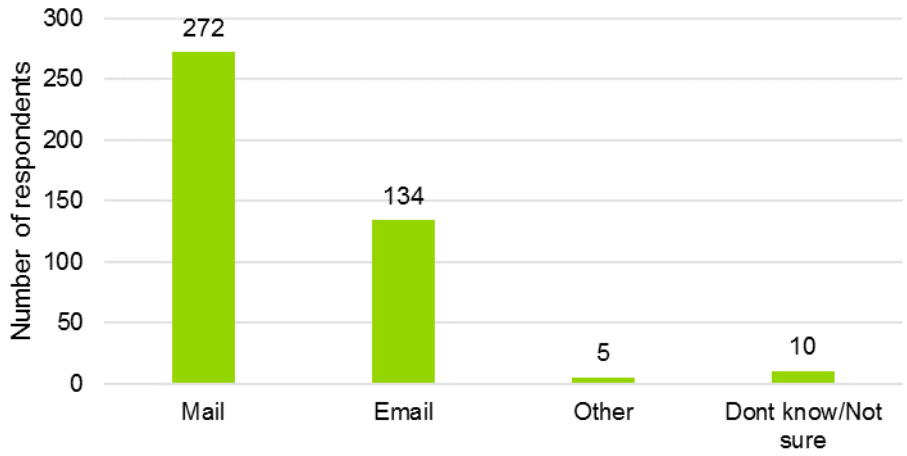


Source: Navigant analysis of post-event survey data, 2018

A.4 Other Survey Findings

This subsection contains additional results from the participant surveys. Navigant's survey asked participants to report the mode by which they receive their monthly DEP bill. Figure A-15 shows that about two-thirds of participants get their bill in the mail.

Figure A-15. Mode of DEP Bill Receipt



Source: Navigant analysis of post-event survey data, 2018

The survey then asked how frequently the participants review the details of their bill. Most participants reported reviewing the details of their bill every month, as shown in Figure A-16.

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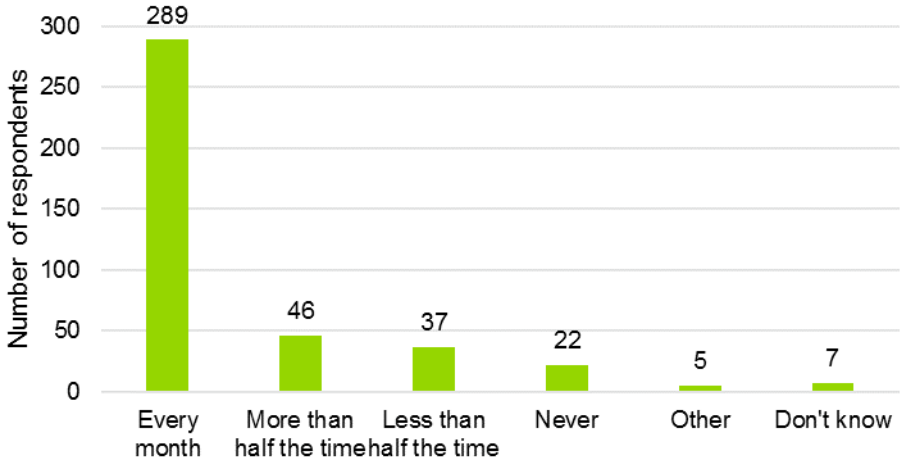
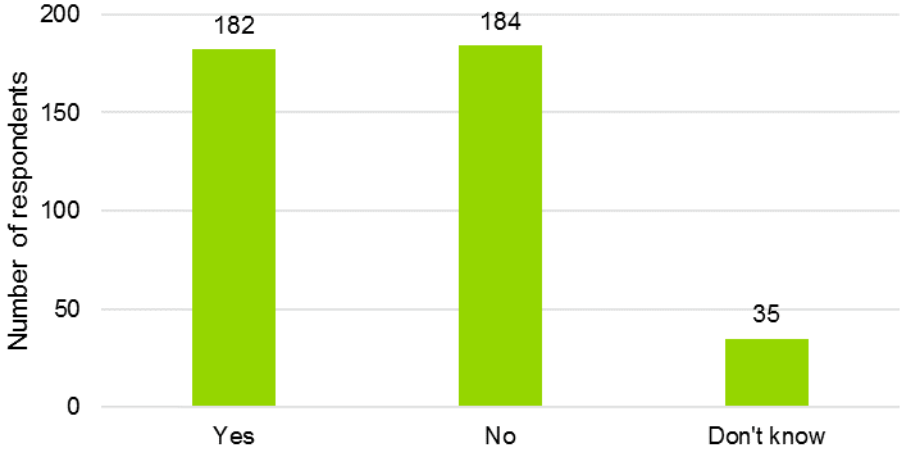
Figure A-16. Frequency of Reviewing DEP Bill



Source: Navigant analysis of post-event survey data, 2018

The survey respondents were then asked whether they have noticed the EnergyWise credit on their bill. As shown in Figure A-17, just under half of participants have noticed.

Figure A-17. Have you noticed the EnergyWise credit on your bill?



Source: Navigant analysis of post-event survey data, 2018

Finally, the survey asked participants who reported noticing the EnergyWise bill credit to rate their satisfaction with the credit amount on a scale of 1-10. The average scores above 8 (shown in Figure A-18) indicate that participants are generally satisfied with the bill credit.

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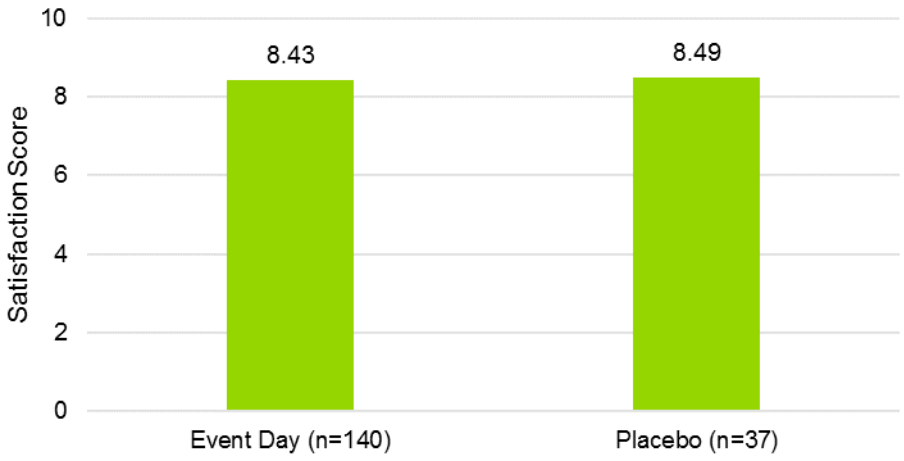
Figure A-18. Satisfaction with Bill Credit Amount



Source: Navigant analysis of post-event survey data, 2018

The evaluation team also asked several questions about the participants' home heat pumps. When participants were asked at what outdoor temperature they will run their heat pumps, the majority did not know the answer. Most participants reported that they run their heat pump every day during cooling season, as opposed to only when it is below a certain temperature. Participants were also asked to report the age of their heat pump. Participants reported a relatively even distribution across ages between new and about 20 years old.

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APPENDIX B. ESTIMATION DETAILS AND MODEL SPECIFICATION

This appendix provides more detail on the methods employed by the evaluation team to estimate DR impacts and the capability of heat strips and water heaters controlled during the winter of 2017/2018. It is divided into two sections. The first addresses heat strips, while the second addresses water heaters.

B.1 Heat Strips Model Specification and Details

Heat strip impacts were estimated using a single regression equation, shown in Equation B-1. Only event days were included in the estimation set. This differs from previous winter EnergyWise evaluations, which also included some non-event days in the estimation set. Limiting the estimation set to include event days only is possible due to the two-group RCT-style experimental design. Heat strips found to be not in use during event days (both those expected to curtail and those not) were excluded from the estimation set.

Equation B-1. Heat Strips Regression Model

$$
\begin{aligned}
y_{i,t} = & \sum_{r=1}^{R=2} \alpha_{i,r} \cdot spline_{r,t} + \sum_{r=1}^{R=2} \sum_{q=1}^{Q=96} \beta_{1,q} \cdot qh_{q,t} \cdot spline_{r,t} + \sum_{r=1}^{R=2} \sum_{q=1}^{Q=96} \beta_{2,q} \cdot qh_{q,t} \cdot cbu_{i,t} \cdot spline_{r,t} \\
& + \sum_{r=1}^{R=2} \sum_{q=1}^{Q=96} \beta_{3,q} \cdot qh_{q,t} \cdot emaHDQH_{i,t} \cdot spline_{r,t} + \sum_{r=1}^{R=2} \sum_{d=1}^{D=16} \gamma_{d,1} \cdot relQH_{d,t} \cdot c_{i,t} \cdot emaHDQH_{i,t} \cdot spline_{r,t} \\
& + \sum_{r=1}^{R=2} \sum_{d=1}^{D=16} \gamma_{d,1} \cdot relQH_{d,t} \cdot c_{i,t} \cdot emaHDQH_{i,t} \cdot PR_{i,t} \cdot spline_{r,t} + \sum_{r=1}^{R=2} \sum_{s=1}^{S=15} \beta_{5,s} \cdot eventHDQH_{i,t} \cdot sb_{i,t,s} \cdot spline_{r,t} \\
& + \sum_{r=1}^{R=2} \sum_{s=1}^{S=15} \beta_{5,s} \cdot eventHDQH_{i,t} \cdot sb_{i,t,s} \cdot PR_{i,t} \cdot spline_{r,t} \cdot \varepsilon_{i,t}
\end{aligned}
$$

Where:

$y_{i,t}$ = Appliance *i*'s demand during quarter-hour of sample *t*.

$spline_{r,t}$ = A set of two dummy variables.

One is equal to 1 when the value of $emaHDQH_t$ is less than 35 (approximately equivalent to taking a value of one when the temperature is greater than 30°F).

The other is equal to 1 when the value of $emaHDQH_t$ is greater than or equal to 35 (approximately equivalent to taking a value of one when the temperature is less than or equal to 30°F). See below for the reasoning for the selection of this value as the spline breakpoint.

α_i = An individual device-level fixed effect. This is equivalent to a battery of dummy variables, one for each device. This set of dummy variables controls for all time-invariant differences in demand between devices (e.g., the size or age of the system, etc.)

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$qh_{q,t}$ = Dummy variables (96) to capture time of day effects. Each one is equal to 1 when quarter-hour of sample *t* is the *q*-th quarter-hour of that day, and 0 otherwise.

cbu_t = Cold buildup observed in quarter-hour of sample *t*. This is a 72-hour geometrically decaying average of the NOAA-defined wind chill/temperature index.[37] It is calculated in the following manner:

$$cbu_t = \sum_{h=1}^{72} 0.96^h \cdot wchill_{t-h} \Big/ 1,000 .$$

Note in this case that the *t* subscript denotes hourly intervals. As noted above, the cbu_t (normalized cold buildup) is a geometrically decaying 72-hour moving average of NOAA's wind chill/temperature index. That variable is calculated in the following manner:

$$wchill_t = 35.74 + 0.6215 \cdot drybulb_t - 35.75 \cdot (0.16 \cdot ws_t) + 0.4275 \cdot drybulb_t \cdot (0.16 \cdot ws_t)$$

Where $drybulb_t$ is the drybulb temperature (in °F) observed at quarter-hour *t* and ws_t is the windspeed in miles per hour observed at quarter-hour *t.*

$emaHDQH_t$ = A 3-hour exponential moving average of heating degree quarter-hours (HDQHs). That is, an exponential moving average that includes the current quarter-hour *t* and the 11 quarter-hours prior to that. The moving average calculated over HDQHs with a base of 65°F (i.e., HDQH is equal to 65 minus temperature, or 0, whichever is highest).

$relQH_{d,t}$ = A set of 16 dummy variables, each equal to 1 when quarter-hour *t* is the *d*-th quarter-hour of the event.

$c_{i,t}$ = A dummy variable equal to 1 when appliance *i* is both expected to curtail (i.e., is in Group A during a Group A curtailment event or is in Group B during a Group B curtailment event) and is found to be either fully or partially responsive to the curtailment signal.

$PR_{i,t}$ = A dummy variable equal to 1 when appliance *i* has been found to be partially responsive to the event on day *t*, and 0 otherwise.

$sb_{i,t,s}$ = A set of 15 dummy variables. Each one is equal to 1 when quarter-hour *t* is the *s*-th quarter-hour following the end of a DR event and when appliance *i* was both expected to curtail and was partially or fully responsive on event day *t*.

$eventHDQH_{i,t}$ = The sum of HDQHs to which the home in which appliance *i* resides was exposed over the course of the event that took place on day *t*, and 0 otherwise.

[37] NOAA, National Weather Service, *Wind Chill/Temperature Index*, accessed February 2018. https://www.weather.gov/oun/safety-winter-windchill

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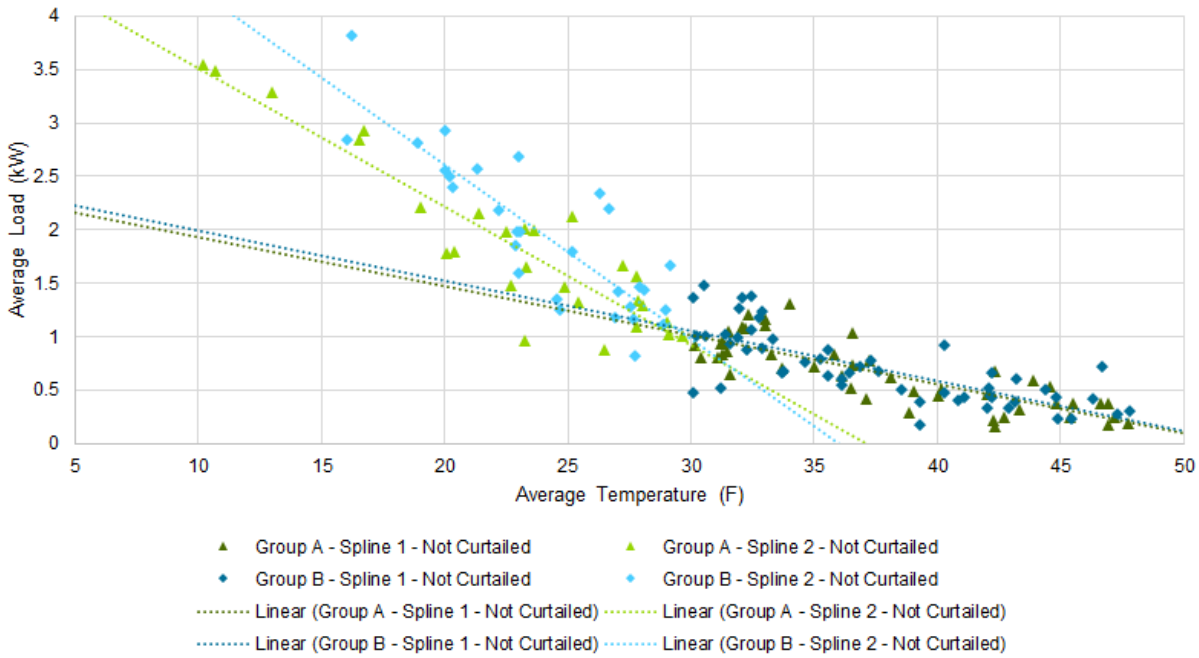
The parameter estimates obtained from this model were used to calculate the estimated impact of each of the curtailment events and the forecast capability at a variety of temperatures.

The purpose of the splines (two dummy variables) is to explicitly account for the highly nonlinear nature of average heat strip demand. The effect of these dummies (which are interacted with every other variable in the model) is analytically equivalent to estimating two different regression equations. Using splines instead of two different equations, however, means that covariances between variables that cross both splines are available for the purposes of calculating aggregated standard errors. The selection of the spline threshold (approximately 30°F) was selected based on a visual inspection of average event period demand on non-event days. A scatter plot of average demand between 6:30 and 7:30 on non-event days, by EM&V group, is plotted in Figure B-1. The dashed lines show how the trend shifts at approximately 30°F.

Figure B-1. Average Non-Event Day Demand and Temperature



Source: Navigant analysis, NOAA data

B.2 Water Heater Model Specification and Details

Water heater impacts were estimated using a single regression equation, shown in Equation B-2. Only event days were included in the estimation set. This differs from previous winter EnergyWise evaluations, which also included some non-event days in the estimation set. Limiting the estimation set to include event days only is possible due to the two-group RCT-style experimental design.

Equation B-2. Water Heater Regression Model

$$y_{i,t} = \alpha_i + \sum_{q=1}^{Q=96} \beta_{1,q} \cdot qh_{q,t} + \sum_{q=1}^{Q=96} \beta_{3,q} \cdot qh_{q,t} \cdot ma2wkHDQH_{i,t}$$
$$+ \sum_{q=27}^{Q=40} \gamma_q \cdot c_{i,t} \cdot qh_{q,t} + \sum_{s=1}^{S=16} \beta_{4,s} \cdot numQH_{i,t} \cdot sb_{i,t,s} + \varepsilon_{i,t}$$

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Where:

$ma2wkHDQH_{i,t}$ = A 2-week moving average of the HDQHs for appliance *i*. Although an inspection of the data indicates there is no material or significant relationship between water heater demand and contemporaneous temperature, the fact that many water heaters are installed in semi-conditioned areas would suggest that longer-term temperature shifts are likely to affect demand. This variable is included principally to improve baseline precision.

$numQH_{i,t}$ = The number of quarter-hours over which the water heater was curtailed.

This is to capture that the longer that a water heater is curtailed, the more energy will need to be taken back by the snapback to restore tank setpoint.

And all other variables are as defined above.

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APPENDIX C. FINAL SURVEY GUIDE USED FOR PARTICIPANT PERCEPTION PHONE SURVEYS

C.1 DEP EnergyWise Home Program Evaluation

Residential Post-Event Survey

Purpose: The EnergyWise program provides residential customers the opportunity to earn credit on their electricity bill by allowing Duke Energy Progress to remotely control air conditioners (AC) in the summer months during times of seasonal peak demand, known as DR events. Telephone surveys will be conducted with program participants following DR events and "placebo" events, where no event is actually called, but features similar conditions to DR event days. The key process research objectives addressed through this survey will include assessing overall participant program satisfaction and evaluating participant awareness and comfort levels during actual DR events as compared to "awareness" of placebo DR events.

FOR EVENT SAMPLE: Use two attempts at different times of the day within 27 hours of event notification before dropping contact from the contact list. Call times are from 10:00 a.m. to 8:00 p.m. EDT or 9-7 CST Monday through Saturday. No calls on Sunday. For example, if a control event occurs on a Monday, calling hours for that particular event would be:

Monday 6:30pm-8pm Eastern (5:30-7 Central)
Tuesday 10am-8pm Eastern (9-7 Central)

FOR NON-EVENT SAMPLE: Use two attempts at different times of the day within 27 hours of weather similar to when a real event would be called but no EnergyWise Home event being called. Call times are from 10:00 a.m. to 8:00 p.m. EDT or 9-7 CST Monday through Saturday. No calls on Sunday. For example, if a high temperature/no event day occurs on a Monday, calling hours for that particular non-event would be:

Monday 6:30pm-8pm Eastern (5:30-7 Central)
Tuesday 10am-8pm Eastern (9-7 Central)

For a Friday Event calls can be made on the Monday following if needed.

State:
( ) North Carolina
( ) South Carolina

Info
Survey ID: _____
Event ID: __DATE_____
Surveyor Name: _____

Basic Customer Data: (To be provided from Sample)

- Name (Adult Customer of Record and/or Spouse)
- Date Survey Completed
- Property Address
- Phone number
- Utility Account Number

Sample Variables:

1. CONTACT_NAME
2. SAMPLE_TYPE (1 = EVENT; 2 = NON-EVENT)
3. HIGHTEMP_DATE
4. EVENT_STARTTIME

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5. EVENT_ENDTIME
6. BEFORE_HIGHTEMP_DATE

INSERT LABEL	Round 1/ Event 1	Round 2/ Event 2	Round 3/ Event 3 (Placebo)
HIGHTEMP_DATE	August 11, 2016	September 8, 2016	September 14, 2016
EVENT_STARTTIME	3:00 p.m.	3:00 p.m.	3:00 p.m.
EVENT_ENDTIME	6:00 p.m.	6:00 p.m.	6:00 p.m.
BEFORE_HIGHTEMP_DATE	August 10, 2016	September 7, 2016	September 13, 2016

INTRO. Hello, my name is (YOUR NAME), and I'm calling from Bellomy Research on behalf of Duke Energy Progress. May I please speak to [INSERT CONTACT NAME]? (IF NOT AVAILABLE, SAY:) May I please speak to the person who would be most familiar with your household's participation in the EnergyWise Home Program? (IF NO ONE AVAILABLE TO SPEAK WITH, TRY TO SCHEDULE A CALLBACK WITHIN THE NEXT 24 HOURS ONLY.)

According to our information, you presently participate in Duke Energy Progress's EnergyWise Home Program. This program allows Duke Energy Progress to cycle your air conditioner when there is a critical need for electricity in the region. This is a short survey that will take about 5 minutes to complete and the information you provide will be confidential and will help to improve the program.

1. Are you aware of your participation in the EnergyWise Home Program?
   1. Yes
   2. No
   98. Don't know/Not sure

[IF Q1 = 2 OR 98 CONTINUE. OTHERWISE, SKIP TO Q2.]

1a. May I please speak to the person who would be most familiar with your household's participation in the EnergyWise Home Program? (IF NOT AVAILABLE, TRY TO SCHEDULE A CALLBACK WITHIN THE NEXT 24 HOURS ONLY.)
   1. Yes, available
   99. Refused

[IF Q1A = 1, CONTINUE. OTHERWISE, THANK AND TERMINATE.]

1b. Hello, my name is (YOUR NAME), and I'm calling from Bellomy Research on behalf of Duke Energy Progress. According to our information, you presently participate in Duke Energy Progress's EnergyWise Home Program. This program allows Duke Energy Progress to cycle your air conditioner when there is a critical need for electricity in the region. This is a short survey that will take about 5 minutes to complete and the information you provide will be confidential and will help to improve the program.
   1. Yes, continue
   99. Refused

[IF 1B = 1, CONTINUE. OTHERWISE, THANK AND TERMINATE.]

2. Has Duke Energy Progress activated the EnergyWise Home device since you joined the program?
(IF THEY ASK WHAT THIS MEANS, RESPOND WITH:) "Duke Energy Progress has the ability to send a signal to activate the device to cycle your central air conditioner on and off during an event." (THEN REPEAT THE QUESTION.)
   1. Yes
   2. No
   98. Don't know/Not sure

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3. How do you know when the device has been activated? (DO NOT READ LIST. RECORD ALL MENTIONS.)
   1. AC shuts down
   2. Home temperature rises
   3. The light on the meter is on
   4. Light on AC unit flashes
   5. Bill credits
   6. Lower bill
   97. Other (Please Specify)
   98. Don't know/Not sure

Has your device been activated within the last 7 days?
   1. Yes
   2. No
   98. Don't know/Not sure

5. [IF SAMPLE_TYPE = 1 "Event", DISPLAY: According to our records, your device was activated on [INSERT HIGHTEMP_DATE] starting at [INSERT EVENT_STARTTIME] and ending at [INSERT EVENT_ENDTIME]].
[IF SAMPLE_TYPE = 1 "EVENT", Q5_INSERT = "during the time of the event?"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q5_INSERT = "at 3pm on [INSERT HIGHTEMP_DATE]?"]
At what temperature was your thermostat set to [INSERT Q5_INSERT]
   1. Less than 65 degrees
   2. 65-68 degrees
   3. 69-72 degrees
   4. 73-75 degrees
   5. 76-78 degrees
   6. 79-81 degrees
   7. 82-84 degrees
   8. 85-87 degrees
   9. 88-90 degrees
   10. 91-94 degrees
   11. 95-97 degrees
   12. 98-100 degrees
   13. Greater than 100 degrees
   14. It's programmed into the thermostat
   15. Thermostat was turned off
   16. Air conditioner was turned off
   98. Don't know/Not sure

[IF SAMPLE_TYPE = 1 "EVENT", Q6_INSERT = "when Duke Energy Progress activated your EnergyWise Home device at that time?"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q6_INSERT = "at that time?"]
6. Were you or any members of your household home [INSERT Q6_INSERT]
   1. Yes
   2. No
   98. Don't know/Not sure

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[IF Q6 = 1, CONTINUE. OTHERWISE, SKIP TO Q14.]
[IF SAMPLE_TYPE = 1 "EVENT", Q71_INSERT = "During this recent activation,"]
[IF SAMPLE_TYPE = 1 "EVENT", Q72_INSERT = "before the recent activation?"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q71_INSERT = "During this time,"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q72_INSERT = "on [INSERT BEFORE_HIGHTEMP_DATE]?"]

7. [INSERT Q71_INSERT] using a scale of 0 to 10, where 0 means "Very Uncomfortable" and 10 means "Very Comfortable", how would you describe your level of comfort [INSERT Q72_INSERT]

Very Uncomfortable										Very Comfortable	Don't know/Not sure
0	1	2	3	4	5	6	7	8	9	10	98

[IF SAMPLE_TYPE = 1 "EVENT", Q8_INSERT = "during the recent activation?"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q8_INSERT = "on [INSERT HIGHTEMP_DATE]?"]

8. Using the same scale of 0 to 10, where 0 means "Very Uncomfortable" and 10 means "Very Comfortable", how would you describe your level of comfort [INSERT Q8_INSERT]

Very Uncomfortable										Very Comfortable	Don't know/Not sure
0	1	2	3	4	5	6	7	8	9	10	98

[IF Q7 OR Q8 = 98 "DK/NS", SKIP TO Q10.]
[IF Q8 ANSWER < Q7 ANSWER, CONTINUE. OTHERWISE SKIP TO Q10.]
[IF SAMPLE_TYPE = 1 "EVENT", Q9_INSERT = "EnergyWise Home Program/Control"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q9_INSERT = "EnergyWise"]

9. What do you feel caused your decrease in comfort? (DO NOT READ LIST. RECORD ALL MENTIONS.)

1. [INSERT Q9_INSERT]
2. Rising temperature
3. Rising humidity
4. Power outage
97. Other (Please Specify)
98. Don't know/Not sure

[IF SAMPLE_TYPE = 1 "EVENT", Q10_INSERT = "When Duke Energy Progress activated your EnergyWise Home device on [INSERT HIGHTEMP_DATE],"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q10_INSERT = "On [INSERT HIGHTEMP_DATE],"]

10. [INSERT Q10_INSERT] did you or any other members of your household adjust the settings on your thermostat?

1. Yes
2. No
98. Don't know/Not sure

[IF Q10 = 1, CONTINUE. OTHERWISE SKIP TO Q12.]
[IF SAMPLE_TYPE = 1 "EVENT", Q11_INSERT = "during the control event?"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q11_INSERT = "on [INSERT HIGHTEMP_DATE]?"]

11. At what temperature was it originally set, and what temperature did you set it to [INSERT Q11_INSERT] (USE 998 FOR DON'T KNOW/NOT SURE.)

_____ Original temperature setting (degrees F) [ENTER NUMBER FROM 0-100.]
_____ Adjusted temperature setting (degrees F) [ENTER NUMBER FROM 0-100.]

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[IF SAMPLE_TYPE = 1 "EVENT", Q12_INSERT = "When Duke Energy Progress activated your EnergyWise Home device on [INSERT HIGHTEMP_DATE],"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q12_INSERT = "On [INSERT HIGHTEMP_DATE],"]

12. [INSERT Q12_INSERT] did you or any other members of your household turn on any fans to keep cool?
    1. Yes
    2. No
    98. Don't know/Not sure

13. What else did you or other members of your household do to keep cool? (DO NOT READ LIST. RECORD ALL MENTIONS.)
    1. Continued normal activities/Didn't do anything different [EXCLUSIVE]
    2. Turned on room/window air conditioners
    3. Closed blinds/shades
    4. Moved to a cooler part of the house
    5. Left the house and went somewhere cool
    6. Wore less clothing
    7. Drank more water/cool drinks
    9. Opened windows
    97. Other (Please Specify)
    98. Don't know/Not sure

14. Now I'm going to ask you some questions about your usual air conditioning use. How often do you use your central air conditioner? Would you say you use it...(READ LIST)? (STOP WHEN RESPONDENT ANSWERS.)
    1. Not at all
    2. Only on the hottest days
    3. Frequently during the cooling season
    4. Most days during the cooling season
    5. Every day during the cooling season
    8. (DO NOT READ) Don't know/Not sure

15. When you think of a typical hot and humid summer day, at what outside temperature do you tend to feel uncomfortably warm? (DO NOT READ LIST.)
    1. Less than 65 degrees
    2. 65-68 degrees
    3. 69-72 degrees
    4. 73-75 degrees
    5. 76-78 degrees
    6. 79-81 degrees
    7. 82-84 degrees
    8. 85-87 degrees
    9. 88-90 degrees
    10. 91-94 degrees
    11. 95-97 degrees
    12. 98-100 degrees
    13. Greater than 100 degrees
    98. Don't know/Not sure

16. At what <u>outside temperature</u> do you tend to turn on the air conditioner? (DO NOT READ LIST.)
    1. Less than 65 degrees
    2. 65-68 degrees
    3. 69-72 degrees
    4. 73-75 degrees
    5. 76-78 degrees
    6. 79-81 degrees

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7. 82-84 degrees
8. 85-87 degrees
9. 88-90 degrees
10. 91-94 degrees
11. 95-97 degrees
12. 98-100 degrees
13. Greater than 100 degrees
14. It's programmed into the thermostat
98. Don't know/Not sure

17. How old is your air conditioner? (DO NOT READ LIST.)
1. 0 to 6 years old
2. 7 to 12 years old
3. 13 to 20 years old
4. Over 20 years old
98. Don't know/Not sure

18. Using a scale of 0 to 10, where 0 means "Very Dissatisfied" and 10 means "Very Satisfied", what is your overall satisfaction with the EnergyWise Home Program?

Very Dissatisfied										Very Satisfied	Don't know/Not sure
0	1	2	3	4	5	6	7	8	9	10	98

[IF Q18 = 0-7, CONTINUE. OTHERWISE SKIP TO Q20.]

19. Why are you less than satisfied with EnergyWise Home? (RECORD ALL MENTIONS.)
1. They activated my EnergyWise Home device more often than I would like
2. The bill credit/incentives were not large enough
3. I was uncomfortable when my EnergyWise device was activated
97. Other (Please Specify)
98. Don't know/Not sure

20. Using a scale of 0 to 10, where 0 means "Very Dissatisfied" and 10 means "Very Satisfied", what is your overall satisfaction with Duke Energy Progress?

Very Dissatisfied										Very Satisfied	Don't know/Not sure
0	1	2	3	4	5	6	7	8	9	10	98

[IF Q20 = 0-7, CONTINUE. OTHERWISE SKIP TO Q22.]

21. Why are you less than satisfied with Duke Energy Progress? (RECORD VERBATIM.)
_____ CODING USE ONLY

22. Using a scale of 0 to 10, where 0 means "Extremely Unlikely" and 10 means "Extremely Likely", how likely is it that you would recommend this program to a friend or colleague?

Extremely Unlikely										Extremely Likely	Don't know/Not sure
0	1	2	3	4	5	6	7	8	9	10	98

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[IF Q22 = 0-7, CONTINUE. OTHERWISE SKIP TO Q24.]

23. Why would you not recommend the program? (RECORD VERBATIM.)
_____ CODING USE ONLY

24. Do you get your Duke Energy Progress bill in the mail or by email?
1. Mail
2. Email
97. Other (Please Specify)
98. Don't know/Not sure

25. How do you pay your bill? Do you…(READ LIST)? (STOP WHEN RESPONDENT ANSWERS.)
1. Mail a check
2. Log into your Duke Energy Progress account and pay online
3. Or, do you have an auto-pay set up for your account
97. (DO NOT READ) Other (Please Specify)
98. (DO NOT READ) Don't know/Not sure

26. On average, how often do you review the details of your Duke Energy Progress bill? (READ LIST.) (STOP WHEN RESPONDENT ANSWERS.)
1. Every month
2. More than half the time
3. Less than half the time
4. Never
97. (DO NOT READ) Other (Please Specify)
98. (DO NOT READ) Don't know/Not sure

27. Have you noticed EnergyWise Home credit on your bill?
1. Yes
2. No
98. Don't know/Not sure

[IF Q27 = 1, CONTINUE. OTHERWISE SKIP TO Q30.]

28. Using a scale of 0 to 10, where 0 means "Very Dissatisfied" and 10 means "Very Satisfied", what is your overall satisfaction with the credit amount?

Very Dissatisfied										Very Satisfied	Don't know/Not sure
0	1	2	3	4	5	6	7	8	9	10	98

[IF Q28 = 0-7, CONTINUE. OTHERWISE SKIP TO Q30.]

29. Why do you say you're not satisfied? (RECORD VERBATIM.)
_____ CODING USE ONLY
[PROGRAMMER: ALLOW A DON'T KNOW/NOT SURE CHECK BOX.]

[IF SAMPLE_TYPE = 1 "EVENT", Q30_INSERT = "Duke Energy Progress about the EnergyWise Home Program?"]
[IF SAMPLE_TYPE = 2 "NON-EVENT", Q11_INSERT = "Duke Energy Progress?"]

30. We have reached the end of the survey. Do you have any comments that you would like for me to pass on to [INSERT Q30_INSERT] (RECORD VERBATIM.)
_____ CODING USE ONLY
[PROGRAMMER: ALLOW A NO COMMENTS CHECK BOX.]

CLOSE 2. Thank you for your time and feedback today!

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EM&V Report for the Small Business Energy Saver Program

Duke Energy Progress and Duke Energy Carolinas

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1. EVALUATION SUMMARY

1.1 Program Summary

The Small Business Energy Saver (SBES) Program is part of a portfolio of energy efficiency programs operated by Duke Energy. Duke Energy selected Lime Energy to implement the SBES program again in the Duke Energy Progress (DEP) jurisdiction, as well as the Duke Energy Carolinas (DEC) jurisdiction for this evaluation cycle. The program caters specifically to small business customers (up to 180 kilowatts demand service, up from 100 kW demand service in previous years) and offers a performance-based incentive up to 80 percent of the total project cost, inclusive of both materials and installation, on high-efficiency lighting and refrigeration equipment.

The SBES Program generates energy savings and peak demand reductions by offering eligible customers a streamlined service including marketing outreach, technical expertise, and performance incentives to reduce equipment and installation costs from market rates on high-efficiency lighting, refrigeration, and HVAC equipment. The SBES Program seeks to bundle all eligible measures together and sell them as a single project to maximize the total achievable energy and demand savings, while working with customers to advise equipment selection to meet their unique needs.

1.2 Evaluation Objectives and High-Level Findings

Evaluation, Measurement, and Verification (EM&V) involves the use of a variety of analytic approaches, including on-site verification of installed measures and application of engineering models. EM&V also encompasses an evaluation of program processes and customer feedback, typically conducted through participant surveys and program staff interviews. This report details the EM&V activities that Navigant Consulting, Inc. (Navigant) performed on behalf of Duke Energy for the SBES Program covering the period between March 1, 2016 through June 30, 2017, referenced simply as PY2016.

The primary purpose of the evaluation assessment is to estimate net annual energy and peak demand impacts associated with SBES activity. Net savings are calculated as the reported “gross” savings from Duke Energy, verified and adjusted through EM&V, and netted for free ridership (i.e., savings that would have occurred even in the absence of the program) and spillover (i.e., additional savings attributable to the program but not captured in program records).

The EM&V assessment of the SBES program included impact and process evaluations.

- The impact evaluation consisted of engineering analysis and on-site field verification and metering to validate energy and demand impacts of reported measure categories, as well as a customer survey to assess net impacts.
- The process evaluation used customer surveys with 150 participants and interviews with program staff and the implementation contractor to characterize the program delivery and identify opportunities to improve the program design and processes. The customer survey data also formed the basis of the evaluation team’s estimation of free ridership and spillover, used to calculate an NTG ratio.

The evaluation team verified gross energy savings at 102 percent of deemed reported energy savings for DEP and 101 percent for DEC, and gross peak demand reductions at 77 percent for DEP and 76 percent for DEC. A net-to-gross (NTG) ratio was estimated at 0.98, yielding total verified net energy savings of

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53,302 megawatt-hours (MWh) for DEP and 90,923 MWh for DEC, and net summer peak demand reductions of 9.4 megawatts (MW) for DEP and 16.6 MW for DEC (Table 1-1 through Table 1-4).

Table 1-1. Program Claimed and Evaluated Gross Energy Impacts

	Jurisdiction	Claimed	Evaluated	Realization Rate
Gross Energy Impacts (MWh)	DEP	53,490	54,390	1.02
Gross Energy Impacts (MWh)	DEC	92,079	92,779	1.01

Source: Navigant analysis and Duke Energy tracking data, totals subject to rounding.

Table 1-2. Program Claimed and Evaluated Gross Peak Demand Impacts

	Jurisdiction	Claimed	Evaluated	Realization Rate
Gross Summer Peak Demand Impacts (MW)	DEP	12.5	9.6	0.77
Gross Winter Peak Demand Impacts (MW)	DEP	12.5	8.7	0.69
Gross Summer Peak Demand Impacts (MW)	DEC	22.3	17.0	0.76
Gross Winter Peak Demand Impacts (MW)	DEC	22.3	15.5	0.69

Source: Navigant analysis and Duke Energy tracking data, totals subject to rounding.

Table 1-3. Program Net Energy Impacts

	Jurisdiction	MWh
Net Energy Impacts	DEP	53,302
Net Energy Impacts	DEC	90,923

Source: Navigant analysis, totals subject to rounding.

Table 1-4. Program Net Peak Demand Impacts

	Jurisdiction	MW
Net Summer Peak Demand Impacts	DEP	9.4
Net Winter Peak Demand Impacts	DEP	8.5
Net Summer Peak Demand Impacts	DEC	16.6
Net Winter Peak Demand Impacts	DEC	15.2

Source: Navigant analysis, totals subject to rounding.

1.3 Evaluation Parameters and Sample Period

To accomplish the evaluation objectives, Navigant performed a variety of primary and secondary research activities including:

- Engineering review of measure savings algorithms
- Field verification and metering to assess installed quantities and characteristics

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- Participant surveys with customers to assess satisfaction and decision-making processes.

Table 1-5 summarizes the evaluated parameters. The targeted sampling confidence and precision for both DEP and DEC was 90 percent ± 10 percent, and the achieved was 90 percent ± 2.4 percent for energy savings, 6.8 percent for summer and 3.1 percent for winter peak demand reductions.[1]

Table 1-5. Evaluated Parameters

Evaluated Parameter	Description	Details
Efficiency Characteristics	Inputs and assumptions used to estimate energy and demand savings	1. Lighting wattage 2. Operating hours 3. Coincidence factors 4. HVAC interactive effects 5. Baseline characteristics
In-Service Rates	The percentage of program measures in use as compared to reported	1. Measure quantities found onsite
Satisfaction	Customer satisfaction with various stages of their project	1. Overall satisfaction with program 2. Satisfaction with implementation and installation contractors 3. Satisfaction with program equipment
Free Ridership	Fraction of reported savings that would have occurred in the absence of the program	
Spillover	Additional, non-reported savings that occurred as a result of participation in the program	1. Inside spillover (at same facility as program measures) 2. Outside spillover (at different facility as program measures)

Source: Navigant analysis

This evaluation covers program participation from March 2016 through June 2017. Table 1-6 shows the start and end dates of Navigant's sample period for evaluation activities.

Table 1-6. Sample Period Start and End Dates

Activity	Start Date	End Date
Field Verification and metering	September 18, 2017	November 30, 2017
Participant Phone Surveys	October 1, 2017	November 30, 2017

Source: Navigant analysis

[1] Navigant designed the impact sample to achieve 90/10 confidence and precision using the industry-standard coefficient of variation of 0.5 and results from previous (PY2013, PY2014, and PY2015) SBES program evaluations in the DEP and DEC jurisdictions. The sample quotas were met as planned, and the final precision was different due to natural variation in individual site level characteristics.

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1.4 Recommendations

The evaluation team recommends four discrete actions for improving the SBES Program, based on insights gained through the comprehensive evaluation effort. These recommendations provide Duke Energy with a roadmap to fine-tune the SBES Program for continued success and include the following broad objectives. Table 1-7 summarizes these program recommendations.

Table 1-7. Summary of PY2016 SBES Recommendations

Increasing Program Participation and Satisfaction
1. **Continue to focus on quality, clear communication, and depth of energy efficiency retrofits.** The most common suggested improvements were post-installation equipment issues and a perceived lack of coordination between the various parties involved in delivering the SBES program. There was also a minority of customers reporting that the program was unable to provide all the energy efficiency equipment they wanted. There are opportunities for continued improvement and channeling to other Duke Energy programs or education about measures that are not offered through the SBES program.
2. **Consider effects of increased program eligibility rules**. With a 180 kW demand limit, there is likely significant overlap between the SBES program and other business programs in Duke Energy's portfolio. The largest project is almost 2 GWh, which is larger than typical large business prescriptive projects seen in other utility offerings. Larger businesses typically have additional resources that small businesses do not, and often do not require the high incentive levels that the SBES program offers. Duke Energy should consider whether the SBES incentive levels are appropriate for these very large projects, or if a different program channel would be sufficient. For example, the Smart $aver program offers LED incentives that are capped at a lower percentage of incremental costs.
Improving Accuracy of Reported Savings
3. **Track burnout lamps and fixtures during the initial audit.** It is likely that some burnouts were present and tolerated by customers, and may contribute to customers not realizing expected savings on their energy bills. Burnouts found during the initial audit are no longer included in tracking data. While not generally required in the industry, customers with many burnouts will not achieve the expected energy savings.
4. **Ensure that the IC has access to up-to-date and accurate customer billing records.** There are several (2706) instances where project deemed savings exceed annualized site data, likely due to incomplete annualized energy usage estimates. Since this is used as an overridable QC check, more accurate data could help reduce the need for such overrides.

Source: Navigant analysis

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2. PROGRAM DESCRIPTION

The Small Business Energy Saver (SBES) Program is part of a portfolio of energy efficiency programs operated by Duke Energy. The program began as a pilot in early 2013 in South Carolina before expanding into the remainder of the Duke Energy Progress (DEP) jurisdiction. The program further expanded into the Duke Energy Carolinas (DEC) jurisdiction in August 2014. Since 2015, the program showed continued growth measured by participant count, claimed energy savings, and peak demand reductions.

2.1 Program Design

The SBES Program is available to qualifying commercial customers with less than 180 kilowatts (kW) demand service, up from 100 kW demand service in previous years. After completing the program application to assess participation eligibility, customers receive a free energy assessment to identify equipment for upgrade. Lime Energy reviews the energy assessment results with the customer, who then chooses which equipment upgrades to perform. Qualified contractors complete the equipment installations at the convenience of the customer.

The SBES Program recognizes that customers with lower savings potential may benefit from a streamlined, one-stop, turnkey delivery model and relatively high incentives to invest in energy efficiency. Additionally, small businesses may lack internal staffing dedicated to energy management and can benefit from energy audits and installations performed by an outside vendor.

The program offers incentives in the form of a discount for the installation of measures, including high-efficiency lighting and refrigeration equipment. These incentives increase adoption of efficient technologies beyond what would occur naturally in the market. In PY2016, the SBES Program achieved most program savings from lighting measures, which tend to be the most cost-effective and easiest to market to potential participants. The SBES program also achieved program savings from refrigeration measures at a similar level to previous years.

The program offers a performance-based incentive up to 80 percent of the total project cost, inclusive of both materials and installation. Multiple factors drive the total project cost, including selection of equipment and unique installation requirements.

2.2 Reported Program Participation and Savings

Duke Energy maintains a tracking database that identifies key characteristics of each project, including participant data, installed measures, and estimated energy and peak demand reductions based on assumed (“deemed”) savings values. In addition, the IC maintains a tracking database that contains additional measure level details that are useful for EM&V activities. For PY2016 Navigant reviewed the IC database as the basis for deemed energy savings. Duke Energy ensured that the IC database savings accurately represents all claimed program savings, and further defined demand ratios that are used to derive final deemed demand impacts.

Table 2-1 provides a summary of the gross reported energy and demand savings and participation for PY2013 through PY2016. Note the growth of average savings per project, especially in PY2016 in the DEC jurisdiction, driven by an increase in maximum customer size eligible for participation in the program (up to 180 kW demand).

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Table 2-1. Reported Participation and Gross Savings Summary

Reported Metrics	PY2013 (DEP)	PY2014 (DEP)	PY2015 (DEP)	PY2015 (DEC)	PY2016 (DEP)	PY2016 (DEC)
Participants	675	1,759	1,790	3,080	1,829	2,435
Measures Installed	42,537	108,816	132,977	234,788	121,181	210,775
Gross Annual Energy Savings (MWh)	14,242	38,665	48,772	77,269	53,490	92,079
Average Quantity of Measures per Project	63	62	74	76	66	87
Average Savings Per Project (MWh)	21.1	22	27.2	25.1	29.2	37.8

Source: SBES Tracking Database

2.2.1 Program Summary by Measure

Efficient LED linear lighting retrofits were the highest contributor to program energy savings in PY2016 across both jurisdictions, followed by T8 linear fluorescent retrofits and a variety of LED lighting measures. In addition, refrigeration measures, T5 linear retrofits and LED exit signs also contributed to savings. The SBES program has rapidly adopted LED lighting products in PY2016, although T8 lighting still contributed over 20% of energy savings. Program staff have indicated that T8 retrofits are actively being phased out of the current SBES program. Figure 2-1 shows the reported gross savings by measure category as reported by Duke Energy.

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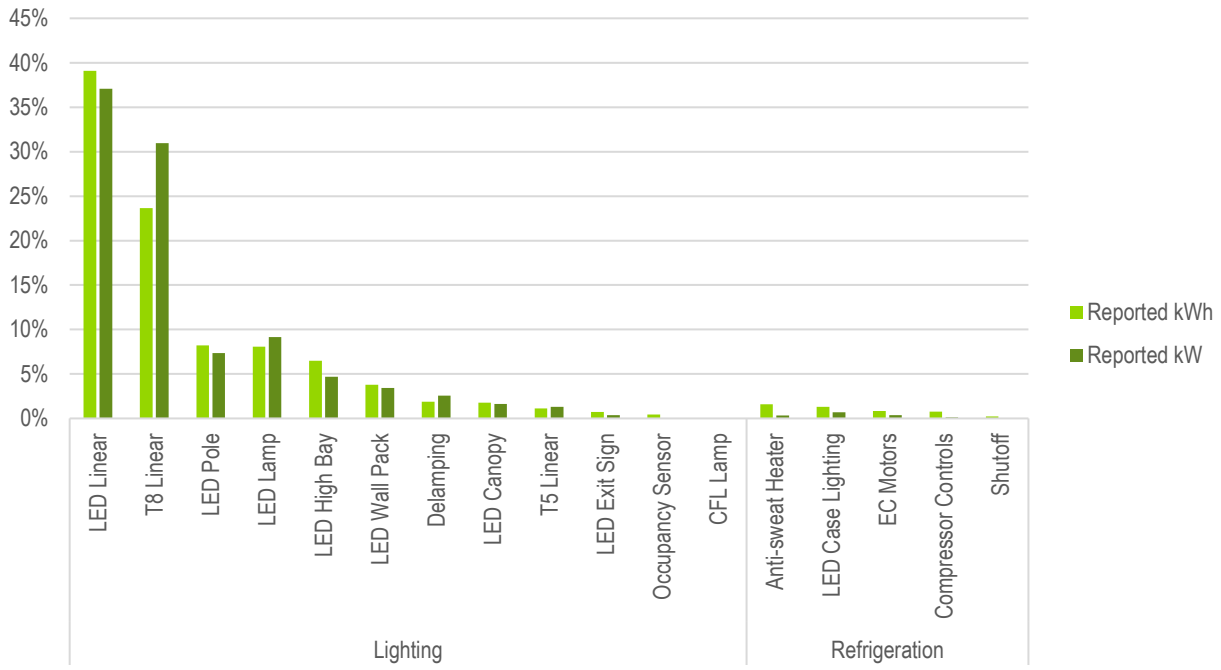
Figure 2-1. Reported Gross Energy Savings by Measure Category



Source: SBES Tracking Database

2.2.2 Savings by Project

Because the SBES program is limited to small business customers only, the variations in project energy and peak demand savings and the quantity of measures installed exhibit less spread than typical large business program offerings. Along with the increase for participant eligibility to 180 kW, however, several very large projects are now part of the program. Figure 2-2 shows the distribution of project sizes. The largest site reported savings of over almost 2 GWh per year, which is nearly four times the value of 500 MWh found during the PY2015 evaluation when eligibility was limited to 100 kW or less.

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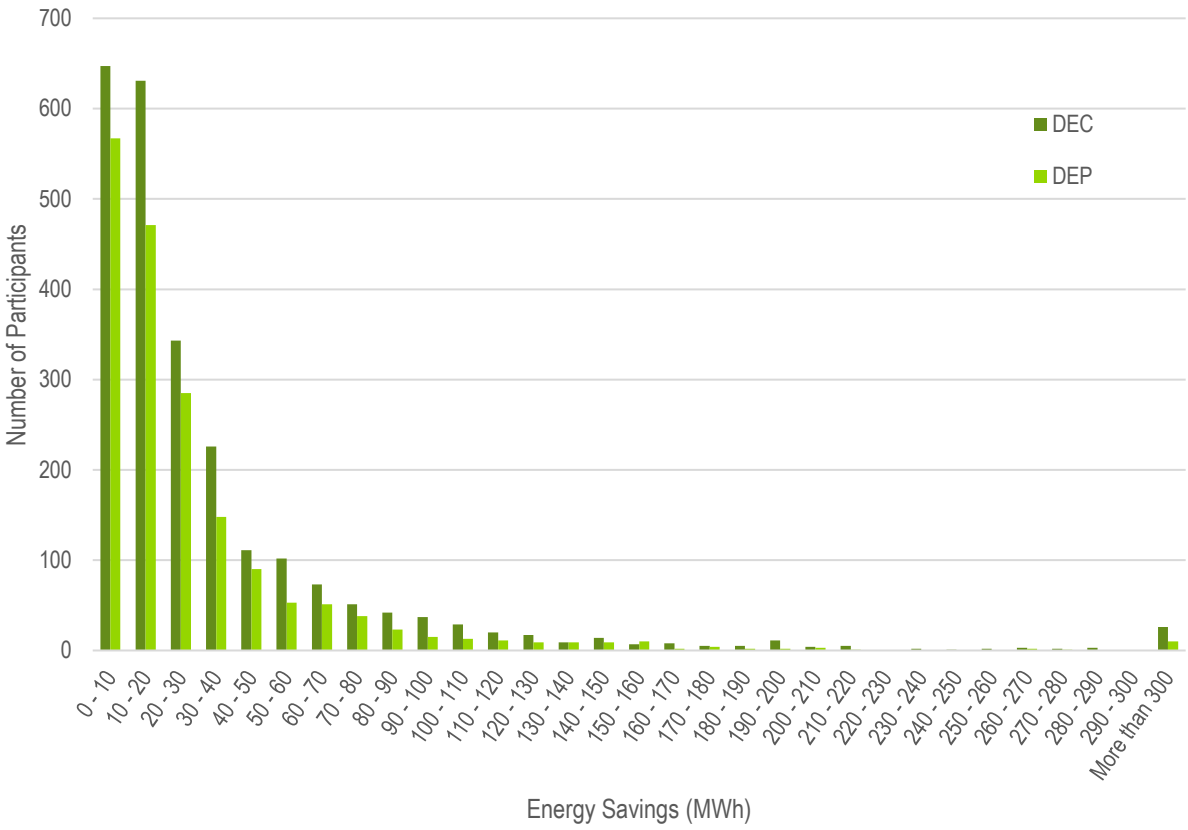
Figure 2-2. Histogram of Reported Energy Savings per Project



Source: SBES Tracking Database

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3. KEY RESEARCH OBJECTIVES

As outlined in the Statement of Work (SOW), the primary purpose of the EM&V activities is to estimate verified net annual energy and peak demand impacts associated with program activity for PY2016. Additional research objectives include the following:

3.1 Impact Evaluation

The impact evaluation focuses on quantifying the magnitude of verified energy savings and peak demand reductions. Objectives include:

- Verify deemed savings estimates through review of measure assumptions and calculations.
- Perform on-site verification of measure installations, and collect data for use in an engineering analysis.
- Estimate the amount of observed energy and peak demand savings (both summer and winter) by measure via engineering analysis.

3.2 Net-to-Gross Analysis

The net-to-gross analysis focuses on estimating the share of energy savings and peak demand reductions that can be directly attributed to the SBES program itself. Objectives include:

- Assess the Net-to-Gross ratio by addressing spillover and free-ridership in customer surveys.

3.3 Process Evaluation

The process evaluation focuses on the program implementation and the customer experience. Objectives include:

- Identify barriers to participation in the program, and how the program can address these barriers.
- Identify program strengths and the potential for introducing additional measures.

3.4 Evaluation Overview

Figure 3-1 outlines the high-level approach used for evaluating the SBES Program, which is designed to address the research objectives outlined above. The impact, net-to-gross, and process sections provide further detail for each of the individual EM&V activities.

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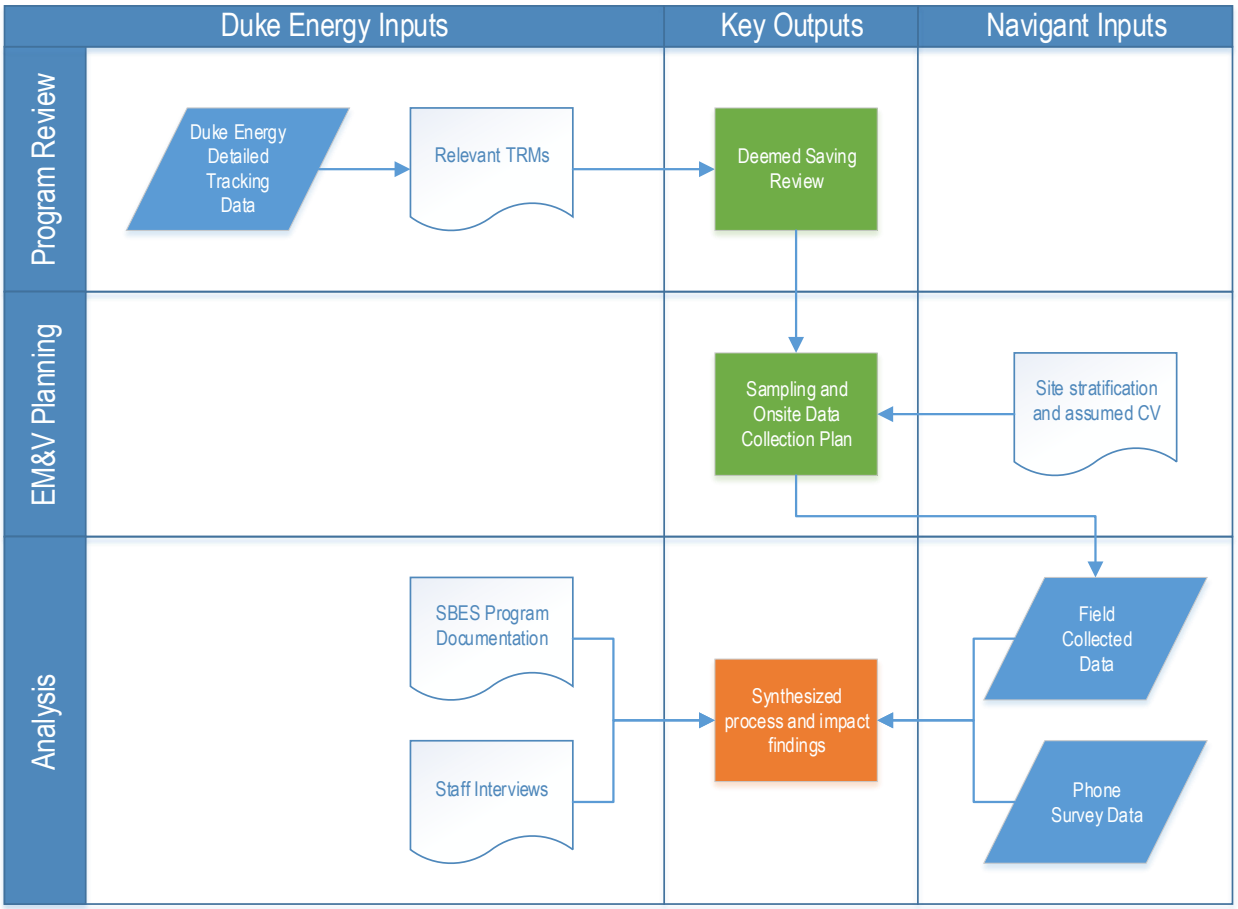
Figure 3-1. Evaluation Process Flow Diagram



Source: Navigant

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4. IMPACT EVALUATION

The purpose of this impact evaluation is to quantify the verified energy and demand savings estimates for the SBES Program in both the DEP and DEC jurisdictions. Table 4-1 and Table 4-2 show high-level program results of Navigant's impact analysis. Ultimately, Duke Energy can use these results for planning purposes.

Table 4-1. PY2016 SBES Summary of Program Impacts for DEP

DEP	Energy Savings (MWh)	Summer Peak Demand Reductions (MW)	Winter Peak Demand Reductions (MW)
Reported Gross Savings	53,490	12.5	12.5
Realization Rate	1.02	0.77	0.69
Verified Gross Savings	54,390	9.6	8.7
NTGR	0.98	0.98	0.98
Verified Net Savings	53,302	9.4	8.5

Source: Navigant analysis, totals subject to rounding.

Table 4-2. PY2016 SBES Summary of Program Impacts for DEC

DEC	Energy Savings (MWh)	Summer Peak Demand Reductions (MW)	Winter Peak Demand Reductions (MW)
Reported Gross Savings	92,079	22.3	22.3
Realization Rate	1.01	0.76	0.69
Verified Gross Savings	92,779	17.0	15.5
NTGR	0.98	0.98	0.98
Verified Net Savings	90,923	16.6	15.2

Source: Navigant analysis, totals subject to rounding.

4.1 Impact Methodology

The methodology for assessing the gross energy savings and peak demand reductions follows IPMVP Option A (Retrofit Isolation: Key Parameter Measurement)[2]. This involved an engineering-based approach for estimating savings, supplemented by key parameter measurements. This also included using time-of-use lighting loggers to directly measure operating hours and coincidence factors for program-incented lighting measures. Note that for the refrigeration measures, verification activities were performed on-site to assess installation and operation.

The evaluation team employed the following steps to conduct the impact analysis:

[2] International Performance Measurement & Verification Protocol Concepts and Options for Determining Energy and Water Savings Volume I. http://www.nrel.gov/docs/fy02osti/31505.pdf

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1. **Review Field Data and Design Sample** – First, the team analyzed the tracking data to determine the most appropriate sampling methodology. The team created four strata based on reported energy savings (small, medium, and large lighting, and refrigeration) to ensure that a variety of different businesses and measures were captured in the site visits. A subset of each strata was selected for more detailed data logger deployment (23 of 62 total sites visits were logged). The sample was designed to utilize double-ratio techniques to meet a precision target of 90/10 at the program level while attempting to minimize sample sizes.
2. **Pull Sample** – Next, the team pulled a sample from the four strata and scheduled site visits, including several backup sites if a visitation could not be arranged.
3. **Perform Participant Site Visits** – The evaluation team used an electronic data collection system in the field to ensure consistency and decrease data processing time. For all site visits, Navigant field technicians uploaded all collected site data to the online system as soon as they were completed. Navigant performed quality control verifications for all field data collection forms and online data entry. This included a thorough inspection of each site's building characteristic inputs, operating schedules, measure-level in-service rates, and descriptions. The following steps were taken at each participant site:
    a. The team first determined the in-service rate (ISR) of the equipment for each measure found. The field technicians accomplished this by visually verifying and counting all equipment included in the project documentation.
    b. The team then calculated the difference in watts between the base-case fixtures and the energy-efficient fixtures for each fixture type installed on-site. The team verified efficient fixture wattage through visual inspection, while deriving base-case fixture wattage from customer-provided data found in the documentation review, if available, or from information found by field technicians during the site visits. There is typically little to no information about the specifications of base-case equipment that has been removed from a site. If both customer data and field data were insufficient, the team utilized the tracking data and assessed the reasonableness of their assumptions.
    c. Operating hours were determined from a detailed customer interview for each unique lighting schedule in the building, and adjusted for holiday building closures. For the subset of sites that received logging, the EM&V team left time-of-use loggers in place for roughly four weeks and then returned to retrieve the logging equipment.
    d. Coincidence factors and HVAC interactive effects were taken from prior Duke Energy program (EEB) evaluation findings[3] and previous SBES reports[4] for similar building types for the verification only sites. For logged sites, the team calculated both summer and winter coincidence factors from the logger data; no further adjustments were made to HVAC interactive effects, however.
4. **Calculate Project-Level Savings** – The team calculated project-level energy and demand savings for each site in the sample based on operational characteristics found on site and engineering-based parameter estimates. The project-level savings represent the total of all the individual measure-level savings at each site.
5. **Calculate Program-Level Savings** – The team calculated verification rates for all sites and applied a ratio, representing the adjustment based on the logger data, resulting in final verified

[3] PY2013 DEP EEB EM&V Report

[4] PY2013 and PY2014 DEP SBES EM&V Report

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savings for each sampled site. Next, the team calculated stratum-level realization rates, consisting of the sum of the verified savings divided by the deemed reported savings. Last, the team applied the stratum-level realization rates to the deemed reported savings for each respective strata, and arrived at final program-level realization rates. Note that for demand savings, final program-level realization rates were calculated by comparing verified demand savings to reported demand savings using the demand ratios outlined in Section 2.2.

4.2 Sample Design

After reviewing the Duke Energy and IC tracking data, the evaluation team opted to split up the population of projects into four strata based on the projects' estimated energy savings to ensure that the sample represented both small, medium and large customers, and that field verification assessed a large percentage of program savings. The strata were designed according to the following guidelines:

1. First, all projects with refrigeration measures were assigned to a single stratum.
2. The remaining projects were sorted from highest claimed savings to lowest claimed savings.
3. The team then examined the reported savings and selected criteria that would result in three strata, each containing an approximately equal share of total claimed savings:
    - Lighting Large – greater than 105,000 kWh reported savings;
    - Lighting Medium – between 35,000 kWh and 105,000 kWh reported savings;
    - Lighting Small – less than 35,000 kWh savings;
    - Refrigeration – all projects with refrigeration savings.

Note that the stratum cutoff points for PY2016 are higher than in PY2015 due to the larger average per-project savings in this evaluation. The limits in PY2014 were 25,000 kWh and 65,000 kWh.

To achieve a 10 percent relative precision at a 90 percent confidence interval, the evaluation team targeted 62 total sites, which were spread roughly equally among the three lighting strata and the refrigeration stratum. Among the 62 sites, a subsample of 23 sites were selected for additional lighting metering to more accurately measure lighting hours of use. Sample sizes were based on coefficients of variations (CV) of 0.45 for verification and 0.2 for metering, which were derived from previous work on SBES evaluations on behalf of Duke Energy in other jurisdictions. Additional detail on the sampling and analysis methodologies are included in APPENDIX A.

Navigant conducted on-site verification at 62 sites during the fall of 2017. While on-site, the team conducted customer interviews and visual verification to collect data on building operation, HVAC system details, and seasonal and holiday schedules. For the subsample of sites that received onsite metering, Navigant conducted logging on key retrofit fixtures to estimate hours of use and coincidence factors. The adjustments to savings based on logged data were extrapolated to the full 62 site sample. Key evaluation parameters came primarily from on-site data; however, where this data was lacking or was deemed unusable, customer application data was used in its place. As there are many parameter inputs to the savings calculation for each site, this approach ensures that the best available data is used for each site's savings estimate.

Table 4-3 below details the final site visit disposition.

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Table 4-3. Onsite Sample Summary

Strata	Population Size	Onsite Verification Sample Size	Onsite Metering Sample Size (Subset of Verification Sample)
Lighting Large	207	15	6
Lighting Medium	744	19	6
Lighting Small	3088	21	9
Refrigeration	226	7	2
Total	**4,265**	**62**	**23**

Source: Navigant analysis

4.3 Algorithms and Parameters

Navigant used data collected from the field and the engineering review to calculate site-level energy and demand savings, using the following algorithms. Table 4-4 shows the algorithms that the evaluation team used to calculate verified savings for lighting measures. The impact evaluation effort focused on verifying the inputs for these algorithms.

Table 4-4. Verified Savings Algorithms for Lighting Measures

Measure	Energy Savings Algorithm	Coincident Peak Demand Savings Algorithm
Lighting Measures	kWh_Verified = Qty_Verified x HOU x Verified_Watts_Reduced x IF_Energy	kW_Verified = Verified x CF x Verified_Watts_Reduced x IF_Demand
Refrigeration	kWh_Verified = Unit_Savings x Qty_Verified	kW_Verified = Unit_Savings x Qty_Verified
ISR = in-service rate (not in calculation, calculated to provide context) Fixture_Quantity_Verified = quantity of equipment verified on-site HOU = verified operating hours CF = coincidence factor IF_Energy = heating, ventilating, and air conditioning (HVAC) interaction factor for energy savings calculations IF_Demand = interaction factor for demand savings calculations Verified Watts Reduced = watts of baseline equipment - watts of energy-efficient equipment. Unit_Savings = deemed per unit savings appropriate for measure.		

Source: Navigant analysis

The detailed description of each parameter and any related assumption are as follows:

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4.3.1 Fixture Quantity Verified and In-Service Rate (ISR)

The Navigant evaluation team visually counted fixtures on-site to quantify the quantity and type of lighting equipment installed. The team calculated the ISR as the ratio between the findings from the on-site verification compared to the quantity reported in the program-tracking databases. On-site verifications determined the total number of installed measure-level equipment.

4.3.2 Verified Watts

The team calculated base and efficient watts at the measure level. Efficient nameplate wattages were determined using manufacturer specifications based on fixture-level data collected on-site. The project documentation contained in the IC tracking database determined base wattages. In the cases where efficient fixture data were unavailable, due to inaccessible fixtures, the wattages found in the IC database values were applied.

4.3.3 HVAC Interactive Effects

Reductions in lighting energy generally increase a building's heating requirements (load) and decrease cooling requirements. The HVAC interactive effects accounts for these secondary effects on the HVAC system energy use and acts as a multiplier in the energy savings algorithms. The team applied the HVAC interactive effects used in prior EEB and SBES program evaluations (both 2013 and 2014) for consistency, which were sourced from a 2011 Navigant study (including over 120 buildings) in Maryland that used building energy models of field-verified building characteristics (i.e., HVAC, lighting, and envelope) and actual billing data to assess the interactive effects of lighting energy reductions on HVAC system energy use. The resulting interaction factors are specific to both building type (e.g., office, warehouse) and heating/cooling systems. Future evaluations will consider updating the HVAC interactive effects specifically for the climate zones in North Carolina and South Carolina within the Duke Energy service territory based on energy simulation modelling.

4.3.4 Annual Operating Hours

Measure-level annual operating hours were determined from a detailed interview with the SBES customer. Hours used per day or week were rolled up to annual hours of use and corrected for holidays, seasonal variations in use, and any other change in operating characteristics. For logged sites, the team extrapolated the time of use logger data to develop annual hours of operation.

4.3.5 Coincidence Factor (CF)

Coincidence factors represent the portion of installed lighting that is operational during the utility peak performance hours. These were determined similarly to HVAC interactive effects by using deemed values by building type in addition to data collected on-site. For example, light-emitting diode (LED) exit signs that are on all day receive a CF on 1.0, while exterior lights on daylight sensors receive a CF of 0.0. For logged sites, the team extrapolated the time of use logger data to develop coincidence factors.

4.3.6 Unit Savings

For refrigeration measures, the engineering analysis follows a deemed savings methodology based on the NY Technical Reference Manual (TRM) unit savings. This methodology is based on measure-specific characteristics and is not dependent on the climate in New York. The assumptions and parameters used to estimate reported energy savings and peak demand reductions were therefore considered appropriate by the evaluation team. The team verified that the measures were installed and operational during on-site visits to projects that installed efficient refrigeration equipment.

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4.4 Key Impact Findings

The energy realization rates by strata are shown in Table 4-5. This shows the verification realization rate, the metering realization rate, and the final realization rate by strata. The total realization rate for each strata is calculated by multiplying the verification realization rate by the metering realization rate adjustment. This method in effect extrapolates the project-specific results to the stratum-level, which implicitly assumes that these findings in aggregate are representative of other sites within their stratum. In addition, the weighted final realization rate for the program is shown, which represents the total program savings as a weighted result of each stratum. Note that strata-level realization rates are derived from both DEP and DEC projects, and are applied to each jurisdiction separately to calculate program level verified energy savings and peak demand reductions. Additional information specific to the metering realization rate adjustments is provided in Section 4.5.

During review of individual project savings, Navigant identified one project within the large stratum that contained a considerable discrepancy between the reported hours of use and the logged hours of use. Upon further investigation, this particular customer had recently opened their business and anticipated a specific operational schedule. This was not realized at the time of the evaluation, however, and the customer was operating significantly fewer hours per week. Navigant's opinion is that this discrepancy was unique to this particular project and not representative of the broader program, and therefore created a separate stratum just for this project. In effect, the low project realization rate is still included in the final program verified savings, but the results are not extrapolated to the rest of the large stratum.

Table 4-5. Energy Impacts by Strata

Strata	Verification Realization Rate (kWh)	Metering Realization Rate Adjustment (kWh)	Total Realization Rate (kWh)
Lighting Large	1.00	1.00	1.00
Lighting Medium	1.02	0.92	0.94
Lighting Small	1.10	1.02	1.12
Refrigeration	1.00	0.93	0.94
Total	**1.02**	**0.97**	**1.01**

Source: Navigant analysis, totals subject to rounding.

The summer and winter peak demand reductions are shown in Table 4-6 and Table 4-7. Contrary to the energy adjustments based on metering, there is a more substantial reduction in the realization rate due to application of measure-specific coincidence factors based on logger data for both the summer and winter periods. Navigant notes that these realization rates are calculated by comparing verified savings with the Duke Energy reported savings calculated from demand ratios rather than reported in the detailed measure database.

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Table 4-6. Summer Peak Demand Impacts by Strata

Strata	Verification Realization Rate (kW)	Metering Realization Rate Adjustment (kW)	Total Realization Rate (kW)
Lighting Large	0.83	0.98	0.81
Lighting Medium	0.91	0.64	0.59
Lighting Small	1.12	0.80	0.90
Refrigeration	0.69	1.02	0.71
Total	**0.87**	**0.86**	**0.76**

Source: Navigant analysis, totals subject to rounding.

Table 4-7. Winter Peak Demand Impacts by Strata

Strata	Verification Realization Rate (Winter kW)	Metering Realization Rate Adjustment (Winter kW)	Total Realization Rate (Winter kW)
Lighting Large	0.90	0.95	0.85
Lighting Medium	0.90	0.60	0.54
Lighting Small	0.89	0.77	0.69
Refrigeration	0.94	0.98	0.93
Total	**0.90**	**0.85**	**0.69**

Source: Navigant analysis, totals subject to rounding.

Overall, the verification realization rates are slightly below 1.0 for energy savings and summer peak demand reduction. This indicates that the program is accurately reporting impacts at the aggregate program level, despite varying realization rates for each individual stratum.

4.5 Detailed Impact Findings

This section examines findings from the evaluation of lighting measures in order to identify the main drivers of the verified savings values. The evaluation team uses the Field Verification Rate (FVR) to describe the overall verified savings relative to the reported savings for each measure. FVRs reflect differences between the quantity of equipment installed on-site and the quantity reported in the tracking database, as well as differences between operating characteristics verified in the field and assumed operating characteristics in the program deemed savings estimates. The team calculates the field verification rate as the verified savings divided by the reported savings by measure, which is driven by a combination of the in-service rate, the hours of use adjustment rate, the lighting power adjustment rate, the HVAC interactive effect adjustment rate, and the coincidence factor, described as follows:

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1. **In-Service Rate**[5] **(ISR)** is the ratio of the verified (i.e., installed) quantity to the reported quantity.
2. **Hours of Use (HOU) Adjustment Rate** reflects discrepancies between reported and verified operating hours.
3. **Lighting Power Adjustment Rate** is a ratio of the verified wattage difference between the efficient and baseline equipment to the reported wattage difference between the efficient and baseline equipment.
4. **HVAC Interactive Effect (IE) Adjustment Rate** is a multiplier that reflects HVAC interactive effects due to space heating and cooling loads caused by a reduction in heat output from efficient lighting. Note that the IC did not deem HVAC IE for any measures so this adjustment is equal to the average HVAC IE itself. There are separate adjustments for energy savings and peak demand reduction.
5. **Coincidence Factor** represents the portion of installed lighting that is on during the peak utility hours. This affects only summer and winter peak demand reductions, not energy savings.

Figure 4-1 below shows the relative effect of each of the aforementioned adjustment rates on the measure-level FVR for energy savings, which the following subsections describe in further detail. Note that FVR cannot be used to derive program level realization rates. This is because the contributions of each parameter update are described relative to their reported value, while the program analysis was structured to stratify savings by participant energy savings per site rather than by individual measures.

[5] In-Service Rate is an industry-standard term that describes verified quantities of installed equipment relative to reported quantities.

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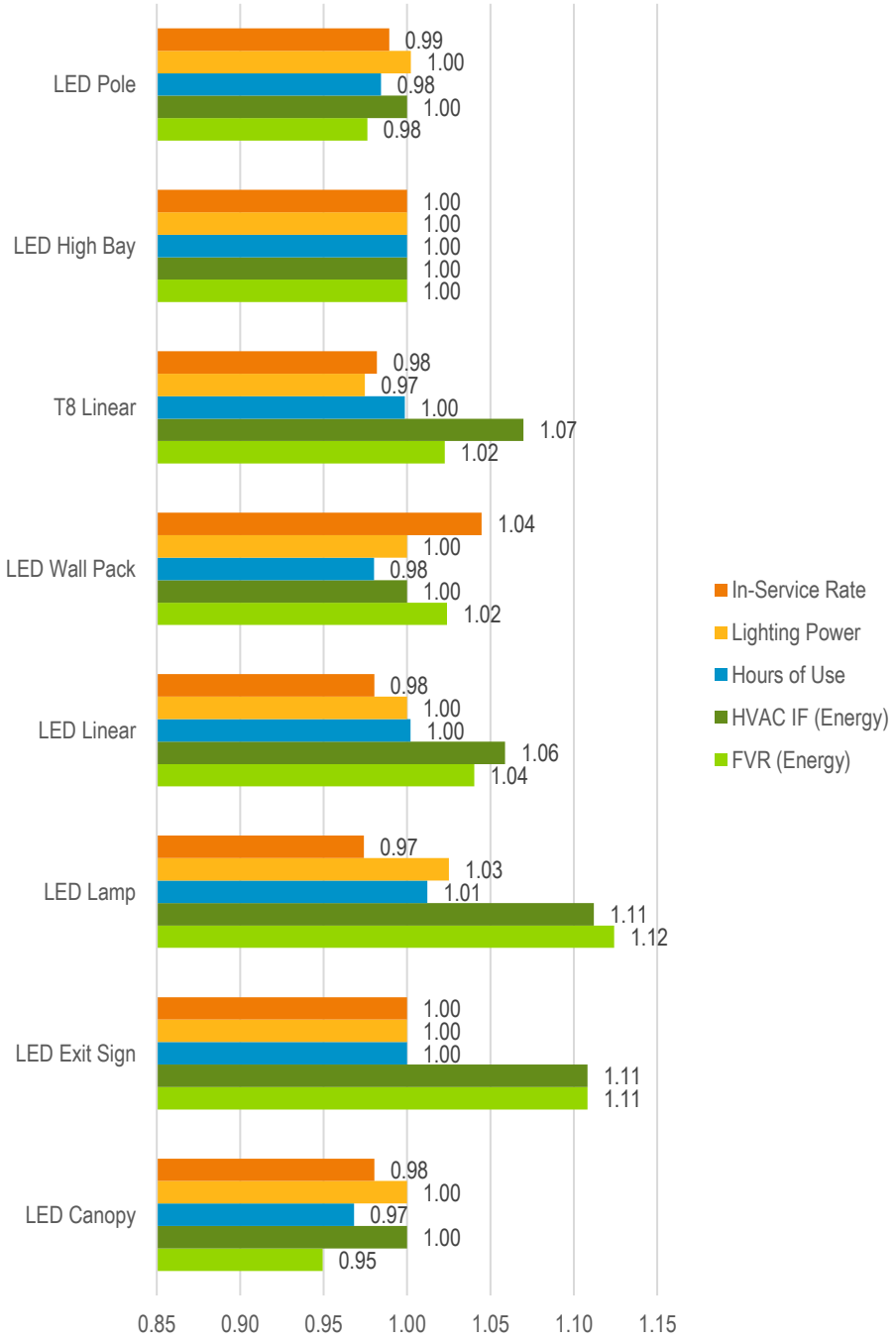
Figure 4-1. Gross Energy Savings Field Verification Rates



Source: Navigant analysis

Figure 4-2 below shows the relative effect of each of the aforementioned adjustment rates on the measure-level FVR for summer peak demand reductions, which the following subsections describe in further detail.

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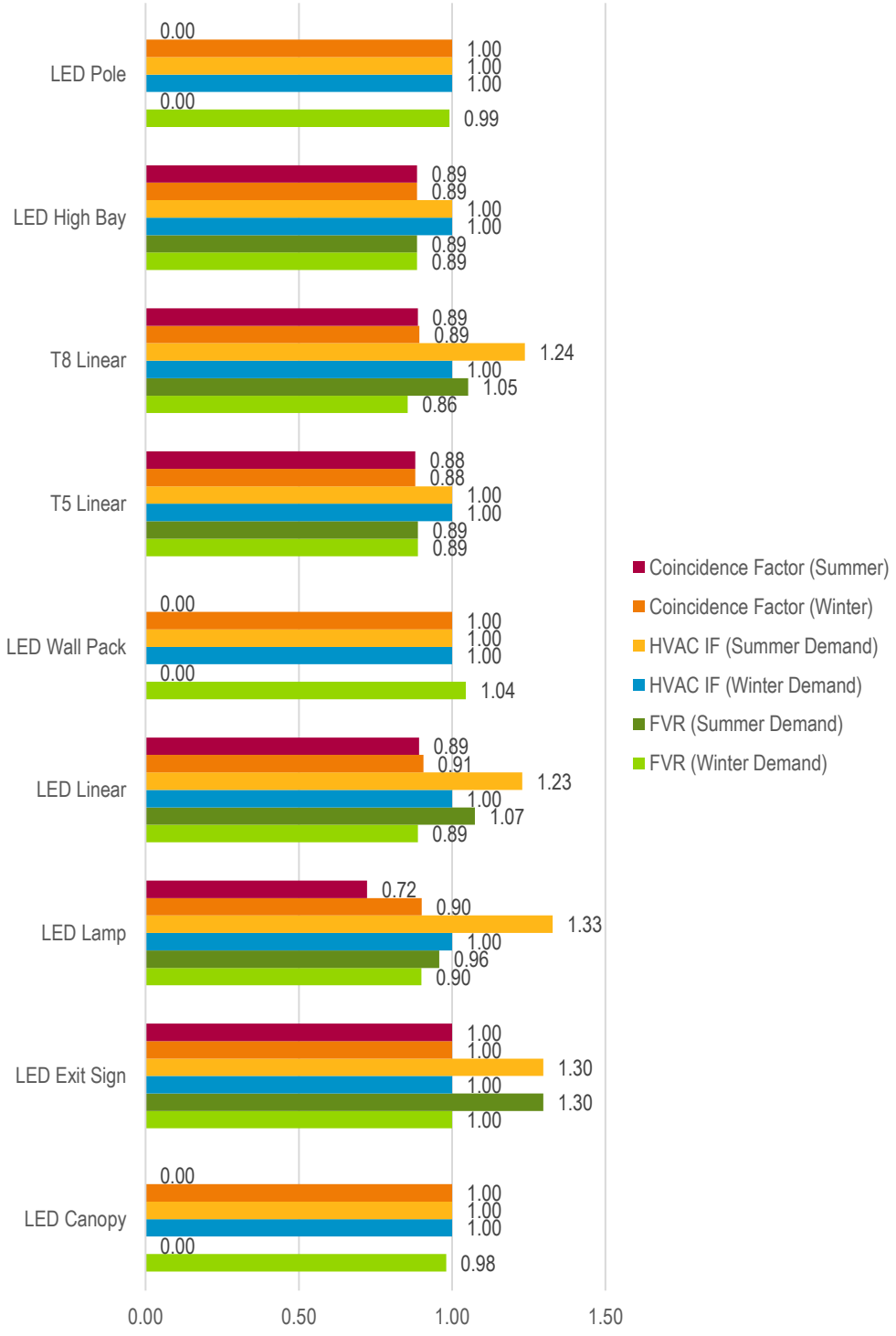
Figure 4-2. Gross Peak Demand Reductions Field Verification Rates



Source: Navigant analysis

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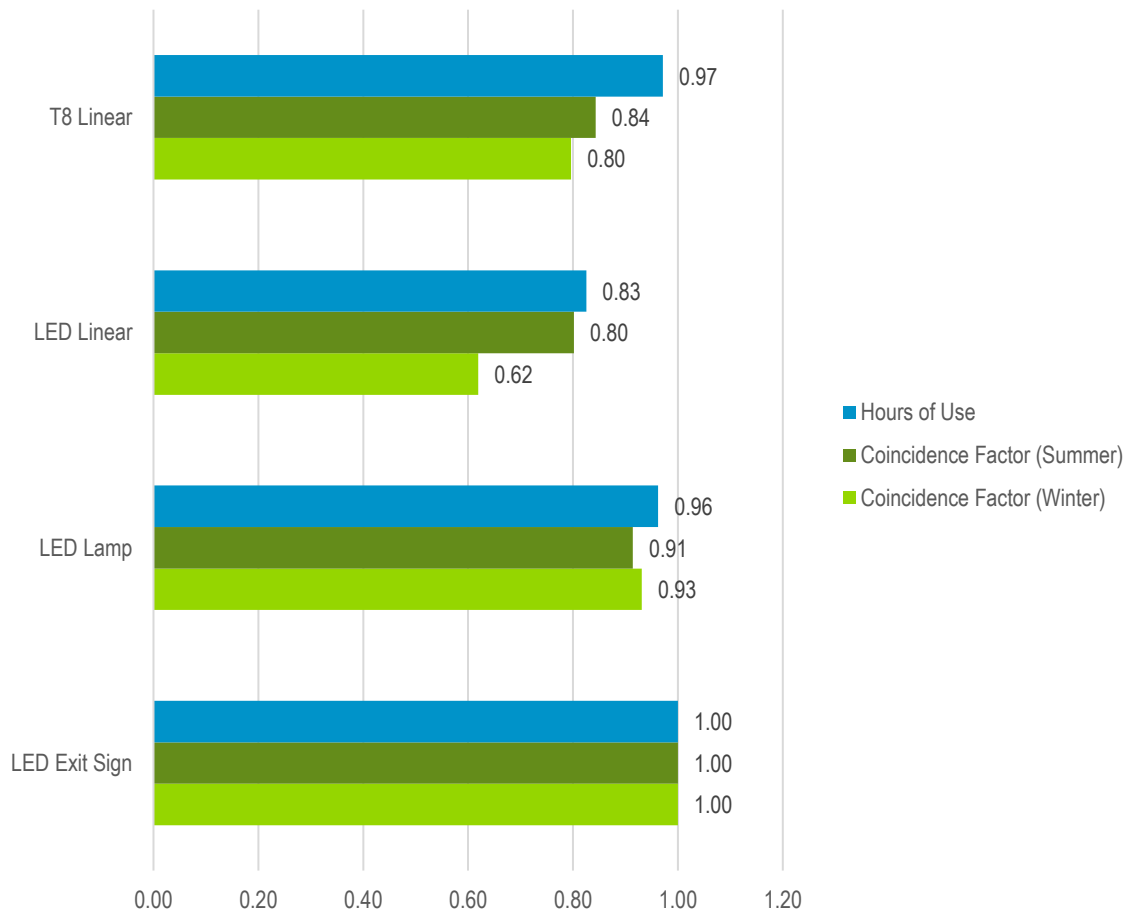
The final adjustment to develop site-specific verified gross savings is the ratio of metered HOU and CF compared to estimated (or deemed) HOU and CF used for verification. The results of these adjustments, analogous to FVR, are shown in Figure 4-3 below. The metered data results in a downward adjustment for both HOU and CF, but this effect is more pronounced for CF due to the high rigor of the HOU estimates compared to the CF estimates in the tracking data.

Figure 4-3. HOU and CF Adjustments from Metered Data



Source: Navigant analysis

The remainder of this section discusses in more detail the parameters that are part of the energy and peak demand savings algorithms: ISR, HOU, lighting power, HVAC interactive effects and coincidence factors.

4.5.1 In-Service Rates

One of the primary functions of evaluation, particularly for lighting measures, is to verify the quantity of the installed equipment relative to the reported quantity. The resulting ratio is the ISR. As shown in Figure 4-1 above, the ISR for each measure varies from 0.97 for LED screw-in lamps and 1.04 for LED wall packs.

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4.5.2 Hours-of-Use Adjustments

The EM&V team performed customer interviews and installed data loggers to make adjustments to hours of use to estimate final verified impacts. Measure-level annual operating hours were determined from confirmation of operation hours with the SBES participant, similar to the approach taken by the IC. For all sample sites, the EM&V team performed interviews with customers using a similar approach as the IC. This relies on the customer to self-report hours used on a daily or weekly basis, and were rolled up to an annual hours of use basis which is also corrected for holidays, seasonal variations in use, and any other change in operating characteristics. The purpose of validating the self-reported hours of use is to confirm whether the estimates provided by the customer during implementation is what actually makes it into the tracking database. The EM&V also installed data loggers at a nested sample of sites to measure the accuracy of the self-reported hours. For logged sites, the team extrapolated the time of use logger data to develop annual hours of operation.

During the on-site participant interviews, the EM&V team found that the hours of use that site technicians reported was close to the HOU reported in the tracking database, with adjustment values ranging from 0.97 for LED canopy fixtures and 1.01 for LED lamps. Overall, these findings suggest that the tracking data is accurately reflecting what customers estimate their operating hours to be. However, it is well-known that estimating operation hours for lighting is difficult, and many evaluations have found that customers tend to overestimate operation hours for lighting. Therefore, the EM&V team used results from the data loggers to adjust impacts.

Additional adjustments based on logger data range from 0.83 for LED linear retrofits and 0.97 for T8 linear retrofits (excluding LED exit signs), as shown in Figure 4-3. This demonstrates that although the IC team notes that overall the IC is reasonably characterizing hours of use based on both customer interviews, and logger data, but the data loggers show that customers tended to overestimate hours of use for both LED and T8 linear lighting measures.

4.5.3 Lighting Power

The evaluation team based the lighting power parameter on the best estimates available for actual power draw of the baseline and efficient equipment. The baseline equipment is assumed to be as-found lighting installed and in use at the time of the audit; however, because the baseline equipment was no longer present at the participant sites, the team could not verify the baseline power draw and defaulted to the IC-provided value.

The evaluation team verified the efficient equipment wattage from manufacturer specification sheets to provide a more accurate lighting power figure than the deemed values that the IC used. Overall lighting power level differences were very minor across the measure categories, between 0.97 for T8 fixtures and 1.03 for LED lamps. Note that the evaluation team found slightly lower than reported lighting power values for T8 lamp and ballast configurations, which resulted in a slight increase in energy savings.

The evaluation team would like to note that newer linear LED systems can be configured in a variety of ways, including with or without an electronic ballast. The manufacturer specifications for these systems typically do not account for every installation scenario with different ballast brands, models, and configurations possible. The team did not perform power measurements as part of this evaluation, but encourages the IC team to ensure that the power consumption of these systems is accurately characterized as their contribution to total program savings grows and T8 retrofits are phased out.

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4.5.4 HVAC Interactive Effects

The evaluation team applied HVAC interactive effects for both energy, summer and winter peak demand. The deemed values are based on the building type and the heating and cooling system types as verified in the field for the sample sites. However, the IC did not apply HVAC IE for any of the lighting measures claimed in PY2016, as in previous evaluations. This adjustment is between 1.00 and 1.11 for energy and 1.00 and 1.33 for summer peak demand. Deemed values are described in Section 9 below for energy and summer peak demand; winter peak demand interactive effects were assumed to be 1.0 for all measures.

4.5.5 Coincidence Factors

Similar to the HVAC interactive effects, the team applied coincidence factors consistent with the deemed values used in the previous Duke Energy program evaluations. This factor takes into account that not all lights are on for the duration of the peak demand period. Coincidence factors range from 0 and 1.0, based on building type, and are detailed in Section 9. The metered data further validates the deemed coincidence factors. Note that although the detailed IC database does not include a coincidence factor, the demand ratios provided by Duke Energy and used as the final reported deemed savings implicitly include these assumptions.

LED exit signs that are on all day receive a CF on 1.0, while exterior lights receive a CF of 0 (summer) and 1.0 (winter). For logged sites, the team extrapolated the time of use logger data to develop coincidence factors. As shown in Figure 4-3, the CF adjustments based on metered data range from 0.80 to 1.0 for summer, and 0.62 to 1.0 for winter. The overall effect on demand savings from metering was a decrease in both summer and winter savings compared to the coincidence factors applied in the verification phase. The overall effect of applying coincidence factors is a decrease from reported savings, and is the primary driver of the demand realization rates.

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5. NET-TO-GROSS ANALYSIS

The impact analysis described in the preceding sections addresses *gross program savings*, based on program records, modified by an engineering review, field verification, and metering of measure installations. *Net savings* incorporate the influence of free ridership (savings that would have occurred even in the absence of the program) and spillover (additional savings influenced by the program but not captured in program records) and are commonly expressed as a NTG ratio applied to the verified gross savings values.

Table 5-1 shows the results of Navigant's NTG analysis. Navigant anticipated low free ridership and spillover based on previous findings from the SBES evaluations. The estimated NTG ratio shown for PY2016 is lower than the findings from the 2015 evaluation, but consistent with 2013.

Table 5-1. Net-to-Gross Results

	PY2013 (DEP)	PY2014 (DEP)	PY2015 (DEP & DEC)	PY2016 (DEP & DEC)
Estimated Free Ridership	0.04	0.04	0.06	0.06
Estimated Spillover	0.02	0.07	0.09	0.04
Estimated NTG	0.98	1.03	1.03	0.98

Source: Navigant analysis, totals subject to rounding.

The results are consistent with the program theory and delivery model, whereby the Implementation Contractor (IC) actively recruits participants and presents a suite of energy efficiency measures to potential customers. Customers are not eligible to retroactively claim incentives under this program, which reduces the potential for free ridership significantly.

This report provides definitions, methods, and further detail on the analysis and findings of the net savings assessment. The discussion is divided into the following three sections:

- Defining free ridership, spillover, and net-to-gross (NTG) ratio
- Methods for estimating free ridership and spillover
- Results for free ridership, spillover, and NTG ratio

5.1 Defining Free Ridership, Spillover, and Net-to-Gross Ratio

The methodology for assessing the energy savings attributable to a program is based on a NTG ratio. The NTG ratio has two main components: free ridership and spillover.

Free ridership is the share of the gross savings that is due to actions participants would have taken even in the absence of the program (i.e., actions that the program did not induce). This is meant to account for naturally occurring adoption of energy efficient technology. The SBES Program covers a range of energy efficient lighting and refrigeration measures and is designed to move the overall market for energy efficiency forward. However, it is likely that some participants would have wanted to install, for various reasons, some high efficiency equipment (possibly a subset of those installed under the SBES Program), even if they had not participated in the program or been influenced by the program in any way.

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Spillover captures program savings that go beyond the measures installed through the program. Also called "market effects," the term "spillover" is often used because it reflects savings that extend beyond the bounds of the program records. Spillover adds to a program's measured savings by incorporating indirect (i.e., non-incentivized) savings and effects that the program has had on the market above and beyond the directly incentivized or directly induced program measures.

Total spillover is a combination of non-reported actions to be taken at the project site itself (*within-facility spillover*) and at other sites (*outside-facility spillover*). Each type of spillover is meant to capture a different aspect of the energy savings caused by the program, but not included in program records.

The **overall NTG ratio** accounts for both the net savings at participating projects and spillover savings that result from the program but are not included in the program's accounting of energy savings. When the NTG ratio is multiplied by the estimated gross program savings, the result is an estimate of energy savings that are attributable to the program (i.e., savings that would not have occurred without the program).

The basic equation is shown in Equation 1.

Equation 1. Net-to-Gross Ratio

$$NTG = 1 - Free\ Ridership + Spillover$$

The underlying concept inherent in the application of the NTG formula is that *only* savings caused by the program should be included in the final net program savings estimate but that this estimate should include *all* savings caused by the program.

5.2 Methods for Estimating Free Ridership and Spillover

5.2.1 Estimating Free Ridership

Data to assess free ridership were gathered through the self-report method—a series of survey questions asked of SBES participants. Free ridership was asked in both direct questions, which aimed at obtaining respondent estimates of the appropriate free ridership rate that should be applied to them, and in supporting or influencing questions, which could be used to verify whether the direct responses are consistent with participants' views of the program's influence.

Respondents were asked three categories of program-influence questions:

- **Likelihood:** to estimate the likelihood that they would have incorporated lighting measures "of the same high level of efficiency," if not for the assistance of the SBES Program. In cases where respondents indicated that they might have incorporated some, but not all, of the measures, they were asked to estimate the share of measures that would have been incorporated anyway at high efficiency. This flexibility in how respondents could conceptualize and convey their views on free ridership allowed respondents to give their most informed response, thus improving the accuracy of the free-ridership estimates.
- **Prior planning:** to further estimate the probability that a participant would have implemented the measures without the program. Participants were asked the extent to which they had considered installing the same level of energy-efficient lighting prior to participating in the program. The general approach holds that if customers were not definitively planning to install all of the

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efficiency lighting prior to participation, then the program can reasonably be credited with at least a portion of the energy savings resulting from the high-efficiency lighting. Strong free ridership is reflected by those participants who indicated they had already allocated funds for the purchase and selected the lighting and an installer.

- **Program importance:** to clarify the role that program components (e.g., information, incentives) played in decision-making, and to provide supporting information on free ridership. Responses to these questions were analyzed for each respondent, not just in aggregate, and were used to identify whether the direct responses on free ridership were consistent with how each respondent rated the "influence" of the program.

Free-ridership scores were calculated for each of these categories[6] and then averaged and divided by 100 to convert the scores into a free-ridership percentage. Next, a timing multiplier was applied to the average of the three scores to reflect the fact that respondents indicating that their energy efficiency actions would not have occurred until far into the future may be overestimating their level of free ridership. Participants were asked, without the program, when they would have installed the equipment. Respondents who indicated that they would not have installed the lighting for at least two years were not considered free riders and had a timing multiplier of 0. If they would have installed at the same time as they did, they had a timing multiplier of 1; within one year, 0.67; and between one and two years, 0.33. Participants were also asked when they learned about the financial incentive; if they learned about it after the equipment was installed, then they had a free ridership ratio of 1.

5.2.2 Estimating Spillover

The basic method for assessing participant spillover (both within-facility and outside-facility) was an approach that asked a set of questions to determine the following:

- **Whether spillover exists at all.** These were yes/no questions that asked, for example, whether the respondent incorporated energy efficiency measures or designs that were not recorded in program records. Questions related to extra measures installed at the project site (within-facility spillover) and to measures installed in non-program projects (outside-facility spillover) within the service territory.
- **The share of those savings that could be attributed to the influence of the program.** Participants were asked if they could estimate the energy savings from these additional extra

[6] Scores were calculated by the following formulas:

» Likelihood: The likelihood score is 0 for those that "definitely would NOT have installed the same energy efficient measure" and 1 for those that "definitely WOULD have installed the same energy efficient measure." For those that "MAY HAVE installed the same energy efficient measure," the likelihood score is their answer to the following question: "On a scale of 0 to 10 where 0 is DEFINITELY WOULD NOT have installed and 10 is DEFINITELY WOULD have installed the same energy efficient measure, can you tell me the likelihood that you would have installed the same energy efficient measure?" If more than one measure was installed in the project, then this score was also multiplied by the respondent's answer to what share they would have done.

» Prior planning: If participants stated they had considered installing the measure prior to program participation, then the prior planning score is the average of their answers to the following two questions: "On a scale of 0 to 10, where 0 means you 'Had not yet planned for equipment and installation' and 10 means you 'Had identified and selected specific equipment and the contractor to install it', please tell me how far along your plans were" and "On a scale of 0 to 10, where 0 means 'Had not yet budgeted or considered payment' and 10 means 'Already had sufficient funds budgeted and approved for purchase', please tell me how far along your budget had been planned and approved."

» Program importance: This score was calculated by taking the maximum importance on a 0 to 10 scale of the four program importance questions and subtracting from 10 (i.e., the higher the program importance, the lower the influence on free ridership).

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measures to be less than, similar to, or more than the energy savings from the SBES program equipment.

- **Program importance.** Estimates were derived from a question asking the program importance, on a 0 to 10 scale. Participants were also asked how the program influenced their decisions to incorporate additional energy efficiency measures.

If respondents said no, they did not install additional measures; they had a zero score for spillover. If they said yes, then the individual's spillover was estimated as the self-reported savings as a share of project savings, multiplied by the program-influence score. Then, a 50 percent discount was applied to reflect uncertainty in the self-reported savings and divided by 10 to convert the score to a spillover percentage.

5.2.3 Combining Results across Respondents

The evaluation team determined free ridership and spillover estimates for each of the following:

- Individual respondents, by evaluating the responses to the relevant questions and applying the rules-based approach discussed above
- Measure categories:
  - For free ridership: by taking the average of each respondent's score within each category
  - For spillover: by taking the sum of the individual spillover results for each measure category and weighting each category by the population
- The program as a whole, by combining measure-level results
  - For free ridership: measure category results were subsequently weighted by each category's share of total savings
  - For spillover: measure category results were summed and then weighted by the sum of the reported savings for the sample (which were also weighted by the population)

5.3 Results for Free Ridership, Spillover, and Net-to-Gross

This section presents the results of the attribution analysis for the SBES Program. Specifically, results are presented for free ridership and spillover (within-facility and outside-facility), which are used collectively to calculate an NTG ratio.

5.3.1 Review of Data Collection Efforts for Attribution Analysis

The EM&V team conducted 150 surveys with SBES participants to estimate free ridership, spillover, and NTG ratios. Table 5-2 shows the number of completions, by measure group.

Table 5-2. Attribution Survey Completes by Project Type

Measure Category	DEP Surverys	DEC Surveys	Total Surveys
Lighting	50	86	136
Refrigeration	5	9	14
Total	**55**	**95**	**150**

Source: Navigant analysis

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5.3.2 Free-Ridership Results

The evaluation team asked participants a series of questions regarding the likelihood, scope, and timing of the investments in energy-efficient lighting if the respondent had not participated in the program. The purpose of the surveys was to elicit explicit estimates of free ridership and perspectives on the influence of the program. The evaluation team estimates free-ridership for the SBES Program at 6 percent of program-reported savings.

5.3.3 Spillover Results

The SBES Program influenced approximately 7 percent of participants to install additional energy efficiency measures on-site (down from 15 percent in PY2015) and influenced 7 percent of participants (down from 12 percent in PY2015) to install additional measures at other locations. Spillover values are consistent with those found in previous evaluations, such as PY2014, however. Based on the survey findings, the evaluation team estimates the overall program spillover to be 4 percent of program-reported savings. Participants reported a variety of spillover measures installed, including AC units, additional lighting, and appliances.

5.3.4 Net-to-Gross Ratio

As stated above, the NTG ratio is defined as follows in Equation 2 below.

Equation 2. Net-to-Gross Ratio

$$NTG = 1 - \text{free ridership} + \text{spillover}$$

Using the overall free ridership value of 6 percent and the overall spillover value of 4 percent, the NTG ratio is 1 – 0.06 + 0.04 = 0.98. The estimated NTG ratio of 0.98 implies that for every 100 megawatt-hours (MWh) of realized savings recorded in SBES records, 98 MWh is attributable to the program.

Table 5-3. SBES Free Ridership, Spillover, and NTG Ratio

	Free Ridership	Spillover	NTG Ratio
SBES Program Total	0.06	0.04	0.98

Source: Navigant analysis

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6. PROCESS EVALUATION

The purpose of the process evaluation is to understand, document and provide feedback on the program implementation components and customer experience for the Small Business Energy Saver (SBES) Program in the DEP and DEC jurisdictions.

The feedback received indicates that **the SBES Program is a successful, mature program for PY2016, but could benefit from continuous improvements** as in previous years. Customer satisfaction with the implementer and contractor are very high, but there are instances where the installation contractor was responsible for a negative customer experience.

6.1 Process Methodology

The evaluation team conducted customer journey mapping and customer participant surveys as part of the process evaluation. In addition, the team gathered information from interactions with participants during the site verification visits and maintained regular communication with Duke Energy program staff, which included a review of program processes to provide the evaluation team with an understanding of the program's operations, nuances and qualitative and quantitative questions on customer satisfaction, participation, marketing, and outreach.

The process findings summarized in this document are based on the results of:

- Customer journey mapping with 13 program participants;
- Participant surveys with 150 program participants;
- Onsite visits at 62 program participant sites;
- Discussions with the Duke Energy Program Manager;
- A review of the program documentation.

6.2 Program Review

The evaluation team designed the program review task to understand changes and updates to the program design, implementation and energy and demand savings assumptions. The key program characteristics include the following:

- **Program Design** – The SBES program is designed to offer high incentives (up to 80 percent of the total cost of the project) on efficient equipment to reduce energy use and peak demand. It specifically targets small business customers that are difficult to reach and often do not pursue energy efficiency on their own. In PY2016 the program increased the eligibility limit from 100 kW to 180 kW demand, resulting in an increase of average project size.
- **Program Implementation** – A third-party contractor, Lime Energy administers the SBES program on Duke Energy's behalf. The IC handles all aspects of the program, including customer recruitment, facility assessments, equipment installation (through independent installers contracted by the IC), and payment and incentive processing. The IC reports energy and peak demand reduction estimates to Duke Energy. The IC has continued to refine their processes to ensure that savings estimates are reasonable, customer complaints are handled in a timely manner.

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- **Incentive Model** – The IC offers potential participants a recommended package of energy efficiency measures along with equipment pricing and installation costs. The incentive is proportional to estimated energy savings and can be as high as 80 percent of the total cost of the project.
- **Savings Estimates** – Energy and peak demand savings are estimated on a per-measure basis, taking into account existing equipment, proposed equipment, and operational characteristics unique to each customer.

6.3 Customer Journey Mapping

The Customer Journey Mapping analysis aimed to gather qualitative data about customer experiences with the SBES Program to understand customer sentiments and perspectives on program performance and establish a deeper understanding of customer satisfaction throughout the program process. Key aspects of journey mapping involved the development of a process map and the identification of the journey mapping lenses. In conversations with program staff, Navigant explored staff perceptions concerning the use of a variety of potential journey mapping lenses. Journey mapping lenses included a set of overarching questions and potential customer satisfaction concerns as the core focus of this research effort and were included in participant interviews. To conduct the customer journey analysis, Navigant completed seven steps, working closely with Duke Energy staff:

1. Program document review and conversations with program staff
2. Development of a process map and identification of journey mapping lenses
3. Development of a sampling plan, recruitment strategy and interview guide
4. Fielding of interviews
5. Analysis of interview notes
6. Development of Journey Map and other findings

In total, Navigant interviewed 13 Duke Energy Carolinas and Duke Energy Progress SBES Program customers across various building types and measures. The final participant sample included a diverse mix of office, retail, and restaurant owners or managers, who participated in upgrading their lighting or lighting and refrigeration equipment through the SBES Program. All interviewees installed lighting measures and two installed refrigeration measures in addition to the lighting measure. Most participants conducted business in North Carolina (11) as compared to South Carolina (2); however, participants were evenly split between Duke Energy Carolinas (8) and Duke Energy Progress (5). **Table 6-1** shows specific customer characteristic information.

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Table 6-1. SBES Interviewee Characteristics

Building Type	Business Type	Lighting	Refrigeration	Lighting KWh*	Utility	Location
Office	Real Estate Office	X	--	Low	DEC	NC
Office	Textile Mill	X	--	Low	DEC	NC
Office	Printing Store	X	--	Low	DEP	NC
Office	Warehouse	X	--	Medium	DEP	NC
Office	Law Office	X	--	Low	DEC	NC
Retail	Materials Distributor	X	--	High	DEC	NC
Retail	Gas Station	X	--	Low	DEP	NC
Retail	Grocery Store	X	--	High	DEC	NC
Retail	Retail Store	X	--	Low	DEP	SC
Restaurant	Multi-Sector**	X	X	High	DEC	NC
Restaurant	Restaurant & Catering	X	--	Low	DEC	NC
Restaurant	Restaurant	X	X	Low	DEC	SC
Restaurant	Diner	X	--	Low	DEP	NC

**Low = <10,000 KWh; Medium = 10,000-30,000 KWh; High = >30,000 KWh*
***Includes convenience stores, restaurants, and car dealerships*
Source: Navigant analysis

6.4 Customer Journey Map Findings

Navigant developed a process map detailing the journey of the customer's experience through the SBES program (see Figure 6-1). Findings depicted in the process map below indicate isolated instances of dissatisfaction with the measure installation and recycling of old equipment processes. Potential customer dissatisfaction and areas of concerns are seen in the presentment onsite energy assessment findings and savings outcomes.

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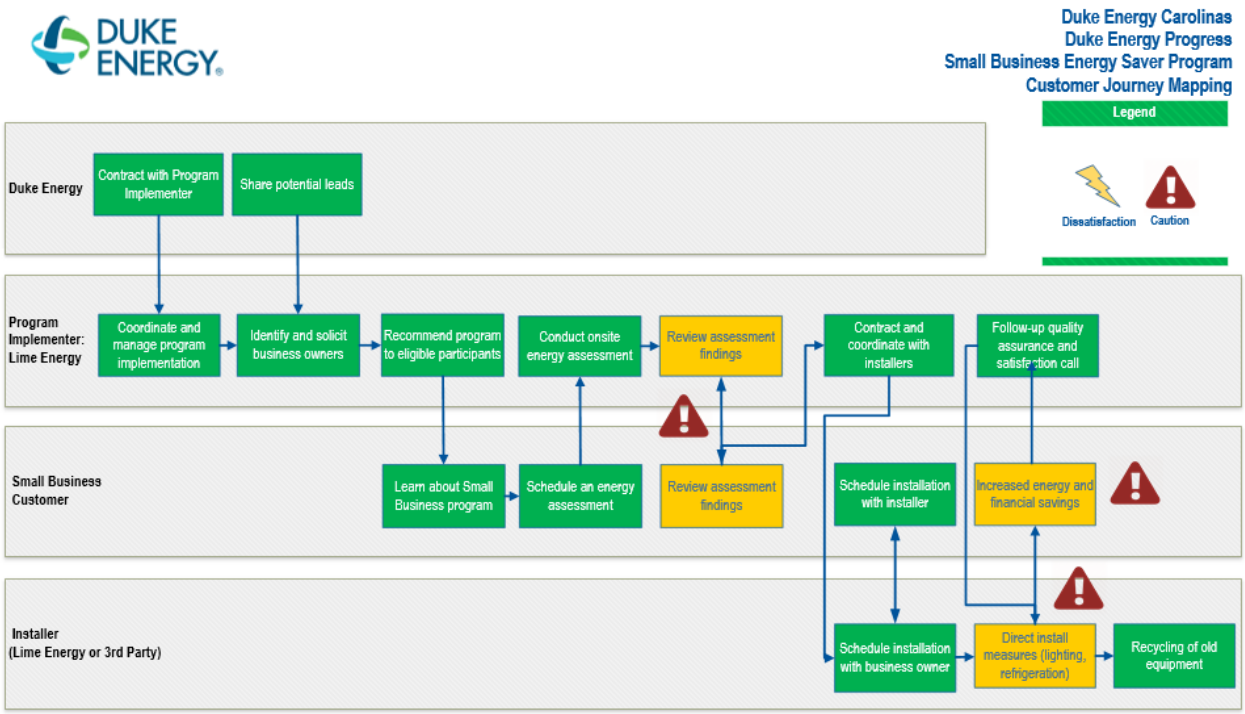
Figure 6-1. DEP and DEC SBES Process Map



Source: Navigant analysis

More specifically, participant interviews offered insight into the overall customer satisfaction with the SBES program and certain steps in the program participation process. Navigant examined the six process customer journey phases within the SBES program: 1) the Initial Contact; 2) the Energy Assessment; 3) the Installation Process; 4) Equipment Performance; 5) Energy Savings Expectations & Perceptions; and 6) Quality Assurance & Satisfaction. The list below outlines the key findings for each of these customer journey phases.

1. **Initial Contact** – Respondents felt highly satisfied with their initial contact and introduction into the program overall. Interviewees cited knowledgeable and professional sales representatives and Duke Energy's reputation as trustworthy as major reasons for their participation in the program and high satisfaction in this phase. Many felt particularly excited about the opportunity to save money and energy.
2. **Energy Assessment** – Similar to the Initial Contact phase, respondents reported high satisfaction with the Energy Assessment process overall. Many thought the assessments were simple and easy to understand. Participants were also pleased to hear about the number of lighting alternatives and customizations available through the program. Despite the high satisfaction overall, some interviewees felt that the representatives did not present the assessment clearly, indicating inconsistencies in presentation.
3. **Installation Process** – Similar to the previous two phases, participants expressed high satisfaction ratings for the Installation Process. In general, respondents were relieved that installers worked around employees and customers, minimizing disruption to the business. Many felt the process went more smoothly and quickly than expected. While respondents generally

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praised installers, a couple felt displeased that crews changed their product order (sometimes necessary due to facility conditions) and communicated poorly about installation timing.

4. **Equipment Performance** – In general, equipment worked as expected and most respondents felt pleased with the enhanced lighting quality, ambiance, and lifespan of the new bulbs. Some even expressed doing additional lighting replacements. However, there were isolated issues in equipment performance, including concerns about equipment quality, performance, and lifespan.
5. **Energy Savings Expectations & Perceptions** – The perceived achievement of energy savings received mixed responses: the majority felt satisfied or unconcerned about bill savings while some felt dissatisfied with savings, especially as compared to the initial energy assessment.
6. **Quality Assurance & Satisfaction** – Customers felt positive about post-program quality assurance and satisfaction. Respondents were particularly pleased that customer representatives remained engaged throughout the program process and followed-up post-installation.

Although respondents provided positive feedback overall, the findings indicate isolated problems throughout the process. This fact indicates inconsistencies in the program participation process, mostly as a result of poor performances from program subcontractors in the energy assessment and installation phases.

In general, interviewees reported high satisfaction ratings with the SBES program despite program inconsistencies. Out of a 1-10 rating scale, customer program satisfaction averaged 8.9, although scores ranged from as high as “10” to as low as “2.” Overall customer satisfaction with the initial contact and energy assessment was a 9.5. Interviewee satisfaction of equipment installation was 9.3. In general, most customers felt that the program process went smoothly and enhanced their business. Figure 6-2 below shows the average satisfaction ratings from interviewees by program component through the installation process.

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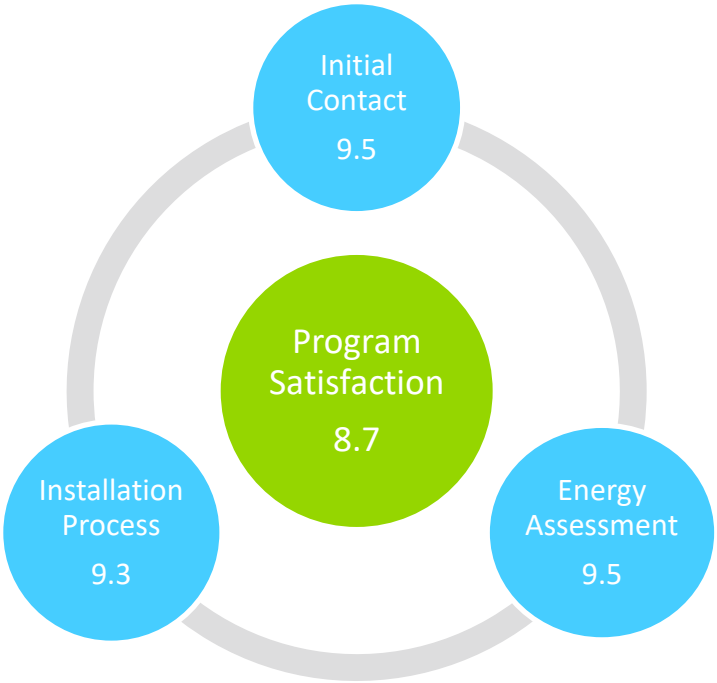
Figure 6-2. Overall Program Satisfaction



Source: Navigant analysis

6.5 Participant Survey Sampling Plan

The participant survey targeted a random sample of all PY2016 program participants broken out by measure family. The two measure families are lighting and refrigeration. Navigant weighed customer responses by their stratum savings for net-to-gross findings as described in the preceding section.

The survey effort targeted 150 participants and successfully completed surveys with 150 customers, of which 135 were participants that only installed lighting measures and 15 were participants that installed some refrigeration measures. The survey targets were designed to achieve 90/10 confidence and precision, with significant oversampling due to the relatively inexpensive per-survey cost.

6.6 Participant Survey Findings

The following sections detail the process findings from the customer surveys, organized by topic. The feedback received indicates that the SBES Program continues to be a successful program in PY2016 and is a mature program in the Duke Energy portfolio.

The following sections detail the process findings and addresses the following topics:

1. Customer Satisfaction;
2. Program Challenges;
3. Marketing and outreach; and
4. Suggested improvements.

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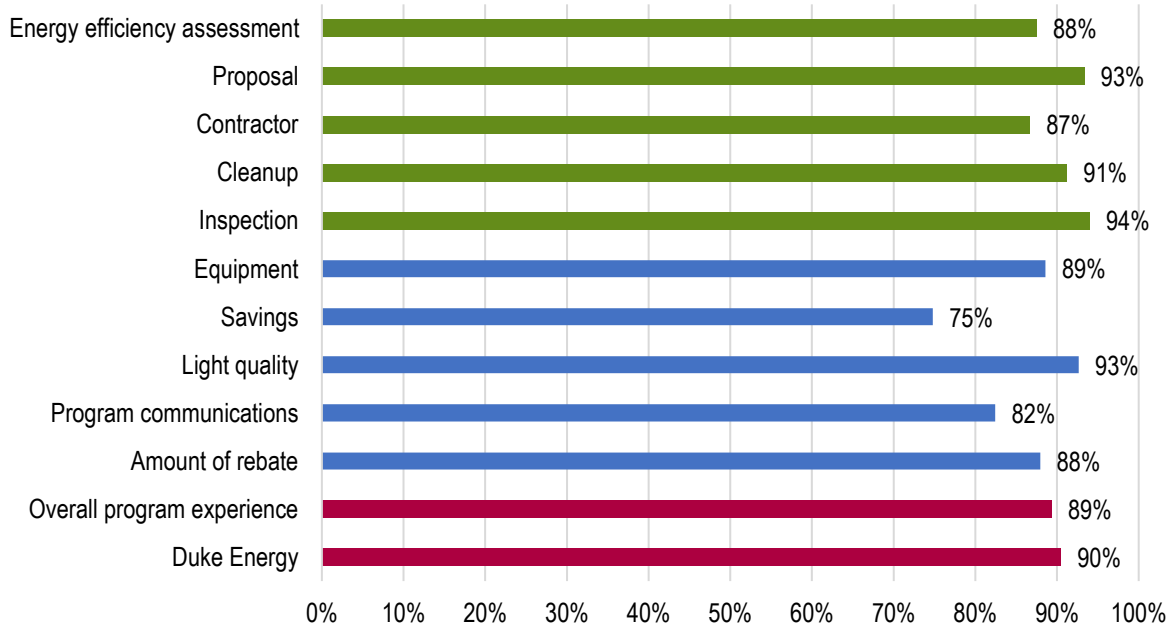
6.6.1 Customer Satisfaction

Participants report high levels of satisfaction with the program overall: 89% of participants rated their satisfaction with the program at an 8 or higher, on a scale from 0 to 10. Satisfaction with Duke Energy was high at 90%. Satisfaction with the equipment installed is *most* strongly correlated with overall program satisfaction. Satisfaction with the rebate amount is *least* correlated with overall program satisfaction.

Participants are most satisfied with the inspection they received, the light quality, and the energy efficiency proposal. Participants are less satisfied with energy savings, program communications, and their installation contractor. Detailed top box (8 or higher out of 10) satisfaction scores are shown below in Figure 6-2.

Figure 6-3. Detailed Satisfaction Scores (n=150)



Source: Navigant analysis

6.6.2 Program Challenges

Despite the high overall satisfaction scores, some customers had minor complaints or identified drawbacks of the program. Figure 6-4 below shows the responses when customers were asked program challenges or drawbacks. The most common challenges were:

- Issues with the equipment after installation
- Perceived lack of coordination and communication between program implementation staff
- Impatience with delays or the length of the process

Looking at total responses to this question, 75% of all customers did not mention *any* of the complaints shown.

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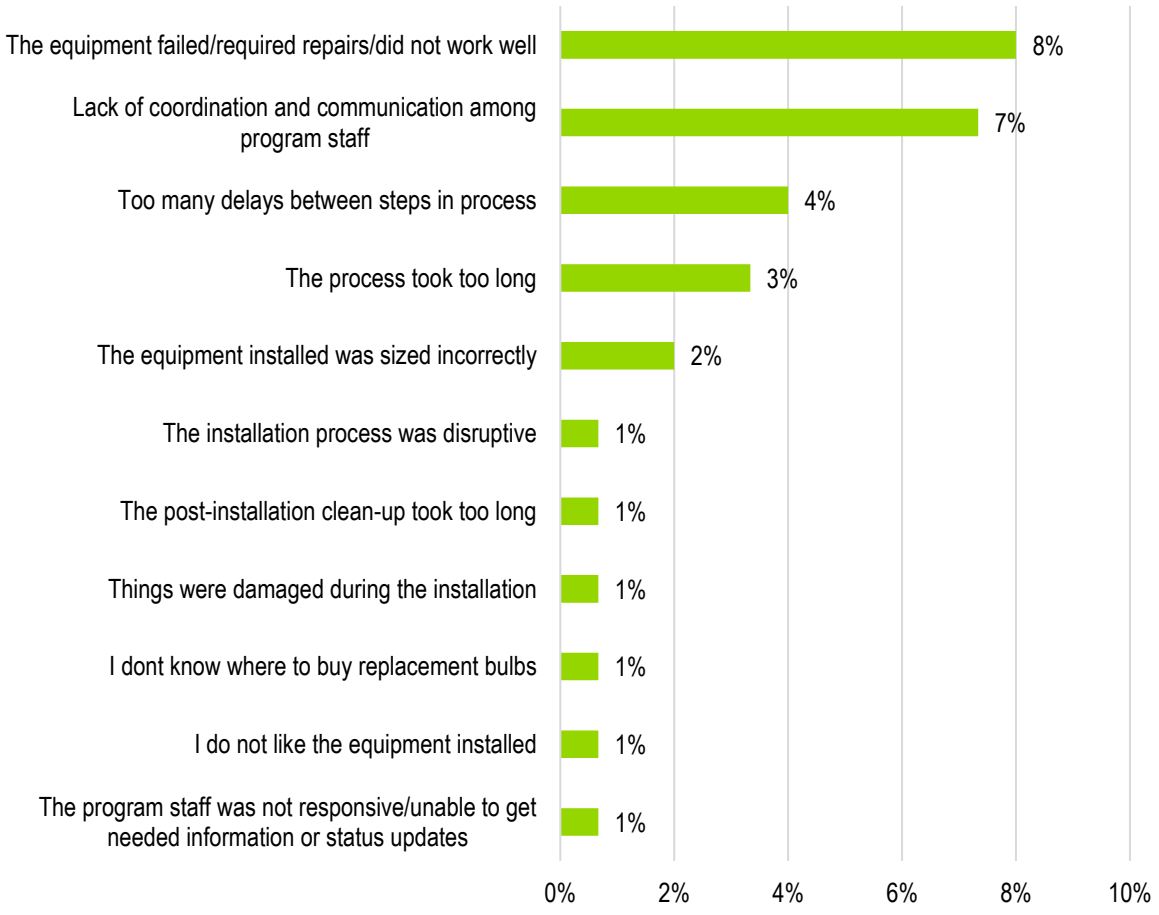
Figure 6-4. Detailed Program Challenges (n=38)



Source: Navigant analysis

6.6.3 Marketing and Outreach

Duke Energy markets the program to eligible customers primarily through direct contact that both Lime Energy and Duke Energy initiate. Participants were asked to indicate all the sources through which they learned about the program. One quarter of the participants indicated that they learned about the program directly from the IC staff (either through direct contact or outreach materials), and almost an additional quarter indicated they had learned about the program through Duke Energy themselves. Figure 6-5 shows the range of ways in which customers found out about the program. Compared to PY2015, less customers reported that they learned about the program through Duke Energy directly (25 percent in PY2016 compared to 38 percent in PY2015), indicating that the IC is generating a larger share of program participation.

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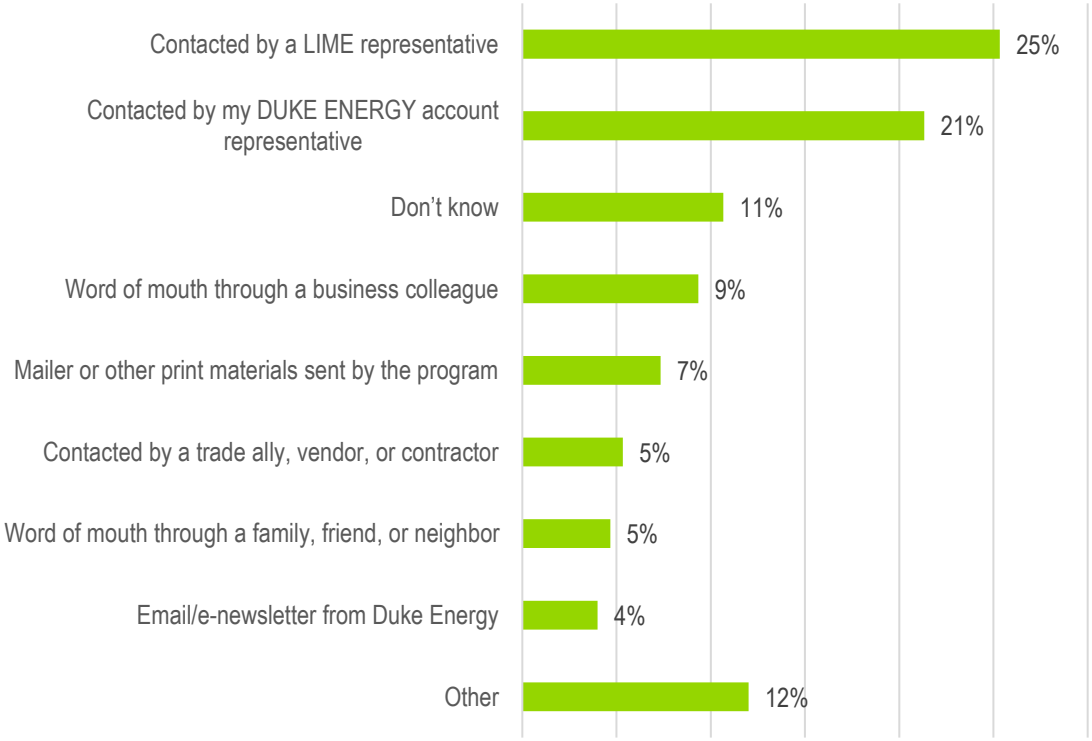
Figure 6-5. How Program Participants First Learned About the SBES Program (n = 150)



Source: Navigant analysis

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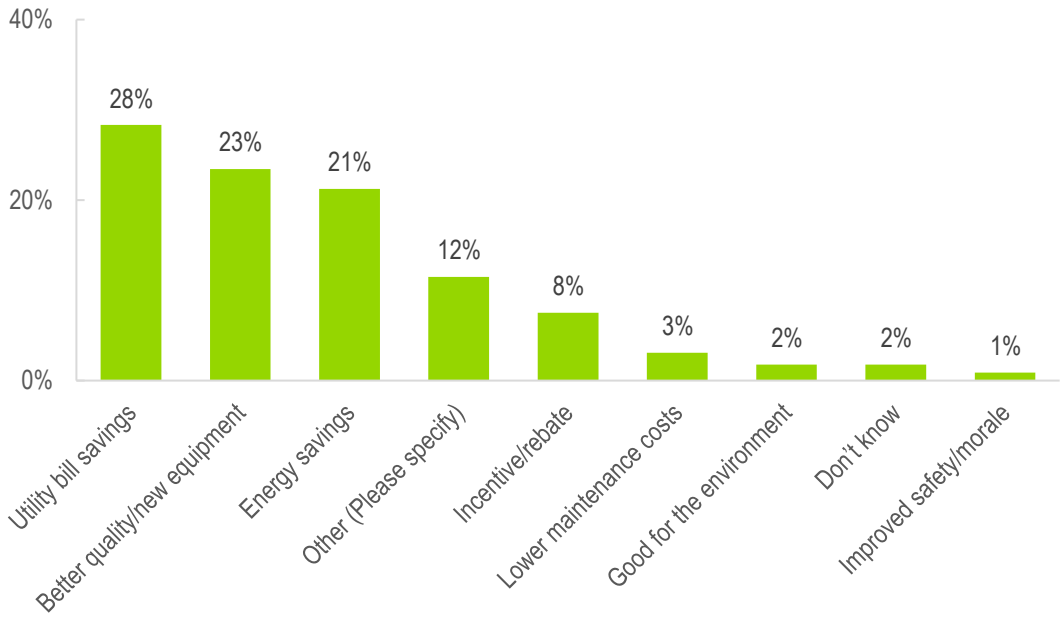
When asked about the main benefits of participating in the program, over one quarter of respondents cited utility bill savings, compared to over 50 percent of survey respondents in PY2015 that cited energy savings as a reason they decided to participate in the program (see Figure 6-6 below). There was an increase in the percentage that reported better quality equipment as a primary driver (23% in PY2016 compared to 14% in PY2015). This indicates that the program marketing and sales communications have likely shifted towards bill savings and quality equipment. Coordinated efforts to market all of the benefits of program participation are key to enhancing participation across the variety of small business customer that Duke Energy serves.

Figure 6-6. Primary Reasons for Deciding to Participate in the Program (n = 150)



Source: Navigant analysis

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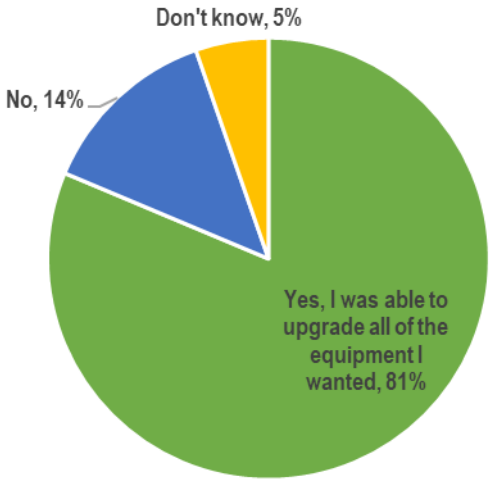
Another important survey finding was that 81 percent of participants stated that equipment offered through the program allowed them to upgrade all of the lighting equipment they wanted at the time of the project, rather than piecing together the upgrades in multiple phases (see Figure 6-7 below). This is a decrease from 89 percent in PY2015, which indicates that there may be opportunity to increase the depth of energy efficiency measures available to participants.

Figure 6-7. Participants Who Stated that Equipment Offered Through the Program Allowed Them to Upgrade All of the Equipment They Wanted at the Time (n = 150)



Source: Navigant analysis

6.6.4 Suggested Improvements

Some customers reported difficulties they faced and provided suggested improvements in the survey's open-ended questions. The list below summarizes a few key points.

Summary of Improvements Mentioned by Customers

- Better communication/improved program information
- Greater program publicity
- More equipment offered through the program.

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7. SUMMARY FORM

SBES Program

Completed EMV Fact Sheet

Description of program

Duke Energy's Small Business Energy Saver Program provides energy efficient equipment to eligible small business customer at up to an 80 percent discount. The program is delivered through an implementation contractor that coordinates all aspects of the program, from the initial audit, ordering equipment, coordinating installation, and invoicing.

The program consists of lighting and refrigeration measures.

- **Lighting measures:** LED lamps and fixtures, T8 fluorescent fixtures, occupancy sensors.
- **Refrigeration measures:** LED case lighting, EC motor upgrades, compressor and fan motor controls.

Date	September 10, 2018
Region(s)	Duke Energy Progress; Duke Energy Carolinas
Evaluation Period	DEP 3/1/16 – 6/30/17 DEC 3/1/16 – 6/30/17
Annual kWh Savings (net)	DEP 53,302,070 kWh DEC 90,923,371 kWh
Per Participant kWh Savings	DEP 29,143 DEC 37,340
Coincident kW Impact	DEP 9,207 DEC 16,308
Net-to-Gross Ratio	0.98
Process Evaluation	Annual
Previous Evaluation(s)	2013, 2014, 2015

Evaluation Methodology

The evaluation team used engineering analysis, onsite field inspections, and time-of-use metering as the primary basis for estimating program impacts. Additionally, telephone surveys were conducted with participants to assess customer satisfaction and determine a net-to-gross ratio. Interviews were conducted with program and implementation team staff to understand program operational changes and enhancements.

Impact Evaluation Details

- **Onsite visits were conducted at 62 participant sites, while 23 of those sites were logged.** The evaluation team inspected program equipment to assess measure quantities and characteristics to compare with the program tracking database, and installed lighting loggers to verify hours of use and coincidence factors.
- **In-Service rates (ISRs) varied by equipment type.** The evaluation team found ISRs ranging from 0.97 for LED screw-in lamps to 1.04 for exterior LED wall packs.
- **Participants achieved an average of 29,143 kWh of energy savings per year in DEP, and 37,340 kWh in DEC.** The program is accurately characterizing energy and demand impacts.

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8. CONCLUSIONS AND RECOMMENDATIONS

The evaluation team performed extensive on-site work, telephone surveys, and analysis to determine gross and net verified savings. Overall conclusions and recommendations appear in the following sections.

8.1 Conclusions

Overall, the SBES Program is a well performing, mature program in the DEP and DEC jurisdictions. The key to continued success is working through quality control issues as they arise and ensuring that the program continues to offer leading energy efficiency equipment.

- **Participants continue to be overwhelmingly satisfied with the SBES Program and Duke Energy**, including overall service, pricing, installation, and efficient equipment quality. Participants were excited about the opportunity to save money and energy, and expressed limited, minor pain points with the program.
- **Duke Energy has successfully increased the eligibility limit** in PY2016. The program had no apparent issues adapting to larger projects, and there are no meaningful differences in the EM&V team's findings between different project sizes. The higher eligibility limit also increased the average project size, and the ability of the program to generate substantial energy savings.
- The **installation of high–efficiency lighting equipment continues to be the key selling point**. The SBES Program continued to expand the LED lighting offerings. LED measures have grown considerably as a share of total program savings, while refrigeration has remained stable from PY2015 at under 10 percent.
- The **energy savings realization rate is 1.02 for DEP and 1.01 for DEC,** and is driven by several EM&V adjustments. The key adjustments the EM&V team made were the hours of use based on metering and HVAC interactive effects. The **peak demand realization rate is lower at 0.77 for DEP and 0.76 for DEC** and is driven by HVAC interactive effects and coincidence factors.
- The evaluation effort estimated **free ridership for the SBES Program at 6 percent and spillover at 4 percent**, which drives an **NTG ratio of 0.98**. This indicates that the SBES Program is successfully reaching customers that would have not completed energy efficiency upgrades in the absence of the program. Spillover has decreased from PY2015, while free-ridership has remained the same.

8.2 Recommendations

The evaluation team recommends four actions for improving the SBES Program, based on insights gained through the comprehensive evaluation effort for PY2016. These recommendations provide Duke Energy with a roadmap to fine-tune the SBES Program for continued success and include the following broad objectives:

Increasing Program Participation and Satisfaction

1. **Continue to focus on quality, clear communication, and depth of energy efficiency retrofits.** The most common suggested improvements were post-installation equipment issues and a perceived lack of coordination between the various parties involves in delivering the SBES program. There was also a minority of customers reporting that the program was unable to

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provide all the energy efficiency equipment they wanted. There are opportunities for continued improvement and channeling to other Duke Energy programs or education about measures that are not offered through the SBES program.

2. **Consider effects of increased program eligibility rules**. With a 180 kW demand limit, there is likely significant overlap between the SBES program and other business programs in Duke Energy's portfolio. The largest project is almost 2 GWh, which is larger than typical large business prescriptive projects seen in other utility offerings. Larger businesses typically have additional resources that small businesses do not, and often do not require the high incentive levels that the SBES program offers. Duke Energy should consider whether the SBES incentive levels are appropriate for these very large projects, or if a different program channel would be sufficient. For example, the Smart $aver program offers LED incentives that are capped at a lower percentage of incremental costs.

Improving Accuracy of Reported Savings

3. **Track burnout lamps and fixtures during the initial audit.** It is likely that some burnouts were present and tolerated by customers, and may contribute to customers not realizing expected savings on their energy bills. Burnouts found during the initial audit are no longer included in tracking data. While not generally required in the industry, customers with many burnouts will not achieve the expected energy savings.

4. **Ensure that the IC has access to up-to-date and accurate customer billing records.** There are several (2706) instances where project deemed savings exceed annualized site data, likely due to incomplete annualized energy usage estimates. Since this is used as an overridable QC check, more accurate data could help reduce the need for such overrides.

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9. MEASURE-LEVEL INPUTS FOR DUKE ENERGY ANALYTICS

The SBES program estimates deemed savings on a per-fixture basis that takes into account specific operational characteristics. This approach differs from a more traditional prescriptive approach that applies deemed parameters by measure type and building type only.

For the lighting measures, the EM&V team applied HVAC interactive effects and coincident factors in the analysis that differed from those used by the IC; the values used are shown in Table 9-1 and Table 9-2. Note that for the PY2016 SBES evaluation the EM&V team applied the summer coincidence factors for both summer and winter peak demand reductions, with additional adjustments based on logger data for each of the corresponding peak periods, as in previous years.

Table 9-1. HVAC Interactive Effects[7]

Building Type	Cooling Type	Heating Type	Energy HVAC Interactive Effect	Demand HVAC Interactive Effect
Grocery	Electric	Electric Resistance	1	1.43
Grocery	Electric	Electric HP	1.08	1.43
Grocery	Electric	Not Electric	1.22	1.42
Grocery	No Cooling	Electric Resistance	0.77	1
Grocery	No Cooling	Electric HP	0.86	1
Grocery	No Cooling	Not Electric	1	1
Grocery	DK	DK	1.14	1.36
Lodging	Electric	Electric Resistance	1.11	1.18
Lodging	Electric	Electric HP	1.11	1.18
Lodging	Electric	Not Electric	1.11	1.18
Lodging	No Cooling	Electric Resistance	1.11	1.18
Lodging	No Cooling	Electric HP	1.11	1.18
Lodging	No Cooling	Not Electric	1.11	1.18
Lodging	DK	DK	1.14	1.36
Manufacturing	Electric	Electric Resistance	1.1	1.29
Manufacturing	Electric	Electric HP	1.1	1.29
Manufacturing	Electric	Not Electric	1.1	1.29
Manufacturing	No Cooling	Electric Resistance	1.1	1.29
Manufacturing	No Cooling	Electric HP	1.1	1.29
Manufacturing	No Cooling	Not Electric	1.1	1.29
Manufacturing	DK	DK	1.14	1.36
Medical	Electric	Electric Resistance	1.05	1.44

[7] PY2013 DEP EEB EM&V Report

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Medical	Electric	Electric HP	1.12	1.44
Medical	Electric	Not Electric	1.22	1.43
Medical	No Cooling	Electric Resistance	0.83	1
Medical	No Cooling	Electric HP	0.89	1
Medical	No Cooling	Not Electric	1	1
Medical	DK	DK	1.14	1.36
Office	Electric	Electric Resistance	1.05	1.44
Office	Electric	Electric HP	1.12	1.44
Office	Electric	Not Electric	1.22	1.43
Office	No Cooling	Electric Resistance	0.83	1
Office	No Cooling	Electric HP	0.89	1
Office	No Cooling	Not Electric	1	1
Office	DK	DK	1.14	1.36
Other	Electric	Electric Resistance	1.05	1.44
Other	Electric	Electric HP	1.12	1.44
Other	Electric	Not Electric	1.22	1.43
Other	No Cooling	Electric Resistance	0.83	1
Other	No Cooling	Electric HP	0.89	1
Other	No Cooling	Not Electric	1	1
Other	DK	DK	1.14	1.36
Restaurant	Electric	Electric Resistance	1	1.43
Restaurant	Electric	Electric HP	1.08	1.43
Restaurant	Electric	Not Electric	1.22	1.42
Restaurant	No Cooling	Electric Resistance	0.77	1
Restaurant	No Cooling	Electric HP	0.86	1
Restaurant	No Cooling	Not Electric	1	1
Restaurant	DK	DK	1.14	1.36
Retail	Electric	Electric Resistance	1	1.43
Retail	Electric	Electric HP	1.08	1.43
Retail	Electric	Not Electric	1.22	1.42
Retail	No Cooling	Electric Resistance	0.77	1
Retail	No Cooling	Electric HP	0.86	1
Retail	No Cooling	Not Electric	1	1
Retail	DK	DK	1.14	1.36
School	Electric	Electric Resistance	1.05	1.44
School	Electric	Electric HP	1.12	1.44

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School	Electric	Not Electric	1.22	1.43
School	No Cooling	Electric Resistance	0.83	1
School	No Cooling	Electric HP	0.89	1
School	No Cooling	Not Electric	1	1
School	DK	DK	1.14	1.36
Warehouse	Electric	Electric Resistance	1.1	1.29
Warehouse	Electric	Electric HP	1.1	1.29
Warehouse	Electric	Not Electric	1.1	1.29
Warehouse	No Cooling	Electric Resistance	1.1	1.29
Warehouse	No Cooling	Electric HP	1.1	1.29
Warehouse	No Cooling	Not Electric	1	1
Warehouse	DK	DK	1.14	1.36

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Table 9-2. Coincidence Factors[8]

Building Type	Summer Coincidence Factor
OFFICE	0.81
SCHOOL	0.42
COLLEGE/UNIVERSITY	0.68
RETAIL/SERVICE	0.88
RESTAURANT	0.68
HOTEL/MOTEL	0.67
MEDICAL	0.74
GROCERY	0.81
WAREHOUSE	0.84
LIGHT INDUSTRY	0.99
HEAVY INDUSTRY	0.99
AVERAGE/MISC	0.77
AGRICULTURAL	0.50

The Duke Energy DSMore table is embedded below for reference.

DSMore table
template - DEC DEP

[8] PY2013 Savings Basis and Changes, December 10, 2013. EEB Program Documentation.

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APPENDIX A. **STATISTICS DETAIL**

This appendix is intended to provide additional context around Navigant's sampling approach and impact findings for the PY2016 SBES evaluation for the DEP and DEC jurisdictions. Overall, Navigant believes that the evaluation results represents the program impacts in accordance with the evaluation approach and sample design. This is evidenced by the calculated statistical confidence and precision values, which were in line with expectations.

A.1 Sampling Approach

Navigant's methodology includes a double-ratio (nested) sampling approach. This approach is designed to efficiently utilize resources for primary data collection while minimizing sampling error. For the SBES program, Navigant chose a relatively large sample of sites to perform onsite verification activities, and a relatively smaller subsample of these sites for more detailed data collection with data loggers. The underlying assumption is that the larger verification sample represents the larger *population*, while the smaller metering sample represents the larger verification *sample*. This allows Navigant to perform high-rigor evaluation at lower cost for a given assumed sampling error.

For this evaluation, Navigant targeted 90/10 sampling and relative precision for the entire program. Sample sizes are ultimately driven by assumptions related to the variability of Navigant's verified savings compared to the Duke Energy deemed savings values. This is represented by the coefficient of variation, or CV. Less variation results in a lower CV value, which in turn results in lower sample sizes.

Based on previous evaluation work with the SBES program, Navigant designed a sample with 62 sites selected for verification, with a subsample of 23 of these sites for additional metering. Figure 9-1 illustrates the sample design and analysis plan.

Navigant will also note that the population split into four separate strata – large, medium, and small lighting, and one strata for refrigeration. The underlying assumption is that similar projects will tend to exhibit similar variations, so by grouping like projects (e.g. all refrigeration projects) we can further reduce sampling error and draw more meaningful conclusions from our onsite data collections efforts.

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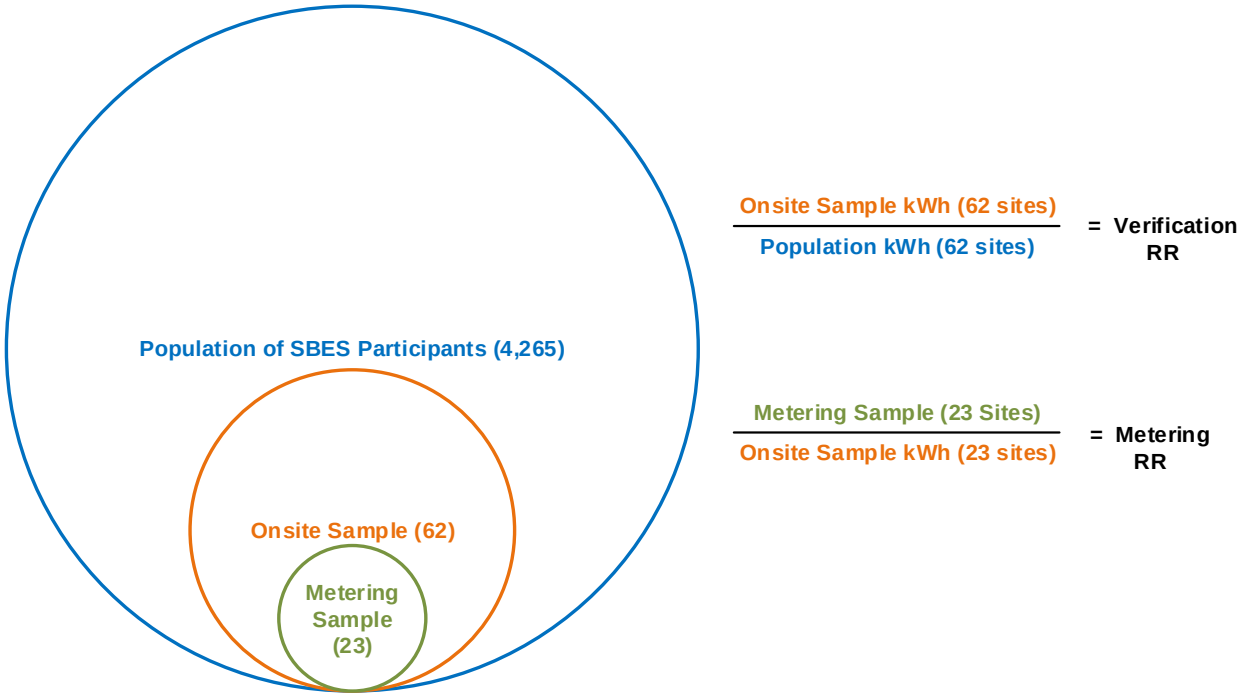
Figure 9-1. Illustration of Nested Sampling Concept



A.2 Analysis Approach

After performing the site visits, the next step is to analyze the measure-level data to develop project-level verification and metering estimates for each site. Because there are three sets of savings estimates, two ratios (hence double-ratio) are required to compare results.

1. The first ratio compares the onsite verification findings to the population for 62 sites. The onsite verification findings include all of Navigant's adjustments performed onsite, such as any adjustments due to in-service rate, HVAC interactive effects, wattage, or customer-reported hours of operation.
2. The second ratio compares the metering findings to the onsite findings for 23 sites. The only adjustment made here is due to hours of use adjustments (or for demand savings, the coincidence factor).

With these ratios, final program-level savings and realization rates are calculated. First, for each stratum, a total realization rate is calculated by multiplying the verification and metering realization rates together (ratios 1 and 2 outlined above). The total realization rate is then multiplied by the stratum deemed savings resulting in the verified savings. The verified savings for each of the four strata are then added together resulting in total program verified savings.

The last step of the analysis includes a statistical analysis to assess whether or not the precision targets were met. In some cases, if there is larger than expected variation between the claimed savings and the verified savings, it is possible that the precision target of 10% is not met. It is also possible that the "true"

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savings value will be outside of the confidence interval calculated from the statistics. This occurs on average 10% of the time at the 90% confidence level.

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Duke Energy Progress

Residential Energy Assessments Program Evaluation Report – Final

October 12, 2018

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1. Evaluation Summary

1.1 Program Summary

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

The REA program targets owner-occupied, single-family residences and relies primarily on direct mail marketing. Our evaluation includes 6,754 customers[1] who participated in the program between April 2016 and March 2017.

1.2 Evaluation Objectives

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

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

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

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

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1.3 High-Level Findings

Table 1-1 presents the participant- and program-level net savings from the billing analysis for the evaluation period, which ran from April 1, 2016 through March 31, 2017. These results include the savings from the measures included in the distributed energy efficiency kits, as well as from additional LEDs provided to program participants. The results also include savings from behavioral changes that participants made based on the recommendations received during the assessment, as well as participant SO attributable to the program.

Table 1-1. Net Impact Results from Billing Analysis

Net Participant Savings			Net Program Savings		
Energy (kWh)	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)	Energy (MWh)	Summer Coincident Demand (MW)	Winter Coincident Demand (MW)
1,095	0.132	0.1051	7,396	0.8912	0.7098

Using information collected during the participant survey, we estimated ISRs ranging from 41% for weather stripping to 85% for LEDs. Table 1-2 presents the ISR estimates and relative precision values for the measures included in the energy efficiency kits. We designed our sample to achieve a relative precision of 10% with 90% confidence; however, for most measures, we were unable to achieve this target due to low installation rates (IRs) among the surveyed participants.

Table 1-2. ISR Results and Relative Precision

	Kit Average	By Measure				
		LEDs	Faucet Aerators	Low-Flow Shower Head	Outlet Seals	Weather Stripping
Sample size (n)	149	132	133	149	92	103
Estimated ISR	61%	85%	54%	60%	51%	41%
Relative precision (at 90% confidence)	6.5%	5.3%	11.2%	10.9%	16.5%	18.5%

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

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

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Table 1-3. Gross Impact Results per Home from Engineering Review

Measure		April 2016–March 2017			
		Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Percent of Total kWh Savings
Energy Efficiency Kit	LEDs (two 9W bulbs)	58.8	0.0087	0.0042	13%
	Low-flow shower head (1)	120.1	0.0051	0.0102	26%
	Bathroom faucet aerator (1)	12.6	0.0012	0.0024	3%
	Kitchen faucet aerator (1)	83.1	0.0041	0.0082	18%
	Outlet seals (package of 6)	4.1	0.0006	0.0019	7%
	Weather stripping (roll of 17 feet)	33.5	0.0140	0.0066	1%
Total kit only		**312.3**	**0.0336**	**0.0335**	**68%**
Additional LEDs (average of 4.4 bulbs)		146.0	0.0216	0.0105	32%
Total per-home estimate		**458.2**	**0.0552**	**0.0440**	**100%**

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

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

Table 1-4. Net-to-Gross Results

Component	FR	SO	NTGR
Energy Efficiency Starter Kit*	23.7%	9.2%	85.5%
LEDs**	53.4%		55.8%
Faucet Aerators***	13.6%		95.6%
Low-Flow Shower Head	15.3%		93.9%
Outlet Seals	13.9%		95.3%
Weather stripping	32.1%		77.1%

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

For planning purposes, Duke Energy requires separate per-participant savings values for the energy efficiency kit and the additional bulbs distributed to participants. To provide these estimates, the evaluation team subtracted the engineering-derived net savings of the average number of additional bulbs distributed (4.4 LED bulbs) from the per-participant billing analysis savings. Taking this step ensures that savings from the additional bulbs are not double-counted, as these savings are already included in the billing analysis estimate (see Table 1-5).

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Table 1-5. DSMore Inputs

Development of DSMore Inputs	kWh	Summer Peak Savings (kW)	Winter Peak Savings (kW)
Net energy efficiency kit savings per participant (excluding additional LEDs)	1,013.5	0.1199	0.0992
Net savings per additional LED bulb: Engineering analysis	18.5	0.0027	0.0013

1.4 Evaluation Recommendations

We have developed a series of recommendations based on the results of our evaluation:

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

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

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

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

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

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- **Ensure that auditors provide all applicable recommendations to customers during assessment visits.** Based on a review of the program-tracking data, several potential audit recommendations were never provided to DEP participants. Recommendations that auditors provided to REA participants in other jurisdictions, but not to DEP participants, included replace or install a heat pump, seal air leaks in duct systems, and turn down water heater temperature. In addition, most recommendations that were given were only provided to about 50% of participants. While it is expected that some recommendations do not apply to all participants, the incidence of recommendations not received appears to be too high to be the result of applicability alone.

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

- **Consider adding "premium" audit services for a fee at the time of the audit or soon thereafter.** Based on interest from the program team, we asked surveyed participants about their desire for "premium" audit services, for a fee, that could be offered in addition to the standard assessment. Customers expressed interest in these additional premium audit services, particularly for blower door tests and thermal imaging. When scheduling an audit, customers could be given this option so that the auditor could come prepared to conduct the free audit, install measures from the energy efficiency kit, and provide additional fee-based audit services.

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2. Program Description

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

2.1 Program Design

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

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

In its program-tracking databases, DEP tracks the date that customers sign up for the program, the recommendations made by the auditor during the assessment, and the number of additional light bulbs given to the customer.

2.2 Program Implementation

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

2.3 Program Performance

The program period under evaluation is April 1, 2016 through March 31, 2017. Over this period, the program served 6,754 unique participants. The program saved participants, on average, 1,095 kWh per household per year. Coincident demand savings per household were 0.132 kW in summer and 0.105 kW in winter.

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3. Key Research Objectives

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

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

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4. Overview of Evaluation Activities

4.1 Program Staff Interview

Opinion Dynamics conducted an in-depth interview with the current REA program manager in October 2017. The purpose of the interview was to gauge the current environment of, and expectations for, the REA program, including the program's goals, successes, and challenges over the evaluation period. During the interview, we discussed the multichannel approach to marketing the program, as well as the receptiveness of DEP customers to participating in this offering.

4.2 Program Materials Review

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

4.3 Participant Survey

Opinion Dynamics implemented a computer-assisted telephone interviewing (CATI) survey in February 2018. The survey gathered data to verify participation in the program; develop measure-level estimates of installation, persistence; and ISRs; estimate the program NTGR; and support our process evaluation.

The survey sample design and sample size were based on customers who participated between April 2016 and March 2017. Of the 6,754 participants in the database, we drew a random sample of 2,001 valid telephone numbers. We used this sample to complete 150 participant telephone surveys.

The average length of the interviews was approximately 27 minutes; the response rate was 23%.

4.4 Billing Analysis

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

4.5 Deemed Savings Review and Engineering Analysis

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

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

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

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

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

[3] Indiana Technical Reference Manual Version 2.2. July 28, 2015. We reviewed several TRMs, including regional TRMs (e.g., Mid-Atlantic) as part of our engineering review. Many of these TRMs reference consistent methodologies for savings calculations and we ultimately followed the Indiana TRM methods to remain consistent with other Duke evaluations but made DEP-specific updates as applicable based on weather and survey data.

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5. Impact Evaluation

5.1 Methodology

5.1.1 Billing Analysis

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

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

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

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

Metric	Treatment Group	Comparison Group
Months of participation	April 2016–March 2017	April 2017–December 2017
# customers included in the analysis	2,198	1,488
Usage data included	9+ Months of Pre- and Post-Participation Data	9+ Months of Pre-Participation Data

The number of customers included in the analysis is approximately 33% of those who participated during the evaluation period, and 38% of those who participated between April and December of 2017. The main reason customers were dropped from the analysis was due to participation in other Duke Energy programs (approximately 52% in the treatment group and 54% in the comparison group). The evaluation team recognizes that this is a large number of customers to exclude from the analysis but took this necessary step to limit the risk of the effects of other programs being confounded with the treatment effect of the REA program. It should be noted that while these customers were not included in the billing analysis model, average modeled savings are still applied to them, i.e., the program receives credit for their savings.

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

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5.1.2 Engineering Analysis

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

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

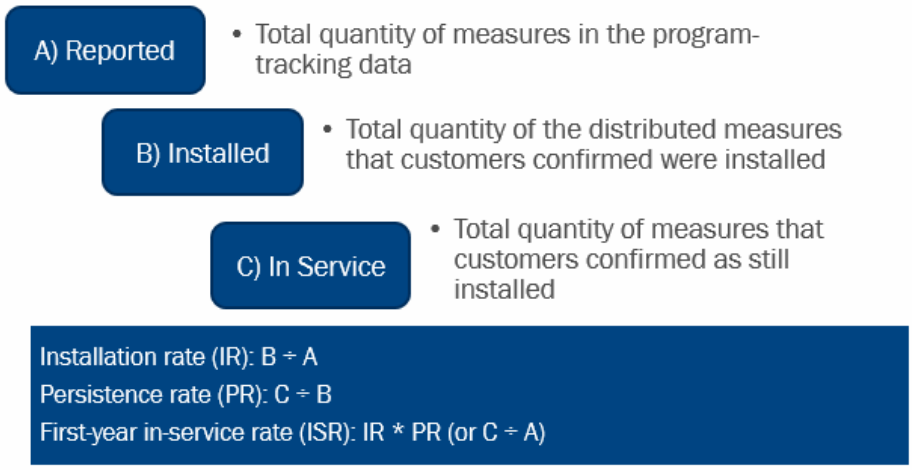
We used the IN TRM V2.2 and other references and assumptions to conduct our engineering analysis. The engineering analysis takes into consideration the measure ISRs to ensure only savings for installed measures are counted. Additional details and information on the engineering analysis are provided in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

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

Installation Verification and Persistence

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

Figure 5-1. Installation Rate Components



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5.2 Results

5.2.1 Billing Analysis Results

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

Table 5-2. Results of Billing Analysis Models

Variable	Coefficient
Post (REA program participation)	5.966773*
Cooling Degree-Days (CDD)[4]	0.141938*
Heating Degree-Days (HDD)	0.041427*
Post-participation period CDD	−0.035910*
Post-participation period HDD	−0.020669*
Additional bulbs received	−0.193460*
Constant	34.271583*
R-squared	0.699741
Additional Terms	**Included**
Monthly effects included	YES
Post-participation period interacted with months included	YES

*p<0.01.

Due to post-participation period interaction terms in the model, it is necessary to recalculate the coefficient of the treatment effect (Post) by combining the average value with the coefficient for each interaction term. The coefficient seen in the regression represents the reduction of daily consumption during the post-participation period, separate of any effect of the included interaction terms. Making these adjustments (detailed in Appendix F), Opinion Dynamics found that REA program participants included in the model realized 3.0 kWh of daily energy savings, on average.

Table 5-3 shows the per-home and program-level savings for the program. Overall, customers who participated in the REA program saved 1,095 kWh per year. During the evaluation period, the program realized 7,396 MWh of energy savings.

[4] A "degree-day" is a unit of measure for recording how hot or how cold it has been over a 24-hour period. The number of degree-days applied to any particular day of the week is determined by calculating the mean temperature for the day and then comparing the mean temperature to a base value of 65 (HDD) and 75 (CDD) degrees F. (The "mean" temperature is calculated by adding together the high for the day and the low for the day, and then dividing the result by 2.) If the mean temperature for the day is 5 degrees higher than 75, then there have been five CDD. On the other hand, if the weather has been cool, and the mean temperature is, say, 55 degrees, then there have been 10 HDD (65 minus 55). http://www.srh.noaa.gov/ffc/?n=degdays.

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Table 5-3. Annual Savings from Billing Analysis

Annual Savings	
April 2016–March 2017 participants	6,754
Per-home daily savings (kWh)	3.0
Per-home annual savings (kWh)	1,095
Program savings (MWh)	**7,396**

5.2.2 Engineering Analysis Results

This section provides the results of the engineering analysis, including ex post deemed savings values, survey-based ISRs, and application of measure quantities to determine per-participant gross energy and demand savings. Table 5-4 shows the net of ISR ex post deemed savings values presented from the deemed savings review completed by the evaluation team (see Appendix E).

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

Measure	Ex Post Deemed Savings per Unit (kWh)	Ex Post Deemed Savings per Kit (kWh)*
LED	34.5	68.9
Low-flow shower head	198.8	198.8
Bathroom faucet aerator	22.8	22.8
Kitchen faucet aerator	149.9	149.9
Outlet seals	1.3	8.0
Weather stripping	4.8	82.2
Energy Efficiency Kit	N/A	530.6

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

Table 5-5 provides the IR, PR, and ISR by measure. Except for LEDs, the evaluation found relatively low ISRs for measures included in the kit. Findings from the participant survey confirm that auditors often do not install kit measures during the assessments.

Table 5-5. Measure-Level ISRs

Measure	IR	PR	ISR
LEDs	88.4%	96.3%	85.2%
Low-flow shower head	67.1	90.0%	60.4%
Bathroom faucet aerator	58.2%	95.3%	55.4%
Kitchen faucet aerator			
Outlet seals	51.2%	100.0%	51.2%
Weather stripping	40.8%	100.0%	40.8%
Additional LEDs*	100.0%	96.3%	96.3%

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

To calculate per-participant engineering gross impacts, we multiplied the deemed savings values by measure-level ISRs and the average distributed quantity of each measure included in the kit. Table 5-6 shows the resulting estimated energy and demand savings for each measure included in the kit. In addition to the kit

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measures, the program reported distributing 29,707 additional LEDs to customers through the assessments, an average of 4.4 per household. The estimated energy savings for these additional LEDs is also included in Table 5-6. The lighting portion of the kit and the additional LEDs accounted for approximately 42% of the energy savings for each household. These estimates of energy savings include the ISRs presented in Table 5-5 above.

Table 5-6. Engineering Analysis Gross Impact Results

Measure		April 2016–March 2017			
		Energy Savings (kWh)	Summer Peak Demand (kW)	Winter Peak Demand (kW)	Percent of Total kWh Savings
Energy Efficiency Kit	LEDs (two 9W bulbs)	58.8	0.0087	0.0042	13%
	Low-flow shower head (1)	120.1	0.0051	0.0102	26%
	Bathroom faucet aerator (1)	12.6	0.0012	0.0024	3%
	Kitchen faucet aerator (1)	83.1	0.0041	0.0082	18%
	Outlet seals (package of 6)	4.1	0.0006	0.0019	7%
	Weather stripping (roll of 17 feet)	33.5	0.0140	0.0066	1%
Total kit only		**312.3**	**0.0336**	**0.0335**	**68%**
Additional LEDs (average of 4.4 bulbs)		146.0	0.0216	0.0105	32%
Total per-home estimate		**458.2**	**0.0552**	**0.0440**	**100%**

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

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

	Total Gross Energy Savings (kWh)	Summer Coincident Peak Savings (kW)	Winter Coincident Peak Savings (kW)	Summer Ratio Multiplier (summer demand/energy savings)	Winter Ratio Multiplier (winter demand/energy savings)
Kit only	312.3	0.034	0.034	0.0001077	0.0001074
Kit + additional LEDs	458.2	0.055	0.044	0.0001205	0.0000960

5.2.3 Comparison between Billing Analysis and Engineering Results

We estimated that the program realized per-participant energy savings of 1,095 kWh during the evaluation period. Savings from our engineering analysis (458 kWh per participant) are smaller in comparison to the billing analysis results. Differences in the estimated savings from these analyses are expected, due to differences in methodology and the fact that the engineering analysis addresses only a subset of program savings (i.e., the Energy Efficiency Starter Kit and the additional LEDs that can be included). In contrast, the billing analysis provides a comprehensive estimate of program impacts. In addition to the components addressed by the engineering analysis, the billing analysis includes reduced energy consumption associated with improvements made due to assessment recommendations and behavioral changes. In addition, the billing analysis captures other unobserved factors that might have resulted in additional energy savings among participants.

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6. Net-to-Gross Analysis

6.1 Methodology

Our participant survey included a NTG module to determine both program and measure-level NTGRs. A NTGR represents the portion of the gross energy savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, a NTGR represents the share of tracked savings that are attributable to the program. A NTGR consists of FR and participant SO components.

6.1.1 Free-Ridership

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

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

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

6.1.2 Spillover

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

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

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

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

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

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

Equation 6-1. Spillover Rate

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

6.1.3 Net-to-Gross Ratios

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

Equation 6-2. Net-to-Gross Ratio

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

6.2 Net-to-Gross Results

This section presents our estimates of FR and participant SO, and the resulting NTGRs. Both FR and SO components of the NTGR were derived from self-reported information from telephone interviews with program participants. The final NTGR is the percentage of gross program savings that can be attributed to the program. Table 6-1 shows FR estimates at the measure level and the SO estimate at the program level. Appendix A of this report contains the participant survey instrument, which includes the questions used in our algorithms. Appendix C provides an overview of the FR algorithm. We estimate program FR to equal 24% and program SO to equal 9%. The resulting NTGR for the REA program for the evaluation period is 86%. When applied to engineering gross estimates, the estimated SO rate of 9% represents an average of about 42 kWh per household.

Table 6-1. Measure-Level NTGRs

Component	FR	SO	NTGR
Energy Efficiency Starter Kit*	23.7%	9.2%	85.5%
LEDs**	53.4%		55.8%
Faucet aerators***	13.6%		95.6%
Low-flow shower head	15.3%		93.9%
Outlet seals	13.9%		95.3%
Weather stripping	32.1%		77.1%

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

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6.2.1 Measure-Level Free-Ridership

Based on responses to measure-level FR questions in our participant survey, we calculated FR scores for customers who installed the measure. Table 6-2 shows the FR estimate for each measure, the resulting NTGR (excluding SO) as well as the relative precision, which was calculated around 1 - FR.

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

	LEDs	Faucet Aerators	Low-Flow Shower Head	Outlet Seals	Weather Stripping
Sample size (n=)	102	106	114	73	65
FR estimate	46.6%	86.4%	84.7%	86.1%	67.9%
1 - FR	53.4%	13.6%	15.3%	13.9%	32.1%
Relative precision around 1 – FR (at 90% confidence)	11.4%	4.5%	4.5%	6.0%	9.9%

6.2.2 Spillover Savings

From our participant survey, we collected information on participants who were influenced by the program and installed additional energy-savings measures in their homes and for which they received no incentive or rebate. In all, 27 unique participants qualified for SO out of the survey sample of 150. The total breakdown of SO savings from these participants is shown in Table 6-3. We estimated a SO rate of 9% by taking the total measure-level SO estimates from survey respondents in Table 6-3 (i.e., 6,313 kWh) and dividing it by the total engineering savings from survey respondents (68,730 kWh).[5]

Table 6-3. Engineering Spillover Summary

Measure Type	Quantity of Measure Type	Total Energy Savings (kWh)	Total Coincident Demand Savings (kW)	Source of Savings
LEDs	80	2,756	0.61	Deemed Savings
Shower head (electric water heating)	5	994	0.13	Deemed Savings
Dishwasher	4	527	0.18	Indiana TRM v2.2
Aerator (electric water heating)	6	518	0.09	Deemed Savings
Clothes washer	6	463	0.06	IL TRM V6
Refrigerator	8	402	0.06	IL TRM V6
Smart thermostat	1	247	0.18	Indiana TRM
Windows	18	162	0.24	Indiana TRM v2.2
Freezer	3	113	0.02	Indiana TRM v2.2
Clothes dryer	1	93	0.01	IL TRM V3 v6.0
Attic insulation	1	25	0.02	IL TRM V3 v6.0
Attic tent*	1	14	0.01	NY TRM
Total	**134**	**6,313**	**1.601**	

*Attic tents cover the opening into the attic with an air sealing and insulating barrier. They are sometimes referred to as attach hatch covers.

[5] Total engineering savings of participants is calculated by multiplying the average engineering savings per home (i.e., 458.2 kWh) by the total number of survey participants (i.e., 150). Note that numbers are rounded.

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7. Process Evaluation

7.1 Researchable Questions

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

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

7.2 Methodology

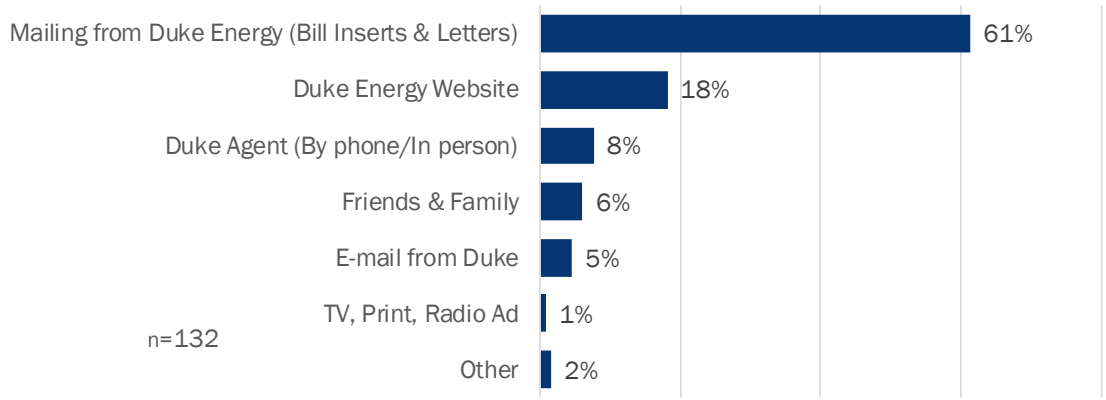
Our process evaluation relied primarily on our interview with program staff, our review of program materials and program-tracking data, and our analysis of the participant survey results. The full survey document is included in Appendix A.

7.3 Key Findings

7.3.1 Marketing and Channeling

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

Figure 7-1. Sources of Program Awareness



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While REA auditors are instructed to inform program participants about other suitable Duke Energy programs for which they might be eligible, only about a quarter of REA participants (23%) recalled learning about other programs during their assessment. Of these participants, the largest share reported hearing about the Residential Smart $aver program (37%), followed by the Home Energy Report (34%) and Power Manager (31%) programs (see Table 7-1). To ensure auditors mention applicable programs, the REA program manager has noted that the implementation team has received additional training in this area around the Spring of 2017.

Table 7-1. Channeling to Other Duke Energy Programs

Which programs did you recall hearing about? (multiple responses accepted) (n=35)	
Smart $aver	37%
Home Energy Report	34%
Power Manager	31%
Solar	9%
Other	17%
Don't know	23%

7.3.2 Satisfaction

Overall, program satisfaction was high across various aspects of the program. Seventy-nine percent of participants said that they were "satisfied" with the program overall. One-third of participants said that they have noticed savings on their Duke Energy bill since participating in the program. However, fewer than half of the participants who said that they were satisfied with the program also noticed savings on their bill. This suggests that satisfaction with the program is not directly tied to noticeable energy savings.

The areas of highest satisfaction relate to the quality and speed of the auditor's work. Professionalism of the auditor was rated a 9.3 out of 10, the length of the assessment was rated 9.0, and the quality of work performed received an average rating of 8.8 (see Figure 7-2). Factors that were rated slightly lower were related to the equipment, the recommendations in the assessments and the scheduling process. Overall, however, all these aspects had a mean satisfaction rating above 8 out of 10 and low levels of dissatisfaction (a rating of 4 or less).

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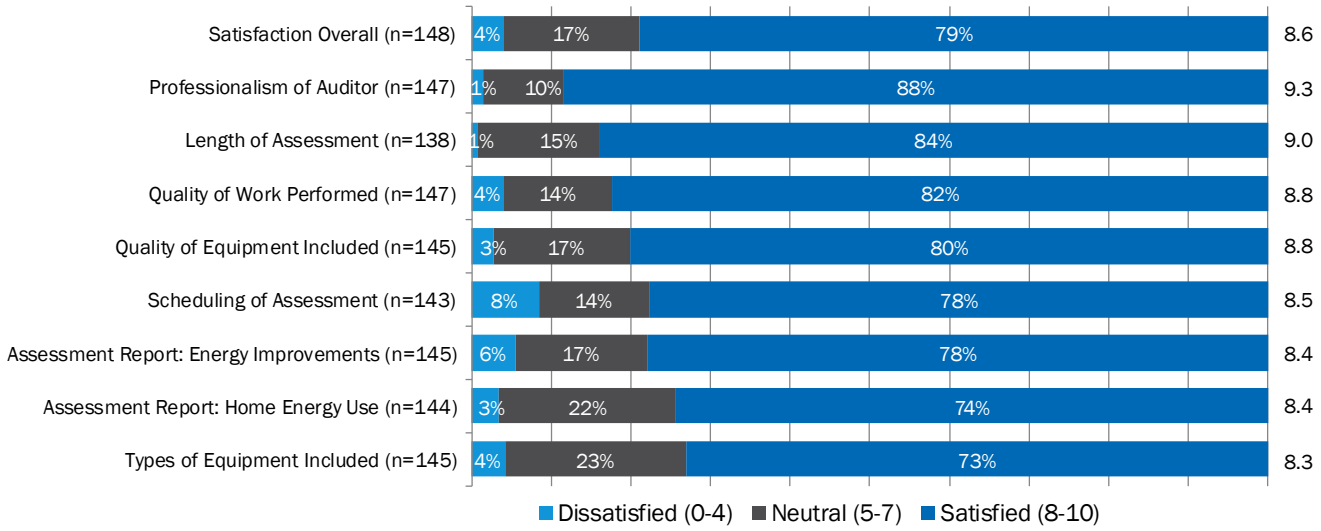
Figure 7-2. Program Satisfaction



7.3.3 Program Value

Understanding customers' motivations for participating can help in developing effective program marketing strategies. Opinion Dynamics asked participants for their reason(s) they participated in the program (Table 7-2). A majority (65%) mentioned saving money on energy bills as a reason for their participation; reducing energy consumption was also cited frequently (40% of participants). Only a small share of participants (9%) cited "it was free" as a reason for participation.

Table 7-2. Reasons for Participating

Why did you choose to participate? (n=150) multiple responses accepted	
Save money on energy/electric/gas bill	65%
Reduce energy consumption	40%
Learn more about home energy use and the program	16%
Make your home more comfortable	13%
It was free	9%
Other	5%
Don't know	2%

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

To assess participants' perception of the value of the REA offerings, the survey asked how much money they would be willing to pay for the energy assessment and for the kit. Participants reported valuing the program components much lower than their actual value. Customers who would be willing to pay for both components of the program (35% of participants) value the assessment and kit at $95.50, which is just over half the stated value ($180) on Duke Energy's website. The average willingness-to-pay for an assessment was $67, based on respondents who would have paid more than $0. Respondents were willing to pay less for the Energy Efficiency Starter Kit, valuing it at nearly $29. The majority of participants found the LEDs most valuable among the kit items (64%); fewer participants found shower heads (28%) and faucet aerators (24%) to be the most valuable measures.

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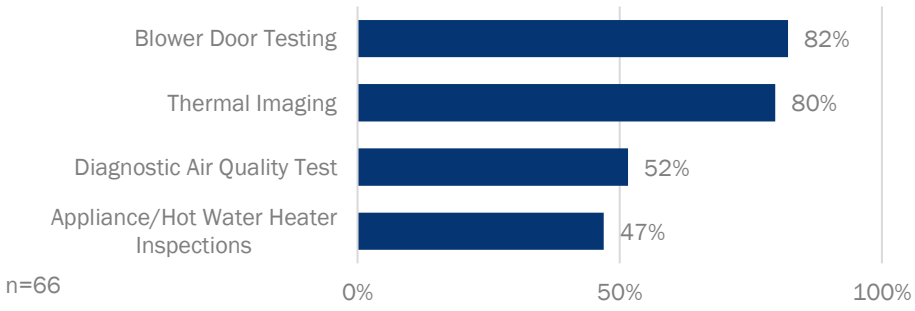
In addition, respondents were asked if they would be willing to pay for additional premium services as part of the energy assessment, including blower door testing, thermal imaging, air quality tests, and appliance inspections. Among the 44% who said that they would be willing to pay for additional audit services, blower door tests were most popular, as seen in Figure 7-3.

Figure 7-3. Additional Assessment Components



7.3.4 Experience with Measures and Program Improvement Suggestions

Respondents who installed some or all of the measures in the energy efficiency kit were asked whether they, the auditor, or both installed each measure. The majority of the installations of LEDs and water measures were performed by the auditor or both, whereas the outlet seals and weather stripping were predominately installed by the customers. The evaluation team believes that the lower installation rates by the auditors contributes to the lower installation rates of outlet seals and weather stripping overall (see Table 7-3). It should be noted that DEP program staff reported that auditors have been given instruction to perform these installations and the proportion of auditor installations has grown since the end of the evaluation period.

Table 7-3. Measure Installations

Measure	IR	Auditor Installed	Customer Installed	Both Installed
LEDs (n=129)	88%	52%	32%	15%
Faucet aerators (n=98)	58%	76%	22%	2%
Shower head (n=100)	67%	64%	34%	N/A
Outlet seals (n=49)	51%	18%	71%	6%
Weather stripping (n=49)	41%	16%	78%	2%

Additionally, respondents who did not install all of the measures in the energy efficiency kit were asked to provide reasons for not installing them. Common reasons varied across the measure types. For LEDs, the majority reported that they were waiting for their current bulbs to burn out to install their new ones (59%), suggesting that they may benefit from additional education about the energy savings benefits of replacing existing bulbs with LEDs. For faucet aerators, the most common response was that the measure did not fit (21%) or that the respondent did not see a need (21%), while for shower heads, the customers did not like the measure (24%) or already had an efficient shower head (24%). Most respondents who had not installed all their weather stripping reported that they did not see a need (30%), whereas for outlet seals respondents noted that they had not had the time to install them yet (30%). See Table 7-4 below for full details of the responses by measure.

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Table 7-4. Common Reasons for Not Installing Measures

Common reasons for not installing	LEDs (n=17)	Faucet Aerators (n=75)	Shower Head (n=50)	Outlet Seals (n=50)	Weather stripping (n=71)
Haven't needed the equipment yet	59%	0%	0%	0%	1%
Did not see a need	0%	21%	2%	12%	30%
Haven't had time	0%	0%	2%	30%	10%
Already have the measure	0%	19%	24%	10%	17%
Did not like the measure	6%	0%	24%	0%	0%
Did not fit	18%	21%	12%	0%	3%
Did not receive enough / Only received one*	0%	20%	10%	10%	10%
Unable to install / Needed assistance	0%	4%	4%	18%	13%
Not enough water pressure	N/A	5%	16%	N/A	N/A
Don't know	18%	9%	6%	20%	11%

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

When asked about additional measures that would be of interest, the majority of participants reported that the kit equipment was sufficient (64%) or that they did not know what other equipment they would have liked in the kit (13%). The list of additional measures that participants reported that they would have liked to receive in addition to those in the kit are listed in Table 7-5.

Participants were also asked to rate their interest in a "Home Energy Score," which uses a 1–10 scale to rate the efficiency of one's home energy usage; 71% said that they were at least somewhat interested in receiving their score.

Table 7-5. Additional Measures

What equipment would you have liked to receive? (n=150)	
More weather stripping/outlet seals	5%
Insulation	4%
Variety of outlet seals	3%
More LED bulbs	2%
Other types of LEDs	1%
Other	8%
Nothing else	64%
Don't know	13%

Consistent with the high satisfaction levels, the majority of respondents (57%) did not have any recommendations to improve the program. Of the 43% who did provide suggestions for improvement, the most common were to include additional measures in the energy efficiency kit, to increase communication and follow-up regarding their assessment, and to increase the quantity of the current measures – all mentioned by less than 10% of respondents (see Table 7-6).

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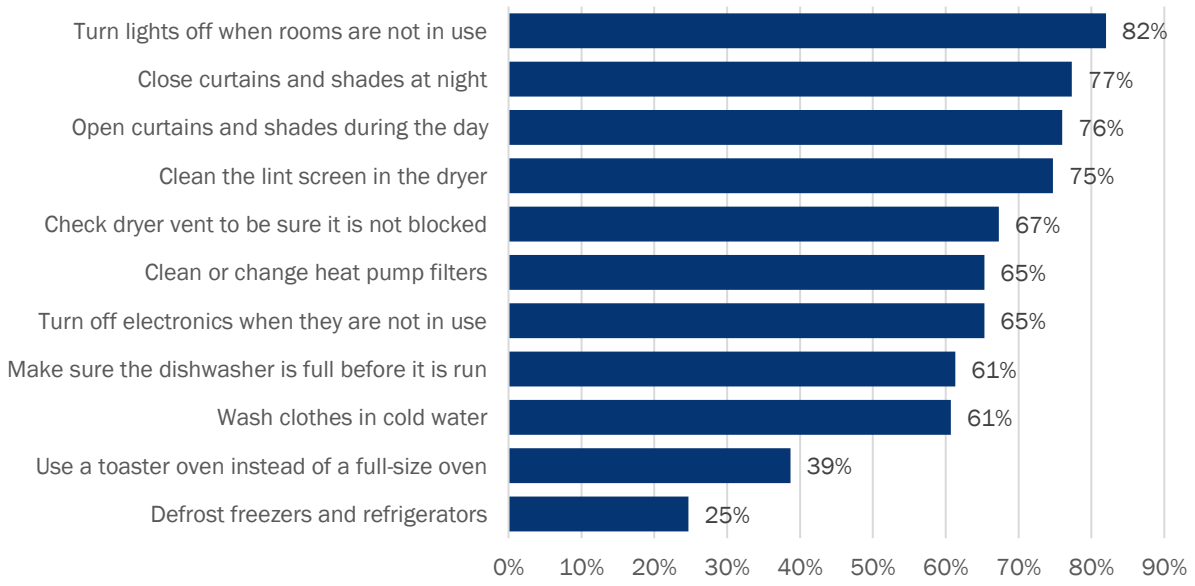
Table 7-6. Suggested Program Improvements

What, if anything, could be done to improve the program? (n=150)	
Add additional measures	9%
Have a pre- or post-audit/follow-up/communicate	7%
Increase current measures	6%
Have auditor install all measures/thorough assessment	5%
Scheduling/timing issues	5%
Offer rebates for repairs	3%
Increase program awareness	2%
Other	6%
Nothing	57%

7.3.5 Education

As part of the Energy Efficiency Starter Kit, customers received a "Department of Energy, Energy Savers Booklet." This educational material outlines how energy is used, and wasted, in the home. The booklet provides insights about the effects that insulation, lighting, appliances, and other items can have on energy use in the home. Most respondents remember receiving the booklet (82%), and 80% of those participants reported taking the time to read it. Included in the booklet is a list of energy-saving tips. All participants were asked about any behavioral changes that they have made since participating and, overall, customers reported high uptake (see Figure 7-4). The only exceptions are two recommendations related to kitchen appliances.

Figure 7-4. Behavioral Changes



7.3.6 Assessment Recommendations

The program-tracking data includes information about specific recommendations on energy efficiency actions provided to DEP REA program participants during the assessment. The telephone survey then asked participants to confirm that they had received the tracked recommendations, which ones they had completed,

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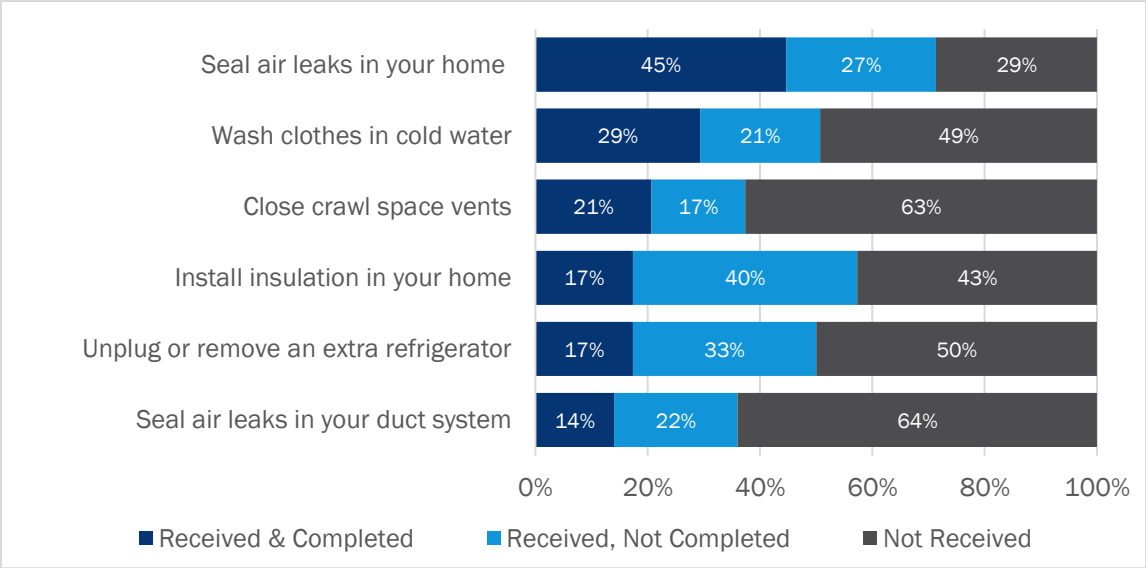
and whether they planned to implement any of those recommendations not yet completed. Note that to reduced survey response burden similar recommendations were grouped into categories for the survey. For example, "seal leaky fireplace", "seal leaky windows", and "seal leaky doors" were all grouped into the category "seal air leaks" in the survey instrument.

Based on the program tracking database, only six categories of recommendations available for auditors to suggest to participants were actually given during the evaluation cycle (shown in Figure 7-5). While there were additional recommendations that auditors had provided through the REA program in other jurisdictions, such as replace or install a heat pump, seal air leaks in duct systems, and turn down water heater temperature, it is not clear why these were not suggested to participants in DEP's jurisdiction. One possible explanation is that they did not think that they were applicable. According to Duke Energy, the program implementer has since received additional training to ensure that all appropriate audit recommendations are provided. In addition, the program refreshed its audit reports in March 2017 to make sure to cover applicable audit recommendations.

The proportion of participants who received and acted on the given recommendations is shown by the dark blue bars in Figure 7-5. The lighter blue bars represent recommendations that were received but not carried out by participants. The grey bars show recommendations not received. Figure 7-5 shows that, on average, recommendations that were given were suggested, on average, just over 50% of the time (the sum of the dark and light blue bars). Among respondents who had not completed any of their recommendations, the majority said that they were currently planning to complete some or all of the remaining recommendations (54%), while the rest either had no plans to complete them (42%) or said that they did not know (4%).

Figure 7-5. Received and Completed Recommendations



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8. Conclusions and Recommendations

The following discussion presents our findings and accompanying recommendations. Note that each finding does not have a recommendation.

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

Finding: Like the REA program that operates in other Duke Energy jurisdictions, not all measures from the Energy Efficiency Starter Kit were installed by auditors. Almost half of the kit measures were not installed by the auditor during the home assessment (weighted average of 52% were installed). However, measures that save more energy, such as LEDs, faucet aerators, and low-flow showerheads were installed more frequently than outlet seals and weather stripping. Of the 50% who did not have their faucet aerators installed, about 20% said it was because they did not fit, and of the 11% of customers who did not have their free LEDs installed, about 60% said they were waiting for their old bulbs to burn out first.

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

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

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

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leave behind applicable materials to market its other programs. Additionally, we recommend that auditors familiarize themselves with Duke Energy's other programs and make recommendations to program participants based on the programs that are most suitable.

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

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

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

Finding: Based on interest from the program team, we asked customers about their desire for "premium" audit services that could be offered in addition to the standard assessment for some price. **We found that customers do have some interest in having the option to pay for certain additional premium audit services, particularly for blower door tests and thermal imaging.**

Recommendation: Consider adding premium audit services, particularly those in which customers have shown an interest. We recommend that DEP consider inquiring with customers about the premium audit services they would consider paying for out of pocket, perhaps through a survey effort with past program participants. It would also be worthwhile to ask customers how much they would be willing to pay for these services to understand how they are valued by program participants.

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9. DSMore Inputs

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

1. We estimated **net savings per additional LED** by multiplying gross savings per additional LED by the LED NTG ratio of 55.8 %.
2. We estimated **net savings of the kit exclusive of additional LEDs** by subtracting net savings for the average number of additional LEDs (4.4 bulbs) from per household savings based on the billing analysis.

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

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

Table 9-1. Development of DSMore Inputs

Data for Development of DSMore Inputs	Energy Savings (kWh)*	Summer Coincident Demand (kW)	Winter Coincident Demand (kW)
Gross savings per additional LED bulb: Engineering analysis	33.19	0.00491	0.00238
LED NTG ratio = 55.8%			
Net savings per LED additional bulb: Engineering analysis	18.52	0.0027	0.0013
Program savings per participant: Billing analysis	1095	0.1313	0.1060
Net Savings for additional LED Bulbs	81.4881	0.0121	0.0058
Net kit savings per participant (excluding additional LEDs)	1013.51	0.1199	0.0992

The DSMore Inputs are included in a separately provided Microsoft Excel file.

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10. Summary Form

Residential Energy Assessments

Completed EM&V Fact Sheet

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

Date	October 12, 2018
Region(s)	Duke Energy Progress
Evaluation Period	April 2016–March 2017
Annual kWh Savings	7,395,630 kWh
Annual kWh Savings (per participant)	1,095 kWh
Coincident kW Impact	0.132 kW (Summer), 0.105 kW (Winter)
Measure Life	Not Evaluated
Net-to-Gross Ratio	85.5%
Process Evaluation	Yes
Previous Evaluation(s)	N/A

Evaluation Methodology

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

Impact Evaluation Details

- Residential customers in DEP service territory who have owned their single-family home for at least four months are eligible for the program. Homes must have an electric water heater, electric heat, or central air conditioning.
- The evaluation team based assumptions and inputs, for deemed savings and gross impacts on the IN TRM V2.2. The engineering analysis applied deemed savings values to measures distributed and in service (e.g., via an Energy Efficiency Starter Kit and additional LEDs).
- Results from the billing analysis reflect savings associated with measures installed, assessment recommendations, SO, and potential behavioral changes from energy efficiency knowledge gained through participation in the REA program.

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Duke Energy Carolinas and Progress

EnergyWise Business Evaluation Report – Final

November 9, 2018

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Contributors

EMI CONSULTING

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1. Evaluation Summary

1.1 Program Summary

The Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) EnergyWise Business (EWB) program is an integrated demand response (DR) and energy efficiency (EE) program that provides small businesses with the opportunity to participate in DR Conservation Period events, earn bill credits, and realize additional energy savings benefits. The program was introduced in 2016 and offers participants either a free programmable, two-way Wi-Fi Thermostat or a Load Control Switch if participants agree to participate in summer Conservation Period events. Participants can select one of three levels of demand response participation—30% cycling, 50% cycling, and 75% cycling—with varying levels of earned bill credits based on the selected cycling strategy. Thermostat participants who have a heat pump with electric resistance heat strips are also offered the option of participating in winter Conservation Period events and can earn additional bill credits per season. Alongside the hardware, participants who install a thermostat also have access to a web-based customer portal via their personal computer, tablet, or mobile phone that allows customers to manage their thermostats remotely, including presets, and advanced control and scheduling options. Duke Energy contracted with Itron (formerly Comverge)[1] to implement this program.

The program targets small businesses with a qualifying central air conditioning system and an average minimum usage of 1,000 kWh per month during the billing months of May through September. By the end of 2017, the program had enrolled a total of 4,561 customers and 8,511 devices. The program called five summer Conservation Period demand response events in 2017 and did not call any winter Conservation Period demand response events.

1.2 Evaluation Objectives

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

- Determine the estimated gross demand response impacts from the program;
- Determine the estimated net energy efficiency impacts from the program;
- Explore how participating customers are interacting with the program, and how satisfied they are; and
- Determine whether any modifications or improvements can be made to program design, program operations, or program equipment/software to reduce customer barriers to enrollment and support increasing enrollment and event participation.

[1] The company Itron acquired Comverge in June 2017. For consistency, this evaluation refers to the implementer as Itron.

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1.3 High-Level Findings

Our impact evaluation assessed program performance in terms of program enrollment and participation, as well as summer Conservation Period demand response impacts and energy efficiency savings. The program overachieved device and thermostat installation goals, but did not meet its per device energy or demand impact goals. Overall, the energy efficiency savings impact analysis found realization rates of 204% for DEC and 5% for DEP; the demand response event analysis found realization rates of 72% for DEC and 70% for DEP.

In 2017, EWB program staff, working in coordination with Itron, enrolled a total of 6,793 devices. The majority of these devices were enrolled in the DEC territory (72% of devices). In terms of devices, the majority of new enrollees selected thermostats (91%), and the majority enrolled in the 30% cycling strategy (84% for DEC and 53% for DEP). Notably, the average size of HVAC units controlled by devices installed in 2017 remained relatively unchanged from 2016, at 4.2 tons,[2] but the DEC program saw enrollment shift towards lower cycling strategies in 2017 compared to 2016.

In terms of gross demand response impacts, the EWB program achieved an average of 2,582 kW per event in DEC and an average of 1,421 kW per event in DEP. Opinion Dynamics conducted a gross demand response analysis to estimate event-specific hourly load impacts for installed devices, by jurisdiction, device type, and cycling strategy. We conducted this analysis using device log data supplied by Itron (which provides device run-time data) in combination with program-tracking data, event data, and weather data. Notably, because the data is at the device level and not the facility level, this analysis produces gross impacts. These gross impacts are not adjusted for participant takeback actions caused by increased temperatures due to central air conditioning (CAC) cycling, such as running fans or increased run-time for refrigeration and/or process cooling equipment.[3]

Despite exceeding enrollment goals, per device demand response load impacts were lower than anticipated across jurisdictions (realization rates of 56% for DEC and 55% for DEP) and cycling strategies. As noted above, device enrollment was heavily distributed towards lower cycling strategies. Device operational rates and opt-out rates were consistent with Itron's expectations for program events (91% of eligible units cycled during an event, and 4% to 7% of devices opt-outed on average per event). Table 1-1 provides average per-unit gross demand response load impacts across all cycling strategies by device type and jurisdiction for all operational devices installed before the end of the 2017 cooling season.

[2] In 2016, the evaluation team found that the tonnage values tracked in the program participation database suggested that Duke Energy's planning values were too high. Duke Energy subsequently lowered their tonnage planning value as a result of the evaluation.

[3] Participant spillover will occur due to takeback actions (see above), likely increasing energy consumption before, during or after an event. Notably, because the data used to conduct this analysis is at the device level (thermostat or switch), this analysis produces gross impacts (e.g., not corrected for participant spillover).

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Table 1-1. Summary of 2017 EWB *Ex Post* Gross Per-Device and Program Demand Response Impacts

DR Load Impact Estimates	Average Reference Load (kW)	Average Load Impact (kW)	Average % of Load
DEC Device Level			
Thermostat	3.28	0.88	27%
Switch	3.07	0.74	24%
Weighted Average	3.27	0.87	27%
DEP Device Level			
Thermostat	2.76	0.80	29%
Switch	2.77	0.65	24%
Weighted Average	2.76	0.79	29%
Program Level[A]			
DEC	9,724	2,582	27%
DEP	4,973	1,421	29%

[A] Reflects per-device load impact multiplied by the average number of devices eligible to participate on an event day and which were cycled (e.g., participated or opted-out) in an event.

For energy efficiency savings, we conducted a consumption analysis using monthly billing data to develop an average energy savings estimate for thermostats enrolled in 2017. The results of this analysis reflect net savings from participation in the EWB program plus any effect of participation in other Duke Energy programs.[4] To estimate net energy savings, we adjusted the billing analysis results using a cross-participation analysis. The purpose of the cross-participation analysis is to determine energy efficiency savings realized by EWB participants as a result of their participation in other Duke Energy non-residential programs. To do so, we identified measures installed through the Non-Residential Prescriptive and Small Business Energy Saver (SBES) Programs, and their savings, during the post-participation period. Once identified, we adjusted billing analysis results by the difference between cross-participation savings of EWB participants and cross-participation savings of the comparison group used in the consumption analysis.[5] This approach accounts for the fact that the consumption analysis already nets out equal cross-participation savings for the comparison group and participants.

Despite overachieving thermostat installation goals across both jurisdictions, per device energy savings realization rates were lower than goals for both jurisdictions. In addition, cross-participation adjustments substantially reduced the program's energy impacts. Table 1-2 provides a summary of the EWB ex post net energy savings in 2017.

[4] This analysis includes a comparison group in the model to adjust for operational changes that non-participating customers are making. Additional changes made by participating customers (within-participant spillover) are captured in the net savings.

[5] Cross-participation savings reflect pro-rated net ex post impacts based on the date of installation.

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Table 1-2. Summary of 2017 EWB *Ex Post* Net Energy Efficiency Savings

Energy Savings Estimates	Unadjusted Energy Savings (kWh)	Cross Participation Adjustment (kWh)	Adjusted Energy Savings (kWh)
Device Level[A]			
DEC	1,060	-549	511
DEP	394	-376	18
Program Level			
DEC	4,759,461	-2,463,014	2,296,448
DEP	677,283	-645,546	31,737

[A] Device-level results reflect all devices enrolled from January 2017-December 2017, including devices that were deactivated.

We identified substantial variation in energy efficiency savings between DEC and DEP: Billing analysis results showed unadjusted energy savings for DEC participants more than 2.5 times those of DEP participants. While the cross-participation analysis found a smaller savings adjustment for DEP participants in absolute terms, it was much higher than for DEC participants as a percentage of unadjusted energy savings. The resulting adjusted energy savings are estimated to be 511 kWh per DEC participant and only 18 kWh per DEP participant.

The evaluation team conducted a series of checks to identify what may be driving lower energy savings in the DEP territory compared to the DEC territory. According to program staff, program design and implementation is relatively consistent across both territories, as are the type of facilities targeted and enrolled in the program. Our analysis found that DEP participants tend to have lower annual average baseline usage and summer average baseline usage than DEC participants, as well as slightly lower average tonnage in terms of the HVAC units being controlled. Other factors, such as customer behavior, e.g., engagement with their thermostat, may play a role. Survey results suggest that DEP customers may change their set points more frequently than DEC customers.

Table 1-3 provides a summary of participation, per-device impacts and total impacts for energy efficiency and demand response impacts.

Table 1-3. Summary of 2017 EWB *Ex Post* Energy Efficiency and Demand Impacts and Realization Rates

Metric	2017 Ex Ante		2017 Ex Post		Realization Rate	
	DEC	DEP	DEC	DEP	DEC	DEP
Demand Response Impacts						
Participation (devices)	2,310	1,414	2,978	1,800	129%	127%
Per Participant Weighted Average Summer Coincident Savings (kW)	1.56	1.44	0.87	0.79	56%	55%
Total Summer Coincident Demand Savings (kW)	3,605	2,035	2,582	1,421	72%	70%
Energy Efficiency Impacts						
Participation (thermostats)	1,755	1,076	4,490	1,719	256%	160%
Per Participant Average Annual kWh	641	562	511	18	80%	3%
Total Energy Savings (kWh)	1,124,522	605,111	2,296,448	31,737	204%	5%

Source: Ex Ante: Duke-provided goals; Ex Post: 2017 evaluation.

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1.4 Evaluation Recommendations

Our recommendations focus on a core set of actionable efforts to increase program impacts while maintaining customer satisfaction, including those related to customer recruitment, education, and retention; program implementation enhancements; device functionality and operations optimization; and data tracking improvements. Notably, we understand that Duke Energy developed this program to provide small business customers an opportunity to participate in demand response, since these customers pay a surcharge but did not have an opportunity to participate in these programs. As a result, recommendations must be considered in light of enhancing program cost-effectiveness as well as equitably serving this historically underserved population.

Recommendation: Customer Recruitment, Education, and Retention

The EWB program staff and their implementation contractors far exceeded enrollment goals in 2017. In fact, recruiters were so successful that the program experienced a backlog in the second half of 2016 where recruited customers had to wait two to three months to have their thermostat or switch installed, instead of the target of four weeks. Building on this success, we recommend that Duke Energy focus on recruiting customers that evaluation results suggest are optimal from a demand response and energy savings impact perspective.

- **Optimize customer recruitment targeting.** Evaluation results from 2016 and 2017 both suggest that the program should seek to recruit customers with specific attributes, such as customers with larger HVAC units and higher monthly usage in summer months. In terms of event participation, several unenrolled participants mentioned that they felt their business segment was not appropriate for event participation. Specifically, unenrolled participants with gyms, massage parlors, and florists report that their business segment do not tolerate large temperature changes. Additionally, a review of event participation data suggests that restaurants tend to have higher opt-out rates than other business types. When examining unenrollment by NAICs code, restaurants are unenrolling at more than double the average rate. We recommend:
  - Continuing to target customers with larger HVAC units and higher average summer consumption.
  - Conducting in-depth upfront vetting customers within specific business types that are less able to accommodate changes in temperature in their facilities to reduce Conservation Period opt-outs, unenrollment, and potentially lower impacts.
- **Enhance customer education for Conservation Period participation.** Our process research found that better participant understanding of program elements is correlated with higher participant satisfaction. Participants report relatively low understanding of cycling levels, and only a quarter of participants could correctly recall their cycling level. In addition, participants who unenrolled from Conservation Periods were less familiar with program elements than on-going participants, which may have contributed to their unenrollment. To minimize participant unenrollment and opt-outs, and increase satisfaction, we recommend:
  - Ensuring canvassers and installers fully explain cycling levels and Conservation Periods, including strategies for minimizing impacts of the events. This could include additional training for canvassers and installers, as well as adjustments to canvassers incentives, as described further below.

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- Developing additional leave-behind materials or welcome email blasts for newly-enrolled program participants. These materials should describe what a customer should expect during Conservation Periods. The materials may also provide suggestions for minimizing the impact of Conservation Periods such as pre-cooling facilities or reducing the use of heat-emitting technologies during Conservation Periods.

- **Encourage customer retention strategies.** The only drop-out prevention strategy noted by participants who unenrolled from the program was the loss of the Conservation Period bill credit. Most interviewed participants who dropped out of the Conservation Periods did so due to discomfort during events. In some cases, the discomfort was exacerbated by issues with their facilities' HVAC systems and building envelopes. We recommend Duke Energy staff:

  - Consider having the program call center employ additional drop-out prevention strategies, such as providing tips for mitigating discomfort during events or helping them understand how to opt out of events.[6] We suggest informing customers about how to opt-out since opting out of some events will yield higher impacts overall than if the customer is to drop out entirely. In addition, the call center might refer customers mentioning issues with their building's HVAC system or building envelope to other Duke Energy programs. While this may not stop a customer from dropping out of the program, it would provide Duke Energy with increased energy savings through the relevant energy efficiency programs.

- **Encourage adoption of, or conversion to, higher cycling strategies.** Enrollment in the lower cycling strategies, especially the 30% strategy, is higher than expected, leading to lower than anticipated per participant impacts.

  - Test options to support converting existing customers to higher cycling strategies. We understand that Duke is already in the process of an analytics project to help identify customers that could use higher cycling strategies. These analytics could help Itron during the installation to assess if customers could increase their cycling strategy, without jeopardizing comfort. An additional option would be to promote higher cycling strategies on the customer portal; especially for customers with higher reference loads. Customers can currently change strategies after they enroll, but according to the program manager, most customers who change after enrollment change to a lower cycling strategy. It should be noted that more aggressive cycling strategy enrollment goals should be balanced with customers' comfort, as we found that higher cycling strategies are tied to more noticeable reductions in comfort, higher opt-out rates, and reduced likelihood of participating in the future.

Recommendation: Program Implementation Enhancements

The program uses a series of marketing channels, including door-to-door marketing ("canvassing"), phone recruitment, email and direct mail, website, and digital marketing. Door-to-door marketing was a successful

[6] Based on information from the program team, assisting customers in changing cycling levels is a retention strategy already employed by the call center.

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strategy in 2017, and program enrollment increased considerably after Duke Energy engaged Threshold Marketing canvassers.

Duke Energy pays Threshold Energy a set fee for every account enrolled in the program. This fee does not vary based on the size or number of HVAC devices that a customer has, or the cycling level chosen. Perhaps as a result, the Threshold program managers describe focusing their efforts on customers where they can likely engage with an on-site decision maker (e.g., "mom and pop" businesses), and described how it was easier and more lucrative for canvassers to enroll customers with fewer HVAC units, since customers with more complex systems required more time to enroll for the same commission. Although engaging willing participants benefits marketing cost-effectiveness and increases participation, these enrollment strategies may not capture the most optimal savings opportunities from an impacts perspective. We recommend:

- **Aligning enrollment incentives with factors known to produce higher impacts to maximize cost-effectiveness.** Threshold's enrollment incentives were not aligned with Duke Energy's goals as they are paid per account regardless of characteristics that affect potential kW and kWh savings (e.g., cycling strategy, number of devices enrolled, baseline usage, or HVAC size). We recommend revisiting how Threshold is compensated by developing a tiered incentive strategy that provides greater compensation for customers with greater savings potential or interest in higher cycling levels. At the same time, customer comfort matters: higher cycling strategies are tied to more noticeable reductions in comfort, higher opt-out rates, and reduced likelihood of participating in the future. Accordingly, any tiered incentive strategy will need to balance recruitment into aggressive cycling strategies with continued support for customer comfort.

- **Considering adjustments to education or incentives to ensure installers offer participants with heat pumps winter Conservation Period participation.** Only half of participants with heat pumps recall installers offering participation in winter Conservation Periods. To increase the number of winter participants, the evaluation team recommends increasing installer education on the benefits of winter participation and on the program goals related to winter participation. The program may also consider adjusting installer incentives for enrolling winter participants.

Recommendation: Device Functionality and Operations Optimization

Our demand response impact analysis identified average percent load impacts that were routinely under the cycling strategy amount. This is consistent with expectations for a duty cycle strategy, as the average run-time of units during non-events is rarely 100%. We also found that energy efficiency savings were lower than anticipated, which may be driven by customer engagement with their set points. We recommend:

- **Incorporating an adaptive cycling strategy for Conservation Period events.** Adaptive cycling replaces the baseline run-time of 100% with an actual run-time percentage during a non-event hot day. For example, in simple 30% duty cycling where the baseline is 100%, event period run-time is limited to 70% (100%-30%). Adaptive cycling, which uses a previous measurement of run-time during hot days for the particular device (e.g., 90%) would limit event period run-time to 63% e.g., 90%* (100%-30%)). This helps to achieve percent run-time reductions closer to the cycling strategy, and it helps customers who may have under- or over- sized units. We understand that Duke Energy will be implementing this approach to cycling for the 2018 Conservation Period events.

- **Implementing strategies to optimize energy efficiency settings for thermostats.** Notably, Duke Energy implemented an "auto-EE" functionality to their customer portal in 2018. This feature assesses the building's thermodynamics and auto-adjusts the set points when the facility is closed to generate additional energy savings compared to customer setpoints. These changes could potentially increase

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the overall energy savings from the thermostats in future program years. We also recommend assessing set points for thermostats to understand programming behavior of installers and customers. Educational materials that help customers optimize their own comfort, while also yielding bill savings, may help customers achieve higher energy savings associated with their devices.

Recommendation: Data Tracking

- **Enhance data tracking across Duke Energy program participation databases, customer billing data, and AMI data, as well as with Itron device log data.** Throughout this evaluation, we encountered a number of data issues that limited our ability to execute the planned analyses and increased evaluation cost and time frames. For example, the original evaluation plan sought to assess net demand impacts using AMI data. However, the DEP AMI data had substantial data availability issues as well as quality issues in terms of anomalous load shapes, necessitating incorporating device log data for the impact analysis. In particular, the load shapes within the available AMI data (based on graphical review) were not consistent with expected AC load shapes, and the amount of AMI data was insufficient to fully represent the population of participants. We offer the following set of recommended data tracking enhancements:

  - Develop an identical set of unique identifiers across datasets and include Account ID and Source Account ID and Source Service Point ID in every dataset. If an identical set of unique identifiers is unavailable due to the data existing in different systems, consider developing a crosswalk that links Source Service Point ID and Service Point ID. Currently, Duke Energy program data tracks participation at the Account level, while the vendor tracks participation at the Source Service Point Level. In addition, for DEP consumption data, provide an identifier that links Meter Number to Source Service Point ID and Account Number. This can support effective identification of the meter associated with a device installation.

  - Track changes in cycling strategies across time rather than replacing the strategies with the latest enrollment status. This will allow us to correctly classify participants by cycling level for each event, even if their cycling level or status changed. For example, a participant who participated with a 30% cycling strategy in July events but then changed their cycling strategy in September would be tracked as at the latest cycling strategy. Since the tracking data currently does not reflect the original cycling strategy and when it changed, we cannot accurately analyze the impacts of a past event.

  - Differentiate between unenrollment date and deactivation/removal date in the program-tracking data. Currently, the Duke Energy program-tracking data records two dates for each measure, start date (start_dt) and end date (end_dt). The start date corresponds to the installation date in Itron's data, while and the end date can correspond to either the unenrollment date or the removal date in Itron's data. The distinction between the two end dates in the Itron data is important because unenrolled devices can still achieve energy savings while removed devices achieve neither energy nor demand response savings.

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2. Program Description

2.1 Program Design

The DEC and DEP EWB program is an integrated demand response (DR) and energy efficiency (EE) program that provides small businesses with the opportunity to participate in Conservation Period events, earn bill credits, and realize additional EE benefits. The program was introduced in 2016 and offers participants either a free programmable two-way Wi-Fi Thermostat or a Load Control Switch if participants agree to participate in summer Conservation Period events. Alongside the hardware, participants who install a thermostat also have access to a web-based customer portal via their personal computer, tablet, or mobile phone that allows customers to manage their thermostats remotely, including presets, advanced control and scheduling options. Participants can select one of three levels of DR participation—30% cycling, 50% cycling, and 75% cycling—with varying levels of earned bill credits based on the selected cycling strategy. Thermostat participants who have a heat pump with electric resistance heat strips are also offered the option of participating in winter Conservation Period events and can earn additional bill credits per season.

Duke Energy designed the program primarily for its demand response benefits. Specifically, the utility wants to provide small business customers with an opportunity to participate in a DR program, since these customers had previously been paying a DR rider without having an opportunity to participate in a program. The energy efficiency savings from the program are an added benefit that is secondary to the demand response savings. The program targets small businesses with a qualifying central air conditioning system and a minimum usage of 1,000 kWh per month during the billing months of May through September.

The program was first implemented by Itron in the DEC and DEP territories in 2016. While Itron is the primary implementer in charge of installing thermostats and calling Conservation Period events, Duke Energy has contracted with two other firms--Lime Energy and Threshold Marketing--to help recruit participants.

The program uses a series of marketing channels, including door-to-door marketing, phone recruitment, email and direct mail, website, and digital marketing. Of these, the most successful channel has been door-to-door recruitment. The program initially engaged Lime Energy to recruit participants as part of their larger contract to implement Duke Energy's Small Business Energy Saver (SBES) program. Specifically, Lime Energy tried to identify potential participants from the pool of SBES program participants. Then, in June 2016, the program engaged Threshold Marketing to help with recruiting efforts. Threshold Marketing canvassers go door-to-door using lists of eligible customers to recruit participants. Representatives from both Lime Energy and Threshold Marketing confirm the eligibility of interested customers, enroll them in the program, and schedule a time for the thermostat or switch installation. As part of this process, canvassers help customers choose their cycling level. When customers learn about the program through a channel other than a canvasser, such as the website or email, these customers enroll online or via phone.

After a customer has enrolled in the program, Itron installers install the thermostat and/or switch during a scheduled installation appointment. Itron installers program the thermostat(s) based on the customer's

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requested schedule, ensure the thermostat is connected to the customer's Wi-Fi network, set up the customer's program web portal account, and train the customer in how to use the thermostat and portal.[7]

Summer events are called on weekdays between May and September when average temperature criteria are met and a high system peak is projected. The events are used to help Duke Energy manage system peak. According to the filings, the control period under the Summer Control option may be up to four hours each day an event is called. Interruption of cooling equipment for cycling purposes is limited to a total of no greater than 40 hours during any one summer season. Winter events can be called between November and March. For customers selecting the Winter Control option, Duke Energy can, at its discretion, interrupt service to the resistance heating elements associated with each electric heat pump unit for up to four hours each day an event is called. Resistance heating element interruptions are also limited to a total of no greater than 40 hours during any one winter season. Duke Energy decides when to call an event and Itron is responsible for implementing the event. Each time an event is scheduled, participants are notified via email. Participants who received a thermostat are also notified through a light on the thermostat and through the web portal. During the event, the devices display a message that an event is in progress. Participants can opt out of events at any time before or during the event.

Customers receive a bill credit for each enrolled HVAC unit with an installed device in each year that they participate in Conservation Period events. The summer DR credits are tied to cycling level, with credits of $50 for 30% cycling, $85 for 50% cycling, and $135 for 75% cycling. In addition, participating customers receive $25 each year they participate in winter Conservation Period events. Customers can opt out of up to two events each year and still receive their bill credit.[8]

2.2 Program Implementation

Based on program staff interviews and program data review, the evaluation team found that the 2017 program implementation was being executed smoothly. Program participation exceeded targets and the program successfully called multiple events during the summer Conservation Period, however, no winter Conservation Period events were called. Duke Energy was happy with the various vendors implementing the program and the vendors described being well-supported by Duke Energy. To illustrate program success, one of the main challenges mentioned was that Itron could not hire fast enough to support demand for the device installation after Threshold Marketing was enlisted and program enrollment increased quickly. The program staff described internal process improvements that helped address some of the early challenges identified during the program's rollout in 2016.[9] The remainder of this section outlines the highlights the most interesting elements of how the program has been implemented.

[7] These activities apply to thermostats only; they do not apply to switches.

[8] Bill credits are paid after customers enroll, so customers that opt out of more than two events are forfeiting the credit on the following year's bill cycle.

[9] These were primarily technical issues related to optimizing program implementation, such as processes for ensuring all of a participant's accounts were enrolled, associating multiple accounts with a single participant log-in, allowing canvassers to enroll participants directly, etc. The program team was able to identify and implement changes to address these challenges early in the program rollout.

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Program enrollment increased considerably after Duke Energy engaged Threshold Marketing to help recruit potential participants. While Lime Energy canvassers had competing priorities with completing lighting and refrigeration measures through Duke Energy's SBES program while discussing EWB with customers, Threshold Marketing canvassers were focused solely on promoting EWB. At the end of 2017, Duke Energy reported that approximately 16% of customers approached by a canvasser agreed to participate in the program. Because of Threshold Marketing's success in recruiting customers, the program experienced a backlog in the second half of 2016, where customers had been recruited and had to wait two to three months to have their thermostat or switch installed, instead of the target of four weeks. In response, the program stopped other forms of marketing and Itron hired more installers to handle the influx of new participants.

Although participation has exceeded expectations, participant characteristics differ from what was expected (see Section 5.1, Participation Analysis). For example, Threshold Marketing has found that thermostats have been more popular than expected. As a result, canvassers typically use the benefits of the smart thermostats to sell the program, before describing the Conservation Period events and bill credits. According to the program manager, this has been a positive development, since the thermostats provide Duke Energy with energy savings in addition to the DR impacts, and because the thermostats cost less than the switches. Participants are also installing more devices per business than assumed (an average of 1.8 devices compared to 1.3[10]). At the same time, however, customers are choosing lower cycling levels and the HVAC equipment on which devices are installed is smaller than anticipated. While the higher number of devices per participant has decreased the marketing cost per device enrolled, the combined effect of lower cycling levels and smaller equipment likely reduces savings and therefore increases the program's cost per kW.

Duke Energy pays Threshold Marketing a fixed fee for every account enrolled in the program. This fee does not vary based on the size or number of HVAC devices or control equipment that a customer has, nor the cycling level chosen. Perhaps as a result, the Threshold Marketing program managers describe focusing their efforts on customers where they are most likely to engage decision makers. As a result, revising the incentive structure to provide tiered incentives based on cycling strategy may support enrollment of higher potential customers.

Once a customer has enrolled in the program, Itron installers arrive during the scheduled time window to install the device. At this point, about 20% of enrolled customers "turn down" the program, or do not go through with the program installation. At the time the evaluation team talked to program staff, there was no reliable data on how many of these customers went on to reschedule a different time to have their thermostat or switch installed versus how many declined to participate in the program. However, Itron was planning on collecting this data in the future to be able to better track customer turn downs. Their understanding was that the most common reasons that customers turned down the program (without rescheduling) were that there were issues with Wi-Fi networks or HVAC equipment not working that precluded the customer from participating. While some customers with HVAC equipment issues install the switch instead, many will fix their HVAC systems, so they can participate. Itron took multiple steps to decrease the turn down rate. Itron also made efforts to make their installations more efficient, to help address the backlog of customers waiting for their installation caused by the increase in enrollment after Threshold Marketing started canvassing. First, installers started bringing Wi-Fi signal detectors and starting installation with the furthest away thermostat, to identify Wi-Fi network issues quickly. Second, installers started bringing Wi-Fi extenders to help address Wi-Fi coverage issues. The

[10] From Duke Energy Stage 2 – Evaluation Screening for: Small Business Demand Response PowerPoint, slide 27.

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Itron program managers thought that the canvassers were doing everything that they could to screen out customers that have incompatible equipment and did not think there was a problem with canvassers not fully vetting customers' eligibility.

There are no differences in how the program is implemented in the DEC and DEP service territories. However, since each canvasser and installer focuses on a geographic region, different staff implement the program in the two territories. For example, a single canvasser was responsible for approximately 30% of all new DEC participant registrations during the 2017 program year. According to program staff, this canvasser registered most or all of their new participants at the 30% cycling level, and thus, skewed all DEC participants towards a 30% cycling level. In addition, the time between enrollment and installation varied by region, based on the number of canvassers and installers available.

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3. Key Research Objectives

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

- Determine the estimated gross demand response impacts from the program;
- Determine the estimated net energy efficiency impacts from the program;
- Explore how participating customers are interacting with the program, and how satisfied they are;
- Determine whether any modifications or improvements can be made to program design (including eligibility requirements or incentive structures), program operations, or program equipment/software to reduce customer barriers to enrollment and support increasing enrollment and event participation.

In addition to the above objectives, the evaluation plan included the following objectives, which were not addressed in this evaluation:

- Winter demand response events: The demand analysis did not include winter events as no winter events were called in 2017.
- Use of AMI data: For the summer demand response analysis, we used telemetry data rather than AMI data. As a result, we conducted the analysis on the population of devices with data, rather than a sample of AMI data. This change was made due to the limited availability and poor quality of the AMI data. This results in gross demand response impacts, rather than net impacts.
- Demand response forecast models: The evaluation did not develop forecast models for DR impact prediction based on peak standard weather due to changes in evaluation priorities.

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

- What are customers' motivations for enrolling in the program?
- To what extent do implementation staff fully and accurately explain the program to customers? Are there questions that customers have that are not being fully addressed?
- Do customers understand how to use their smart thermostat? Is program training on how to use the thermostat sufficient?
- Do customers understand how to access and interpret information in the program portal?
- Are program implementers offering the winter demand response control option to all customers with electric heat pumps?
- What barriers do customers have that prevent them from enrolling in the program? Why do customers approached by implementers Lime Energy and Threshold Marketing decide not to participate? How could Duke Energy help customers overcome these barriers?
- Are there barriers that prevent customers who enroll in the program from participating in demand response events?
- Why do customers choose to unenroll from the demand response portion of the EWB Program?
- How satisfied are participants with various program elements and the program overall?

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- What were customers' experiences during Conservation Periods? Have there been any aspects of their event experience that will influence their willingness to participate in future events?

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4. Overview of Evaluation Activities

To address the evaluation research objectives and questions, the evaluation team performed a range of data collection and analytical activities. Table 4-1 provides a summary of evaluation activities and associated areas of inquiry. Following the table, we provide detail on each activity's scope, sampling approach (if applicable), and timing.

Table 4-1. Overview of Evaluation Research Activities

#	Evaluation Activity	Impact	Process	Purpose of Activity
1	Program Staff Interviews		X	▪ Provide insight into program design and delivery ▪ Support process assessment
2	Materials Review	X	X	▪ Provide insight into program design and delivery ▪ Inform planning savings assumptions
3	Early Participant Interviews		X	▪ Identify topics related to participants' experience to explore further through participant survey ▪ Identify and provide early feedback on any issues associated with the program rollout
4	Participant Survey		X	▪ Assess participants' motivations and barriers to participation, experiences with program thermostats and demand responses events, and satisfaction with the program
5	Non-Participant and Un-Enrolled Participant Interviews		X	▪ Understand why customers approached about the program decline to participate ▪ Understand why previously-enrolled customers stop participating in demand response events
6	Participation Analysis	X	X	▪ Provide overall installation count by cycling strategy, jurisdiction, and other features of interest
7	Gross Demand Response Impact Analysis	X		▪ Calculate gross load impacts associated with the five summer Conservation Period events called in 2017
8	Net Energy Savings Impact Analysis	X		▪ Calculate net energy savings impacts associated with thermostats installed in 2017

4.1 Program Staff Interviews

In February and March 2017, the evaluation team completed seven interviews with program staff at Duke Energy and program implementers. In addition to the Duke Energy program manager, the evaluation team talked to program managers and supervisor from Itron (three interviews), Threshold Marketing (two interviews), and Lime Energy (one interview). The interviews explored program design and implementation, program performance, incentivized demand response event specifications, and tracking and communication processes, among other topics. To supplement these interviews, Duke Energy also provided the evaluation team with a demonstration of the program portal.

4.2 Program Materials Review

In support of the impact and process evaluations, the evaluation team reviewed program materials and data, including marketing materials, program plans, training materials, enrollment forms, past research studies. This information informed our research design, provided insight into program design and delivery, and supported the assessment of program impacts.

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4.3 Customer Interviews

4.3.1 Early Participant In-Depth Interviews

In preparation for survey design, the evaluation team completed 10 in-depth interviews with early participants (who participated before October 2016).[11] The goals of these interviews were to (1) provide program staff with early feedback about the program roll out and first demand response events and (2) help identify key issues to explore through the larger participant survey effort. Respondents were offered a $25 incentive for completing the interview. The evaluation team conducted a purposive sample of 10 participants based on a review of program-tracking data and interviews with program staff. Program staff indicated interest in the customer experience differences between those customers recruited by Lime Energy versus those recruited by Threshold Marketing. To explore these differences, the evaluation team interviewed five early participants recruited by each contractor for a total of 10 interviews. The interviews were completed between April 25 and May 4, 2017.

4.3.2 Participant Survey

Sample Design and Fielding

The evaluation team fielded an online survey of program participants. As the population of participants was small (2,811 unique 2017 enrolled participants at the time of the survey data request in August 2017), the evaluation team attempted a census of all program participants with a valid email address. Survey participants were offered a $25 incentive to complete the survey. The evaluation team fielded the survey on September 13, 2017, and closed the survey after receiving 242 completes, far exceeding the target of 200 completes. The portion of DEC and DEP respondents was slightly different from the population (Table 4-2).

Table 4-2. Comparison of Participant Survey Respondents to the Program Population

Utility	Percent of Survey Respondents (n=242)	Percent of Population (N=2,811)
DEC	74%	66%
DEP	26%	34%

Note: Population reflects unique customers at the time of survey fielding.

Survey Disposition and Response Rate

The survey response rate was 16.9% for DEC and 17.6% for DEP (Table 4-3). As a census of all program participants was attempted, the evaluation team did not calculate confidence and precision.

[11] Because there was no process evaluation of the 2016 program, the 2017 evaluation included early interviews with participants to provide Duke Energy with advance feedback on any potential issues with the program rollout. These interviews included early 2016 participants to represent customers recruited by Lime Energy, and thereby gather data to assess whether there were meaningful differences between customers recruited by Lime Energy versus Threshold Marketing.

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Table 4-3. Participant Survey Response Rate

Disposition	DEC	DEP	Overall
Response Rate (AAPOR RR3)	16.9%	17.6%	17.1%

To develop the sample, we first removed duplicate emails across premises and business with multiple projects. Of all the accounts in the program tracking data, about 50% represented a unique email address of a customer actively enrolled in the program and were included in the survey (1,065 DEC and 353 DEP). Table 4-4 presents the survey dispositions.

Table 4-4. Participant Survey Dispositions

Disposition	DEC	DEP
Complete	180	62
Partial Complete	11	6
Terminate Before Screening Questions	84	36
Refusal	7	2
No Response	783	247
Total	1,065	353

4.3.3 Non-Participant and Unenrolled Participant Interviews

The evaluation team conducted in-depth interviews with 10 "non-participants," defined as customers approached about the program that have decided not to participate, and 10 "unenrolled participants," defined as customers who enrolled in the program but later decided to no longer participate in Conservation Periods (Table 4-5). The evaluation team attempted a census of all unenrolled participants, as well as all non-participant customers tracked in the program database who had declined to participate in the program and did not have valid reason listed (i.e., already had smart thermostat or did not qualify). Both groups were offered a $25 incentive upon completion of the interview. Interviews were completed between July 21 and October 10, 2017.

Table 4-5. Completes and Sample Size

Group	Completes	Sample
Non-participants	10	980
Unenrolled participants	10	100

4.4 Participation Analysis

As part of our evaluation, we summarized program enrollment and demand response event participation based on program-tracking data. As part of these analyses, we reviewed the Duke Energy and Itron program participation databases to determine the total number of enrolled devices and participants, the type of devices installed, the selected cycling strategies, as well as installation dates. In addition, we reviewed thermostat and switch log data to determine device operability and opt-out rates. Notably, different analyses use different subsets of participants, outlined in greater detail in Section 5.

4.5 Gross Demand Response Impact Analysis

Opinion Dynamics conducted a gross demand response analysis to estimate event specific hourly load impacts for installed devices, by jurisdiction, device type, and cycling strategy. We conducted this analysis using device

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log data supplied by Itron (which provides device run-time data) in combination with program-tracking data, event data, and weather data from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information.

To estimate impacts, we first cleaned device log data. We then developed a counterfactual for what would have occurred on a non-event day in the absence of the demand response event by identifying similar non-event days (in terms of weather, day of week, and other variables). Using these proxy non-event days, we used linear regression models to estimate changes in run-time during events. The actual run-time during the event is compared to the estimated counterfactual to establish hourly impacts. We then converted run-time impacts to load impacts by applying the full load estimate (HVAC capacity divided by SEER) from program-tracking data. We used the cleaned log data and program-tracking data to determine device operational rates and opt-out rates for each event, and applied the average per-device impacts for each event to the number of operational devices. We used the average of these values across the five events to calculate net realization rates against ex ante goals. A summary of the approach is provided in Section 5.2.

4.6 Net Energy Savings Impact Analysis

Opinion Dynamics conducted a consumption analysis and a cross-participation analysis to estimate net energy savings impacts for thermostats installed in 2017. We conducted the consumption analysis using customer billing data, program participation data and weather data. We used a linear fixed effects regression (LFER) model, which controls for all facility factors that do not vary over time using the individual constant terms in the equation. The consumption analysis used a comparison group matched on pre-period energy consumption patterns.

Our team also conducted a cross-participation analysis. The purpose of the analysis was to adjust consumption analysis results for energy savings as a result of participation in other Duke Energy non-residential programs. To do so, we identified measures installed through the Non-Residential Prescriptive and SBES Programs, and their savings, during the post-participation period. Savings reflect pro-rated net ex post impacts based on the date of installation. Once identified, we removed the difference between cross-participation savings of EWB participants relative to the comparison group. This accounts for the fact that the consumption analysis already nets out equal cross-participation savings for the comparison group and participants.

To calculate total energy savings impacts, our team applied per-device impacts to the total number of thermostats enrolled in 2017. We used this value to calculate net realization rates against ex ante goals. A summary of the approach is provided in Section 5.1.

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5. Impact Evaluation

Our impact evaluation included three main research efforts: a participation analysis, a gross demand response impact analysis, and a net energy savings impact analysis. The following subsections describe our approach and the results for each of these research efforts.

5.1 Participation Analysis

As part of our evaluation, we summarized program enrollment and event participation based on program-tracking data. Notably, different analyses use different subsets of participants, as summarized in Table 5-1, and further described in the subsections below.

Table 5-1. Summary of Participation Counts for 2017 Impact Analyses

Participation Type	Description	DEC	DEP
2017 Program Enrollment	Count of all devices (switches and thermostats) installed in 2017 and not deactivated.	4,878	1,915
Demand Response	Count of all devices (switches and thermostats) installed as of the end of the 2017 summer Conservation Period events (program launch to September 30, 2017) that were eligible to participate during an event (i.e., active, enrolled devices with a known cycling strategy), were operational and could be cycled during each 2017 Conservation Period.	2,978	1,800
Energy Savings	Count of *premises with thermostats* installed in 2017, including deactivated devices.	4,490	1,719
Cumulative Program Enrollment	Count of all *devices* (switches and thermostats) installed from program initiation through December 31, 2017 and not deactivated.	5,876	2,635

5.1.1 2017 Program Enrollment

According to information provided by Duke Energy, anticipated participation in the program was 1,848 devices for DEC and 1,132 devices for DEP, for a total of 2,980 devices.

Review of the program-tracking data indicated that, during 2017, the program achieved a total enrollment of 4,878 devices in the DEC service territory (264% of goal) and 1,915 devices in the DEP service territory (169% of goal), for a total of 6,793 devices across both territories. Consistent with 2016, the program-tracking data showed that thermostats were more popular than expected. Nearly all new customers chose the thermostat (91% of installed devices) over the switch (9% of installed devices). Process analysis indicated that most customers with switches had been interested in a thermostat but had an issue with their HVAC unit not being compatible, and thus could only participate using a switch. Table 5-2 provides projected and actual program enrollment in 2017, by jurisdiction and device type.

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Table 5-2. 2017 Projected and Achieved EWB Device Enrollment

Jurisdiction	Device Type	# Projected	# Achieved	% Achieved
DEC	Thermostat	1,755	4,490	256%
	Switch	92	388	420%
	Total	**1,848**	**4,878**	**264%**
DEP	Thermostat	1,076	1,719	160%
	Switch	57	196	346%
	Total	**1,132**	**1,915**	**169%**

Note: Reflects devices enrolled from January 1, 2017—December 31, 2017 excluding deactivated devices.

To develop expected savings from Conservation Period events, the program assumed 50% enrollment in the 30% cycling strategy, 30% enrollment in the 50% cycling strategy, and 20% enrollment in the 75% cycling strategy. DEP participant uptake was relatively consistent with these assumptions, but DEC participant uptake tended more heavily towards lower cycling strategies (see Table 5-3). Everything else being equal, a lower cycling strategy will generate lower DR savings. To realize expected demand response load impacts, the program may therefore need to more strongly promote the higher cycling strategies, particularly among DEC customers.

Table 5-3. 2017 Projected and Achieved Enrollment Cycling Strategy Distribution of Cycling Strategies

Jurisdiction	Projected[A]	Achieved[B]
30% Cycling Strategy		
DEC	50%	84%
DEP		53%
50% Cycling Strategy		
DEC	30%	12%
DEP		25%
75% Cycling Strategy		
DEC	20%	5%
DEP		22%

[A] Projected enrollment assumptions based on 8/18/2014 PowerPoint presentation, entitled "Small Business Demand Response – Evaluation Gate Presentation".
[B] Device counts reflect devices installed from January 2017–December 2017 excluding deactivated devices.

Compared to 2016, DEC enrollment in 2017 shifted towards lower cycling strategies while DEP enrollment shifted towards the 75% cycling strategy (see Table 5-4).

Table 5-4. Comparison of 2016 and 2017 EWB Cycling Strategies Enrollment Distribution

Jurisdiction	2016	2017
DEC		
30%	56%	84%
50%	25%	12%
75%	19%	5%
DEP		
30%	65%	53%

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Jurisdiction	2016	2017
50%	25%	25%
75%	10%	22%

We also assessed whether average size and efficiency of units changed from 2016 to 2017, reflecting an attempt by the program to target facilities with larger HVAC units. In our 2016 evaluation, we found that ex ante per-unit savings assumptions were considerably higher than ex post impacts, mostly due to an overestimate of the size (tonnage) of the controlled air conditioning units. Since equipment size is directly correlated with savings, the smaller-than-expected controlled units significantly affected realized energy efficiency and DR impacts. Our review of 2017 participation data showed that the average size of units was virtually identical in 2016 and 2017 (Table 5-5).

Table 5-5. Comparison of 2016 and 2017 EWB Average HVAC Size and Efficiency

Jurisdiction	Average SEER Value		Average Tonnage Value		Average Tonnage/SEER Value	
	2016	2017[A]	2016	2017	2016	2017
DEC	11.2	11.2	4.41	4.35	0.394	0.388
DEP	11.8	11.8	4.08	4.01	0.364	0.340

A: 2017 SEER values were based on 2016 participants, as this data was not available in the 2017 participant data.

5.1.2 Energy and Demand Impacts Participation

As noted earlier, this evaluation used different participation counts to estimate energy efficiency impacts and demand response load impacts (Table 5-6). Energy efficiency savings reflect thermostats installed in 2017 (4,490 devices in DEC service territory and 1,719 devices in DEP service territory). We report participation in 2017 Conservation Period events in terms of the average number of devices that were operational and could be cycled during each 2017 Conservation Period. Therefore, demand response load impacts from Conservation Period events reflect a device-weighted average of operational devices cycled during each 2017 Conservation Period event (2,978 devices in DEC service territory and 1,800 devices in DEP service territory).

Table 5-6. Devices Included in 2017 Energy Efficiency and Demand Response Impacts Analysis

Jurisdiction and Cycling Strategy	2017 Thermostat Installations (EE Impacts)	2017 Conservation Period Devices (DR Impacts)		
		Thermostat	Switch	Total
DEC				
30%	4,490	2,141	143	2,285
50%		406	41	447
75%		234	12	246
Jurisdiction Total		2,781	196	2,978
DEP				
30%	1,719	1,020	99	1,119
50%		413	32	445
75%		223	12	236
Jurisdiction Total		1,656	143	1,800

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5.1.3 Cumulative Program Enrollment

Based on the program-tracking database, the program installed a cumulative total of 8,511 devices as of the end of 2017, associated with 4,561 unique customer premises. As with the new 2017 enrollees, customers to date have overwhelmingly opted for smart thermostats (92%) over load control switches (8%). The 30% cycling strategy is the most popular among customers, with 79% of DEC and 58% of DEP devices enrolled into that cycling level. Only 14% of DEC and 23% of DEP devices were enrolled in the 50% cycling strategy and 7% of DEC and 17% of DEP devices enrolled in the 75% cycling strategy. As of December 2017, 218 devices were deactivated (e.g., removed the device), and 343 devices were un-enrolled (e.g., customers who opted out of participating in all Conservation Period events and are listed as 0% cycling).

Table 5-7 provides the distribution of device types and cycling strategies enrolled in the program since inception (2015) through December 31, 2017. Notably, cumulative installed devices suggest that there is an increased potential for Conservation Period summer event participation in 2018, compared to 2017 summer events. Substantial enrollment after the summer 2017 Conservation Period drives this increased potential.

Table 5-7. 2015 – 2017 Enrolled EWB Devices, by Jurisdiction, Type, and Cycling Strategy

Jurisdiction and Cycling Strategy	Number of Devices			Percentage of Total Devices in Jurisdiction		
	Thermostat	Switch	Total	Thermostat	Switch	Total
DEC						
30%	4,316	300	4,616	79%	69%	79%
50%	707	96	803	13%	22%	14%
75%	397	35	432	7%	8%	7%
Multiple/Unknown	24	1	25	0%	0%	0%
Jurisdiction Total	5,444	432	5,876	100%	100%	100%
DEP						
30%	1,377	140	1,517	57%	62%	58%
50%	577	32	609	24%	14%	23%
75%	428	25	453	18%	11%	17%
Multiple/Unknown	26	30	56	1%	13%	2%
Jurisdiction Total	2,408	227	2,635	100%	100%	100%

Note: Device counts reflect all devices from 2015 through December 2017, excluding devices that were deactivated (e.g., removed).

Table 5-8 summarizes device enrollment by the various program design features, such as device type (e.g., thermostat and switch), the choice of cycling strategy, enrollment in summer and/or winter events, one or more locations participating in the program, and others. Note that enrollment is very low for both summer and winter Conservation Period events compared to summer Conservation Period events alone. This is because thermostat customers must have a heat pump and electric resistance heat strips to be eligible to participate in winter events. By participating in the winter events, the program has 100% control of the electric resistance heating elements during the Conservation Period event.

Table 5-8. 2015—2017 EWB Device Enrollment by Program Design Features

Program Design Feature	DEC Devices (n=5,876)[A]	DEP Devices (n=2,635)[A]
Device Type		
Thermostat	93%	91%
Switch	7%	9%

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Program Design Feature	DEC Devices (n=5,876)[A]	DEP Devices (n=2,635)[A]
Cycling Levels		
30%	79%	58%
50%	14%	23%
75%	7%	17%
Multiple/Unknown[B]	0%	2%
Summer and Winter Participants		
Summer Only	89%	91%
Summer and Winter	9%	6%
Unknown[B]	2%	3%
Number of Locations Participating in the Program		
One	98%	96%
Two or More	2%	4%
Recruitment/Marketing Source		
Business Energy Advisor	3%	3%
Canvasser	44%	57%
Email	5%	3%
Flyer	4%	8%
Friend	2%	0%
Installer	0%	0%
Small Business Energy Saver (SBES)	1%	1%
Telemarketing	7%	8%
Web	1%	1%
Other	3%	3%
Unknown[B]	31%	15%

[A] Device counts reflect devices installed through December 2017 excluding deactivated devices.
[B] Devices enrolled September through December 2017 did not have vendor data available, so are marked as unknown.

5.2 Gross Demand Response Impact Analysis

5.2.1 Methodology

The demand response impact analysis assessed summer Conservation Period gross impacts from switches and thermostats in place and operational at the time of the 2017 summer Conservation Period events.

For demand response programs, the concept of freeridership is not applicable. This is because customers will rarely, if ever, choose to cycle their units off during a hot day without program intervention. Non-participant spillover is also not applicable because non-participants are not notified of Conservation Period events. Participant spillover is unlikely to occur because customers rarely turn off other equipment during program events. However, takeback effects, such as running fans to compensate for the cycling of the AC unit and/or increased run-time for refrigeration and/or process cooling equipment, may occur. Because we used device-level (thermostat or switch) log data to conduct this analysis, rather than facility-level data, this analysis produces gross impacts, i.e., results are **not adjusted** for takeback effects. Notably, the original evaluation

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plan sought to assess net demand impacts using AMI (advanced metering infrastructure) data. However, the DEP AMI data had substantial data availability issues, and both DEC and DEP had quality issues related to anomalous load shapes, necessitating the use of device log data for the impact analysis. In particular, the load shapes within the AMI data—based on graphical review—were not consistent with AC load shapes, and the amount of AMI data was insufficient to fully represent the population of participants.

Activities included:

- Cleaned and prepared data by reviewing event data, as well as program participation, weather data and logger data to identify the number of devices eligible and available to participate in summer events;
- Determined baseline load by identifying similar non-event days (in terms of weather, day of week, and other variables);
- Modeled program impacts by conducting linear fixed effects regression analysis with similar non-event days using device log data and weather data to estimate per device run-time impacts;
- Converted run-time impacts to per device load impacts by applying the full load estimate (HVAC capacity divided by SEER); and
- Identified the number of participating devices (i.e., those eligible and operational) and calculated gross event impacts by multiplying the per device full load impacts by the number of participating devices; and
- Calculated gross impacts for each event by multiplying the per device load impacts by the number of participating devices by specific categories, including device type, cycling strategy and jurisdiction. We calculated the average program-level impact as the weighted average of load impacts across events by jurisdiction, weighting by the number of participating devices.

Clean and Prepare Data

As part of the data cleaning process to prepare for modeling, we excluded devices for the following reasons:

- Enrolled after last summer 2017 Conservation Period events
- Deactivated, unenrolled, or failed prior to event period or event
- Unknown cycling strategy
- No run-time during event and non-event days (less than 1% of participating devices)
- Insufficient run-time data (e.g., run-time data had zeroes for each 15-minute interval)
- Run-time greater than 100%

In total, we had 5,398 devices (3,454 in DEC and 1,944 in DEP) in our modeling data set. Table 5-9 shows in detail the total number of devices left after each data cleaning step by jurisdiction.

Table 5-9. Run-Time Modeling Data Cleaning Steps

Jurisdiction	# Devices Left	Drop Reason
DEC	3,645	Initial Count of Devices
	3,615	Missing Run-time Data
	3,565	Missing Run-time Data on Event and Matched Comparison Days

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Jurisdiction	# Devices Left	Drop Reason
	3,554	Unknown Cycling Strategy
	3,455	Devices with Insufficient Run-time Data (Run-time is Zero for All Observations)
	3,454	Time Intervals > 60 Minutes/Percent Run-time Greater than 100% in an Interval
DEP	2,031	Initial Count of Devices
	2,009	Missing Run-time Data
	1,984	Missing Run-time Data on Event and Matched Comparison Days
	1,983	Unknown Cycling Strategy
	1,944	Devices with Insufficient Run-time Data (Run-time is Zero for All Observations)
	1,944	Time Intervals > 60 Minutes/Percent Run-time Greater than 100% in an Interval

We applied the modeled impact to all devices that received an event signal and cycled their unit during an event, regardless of their inclusion in the model.

Determine Baseline Load

We used a quasi-experimental design to estimate the load impacts of the EWB program. Our selected approach used proxy weather days[12] (i.e., non-event days with similar weather to event days in May through September 2017) to help replicate baseline conditions for event days (i.e., what would the participant's load have been in the absence of the EWB program event?). To develop matches, we used propensity score matching to select four non-event days that were similar in weather profile for each of the five event days. When using propensity score matching, we first build a logistic regression model to estimate each day's probability of being an event day, or its "propensity score," based on hourly weather. We then match each day to the nearest event day in terms of propensity scores (Figure 5-1 and Figure 5-2). The blue lines in the figures represent the event days, and the gray lines represent the matched non-event days. As can be seen, average hourly temperature profiles match fairly well between event and matched comparison days. It should be noted that Events 1 and 4 had more severe thunderstorms in DEP territory, which limited the quality of relevant proxy days available for analysis. We corrected for this issue through the models.

[12] We used participant addresses to geocode the locations of all participants and found the weather station that was closest to each participant's zip code.

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Figure 5-1. Average Hourly Temperatures on Event Days and Matched Non-Event Days in DEC Territory

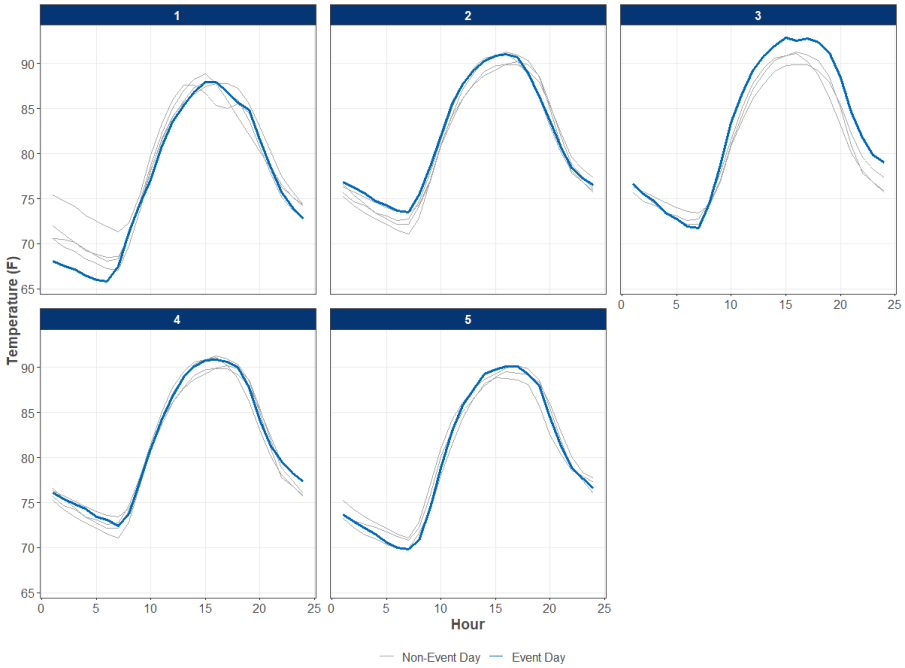
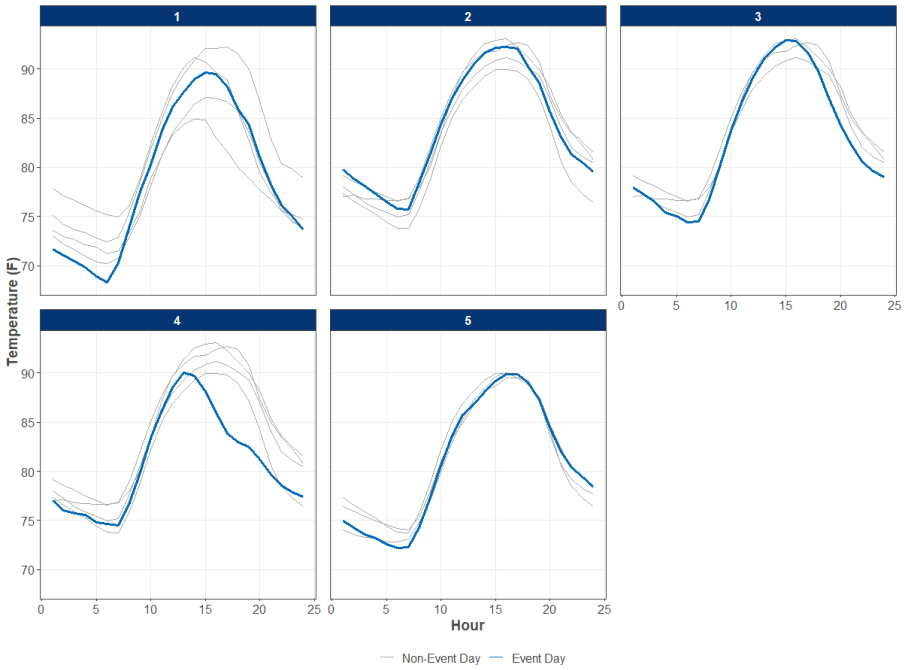


Figure 5-2. Average Hourly Temperatures on Event Days and Matched Non-Event Days in DEP Territory



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Model Program Impacts

We used a linear fixed-effects regression modeling approach for the demand response impact analysis. The model estimates the percentage of hourly run-time on a per-device level. Event impacts are the mean difference between the modeled (predicted) baseline run-time and the event run-time over the event period,[13] multiplied by mean full load demand (described below). The "fixed-effects" modeling approach allows us to control for the time-invariant device-level factors affecting demand (i.e., factors that do not change over the study period, such as type of facility or square footage) without measuring those factors explicitly in the models. All operational devices were included in the model, including those which opted out of the event. The impact estimates therefore include the effect of any participant opt-outs.

Figure 5-3 provides the actual event day hourly run-time (blue) and predicted run-time (gray) for each event for thermostats in the DEC territory. All events show clear evidence of run-time reduction during event hours. All events also show snapback (an increase in run-time following the event as temperatures are returned to their pre-event levels). The presence of snapback means that energy efficiency savings are likely minimal during the event days.

[13] The statistical regression model used to estimate the baseline hourly run-time during event periods predicts what the hourly run-time would have been during the event, if no event had been called. We then compare this baseline run-time to actual event day run-time to establish the demand savings by hour for each event. We estimated a separate model for each jurisdiction, device (thermostat and switch), cycling strategy (30%, 50%, and 75%), and event. However, because there were so few switches for the 75% cycling strategy, we combined these devices across jurisdictions.

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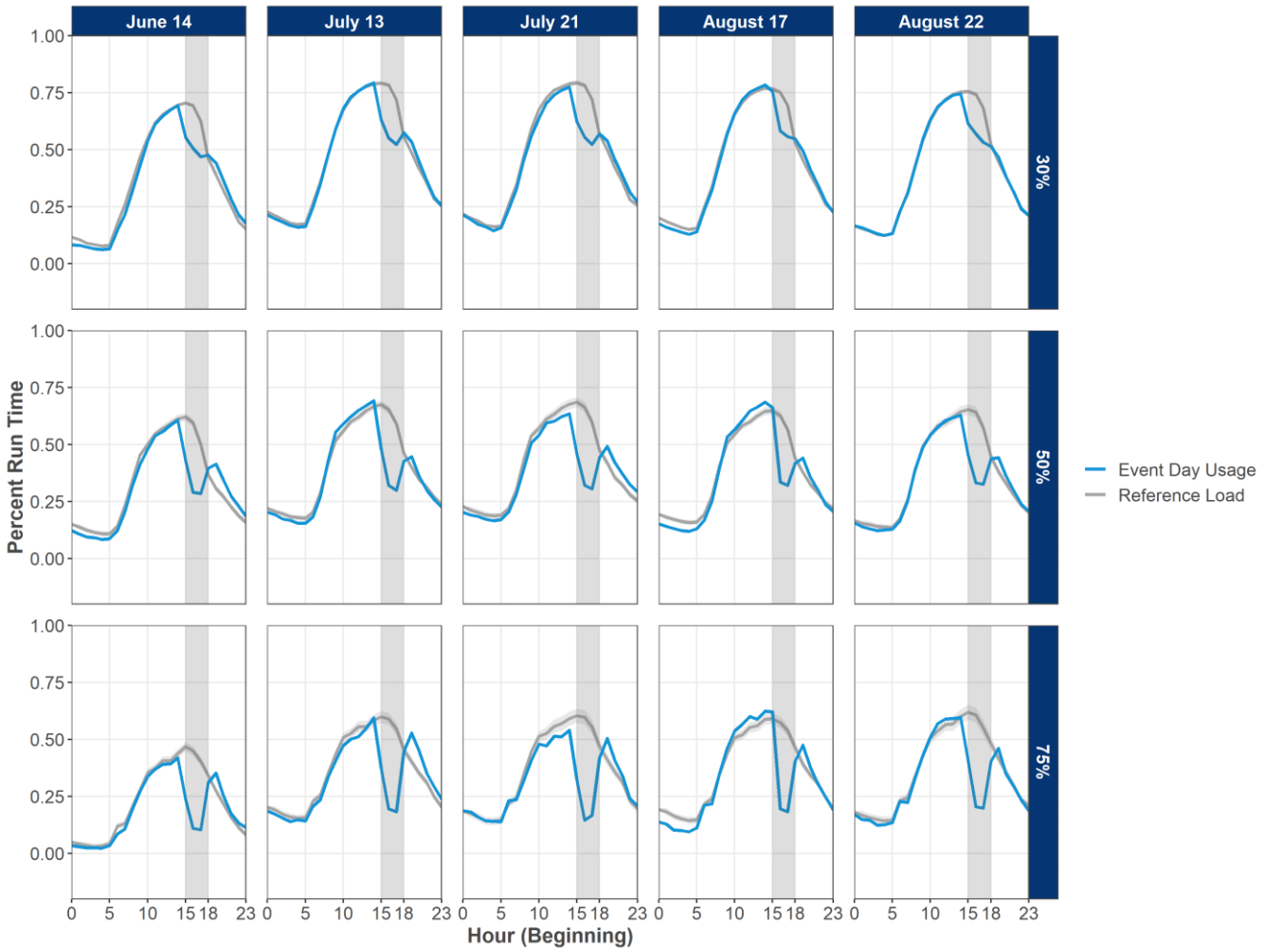
Figure 5-3. Summer Event Day Usage and Estimated Baseline with 90% Confidence Interval (DEC Thermostats)



Convert Run-time Impacts to Demand Impacts

Converting percent run-time impacts to kW reduction involves multiplying the run-time reduction by the assumed full load demand of each device. Opinion Dynamics calculated the full load demand for each device based on Equation 5-1, which uses equipment cooling capacity and efficiency values. We used tonnage values provided in the participant data to calculate equipment cooling capacity (in Btu per hour). The participant data had this information for the majority of devices (81%). If a device did not have a tonnage value, we applied the average tonnage by device and jurisdiction. Efficiency values for the air conditioning systems were not available in the participation data. As a result, we applied the average 2016 evaluated SEER values by jurisdiction.

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Equation 5-1. Per Participant Full Load kW for Air Conditioners

$$\text{Full load kW} = \frac{\text{Capacity}}{\text{SEER}}$$

Where:

Capacity = tons * 12 Btu/hour

SEER (Btu/watt-hour) = 11.2 (DEC) or 11.8 (DEP)

Calculated Event Participation and Gross Event Impacts

We first determined device participation for each event by identifying how many devices were (1) operational and (2) eligible. Operational devices are those that received an event signal and could be cycled. This excludes devices that had zero run-time during the day of the event or were in an incompatible mode (e.g., off mode). Eligible devices are defined as those that are active during an event and enrolled with a known cycling strategy. Eligible devices therefore exclude deactivated and unenrolled devices, and devices with an unknown cycling strategy. Notably, because there are five events and enrollment continued throughout the summer period, the number of eligible devices is different for each event.

We calculated gross impacts for each event by multiplying the per device load impacts by the number of participating devices by specific categories, including device type, cycling strategy and jurisdiction. We calculated the average program-level impact as the weighted average of load impacts across events by jurisdiction, weighting by the number of participating devices.

5.2.2 Results

Duke Energy called five summer Conservation Period events during the 2017 cooling season (June 14, July 13, July 21, August 17, and August 22). The temperatures were fairly similar across these events, with an average maximum event temperature of 95°. In Table 5-10, we summarize key features for these events, as well as the total number of eligible and operational devices. Notably, many devices were installed after the summer Conservation Period, and as a result are not included in the analysis because they were not eligible to participate in any events.

Table 5-10. 2017 EWB *Ex Post* Demand Response Events

Event Date	Day of Week	Start Time	End Time	Average Event Temp (F)	Max Event Temp (F)	Devices Eligible to Receive a Signal	Devices that Received a Signal and Cycled During Event	Operational Rate
June 14	Wednesday	3:00 PM	6:00 PM	89	94	4,790	4,334	90%
July 13	Thursday	3:00 PM	6:00 PM	92	96	5,133	4,658	91%
July 21	Friday	3:00 PM	6:00 PM	94	97	5,175	4,698	91%
August 17	Thursday	3:30 PM	6:00 PM	88	95	5,576	5,082	91%
August 22	Tuesday	3:00 PM	6:00 PM	89	95	5,613	5,116	91%
Average				**91**	**95**	**5,257**	**4,778**	**91%**

Note: Averages may not compute correctly due to independent rounding.

We also reviewed opt-out rates by event. Per conversations with Itron, the evaluated opt-out rates are consistent with their expectations for this program. Notably, we identified higher opt-out rates for food / liquor SIC codes, which is consistent with findings from our process survey.

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Table 5-11. 2017 Summer Conservation Period Opt-Out Rates by Event and Business Type

Event	Food	Non-Food	Overall
DEC			
June 14	6%	3%	3%
July 13	10%	3%	4%
July 21	13%	4%	5%
August 17	6%	3%	4%
August 22	6%	4%	4%
Average	**8%**	**4%**	**4%**
DEP			
June 14	4%	5%	5%
July 13	13%	3%	4%
July 21	15%	6%	7%
August 17	3%	3%	3%
August 22	3%	3%	3%
Average	**8%**	**3%**	**4%**

Table 5-12 provides per device average load impacts by cycling strategy and device for DEC. As can be seen, customers who enroll in the highest cycling strategy tend to have lower reference loads, but achieve the highest load impacts. In addition, contrary to expectations based on typical customer engagement and opt-out behavior of participants with thermostats, thermostats achieved slightly greater load impacts than switches. According to program staff, this may be driven by the types of facilities that enroll with switches: program staff observed that a greater number of schools and storage facilities enrolled with switches, and these types of facilities may have lower reference load during summer event days compared to the average business.

Table 5-12. 2017 DEC *Ex Post* Average Event Demand Response Load Impacts by Cycling Strategy and Device

Device	Cycling Strategy	Per Device		% Load Impact
		Reference Load (kW)	Load Impact (kW)	
Thermostats	30%	3.355	0.740	22%
	50%	3.348	1.310	39%
	75%	2.471	1.371	56%
	Total	**3.280**	**0.876**	**27%**
Switches	30%	3.240	0.668	21%
	50%	2.777	0.872	31%
	75%	2.006	1.071	53%
	Total	**3.066**	**0.736**	**24%**

Table 5-13 provides per device average load impacts by cycling strategy and device for DEP. Trends in per device reference load and load impacts are similar to those for DEC: customers enrolled in the highest cycling strategy tend to have lower reference loads but achieve the highest load impacts. In DEP, thermostats also achieved greater load impacts than switches.

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Table 5-13. 2017 DEP *Ex Post* Average Event Demand Response Load Impacts by Cycling Strategy and Device

Device	Cycling Strategy	Per Device		% Load Impact
		Reference Load (kW)	Load Impact (kW)	
Thermostats	30%	2.993	0.636	21%
	50%	2.393	0.939	39%
	75%	2.396	1.301	54%
	Total	**2.763**	**0.801**	**29%**
Switches	30%	2.925	0.550	19%
	50%	2.572	0.814	32%
	75%	2.006	1.079	54%
	Total	**2.766**	**0.655**	**24%**

Our impact analysis identified average percent load impacts that were routinely under the cycling strategy level. Overall, we found that the percent load impact from devices were lower than the duty cycle enrollment. For example, for DEP the 30% strategy achieved a load reduction of 21%, the 50% strategy a reduction of 39%, and the 75% strategy a reduction of 54%. This is consistent with expectations for a duty cycling[14] strategy, as the average run-time of units during non-events is rarely 100%. We recommend incorporating an adaptive cycling strategy for calling events. Adaptive cycling cycles the air conditioner as a percent of baseline during a hot day run-time rather than as a percent of total run-time. This helps to achieve percent run-time reductions closer to the cycling strategy, and it helps customers who may have over-sized units. Based on information from the program team, Duke Energy will implement this cycling strategy for the 2018 Conservation Period events.

Table 5-14 provides a summary of Conservation Period event impacts for DEC. Overall, DEC achieved 72% of its program-level demand response impact goal. While enrollment exceeded goals (realization rate of 129%), per unit savings for each cycling strategy fell short of expectations (realization rates of 56% for thermostats and 46% for switches). In addition, device enrollment is heavily distributed towards lower cycling strategies. The combination of lower cycling strategies and lower per device impacts drives the overall low realization rate.

Table 5-14. 2017 DEC Average Event Demand Response Load Impact Realization Rates

Device	Cycling Strategy	Participation			Gross Annual Summer Coincident kW/Unit			Gross Annual Summer Coincident Aggregate kW		
		Ex Ante[A]	Ex Post	RR	Ex Ante[A]	Ex Post	RR	Ex Ante[A]	Ex Post	RR
Thermostat	30%	1,097	2,141	195%	0.927	0.740	80%	1,017	1,585	156%
	50%	658	406	62%	1.729	1.310	76%	1,138	532	47%
	75%	439	234	53%	2.876	1.371	48%	1,263	320	25%
	TOTAL	**2,194**	**2,781**	**127%**	**1.558**	**0.876**	**56%**	**3,417**	**2,438**	**71%**

[14] A *duty cycle* is the fraction of one period in which a system is active. Thus, a 75% *duty cycle means* the unit is off 75% of the time and allowed to operate 25% of the time.

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Device	Cycling Strategy	Participation			Gross Annual Summer Coincident kW/Unit			Gross Annual Summer Coincident Aggregate kW		
		Ex Ante[A]	Ex Post	RR	Ex Ante[A]	Ex Post	RR	Ex Ante[A]	Ex Post	RR
Switch	30%	58	143	247%	1.044	0.668	64%	61	96	158%
	50%	35	41	117%	1.776	0.872	49%	62	36	57%
	75%	23	12	54%	2.820	1.071	38%	65	13	20%
	TOTAL	**116**	**196**	**169%**	**1.617**	**0.736**	**46%**	**188**	**145**	**77%**
All Devices	**TOTAL**	**2,310**	**2,978**	**129%**				**3,605**	**2,582**	**72%**

[A] Ex Ante impact assumptions from Duke Energy. Source file: "DEC-DEP SBDREE Ex-Ante Savings - 05-10-18.xlsx" and "2017 Budget.xlsx".

Table 5-15 provides a summary of Conservation Period event impacts for DEP. Overall, DEP achieved 70% of its demand response impact goal. As with DEC, enrollment exceeded goals (realization rate of 127%), but per participant impacts were lower than expected for each cycling strategy (realization rates of 56% for thermostats and 47% for switches) and enrollment was heavily distributed towards lower cycling strategies. The combination of lower cycling strategies and lower per device impacts results in the lower realization rate.

Table 5-15. 2017 DEP Average Event Demand Response Load Impact Realization Rates

Device	Cycling Strategy	Participation			Gross Annual Summer Coincident kW/Unit			Gross Annual Summer Coincident Aggregate kW		
		Ex Ante[A]	Ex Post	RR	Ex Ante[A]	Ex Post	RR	Ex Ante[A]	Ex Post	RR
Thermostat	30%	672	1,020	152%	0.857	0.636	74%	576	649	113%
	50%	403	413	102%	1.600	0.939	59%	645	388	60%
	75%	269	223	83%	2.661	1.300	49%	716	290	41%
	TOTAL	**1,344**	**1,656**	**123%**	**1.441**	**0.801**	**56%**	**1,937**	**1,327**	**69%**
Switch	30%	35	99	283%	0.904	0.550	61%	32	54	172%
	50%	21	32	152%	1.537	0.814	53%	32	26	81%
	75%	14	12	89%	2.442	1.079	44%	34	13	39%
	TOTAL	**70**	**143**	**205%**	**1.402**	**0.655**	**47%**	**98**	**94**	**96%**
All Devices	**TOTAL**	**1,414**	**1,800**	**127%**				**2,035**	**1,421**	**70%**

[A] Ex Ante impact assumptions from Duke Energy. Source file: "DEC-DEP SBDREE Ex-Ante Savings - 05-10-18.xlsx" and "2017 Budget.xlsx".

When looking across both jurisdictions, enrollment exceeded goals, but was heavily distributed towards lower cycling strategies (Table 5-3). Per device load impacts were lower than anticipated across jurisdictions (56% for DEC and 55% for DEP) and cycling strategies (Table 5-14 and Table 5-15). Both utilities underachieved overall total summer coincident demand savings goals (72% for DEC and 70% for DEP); however, DEC had higher average per-event load impacts than DEP, perhaps driven by higher reference loads in the DEC jurisdiction. Conversely, DEP had a larger share of its enrollments on more aggressive cycling strategies than DEC.

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Table 5-16. Summary of 2017 DEC and DEP *Ex Post* Average Event Demand Response Load Impacts

Metric	2017 Ex Ante		2017 Ex Post		Realization Rate	
	DEC	DEP	DEC	DEP	DEC	DEP
Participation (devices)	2,310	1,414	2,978	1,800	129%	127%
Per Device Weighted Average Summer Coincident Savings (kW)	1.56	1.44	0.87	0.79	56%	55%
Total Summer Coincident Demand Savings (kW)	**3,605**	**2,035**	**2,582**	**1,421**	**72%**	**70%**

5.3 Net Energy Savings Impact Analysis

5.3.1 Methodology

Opinion Dynamics conducted a series of analytical steps to estimate net energy efficiency savings attributable to thermostats installed in 2017. These steps included:

- Cleaned and prepared data, including review of program participation data to identify the number of premises with enrolled and installed thermostats in 2017;
- Modeled program impacts by conducting a consumption analysis, using a linear fixed effects regression model with a comparison group matched on pre-period energy consumption to estimate premise-level energy efficiency savings;
- Conducted a cross-participation analysis to understand the savings that EWB participants achieved from participation in other Duke Energy programs and account for them in consumption analysis at the premise-level; and
- Calculated total net energy savings by adjusting the average per-premise energy savings for cross-participation and multiplying per-premise savings by the number of premises with a thermostat enrolled in 2017. We then calculated per-device impacts by applying the average number of devices installed per-premise to calculate a realization rate against per-device ex ante goals.

Clean and Prepare Data

We excluded customer accounts from our energy efficiency impact models for the following reasons:

- Switch customers (ineligible for energy efficiency impacts);
- Extremely high (greater than 50,000 kWh/month) or low (less than 500 kWh/month) average daily consumption (10 customers were removed); and
- Inadequate billing history before or after program participation (1,017 customers were removed).

As a result of this data cleaning, we dropped 1,027 of 2,903 premises from the consumption analysis. The primary driver for the removal of these premises was insufficient post-period data, which was a limitation due to the timing of the evaluation rather than any problem inherent in the data. A review of consumption data indicated that customers excluded from the analysis had similar pre-period energy consumption as those included in the analysis. It should also be noted that we applied the estimated savings to all eligible participants, regardless of their inclusion in the model.

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Model Program Impacts

Prior to conducting the consumption analysis, Opinion Dynamics created a matched comparison group. Utilizing a comparison group allows us to establish a counterfactual, i.e., the baseline energy that participants likely would have used in the absence of the program. Matched comparison groups consist of non-participants who have similar known traits to participants. We matched participants with non-participants in terms of business type (based on a combination of SIC codes) and monthly energy usage. Within business type, the five non-participants with the closest monthly energy usage to a participant were included in the comparison group.

A consumption analysis with a comparison group inherently provides net impacts. Because the comparison group represents energy use in the absence of the program, results from the consumption analysis are net results, and application of a net-to-gross ratio (NTGR) is unnecessary. Participant spillover, where the participant takes additional non-program energy-saving actions attributable to the program, is directly captured in the consumption analysis results. However, results from the consumption analysis also reflect savings from participation in other Duke Energy programs. As a result, consumption analysis results need to be adjusted for such cross-participation (see next subsection).

The consumption analysis employed a LFER model, which accounted for factors that are not expected to vary over time via the constant terms of the equation, such as square footage. This model also accounts for differences in weather and pre-program energy use between participants. To improve our estimate of what participants' usage would have been absent the program, we added dummy variables for each of the 12 months of the year.[15] Including these variables in the model helped control for monthly trends such as seasonal effects and allowed for a more accurate estimate of pre- and post-program usage. The model included weather terms as well as interaction terms between weather and the post-participation period for the treatment group to account for differences in weather patterns across years. We also included interaction terms to control for any differences in baseline usage between the treatment and comparison groups.

We included 2016 participants in the models to increase the robustness of our model results but did not apply the resulting estimated per-participant savings to 2016 participants when calculating 2017 impacts. We included 2016 participants in the model because many of the 2017 participants enrolled towards the latter half of 2017, resulting in an insufficient sample of 2017 participants with the required months of post-installation energy consumption data. We selected this approach after discussing program design and implementation with program staff, who indicated that there were few changes to implementation across the two program years, suggesting that per unit energy savings would likely be similar. In addition, we confirmed that 2016 and 2017 participants had very similar pre-participation energy usage and HVAC tonnage. A more detailed discussion of the consumption analysis methodology, including data cleaning steps, a comparison group assessment, and the final model, is provided in Volume II.

Apply Cross-Participation Analysis

The consumption analysis not only reflects EWB program savings but also savings from participation in other Duke Energy programs. As a result, the consumption analysis has the potential for overestimating energy savings (if EWB participants have higher cross-participation savings than the comparison group) or

[15] Dummy variables are binary terms for each month, with "1" signifying that the bill occurred in that month.

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underestimating energy savings (if the comparison group has higher cross-participation savings than participants). We conducted a cross-participation analysis for participants and the comparison group to identify and correct for this. To do so, we identified measures that participants and the comparison group customers installed through the Non-Residential Prescriptive and SBES Programs, and their savings, during the post-participation period.[16] Savings reflect pro-rated net ex post impacts based on the date of installation. Once identified, we removed the difference between cross-participation savings of the comparison group and of the EWB participants. This accounts for the fact that the consumption analysis already nets out equal cross-participation savings for the comparison group and EWB participants.

It should be noted that program staff made implementation changes between 2016 and 2017 and discontinued the specific targeting of SBES participants for recruitment into EWB. This change improved cross-participation rates for 2017 EWB participants when compared to 2016 EWB participants.

Calculate Total Energy Savings

Energy efficiency impact estimates reflect changes in energy consumption at a premise level (i.e., billing data is at a premise level). Calculating total energy savings entails multiplying the per-premise savings by the number of thermostats installed between January 1 and December 31, 2017, including deactivated devices.[17] To calculate program realization rates relative to Duke Energy's ex ante assumptions, we converted premise-level energy efficiency savings to the thermostat level by identifying the average number of devices per premise (Table 5-17).

Table 5-17. 2017 EWB Thermostat Enrollments, Premises and Average Devices Per Premise

Jurisdiction	Number of Thermostats Installed in 2017	Number of Premises	Average Number of Devices per Premise
DEC	4,490	2,577	1.7
DEP	1,719	879	2.0
Total	6,209	3,456	1.8

Note: Device counts reflect all devices enrolled in January 2017-December 2017, including devices deactivated in 2017.

5.3.2 Results

Table 5-18 provides a summary of the daily and annual energy savings results by jurisdiction, before accounting for cross-participation. We identified substantial variation in energy efficiency savings between DEC and DEP, with DEC participants saving more than twice (5 kWh per day and over 3% of baseline usage) what DEP participants saved (2 kWh per day and less than 1.5% of baseline usage).

[16] We matched EWB participants to other program-tracking data by account and service point ID.

[17] The consumption analysis credits energy efficiency savings for each participant until the date of deactivation.

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Table 5-18. 2017 EWB *Ex Post* Daily and Annual Energy Efficiency Savings

Jurisdiction	Daily Energy Savings Estimate (kWh/Day)			Annual Energy Savings Estimate (kWh/Year)	
	Daily Estimate	Baseline Usage	Percent Savings	Per Premise	Per Thermostat[A]
DEC	5.06	155	3.29%	1,847	1,060
DEP	2.11	145	1.44%	771	394

[A] Converted to thermostat level by applying average number of devices/premise. Results are not adjusted for cross-participation analysis findings.

We have used our knowledge of the program, participants, and similar programs to make conjectures for factors that might explain the differences in energy efficiency between jurisdictions, however, due to the nature of billing analyses results, it is not possible to determine which of these factors is causally related to the savings difference nor how to attribute the quantity of savings differences to each factor. We offer the following series of checks we conducted to identify what may be driving lower energy savings in the DEP territory versus DEC territory.

According to program staff, program design and implementation is relatively consistent across both territories, including the type of facilities targeted and enrolled in the program. Our analysis found the following differences in characteristics between DEC and DEP participants:

- DEP participants tend to have lower annual average baseline usage, compared to DEC participants.
- DEP participants have slightly lower average tonnage in terms of the HVAC units being controlled.
- DEP participants have slightly more thermostats per premise than DEC participants.
- During the cooling season (May through September), DEC participants tend to use their program-controlled air conditioning units slightly more than DEP participants (expressed as runtime percentage).

Individually, these differences between DEC and DEP participants are small and unlikely to fully account for the observed differences in savings. However, all differences directionally support lower savings for DEP participants. Table 5-19 summarizes these participant characteristics.

Table 5-19. Comparison of DEC and DEP Participant Characteristics

Characteristics	DEC	DEP
Average Daily Baseline Usage	155	145
Average AC Size (Tons)	4.35	4.01
Average Cooling Season Run-time	28.7%	27.5%
Average Number of Thermostats per Premise	1.74	1.96

Other factors, such as customer behavior may play a role, e.g., engagement with their thermostat. Survey results suggest that DEP participants may change their set points or use the web portal more frequently than DEC customers. Additionally, the energy-saving benefits of the Wi-Fi-enabled thermostat are largely a function of how customers were using their existing (baseline) thermostat. Other customer behaviors not observable in this evaluation, such as those linked to business types and thermostat set-points, may further drive savings differentials. Future research efforts should assess whether there are differences in enrollment by SIC code that are correlated with lower energy savings impacts and investigate non-event day customer set points.

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The cross-participation analysis results call for removing a substantial portion of energy savings from the consumption analysis results (Table 5-20). Approximately 18% of EWB participants also participated in other Duke Energy programs in 2016 and 2017, while 7% of matched comparison group non-participants participated in other Duke Energy programs. The majority of cross-program participation was in the Non-Residential Prescriptive Program, which also contributed the largest share of savings adjustments (60% compared to 40% from SBES). These rates were consistent across jurisdictions.

Table 5-20. Thermostat-Level Cross-Participation Analysis Results

Jurisdiction	(A) Consumption Analysis Savings (kWh)	Pro-Rated Cross-Participation Savings (kWh)			(E) Adjusted Energy Savings (kWh) (A-D)
		(B) EWB Participant	(C) Matched Comparison Group	(D) Difference Between EWB Participant and Matched Comparison Group (B-C)	
DEC	1,060	937	388	549	511
DEP	394	503	128	376	18

Table 5-21 shows the per-thermostat and program-level savings for the program in each jurisdiction. DEC participants saved 2,296 MWh and DEP participants saved 31.7 MWh annually.

Table 5-21. 2017 *Ex Post* Annual EWB Energy Efficiency Savings

	Consumption Analysis Savings (kWh)	Cross Participation Deduction (kWh)	Adjusted Energy Savings (kWh)
DEC			
Thermostat Level	1,060	-549	511
Program Level	4,759,461	-2,463,014	2,296,448
DEP			
Thermostat Level	394	-376	18
Program Level	677,283	-645,546	31,737

Table 5-22 provides the energy efficiency savings realization rate for 2017. Overall, we found that the program overachieved thermostat installation goals across both jurisdictions (realization rates of 256% for DEC and 160% for DEP). However, per device energy savings were lower than expected across jurisdictions (realization rates of 80% for DEC and 3% for DEP), which was largely driven by cross-participation. The resulting overall realization rate is 204% for DEC and 5% for DEP. It should be noted that Duke Energy added an "auto-EE" functionality to their customer portal in 2018. This feature assesses the building's thermodynamics and auto-adjusts the set points when the facility is closed to generate additional energy savings. These changes could potentially increase the overall energy efficiency savings from the thermostats in future program years.

Table 5-22. Summary of 2017 DEC and DEP *Ex Post* Energy Efficiency Impacts

Metric	2017 Ex Ante		2017 Ex Post		Realization Rate	
	DEC	DEP	DEC	DEP	DEC	DEP
Participation (thermostats)	1,755	1,076	4,490	1,719	256%	160%
Per Participant Average Annual kWh	641	562	511	18	80%	3%
Total Energy Savings (kWh)	**1,124,522**	**605,111**	**2,296,448**	**31,737**	**204%**	**5%**

Note: Averages may not compute correctly due to independent rounding.

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6. Process Evaluation

6.1 Methodology

The process assessment leveraged the following data collection methods and research activities:

- Program staff interviews (n=7)
- Materials review
- Program-tracking data analysis
- Early participant interviews (n=10)
- Participant survey (n=242)
- Non-participant interviews (n=10)
- Unenrolled participant interviews (n=10)

We provide a detailed overview of these data collection method and research activities in Section 4.

6.2 Findings

This section provides detailed findings from the EWB process evaluation, starting with the experiences of participants, followed by non-participants and then unenrolled participants. Throughout this section, we include feedback from the program staff interviews to help provide context or explain results, where applicable.

6.2.1 Participant Experiences

This section details participants' experiences with the EWB program. These results draw primarily from the participant survey, with findings from the early participant interviews provided where these results can help complement the survey results. The evaluation team assessed differences in participant survey results based on jurisdiction and the and cycling level chosen by customers.[18]

This section starts by providing context about who survey respondents were, then summarizes participant satisfaction with the program. We then detail the various aspects of program participation, starting with motivations for participation and the enrollment and installation processes, followed by thermostat and portal usage and conservation period experiences.

[18] The evaluation team investigated assessing differences between participants recruited by Threshold Marketing and Lime Energy but was not able to do so as the sample frame only included six participants recruited by Lime Energy, and only one of these six participants completed the survey.

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Participant Survey Respondent Firmographics

To provide early process feedback, the participant survey was fielded in September 2017. As a result, the survey sample frame included 2017 program participants enrolled at the time of the data request, in August 2017. A comparison of DEC and DEP participants showed similarities in terms of many elements of program enrollment. However, DEC participants more often chose the lowest (30%) cycling level (86% DEC vs. 56% DEP)[19] and less often installed multiple devices in their businesses (37% DEC vs. 43% DEP).[20] Because there were no other differences in how the program was implemented in each jurisdiction, these differences in participant characteristics across the two jurisdictions likely account for some of the variation in survey responses between the two groups, as survey participants closely mirror the population for both jurisdictions.

Table 6-1. Participant Enrollment Characteristics

	DEC		DEP	
Characteristic	Survey Respondents (n=180)	Population (n=2,699)	Survey Respondents (n=62)	Population (n=943)
Cycling Level				
30%	77%	86%	42%	56%
50%	15%	10%	31%	22%
75%	8%	4%	27%	22%
Enrollment in Summer and Winter Events				
Summer Only	95%	93%	95%	96%
Summer & Winter	5%	7%	5%	4%
Number of Devices Across All Locations				
One	60%	63%	45%	57%
Two or more	40%	37%	55%	43%
Device Type				
Thermostat	96%	92%	95%	90%
Switch	3%	7%	3%	10%
Both	1%	1%	2%	1%
Recruited by Lime Energy or Threshold Marketing				
Yes	84%	89%	85%	85%
No	16%	11%	15%	15%

Note: The sample frame includes all 2017 participants enrolled when data was requested for the survey in August 2017, with customers who participated at multiple locations de-duped to one observation. The population data include all 2017 participants enrolled through December 2017.

[19] During conversations with program staff, the evaluation team learned that the activities of one canvasser may be responsible for most of the disparity between cycling levels in the two jurisdictions. A single canvasser for DEC was responsible for approximately 30% of all new participant registrations during the 2017 program year. The canvasser registered most or all of their new participants at the 30 percent cycling level, and thus, skewed all DEC participants towards a 30 percent cycling level.

[20] By the end of the evaluated period, DEC and DEP participants showed increasingly similar rates of multiple-device installations.

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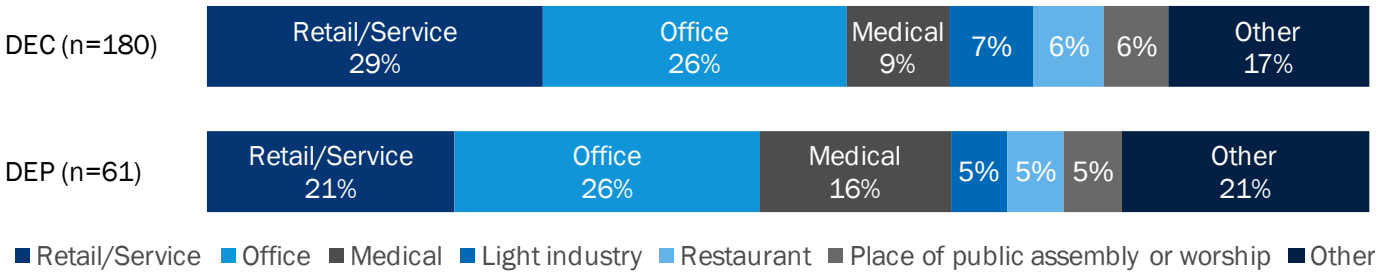
Business types of survey respondents are similar across the two jurisdictions, with most being retail/service, office, or medical businesses (see Figure 6-1).

Figure 6-1. Participant Survey Respondent Business Type



Participant Satisfaction

Overall, participants report high satisfaction with program elements. In general, participants are highly satisfied with the program enrollment and installation processes, the performance of their thermostat or switch, and the Duke Energy and implementation vendor staff. While still generally satisfied, average satisfaction is lower for the program portal and the Conservation Period events, as quantified for each jurisdiction below and detailed throughout the remainder of the participant survey results section.

DEC participants highly rate their satisfaction with their enrollment experiences, whether they enrolled on their own or through a canvasser. DEC participants highly rate their satisfaction with the ease of program enrollment when enrolling on their own (mean of 9.2, see Figure 6-2). On average, DEC participants provide the same high rating for their satisfaction with the representatives who installed the device, the time required to install the device, the time between enrollment and installation, and the time required to enroll in the program (mean of 9.1). Program data suggests that the average time between enrollment and installation is 26.1 days, and typically it takes longer in DEP territory and for switches. DEC participants report lower satisfaction with participation in Conservation Periods (mean of 8.3) and with their use of the program's online portal (mean of 8.4).

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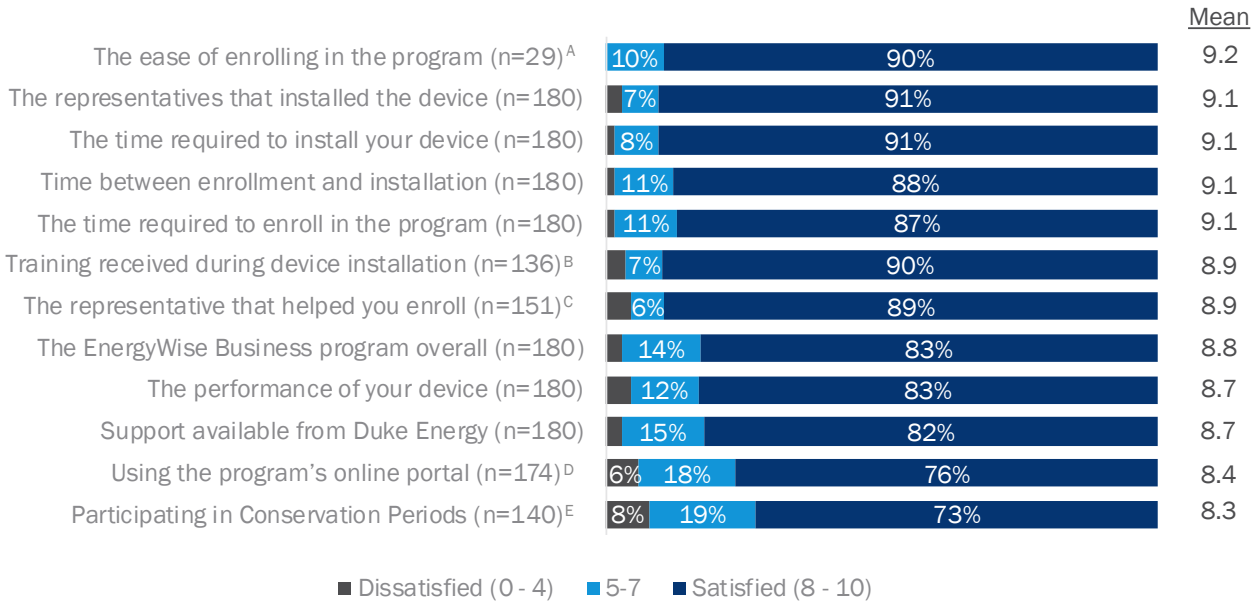
Figure 6-2. DEC Participant Satisfaction



A: Only includes customers not recruited by canvassers.
B: Only includes customers present during installation.
C: Only includes customers recruited by canvassers.
D: Only includes customers receiving at least one thermostat.
E: Only includes customers recalling participation in any Conservation Period.

DEP participants most highly rate satisfaction with the time required to install their device (mean of 9.4, see Figure 6-3), the training received during installation if they were present for it (mean of 9.3), and the representative that installed their device (mean of 9.2). Like DEC participants, DEP participants report lower satisfaction with participation in Conservation Periods (mean of 7.2) and with their use of the program's online portal (mean of 8.2). Though DEP participants highly rate satisfaction with most program elements, DEP participants are significantly less satisfied with the program overall than DEC participants and report they are less likely to continue to participate in the program.[21]

[21] The evaluation team explored the relationship between cycling level differences between the two jurisdictions and their satisfaction with the program overall. Though sample sizes are too small to produce significant results, DEP customers still report lower satisfaction with the program than DEC participants after controlling for differences in cycling levels.

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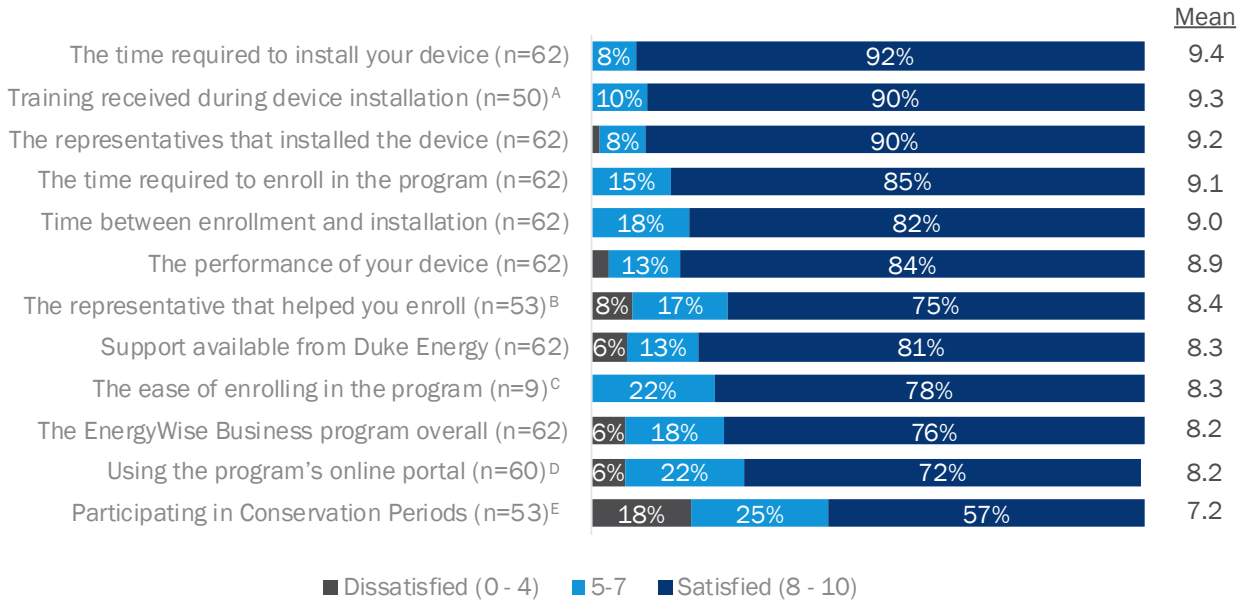
Figure 6-3. DEP Participant Satisfaction



A: Only includes customers present during installation.
B: Only includes customers recruited by canvassers.
C: Only includes customers not recruited by canvassers.
D: Only includes customers receiving at least one thermostat.
E: Only includes customers recalling participation in any Conservation Period.

One noteworthy finding is the high satisfaction with the time between enrollment and equipment installation for both DEC and DEP participants. After Threshold Marketing was brought on board and the program enrollment rate increased, the time between enrollment and installation increased until Itron could hire more installers. For that period, the wait between program enrollment and thermostat installation increased to two to three months, exceeding the target of four weeks. Based on the results above, this lag does not seem to have impacted participants' satisfaction with the program.[22]

Participant survey findings reflect similar sentiments from early participant interviews. Like most participants, early participants highly rate their satisfaction with the program overall (mean of 9.2) and with the Wi-Fi enabled thermostat they received from the program (mean of 9.3). During one interview, an early participant mentioned that "everybody [associated with Duke Energy] was polite and easy to get along with."

Motivations for Participation

When asked about customers' reasons for participating in the program, Threshold Marketing managers reported that customers enroll for the free thermostat installation and energy savings. Their canvassers tell

[22] The evaluation team tested the correlation between the days from enrollment to installation and customer satisfaction and found no meaningful correlation.

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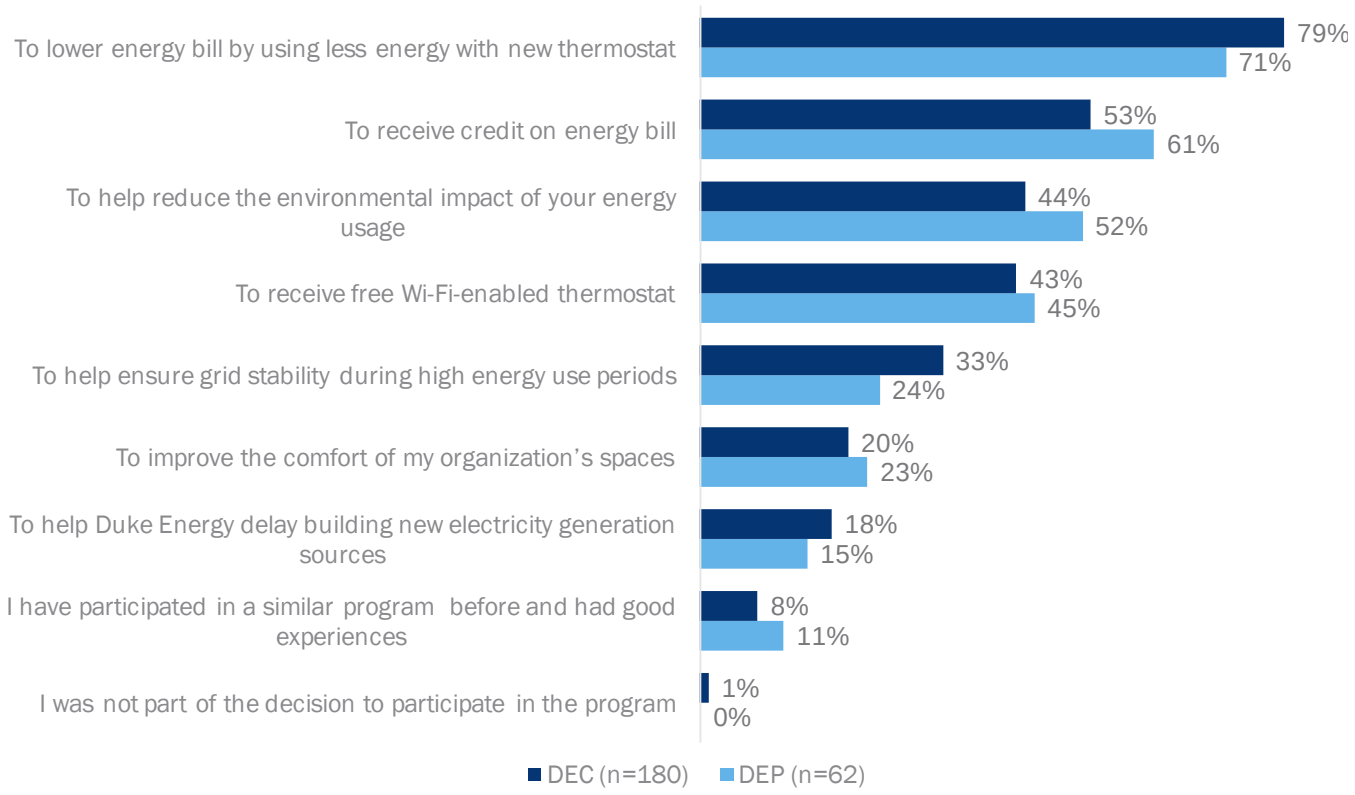
customers they can expect five percent savings with the new thermostat and find that business owners are especially interested in the benefits of being able to remotely track and control their thermostat(s). The Threshold Marketing program managers reported typically using the energy savings and benefits of the free thermostat first to get customers interested, and then explaining the Conservation Periods second. Similarly, Duke Energy's program marketing collateral also leads with the benefits of the smart thermostat.

Survey respondents report a variety of motivations for participating in the program. Participants most commonly cite bill savings (79% for DEC and 71% for DEP, see Figure 6-4) and bill credits (53% for DEC and 61% for DEP) as a motivation for enrolling in the program, followed by environmental benefits (44% for DEC and 52% for DEP), and the free thermostat itself (43% for DEC and 45% for DEP).

Figure 6-4. Participant Motivation for Enrollment: All Reasons



Note: Figure includes all reasons for enrolling.
This question allowed for multiple responses.

When participants were asked for the most important motivation for program participation, about half reported the most important motivation was lowering their energy bill (54% DEC, 49% DEP, see Figure 6-5), which is consistent with how the program is marketed. When comparing responses between general motivations and the primary motivation among those respondents who reported more than one motivation to participate, receiving a bill credit, reducing the environmental impact of energy usage, and receiving a free Wi-Fi-enabled thermostat appear to be secondary motivations.

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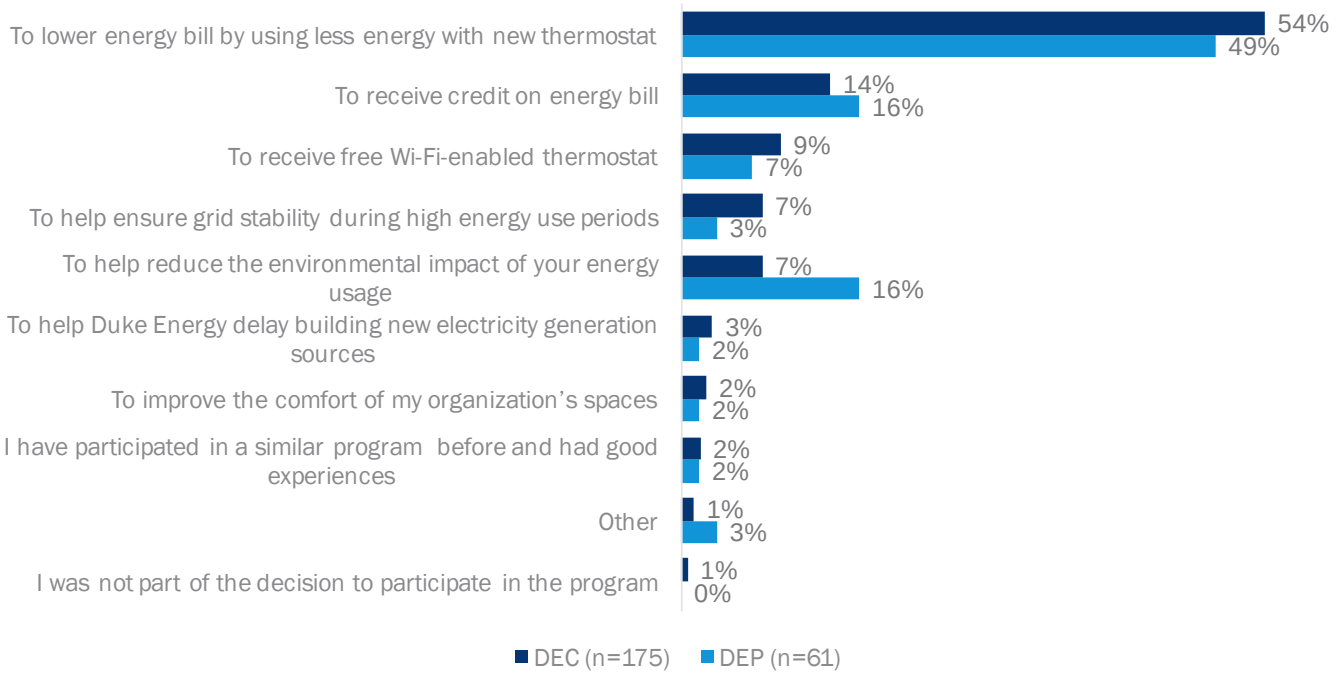
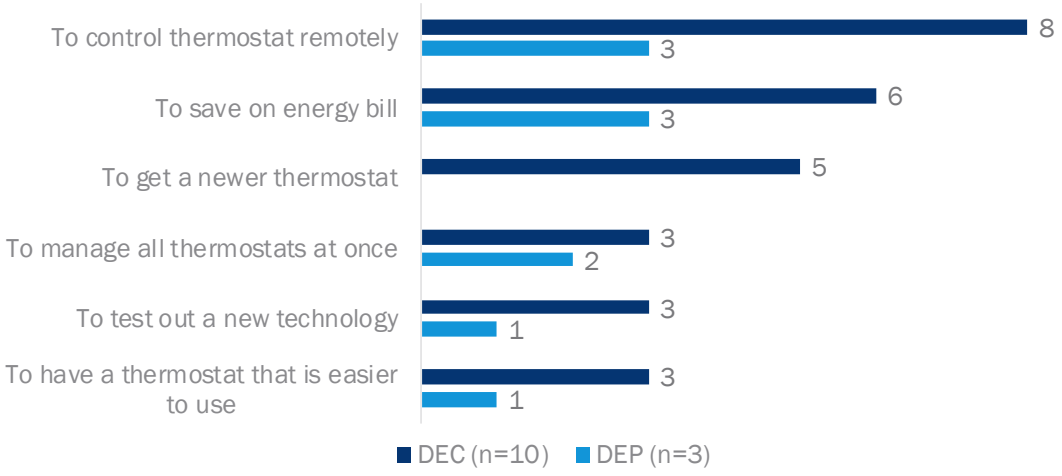
Figure 6-5. Participant Motivation for Enrollment: Primary Reason



Note: Figure includes only most important reason for enrolling.

Participants who cite receiving a free Wi-Fi-enabled thermostat as a motivation for program participation were also asked about the elements of the thermostat that were most appealing. Most cite the ability to remotely control their thermostat as an appealing element (8 of 10 DEC, 3 of 3 DEP, see Figure 6-6). Responses are similar for early program participant interviews. One early program participant interviewee additionally cites the "lockout" feature, which password protects changes to the thermostat, as the most appealing feature.

Figure 6-6. Thermostat Features Appealing to Participants



Note: Figure reports counts of participants indicating each feature was appealing, and includes all features mentioned by respondents.

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Enrollment Process

Most participants were initially recruited to participate in the program by a canvasser (84% DEC, 86% DEP). Almost all participants who had been recruited by a canvasser recall the canvasser visit (97% DEC, 98% DEP) and most report that based on their conversation with the canvasser, they understood program elements very well when they enrolled.

To characterize customer understanding of specific program elements, the evaluation team first asked participants if they recalled a visit from the canvasser and then if they recalled specific pieces of information discussed by the canvasser. The responses from these two questions were then aggregated together to describe the understanding of all participants. Of the various program elements asked about in the survey, participants report having the best understanding of elements related to the thermostat, including when they could expect their device to be installed (77% DEC, 85% DEP, see Figure 6-7 and Figure 6-8) and the benefits of a Wi-Fi thermostat or switch (72% DEC, 81% DEP). Participants who did not recall discussions with the canvasser are labelled in the graph as "did not recall the discussion at all."

Participants report lower understanding with the DR components of the program, including that Duke Energy would temporarily lower HVAC usage during Conservation Periods, the bill credits for participating in Conservation Periods, and the cycling level they could choose. While about half of participants (51% DEC, 56% DEP) understood cycling levels very well, 39% of DEC and 21% of DEP participants did not remember discussing cycling levels at all. These results are consistent with how program staff described the recruitment and enrollment process: canvassers would lead with the benefits of the thermostats to interest customers and explain the Conservation Periods second. Itron program managers also mentioned that, at the time of installation, customers were not always well-informed about the program. While it was unclear if that was because customers did not recall conversations with canvassers or if canvassers were not providing all the information, Itron did find that installers sometimes had to explain the program to customers.

While most participants understood the Wi-Fi network requirements for the program, 25% of DEC and 13% of DEP participants do not remember discussing Wi-Fi requirements with their canvasser. Again, while it is unclear if this is related to customer recall versus what canvassers emphasized during their recruitment pitch, this finding is interesting since Wi-Fi network issues are one of the top two reasons[23] that recruited customers turn down the thermostat at installation. Threshold Marketing managers reported that canvassers do check for Wi-Fi connectivity when qualifying customers but err on the side of enrolling customers when there are doubts about their eligibility, to give the Itron installers the opportunity to make the installation happen.

More DEP participants report understanding each program element very well compared to DEC participants. The differences between the two jurisdictions are unlikely to result from differences in program design, as the programs are run virtually identically in the two jurisdictions. The differences also do not appear to result from firmographic differences between the two jurisdictions as respondents report a similar composition of business types. It is likely that the differences arise from services delivered by different implementation staff in the two jurisdictions. As the jurisdictions are serviced by different individual canvassers and different individual installers, the differences between jurisdictions may be the result of particular staff members servicing the two territories.

[23] Program staff reported that Wi-Fi issues were tied with HVAC equipment issues as the top reason for turn downs.

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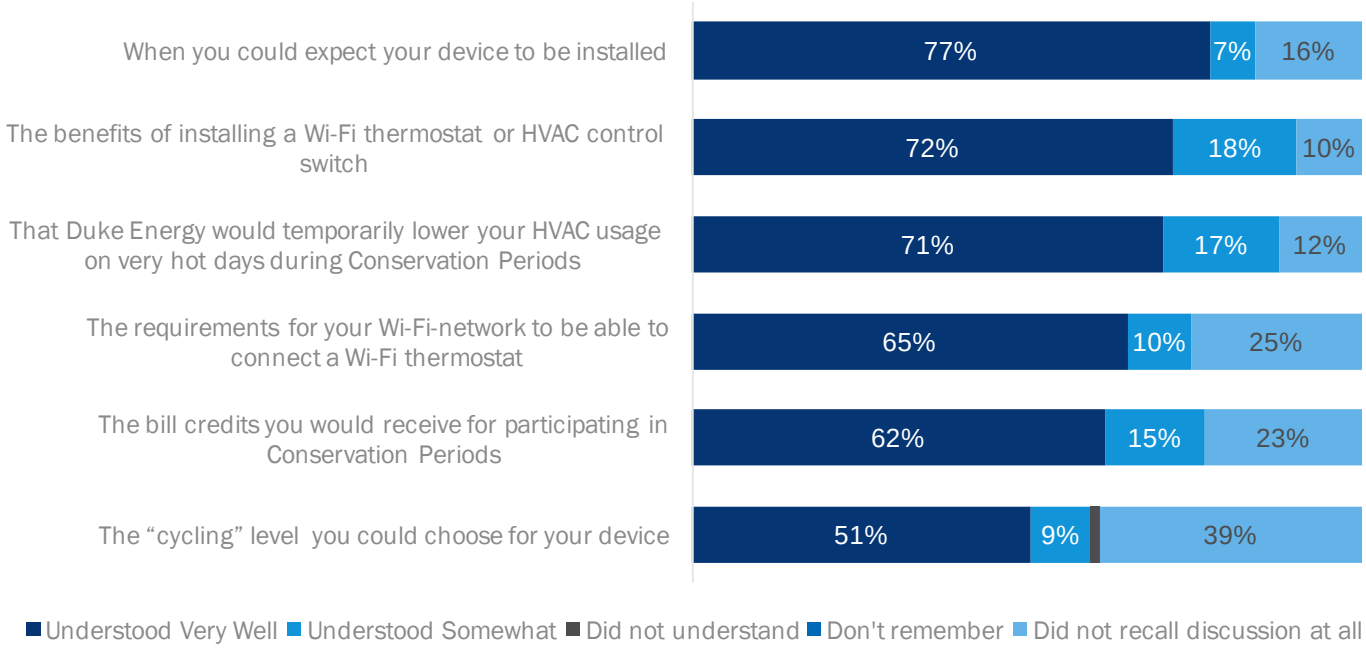
After enrolling in the program, most participants did not have any additional questions about the program (DEC 90%, DEP 82%). For those who did, questions typically related to bill credit timing and the number of demand response events Duke Energy planned to call.

Figure 6-7. Recruited Participants' Understanding of Elements: DEC (n=146)



Note: "Did not recall discussion at all" represents customers who did not recall talking about program elements with a Duke Energy representative during enrollment. "Don't remember" indicates customers who recalled talking about the element but did not remember how well they understood.

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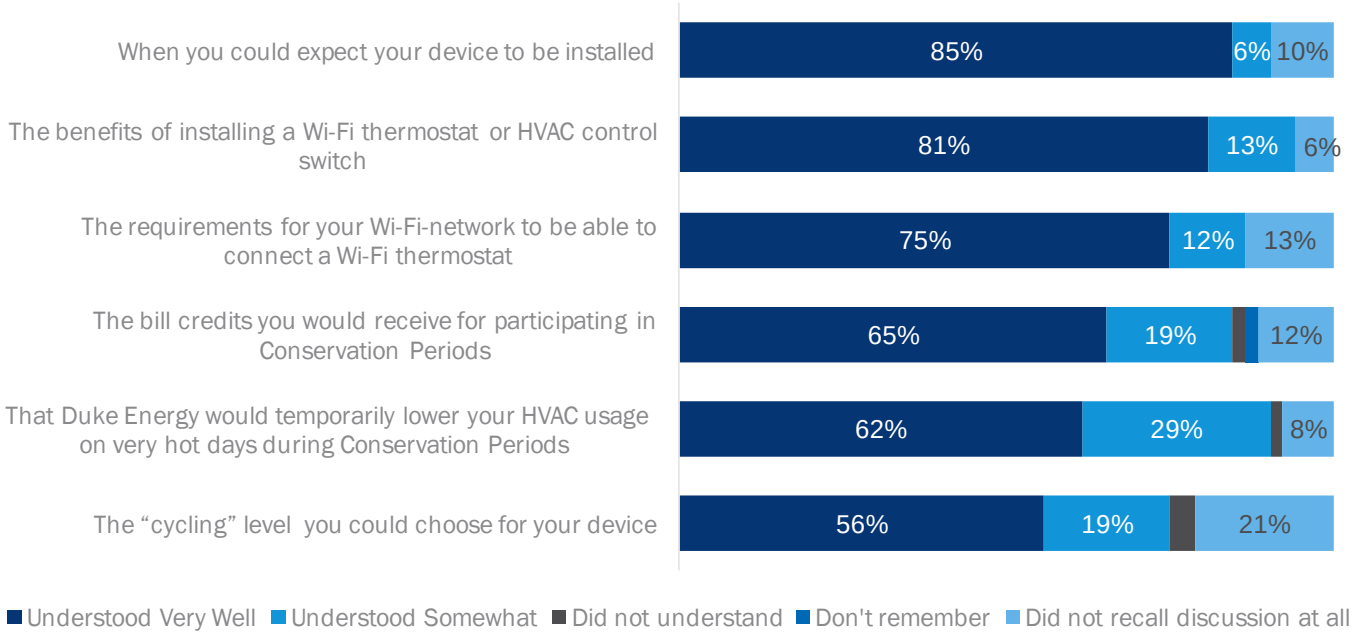
Figure 6-8. Recruited Participants' Understanding of Elements: DEP (n=52)



Note: "Did not recall discussion at all" represents customers who did not recall talking about program elements with a Duke Energy representative during enrollment. "Don't remember" indicates customers who recalled talking about the element but did not remember how well they understood.

Survey participants who were not recruited by a canvasser[24] report lower understanding of program elements before enrolling in the program than participants recruited by a canvasser. Most non-recruited participants report being unaware of the cycling level they could choose for their device (19 of 27 DEC, 6 of 9 DEP, see Figure 6-9 and Figure 6-10), when they could expect their device to be installed (18 of 29 DEC, 6 of 9 DEP), and the requirement for their Wi-Fi network to connect a Wi-Fi enabled thermostat (17 of 29 DEC, 6 of 9 DEP). The majority of DEC non-recruited participants also report being unaware that Duke Energy would call demand response events (17 of 29).

[24] The customers would have heard about the program through one of Duke Energy's other marketing channels and enrolled themselves online or by calling.

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Figure 6-9. Non-Recruited Participants' Understanding of Elements: DEC (n=29)

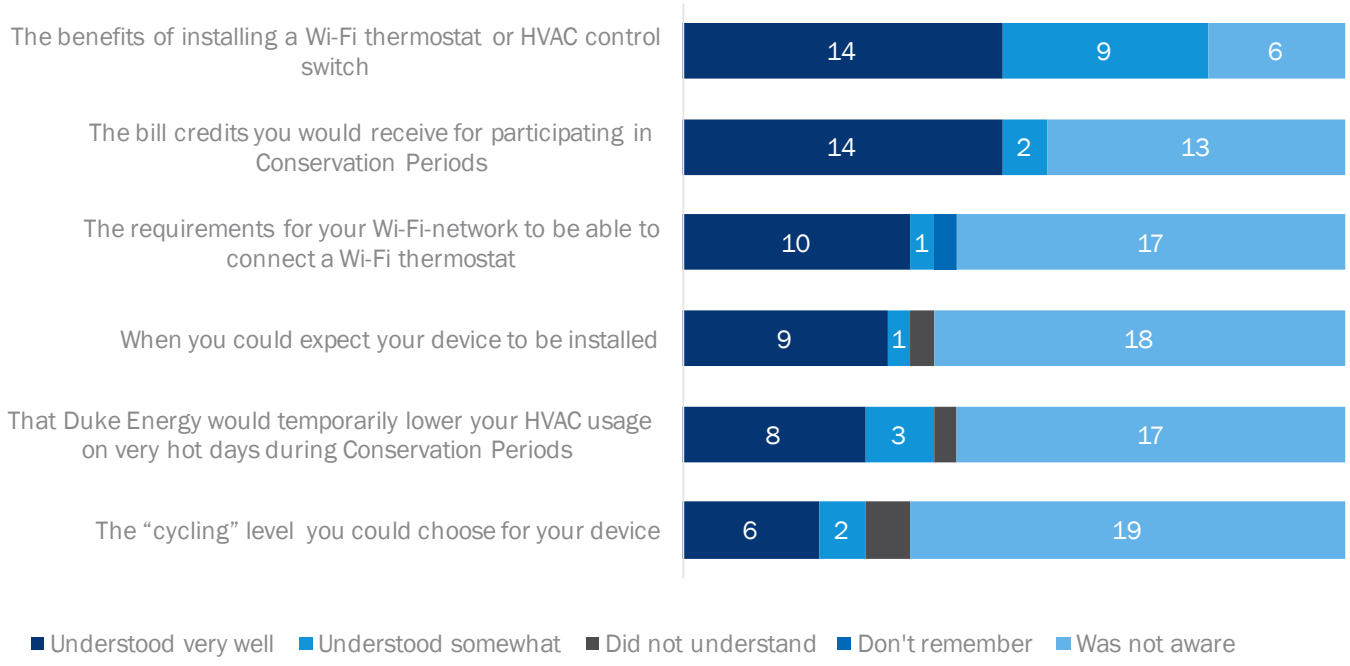
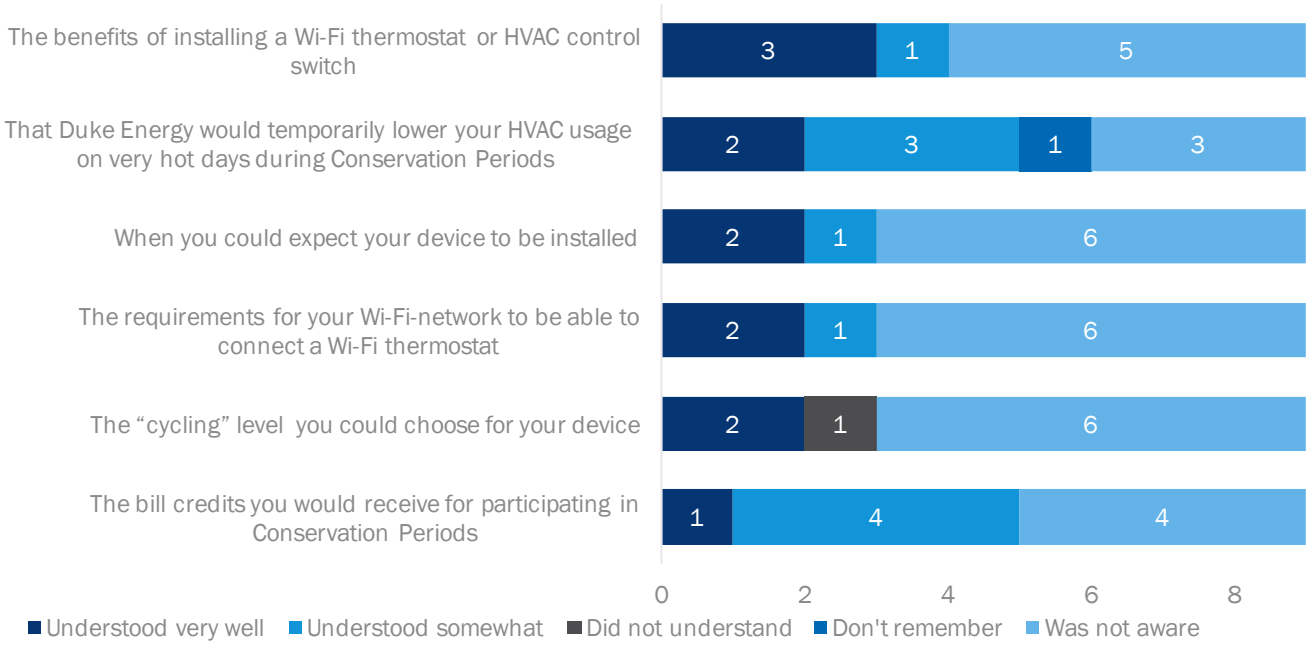


Figure 6-10. Non-Recruited Participants' Understanding of Elements: DEP (n=9)



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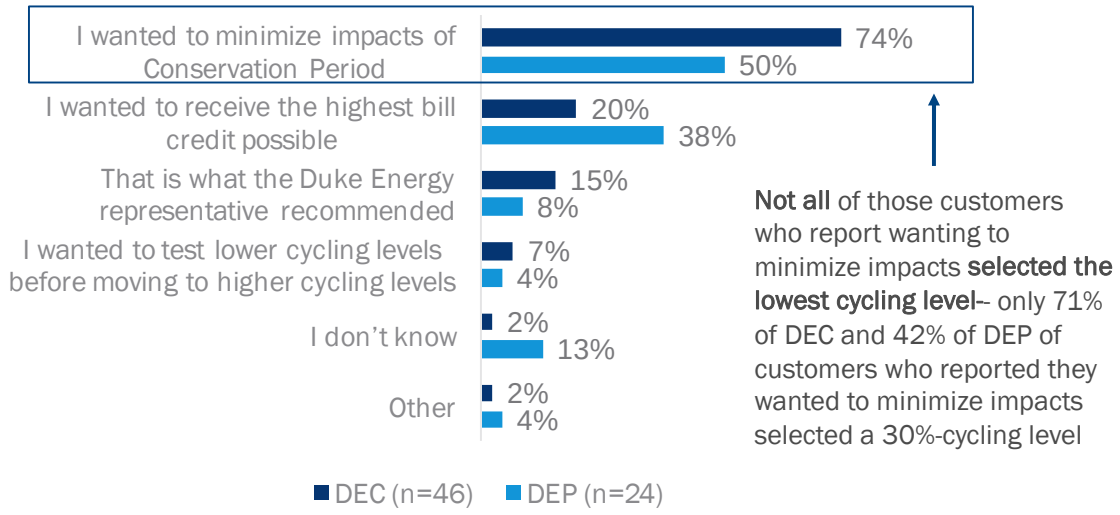
During program enrollment, customers are asked to select their cycling level. To better understand how well they understand cycling levels, participants were asked about their chosen cycling level. About half of DEC participants and almost two-thirds of DEP participants recall choosing a cycling level (52% DEC, 61% DEP, see Table 6-2). However, only about one-quarter of all participants correctly recall the cycling level they chose (22% DEC, 31% DEP). The evaluation team analyzed responses and did not find any correlation between the accuracy of cycling level recall and the cycling level the customer chose. These results further demonstrate the earlier finding that few participants understand their cycling levels; even amongst customers who remember choosing a cycling level, less than half knew what their cycling level was.

Table 6-2. Participant Recall of Cycling Levels

Recall of Cycling Level	DEC (n=180)	DEP (n=62)
Recalled correct cycling level	22%	31%
Recalled incorrect cycling level	5%	10%
Recalled choosing a level, but did not recall the level itself	25%	21%
Did not recall choosing cycling level	48%	39%

When asked their rationale for choosing their cycling level, most participants report a desire to minimize the impacts of Conservation Periods on their business (74% DEC, 50% DEP, see Figure 6-11). Surprisingly, a large portion of these participants selected a cycling level that did not align with this stated rationale. Of those who reported that they chose their cycling level to minimize the impact of Conservation Periods, only 71% (DEC) and 42% (DEP) selected the lowest (30%) cycling level. The remaining 29% of DEC and 58% of DEP participants chose a higher cycling level, meaning their selected cycling strategy would not minimize the impacts of Conversation Periods.

Figure 6-11. Participant Rationale for Choosing Cycling Level



Note: Figure includes only customers who recalled their cycling level, even if recalled incorrectly.
This question allowed for multiple responses.

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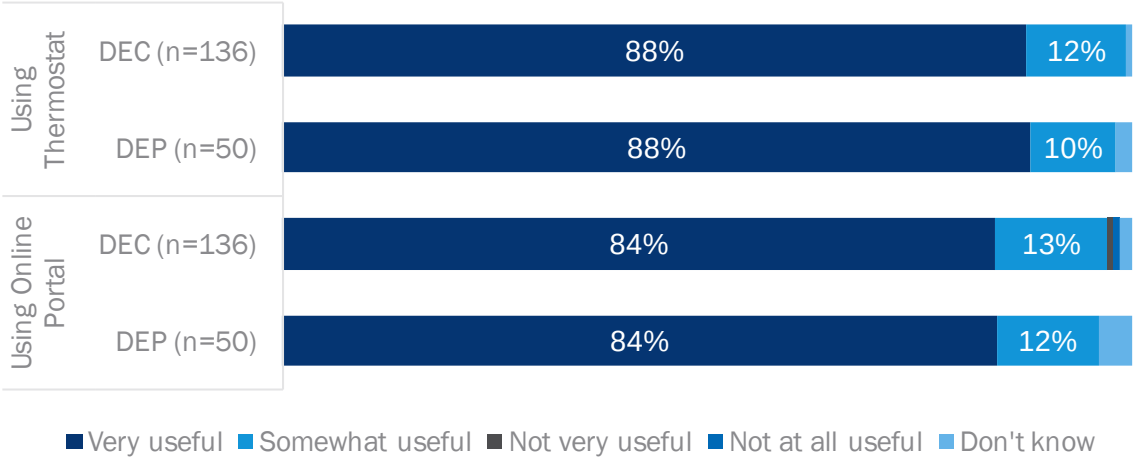
Installation Process

After enrolling in the program, customers schedule a time for program implementation staff to install their new equipment. During the installation, program implementation staff are tasked with conducting training regarding the thermostat itself and the online portal. Most participants in both jurisdictions report they were present during installation (82% DEC, 90% DEP). Of these, almost all recall the training administered by implementation staff (94% DEC, 93% DEP). Most participants report that both the thermostat training and portal training were very useful (88% for thermostat training and 84% for portal training, see Figure 6-12).

Figure 6-12. Participant Rating of Usefulness of Training about Using the Thermostat and the Online Portal



Note: Figure includes only customers who recalled training.

Program implementation staff are also tasked with programming new thermostats after installation. More than four-fifths of participants recall the installer programming their thermostat directly following the installation (88% DEC, 85% DEP, Table 6-3) and did not have additional questions for implementation staff. Of those whose thermostats were programmed, almost all report installers programmed their thermostat as requested (96% DEC and DEP). Of those instances where the installer did not program the thermostat, participants most often asked installers not to program the thermostat (6 of 14 DEC, 2 of 5 DEP), and only a few reported installers not offering to program their thermostats (3 of 14 DEC, 2 of 5 DEP). Very few participants have lingering questions about their thermostat (7% DEC, 6% DEP). Questions include how to set the thermostat to turn off the AC on weekends and how to switch between heating and cooling functions.

Table 6-3. Participant Recall of Representative Programming Thermostat

Representative Programmed Thermostat	DEC (n=144)	DEP (n=54)
Programmed	88%	85%
Did not program	10%	9%
Don't know	2%	6%

Note: Table includes only those customers present at time of installation.

One process-related research question for this evaluation was to understand how well Itron installers are doing in terms of enrolling customers with heat pumps into winter demand response events. Because winter DR is only applicable to customers with specific electric heating types, Duke Energy decided not to let canvassers

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or customers directly sign up for winter Conservation Period events. Instead, Itron installers are tasked with confirming customers' heating systems and asking eligible customers if they would like to participate in winter Conservation Period events. To assess how well that was happening, survey respondents were first asked about their heating equipment, and then, if applicable, whether they were offered winter event participation. Of survey participants who report having heat pumps, about half (45% DEC, 50% DEP, see Table 6-4) recall being offered the opportunity for winter participation, while one-third said they were not (36% DEC, 33% DEP).

Table 6-4. Participant Recall of Winter Participation Offered by Duke Energy Canvasser

Winter Participation Offered by Duke Energy Canvasser	DEC (n=75)	DEP (n=18)
Yes	45%	50%
No	36%	33%
Don't Know	19%	17%

Note: Table includes only those customers who report having a heat pump

Portal and Thermostat Usage

Participants were also asked about their usage of the program online portal and thermostat. More than three-quarters of participants were aware of the online portal prior to completing the survey, with DEP participants reporting higher awareness (85%) than DEC participants (76%). Of those who were aware of the portal, more than one-third report using the portal to control their thermostat's temperature (34% DEC, 40% DEP, see Figure 6-13). Few report regularly viewing information about how much their HVAC system has been running (10% DEC, 5% DEP) or information on their organization's energy use (10% DEC, 8% DEP). A large portion of customers are unaware of specific portal features or unaware or the portal altogether; taken together, about one-third of DEC and DEP participants are unaware of the portal's ability to display information about how much their HVAC system has been running (42% DEC, 32% DEP) and more than one-quarter are unaware of the portal's ability to display information on their organization's energy use (35% DEC, 27% DEP).

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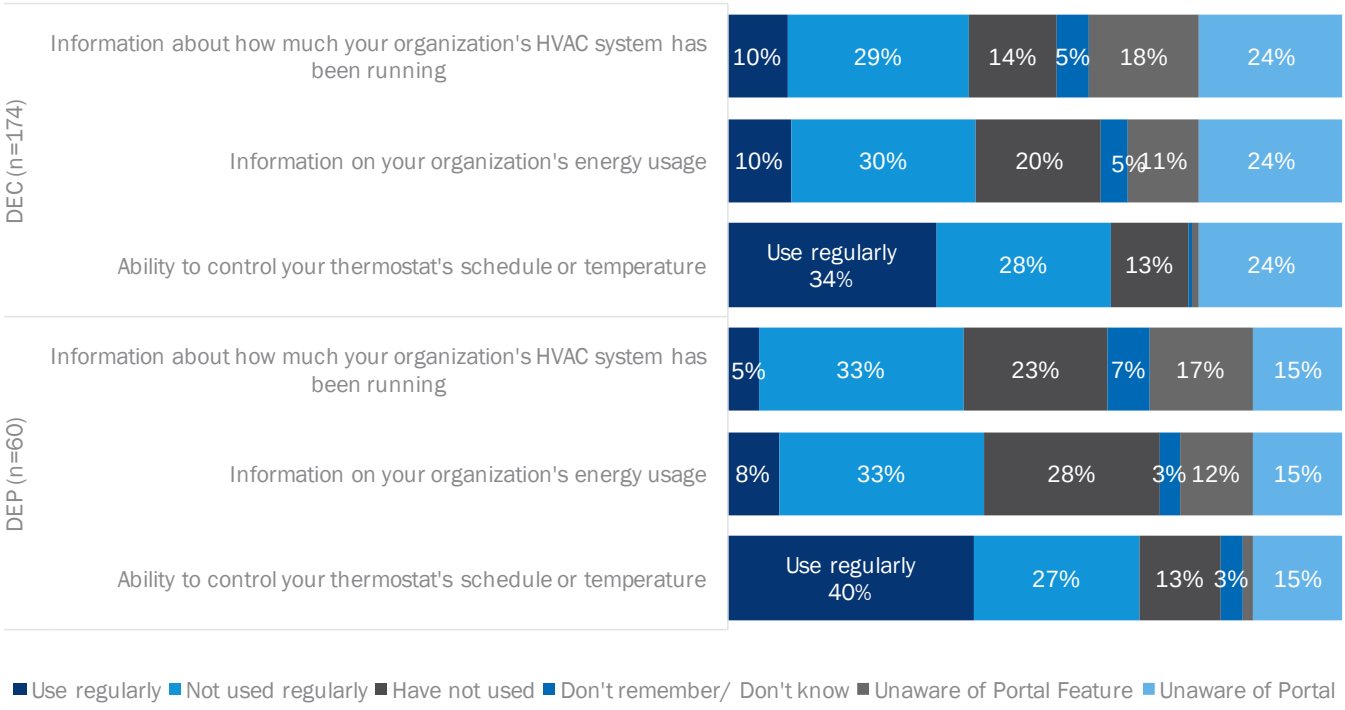
Figure 6-13. Participant Online Portal Awareness and Usage



Participants report lower satisfaction with the portal than with any other program element with the exception of their participation in Conservation Periods. Few participants regularly use portal features, which likely drives their dissatisfaction. Though the program has a smart phone application through which participants can control their thermostats, when asked how the portal could be improved, a small percentage of participants (6%) recommend improvements such as linking the portal to a phone app. These participants may not be familiar with the program's smart phone application. Participants also mentioned portal improvements such as the ability to switch between heating and cooling on the portal (2%),[25] making the website faster (2%), and allowing control of multiple thermostats from a single page (1%).

Early participants provided additional insights into the benefits of the portal. Most early participants have accessed the online portal (8 of 10) and have used the portal to control their HVAC systems over the weekend or at night (3 of 8) or to control multiple thermostats from a single page (3 of 8). One early participant who uses the portal to remotely control their AC felt the function was extremely useful, stating that "if my guys had set the air conditioning on at 70 degrees and then forgot to raise it when they went home or on a Sunday when we're closed, that was the critical thing for me." Another early participant lived far from his business and asked the interviewer to "imagine what it's like to get a call about a room being too hot and having to drive an hour to fix it." Another survey participant who controlled multiple thermostats at once commented: "[I decided to

[25] The Itron thermostat does not have the ability to automatically switch between heating and cooling.

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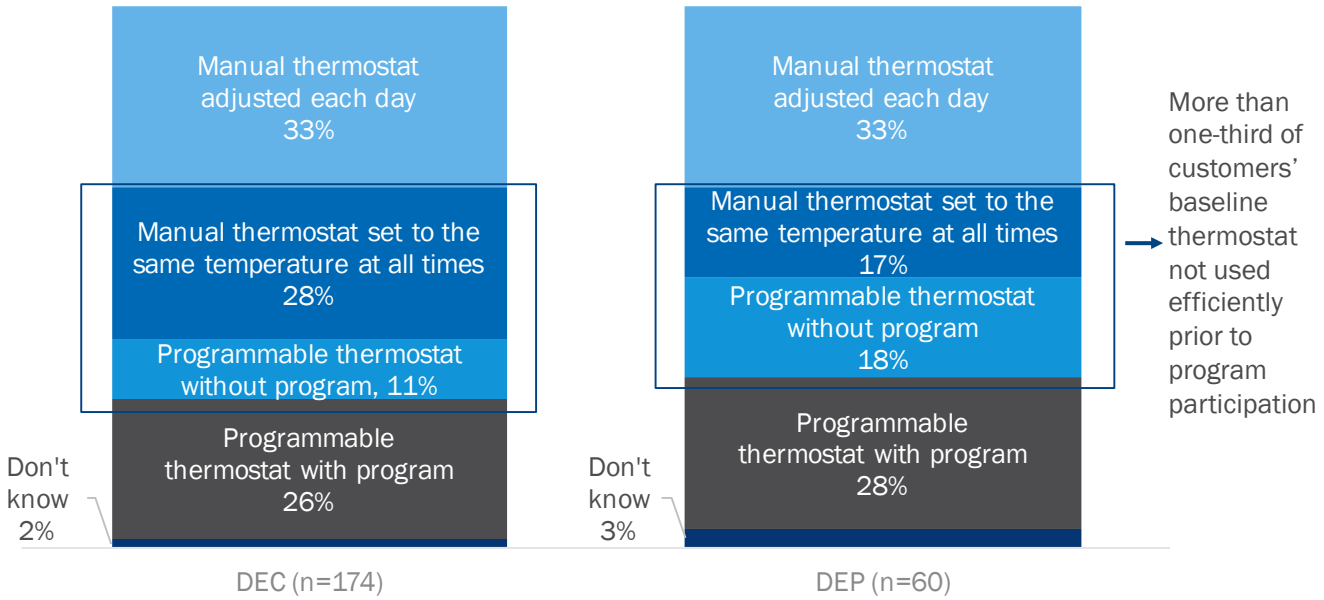
enroll in the] program for thermostats, that it could be programmed and set to one location. 'Cause if I went out and set all 10 of them right now, just walking it, I'd have a 30 minute walk."

The energy-saving benefits of the Wi-Fi-enabled thermostat are largely a function of how customers were using their existing (baseline) thermostat. More than one-third of participants report their baseline equipment was not adjusted daily and was therefore energy inefficient (39% DEC, 35% DEP, see Figure 6-14). Conversely, a little more than one-quarter of participants report having had a programmable thermostat that was programmed with a schedule (26% DEC, 28% DEP), while one-third had been adjusting the temperature on their manual thermostat every day.

Figure 6-14. Participant Thermostat Use Before Participation



Few participants report difficulties changing the programming of their Wi-Fi-enabled thermostats. About two-thirds of participants have changed their thermostat schedule since installation (65% DEC, 68% DEP). Of those who have not changed the schedule, most have had no need to change it (77% DEC, 93% DEP). Of those who have tried to change their schedule, almost all are able to do so successfully (95% DEC and DEP). Approximately two-thirds of participants report that making changes to their thermostat was very easy (63% DEC, 59% DEP, see Table 6-5) and most of the remaining participants report it was fairly easy (36% DEC, 38% DEP).

Table 6-5. Participant Thermostat Use After Participation

Difficulty of Making Changes to Thermostat	DEC (n=107)	DEP (n=39)
Very easy	63%	59%
Fairly easy	36%	38%
Somewhat difficult	2%	3%

Note: Table includes only those customers who were able to make changes to their thermostat's schedule.

Most participants have not experienced any problems with their new thermostat (72% DEC and DEP, see Figure 6-15). The most common issues reported by participants are losing the Wi-Fi connection with the

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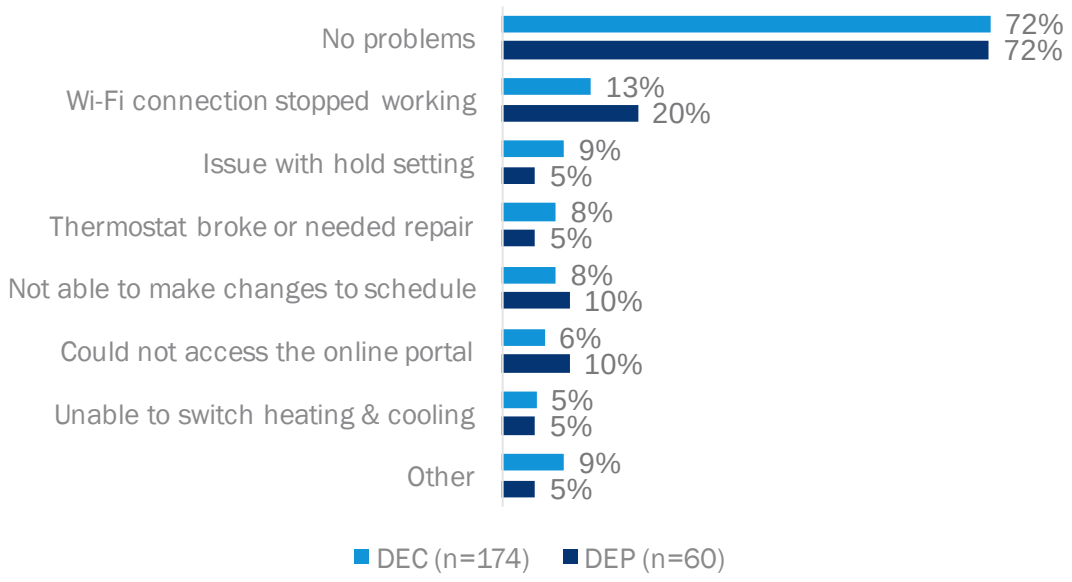
thermostat (13% DEC, 20% DEP), problems with the hold setting (9% DEC, 5% DEP),[26] or that the thermostat broke or needed repairing (8% DEC, 5% DEP).

Figure 6-15. Participant Difficulty with Thermostat



Note: This question allowed for multiple responses.

Only about one-quarter of participants have contacted a program representative for any reason (19% DEC, 29% DEP). Of these, most were able to contact the appropriate support staff member (94% DEC and DEP) and most were able to resolve their issue (77% DEC, 83% DEP). Survey participants generally called about lost Wi-Fi signals (6 of 35 DEC, 6 of 18 DEP), event opt-outs (4 of 34 DEC, 1 of 18 DEP), and hold issues (3 of 35 DEC). After talking with a program representative, most were able to resolve their issue (77% DEC, 83% DEP).

Summer Conservation Period Experiences

Nearly all participants recall participating in a summer Conservation Period event (89% DEC, 91% DEP). As noted above, participants rate their satisfaction with participation in these Conservation Periods lower than any other program element. Of those recalling Conservation Period events, almost all recall receiving some type of notification prior to the event (94% DEC, 96% DEP). Most participants recall receiving an email notification (82% DEC, 74% DEP, see Figure 6-16) and few recall notifications through the program's online portal (5% DEC, 7% DEP) or receiving a notification by the alert light on their thermostat (4% DEC, 10% DEP). Responses to the participant survey stand in contrast to responses from customers who unenrolled in the program, as described later in this section. Less than half of unenrolled customers (4 of 10) recall receiving advanced notification of a Conservation Period event.

[26] The hold function allows the user to override the pre-set temperature and thermostat setting.

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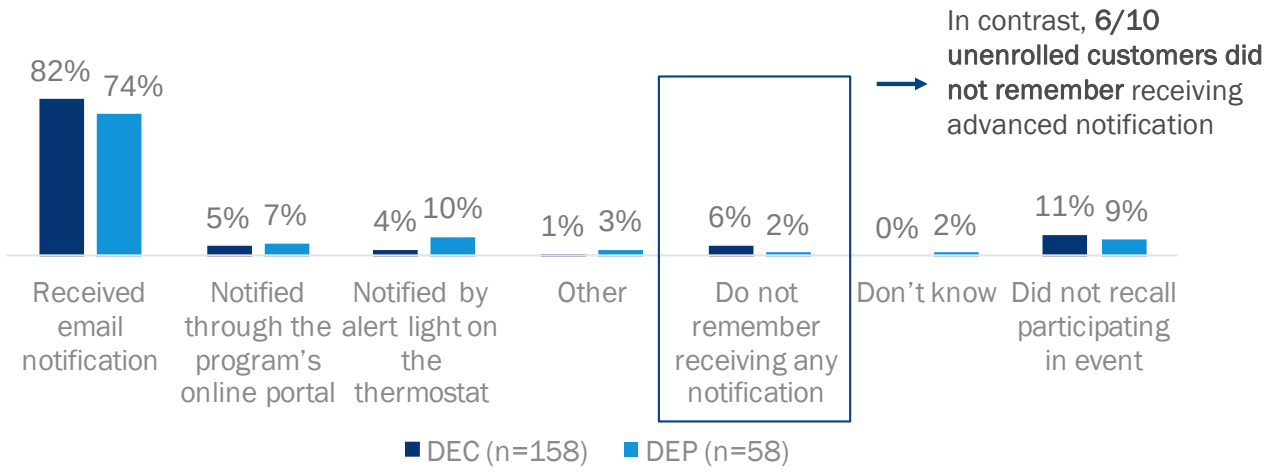
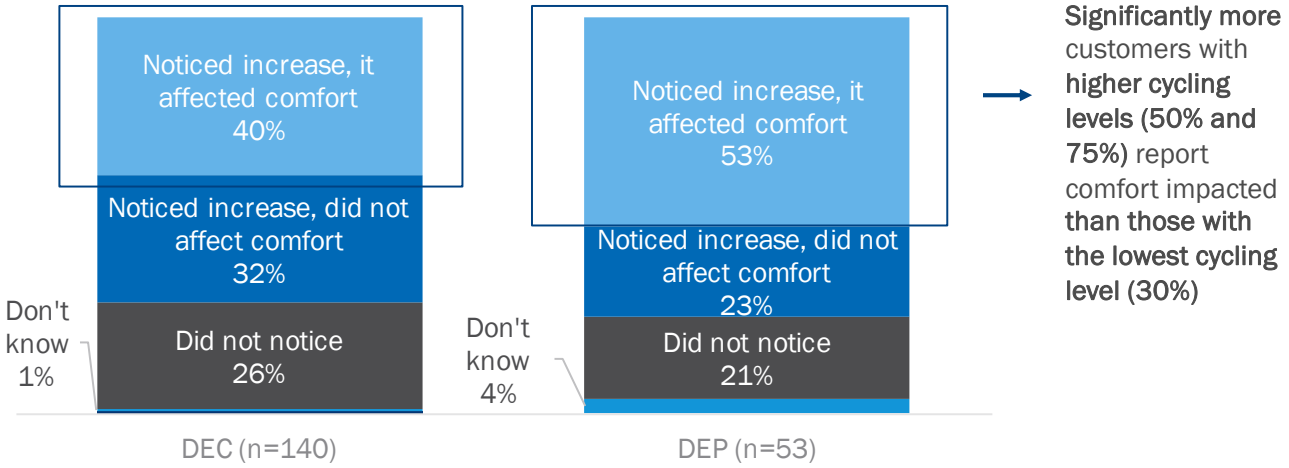
Figure 6-16. Participant Types of Advanced Notification



Note: This question allowed for multiple responses.

Participants recalling events had different perceptions of how the events affected their facilities' temperature and comfort. About one-quarter of participants (26% DEC and 21% DEP) did not notice any changes in temperature during the events (see Figure 6-17). Slightly more (32% DEC and 23% DEP) noticed temperature increases that did not impact their comfort. However, two-fifths of DEC participants and about half (53%) of DEP participants did report that temperature increases during the Conservation Periods impacted their comfort. When comparing perceived impacts of Conservation Periods to cycling levels, significantly more participants with higher cycling levels (50% or 75% cycling levels) report that their comfort was impacted by Conservation Periods than those with the lowest cycling level (30%).

Figure 6-17. Participant Perceived Impact of Conservation Periods on Temperature and Comfort



Note: Totals may not sum to 100% due to rounding.

The majority of participants report they are very likely to continue participating in Conservation Periods in future years (71% DEC, 57% DEP, see Figure 6-18). Participants who are unlikely to participate in future years

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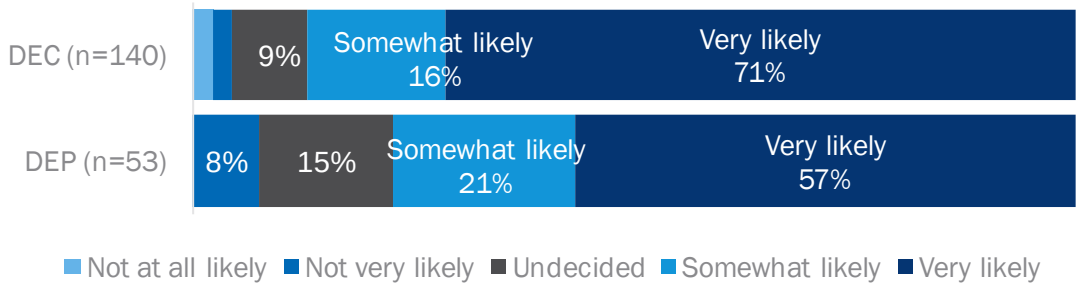
mentioned the high number of Conservation Periods[27] (2 of 6 DEC, 1 of 4 DEP) and Conservation Periods impacting business (1 of 6 DEC, 1 of 4 DEP) as the reasons why they are unlikely to participate. One survey participant reports "we noticed the temperature change and made it vastly uncomfortable for my employees and we needed to close."

Figure 6-18. Participant Likelihood of Continued Participation



Note: Figure includes only customers who recall Conservation Periods.

To better understand the implications of discomfort during events on customers' experiences and likelihood of continuing in the program, the evaluation team explored the statistical relationships between participants' cycling level, satisfaction, and likelihood to participate in the program in the future. First, the evaluation team found that experiences during Conservation Periods are highly correlated with overall satisfaction with the program and program elements. Compared to those whose comfort was not affected, participants whose comfort was affected have significantly lower satisfaction with events (mean of 6.1 versus 9.1 and 9.7, see Figure 6-19) and the program overall (mean of 7.6 versus 9.7 and 9.2); they are also significantly less likely to participate in the future.[28]

[27] The program called five events in 2017 out of the maximum of ten events allowed through the enrollment contract.

[28] Testing of statistical significance was conducted on the combined DEC and DEP results.

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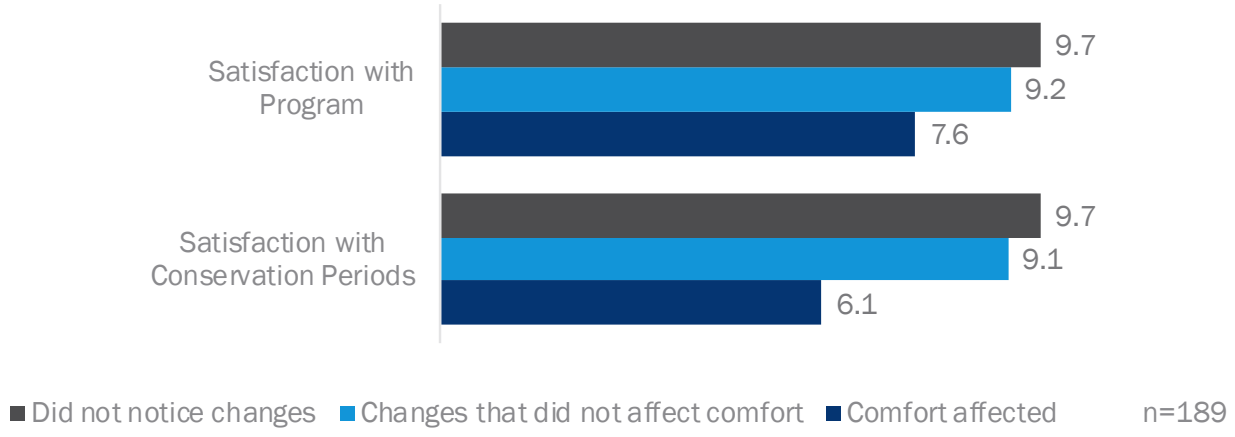
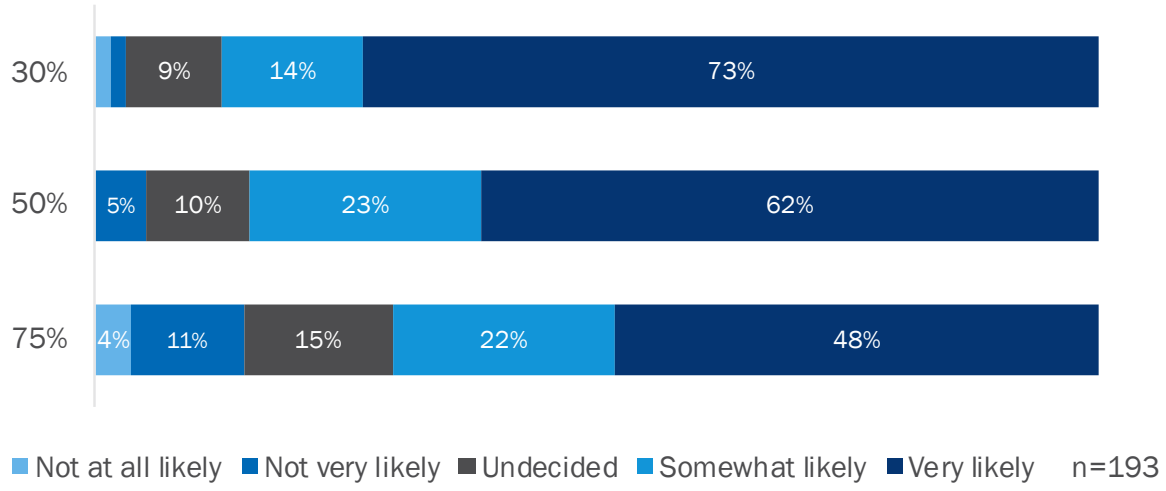
Figure 6-19. Mean Participant Satisfaction by Conservation Period Experience (DEC and DEP Combined)



The evaluation team also explored how this dynamic varied across cycling levels. The evaluation team found that participants with the lowest cycling level are significantly more satisfied with Conservation Periods and more often report they are very likely to participate in the program in the future (73% versus 62% and 48%, see Figure 6-20).

Figure 6-20. Participant Likelihood of Participating in Future by Cycling Level (DEC and DEP Combined)



Given the earlier finding that some customers did not understand cycling levels and Conservation Periods well when enrolling in the program, the evaluation team explored how much of the pattern between satisfaction, cycling level, and future participation was driven by customers' understanding of the program when they enrolled. Participants who understood Conservation Periods very well when enrolling are significantly more satisfied with the program and Conservation Periods than those who only somewhat understood the Conservation Periods (mean of 8.9 versus 8.3, see Figure 6-21). Those who understood cycling levels very well when enrolling are significantly more satisfied with the program than those who only somewhat understood cycling levels (mean of 8.4 versus 6.8, see Figure 6-22.

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Figure 6-21. Participant Satisfaction by Understanding of Conservation Periods (DEC and DEP Combined)

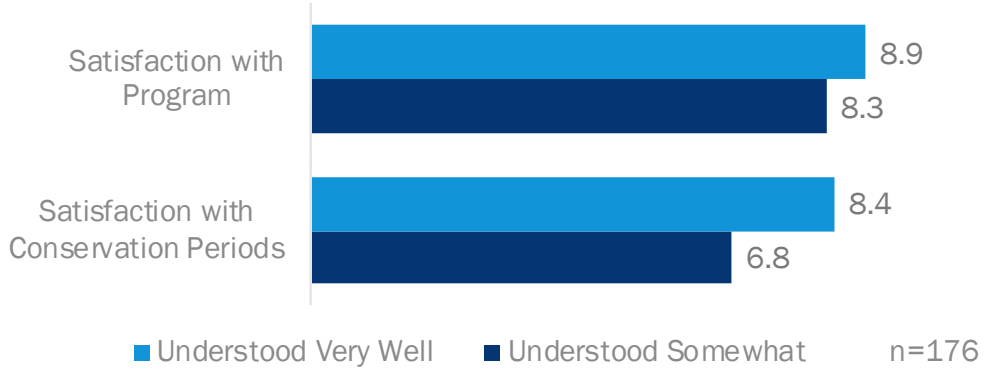
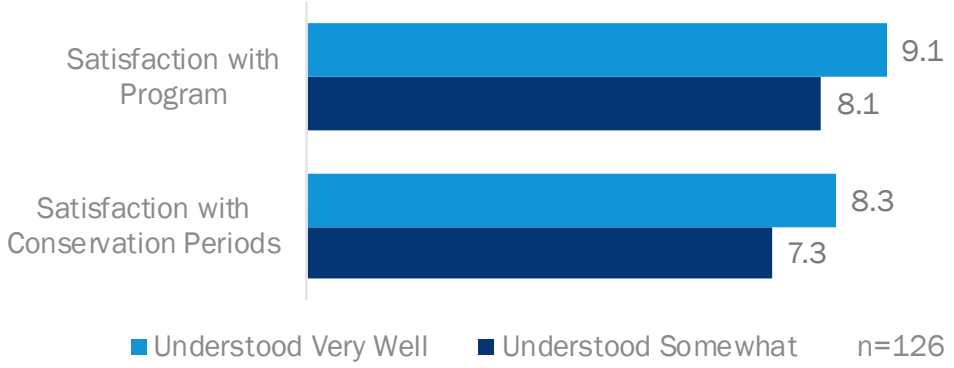


Figure 6-22. Participant Satisfaction by Understanding of Cycling Levels (DEC and DEP Combined)



The evaluation team also examined the statistical relationship between business type and participant satisfaction. The team found that restaurants have significantly lower satisfaction with the program overall (7.5) and with Conservation Periods (5.4) than other business types (8.7, 8.2).[29] These results are unsurprising as over three-quarters of restaurant participants report that Conservation Periods affected their comfort. Restaurant participants also report they are less likely to participate in the Conservation Periods in the future. In line with this customer feedback, opt-out analysis indicates that restaurants and food service establishments tended to opt out of 2017 Conservation Periods at a higher rate (5% to 14% per event) than non-food businesses (3% to 5% per event).

[29] The evaluation team did not find statistically significant differences for other common participant business types (medical, office, retail, light industry, or place of public assembly or worship). The evaluation team may have been unable to detect differences among these groups due to smaller sample sizes.

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Based on program-tracking data, a small share of survey participants opted out of at least one Conservation Period (6% DEC, 15% DEP).[30] When asked, almost all of these participants recalled their request (9 of 10 DEC, 7 of 8 DEP). Some of these participants simply had a special need on the day of the event, such as a "changing daily work load [that] can cause higher need on some afternoons" or that the Conservation Period "was supposed to happen during a time when we had many clients scheduled." Others noted that Conservation Periods were impacting business functions. One participant mentioned that their "office was getting too warm to the point that productivity was lost and some employees left early." Participants who opt out of Conservation Periods are also significantly less likely to participate in the program in the future compared to those who did not opt out of an event.

6.2.2 Non-Participant Customer Experiences

The following section presents results from the non-participant customer interviews. The evaluation team conducted 10 interviews with customers who were approached about the program but decided not to participate. The interviews explored non-participant customer barriers to enrolling in the program, understanding of program elements, and understanding of Conversation Periods.

Firmographics

The evaluation team spoke with representatives from ten companies who were recruited by a canvasser but declined to participate in the program ("non-participants").[31] The evaluation team spoke with these companies' managers (6 of 10) and company owners (4 of 10). Non-participants were fairly evenly split between companies with few employees and companies with a moderate number of employees (4 companies employ fewer than 10 employees at all locations; 6 employ between 10 and 55 employees at all locations). More of the interviewed non-participants are in the retail business sector (5 of 10, Table 6-6) compared to respondents to the participant survey (29% DEC, 21% DEP).

[30] In the final year-end population, about 11% of customers across both jurisdictions opted out of at least one event.

[31] Due to the small sample size, the evaluation team did not break out results by jurisdiction.

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Table 6-6. Non-Participant Firmographics

Characteristic	Count (n=10)
Business Type	
Retail	5
Restaurant	3
Construction	1
Office	1
Tenure	
Lease	6
Own	4
Thermostats	
One	7
Two or more	3

Barriers to Enrollment

Most interviewed non-participants were aware of the program (8 of 10), and for those unaware, interviewers described the main features of the program. Though most non-participants were visited by canvassers according to the program-tracking data (7 of 10), only a few recalled the visit (3 of 10). Others heard about the program through mailers (3 of 10), phone calls from Duke Energy representatives (3 of 10), and email (1 of 10).

The most common reason for non-participation was the perception that the program would negatively impact business (6 of 10, Table 6-7). Other reasons for non-participation included satisfaction with current thermostat systems (2 of 10), a lack of trust of networked devices (1 of 10), distrust of an outsider controlling the thermostat (1 of 10), and currently ineffective air conditioning equipment (1 of 10).

Table 6-7. Non-Participant Barriers to Program Enrollment

Barrier to Enrollment	Count (n=10)
Would negatively impact business	6
No need for more complicated system	2
Does not trust networked infrastructure	1
Did not like concept of outsider controlling thermostat	1
Air conditioning currently struggling to cool business	1

Note: Barriers to participation coded from customer open end responses.

Interviewed non-participants generally fall into one of two groups: those who felt their business was not a good target for the program (4 of 10), and those who felt their outdated equipment or uninsulated facility would increase the impact of the Conservation Periods (3 of 10). One non-participant who thought their business was not a good target owns a massage parlor and reported that "...people are pretty picky about being comfortable while they're getting their massage. Noise level and air quality are probably the two really important things for my type of business." Among those who felt Conservation Periods would overly impact their businesses, one non-participant thought that their facility "...heats up in here really quick. We've had a couple problems over the years with our AC, and when it stops working you know it very, very quickly."

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Understanding of the Program and Events

The evaluation team also asked questions to understand whether these customers' decision not to participate was related to an incomplete understanding of the program. For non-participants who were familiar with the program (8 of 10), most understood the program when declining participation (6 of 8). Only one non-participant was not familiar with the cycling level options and one other non-participant was not familiar with the ability to opt out of events. Interviewed non-participants did not have any additional questions about the program and were not interested in learning more about the program.

Though our sample size was too small to extrapolate findings to the population, interviewed non-participants generally did not seem like good candidates for program participation or likely future participants. In other words, it did not appear that there was an opportunity to increase their participation by better explaining the program.

6.2.3 Unenrolled Participant Experiences

The following section presents results from interviews with 10 customers who enrolled in the program but later decided to no longer participate in Conservation Periods ("unenrolled participants"). These interviews explored reasons for unenrollment, reasons for initial enrollment, understanding of program elements, understanding of Conservation Periods, and experiences with the program call center.[32]

Firmographics

Interviewed unenrolled participants included company executives, such as owners (5 of 10, see Table 6-8), managers (3 of 10), and CFOs (2 of 10). Most interviewed unenrolled participants employ fewer than 10 employees (6 of 10) and the remaining companies employ between 10 and 49 employees (4 of 10). Many are retailers (5/10) and most are renting their facilities (8/10). More of the unenrolled participants are in the retail business sector (5/10, see Table 6-8) compared to respondents to the participant survey (29% DEC, 21% DEP). The evaluation team interviewed approximately the same portion of single thermostat unenrolled participants (6 of 10) as we did for the participant survey (60% DEC, 45% DEP).

[32] Due to the small sample size, the evaluation team did not break out results by jurisdiction.

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Table 6-8. Unenrolled Participant Firmographics

Characteristic	Count (n=10)
Business Type	
Retail	5
Gym/exercise facility	2
Restaurant	2
Place of worship	1
Tenure	
Lease	8
Own	2
Thermostats	
One	6
Two or more	4

Reasons for Unenrollment

Almost all interviewed customers (9 of 10) chose to unenroll their thermostats because higher temperatures during Conservation Periods were impacting business. One customer noted that "it [getting over 90 degrees] was happening all the time." Another unenrolled participant stated that on "one day in particular, it was 90-some degrees outside, and within 20 minutes, my restaurant was over 95 degrees." A third reported that Conservation Periods were getting "extremely prohibitive because when that would happen, it would get up to like 85, 90 degrees in here... It was driving off customers." Based on these responses, the evaluation team expected unenrolled participants to have selected higher cycling levels, however, most had selected the lowest possible cycling level (Table 6-9).[33]

Table 6-9. Unenrolled Participant Customer Cycling Level

Cycling Level in Program Data	Count (n=10)
30%	7
50%	2
75%	1

Undersized equipment or lack of insulation may have caused higher indoor temperatures during Conservation Periods for unenrolled participants. Three unenrolled participants specifically mentioned that lack of insulation or undersized equipment made participation in Conservation Periods more difficult.[34] One customer stated that "This is an older building, but we also have a blower on the oven, and that helps reduce some of the excess heat from the oven, but when you got the sun bearing down... We got those sun bearing down on those rooftops, they're metal rooftops... It's just going to cause it to get really hot." Another customer reported that their air conditioners could not keep up with the cooling load, stating that "by 3:30, 4:00 in the afternoon, bam, there, we got to turn the air on.... I mean, I don't know if it's because of the space we have, or if it's our

[33] Only a few unenrolled participants recall the cycling level (3 of 10).

[34] Statements were collected from the customers who explicitly mentioned their facilities and equipment in the interviews.

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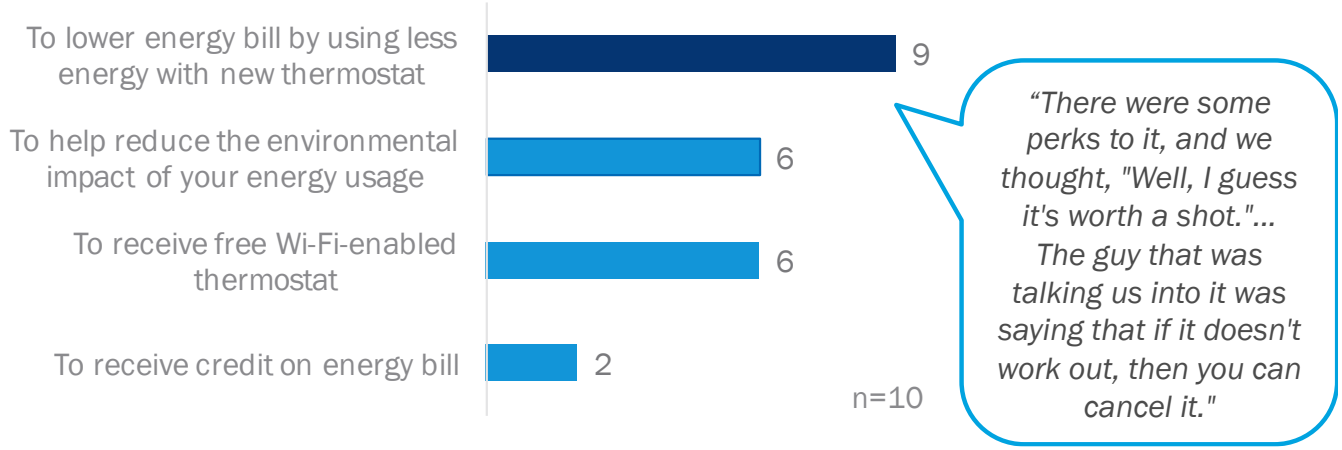
... Or if our air conditioners are just ... I mean, I know they're not efficient." Another customer noted that their space was not well-suited to changes in the temperature and that "it takes about an hour to cool down our warehouse, so it's not gonna be cool out there even when our last group starts [during the Conservation Period]." These experiences could explain why 30% cycling levels produced such high temperatures for several interviewed unenrolled participants.

Eight of the ten unenrolled participants reported they would have never enrolled if they had understood the full ramifications of the program. Notably, both of the interviewed staff representing gym facilities mentioned that demand response programs were not appropriate for their business type. One gym facility staffer reported that participation in the program did not fit the national gym standard their facility subscribed to, stating that "it's even like an ACSM [American College of Sports Medicine] guideline that you do not go above 72 in those conditions." However, when compared to participant survey responses, results were mixed in terms of whether gym customers were satisfied with the program.

Reasons for Initial Enrollment

The evaluation team explored whether there are any differences in the rationale for initial program enrollment between unenrolled participants versus on-going participants, to better understand why customers unenroll from the program. Similar to ongoing participants, almost all interviewed unenrolled participants were originally motivated by lower energy bills (9 of 10, see Figure 6-23). On-going participants are more often also motivated by receiving a bill credit (53% DEC, 61% DEP) than unenrolled participants (2 of 10), and conversely, unenrolled participants are more often motivated by receiving a free Wi-Fi enabled thermostat. Thus, these unenrolled customers may have less motivation to continue DR participation, as they still continue to utilize the program Wi-Fi enabled thermostat (which was more often cited as a motivation for initial participation) and only lose out on the bill credits (which was less often cited as a motivation for initial participation). One unenrolled participant reported that implementation staff stated, "that if it doesn't work out, then you can cancel it."

Figure 6-23. Unenrolled Participant Reasons for Initial Enrollment



Note: This question allowed for multiple responses.

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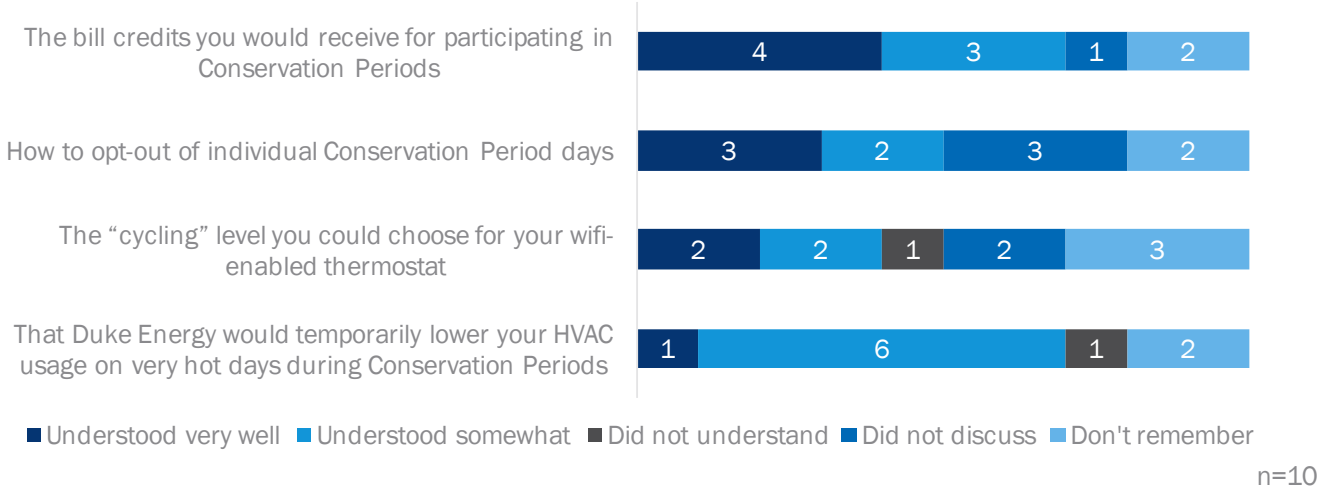
Understanding of the Program and Events

Interviewed unenrolled participants generally seemed less familiar with program elements than on-going participants, which may have contributed to their unenrollment. Fewer unenrolled participants (1 of 10, see Figure 6-24) reported understanding very well when they enrolled in the program that Duke Energy would lower HVAC usage during events, compared to ongoing participants (68%). Unenrolled thermostat customers generally had very high temperatures in their facilities and participating in any event seemed like an issue – not just an issue of them not understanding how to opt out of the occasional Conservation Periods that might pose an issue for their business. Most unenrolled participants understood in a general sense that Duke Energy would lower their HVAC usage, but many did not have a sense of the timing or the impact of that timing. The program could very well have given customers information about the program and the various elements, but customers did not recall it and did not feel they have a firm understanding.

Figure 6-24. Unenrolled Participant Understanding of Program Elements



More than half of interviewed unenrolled participants felt they had an incorrect understanding of Conservation Periods when they enrolled (6 of 10). Before experiencing Conservation Periods, one customer thought that Conservation Periods would be called at different times of the day instead of just during the peak hours. Another customer reported that information about Conservation Periods was not shared, and felt that Duke Energy staff "need to say, 'This happens every year, this is exactly how it's gonna work, it's a three-hour time period, your air condition's gonna be on for this amount of time, it's gonna be off for this amount of time' … It's just … And there's no documentation to explain the Conservation Period or how much that works."

Experiences with the Call Center

Unenrolled participants generally had positive experiences with the program call center, though few mentioned that call center staff had employed retention strategies when they called to unenroll. Almost all (9 of 10) unenrolled participants reported that call center staff were friendly and helpful. When customers called to unenroll, the only drop-out prevention strategy customers described being used by call center staff was discussing the loss of their Conservation Period rebate (2 of 10). The evaluation team did not ask explicitly about retention strategies for the program but asked generally about unenrolled participants' experience with the call center. One customer reported that they did not realize they would receive a rebate for participation in Conservation Periods until they called to unenroll. Another customer mentioned a drop-out prevention

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strategy to the call center staff, recalling that “after we opted out of the first one, I called back and said, ‘Hey can we go down to like the next lowest one?’ Which was I think 50%." Call Center staff may be employing these or other retention strategies, but the small sample of unenrolled participants the evaluation team spoke with did not mention them when asked generally about the call center staff.

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7. Conclusions and Recommendations

7.1 Conclusions

Our evaluation of the 2017 EWB program found that program participants are satisfied with the program and are motivated to enroll to save money on their energy bill. Further, despite participants indicating that they understand program elements very well overall, survey results suggest that participants have a relatively low understanding of cycling levels, and only a quarter of participants could correctly recall their cycling level. Despite overachieving device installation goals, the program did not achieve its per device impact goals, and device enrollment was heavily skewed towards the lower cycling strategies. Overall, the program achieved demand impact realization rates of 72% for DEC and 70% for DEP and energy impact realization rates of 204% for DEC and 5% for DEP.

The following bullets present key findings and conclusions from our evaluation.

- Total participation exceeded expectations, but participant characteristics are different than Duke Energy's expectations. Overall, we found that customers enrolled 6,793 devices in 2017, achieving 182% of the program enrollment goal.
    - The majority of enrolled devices were in DEC territory (72%) compared to DEP (28%). Most participants selected thermostats (91%), exceeding the anticipated share (60%).
    - The majority of participants selected the 30% cycling strategy, which is the lowest strategy available: 84% of DEC participants are enrolled in the 30% cycling strategy compared to 53% of DEP participants. For DEC, enrollment shifted towards lower cycling strategies from 2016 to 2017.
    - Average size of HVAC units controlled by devices installed in 2017 remained relatively unchanged from 2016, at 4.2 tons.
- The program called five summer Conservation Period events in 2017 and achieved average per event demand savings of 2,582 kW in DEC and 1,421 kW in DEP.
    - As noted above, both utilities underachieved their goals, despite overall enrollment exceeding goals. Device enrollment was heavily distributed towards lower cycling strategies.
    - Per device load impact realization rates were lower than anticipated goals across jurisdictions (56% for DEC and 55% for DEP) and cycling strategies.
    - Operational rates and opt-out rates were consistent with Itron's expectations for the program (on average, of the eligible units, 4% to 7% opted-out and 91% cycled).
- The thermostats installed through the program in 2017 achieved energy savings of 2,296,448 kWh in DEC and 31,737 kWh in DEP.
    - Despite exceeding thermostat installation goals across both jurisdictions, per device energy efficiency savings realization rates were lower than expected in both jurisdictions.
    - Cross-participation adjustments substantially reduced energy impacts for both jurisdictions.
    - Despite similar program design and implementation, and few differences in the types of facilities enrolled, the evaluation identified substantial variation in energy efficiency savings between DEC

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and DEP: consumption analysis results showed unadjusted energy savings for DEC participants more than 2.5 times those of DEP participants. While the cross-participation analysis found a smaller savings adjustment for DEP participants in absolute terms, it was much higher than for DEC participants as a percentage of unadjusted energy savings. Our analysis found that DEP participants tend to have lower annual average baseline usage and summer average baseline usage than DEC participants, as well as slightly lower average tonnage in terms of the HVAC units being controlled. Other factors, such as customer behavior, e.g., engagement with their thermostat, may play a role. Survey results suggest that DEP customers may change their set points or use the web portal more frequently than DEC customers.

- Participants are generally satisfied with the program overall (mean ratings of 8.8 for DEC and 8.2 for DEP).
  - There are small, but significant, differences in participant satisfaction across territories. DEP participants report significantly lower satisfaction with the program overall (mean 8.2) and with Conservation Periods (mean of 7.2) than DEC participants (means of 8.8 and 8.3, respectively).
  - Participants with the 30% cycling level are significantly more satisfied with Conservation Periods and more often report that they are very likely to participate in the program in the future, compared to those enrolled in higher cycling levels.
  - Restaurants have significantly lower satisfaction with the program overall (mean rating of 7.5) and with Conservation Periods (5.4) than other business types (8.7 program overall, 8.2 Conservation Periods). Restaurants and food service establishments tended to opt out of Conservation Periods at slightly higher rates than other types of businesses.
- Participants most often report being motivated to enroll in the program to lower their energy bills (79% DEC, 71% DEP).
- Most participants report understanding program elements very well, and this understanding is linked to participant satisfaction.
  - Participants who understood Conservation Periods very well when enrolling are significantly more satisfied with the program and Conservation Periods than those who only somewhat understood the Conservation Periods.
  - Participants who understood cycling levels very well when enrolling are significantly more satisfied with the program than those who only somewhat understood cycling levels.
  - Few participants correctly recall which cycling level they chose (22% DEC, 31% DEP).
- Of those participants who have tried to change their thermostat schedule, almost all are able to do so successfully (95% DEC; 95% DEP).
- Less than half of participants use the online portal to control their thermostat's schedule or temperature.
  - About one-third of DEC and DEP participants are unaware of the portal's ability to display information about how much their HVAC system has been running (42% DEC, 32% DEP) and more than one-quarter are unaware of the portal's ability to display information on their organization's energy use (35% DEC, 27% DEP).
- About half of participants with electric heat pumps recall implementers offering the winter demand response option (45% DEC, 50% DEP).

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- About one half of DEP participants (53%) and two-fifths of DEC participants (40%) experienced discomfort during the Conservation Periods.
  - Participants whose comfort was affected report significantly lower satisfaction with Conservation Period events and the program overall and are less likely to participate in Conservation Periods in the future.
- Non-participants most often report not enrolling in the program because they feel their business would be negatively impacted by the Conservation Periods (6 of 10).
- Participants chose to unenroll from Conservation Periods because higher temperatures were impacting their business (9 of 10).

7.2 Recommendations

Our recommendations focus on a core set of actionable efforts to increase program impacts while maintaining customer satisfaction, including those related to customer recruitment, education, and retention; program implementation enhancements; device functionality and operations optimization; and data tracking improvements. Notably, we understand that Duke Energy developed this program to provide small business customers an opportunity to participate in demand response, since these customers pay a surcharge but did not have an opportunity to participate in these programs. As a result, recommendations must be considered in light of enhancing program cost-effectiveness as well as equitably serving this historically underserved population.

Recommendation: Customer Recruitment, Education, and Retention

The EWB program staff and their implementation contractors far exceeded enrollment goals in 2017. In fact, recruiters were so successful that the program experienced a backlog in the second half of 2016 where recruited customers had to wait two to three months to have their thermostat or switch installed, instead of the target of four weeks. Building on this success, we recommend that Duke Energy focus on recruiting customers that evaluation results suggest are optimal from a demand response and energy savings impact perspective.

- **Optimize customer recruitment targeting.** Evaluation results from 2016 and 2017 both suggest that the program should seek to recruit customers with specific attributes, such as customers with larger HVAC units and higher monthly usage in summer months. In terms of event participation, several unenrolled participants mentioned that they felt their business segment was not appropriate for event participation. Specifically, unenrolled participants with gyms, massage parlors, and florists report that their business segment do not tolerate large temperature changes. Additionally, a review of event participation data suggests that restaurants tend to have higher opt-out rates than other business types. When examining unenrollment by NAICs code, restaurants are unenrolling at more than double the average rate. We recommend:
  - Continuing to target customers with larger HVAC units and higher average summer consumption.
  - Conducting in-depth upfront vetting customers within specific business types that are less able to accommodate changes in temperature in their facilities to reduce Conservation Period opt-outs, unenrollment, and potentially lower impacts.

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- **Enhance customer education for Conservation Period participation.** Our process research found that better participant understanding of program elements is correlated with higher participant satisfaction. Participants report relatively low understanding of cycling levels, and only a quarter of participants could correctly recall their cycling level. In addition, participants who unenrolled from Conservation Periods were less familiar with program elements than on-going participants, which may have contributed to their unenrollment. To minimize participant unenrollment and opt-outs, and increase satisfaction, we recommend:
  - Ensuring canvassers and installers fully explain cycling levels and Conservation Periods, including strategies for minimizing impacts of the events. This could include additional training for canvassers and installers, as well as adjustments to canvassers incentives, as described further below.
  - Developing additional leave-behind materials or welcome email blasts for newly-enrolled program participants. These materials should describe what a customer should expect during Conservation Periods. The materials may also provide suggestions for minimizing the impact of Conservation Periods such as pre-cooling facilities or reducing the use of heat-emitting technologies during Conservation Periods.
- **Encourage customer retention strategies.** The only drop-out prevention strategy noted by participants who unenrolled from the program was the loss of the Conservation Period bill credit. Most interviewed participants who dropped out of the Conservation Periods did so due to discomfort during events. In some cases, the discomfort was exacerbated by issues with their facilities' HVAC systems and building envelopes. We recommend Duke Energy staff:
  - Consider having the program call center employ additional drop-out prevention strategies, such as providing tips for mitigating discomfort during events, or helping them understand how to opt out of events. We suggest informing customers about how to opt-out since opting out of some events will yield higher impacts overall than if the customer is to drop out entirely. In addition, the call center might refer customers mentioning issues with their building's HVAC system or building envelope to other Duke Energy programs. While this may not stop a customer from dropping out of the program, it would provide Duke Energy with increased energy savings through the relevant energy efficiency programs.
- **Encourage adoption of, or conversion to, higher cycling strategies.** Enrollment in the lower cycling strategies, especially the 30% strategy, is higher than expected, leading to lower than anticipated per participant impacts.
  - Test options to support converting existing customers to higher cycling strategies. We understand that Duke is already in the process of an analytics project to help identify customers that could use higher cycling strategies. These analytics could inform Itron work with customers during the installation to assess if customers could increase their cycling strategy, without jeopardizing comfort. An additional option would be to promote higher cycling strategies on the customer portal; especially for customers with higher reference loads. Customers can currently change strategies after they enroll, but according to the program manager, most customers who change after enrollment change to a lower cycling strategy. It should be noted that more aggressive cycling strategy enrollment goals should be balanced with customers' comfort, as we found that higher cycling strategies are tied to more noticeable reductions in comfort, higher opt-out rates, and reduced likelihood of participating in the future.

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Recommendation: Program Implementation Enhancements

The program uses a series of marketing channels, including door-to-door marketing ("canvassing"), phone recruitment, email and direct mail, website, and digital marketing. Door-to-door marketing was a successful strategy in 2017, and program enrollment increased considerably after Duke Energy engaged Threshold Marketing canvassers.

Duke Energy pays Threshold Marketing a set fee for every account enrolled in the program. This fee does not vary based on the size or number of HVAC devices that a customer has, or the cycling level chosen. Perhaps as a result, the Threshold Marketing program managers describe focusing their efforts on customers where they can likely engage with an on-site decision maker (e.g., "mom and pop" businesses), and described how it was easier and more lucrative for canvassers to enroll customers with fewer HVAC units, since customers with more complex systems required more time to enroll for the same commission. Although engaging willing participants benefits marketing cost-effectiveness and increases participation, these enrollment strategies may not capture the most optimal savings opportunities from an impacts perspective. We recommend:

- **Aligning enrollment incentives with factors known to produce higher impacts to maximize cost-effectiveness.** Threshold's enrollment incentives were not aligned with Duke Energy's goals as they are paid per account regardless of characteristics that affect potential kW and kWh savings (e.g., cycling strategy, number of devices enrolled, baseline usage, or HVAC size). We recommend revisiting how Threshold is compensated by developing a tiered incentive strategy that provides greater compensation for customers with greater savings potential or interest in higher cycling levels. At the same time, customer comfort matters: higher cycling strategies are tied to more noticeable reductions in comfort, higher opt-out rates, and reduced likelihood of participating in the future. Accordingly, any tiered incentive strategy will need to balance recruitment into aggressive cycling strategies with continued support for customer comfort.

- **Considering adjustments to education or incentives to ensure installers offer participants with heat pumps winter Conservation Period participation.** Only half of participants with heat pumps recall installers offering participation in winter Conservation Periods. To increase the number of winter participants, the evaluation team recommends increasing installer education on the benefits of winter participation and on the program goals related to winter participation. The program may also consider adjusting installer incentives for enrolling winter participants.

Recommendation: Device Functionality and Operations Optimization

Our demand response impact analysis identified average percent load impacts that were routinely under the cycling strategy amount. This is consistent with expectations for a duty cycle strategy, as the average run-time of units during non-events is rarely 100%. We also found that energy efficiency savings were lower than anticipated, which may be driven by customer engagement with their set points. We recommend:

- **Incorporating an adaptive cycling strategy for Conservation Period events.** Adaptive cycling replaces the baseline run-time of 100% with an actual run-time percentage during a non-event hot day. For example, in simple 30% duty cycling where the baseline is 100%, event period run-time is limited to 70% (100%-30%). Adaptive cycling, which uses a previous measurement of run-time during hot days for the particular device (e.g., 90%) would limit event period run-time to 63% e.g., 90%* (100%-30%)). This helps to achieve percent run-time reductions closer to the cycling strategy, and it helps customers who may have under- or over- sized units. We understand that Duke Energy will be implementing this approach to cycling for the 2018 Conservation Period events.

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- **Implementing strategies to optimize energy efficiency settings for thermostats.** Notably, Duke Energy implemented an "auto-EE" functionality to their customer portal in 2018. This feature assesses the building's thermodynamics and auto-adjusts the set points when the facility is closed to generate additional energy savings compared to customer setpoints. These changes could potentially increase the overall energy savings from the thermostats in future program years. We also recommend assessing set points for thermostats to understand programming behavior of installers and customers. Educational materials that help customers optimize their own comfort, while also yielding bill savings, may help customers achieve higher energy savings associated with their devices.

Recommendation: Data Tracking

- **Enhance data tracking across Duke Energy program participation databases, customer billing data, and AMI data, as well as with Itron device log data.** Throughout this evaluation, we encountered a number of data issues that limited our ability to execute the planned analyses and increased evaluation cost and time frames. For example, the original evaluation plan sought to assess net demand impacts using AMI data. However, the DEP AMI data had substantial data availability issues as well as quality issues in terms of anomalous load shapes, necessitating incorporating device log data for the impact analysis. In particular, the load shapes within the available AMI data (based on graphical review) were not consistent with expected AC load shapes, and the amount of AMI data was insufficient to fully represent the population of participants. We offer the following set of recommended data tracking enhancements:

  - Develop an identical set of unique identifiers across datasets and include Account ID and Source Account ID and Source Service Point ID in every dataset. If an identical set of unique identifiers is unavailable due to the data existing in different systems, consider developing a crosswalk that links Source Service Point ID and Service Point ID. Currently, Duke Energy program data tracks participation at the Account level, while the vendor tracks participation at the Source Service Point Level. In addition, for DEP consumption data, provide an identifier that links Meter Number to Source Service Point ID and Account Number. This can support effective identification of the meter associated with a device installation.

  - Track changes in cycling strategies across time rather than replacing the strategies with the latest enrollment status. This will allow us to correctly classify participants by cycling level for each event, even if their cycling level or status changed. For example, a participant who participated with a 30% cycling strategy in July events but then changed their cycling strategy in September would be tracked as at the latest cycling strategy. Since the tracking data currently does not reflect the original cycling strategy and when it changed, we cannot accurately analyze the impacts of a past event.

  - Differentiate between unenrollment date and deactivation/removal date in the program-tracking data. Currently, the Duke Energy program-tracking data records two dates for each measure, start date (start_dt) and end date (end_dt). The start date corresponds to the installation date in Itron's data, while and the end date can correspond to either the unenrollment date or the removal date in Itron's data. The distinction between the two end dates in the Itron data is important because unenrolled devices can still achieve energy savings while removed devices achieve neither energy nor demand response savings.

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8. Summary Form

Duke Energy Carolinas and Progress EnergyWise Business Program

Completed EMV Fact Sheet

Duke Energy Progress' and Carolinas' EnergyWise Business Program is a demand response program that provides small businesses with the opportunity to participate in DR events, earn incentives, and realize additional EE benefits. The program offers customers either a programmable, two-way Wi-Fi Smart Thermostat or a Load Control Switch. Customers can select one of three levels of DR participation: 30% cycling, 50% cycling, and 75% cycling, with varying levels of earned incentives based upon the selected cycling strategy. Thermostat participants with a heat pump with electric resistance heat strips are also offered the option of participating in winter DR events and can earn additional incentives per season.

Date	November 9, 2018
Region(s)	Duke Energy Carolinas & Progress
Evaluation Period	1/1/17 through 12/31/17
Annual kWh Savings	DEC: 2,296,448 DEP: 31,737
Coincident kW Impact	DEC: 2,582 DEP: 1,421
Measure Life	Not evaluated
Net-to-Gross Ratio	Not evaluated
Process Evaluation	Yes
Previous Evaluation(s)	2016

To determine program impacts, the evaluation team used a three-step process: (1) we conducted a participation analysis; (2) we assessed energy savings impacts via a consumption analysis and cross-participation analysis; and (3) we estimated ex post gross demand impacts through a regression analysis. These results were then used to calculate realization rates.

Step 1: Participation Analysis. Reviewed program-tracking data to assess program participation during the evaluation period.

- Reviewed program participation database to determine device and participant counts, types of devices installed, and cycling strategies employed, as well as installation dates.
- Reviewed thermostat and switch log data to determine device operability rates and identify opt-outs.

Step 2: Net Energy Savings Analysis. Conducted a regression analysis and cross-participation analysis to estimate energy savings impacts for thermostats installed in 2017.

- Cleaned participation and customer billing data; developed matched comparison group to assess net energy impacts. Conducted regression analysis by jurisdiction.
- Conducted cross-participation analysis to deduct any double counted savings from other Duke Energy programs.
- Applied per-device impacts to enrolled thermostats and calculated net realization rates.

Step 3: Gross Demand Response Analysis. Conducted a regression analysis to estimate event-specific load impacts across cycling strategy, jurisdiction and device type.

- Cleaned participation and device log data; developed matched proxy-weather days to assess counterfactual. Conducted regression analysis by jurisdiction.
- Calculated opt-out and operational rates for devices.
- Converted run-time to kW by applying full load capacity.
- Applied per-device impacts to operational devices and calculate net realization rates.

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Nexant
Reimagine tomorrow.

Smart $aver® Non-Residential Custom Program Years 2016-2017 Evaluation Report

Submitted to Duke Energy Carolinas
in partnership with Tetra Tech

November 29, 2018

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1 Executive Summary

1.1 Program Summary

Duke Energy's Non-Residential Smart $aver® Custom Incentive Program (NR Custom) offers financial assistance to qualifying commercial, industrial and institutional customers in the Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) service territories to enhance their ability to adopt and install cost-effective electrical energy efficiency projects.

The program is designed to meet the needs of non-residential customers with electrical energy saving projects involving more complicated or alternative technologies, or those measures not covered by the non-residential Smart $aver Prescriptive Program. The intent of the program is to encourage the implementation of energy efficiency projects that would not otherwise be completed without the companies' technical or financial assistance.

1.2 Evaluation Objectives and High Level Findings

This report presents the results and findings of evaluation activities for DEC's and DEP's NR Custom program conducted by the evaluation team, collectively Nexant Inc. and our subcontracting partner, Tetra Tech, for the period of January 2016 through December 2017.

1.2.1 Impact Evaluation

The overarching goals for the NR Custom impact evaluation were to:

- Quantify accurate and supportable energy impacts (kWh) and summer and winter demand (kW) savings for energy efficient measures and equipment implemented in participants' facilities.
- Assess the rate of free riders from customer and contractor perspective.
- Determine spillover effects
- Consider and verify measure installation vintage aligned with measure baseline definitions, i.e. early replacement, burnout on failure, etc.

Evaluation activities included in-depth reviews and on-site verification of a representative sample of projects, in-person or phone interviews with program participants, deploying metering equipment, collecting building automation system/energy management system (BAS/EMS) data, and engineering analyses to estimate gross and net savings for all implemented measures attributed to the NR Custom Program.

1.2.2 Process Evaluation Objectives

Process evaluations are designed to support continuous program improvement by identifying successful program elements that can be expanded upon as well as underperforming/inefficient processes that could be holding back program performance. The process evaluation for the NR Custom Program sought to:

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- Assess how participant characteristics compare to segments targeted for the program
- Assess the sources of customer engagement and most effective marketing source
- Assess influence the program has on customers' decisions to install energy efficient (EE) measures
- Assess whether sufficient documentation and information are provided to customers
- Assess persistence of program engagement with participants
- Assess satisfaction with the program and its components including suggestions for program changes

To meet these objectives, the evaluation team conducted interviews with key program staff, reviewed program documentation, and utilized telephone surveys to ask program participants and trade allies about their experiences with the program.

1.2.3 High Level Findings

1.2.3.1 Gross Impact Evaluation Key Findings – DEC

The impact evaluation results indicate that program internal processes for project review, savings estimation, and installation verification are producing quality estimates of project impacts. For DEC energy realization rates exceed 100% for three of the four strata (Lighting - Large, Lighting - Small, and Non-lighting - Large). The realization rate for the Non-lighting - Small strata was better than 96%. Realization rates for Summer and Winter demand were also above 100% at the program level. Findings from the gross impact evaluation of DEC projects are summarized in Table 1-1, Table 1-2, and Table 1-3.

Table 1-1 DEC Program Reported and Verified Gross Energy Impacts for Projects Completed January 2016 – December 2017

Measure Category	Strata	Gross Reported Energy Savings (kWh)	Gross Verified Energy Savings (kWh)	RR (%)
Lighting	Large (>1,000 MWh)	35,491,559	37,792,452	106.5%
	Small (<1,000 MWh)	34,500,751	37,552,406	108.8%
Non-lighting	Large (>2,000 MWh)	21,661,701	23,301,600	107.6%
	Small (<2,000 MWh)	22,645,465	21,862,911	96.5%
Total		**114,299,476**	**120,509,369**	**105.4%**

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Table 1-2 DEC Program Reported and Verified Gross Summer Demand Impacts for Projects Completed January 2016 – December 2017

Measure Category	Strata	Gross Reported Summer Demand Savings (kW)	Gross Verified Summer Demand Savings (kW)	RR (%)
Lighting	Large (>1,000 MWh)	4,854	5,636	116.1%
	Small (<1,000 MWh)	6,151	6,758	109.9%
Non-lighting	Large (>2,000 MWh)	2,107	3,369	159.9%
	Small (<2,000 MWh)	3,276	3,237	98.8%
Total		**16,389**	**19,000**	**115.9%**

Table 1-3 DEC Program Reported and Verified Gross Winter Demand Impacts for Projects Completed January 2016 – December 2017

Measure Category	Strata	Gross Reported Winter Demand Savings (kW)	Gross Verified Winter Demand Savings (kW)	RR (%)
Lighting	Large (>1,000 MWh)	4,398	5,031	114.4%
	Small (<1,000 MWh)	5,218	5,996	114.9%
Non-lighting	Large (>2,000 MWh)	2,559	5,372	209.9%
	Small (<2,000 MWh)	2,933	2,316	79.0%
Total		**15,108**	**18,715**	**123.9%**

1.2.3.2 Gross Impact Evaluation Key Findings – DEP

The impact evaluation results indicate that program internal processes for project review, savings estimation, and installation verification are producing quality estimates of project impacts. For DEP, energy realization rates exceed 100% for three of the four strata (Lighting - Large, Non-lighting - Large, and Non-lighting - Small). The realization rate for the Lighting - Small strata was better than 97%. Realization rates for Summer and Winter demand were 99.5% and 122.7%, respectively. Findings from the gross impact evaluation of DEP projects are summarized in Table 1-4, Table 1-5, and Table 1-6.

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Table 1-4 DEP Program Reported and Verified Gross Energy Impacts for Projects Completed January 2016 – December 2017

Measure Category	Strata	Gross Reported Energy Savings (kWh)	Gross Verified Energy Savings (kWh)	RR (%)
Lighting	Large (>250 MWh)	3,289,490	3,662,303	111.3%
	Small (<250 MWh)	3,204,111	3,119,250	97.4%
Non-lighting	Large (>500 MWh)	5,979,116	6,075,769	101.6%
	Small (<500 MWh)	3,667,824	4,202,872	114.6%
Total		**16,140,541**	**17,060,194**	**105.7%**

Table 1-5 DEP Program Reported and Verified Gross Summer Demand Impacts for Projects Completed January 2016 – December 2017

Measure Category	Strata	Gross Reported Summer Demand Savings (kW)	Gross Verified Summer Demand Savings (kW)	RR (%)
Lighting	Large (>250 MWh)	475	519	109.4%
	Small (<250 MWh)	518	450	86.8%
Non-lighting	Large (>500 MWh)	531	519	97.7%
	Small (<500 MWh)	386	413	106.9%
Total		**1,910**	**1,901**	**99.5%**

Table 1-6 DEP Program Reported and Verified Gross Winter Demand Impacts for Projects Completed January 2016 – December 2017

Measure Category	Strata	Gross Reported Winter Demand Savings (kW)	Gross Verified Winter Demand Savings (kW)	RR (%)
Lighting	Large (>250 MWh)	499	667	133.8%
	Small (<250 MWh)	379	532	140.3%
Non-lighting	Large (>500 MWh)	632	622	98.5%
	Small (<500 MWh)	512	659	128.5%
Total		**2,022**	**2,480**	**122.7%**

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1.2.3.3 Net Impact Evaluation Key Findings

The results of the net impact evaluation show that the gross energy savings are largely attributable to the program's activities. Customers did not report implementing efficient projects outside of the program, which suggests that the program is effective at getting customers to participate when they are considering efficiency projects. A large portion of the free-ridership stemmed from customers who reported they planned to complete the same project prior to learning about the program, and would have paid the additional incentive amount to complete the efficiency project. A small number of customers also rated all aspects of the program as having no influence on their project decisions.

Findings from the net impact evaluation are summarized in Table 1-7. While the table presents territory-specific findings for DEP, these results are based on a small number of survey responses and therefore have a higher statistical precision (±16%) than industry standard.[1] The evaluation team recommends using the Combined net-to-gross results for reporting DEP net impacts, which has the same precision as DEC-specific results at ±4.5%. Because the DEC results do fall within ±10% on their own, the evaluation team recommends using the DEC-specific results for reporting DEC net impacts.

Table 1-7 Net-to-Gross Evaluation Results

Net-to-Gross Component	DEC	DEP	Combined
Net of Free-ridership	78.9%	70.8%	78.5%
Program-influenced Spillover	0.4%	0.0%	0.4%
Net-to-Gross	**79.2% ***	**70.8%**	**78.8%**

* Note: Sum of Net of Free-ridership and program-influenced spillover equals 79.2% due to rounding.

1.2.3.4 Process Evaluation Key Findings

Overall, the program is operating as intended, and customers and trade allies are satisfied with their experiences with the program as well as with Duke Energy. Contractors play a key role in the program by making customers aware of the program offerings, and contractors have utilized the program to encourage customers to purchase high efficiency equipment. Contractors felt the program was influential in getting customers to move forward with projects where they would not have otherwise. Participants provided similar feedback, stating they have appreciated the support they received from trade allies and Duke Energy. Numerous customers mentioned they have previously participated in the program, speaking to their satisfaction and the ease of participation.

Additional high-level findings include the following:

- The primary source of participants' program awareness is their contractor.

[1] A common industry standard for evaluation is ±10% precision at the 90% confidence level, meaning if the research were repeated with the same sample size, the result would fall within ±10% of the estimate 90% of the time.

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- Satisfaction with the program overall and its components is high among participants and trade allies.
- The contractor assistance was the most valuable program component as rated by participant respondents.
- The program-provided calculators were used by participant and contractor respondents with contractors indicating that the calculators were useful[2].
- Contractors value the program and use the incentives to encourage customers to purchase high efficiency equipment.
- Program application and processes are geared to lighting projects, leading to some confusion.
- The tracking database was occasionally missing phone numbers and email addresses for participants requiring follow-up data requests

[2] Participant respondents were not asked to rate the usefulness of the calculators (only contractors were).

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1.3 Evaluation Conclusions and Recommendations

Based on evaluation activities and findings, the evaluation team concluded the following and provides several recommendations for program improvement.

1.3.1 Impact

Conclusion 1: The evaluation team's analysis resulted in a 105.4% realization rate (energy) for the DEC NR Custom Program and 105.7% for the DEP NR Custom Program. The strong realization rates indicate that Duke Energy's internal processes for project review, savings estimation, and installation verification are working to produce high quality estimates of project impacts. Reported energy and demand savings could be increased by incorporating interactive factors into ex-ante impact estimates for lighting measures.

Recommendation 1: The evaluation team recommends that Duke continue to operate this program with the current level of rigor. For interior lighting projects, Duke should consider developing and applying deemed interactive factors to quantify the interactive effects between lighting retrofits and their associated HVAC systems.

Conclusion 2: Assumptions used in ex ante energy savings estimates are well-documented, but there are opportunities for improvement on new construction lighting projects and some non-lighting projects.

Recommendation 2: The evaluation team recommends that any adjustments made to baseline assumptions on new construction projects be well-documented within the incentive calculation spreadsheet developed by the program. This will provide better transparency when deviations from a lighting power density approach are used in ex-ante energy savings estimates.

Conclusion 3: The NR Custom Program uses T12 baseline fixture wattages in ex-ante energy savings estimates for applicable linear fluorescent to LED tube retrofit measures. This practice is defensible given the availability of high color rendering index (CRI) replacement lamps; however, peer Demand Side Management (DSM) programs no longer credit energy or demand savings beyond a T8 baseline.

Recommendation 3: It is recommended that the Duke NR Custom Program consider using a T8 equivalent when developing ex-ante energy and demand savings estimates for T12 to LED tube retrofit measures.

1.3.2 Process

Conclusion 1: The program is operating as intended and has resulted in high satisfaction across participant and contractor respondents. The most common source of program awareness for customers was their contractor, which is consistent with how the program is marketed.

Technical assistance from the contractor was the highest rated aspect of the program, which highlights the contractors' technical competence and the significant role contractors play in the program. Many customer respondents also commented on how their contractors are knowledgeable which made the entire process easy.

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Recommendation 1: Continue program outreach efforts and continue to engage contractors in the program and keep them informed of the program and any future changes to increase awareness among customers and encourage the installation of program-qualifying equipment.

Conclusion 2: As part of the application process, an appropriate worksheet or calculator must be submitted. Duke Energy provides access to two types of calculators: Classic Custom and Custom-to-go. Over two-thirds of contractors and one-third of participant respondents indicated they have used Duke's tools to calculate savings. Contractors who used Duke Energy's provided tools rated their usefulness high. That said, contractors who install non-lighting equipment were more likely to use their own calculators or rated the usefulness of Duke's calculators low.

Recommendation 2a: Continue to keep the Custom-to-Go and Classic Custom calculators updated and available to customers and contractors who need a tool to estimate savings.
Recommendation 2b: Consider reviewing the calculators for non-lighting equipment to ensure they perform as expected and do not require lighting-specific information.

Conclusion 3: Almost all customer and contractor respondents found the time to review applications acceptable.

Program participants were generally satisfied with the review process. Most contractors were also satisfied with the process. However, five contractors felt the preapproval process could be improved. Specifically, three indicated that the non-lighting preapproval process can take significantly longer than lighting preapproval. As different technologies come into the market, it will be important to ensure customers are getting feedback in a timely manner.

Recommendation 3: Monitor the time it takes to review applications for preapproval to ensure the time does not exceed six weeks.

Conclusion 4: Most participant respondents reported high satisfaction with the application process, although five respondents indicated the program could benefit from simplifying the application. A few contractors also recommended the application is geared towards lighting projects, leading to some confusion in what information is needed.

Recommendation 4: Streamline the application paperwork to minimize customer burden and collect only the information relevant to specific equipment types.

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2 Introduction and Program Description

2.1 Program Description

Duke Energy's Non-Residential Smart $aver® Custom Incentives program (NR Custom) offers financial assistance to qualifying commercial, industrial and institutional customers (that have not opted-out) in the Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) service territories to enhance their ability to adopt and install cost-effective electrical energy efficiency projects.

The program is designed to meet the needs of each Company's non-residential customers with electrical energy saving projects involving more complicated or alternative technologies, or those measures not covered by the non-residential Smart $aver Prescriptive Program. The intent of the program is to encourage the implementation of energy efficiency projects that would not otherwise be completed without the company's technical or financial assistance. The program requires pre-approval prior to the project implementation. Proposed energy efficiency measures may be eligible for customer incentives if they clearly reduce electrical consumption and/or demand.

The two approaches for applying for incentives for this program are Classic Custom and Custom-to-Go. The difference between the two approaches focuses on the method by which energy savings are calculated. The documents required as part of the application process vary slightly.

The custom application forms are located on the company's website under the Smart $aver® Incentives (Business and Large Business tabs). The application forms are offered in Word (doc) and Adobe (pdf) format with the designated worksheet in Excel format for projects saving more than 700,000 kWh annually. Customers can utilize provided calculation tools (Custom-to-Go) for energy management system (EMS) projects savings less than 700,000 kWh annually or request worksheets in another format if preferred. Customers or their vendors submit the forms with supporting documentation. Forms are designed for multiple projects and multiple locations. Custom incentive application (doc or pdf) is submitted with one or more of the following worksheets:

- Classic Custom approach (> 700,000 kWh or no applicable Custom-to-Go calculator)
  - Lighting worksheet (Excel)
  - Variable Speed Drive (VFD) worksheet (Excel)
  - Compressed Air worksheet (Excel)
  - Energy Management System (EMS) worksheet (Excel)
  - General worksheet (Excel), to be used for projects not addressed by or not easily submitted using one of the other worksheets

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- Custom-to-Go Calculators (< 700,000 kWh and applicable Custom-to-Go calculator)
  - Energy Management Systems
  - Process VFDs
  - Compressed Air

The Companies contract with Alternative Energy Systems Consulting (AESC) to perform technical review of applications. The Weidt Group is an energy modeling and outreach consultant that provides energy consulting services and whole-building energy modeling to facilitate and guide the process designing energy efficiency measures into new buildings and major renovations. All other analysis is performed internally at Duke Energy, including DSMore runs for every custom measure that is recorded by the program.

2.1.1 Participation Summary – DEC

Table 2-1 summarizes program participation and reported energy savings for the full evaluation period of January 2016 through December 2017 for the DEC service territory. There were a total of 334 projects completed during the evaluation period. For the purposes of this report a project is defined as a unique enrollment ID. These 334 projects collectively accounted for a total of 944 unique database line items. Database line items typically represent single-measure projects or an individual measure implemented as part of a multi-measure project. There are also a few instances where a line item in the tracking database represents a unique project site where a common scope of work was completed as part of a larger portfolio of sites (i.e. Adams Outdoor Advertising). Table 2-2 outlines the reported summer and winter demand (kW) for the evaluation period for the DEC service territory.

Table 2-1 DEC NR Custom Program Participation and Energy Summary

Category & Strata		Database Line Items		Enrollment IDs		Reported Savings	
		Custom-To-Go	Classic	Custom-To-Go	Classic	Custom-To-Go Gross MWh	Classic Custom Gross MWh
Lighting	Large (>1,000 MWh)	-	206	-	18	-	35,492
	Small (<1,000 MWh)	336	311	144	117	16,471	18,030
Non-lighting	Large (>2,000 MWh)	-	5	-	5	-	21,662
	Small (<2,000 MWh)	9	77	8	42	1,881	20,764
Total		**345**	**599**	**152**	**182**	**18,352**	**95,947**
Grand Total		**944**		**334**		**114,299**	

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Table 2-2 DEC NR Custom Program Demand Savings Summary

Category & Strata		Enrollment IDs		Summer Demand		Winter Demand	
		Custom-To-Go	Classic	Custom-To-Go Gross Summer kW	Classic Custom Gross Summer kW	Custom-To-Go Gross Winter kW	Classic Custom Gross Winter kW
Lighting	Large (>1,000 MWh)	-	18	-	4,854	-	4,398
	Small (<1,000 MWh)	144	117	3,062	3,089	2,401	2,818
Non-lighting	Large (>2,000 MWh)	-	5	-	2,107	-	2,559
	Small (<2,000 MWh)	8	42	110	3,167	138	2,795
Total		**152**	**182**	**3,172**	**13,217**	**2,539**	**12,569**
Grand Total		**334**		**16,389**		**15,109**	

Figure 2-1, Figure 2-2, and Figure 2-3 summarize the distribution of reported energy (kWh) and demand (kW) savings at the program level by technology category for the DEC service territory.

Figure 2-1 Distribution of Reported Energy Savings from NR Custom DEC Program Projects by Technology

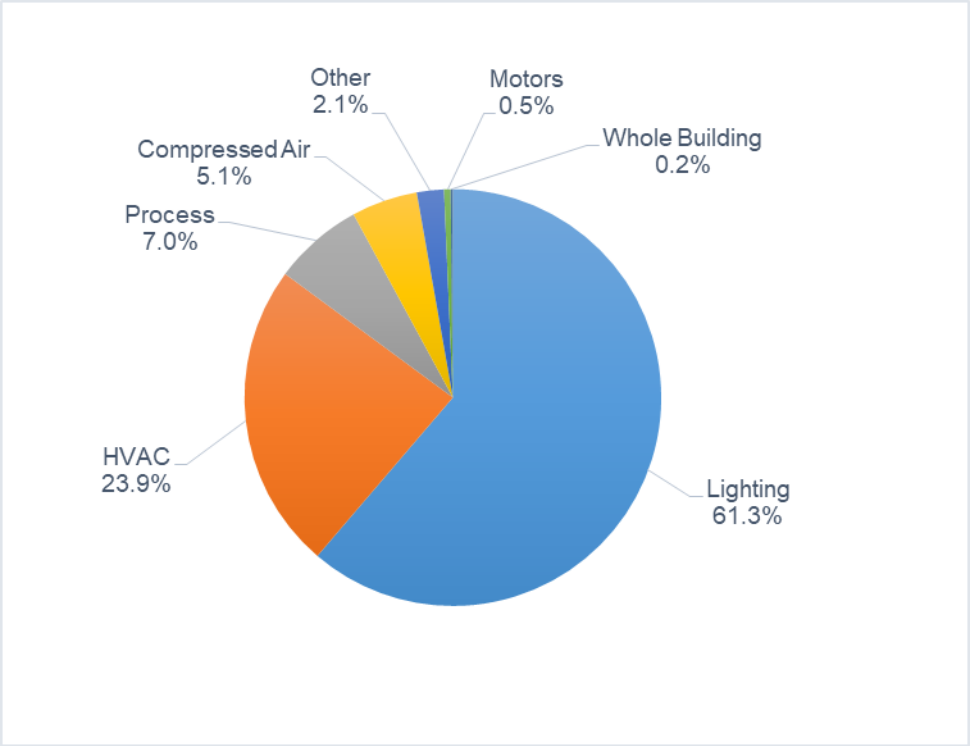

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Figure 2-2 Distribution of Reported Summer Demand Savings from DEC NR Custom Projects by Technology

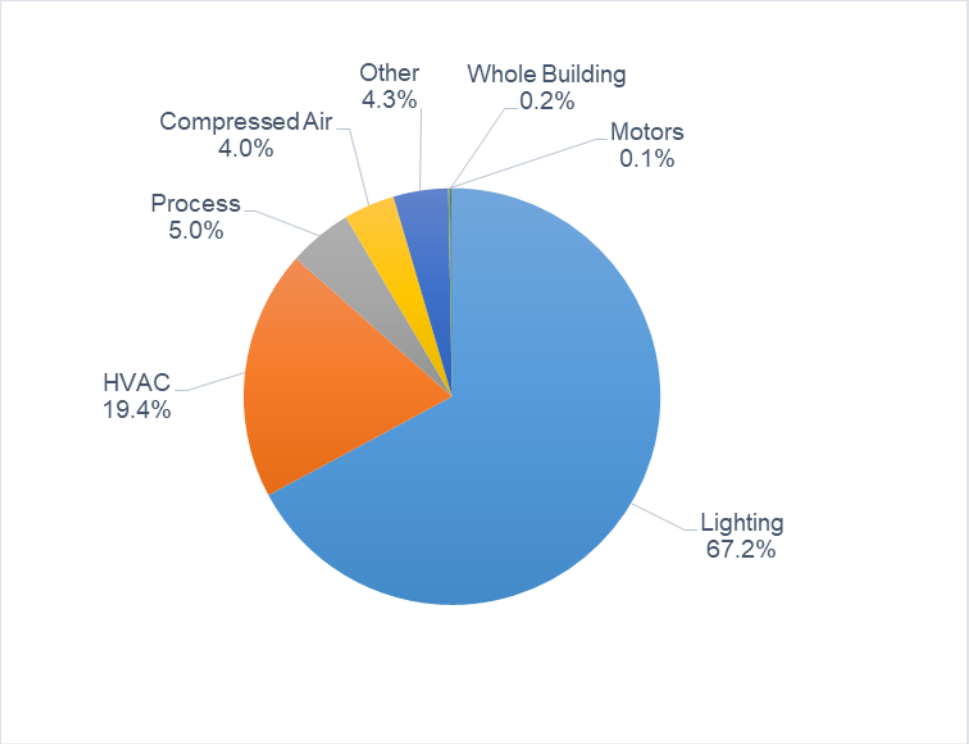
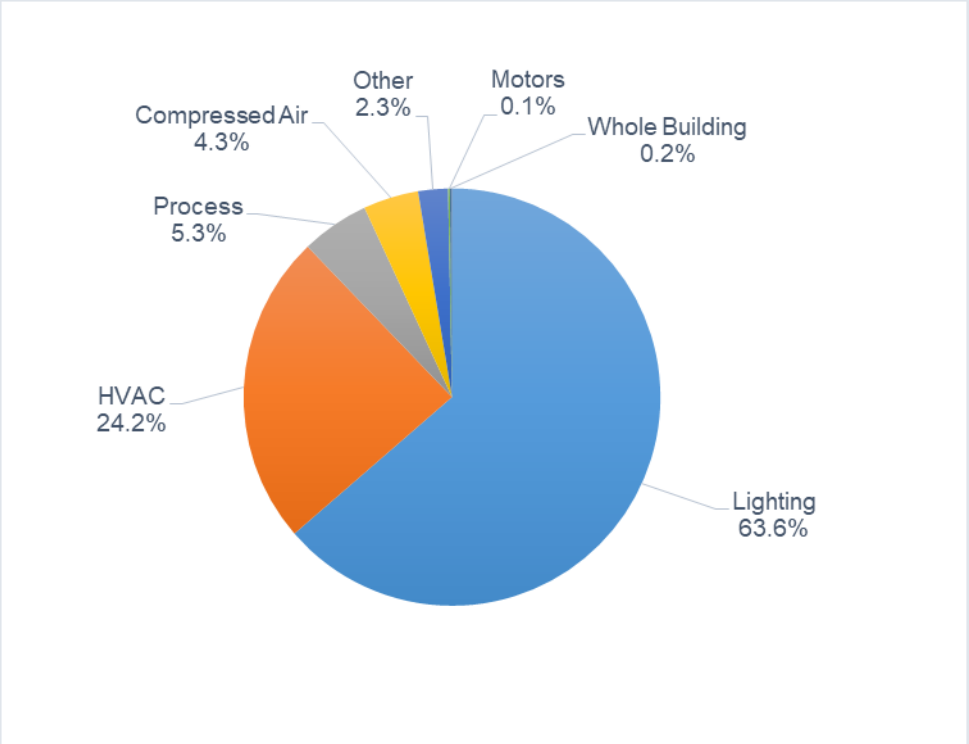


Figure 2-3 Distribution of Reported Winter Demand Savings (kW) from DEC NR Custom Projects by Technology



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2.1.2 Participation Summary – DEP

Table 2-3 summarizes program participation and reported energy savings for the full evaluation period of January 2016 through December 2017. There were a total of 117 projects completed during the evaluation period. These 117 projects collectively accounted for a total of 276 unique database line items. Table 2-4 outlines the reported summer and winter demand (kW) for the evaluation period for the DEP service territory.

Table 2-3 DEP NR Custom Program Participation and Energy Summary

Category & Strata		Database Line Items		Enrollment IDs		Reported Savings	
		Custom-To-Go	Classic	Custom-To-Go	Classic	Custom-To-Go Gross MWh	Classic Custom Gross MWh
Lighting	Large (>250 MWh)	15	55	3	6	835	2,454
	Small (<250 MWh)	83	65	51	31	2,071	1,124
Non-lighting	Large (>500 MWh)	3	7	1	4	541	5,438
	Small (<500 MWh)	5	43	5	16	781	2,896
Total		**106**	**170**	**60**	**57**	**4,228**	**11,912**
Grand Total		**276**		**117**		**16,140**	

Table 2-4 DEP NR Custom Program Demand Savings Summary

Category & Strata		Enrollment IDs		Reported Summer Demand (kW) Savings		Reported Winter Demand (kW) Savings	
		Custom-To-Go	Classic	Custom-To-Go	Classic	Custom-To-Go	Classic
Lighting	Large (>250 MWh)	3	6	237	237	237	262
	Small (<250 MWh)	51	31	350	166	236	143
Non-lighting	Large (>500 MWh)	1	4	41	490	71	561
	Small (<500 MWh)	5	16	94	294	38	475
Total		**60**	**57**	**722**	**1,188**	**581**	**1,441**
Grand Total		**117**		**1,910**		**2,022**	

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Figure 2-4, Figure 2-5, and Figure 2-6 summarize the distribution of reported energy (kWh) and demand (kW) savings at the program level by technology category for the DEP service territory.

Figure 2-4 Distribution of Reported Energy Savings from DEP NR Custom Program Projects by Technology

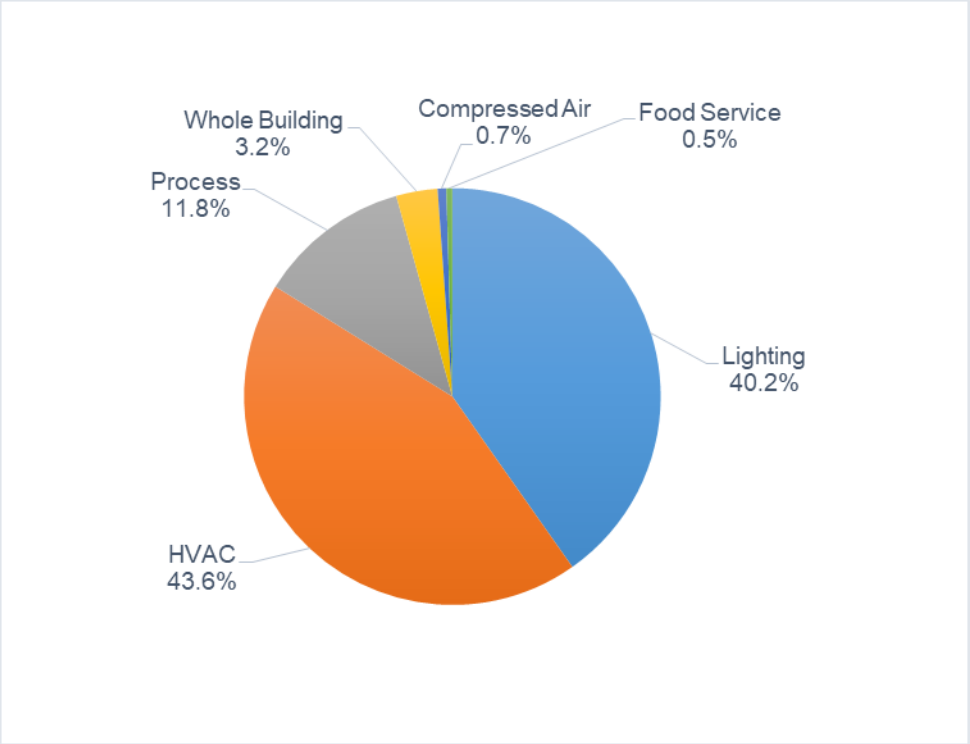

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Figure 2-5 Distribution of Reported Summer Demand Savings from DEP NR Custom Projects by Technology

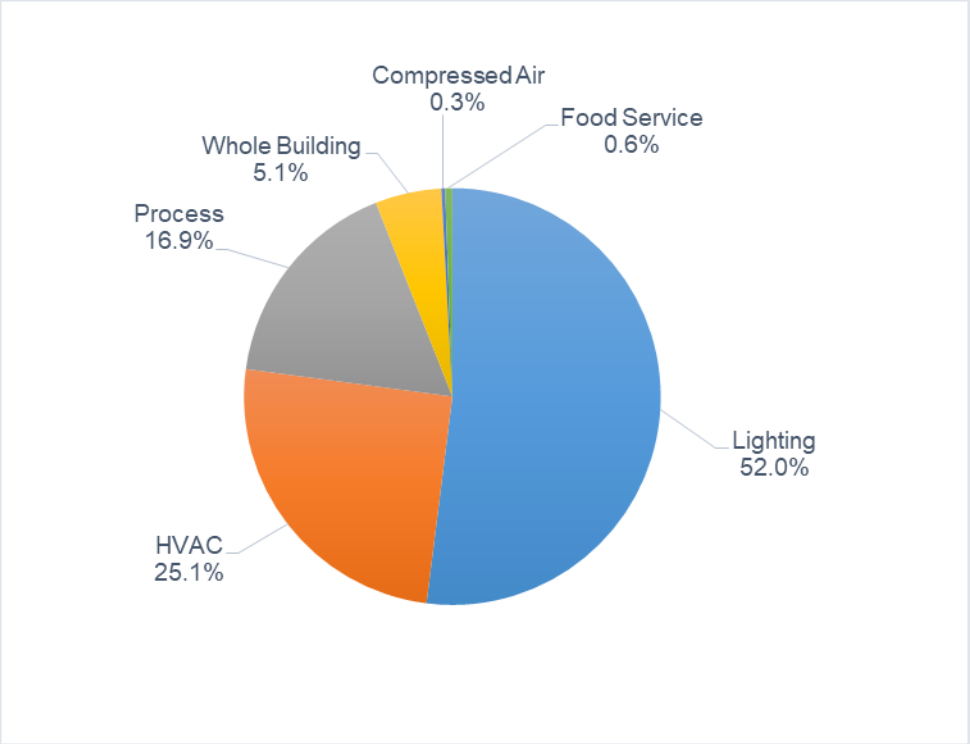
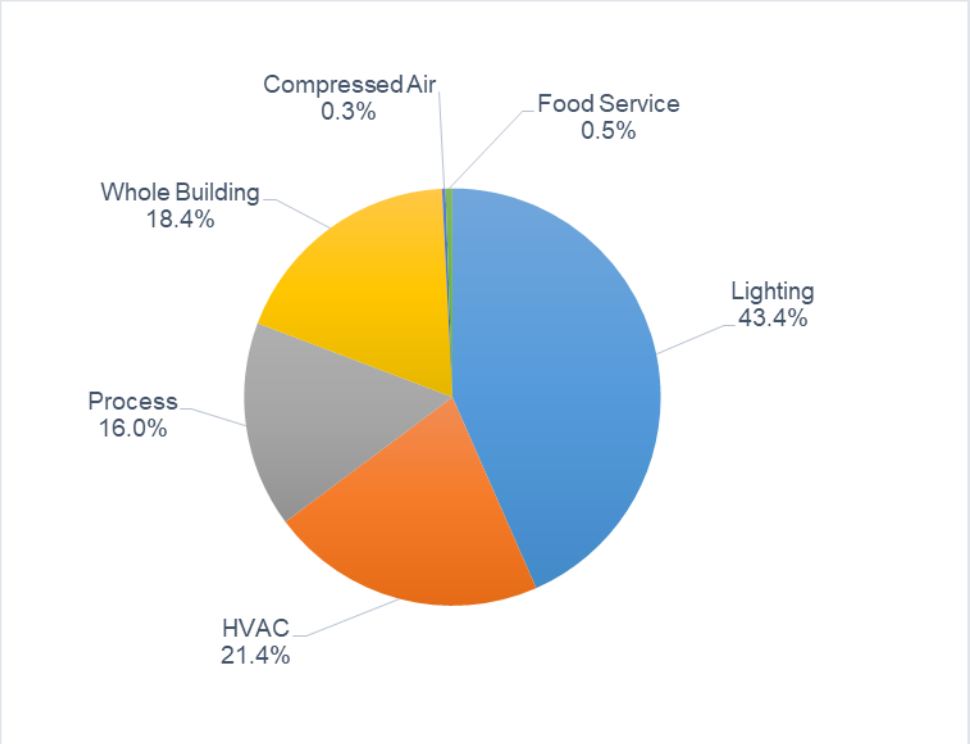


Figure 2-6 Distribution of Reported Winter Demand Savings (kW) from DEP NR Custom Projects by Technology



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3 Key Research Objectives

3.1 Gross Impact

The impact evaluation processes followed standard industry protocols and definitions, where applicable, and include the Department of Energy Uniform Methods Protocol[3], as an example. As part of evaluation planning, the evaluation team outlined the following activities for this program evaluation:

- Quantify accurate and supportable energy (kWh) and demand (kW) savings for measures and equipment being implemented in customer facilities attributed to the NR Custom Program in the DEC service territory, the DEP service territory, and for both territories combined
- Assess the rate of free riders from customer and contractor perspectives and determine spillover effects; and,
- Consider and verify measure installation vintage aligns with measure baseline definitions, i.e. early replacement, burnout on failure, new construction etc.

3.2 Net Impact

The goal of the net impact evaluation was to estimate the overall energy impacts that are attributable to the program. This estimate comprises two components: free-ridership and spillover.

Free-ridership is the estimate of what proportion of the program's savings would have happened in the absence of the program. Free-ridership takes into account the customers' plans prior to engaging the program and the various influences the program can have on the customer such as incentives and other interactions with the program staff, contractors, and marketing materials.

Spillover estimates additional energy savings for efficiency projects that were completed without receiving a program incentive, but were influenced by the program in some other way.

Net program results are calculated through a net-to-gross ratio, as follows:

$$\text{Net-to-gross} = (1 - \text{Free-ridership } \%) + \text{Spillover } \%$$

$$\text{Net Savings} = \text{Net-to-gross } (\%) * \text{Gross Verified Savings}$$

A single NTG value was determined jointly for the DEC and DEP jurisdictions.

[3] The DOE's Uniform Methods Project for Determining Energy Efficiency Program Savings can be found at http://www1.eere.energy.gov/office_eere/de_ump.html.

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3.3 Process

The evaluation team collected data from a variety of sources to address the researchable questions identified at the beginning of the study. Because the program is delivered the same in both DEC and DEP territories, the process evaluation reports on the overall program. Table 3-1 contains the list of research objectives and the data sources used to investigate each one.

Table 3-1 Process Evaluation Research Questions and Activities

Preliminary Research Questions	Document Review	Interviews with Key Contacts	Participant Survey	Trade Ally Survey
How is the program promoted? How important are account representatives? Are contractors or vendors identifying potential projects?	✓	✓	✓	✓
Understand participant experience. What steps are involved in identifying and scoping projects and obtaining pre-approval? What issues emerge during the process? How are these addressed?		✓	✓	✓
Why do potential projects drop out? Are there opportunities to make the process simpler or more streamlined while maintaining robust quality control (QC)?		✓		✓
Is the uptake of custom vs. custom-to-go projects as expected? How do the projects and/or the customer experience differ between the two participation paths?	✓	✓	✓	✓
What is the customer's decision-making process regarding energy efficiency upgrades or equipment? How influential were various aspects of the program in their decision? How influential was the contractor they worked with?	✓		✓	✓

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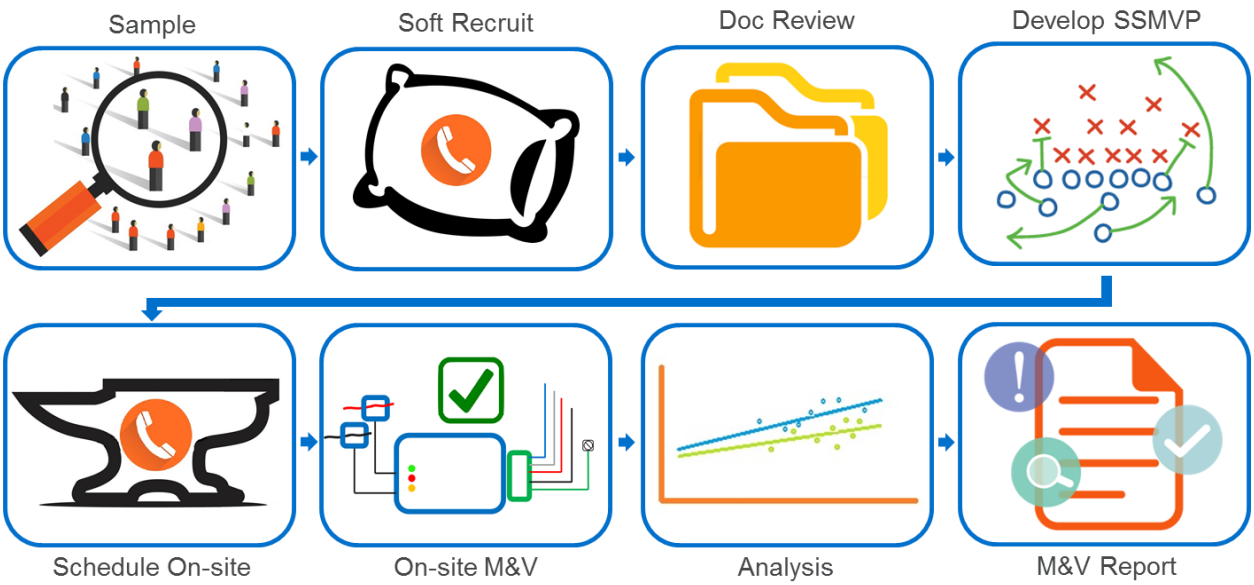
4 Impact Evaluation

4.1 Approach

The primary determinants of impact evaluation costs are the sample size and the level of rigor employed in collecting the data used in the impact analysis. The accuracy of the study findings is in turn dependent on these parameters. Techniques that we used to conduct the evaluation, measurement, and verification (EM&V) activities, and to meet the goals for this evaluation, include on-site inspections and measurements, utility billing analysis, telephone surveys, documentation review, best practice review, and interviews with implementation staff, trade allies, program participants, and general business customers.

The evaluation team's impact analysis focused on the energy and demand savings attributable to the NR Custom Program for the period of January 2016 through December 2017. A variety of techniques were used to develop independent assessments of gross and net energy savings for each sampled project. All sampled custom projects received both a desk review and on-site verification. Figure 4-1 provides a high-level process flow diagram of all impact evaluation activities and brief summary of each step in the process is provided below.

Figure 4-1 Process Flow Diagram of Impact Evaluation Activities



The evaluation team verified energy and demand savings attributable to the program by conducting the following impact evaluation activities:

- **Sample:** Conduct review of NR Custom Program participant database on a quarterly basis, identify all new projects, and draw representative sample of projects for on-site M&V.
- **Soft Recruit:** Attempt to reach all sampled participants by phone or email, prior to conducting an in-depth review of project documentation or developing a site specific

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measurement and verification plan (SSMVP), to inform participants of the ongoing evaluation and request permission to conduct an on-site inspection. Nothing would be formally scheduled during this call.

- **Document (Doc) Review:** Request, receive, and review all project documentation available for those sites successfully recruited.
- **Develop SSMVP:** Develop document providing general overview of the project, reported benefits and costs, proposed level of rigor, M&V equipment, and key data to be gathered in the field.
- **Schedule On-site:** Schedule on-site inspection with participant after Duke team provides comments and approves SSMVP. The purpose of the Duke team reviews were to verify that all measures were included in the plan, reported energy and demand savings were accurate, and proposed M&V approaches were appropriate.
- **On-site M&V:** Verify measure implementation, deploy metering equipment, interview key project personnel, and obtain trend data from existing BAS/EMS systems.
- **Analysis:** Estimate gross verified energy and demand savings for sampled measures and projects using data collected from on-site measurement and verification.
- **M&V Report:** Compare gross-verified energy and demand savings to program-reported values to determine project-level realization rates and summarize findings for each sampled site in M&V report.
- **Gross Verified Savings:** Summarize project-level results to stratum-level for determining program-level realization rates and verified gross energy and demand savings.
- **Net Verified Savings:** Apply attribution survey data to estimate net-to-gross ratios and net-verified savings at the program level.

4.2 Database Review

The program participation database informed many of the evaluation activities including sample design, project-level savings review, and estimating program-level gross verified energy and demand savings. Starting in 2016 participation database extracts were requested and received quarterly in real time with the program implementation. Data included customer contact, measures, and savings information. A random sample of projects was then drawn from the population of new projects and the the evaluation team would receive site contact information and sufficient project details so as to initiate preliminary “soft-recruiting” efforts.

Once a participant was successfully recruited into the evaluation, the impact team requested detailed project documentation for each project and conducted an in-depth review of all information. While reviewing project documentation, the evaluation team would verify whether parameters such as reported energy and demand savings, energy conservation measure (ECM) quantities, and measure descriptions matched those indicated in the tracking database. Any identified discrepancies between the two sources were then identified in the SSMVP and later resolved based on feedback provided by the Duke program team.

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At the conclusion of the project, the evaluation team requested a full database extract for the entire evaluation period (January 2016 through December 2017) for comparison to the compiled database maintained by the evaluation team throughout the course of the evaluation for reconciliation. There were a number of inconsistencies in the database revealed through the reconciliation. Common inconsistencies included:

- Lighting projects where ECM Quantity was indicated as “1” in the tracking database for non one-for-one retrofit measures or measures involving multiple post installation fixture types, but a common baseline fixture type. The actual quantity was usually determined from project documents or the “Measure Name” field within the tracking database itself.
- Inaccurate phone numbers or phone numbers listed as 999-9999, as a generic default. This issue was generally resolved through follow-up information requests.
- No email address for site contact. Also generally resolved through follow-up information requests if participant could not be reached by phone.

The inconsistencies identified do not have a direct impact on overall program performance, but it is recommended that these issues be addressed by the Duke Team internally so as to improve the overall evaluability of the program and eliminate lost effort chasing and correcting them.

4.3 Sampling and Estimation

The gross and net verified energy and demand savings estimates presented in this report from the Duke Energy Smart $aver Non-residential Custom Program were generally determined through the observation of key measure parameters among a sample of program participants. A census evaluation would involve surveying, measuring, or otherwise evaluating the entire population of projects within a population. Although a census approach would eliminate the sampling uncertainty for an entire program, the reality is that M&V takes many resources both on the part of the evaluation team and the program participants who agree to be surveyed or have site inspections conducted in their business. When a sample of projects is selected and analyzed, the sample statistics can be extrapolated to provide a reasonable estimate of the population parameters. Therefore, when used effectively, sampling can improve the overall quality of an evaluation study. By limiting resource-intensive data collection and analysis to a random sample of all projects, more attention can be devoted to each project surveyed.

For the NR Custom impact evaluation the most important sampling objective was representativeness – that is that the projects selected in the evaluation were representative of the population they were selected from and would produce unbiased estimates of population parameters. The evaluation team used a ratio estimation technique for this evaluation. This technique assumes that the ratio of the sum of the verified savings estimates to the sum of the reported savings estimates within the sample is representative of the program as a whole. This ratio is referred to as the realization rate, or ratio estimator, and is calculated in .

Equation 1.

Equation 1: Realization Rate

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$$Realization\ Rate = \frac{\sum_i^n Verified\ Savings}{\sum_i^n Reported\ Savings}$$

Where *n* is the number of projects in the evaluation sample. The realization rate is then applied to the claimed savings of each project in the population to calculate gross verified savings.

Stratification

The evaluation team used sample stratification with ratio estimation techniques for the NR Custom Program in both the DEC and DEP service territories. Stratification is a departure from simple random sampling (SRS), where each sampling unit (customer/project/rebate/measure) has an identical likelihood of being selected in the sample. Stratified random sampling refers to the designation of two or more sub-groups (strata) from within a program population prior to the selection process.

The evaluation team took great care to ensure that each sampling unit within the population belonged to one (and only one) stratum. In a stratified sample design, the probability of selection is different between strata and this difference must be accounted for when calculating results. The inverse of the selection probability is referred to as the *case weight* and is used in estimation of impacts when stratified random samples are utilized. Consider the following simplified example in Table 4-1 based on a fictional program with two measures; LED lighting and variable frequency drives (VFDs).

Table 4-1 Case Weights Example

Measure	Population Size	Sample Size	Case Weight
LED lamps	15,000	30	500
VFDs	6,000	30	200

Because LED lighting measures are sampled at a higher rate (1-in-200) than VFDs (1-in-500), each sample point carries less weight in the program results than an individual VFD sample point. In general, the evaluation team designed samples so that low case weights were reserved for large and complex measures such as the L-Large and NL-Large strata.

The evaluation team felt that stratification was advantageous and utilized it in the sample design for a variety of reasons:

- Increased precision of the within-stratum variability was expected to be small compared to the variability of the population as a whole. Stratification in this case allows for increased precision and smaller total sample sizes.
- It enabled the evaluation team to ensure that a minimum number of units within a particular stratum were verified.

Presentation of Uncertainty

There is an inherent risk, or uncertainty, that accompanies sampling, because the projects selected in the evaluation sample may not be representative of the program population as a whole with respect to the parameters of interest. As the proportion of projects in the program

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population that are sampled increases, the amount of sampling uncertainty in the findings decreases. The amount of variability in the sample also affects the amount of uncertainty introduced by sampling. A small sample drawn from a homogeneous population will provide a more reliable estimate of the true population characteristics than a small sample drawn from a heterogeneous population. Variability is expressed using an error ratio for programs that use ratio estimation.

When ratio estimation is utilized, standard deviations will vary for each project in the population. The error ratio is an expression of this variability and is analogous to the coefficient of variation, $C_{v,}$ for simple random sampling.

Equation 2 provides the formula for estimating error ratio.

Equation 2: Error Ratio

$$Error\ Ratio = \frac{\sum_{i=1}^{N} \sigma_i}{\sum_{i=1}^{N} \mu_i}$$

Equation 3 shows the formula used to calculate the required sample size for each evaluation sample, based on the desired level of confidence and precision. Notice that the *Error Ratio* term is in the numerator, so required sample size will increase as the level of variability increases.

Equation 3: Required Sample Size

$$n_0 = \left(\frac{z * Error\ Ratio}{D}\right)^2$$

Where:

n_0	=	*The required sample size before adjusting for the size of the population*
Z	=	*A constant based on the desired level of confidence (equal to 1.645 for 90% confidence two-tailed test)*
D	=	*Desired relative precision*

The sample size formula shown in Equation 3 assumes that the population of the program is infinite and that the sample being drawn is reasonably large. In practice, this assumption is not always met. For sampling purposes, any population greater than approximately 7,000 may be considered infinite for the purposes of sampling. For smaller, or finite, populations, (such as the Duke Energy Indiana NR Custom participant population) the use of a finite population correction factor (FPC) is warranted. This adjustment accounts for the extra precision that is gained when the sampled projects make up more than about 5% of the program savings. Multiplying the results of Equation 3 by the FPC formula shown in Equation 4 will produce the required sample size for a finite population.

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Equation 4: Finite Population Correction Factor

$$fpc = \sqrt{\frac{N - n_0}{N - 1}}$$

Where:

N = *Size of the population*

n_0 = *The required sample size before adjusting for the size of the population*

The required sample size (*n*) after adjusting for the size of the population is given by Equation 5.

Equation 5: Application of the Finite Population Correction Factor

$$n = n_0 * fpc$$

Verified savings estimates always represent the point estimate of total savings, or the midpoint of the confidence interval around the verified savings estimate for the program. Equation 6 shows the formula used to calculate the margin of error for a parameter estimate.

Equation 6: Error Bound of the Savings Estimate

$$Error\ Bound = se * (z - statistic)$$

Where:

se = *The standard error of the population parameter of interest (proportion of realization rate, total energy savings, etc.) This formula will differ according to the sampling technique utilized.*

$z - statistic$ = *Calculated based on the desired confidence level and the standard normal distribution.*

The 90% confidence level is a widely accepted industry standard for reporting uncertainty in evaluation findings. The confidence levels and precision values presented in this report are at the 90% confidence level. The z-statistic associated with 90% confidence is 1.645.

When evaluators or regulators use the term “90/10”, the 10 refers to the relative precision of the estimate. The formula for relative precision shown in Equation 7:

Equation 7: Relative Precision of the Savings Estimate

$$Relative\ Precision_{Verified\ Savings} = \frac{Error\ Bound_{(kWh\ or\ kW)}}{Verified\ Impact_{(kWh\ or\ kW)}}$$

An important attribute of relative precision to consider when reviewing achieved precision values is that it is “relative” to the impact estimate. Therefore programs with low realization rates are likely to have larger relative precision values because the error bound (in kWh or kW) is being divided by a smaller number. This means two programs with exactly the same reported savings and sampling error in absolute terms, will have very different relative precision values, as shown in Table 4-2.

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Table 4-2 Relative Precision Example

Program	Reported kWh	Realization Rate	Error Bound (kWh)	Verified kWh	Relative Precision (90%)
Program #1	4,000,000	0.5	400,000	2,000,000	± 20%
Program #2	4,000,000	1.0	400,000	4,000,000	± 10%

In many cases a program-level savings estimate requires summation of the verified savings estimates from several strata. In order to calculate the relative precision for these program-level savings estimates, the evaluation team used Equation 8 to estimate the error bound for the program as a whole from the stratum-level error bounds.

Equation 8: Combining Error Bounds across Strata

$$Error\ Bound_{Program} = \sqrt{Error\ Bound^2_{Stratum1} + Error\ Bound^2_{Stratum2} + Error\ Bound^2_{Stratum3}}$$

Using this methodology, the evaluation team developed verified savings estimates for the program and an error bound for that estimate. The relative precision of the verified savings for the program is then calculated by dividing the error bound by the verified savings estimate.

4.4 Targeted and Achieved Sampling

4.4.1 DEC Sampling

Table 4-3 presents the final achieved sample size for the DEC service territory based on data collection activity (verification and M&V) and the program delivery stream method (Classic versus Custom-to-Go). Impact sample sizes targeted a 90/10 confidence precision based on the expected participation counts for the evaluation period. Samples were selected on an on-going basis across the evaluation period (January 2016 - December 2017) to help ensure proper representation of measure types and program approaches as the program progressed.

Table 4-3 DEC NR Custom Sampling Plan Custom-to-Go vs. Custom Classic - Achieved

Utility	Data Collection Activity	Custom to Go	Classic	Total
Duke Energy Carolinas	Share of Participation	24%	76%	100%
	Site Visits – On-site Measurement	10	28	38
	Site Visits – On-site Verification	4	17	21
	Total	**14**	**45**	**59**

The evaluation team stratified the participant population by technology category (lighting vs. non-lighting) and relative magnitude of savings (kWh) to ensure that the evaluated sample represented the population make-up of the total program-level savings and in order to achieve higher statistical precision by reducing the variability within the sample. Our stratification approach and achieved sample sizes are summarized in Table 4-4.

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Table 4-4 DEC NR Custom Stratified Sampling - Achieved

Strata	Population	Pop Reported Savings (kWh)	Achieved Sample Size
L-Large (>1,000 MWh)	18	35,491,559	5
L-Small (<1,000 MWh)	261	34,500,751	27
NL-Large (>2,000 MWh)	5	21,661,701	2
NL-Small (<2,000 MWh)	50	22,645,465	25
Total	**334**	**114,299,476**	**59**

The evaluation team used a savings threshold of 1,000 MWh as the threshold for large Lighting (L) projects and 2,000 mWh for large Non-Lighting (NL) projects. The thresholds were chosen based upon an analysis of the distribution of participant savings.

4.4.2 DEP Sampling

Table 4-5 presents the final achieved sample size for the DEP service territory. The evaluation team stratified the DEP participant population by technology category (lighting vs. non-lighting) and relative magnitude of savings (kWh). The evaluation team used a savings threshold of 250 MWh for large Lighting (L) projects and 500 MWh for large Non-Lighting (NL) projects. Our stratification approach and achieved sample sizes are summarized in Table 4-6.

Table 4-5 DEP NR Custom Sampling Plan Custom-to-Go vs. Custom Classic - Achieved

Utility	Data Collection Activity	Custom to Go	Classic	Total
Duke Energy Progress	Share of Participation	44%	56%	100%
	Site Visits – On-site Measurement	11	8	19
	Site Visits – On-site Verification	9	5	14
	Total	**20**	**13**	**33**

Table 4-6 DEP NR Custom Stratified Sampling - Achieved

Strata	Population	Pop Reported Savings (kWh)	Achieved Sample Size
L-Large (>250 MWh)	9	3,289,490	4
L-Small (<250 MWh)	82	3,195,020	19
NL-Large (>500 MWh)	5	5,979,116	3
NL-Small (<500 MWh)	21	3,676,915	7
Total	**117**	**16,140,541**	**33**

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4.5 Data Collection

As outlined in prior sections, the gross impact evaluation process began with a thorough review of project documentation. This information was provided upon formal request. Documents commonly provided by the program team include:

- Smart $aver Incentive Calculation workbooks
- DSMore Summary workbooks
- Custom Incentive Application Forms
- Contractor Proposals
- Detailed project narratives
- Product specifications and invoices
- Customer utility data (billing history)
- Incentive payment request forms
- Email correspondence between members of the program management team and participants
- Other documents commonly provided on lighting project include:
  - Smart $aver Custom Incentive Program Lighting Calculators
  - Specification sheets for retrofit lighting systems
- Other documents commonly provided for non-lighting projects include:
  - Customer submitted energy and demand savings calculations
  - Detailed reports developed by third-party engineering consultants
  - Building energy simulation model output files

After reviewing all program-supplied project documentation the evaluation team engineer assigned to each project then developed a site-specific measurement and verification plan (SSMVP) for each unique premise. These were developed in order to create a standardized, rigorous process for the verification of project claims while on-site. Each SSMVP was specifically tailored to verify the equipment that was installed and measures that were implemented per the provided project documentation. The SSMVP also identified baseline assumptions for verification with on-site personnel in order to validate ex-ante, forecasted savings estimates.

Each SSMVP also identified the specific parameters to be gathered in the field for each measure. These plans followed guidelines set forth in multiple Department of Energy Uniform Methods Project (DOE UMP) protocols including:

- Chapter 2: Commercial and Industrial Lighting Evaluation Protocol
- Chapter 14: Chiller Evaluation Protocol
- Chapter 18: Variable Frequency Drive Evaluation Protocol

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- Chapter 19: HVAC Controls (DDC/EMS/BAS) Evaluation Protocol
- Chapter 22: Compressed Air Evaluation Protocol
- Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol

The plans also identify a preferred and one or two alternate analysis approaches (level of rigor) along with the critical data to be gathered for each. Regardless of the method ultimately selected for the savings analysis, field engineers were instructed to gather the data necessary for all methods identified in the SSMVP. Table 4-7 provides a few examples of the data points typically gathered for several of the more commonly-encountered energy conservation measures (ECMs).

Once completed each SSMVP was then submitted to the Duke EM&V Team for review and approval. Upon approval from Duke an on-site inspection was then scheduled with the participant.

4.5.1 On-site Verification Activities

During on-site verification, field engineers would verify that measures were appropriately implemented in accordance with the SSMVP developed for the site. Field engineers would also deploy metering equipment for short-term monitoring of parameters such as lighting hours of use, energy consumption (amps or kW), and loads. They also requested copies of equipment specifications and sequences of operation, as appropriate. Any available historic trend data (when available) was also obtained from existing HVAC control and central plant sequencing control systems.

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Table 4-7 Key Data Points Gathered for Commonly Encountered ECMs

Measure Name	Baseline or Retrofit
Interior Lighting Retrofits	Quantity of existing fixtures Fixture type of existing fixtures Quantity of retrofit fixtures Fixture type of retrofit fixtures Existing fixture controls, if any New fixture controls, if any Typical schedule and hours of operation Space temperature Type of heating and cooling equipment/specifications
HVAC Control/EMS	Determine baseline setpoints and schedules through customer interviews Determine post-retrofit setpoints and schedules through central BAS Obtain any available trend data Verify occupancy and equipment schedules Gather nameplate information from primary heating and cooling systems
Variable Speed Drive on Pump	Determine baseline method of pump control Determine conditions that dictate the speed of the VSD Determine whether loads modulate or are fairly constant If loads modulate, determine load profile (% load bins) Nameplate information from pump Nameplate information from VSD Gather any available trend data Deploy metering equipment capable of measuring true polyphase RMS power Perform spot power measurements (kW) of pump while running under normal operating conditions
VSD Air Compressor	Determine baseline method of control Gather information on baseline air compressor system (kW/CFM, hp, CFM output, system type, etc.) Determine how loads vary daily, weekly, seasonally, annually for VSD compressor Nameplate information from new air compressor Gather any operational parameters displayed on control panels Gather any available trend data from central controls system Determine whether compressor serves central plant with multiple compressors or is stand-alone. If part of multi-compressor plant determine role and sequences of operation (primary, secondary, trim, etc.) Deploy metering equipment capable of measure true polyphase RMS power

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4.6 Level of Rigor

A variety of analysis approaches were utilized for the impact evaluation. The approach applied was decided based upon the methods used by the participant, trade ally, or program in generating the ex-ante[4] savings estimates, the availability of information, and the extent of interactive effects. An overview of each analysis approach applied is provided in Sections 4.6.1 through 4.6.3.

4.6.1 Basic Rigor: Simple Engineer Model (SEM) with On-Site Measurement

Consistent with IPMVP Option A (Partially Measured Retrofit Isolation), this approach was used for the majority of lighting, custom process, and compressed air measures. This method uses engineering calculations, along with site measurements of a limited number of important parameters, to verify the savings resulting from specific measures. This was the most prevalent level of rigor applied for this evaluation.

An overview of the key inputs and algorithms used to develop energy and demand savings estimates for lighting measures and compressed air measures is provided in Section 4.6.1.1 and 4.6.1.2.

4.6.1.1 Lighting Measures

Equation 9 and Equation 10 were used to calculate energy and demand savings for all lighting retrofit measures.

Equation 9: Lighting Demand Savings

$$\Delta kW = (Qty_{BASE} \times Watts_{BASE} - Qty_{EE} \times Watts_{EE}) / 1000 \times WHF_d$$

Equation 10: Lighting Annual Energy Savings

$$\Delta kWh/yr = (Qty_{BASE} \times Watts_{BASE} - Qty_{EE} \times Watts_{EE}) / 1000 \times HoursWk \times Weeks \times WHF_e$$

Where:

Qty_{BASE}	=	*Quantity of baseline fixtures*
$Watts_{BASE}$	=	*Watts of baseline fixture (based on the specified existing fixture type) (Watts)*
Qty_{EE}	=	*Quantity of energy efficient fixtures*
$Watts_{EE}$	=	*Watts of energy efficient fixture (based on the specified installed fixture type) (Watts)*
HoursWk	=	*Weekly hours of equipment operation (hrs/week)*
Weeks	=	*Weeks per year of equipment operation (weeks/year)*

[4] The term "ex ante" represents the forecasted energy and demand savings rather than the actual results.

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WHF_d	=	*Waste heat factor for demand to account for cooling savings from efficient lighting**
WHF_e	=	*Waste heat factor for energy to account for cooling savings from efficient lighting**
1000	=	*Conversion: 1000 Watts per kW*

Fixture Wattages

The pre-existing fixture wattages were quoted from industry standards and commercial literature for the applicable type of fixtures.

The installed light fixture wattages were taken from the manufacturer's cut sheets.

Hours of Use

Nexant verified hours of use assumptions by deploying lighting loggers. The lighting operating hours may exceed the facility's posted hours of business.

4.6.1.2 Compressed Air Measures

Energy use reduction for all compressor projects can be calculated by the difference between the energy consumed in the baseline operation minus the energy consumed in the post-retrofit operation. Generally, information is required for compressor capacity in both the baseline and post-retrofit scenarios. Appropriate adjustments are made to ensure the flow profile is equivalent between pre- and post-retrofit conditions unless demand improvements have been made that result in a change in the flow profile. Compressor power at full load can be calculated using Equation 11 and Equation 12.

Equation 11: Compressor Power at Full Load (No VSD)

$$\text{Full Load } kW_{rated} = \frac{(\text{Compressor hp}) \times LF_{rated} \times (0.746\ kW/hp)}{(\eta_{motor})}$$

Equation 12: Compressor Power at Full Load (w/ VSD)

$$\text{Full Load } kW_{rated} = \frac{(\text{Comp hp}) \times LF_{rated} \times (0.746\ kW/hp)}{(\eta_{motor}) \times (\eta_{VSD})}$$

Where:

Comp hp	=	*compressor horsepower, nominal rating of the prime mover (motor)*
0.746	=	*horsepower to kW conversion factor*
η_{moto}	=	*motor efficiency (%)*
η_{VSD}	=	*variable-speed drive efficiency (%)*
LF_{rated}	=	*load factor of compressor at full load (typically 1.0 to 1.2)*

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The above methods for determining the instantaneous demand of an air compressor at a given load is then repeated for many bins of hour-CFM operation. This is commonly referred to as a CFM demand profile. A demand profile is developed to provide accurate estimates of annual energy consumption. A demand profile typically consists of a CFM-bin hour table summarizing hours of usage under all common loading conditions throughout a given year.

The annual CFM profile is used to determine base case and proposed case energy use. For both, compressor electricity demand for each CFM-bin is determined from actual metering data, spot power measurements, historical trend data or CFM-to-kW lookup tables.

The difference in energy consumption between an air compressor operating in idling mode and being physically shut down can be significant depending on the base case and post-retrofit case methods of system control. For example, a rotary screw compressor with inlet valve modulation (w/ blowdown) controls will draw 26% of full-load power (kW) when operating in idling mode; whereas a VSD-controlled system (w/stopping) has zero load for the same bin-hours. Table 4-8 shows the average percent power versus percent capacity for rotary screw compressors with various control methods[5].

Table 4-8 Average Percent Power versus Percent Capacity for Rotary Screw Compressors with Various Control Methods

	% Power							
% Capacity	**On/Off Control**	**Load/Unload (1 gal/CFM)**	**Load/Unload (10 gal/CFM)**	**Inlet Valve Modulation (w/o Blowdown)**	**Inlet Valve Modulation (w/ Blowdown)**	**Variable Displacement**	**VSD w/Unloading**	**VSD w/Stopping**
0%	0%	27%	27%	71%	26%	25%	12%	0%
10%	10%	32%	35%	74%	40%	34%	20%	12%
20%	20%	63%	42%	76%	54%	44%	28%	24%
30%	30%	74%	52%	79%	62%	52%	36%	33%
40%	40%	81%	60%	82%	82%	61%	45%	41%
50%	50%	87%	68%	86%	86%	63%	53%	53%
60%	60%	92%	76%	88%	88%	69%	60%	60%
70%	70%	95%	83%	92%	92%	77%	71%	71%
80%	80%	98%	89%	94%	94%	85%	80%	80%
90%	90%	100%	96%	97%	97%	91%	89%	89%
100%	100%	100%	100%	100%	100%	100%	100%	100%

[5] Source: Department of Energy Uniform Methods Project: Chapter 22: Compressed Air Evaluation Protocol

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The energy consumption for each CFM-bin is determined from the product of the average compressor demand and the number of hours in each bin (Equation 13). The sum of the kWh bin values gives the annual consumption (Equation 14).

Equation 13: Energy Consumption of CFM-bin

$$\Delta kWh_{bin1} = (Base\ kW_{operating_bin1} - Post\ kW_{operating_bin1}) \times CFM\text{-}bin\ 1\ Hours$$

$$\Delta kWh_{binN} = (Base\ kW_{operating_binN} - Post\ kW_{operating_binN}) \times CFM\text{-}bin\ N\ Hours$$

Where:

$Base\ kW_{operating_bin1}$ = *baseline demand at part-load associated with CFM-bin 1*

$Post\ kW_{operating_bin1}$ = *post demand at part-load associated with CFM-bin 1*

$Base\ kW_{operating_binN}$ = *baseline demand at part-load associated with CFM-bin N*

$Post\ kW_{operating_binN}$ = *post demand at part-load associated with CFM-bin N*

Equation 14: Total Energy Consumption of All CFM-bins

$$Total\ Energy\ Reduction\ (kWh/yr) = \sum_{o\text{-}n} [\ \Delta kWh_{bin1} + \Delta kWh_{bin2} + \ldots + \Delta kWh_{binN}\ ]$$

Where:

ΔkWh_{bin1} = *energy reduction for CFM-bin 1*

ΔkWh_{binN} = *energy reduction for CFM-bin N*

4.6.2 Basic Rigor: Simple Engineer Model (SEM) with On-Site Verification Only

This approach is very similar to SEM with On-site Measurement, but without direct measurement of key parameters. This approach was generally applied to measures that are not conducive to direct measurement such as outdoor lighting or building envelope improvements. This approach was also used in instances where process equipment could not be de-energized for the purposes of deploying metering equipment. The algorithms and inputs described in Section 4.6.1 are still applicable to this approach.

4.6.3 Enhanced Rigor: Billing Analysis with On-Site Verification Only

Consistent with IPMVP Option C (Whole Building), this approach was used for projects involving multiple HVAC control measures with interactive effects, when final ex ante building simulation models could not be obtained from the trade ally. It was also used for large industrial custom process measures involving equipment that could not be de-energized to accommodate installation of data logging equipment. This approach was only applied on projects where the reported gross energy savings exceeded 10% of annual energy consumption. This approach entailed a pre- and post-retrofit comparison of weather-normalized whole facility energy consumption. This approach adhered to guidelines set forth in the Department of Energy Uniform Methods Project Protocols for HVAC Controls (Chapter 19) and Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol (Chapter 8).

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Our general approach consisted of the following:

1. Fit a premise-level degree-day regression model separately for the pre- and post-periods.
2. For each period (pre- and post-) use the coefficients of the fitted model with normal year degree days to calculate weather-normalized annual consumption (NAC) for that period.
3. Calculate the difference between the pre- and post-period NAC for the site.

This approach was used for four of the Custom Incentive Participant projects. Outlined below is the step-by-step process for this analysis:

Step 1. Fit the Regression Model: The degree-day regression for the site and year (pre or post) are modeled as:

Equation 15: Average Consumption per Day

$$E_m = \mu + \beta_H H_m + \beta_C C_m + \varepsilon_m$$

Where:

E_m	=	*Average consumption per day during interval m*
H_m	=	*Specifically, $H_m(T_H)$, average daily heating degree days at the base temperature (T_H) during meter read interval m, based on daily average temperatures on those dates*
C_m	=	*Specifically, $C_m(T_C)$, average daily cooling degree days at the base temperature (T_C) during meter read interval m, based on daily average temperatures on those dates*
μ	=	*Average daily baseload consumption estimated by the regression*
β_H, β_C	=	*Heating and cooling coefficients estimated by the regression*
ε_m	=	*Regression residual*

Step 2. Applying the Model: To calculate NAC for the pre- and post-installation periods for the given site and timeframe, combine the estimated coefficients μ, β_H, and β_C with the annual normal-year or typical meteorological year (TMY) degree days H_0 and C_0 calculated at the site-specific degree-day base, T_H and T_C. The example shown below puts all premises and periods on an annual and normalized basis.

Equation 16: Weather-Normalized Annual Consumption

$$NAC = \mu * 365.25 + \beta_H H_0 + \beta_C C_0$$

Step 3. Calculate the Change in NAC: The difference between pre- and post-program NAC values (ΔNAC) represents the change in consumption under normal weather conditions.

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4.6.4 Peak Period Definition

Demand savings were evaluated based on the definition of the peak period provided by Duke Energy, as summarized Table 4-9.

Table 4-9 Definition of Peak Demand Periods

	Summer	Winter
Month	July	January
Hour	4pm – 5pm	7am – 8am

4.7 Measurement & Verification Reports

Once a savings analysis was complete all findings from on-site verification and each project-level savings analysis was summarized in a standalone Measurement and Verification Report. Each report contained the full contents of the original SSMVP (Sections 1 through 3) prepared in advance of the on-site inspection as well as a new section (Section 4) summarizing all site visit findings, the chosen approach for quantifying energy savings, the verified energy and demand savings, and commentary on reasons for differences between the reported and verified savings values. Each individual M&V Report was then submitted to the Duke EM&V Team for review, comment, and approval. The 94 individual M&V Reports developed as part of this evaluation were provided under separate cover.

4.8 Impact Evaluation Analysis and Findings

4.8.1 High Level Findings

4.8.1.1 Continue with Current Work

Based upon the results of the gross impact evaluation it is evident that the level of rigor being applied to each project as it goes through the application process of the NR Custom Program is resulting in accurate estimates of energy and demand savings in both service territories. The practice of subjecting each project to a thorough engineering review by AESC followed by a high-level review by the program team seems to be providing a level of quality control that minimizes calculation errors or instances of over-claimed energy or demand savings. In fact, the evaluated energy and demand realization rates indicate that the program is conservative when developing savings estimates. The strata-level realization rates also indicate that an appropriate level of rigor is being applied to every project regardless of its size (magnitude of energy /demand savings) or measure category (lighting vs. non-lighting).

4.8.1.2 Interactive Energy Changes for Lighting Retrofits

How energy-efficiency projects change the energy use of other equipment, not associated directly with the projects themselves, should be a consideration in estimating the energy efficiency program benefits. These interactive energy changes can be challenging to quantify, but should be accounted for whenever possible.

Interactive energy changes come in a number of forms and affect different fuel types. A measure that directly saves electricity may cause another building system to consume less

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energy. Alternatively, a measure that directly saves electricity could cause another building system to consume more energy. Sometimes, a single project can have both positive and negative interactive effects on other systems. For example, upgrading to energy efficient lighting reduces the electricity that a participant uses on lighting; the associated reduction in waste heat reduces the burden on the cooling system in the summer – but increases the burden on the heating system in the winter.

Lighting projects produce relatively predictable interactive energy changes enabling the development of stipulated factors through building energy simulation modeling. For this evaluation building energy simulation models were developed for 18 facility types using DOE-2 based modeling software and Database of Energy Efficiency Resources (DEER) building prototypes. Five sets of models was developed for the DEC and DEP service territories using TMY3 weather data from Raleigh-Durham, Charlotte, Asheville, Greensboro and Greenville. Table 4-10 presents the interactive factors developed by the evaluation team for each building type and weather station.

Table 4-10 Interactive Factors by Facility Type and Weather Station

Building Type	Asheville, NC	Greensboro, NC	Greenville, SC	Raleigh-Durham, NC	Charlotte, NC
Assembly	104.4%	107.6%	108.6%	108.7%	109.0%
Bio Tech Manufacturing	107.1%	112.2%	113.7%	114.0%	114.4%
Community College	104.1%	107.1%	108.0%	108.2%	108.4%
Hospital	106.0%	110.3%	111.6%	111.8%	112.2%
Hotel	105.5%	109.4%	110.5%	110.8%	111.1%
Light Industrial Manufacturing	100.1%	100.1%	100.1%	100.1%	100.1%
Motel	114.4%	124.6%	127.7%	128.3%	129.1%
Nursing Home	113.2%	122.7%	125.6%	126.2%	126.9%
Office Large	103.1%	105.3%	106.0%	106.1%	106.3%
Office Small	101.4%	102.5%	102.8%	102.8%	102.9%
Primary School	100.6%	101.1%	101.2%	101.3%	101.3%
Restaurant Fast Food	101.7%	102.9%	103.2%	103.3%	103.4%
Restaurant Sit Down	98.4%	97.2%	96.9%	96.8%	96.7%
Retail Large	102.2%	103.8%	104.2%	104.3%	104.5%
Retail Small	100.4%	100.7%	100.8%	100.8%	100.8%
Secondary School	101.1%	101.8%	102.1%	102.1%	102.2%
University	108.2%	114.0%	115.8%	116.1%	116.6%
Warehouse Conditioned	105.7%	109.7%	111.0%	111.2%	111.5%

Interactive effects were estimated for each facility type by simulating a reduction in annual lighting end use energy consumption of approximately 4%. This value was chosen based upon

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Nexant's experience with evaluating other custom and prescriptive lighting programs across the country.

Table 4-11 provides an overview of the verified energy savings attributed to interior lighting measures within conditioned spaces and the relative contribution to savings by interactive effects estimated by the evaluation team. Total savings attributable to interactive effects within the evaluated sample is estimated to be approximately 724,277 kWh or 4.6% of total verified energy savings (15,678,725 kWh) for all lighting projects. Interactive effects account for approximately 6.0% of verified energy savings for projects with space cooling.

Table 4-11 Verified Energy Savings (kWh) and Relative Contribution of Interactive Effect Savings by Facility Type from Evaluated Sample for Facilities with Space Cooling

Building Type	Verified Energy Savings (kWh)	Interactive Effects Savings (kWh)	% Savings Attributable to Interactive Effects
Warehouse	7,330,480	662,018	9.03%
Light Industria/Manufacturing	3,727,968	3,458	0.09%
University	517,321	52,058	0.80%
Retail	371,303	2,971	10.06%
Office	44,378	1,049	2.36%
Primary School	32,236	413	1.28%
Assembly	22,484	1,973	8.78%
Healthcare	5,598	335	5.99%
Total	**12,051,767**	**724,277**	**6.01%**

4.8.2 Gross Impacts - DEC

Table 4-12, Table 4-13, and Table 4-14 summarize gross impact results for energy (kWh), Summer demand (kW), and Winter demand (kW) for the DEC service territory. Detailed results for each sampled project are provided in the standalone M&V Reports.

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Table 4-12 DEC Gross Verified Energy Savings (kWh) by Stratum

Stratum	Population (N)	Sample Count (n)	Gross Reported Energy Savings (kWh)	Gross Verified Energy Savings (kWh)	Realization Rate (%)	Relative Precision @ 90% Confidence
L-Large (>1,000 MWh)	18	5	35,491,559	37,792,452	106.5%	4.4%
L-Small (<1,000 MWh)	261	27	34,500,751	37,552,406	108.8%	30.7%
NL-Large (>2,000 MWh)	5	2	21,661,701	23,301,600	107.6%	9.2%
NL-Small (<2,000 MWh)	50	25	22,645,465	21,862,911	96.5%	38.0%
Total	**334**	**59**	**114,299,476**	**120,509,368**	**105.4%**	**12.0%**

Table 4-13 DEC Gross Verified Summer Demand Savings (kW) by Stratum

Stratum	Population (N)	Sample Count (n)	Gross Reported Summer Demand Savings (kW)	Gross Verified Summer Demand Savings (kWh)	Realization Rate (%)	Relative Precision @ 90% Confidence
L-Large (>1,000 MWh)	18	5	4,854	5,636	116.1%	4.8%
L-Small (<1,000 MWh)	261	27	6,151	6,758	109.9%	29.8%
NL-Large (>2,000 MWh)	5	2	2,107	3,369	159.9%	38.5%
NL-Small (<2,000 MWh)	50	25	3,276	3,237	98.8%	76.6%
Total	**334**	**59**	**16,389**	**19,000**	**115.9%**	**18.2%**

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Table 4-14 DEC Gross Verified Winter Demand Savings (kW) by Stratum

Stratum	Population (N)	Sample Count (n)	Gross Reported Winter Demand Savings (kW)	Gross Verified Winter Demand Savings (kW)	Realization Rate (%)	Relative Precision @ 90% Confidence
L-Large (>1,000 MWh)	18	5	4,398	5,031	114.4%	6.5%
L-Small (<1,000 MWh)	261	27	5,218	5,996	114.9%	33.8%
NL-Large (>2,000 MWh)	5	2	2,559	5,372	209.9%	9.2%
NL-Small (<2,000 MWh)	50	25	2,933	2,316	79.0%	126.9%
Total	**334**	**59**	**15,109**	**18,716**	**123.9%**	**19.3%**

4.8.2.1 Custom-to-Go vs. Custom Classic - DEC

Custom-to-Go realization rates were higher primarily based upon the fact that the majority of savings come from lighting measures. Lighting measures represent 89.7% of total Custom-to-Go project reported energy savings, whereas for Classic Custom projects lighting measures account for only 55.8% of gross reported energy savings. Figure 4-2 shows the distribution of reported energy savings for classic custom projects broken down by technology category. Figure 4-3 shows the distribution of reported energy savings for Custom-to-Go projects.

Figure 4-2 Distribution of Reported Energy Savings for DEC Classic Custom Projects by Technology Category

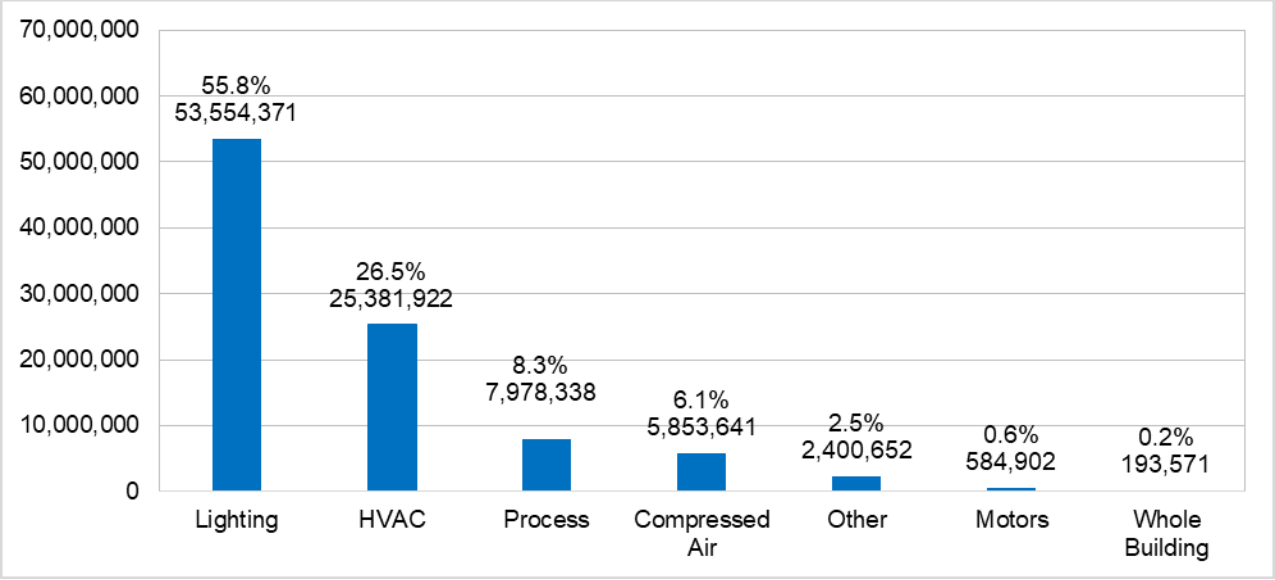

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Figure 4-3 Distribution of Reported Energy Savings for DEC Custom-to-Go Projects by Technology Category

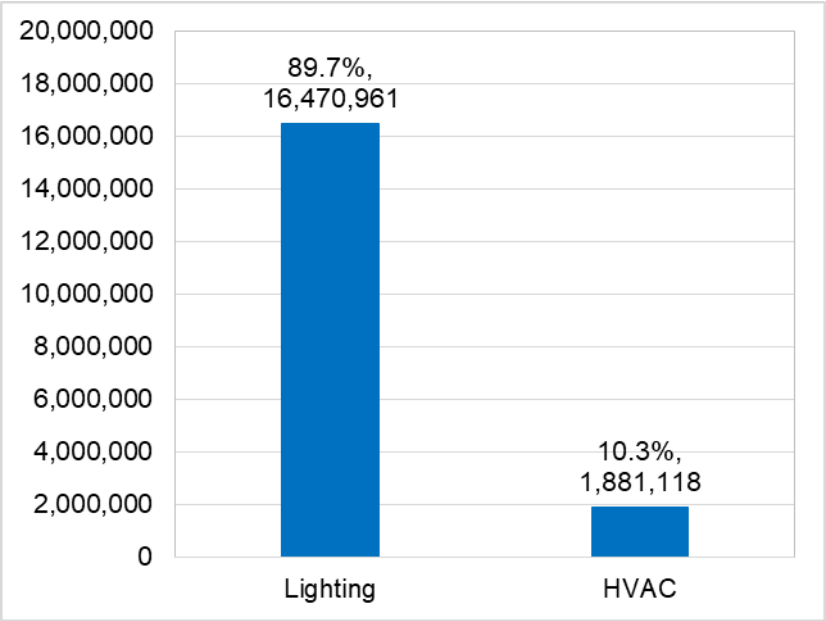

Table 4-15 shows the reported and verified energy (kWh) savings stratified by technology category (lighting vs. non-lighting) and participation track (Custom Classic vs. Custom-to-Go) for the evaluated sample.

Table 4-15 Comparison of Strata-Level Realization Rates - Classic vs. Custom-to-Go - DEC

Track	Measure Category	Sample	Sample Reported (kWh)	Sample Verified (kWh)	Realization Rate (%)
Classic	Lighting	21	10,890,605	11,648,353	107.0%
	Non-lighting	24	21,982,540	22,212,501	101.0%
	Total	**45**	**32,873,146**	**33,860,855**	**103.0%**
Custom-to-Go	Lighting	11	805,776	901,186	111.8%
	Non-lighting	3	834,272	820,142	98.3%
	Total	**14**	**1,640,048**	**1,721,328**	**105.0%**

4.8.3 Gross Impacts - DEP

Table 4-16, Table 4-17, and Table 4-18 summarize gross impact results for energy (kWh), Summer demand (kW), and Winter demand (kW) for the DEP service territory. Detailed results for each sampled project are provided in the standalone M&V Reports.

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Table 4-16 DEP Gross Verified Energy Savings (kWh) by Stratum

Stratum	Population (N)	Sample Count (n)	Gross Reported Energy Savings (kWh)	Gross Verified Energy Savings (kWh)	Realization Rate (%)	Relative Precision @ 90% Confidence
L-Large (>250 MWh)	9	4	3,289,490	3,662,303	111.3%	6.6%
L-Small (<250 MWh)	82	19	3,195,020	3,110,400	97.4%	41.0%
NL-Large (>500 MWh)	5	3	5,979,116	6,075,769	101.6%	0.9%
NL-Small (<500 MWh)	21	7	3,676,915	4,213,289	114.6%	20.6%
Total	**117**	**33**	**16,140,541**	**17,061,762**	**105.7%**	**9.2%**

Table 4-17 DEP Gross Verified Summer Demand Savings (kW) by Stratum

Stratum	Population (N)	Sample Count (n)	Gross Reported Summer Demand Savings (kW)	Gross Verified Summer Demand Savings (kWh)	Realization Rate (%)	Relative Precision @ 90% Confidence
L-Large (>250 MWh)	9	4	475	519	109.4%	11.4%
L-Small (<250 MWh)	82	19	516	448	86.8%	143.0%
NL-Large (>500 MWh)	5	3	531	519	97.7%	0.7%
NL-Small (<500 MWh)	21	7	388	415	106.9%	55.7%
Total	**117**	**33**	**1,910**	**1,901**	**99.5%**	**36.1%**

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Table 4-18 DEP Gross Verified Winter Demand Savings (kW) by Stratum

Stratum	Population (N)	Sample Count (n)	Gross Reported Winter Demand Savings (kW)	Gross Verified Winter Demand Savings (kW)	Realization Rate (%)	Relative Precision @ 90% Confidence
L-Large (>250 MWh)	9	4	499	667	133.8%	27.7%
L-Small (<250 MWh)	82	19	379	532	140.3%	227.8%
NL-Large (>500 MWh)	5	3	632	622	98.5%	1.8%
NL-Small (<500 MWh)	21	7	512	659	128.5%	17.2%
Total	**117**	**33**	**2,022**	**2,480**	**122.7%**	**49.6%**

4.8.3.1 Custom-to-Go vs. Custom Classic - DEP

Custom-to-Go realization rates were higher primarily based upon the fact that the majority of savings come from lighting measures. Lighting measures represent 68.7% of total Custom-to-Go project reported energy savings, whereas for Classic Custom projects lighting measures account for only 30.1% of gross reported energy savings. Figure 4-4 shows the distribution of reported energy savings for classic custom projects broken down by technology category. Figure 4-5 shows the distribution of reported energy savings for Custom-to-Go projects.

Figure 4-4 Distribution of Reported Energy Savings for DEP Classic Custom Projects by Technology Category

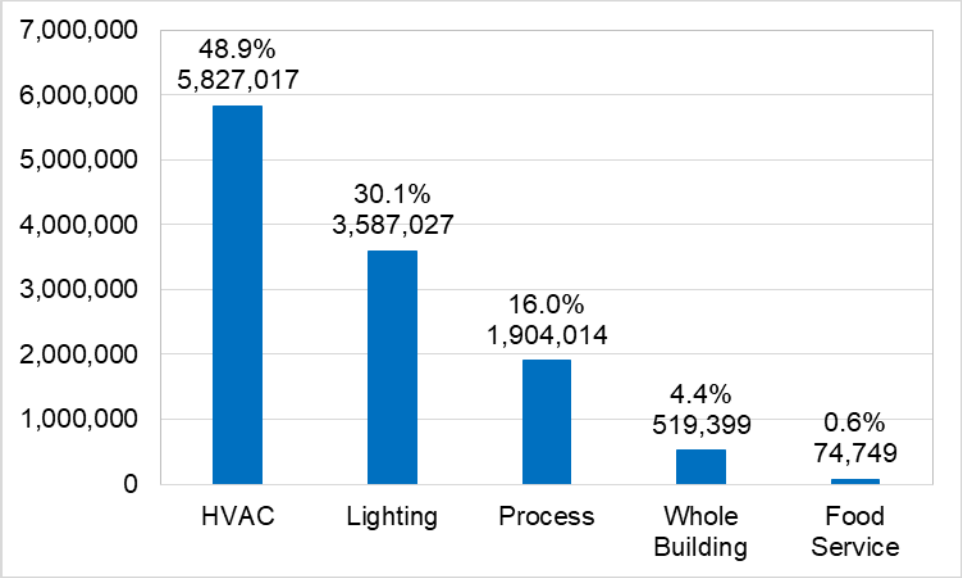

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Figure 4-5 Distribution of Reported Energy Savings for DEP Custom-to-Go Projects by Technology Category

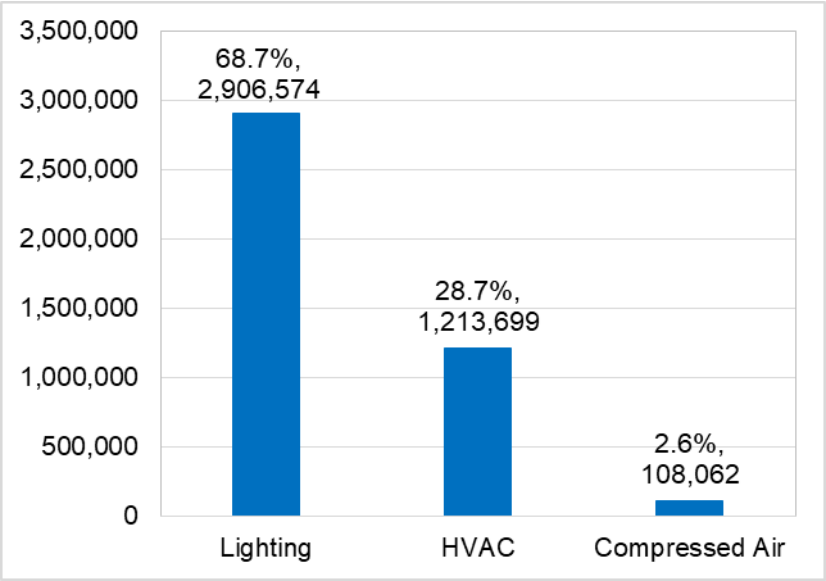

Table 4-19 shows the reported and verified energy (kWh) savings stratified by technology category (lighting vs. non-lighting) and participation track (Custom Classic vs. Custom-to-Go) for the evaluated sample.

Table 4-19 Comparison of Strata-Level Realization Rates - Classic vs. Custom-to-Go - DEP

Track	Measure Category	Sample	Sample Reported (kWh)	Sample Verified (kWh)	Realization Rate (%)
Classic	Lighting	7	948,608	958,886	101.1%
	Non-lighting	6	2,993,031	3,090,401	103.3%
	Total	**13**	**3,941,639**	**4,049,287**	**102.7%**
Custom-to-Go	Lighting	16	1,373,216	1,477,834	107.6%
	Non-lighting	4	909,075	979,924	107.8%
	Total	**20**	**2,282,292**	**2,457,759**	**107.7%**

4.8.3.2 Baseline Assumptions for Linear Fluorescent T12 Fixture Retrofits

Starting in 2017, the evaluation team agreed to ask participants and trade allies about the continued use of linear fluorescent T12 lamps. The evaluation team sought to understand how claimed energy savings for linear fluorescent to LED retrofit measures would be estimated with a T8 baseline as opposed to a T12 baseline, even if the pre-existing fixture was a T12. Additionally, the research sought to understand how high Color Rending Index (CRI) T12s are still readily available in the marketplace enabling participants to continue using T12 lighting

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systems. This research was completed in a cross-cutting manner for NR Custom evaluations for multiple Duke jurisdictions including Indiana, Ohio, North Carolina, and South Carolina.

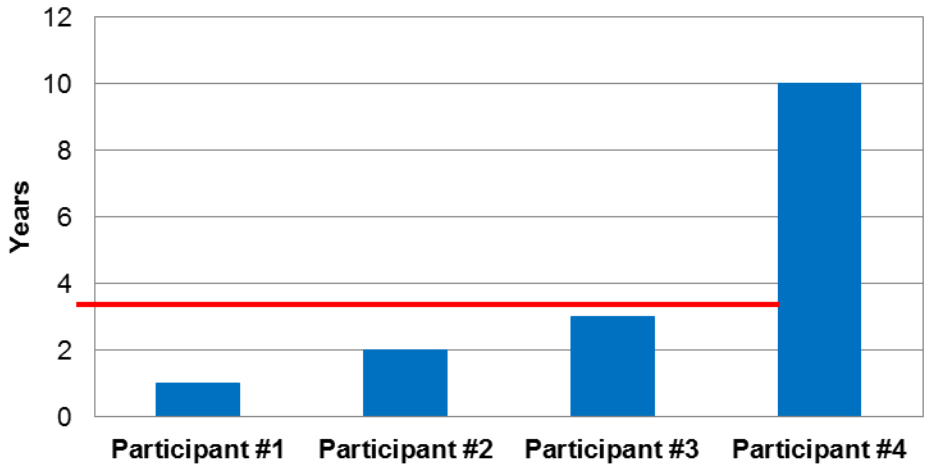
In an effort to gain direct insights on this issue from participants and trade allies, the evaluation team developed a battery of survey questions for each program participant and incorporated them into the survey instruments developed for this evaluation. The set of survey questions developed for participants was only fielded by those who implemented lighting retrofits involving linear fluorescent T12s, which was very limited (total of four across all jurisdictions being evaluated and only one from DEI). The questions asked and a summary of the responses received are summarized below.

Participant Surveys

Sampled participants with projects involving T12 retrofits (4) were asked:

- **Question #1:** *"Would you have continued using linear fluorescent T12 fixtures if you had not received a financial incentive to upgrade to LED?"*
  - Two respondents said *"Yes"*
  - Two respondents said *"No"*
- **Question #2:** *"Were you previously purchasing high Color Rendering Index (CRI) T12 replacement lamps as a means of postponing full fixture replacements?"*
  - Two respondents said *"Yes"*
  - Two respondents said *"No"*
- **Question #3:** "How long could replacement lamps have allowed you to continue to use T12 fixtures?" (Responses in Figure 4-6)

Figure 4-6 How Long Participant Could Have Continued Using T12 Fixtures



Trade Ally Surveys

Trade allies were asked the following questions regarding historic 2017 sales and forecasted 2018 sales for linear fluorescent T12 lamps and fixtures:

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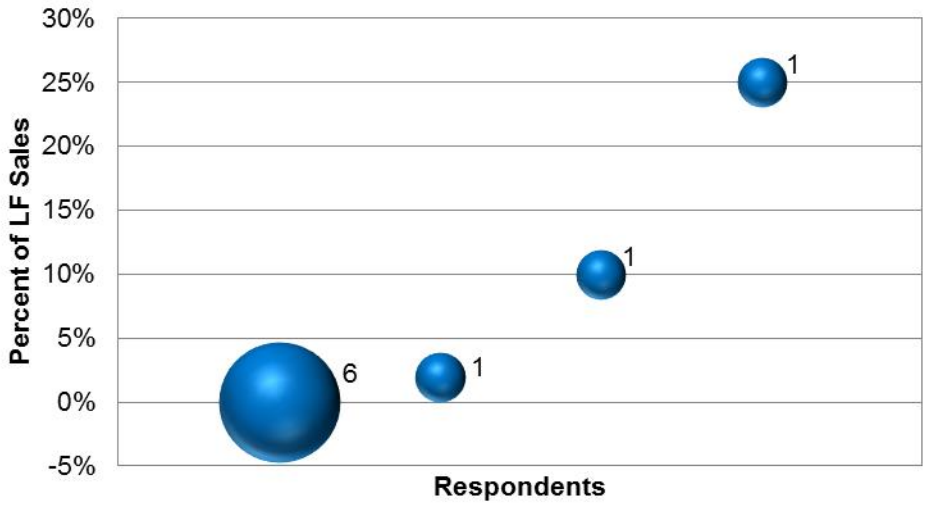
- **Trade Ally Question #1: "**Of your linear fluorescent lighting system sales in 2017, what percent were T12s?" (Responses in Figure 4-7)

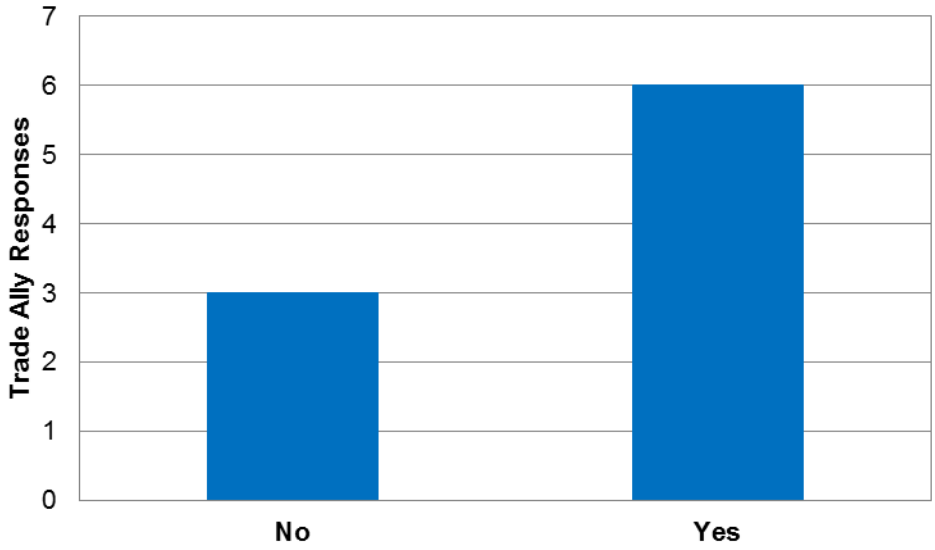
Figure 4-7 Percentage of 2017 Linear Fluorescent Lighting Sales that were T12 According to Surveyed Trade Allies



Trade ally responses to Question #1 suggest that the majority of the market has already shifted away from linear fluorescent T12s. Six of the nine trade allies surveyed reported that 0% of 2017 linear fluorescent sales were of the T12 variety.

- **Trade Ally Question #2:** "Are you still stocking and selling linear fluorescent T12 lighting systems and replacement lamps?" (Responses in Figure 4-8)

Figure 4-8 Are Trade Allies Still Stocking Linear Fluorescent T12 Replacement Lamps



Responses to Trade Ally Question #2 were also mixed. Six of the surveyed trade allies reported that they are still stocking linear fluorescent T12 lamps; however, only three of the trade allies

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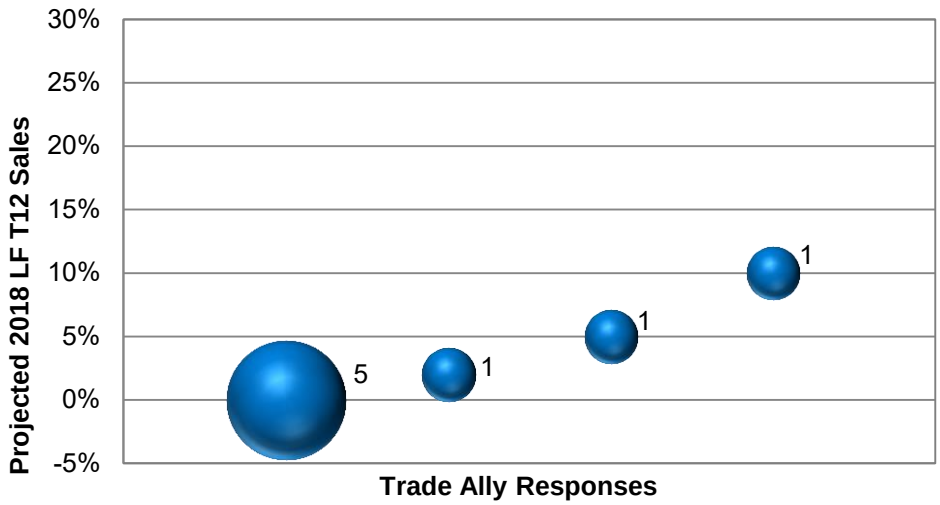
surveyed reported to have sold T12s in 2017. This indicates that T12 lamps are being stocked, but not sold.

- **Trade Ally Question #3**: "Thinking of your 2018 sales of linear fluorescent lighting system sales, what percent will be T12s?" (Responses in Figure 4-9)

Figure 4-9 Estimated Percentage of 2018 Linear Fluorescent Lamps Sales That Will Be T12



Responses to Trade Ally Question #3 suggest that linear fluorescent T12 sales are expected to decline even further in 2018. Five of the nine trade allies surveyed indicated that 0% of 2018 linear fluorescent sales would be T12s.

In addition to asking participants and trade allies about linear fluorescent T12 lamps and fixtures, the evaluation team also quantified the difference in verified energy savings for all T12 measures sampled. For this analysis the evaluation team calculated the measure level savings using two scenarios. The first approach used a T12 baseline which is consistent with what the program uses in ex-ante energy savings estimates. The second approach used a reduced baseline fixture wattage consistent with a linear fluorescent T8 equivalent. The results of this analysis are summarized in Figure 4-10.

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Figure 4-10 Comparison of Verified Energy Savings (kWh) and Realization Rates when Using T12 vs. T8 Baseline for Linear Fluorescent Retrofits

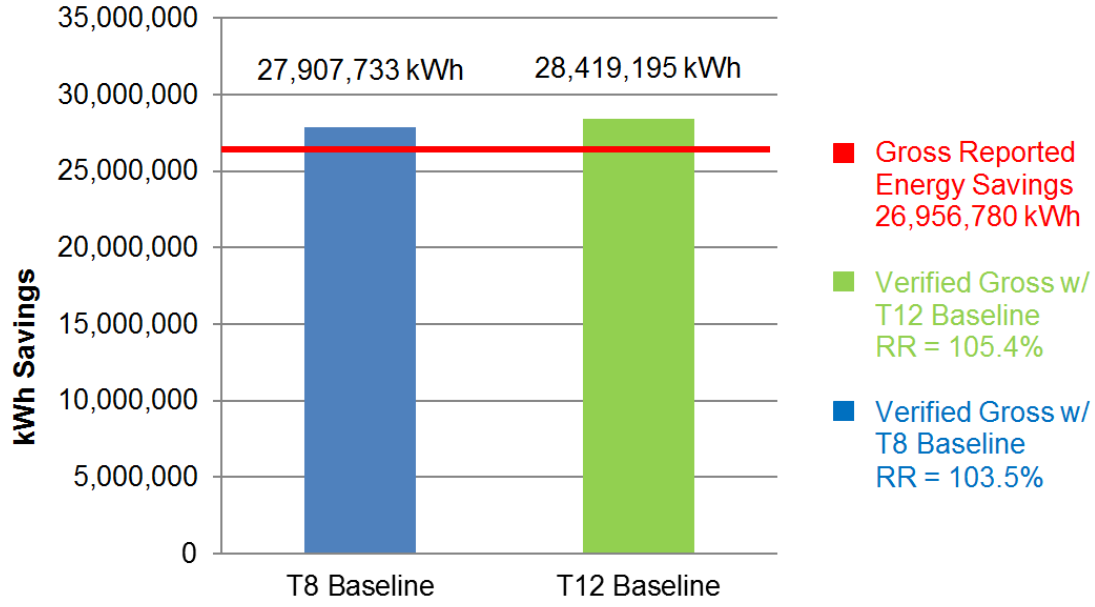

Figure 4-10 indicated that the overall impact on verified energy savings at the program level is very small regardless of whether a T12 or a T8 baseline is used for linear fluorescent fixture retrofits. Verified energy savings would reduce by approximately 511,462 kWh or 1.8%. Due to the relative minimal impact and in keeping with current industry standards, it is recommended that the NR Custom Program adopt a T8 baseline standard.

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5 Net-to-Gross

5.1 Methodology

The evaluation team based the net-to-gross evaluation on customer self-report surveys, as described in the Uniform Methods Project, Chapter 23: Estimating Net Savings: Common Practices.[6] The survey was designed based on established methodologies outlined in the Pennsylvania Evaluation Framework.[7]

Net-to-gross analysis for this program involved two calculations: free-ridership and spillover. The results of these calculations are combined to produce the program-level net-to-gross ratio as follows:

Equation 17: Net-to-Gross Equation

$$NTG_p = (1 - FR_p) + SO_p$$

Where:

NTG_p	=	*program-level net-to-gross ratio*
FR_p	=	*program-level free-ridership ratio*
SO_p	=	*program-level spillover ratio.*

The program net verified energy savings are calculated by multiplying the program net-to-gross ratio by the gross verified energy savings resulting from the impact evaluation activities as described in Section 4.

Equation 18: Net Verified Energy Savings

$$kWh_{nv} = kWh_{gv} \times NTG_p$$

The calculations of the program-level free-ridership and spillover ratios are detailed in the following sections.

5.1.1 Free-Ridership

The evaluation calculated free-ridership for each survey respondent based on their answers to a series of questions. These questions collected information on the customers' *intention* prior to interacting with the program and the *influence* of the program on changing those intentions.

Survey respondents were asked how the project would have changed if the incentive were not available. Responses were scored on a scale from 0 to 50 as shown in Table 5-1. If the respondent indicated they would do a smaller or less efficient project, they are prompted to categorize it as a small, moderate, or large reduction in scope. If the respondent answered they

[6] https://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf, Section 3.2.

[7] http://www.puc.state.pa.us/Electric/pdf/Act129/SWE_PhaseIII-Evaluation_Framework082516.pdf, Appendix B.

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would have done exactly the same project without the program, they are asked if they would have paid the additional amount they received in incentives to complete the project.

Table 5-1 Net-to-Gross Intention Score Methodology

Response	Intention Score
Done nothing	0
Canceled or postponed the project	0
Done a smaller or less efficient project	Small = 37.5 Moderate = 25 Large = 12.5 Don't know = 25
Done exactly the same project	Would have paid = 50 Would not have paid = 25 Don't know = 37.5

To recognize the direct points of influence that the program has on customers' decisions, the survey asked respondents to rate the influence of several program aspects (where 10 is extremely influential and 0 is not at all influential). The highest rating for each customer was scored, again on a scale of 0 to 50. The rationale is that if any aspect of the program is highly influential on a customer's decision, then the program overall was equally influential (see Table 5-2).

Table 5-2 Net-to-Gross Influence Score Methodology

Program Aspect	Max Rating → Influence Score
Incentive provided by Duke Energy	0-1 → 50 2 → 43.75 3 → 37.5 4 → 31.25 5 → 25 6 → 18.75 7 → 12.5 8 → 6.25 9-10 → 0
Interactions with Duke Energy	
Duke Energy marketing materials	
Previous experience with Duke Energy programs	
Contractor or vendor recommendation	

The intention and influence scores are added together to produce each respondent's free-ridership ratio using Equation 19.

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Equation 19: Respondent Free-ridership Ratio

$$FR_i = \frac{Intention + Influence}{100}$$

The ratio is multiplied by that respondent's verified gross savings to result in free rider savings, or savings that would have occurred without the program. The program free-ridership ratio is the sum of free rider savings divided by the sum of verified gross savings as shown in Equation 20.

Equation 20: Program Free-ridership Ratio

$$FR_p = \frac{\sum(FR_i \times kWh_{gv})}{\sum kWh_{gv}}$$

5.1.2 Spillover

Spillover is an estimate of savings resulting from the installation of energy efficient projects that were completed without a program incentive but that still were influenced by the program. There are two components to arriving at these program-attributable savings.

First, the survey collects information on the type of energy-efficiency equipment that was installed but for which an incentive was not received. This is used to estimate energy savings through the application of established calculation methodologies, often a technical reference manual.

Second, the survey asks the respondent to rate the influence of the program on their decision to implement the project despite not receiving an incentive. That score is used to prorate the total project savings, recognizing that the program may not have been the only influence in the completion of the project. The result of this calculation is program-attributable spillover, shown in Equation 21:

Equation 21: Program-Attributable Spillover

$$kWh_{aso} = kWh_{gso} \times Influence$$

Where:

kWh_{aso} = *program-attributable spillover savings*

kWh_{gso} = *gross spillover savings*

Influence is the value based on the respondent's rating of the program influence, as shown in Table 5-3.

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Table 5-3 Participant Spillover Program Influence Values

Reported SmartSaver Program Influence	Influence Value
0	0.0
1	0.1
2	0.2
3	0.3
4	0.4
5	0.5
6	0.6
7	0.7
8	0.8
9	0.9
10	1.0
Don't know / Refused	Sector-level measure average

This number is divided by the total verified gross energy savings for the program to produce a program spillover ratio (Equation 22):

Equation 22: Program Spillover Ratio

$$Program\ SO\ Ratio = \frac{\sum kWh_{aso}}{kWh_{gv}}$$

5.2 Net-to-Gross Analysis and Findings

The evaluation team conducted net-to-gross interviews with 61 customers who completed projects at 75 different locations in the DEP and DEC territories. Most customers (51 of 75 projects) reported they would have put off the project, canceled it entirely, or reduced the scope or efficiency of the project. The remaining customers said they planned to do the same project prior to learning about the Smart $aver Custom Program, and all of those customers said they would have paid the cost of the upgrade if the incentive were not available. The full distribution of responses is shown in Table 5-4.

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Table 5-4 What Would You Have Done Had You Not Received an Incentive?

Response	DEC	DEP
Canceled or postponed the project	29	9
Done a smaller or less efficient project	11 Large reduction (1) Moderate reduction (6) Small reduction (4)	2 Large reduction (0) Moderate reduction (2) Small reduction (0)
Done exactly the same project	21 Would have paid (21) Would not have paid (0)	3 Would have paid (3) Would not have paid (0)

When asked to rate the influence of the program on their decision to complete the energy-efficiency project, nearly all respondents rated at least one program aspect a 7 or higher on a 0 to 10 scale, where 0 means "not at all influential" and 10 means "extremely influential." The program incentive and contractors' recommendations were the program aspects most commonly given a high rating. Customers who had previously participated a Duke Energy program rated that experience as particularly influential.

The resulting free-ridership, spillover, and net-to-gross ratios are shown in Table 5-5 below. These results indicate that the program is extremely effective in encouraging customers to complete projects they would not otherwise do.

Table 5-5 Net-to-Gross Evaluation Results

Measurement	DEC	DEP	Combined[8]
Net of Free-ridership	78.9%	70.8%	78.5%
Program-influenced Spillover	0.4%	0.0%	0.4%
Net-to-Gross	**79.2%**	**70.8%**	**78.8%**

The evaluation team notes that the DEP results are based on a small number of completed interviews. While the DEC results are estimated to be accurate ±4.5% with 90% confidence, the DEP results have a much wider confidence interval of ±16%. The combined results have a confidence interval of ±4.5%. This reflects that the DEP result is only based on 14 observations and there is notable variation in the individual responses. Because the evaluation team did not originally plan to produce a precise result for each territory individually, we did not stratify our survey sample or target a certain level of response from each territory. We recommend that Duke Energy should use the combined result for DEP since we believe it is more reflective of program operations.

The overall result of 78.8 percent net-to-gross reflects that the program was a primary influence in customers' energy savings actions. The evaluation team offers some observations on the

[8] The combined results are weighted using the same kWh-based weights used for DEC and DEP results, since this accounts for individual project sizes as well as the relative size of the programs across the two jurisdictions.

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drivers of the free-ridership that does exist, though many of these observations are qualitative since they are based on a small number of observations.

- Controls (BAS), HVAC Units, LEDs, and Compressors had higher than average free-ridership, while Chillers, Manufacturing Equipment, and Occupancy Sensors were lower than average. The result of 25% free-ridership for LEDs is the only result with a sufficient number of responses (60) to be a meaningful result, the other measures range from one to eight responses.
- Responses to the second wave of the survey resulted in much higher net-to-gross (94%, n=18) than those from the first wave (76%, n=57).
- There were no full free-riders, or customers with 100% freeridership scores, in the DEC territory, but there were several in the DEP territory.

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6 Process Evaluation

6.1 Summary of Data Collection Activities

Process evaluation activities are designed to support continuous program improvement by identifying successful program elements that can be expanded or built upon, as well as underperforming or inefficient program processes that could be holding back program performance or participation. Because the program is delivered the same between the two territories, we report combined activites and results for DEC and DEP together for the process evaluation. The data collection activities for the process evaluation of the NR Custom Program included a database review, and interviews with key contacts involved in program operations, participating customers, and contractors who assisted customers with projects.

The evaluation team developed data collection instruments designed to explore the research questions identified. Table 6-1 summarizes the process evaluation data collection activities.

Table 6-1 Summary of Process Evaluation Data Collection Activities

Target Group	Completes
Staff	2 In-depth interviews
Participants	81 Telephone survey (65 unique participants)[9]
Contractors	24 In-depth interviews

6.1.1 Program Staff Interviews and Database Review

Two interviews were conducted in June 2016 with Duke Energy's NR Custom program staff so that the evaluation team had a good understanding of the program and to get background information on program design and implementation practices. The program staff provided valuable feedback on intended operations, processes of the program's stated (and unstated) goals and objectives, perceived barriers to program up-take, and modifications to any program components based on the previous program cycle as well as the rationale for those modifications. The information the team gathered assisted in the design of the interview guides and surveys for customers and contractors.

In addition to the program staff interviews, the evaluation team reviewed the program tracking database to ensure necessary data and information was being collected to track program progress.

6.1.2 Contractor Interviews and Surveys

Custom programs include a variety of types of contractors and projects that require preapproval. For these programs to be successful, contractors must be able to access and use calculation

[9] 65 DEC participant projects (52 unique survey respondents); 16 DEP participant projects (13 unique survey respondents)

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tools, navigate preapproval processes, and communicate the steps involved to project representatives. Contractors are important market actors, especially in large custom programs, and a good understanding of their experience with program processes, preapprovals, customer decision making, and persistent barriers to additional projects is crucial to the success of custom programs.

The evaluation team selected implementation contractors associated with customer projects from the tracking database provided by Duke Energy. Discussion topics in the interviews included program awareness among customers, program guidelines and processes, interactions with customers, and suggestions for improving the program. Interviews were completed with 24 of 59 program contractors who participated in the program. The interviews were completed in February and March 2018 and the average interview length was 26 minutes. The average number of telephone attempts for cases that were not completed was 4.5. Table 6-2 outlines the contractor response rate for the evaluation.

Table 6-2 Contractor Response Rate

Disposition	Contractor Count
Starting Sample	**59**
Does not recall participating	1
No knowledgeable respondent	5
Refusal	4
Bad phone number	1
Attempted but not completed	24
Completes	**24**
Response Rate (Complete/Starting Sample)	**40.6%**

6.1.3 Participant Surveys

Collecting survey data from program participants provides data suitable for quantitative analyses of participant characteristics and satisfaction with key aspects of the program. The evaluation team conducted a telephone survey with program participants, defined by customers who received a rebate through Duke Energy's NR Custom program between January 2016 and December 2017. Surveys were conducted with program participants in two waves; the first wave was in October 2017 and the second wave was in March 2018. Surveys focused on customers' experience with the program, sources of awareness, decisions to install equipment, barriers to participation, satisfaction with various aspects of the program, and any program improvement suggestions. Surveys were completed for 81 of the 118 projects completed through the program (52 DEC and 13 DEP unique respondents).

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Table 6-3 outlines the participant response rate of the evaluation.

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Table 6-3 Participant Response Rate

Disposition	DEC	DEP	Overall
Starting Sample	**89**	**29**	**118**
Does not recall participating	2	0	2
Refusal	4	5	5
Incompletes (partial surveys)	0	1	1
Wrong number	2	0	2
Not completed	16	11	27
Completes	**65**	**16**	**81**
Response Rate (Complete/Starting Sample)	**73.0%**	**55.2%**	**68.6%**

Wave 1 calling started October 5, 2017 and ended October 26, 2017

Wave 2 calling started March 14, 2018 and ended March 23, 2018

6.2 Process Evaluation Findings

6.2.1 Program Staff and Database Review

The program staff interviews were extremely useful in helping the evaluation team understand how the program operates, and the information obtained from the interviews was used to design the interview guides and surveys for program participants and contractors. Information from staff interviews are included throughout the findings section to add context around respondent answers.

An additional part of the evaluation activities included reviewing the program database to ensure the necessary information needed to track the program and conduct evaluation activities existed. Program staff use the tracking database to document customers who participated in the program, the details of the equipment being installed, and the savings associated with the project. Once the application is received, this information is passed to AESC, the vendor responsible for the technical review. AESC verifies the accuracy of the savings calculations, and provides Duke Energy with verification in a systematic format. Duke Energy engineers also review the application information to verify savings calculations.

The evaluation team utilized this same database to select samples for impact and process evaluation activities. For evaluation purposes, some necessary information was not electronically documented. Specifically, some contact information was missing from the file, specifically contact phone numbers and email addresses. Additionally, the quantities of installed equipment (particularly for lighting) and some savings values associated with projects was incorrect. Understanding which customers received a Custom incentive is critical in evaluating progress towards program goals and conducting an independent review of program participants.

The evaluation team recommends that post installation ECM quantities be tracked in the participation tracking database and incentive calculation worksheets so as to improve the evaluability of the program. . The evaluation team encountered several lighting projects where the ECM quantity was indicated to be “1”, but was known to be multiple based upon review of other project documentation, invoices, and/or application forms. The evaluation team determined that this was an internal policy for non one-for-one retrofits or in cases where

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measure-level savings represented a mix of post installation fixture wattages. This issue created a challenge when it came to determining what the program used for baseline watts per fixture in ex ante energy savings estimates. The evaluation team understands why this approach is used by the program team, but feels that accurately tracking post installation ECM quantities within the tracking database would make per fixture energy savings more transparent.

In conducting the process evaluation telephone efforts, some contact information associated with some participants was also out of date. Some level of personnel turnover at companies is expected, resulting in having contact information for people who no longer work for listed companies. Also, in trying to reach contractors, the evaluation team had more success on records where contractors provided a phone number for a cellphone. When office numbers were provided, many calls went straight to voicemail with very few messages returned. Contractors tend to work outside the office so the ability to reach them on their cell is key to gaining their feedback and having the ability to schedule a call during a convenient time.

The evaluation team recommends that Duke pursue and obtain alternate site contact names, phone numbers, and email addresses from program participants to better ensure a line of communication is maintained between the contract information and the program records once a project is completed.

6.2.2 Contractors

The evaluation team interviewed 24 contractors who were involved in the installation of participating customer's projects during the evaluation period. Most of the interviewed contractors were companies that mainly provided lighting retrofit services (22 respondents). The remaining contractor respondents serve other end uses such as HVAC equipment and compressors. The amount of time these contractors have been involved in the program varied with two contractors indicating they have participated in Duke Energy's programs for one to two years, eight contractors indicating they have been involved between three to five years, and eleven have been involved for more than five years. Three contractors could not recall how long they have been participating in Duke's NR Custom program.

Responses regarding the number of projects contractors have completed during their time with the program varied from less than 5 projects to over 50 with most indicating between 20 and 50 projects. Figure 6-1 shows the number of contractors and an estimate of the number of projects they recall completing through the program since they began.

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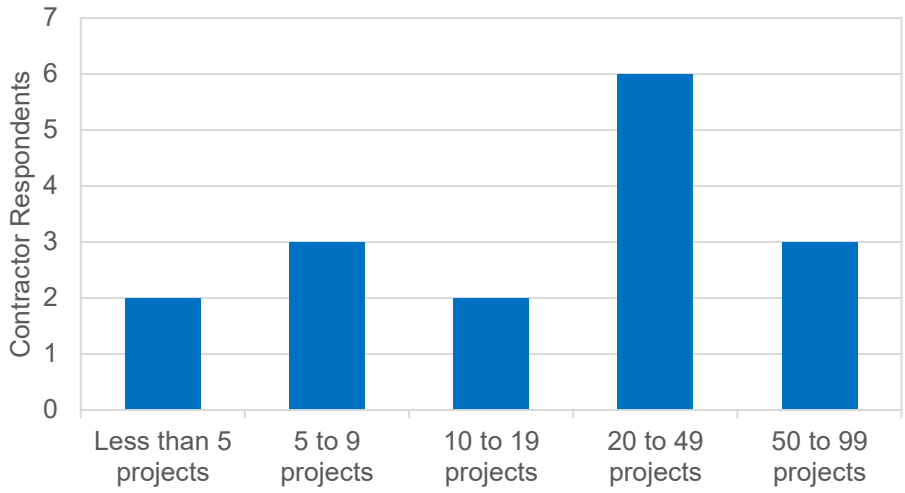
Figure 6-1 Number of Total Completed Projects



6.2.2.1 Communication

Duke Energy has a dedicated trade ally outreach team who travel and conduct in-person meetings. Trade allies can sign up and become an approved trade ally and be mentioned on Duke Energy's website. Most contractors reported that communication with Duke Energy program staff was effective and that staff was available when they had any questions about the program or application. Eleven contractor respondents indicated they have received trainings and information from Duke Energy about the NR Custom program in the form of one-on-one informational meetings, lunch and learns at the company, or webinars. Five contractors were not sure if they received a training, and the remaining nine reported not receiving a training. Few of the latter contractors indicated that they were able to gather the necessary information about the program from Duke Energy through the website or emails. Three contractors stated that additional trainings/information could be provided regarding savings estimations, non-lighting equipment, and new services provided by Duke Energy. Some specific comments included the following:

> *"The application seemed to be geared towards lighting, compressors are a small segment of the rebate process. A guide of everything that would be applicable to the program [not just related to compressors and dryers but if there is something else like vacuums] would be helpful."*

> *"...especially training with building automation would be beneficial. It's hard to know what path to achieve to save the customer money. It's hard to figure out if I have a viable custom incentive project."*

6.2.2.2 Customer Interaction

Many contractors felt they were at least partially responsible for customer awareness, especially in explaining the difference between custom and prescriptive and the application process. Fourteen contractor respondents felt that their customers were not aware of the program prior to telling them about it. Many of these contractors indicated, however, that the customers were aware of the availability of rebates through Duke Energy but did not specifically know about the Smart$aver programs or the custom incentives offering. Three contractors felt that few of their

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customers were aware of the program, and six other contractors reported that at least half of their customers knew about it. The remaining respondent could not comment on program awareness because he was not involved in sales.

When asked about the impact of the program on their recommendations of high efficiency equipment, 15 contractor respondents reported that they always recommend high efficiency equipment since that is the nature of their business (e.g. LED lighting, retrofits), and 3 contractor respondents indicated that they recommend high efficiency equipment over 90 percent of the time. Although most of the contractors also reported that their recommendations before and after the program have not changed, one contractor indicated that his recommendations of high efficiency equipment increased from 50 to 75 percent after learning about the program. One contractor, who indicated they always recommend high efficient equipment, added that "*once the rebates came into play we definitely started educating our customers and advising them to purchase high efficiency equipment*." The remaining respondents did not know or were not able to answer the question.

Contractors were asked to estimate the frequency in which their customers planned to purchase high efficiency equipment before and after learning about the program. Ten contractor respondents indicated that customer plans to purchase high efficiency equipment increased on average from 40 to 80 percent after learning about the program. Two contractors reported that customers' plans were the same before and after learning about the program with one contractor indicating they only sell high efficiency products. Some of the remaining respondents did not provide a percentage but indicated that the program helps sell more high efficiency equipment.

When talking with contractors, 6 of 24 respondents indicated that customers do not have any concerns about the program. From the remaining respondents, 15 contractors mentioned a variety of customer concerns about participating, as outlined in the table below. Uncertainty about the preapproval process was the frequently cited concern; it includes thinking that the preapproval process is going to be too long, or that the company is obliged to move forward with the project after getting preapproved. Three contractors felt there was some customers confusion about the differences between custom and prescriptive, specifically, the steps required in the application process, and the quality of the qualified equipment. Three contractors mentioned concern about the incentives not being as high as estimated and another contractor reported a concern about receiving incentive at all. Two contractors indicated that customers are sometimes skeptical and need reassurance from Duke Energy about the program and a confirmation that the contractor is a program trade ally. The remaining contractors reported that customers are sometimes not sure if the equipment qualifies, or if they can keep the old equipment.

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Table 6-4 Contractor Reported Customer Concerns About the Program

Concern	Respondents
Uncertainty about the preapproval process	7
Unsure about the difference between custom and prescriptive	3
Unsure if the incentive will be as high as estimated	3
Skeptical about the program offerings	2
Unsure if they will receive the incentive	1
Unsure if the equipment qualifies	1
Unsure if they can keep the old equipment (in case it is still functional)	1
Respondents	**15**

Source: Question 7
Don't know responses are excluded.

Eight of the 24 contractor respondents indicated that they use the program as a sales tool and that the program is helpful in selling energy efficient equipment. Many contractor respondents reported that the main reason some customers do not move forward with projects is financial in nature such as lack of funds or high costs (10 respondents). This was followed by reallocation of funds due to an emergency (2 respondents), project not meeting payback or ROI criteria (1 respondent), the prescriptive option being cheaper (1 respondent), and a timing issue (1 respondent). One contractor explained that they sometimes did not vet the customer well enough to assess their ability to move forward with the project before offering a potential custom incentive. Some specific comments included the following:

> *"Normally it's just because [the customers] decided not to complete the project in general. Whether the funds were not available or the project was not approved at the customer side for financial reasons."*
>
> *"Nothing to do with Duke, it's more where [the customers] need to be from a payback stand point, from corporate."*
>
> *"Something came up or some catastrophic thing happened, which made [the customer] reallocate the funds, or the customer realized that cost of opting in was too much to justify the reward."*

6.2.2.3 Application Process

Thirteen contractor respondents indicated that they received a request for additional information after submitting their initial application for preapproval. Typical requests were related to missing documents such as electricity bills (7 respondents), clarification about calculations and energy model assumptions (4 respondents), additional documentation about the equipment such as specification sheets (3 respondents), or updated W9 forms (2 respondents).

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Based on contractor respondent feedback, the preapproval process takes on average 2.8 weeks for lighting projects and longer, 6 to 12 weeks, for non-lighting projects. Most contractors seemed satisfied with the duration, however, when asked if there were any suggestions to improve the program, seven contractor respondents had improvement suggestions specific to the application. Five contractor respondents requested shortening the preapproval process while four contractor respondents recommended streamlining the application process. Streamlining suggestions including simplifying the calculation requirements and paperwork by providing engineering services to reduce the burden on the contractors, or by tailoring it to non-lighting equipment (e.g. compressors). Some specific comments included the following:

> *"Every time, I have to submit duplicate documents. I understand the need for it but I would think that certain things could be kept on file. When I send an email, it would be with 11 or 13 attachments. A lot of stuff to send in."*
>
> *"Take out the need for a full-blown engineering solution so that a sales person like me could do [the application] without the need for an engineer. That's the difficulty there. If Duke would provide the engineering service, that would be helpful."*
>
> *"The pre-approval process is confusing for some customers, you get an estimated offer and it is turned into an actual offer. Sometimes it didn't come back a match penny for penny. A quicker turnaround time and explanation as why the incentive amount has changed would be helpful."*

Email applications have been used almost exclusively for the past three years. Although starting in 2016, an online application portal was launched. All but four contractors were aware of the online application portal, and 13 indicated they have used the portal and found it very useful. The contractor respondents who were aware of the online portal but have not used it (5 respondents) mentioned that they prefer to use paper and/or to have a tangible document to show to the customer. No matter the method, most contractors reported they submit the application for their customers.

6.2.2.4 Calculators

As part of the application process, and to receive incentives through the NR Custom program, an appropriate worksheet or calculator must be submitted. Duke Energy provides access to two types of calculators: Classic Custom and Custom-to-go. Classic Custom calculators are Excel-based worksheets available for five different technologies. One Custom-to-go Windows-based calculation tool is also available.

Contractors were asked how they typically estimate savings for projects that were submitted through the program. Sixteen respondents mentioned using Duke Energy provided tools while seven mentioned they only use their own/other tools (Table 6-5).

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Table 6-5 Calculators Used by Contractors

Calculators Used	Respondents
Custom-to-go only	9
Own calculators only	7
Custom-to-go and own calculators	2
Classic Custom only	2
Classic Custom and own calculators	2
Custom-to-go, Classic Custom and own calculators	1
Respondents	**23**

Source: Question 24
Don't know responses are excluded.

Contractor respondents who used Duke provided calculators were asked to rate their usefulness on a 0 to 10 scale where 0 was 'not at all useful' and 10 was 'very useful.' Both calculators were rated as being useful with mean scores of 9.0 and 8.3 for Custom-to-go and Classic Custom, respectively. While overall the usefulness of the calculators was high, those contractors who complete non-lighting projects rated the usefulness lower or use their own calculators.

Respondents who did not use the calculators provided by Duke reported using their own calculators because they are trained to use them, or their calculators are customized to their company or are more advanced.

6.2.2.5 Satisfaction

Overall, contractor respondents were satisfied with the NR Custom program and with Duke Energy. Respondents were asked to rate their satisfaction on a 0 to 10 scale where 0 was 'not at all satisfied' and 10 was 'very satisfied'. On average, contractor respondents rated their satisfaction with Duke Energy 8.7 and their satisfaction with the program 8.2. Using the same scale, contractors were also asked to rate their satisfaction with the incentives provided through the NR Custom program. Contractors were generally satisfied with the incentives, as shown in Figure 6-2.

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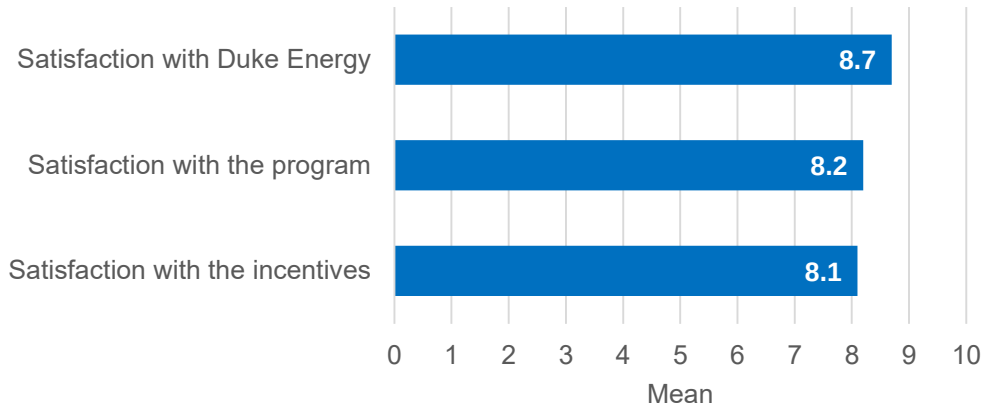
Figure 6-2 Contractor Satisfaction with Program Components



Source: Questions 13, 16, 17
Don't know responses are excluded.

Most contractor respondents felt the incentives was the most influential in customers' decision to purchase high-efficiency equipment; on average a rating of 8 on a 0 to 10 scale where 0 was 'not at all influential' and 10 was 'very influential.' Other factors that play a role in customers deciding to purchase high-efficiency equipment mentioned by the contractors included planning and financing (3 respondents), reliability of the equipment (2 respondents), energy and long term monetary savings (2 respondents), and increased capacity (1 respondent).

As far as improvements to the program, nine contractor respondents indicated no changes were needed. Most of the remaining contractor respondents (7 of 12) had suggestions related to the application process, as described above. Other responses varied between increasing the incentives to make the custom program more attractive to customers (e.g., to encourage controls offerings such as motion sensors) (3 respondents), increasing transparency in relation to savings estimations or changes in the final incentives amount received by the customer (2 respondents), moving more lighting equipment to prescriptive (1 respondent), and keeping contractors informed about program changes (e.g., new W9 form) (1 respondent).

Table 6-6 Contractor Suggestions for Program Improvements

Suggestion	Overall
Shorten preapproval time	5
Streamline the application process	4
Increase the incentives	3
Increase transparency	2
Move more lighting equipment to prescriptive	1
Keep contractors informed about program changes	1
Respondents	**12**

Source: Question Q31
Don't know responses are excluded.

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Some specific comments included the following:

> *"The only thing that comes to mind is the value of potential incentives for controls offerings to encourage folks to utilize controls more frequently, for example motion sensors. That's the single biggest thing. Also, the incentive could be more generous."*

> *"The only thing they could do is make it more easier to explain to our customers and for us to estimate the savings and ROI upfront."*

> *"Shorten preapproval time… the actual incentive amounts should be higher. Custom projects tend to cost the customers more money so anything you can do to make the incentive amount more attractive to the customer."*

6.2.3 Participants

Surveys were conducted with program participants, or customers who received a rebate through the NR Custom program. This section provides detailed findings from 65 customer respondents who completed the surveys.

6.2.3.1 Marketing Practices

Prior to 2016, the program largely focused on account managers as the primary source of program promotion. In 2016, traditional marketing channels were used such as direct mail, ads on social media or other websites and emails to a subset of customers by segment. Starting in 2016, contractor outreach representatives marketed the program directly to contractors, which Duke staff indicates accounts for a significant percentage of projects. When asked how they heard about the program, the three primary sources of awareness of the NR Custom program among participant respondents were their contractor or vendor (48 percent), previous experience with the program (15 percent), and their account representative (11 percent). Figure 6-3 shows breakdown of the awareness sources among customer respondents. Sources of awareness were similar between the two territories.

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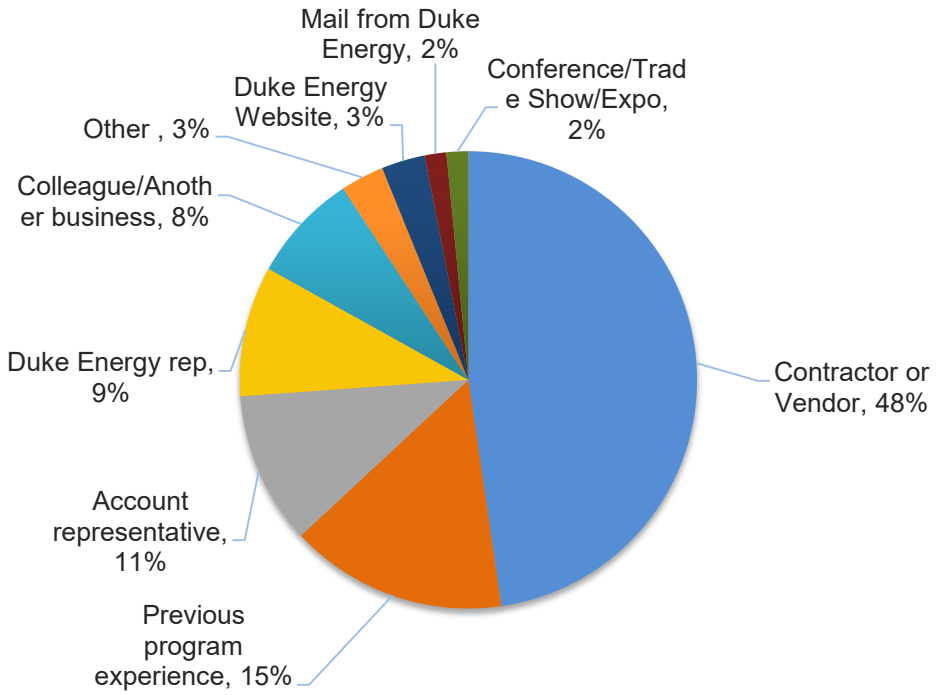
Figure 6-3 Participant Source of Program Awareness



Source: Question Q1
Don't know responses are excluded.

For respondents who heard about the program from their contractor, account representative, or business energy advisor, the majority of respondents indicated they were provided with enough information about the program and no additional follow-up or information was needed. This supports what was reported by the interviewed contractors and the role they play in increasing program awareness. This also shows that contractors, in addition to Duke staff, are well-versed on the program and can answer customer questions.

Program website materials note that the NR Custom incentives “can help you offset up-front costs and improve your bottom line.” When respondents were asked what made them decide to apply for the NR Custom Incentive program, the incentives, energy savings, and the monetary savings were most frequently mentioned by participants.

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Table 6-7 Reasons for Participating in Smart $aver Custom Incentive Program

Reason	DEC	DEP	Overall
Duke Energy rebate/incentive	22	4	40%
The energy savings	15	4	29%
The monetary savings	14	5	29%
Ability to get a better product cheaper	7	2	14%
Needed new equipment	3	2	8%
ROI/payback	5	0	8%
Other	5	0	8%
Respondents	**52**	**13**	**65**

Source: Question Q6
Don't know responses are excluded.

6.2.3.2 Application Process

According to program staff, the review process takes about four to six weeks. Staff mentioned they have worked to improve the turnaround, which is now around 20 days. While Duke staff felt the review process could be improved, program participants were satisfied with the review process (Table 6-8). When asked about their satisfaction with various aspects of the application process, respondents rated their satisfaction highly, with mean scores for each aspect of the application 8.7 or higher for participants (using a 0 to 10 scale where 0 is 'very dissatisfied' and 10 is 'very satisfied'). Only one participant respondent (from DEC) rated their satisfaction low for an aspect of the application process (less than 4) and this was due to the complexity of the application.

Table 6-8 Satisfaction with Application Process

	DEC		DEP		Overall	
Application Aspect	Mean	Respondents	Mean	Respondents	Mean	Respondents
Process to fill out and submit your application	8.9	45	9.5	12	9.0	57
Staff time it took to submit the application	8.7	49	8.8	13	8.7	62
Duke Energy's processing and preapproval of your application	9.1	51	9.5	13	9.2	64

Source: Questions Q8, Q9, Q10
Don't know responses are excluded.

About half of participant respondents indicated they received a request for additional information after submitting their initial application for preapproval. Most respondents could not recall the specifics around the request although of the 19 respondents who recalled, most noted that it was additional equipment specifications (11 respondents), or building/address specifications (5 respondents).

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As far as who was involved in completing the application, over half of participant respondents (57 percent) indicated their contractor filled out the NR Custom program application. Someone within the organization was the second most common way the application was completed (25 percent), followed by a combination of the contractor and someone within the organization (18 percent). These responses were similar across the two territories although the contractor was slightly more likely to be involved in the DEP territory.

6.2.3.3 Calculators

As mentioned above, as part of the application process and to receive incentives through the program, an appropriate worksheet or calculator must be submitted. In addition to the feedback contractors provided, participant respondents were also asked if they used any of the calculators provided by Duke Energy or if they used their own methods to calculate energy savings. While contractors were the most common method used to calculate energy savings, one-third of respondents reported using the tools Duke Energy provided (Table 6-9). This is similar to the feedback received from contractors where 16 of the 23 contractors indicated they used Duke tools to calculate savings.

Table 6-9 Calculators Used by Participants

Calculators Used	DEC	DEP	Overall
Contractor calculated only	37%	25%	34%
Own methods only	27%	42%	30%
Custom-to-go only	29%	25%	28%
Custom-to-go and own methods	4%	0%	3%
Own methods and contractor	2%	8%	3%
Custom-to-go and contractor	2%	0%	2%
Respondents	**49**	**12**	**61**

Source: Question Q12
Don't know responses are excluded.

6.2.3.4 Program Satisfaction

Overall, program participants were highly satisfied with the NR Custom program. Respondents were asked to rate their overall experience with the program and with Duke Energy on a scale of 0 to 10, where 0 is ‘very dissatisfied’ and 10 is ‘very satisfied.’ Respondents rated their overall satisfaction with the program overall highly, 9.0 overall, and rated Duke Energy highly as their service provider, 8.7 overall. Respondents were also asked to rate the value of different program components on a similar 0 to 10 scale. All program aspects were rated an average of 8.2 or higher.

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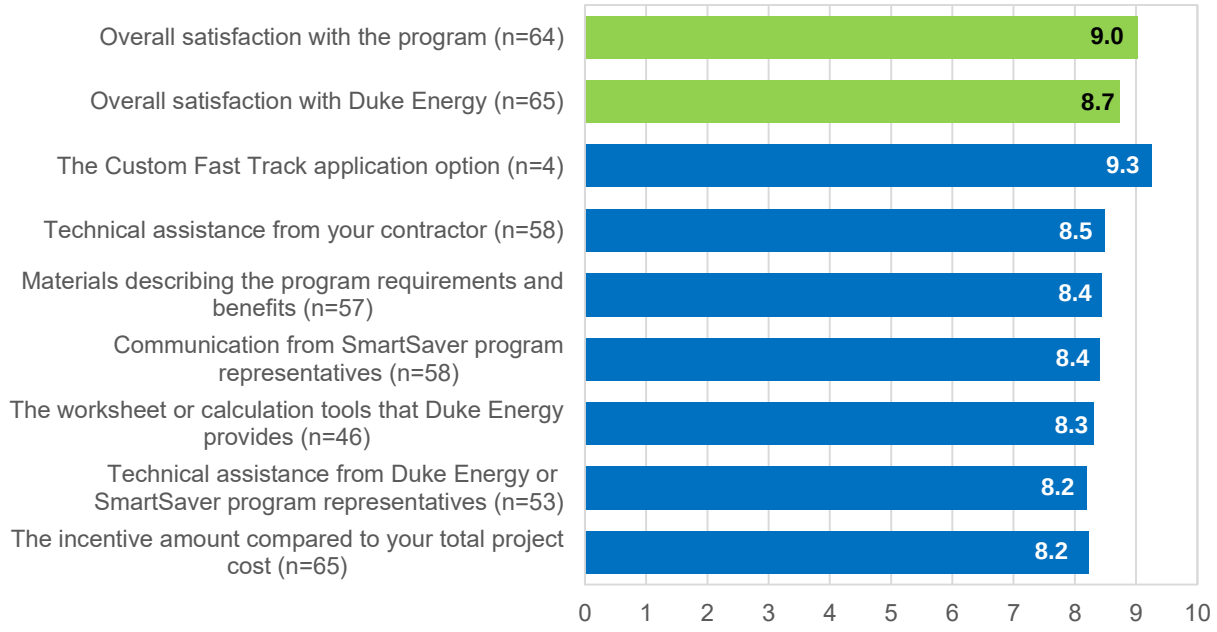
Figure 6-4 Program Participant Satisfaction and Value of Program Aspects



Source: Question SAT5, SAT11, SAT13
Don't know responses are excluded.

As far as the program aspect that is most valuable to their organization, about half of the participant respondents indicated the incentive compared to their total project cost, which correlates with the contractor responses (19 of 45 respondents). This was followed by the technical assistance they received from their contractor (13 of 45 respondents).

As another gauge of satisfaction, customers were asked if they have recommended the program to others. As shown in the figure below, most participants reported that they had already recommended the program. If provided the opportunity, the remaining respondents said they would recommend the program. Furthermore, all respondents but one indicated they would participate in the program again. The one respondent who did not indicate he would participate in the program again was not sure (did not know) and provided no indication of dissatisfaction throughout the survey.

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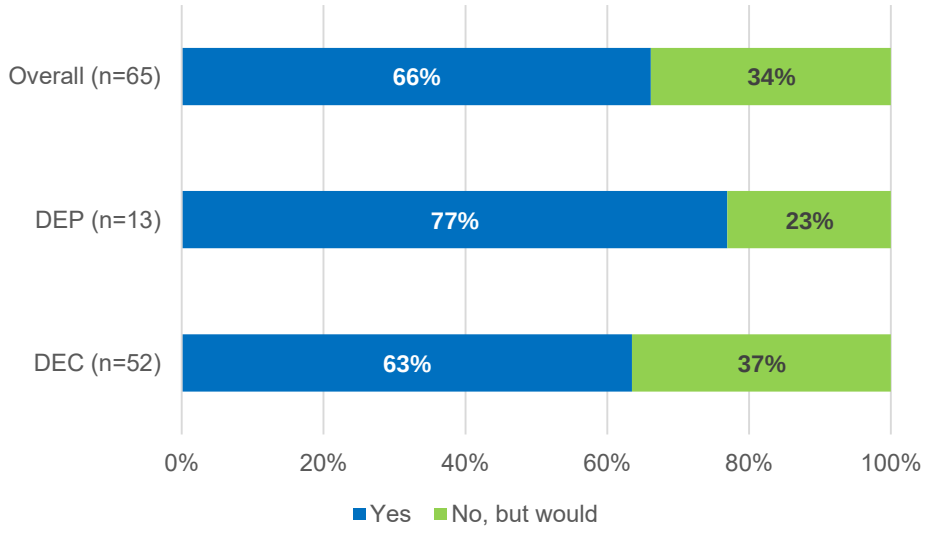
Figure 6-5 Have You Recommended the Program to Others?



Source: Questions SAT8, SAT9

The primary reason respondents reported rating the program highly (providing a rating of an 8 or higher) was the ease of the process. This was followed by the availability of the incentive/monetary savings, and the energy savings they expect to achieve.

Table 6-10 Reasons for Rating the Program Highly

Reason	DEC	DEP	Overall
Ease of the process	21	3	24
Incentive/Monetary savings	14	8	22
Energy savings	7	3	10
Duke service	3	2	5
Contractor service	1	0	1
Respondents	**45**	**12**	**57**

Source: Question SAT12o
Don't know responses are excluded.

Seven participant respondents rated their satisfaction less than an 8. While some had to do with the application process, other responses varied. Below are specific comments respondents provided along with how they rated their overall satisfaction with the program in parentheses.

> *"Some parts of it were easy, did exactly what they said, and other parts were harder to get done, some of the application process. People who don't know about lighting like we do would not be able to do those applications".* (5)

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"I'd like to be more informed about what's going on. I'm a person who likes someone to give me a call instead of shooting an email at me." (5)

"Well because it was almost not worth the trouble of going through the application process for an incentive of $27. It took me hours." (6)

"Some of the time it's a lot of work. For some of the products they understand they offer significant incentives, and for technology they don't understand they don't offer much incentive. You can see that in the incentives they offer." (7)

"There were difficulties getting status updates during the application process. There seemed to be a long time for approval." (7)

"Give me more." (7)

"On the plus side for receiving the incentive, and on the negative having to opt in or opt out." (7)

When asked what they would change about the NR Custom program, over half of participant respondents (33 of 64) indicated they would not change anything. Of the remaining respondents, 13 respondents mentioned the incentive. Specifically, 12 respondents asked for higher incentives and 1 respondent asked not to reduce the incentives. Other suggestions included simplifying the application especially in relation to the language used and the calculations needed (5 respondents), extending the deadlines for pre- and post-approval especially for large projects (4 respondents), updating or extending the list of eligible equipment (3 respondents), increasing awareness about the program (3 respondents), and decreasing the initial processing time (3 respondents).

Table 6-11 Recommended Program Changes

Reason	DEC	DEP	Overall
Nothing	25	8	33
Increase rebate amount	11	2	13
Simplify application	4	1	5
Extend deadlines	3	1	4
Updating or extending the equipment list	2	1	3
Increase awareness	2	1	3
Decrease the preapproval time	2	1	3
Other	2	0	2
Remove the preapproval requirement	0	1	1
Make the website more user friendly	1	0	1

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Reason	DEC	DEP	Overall
Streamlining the process	1	0	1
Interaction with staff & contractor	1	0	1
Improve payment process	1	0	1
Respondents	**51**	**13**	**64**

Source: Question SAT1
Don't know responses are excluded.

Some specific comments included the following:

> *"Clearer and more up-to-date list of appliances that qualify for the program."*
>
> *"More interaction between Duke and the third party especially during initial approval and application."*
>
> *"They reduced the incentive in 2018. Because of that, we are going to evaluate how we approach our lighting."*
>
> *"More publicity. We would not have known about it without our vendor, Batteries Plus. More advertising to businesses."*

6.2.3.5 Fast Track

Duke Energy offers a fast track option where customers with a project under a tight timeline can pay a $550 fee to accelerate the review of their project from four to six weeks to about one week. Customers must also commit to participating in a kick off meeting and promptly responding to any requests.

When customers were asked about their awareness and interest in the offering, over one-quarter (17 of 65 participant respondents) were aware of the Fast Track offering.[10] Awareness was similar between DEC and DEP respondents. Four DEC respondents have utilized the Fast Track offering, two participants found out from their contractors, one participant from their account representative, and one participant from their business energy advisor.

[10] Fourteen contractor respondents reported being aware of the Fast Track option. An additional five contractor respondents did not know it was offered by Duke Energy.

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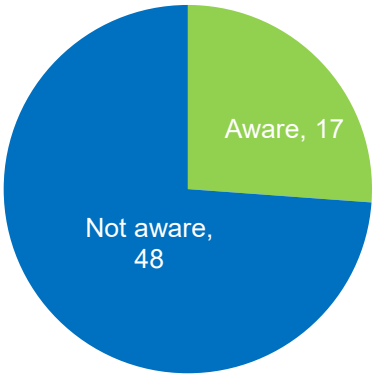
Figure 6-6 Awareness about the NR Custom Program Fast Track Option



Source: Question FT10
Don't know responses are excluded.

Respondents who have not utilized the fast track option were asked about their interest in the offering. Over half of respondents (32 of 55 respondents) indicated they would be willing to pay a fee to have an accelerated review of their application if they had a project under a tight timeline. For those who were not willing to pay the fee, six participants explained that the extra fee would reduce the return on investment or increase the costs. Other respondents indicated reasons such as not having projects that would require needing an expedited process or under tight deadlines (5 respondent), or delaying the project or planning ahead to avoid having to pay a fee (4 respondents). Four other participant respondents reported that they cannot afford to pay that money or get approval for it. Other respondent mentioned that the fee "*defeats the purpose*," or that they would have to *"find something else."*

While the fee may be a barrier, the meetings may not be. Over two-thirds of respondents (43 of 58 respondents) would be willing to participate in an entrance meeting and respond to requests about the project specifications in a timely manner. Fifteen participant respondents indicated they would not be willing to pay the fee nor participate in the necessary meetings. Overall, when asked about the value of the Fast Track option, responses were mixed. The average response was 5.4 (on a 0 to 10 scale with 0 being 'not at all valuable' and 10 being 'very valuable'). Nine respondents rated the value a 0 (not at all valuable), 17 respondents rated the value a 5, and 9 respondents provided a rating of 10 (very valuable). Other respondents were sprinkled in between, resulting in mixed feedback on the value of the service.

6.2.3.6 Participating Customer Characteristics

Facility types varied across participant respondents' locations. The most frequently mentioned types of businesses were industrial/manufacturing (25 percent), followed by retail (17 percent), warehouse or distribution center (14 percent) and office building (12 percent). The facility types are consistent with how the program was marketed, which initially targeted larger industrial customers. Historically, there have been a lot of large customers that would normally participate

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in a custom program, but now more of the large customers are opting out, which will narrow the number of customers eligible for the program.[11]

When participants were asked how their companies make budget decisions and whether they were decided locally, regionally, nationally, worldwide or something else, most respondents reported that decisions are made locally (68 percent). Most respondents tended to plan one year (39 percent) or less than 1 year (18 percent) into the future when creating budget and financial plans. The figure below shows the participant business characteristics.

[11] The opt in/out requirements are different between DEC and DEP. DEC is a one year opt in period for the calendar year and customers have a window where they are able to opt in and opt out. DEP you can opt in at any time. As soon as a customer receives their incentive, they opt in for 3 years.

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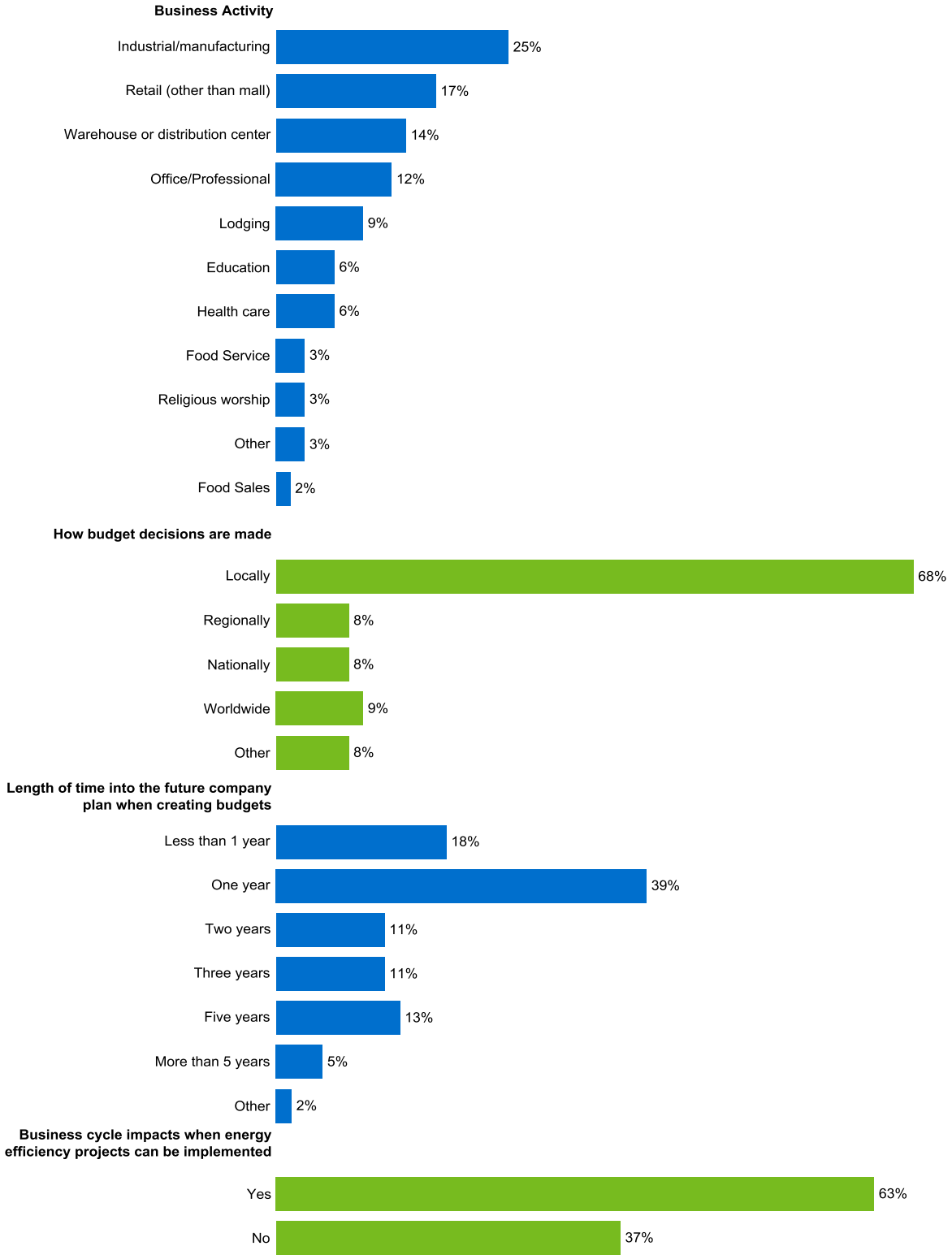
Figure 6-7 Smart $aver Custom Incentive Program Participant Characteristics



Source: Questions C1, C2, C3, C4
Don't know responses are excluded.

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7 Conclusions and Recommendations

7.1 Impact Evaluation

Conclusion 1: The evaluation team's analysis resulted in a 105.4% realization rate (energy) for the DEC NR Custom Program and 105.7% for the DEP NR Custom Program. The strong realization rates indicate that Duke Energy's internal processes for project review, savings estimation, and installation verification are working to produce high quality estimates of project impacts. Reported energy and demand savings could be increased by incorporating interactive factors into ex-ante impact estimates for lighting measures.

Recommendation 1: The evaluation team recommends that Duke continue to operate this program with the current level of rigor. For interior lighting projects, Duke should consider developing and applying deemed interactive factors to quantify the interactive effects between lighting retrofits and their associated HVAC systems.

Conclusion 2: Assumptions used in ex ante energy savings estimates are well-documented, but there are opportunities for improvement on new construction lighting projects and some non-lighting projects.

Recommendation 2: The evaluation team recommends that any adjustments made to baseline assumptions on new construction projects be well-documented within the incentive calculation spreadsheet developed by the program. This will provide better transparency when deviations from a lighting power density approach are used in ex-ante energy savings estimates.

Conclusion 3: The NR Custom Program uses T12 baseline fixture wattages in ex-ante energy savings estimates for applicable linear fluorescent to LED tube retrofit measures. This practice is defensible given the availability of high color rendering index (CRI) replacement lamps; however, peer Demand Side Management (DSM) programs no longer credit energy or demand savings beyond a T8 baseline.

Recommendation 3: It is recommended that the Duke NR Custom Program consider using a T8 equivalent when developing ex-ante energy and demand savings estimates for T12 to LED tube retrofit measures.

7.2 Process Evaluation

Conclusion 1: The program is operating as intended and has resulted in high satisfaction across participant and contractor respondents. The most common source of program awareness for customers was their contractor, which is consistent with how the program is marketed.

Technical assistance from the contractor was the highest rated aspect of the program, which highlights the contractors' technical competence and the significant role contractors play in the program. Many customer respondents also commented on how their contractors are knowledgeable which made the entire process easy.

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Recommendation 1: Continue program outreach efforts and continue to engage contractors in the program and keep them informed of the program and any future changes to increase awareness among customers and encourage the installation of program-qualifying equipment.

Conclusion 2: As part of the application process, an appropriate worksheet or calculator must be submitted. Duke Energy provides access to two types of calculators: Classic Custom and Custom-to-go. Over two-thirds of contractors and one-third of participant respondents indicated they have used Duke's tools to calculate savings. Contractors who used Duke Energy's provided tools rated their usefulness high. That said, contractors who install non-lighting equipment were more likely to use their own calculators or rated the usefulness of Duke's calculators low.

Recommendation 2a: Continue to keep the Custom-to-Go and Classic Custom calculators updated and available to customers and contractors who need a tool to estimate savings.
Recommendation 2b: Consider reviewing the calculators for non-lighting equipment to ensure they perform as expected and do not require lighting-specific information.

Conclusion 3: Program participants were generally satisfied with the review process. Most contractors were also satisfied with the process. However, five contractors felt the preapproval process could be improved. Specifically, three indicated that the non-lighting preapproval process can take significantly longer than lighting preapproval. As different technologies come into the market, it will be important to ensure customers are getting feedback in a timely manner.

Recommendation 3: Monitor the time it takes to review applications for preapproval to ensure the time does not exceed six weeks.

Conclusion 4: Most participant respondents reported high satisfaction with the application process, although five respondents indicated the program could benefit from simplifying the application. A few contractors also recommended the application is geared towards lighting projects, leading to some confusion in what information is needed.

Recommendation 4: Streamline the application paperwork to minimize customer burden and collect only the information relevant to specific equipment types.

Appendix A Summary Forms

Duke Energy Carolinas Smart $aver NR Custom Program

Completed EMV Fact Sheet

Description of Program

Duke Energy's Non-Residential Smart $aver® Custom Incentive Program (NR Custom) offers financial assistance to qualifying commercial, industrial and institutional customers in the Duke Energy Carolinas (DEC) service territory to enhance their ability to adopt and install cost-effective electrical energy efficiency projects. The Program targets energy saving projects involving more complicated or alternative technologies, or those measures not covered by the non-residential Smart $aver Prescriptive Program. The intent of the program is to encourage the implementation of energy efficiency projects that would not otherwise be completed without the company's technical or financial assistance. The program requires pre-approval prior to the project implementation.

Summary		Strata	Verified Net Savings (kWh)
Region(s)	*Carolinas*	*Lighting*	*59,695,834*
Evaluation Period	*Jan 1, 2016 – Dec 31, 2017*		
Annual kWh Net Savings	*95,479,738*	*Non-lighting*	*35,783,904*
Coincident kW Net Impact - Summer	*15,054*		
Coincident kW Net Impact - Winter	*14,829*		
Net-to-Gross Ratio	*79.2%*		
Process Evaluation	*Yes*		
Previous Evaluation(s)	*N/A*		

Evaluation Methodology

mpact Evalulation Activities

- *59 On-site Measurement & Verification*

Impact Evaluation Findings

- *Energy Realization Rate: 105.4%*
- *Summer Demand Realization Rate: 115.9%*
- *Winter Demand Realization Rate: 123.9%*
- *Net-to-gross: 79.2%*

Process Evaluation Activities (DEC & DEP Combined)

- *Program Staff; 2 interviews with program staff*
- *Trade Allies; 24 in-depth interviews*
- *Participants; 81 telephone surveys*

Process Evaluation Findings

- *Primary source of program awareness is contractors*
- *Satisfaction with program is high among participants and trade allies*
- *Contractor assistance was most valuable program component as rated by participants*
- *Program-provided calculators are being used by participants and are useful to contractors*
- *Contractors value the program and use incentives to encourage customers to purchase high efficiency equipment*
- *Program application and processes are geared toward lighting projects leading to some confusion*

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Duke Energy Progress Smart $aver NR Custom Program

Completed EMV Fact Sheet

Description of Program

Duke Energy's Non-Residential Smart $aver® Custom Incentive Program (NR Custom) offers financial assistance to qualifying commercial, industrial and institutional customers in the Duke Energy Progress (DEP) service territory to enhance their ability to adopt and install cost-effective electrical energy efficiency projects. The Program targets energy saving projects involving more complicated or alternative technologies, or those measures not covered by the non-residential Smart $aver Prescriptive Program. The intent of the program is to encourage the implementation of energy efficiency projects that would not otherwise be completed without the company's technical or financial assistance. The program requires pre-approval prior to the project implementation.

Summary		Strata	Verified Net Savings (kWh)
Region(s)	Progress	Lighting	5,336,890
Evaluation Period	Jan 1, 2016 – Dec 31, 2017		
Annual kWh Net Savings	13,444,668	Non-lighting	8,107,778
Coincident kW Net Impact - Summer	1,498		
Coincident kW Net Impact - Winter	1,954		
Net-to-Gross Ratio	78.8 combined		
Process Evaluation	Yes		
Previous Evaluation(s)	N/A		

Evaluation Methodology

Impact Evaluation Activities

- *33 for DEP and 59 for DEC On-site Measurement & Verification*

Impact Evaluation Findings

- *Energy Realization Rate: 105.7%*
- *Summer Demand Realization Rate: 99.5%*
- *Winter Demand Realization Rate: 122.7%*
- *Net-to-gross: 78.8 combined%*

Process Evaluation Activities (DEC & DEP Combined)

- *Program Staff; 2 interviews with program staff*
- *Trade Allies; 24 in-depth interviews*
- *Participants; 81 telephone surveys*

Process Evaluation Findings

- *Primary source of program awareness is contractors*
- *Satisfaction with program is high among participants and trade allies*
- *Contractor assistance was most valuable program component as rated by participants*
- *Program-provided calculators are being used by participants and are useful to contractors*
- *Contractors value the program and use incentives to encourage customers to purchase high efficiency equipment*
- *Program application and processes are geared toward lighting projects leading to*

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Appendix B Survey Instruments

Duke Energy Nonresidential Custom Carolinas Program
Participant Survey

Sample Variables

CONTACT NAME Primary customer contact name

MEASURE Summary of project measure implemented
1 lighting
2 process
3 compressed air
4 HVAC

MeasureType Type of measure sampled

LightFlag Customers who will get asked the T12 lighting questions

LightingType Specific lighting type rebated through the program

YEAR The year the measure was completed and paid

PREMISE_ADDR The address of the site where the measure was installed

INCENTIVE The amount of the incentive paid for the measure

CONTRACTOR Flag that customer worked with external contractor

1 Worked with contractor
0 Implemented within company

FASTTRACK Flag that customer went through the Custom Fast Track application process

1 Fast track customer
0 Standard process customer

STRATUM
NC North Carolina
SC South Carolina

TOTAL_KWH

PROGRESS

0 States

1 Progress case

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Introduction and Screening

INT01 Hello, my name is [NAME], and I am calling on behalf of Duke Energy. May I speak with [CONTACT NAME] or the person who decided to participate in <UTILITY>'s SmartSaver Custom Incentive program?

01 Yes
02 No

MULTCHK [ASK IF MULTFLAG=1] [INTERVIEWER: Is this the first case of a multiple?

01 Yes, first case
02 No, subsequent case [SKIP TO Q1]

PREAMBLE I'm calling from Tetra Tech, an independent research firm. We were hired by Duke Energy to talk with some of their customers about their participation in the SmartSaver Custom Incentive Program.

Our records indicate that you participated in Duke Energy's SmartSaver Custom Incentive Program that included a [MEASURE] project in [YEAR] at [PREMISE_ADDR]. Are you able to answer questions about your company's participation in this program?

01 Yes, I'm able to answer SKIP TO SCREEN1
02 Yes, but information isn't quite right (specify) SKIP TO SCREEN1
03 No, I'm not able to answer
04 We have not participated [THANK AND TERMINATE 82]
99 Refusal [THANK AND TERMINATE 91]

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

01 Yes
02 No [THANK AND TERMINATE 81]
99 Refusal [THANK AND TERMINATE 91]

AVAILABLE_R May I please speak with that person?

01 Yes
02 No (When would be a good time to call back?)
03 We have not participated [THANK AND TERMINATE 82]
99 Refusal [THANK AND TERMINATE 91]

SCREEN1 Were you involved in the decision to complete the [MEASURE] project?

01 Yes
02 No SKIP TO OTHER_R

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PREAMBLE2 Great, thank you. I'd like to assure you that I'm not selling anything, I would just like to ask your opinion about this program. Your responses will be kept confidential and your name will not be revealed to anyone. For quality and training purposes, this call will be recorded.

Program Awareness and Marketing

Q1 [IF MULTCHK=2 SKIP TO MEASCHK] How did you first hear about the SmartSaver Custom Incentive Program? (Select one)

01	Account representative	
02	Business Energy Advisor	
03	Contractor / Vendor	[CONTRACTOR = 1]
04	Email from Duke Energy	
05	Mail from Duke Energy	
06	Colleague/Another business	
07	Conference/Trade Show/Expo	
08	Duke Energy website	
09	Duke Energy representative (other than an account rep)	
10	Previous program experience / participation	
11	Other (specify)	
88	Don't know	

Q2 [ASK IF Q1 = 1, 2 or 3] Did the [response from Q1] provide you with enough information about the program?

01	Yes	SKIP TO Q4
02	No	

Q3 [ASK IF Q1 = 1, 2 or 3] What additional information would you have liked [response from Q1] to provide?

[RECORD VERBATIM]

Q4 [ASK IF Q1<>3] Did you work with a contractor or vendor to implement the [MEASURE] project or did you work with internal staff at your company?

01	Worked with a contractor / vendor	[CONTRACTOR = 1]
02	Internal staff at company	[CONTRACTOR = 0]
03	Both the contractor and internal staff	[CONTRACTOR = 1]
88	Don't know	[CONTRACTOR = 0]

Q5 Before your [MEASURE] project in [YEAR], had you participated in the SmartSaver program before?

01	Yes
02	No
88	Don't know

Q6 What made you decide to apply to the SmartSaver program?

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[RECORD VERBATIM]

Q7 [IF CONTRACTOR=1] Did someone at your company fill out your application for the SmartSaver Custom Incentives program or did your contractor or vendor?

01 Someone at my company
02 Contractor / Vendor
03 Both someone at our company and the contractor
88 Don't know

Q7a [ASK IF Q7=1,3] Did you submit your application by hard copy application or electronically?

01 Hard copy
02 Electronically
03 Other (specify)
88 Don't know
99 Refused

Q8 Using a scale of 0 to 10, where 0 is "very dissatisfied" and 10 is "very satisfied", how satisfied are you with the process to fill out and submit your application?

___ [RECORD RESPONSE]
77 Does not apply
88 Don't know
99 Refused

Q9 Using the same scale of 0 to 10, where 0 is "very dissatisfied" and 10 is "very satisfied", how satisfied are you with the staff time it took to submit the application and necessary paperwork?

___ [RECORD RESPONSE]
77 Does not apply
88 Don't know
99 Refused

Q10 Using the same scale [OPTIONAL: "of 0 to 10, where 0 is "very dissatisfied" and 10 is "very satisfied"], how satisfied are you with Duke Energy's processing and preapproval of your application?

___ [RECORD RESPONSE]
88 Don't know
99 Refused

Q11 [IF Q8=1,2,3 OR Q9=1,2,3 OR Q10=1,2,3] What could the program have done differently to make the application process easier?

[RECORD VERBATIM]

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Q12 Did you use the Custom-to-Go calculators provided by Duke Energy, or did you calculate energy savings using your own methods? [SELECT ALL THAT APPLY]

01 Custom-to-Go
02 Own methods
03 Other (specify)
04 Contractor / Vendor calculated
88 Don't know

Q12a [ASK IF Q12 = 4] How did the contractor/vendor calculate the energy savings? [SELECT ALL THAT APPLY]

01 Custom-to-Go calculators provided by Duke Energy
02 Own methods
03 Other (specify)
88 Don't know

Q13 After submitting your initial application for preapproval, did you receive any requests for additional information while Duke Energy was processing your application?

01 Yes
02 No
88 Don't know

Q13O [ASK IF Q13=1] What additional information was requested?

[IF DON'T KNOW OR DOES NOT RECALL PROBE: Do you recall if it was information about your building, the equipment installed or the prior equipment?)

[RECORD VERBATIM]

Q14 Was your project under pressure to be completed in a short amount of time?

01 Yes
02 No

Q15 Did you work with a Duke Energy-provided Energy Advisor as part of this project?

01 Yes
02 No
88 Don't know

Q16 [ASK IF Q15 = 1] Using a scale of 0 to 10, where 0 is "very dissatisfied" and 10 is "very satisfied", how satisfied are you with the Energy Advisor?

___ [RECORD RESPONSE]

88 Don't know
99 Refused

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Equipment Questions

E1 Was the [MEASURE] equipment part of a newly constructed building or major renovation of an existing facility?

01 Yes [SKIP TO MeasChk]
02 No
88 Don't know
99 Refused

E2 Did the [MEASURE] equipment you purchased replace an existing [MeasureType]?

01 Yes
02 No [SKIP TO MeasChk]
88 Don't know [SKIP TO MeasChk]
99 Refused [SKIP TO MeasChk]

E3 About how old was your existing [MEASURE] equipment?

___ Years
888 Don't know

E4 What condition was your existing [MEASURE] unit when you decided to purchase a new one? (Read list)

01 Operating with no performance issues
02 Operating but in need of repair
03 No longer operating (broken, did not work)
88 [DO NOT READ] Don't know
99 [DO NOT READ] Refused

Net-to-Gross

MeasCHK [ASK IF MULTCHK = 2 ELSE SKIP TO FR1]
[INTERVIEWER QUESTION: Is this case's MEASURE variable the same as a previous case's MEASURE variable?]

1 Yes; Duplicate measure
2 No, New measure [SKIP TO Q4_MULT]

DecisionCHK [ASK IF MeasCHK=1]
Now, thinking about the [MEASURE] project at [PREMISE_ADDR], was the decision making process the same or different from the previous [MEASURE] project we discussed?

1 Same decision making process [SKIP TO INT99]
2 Different decision making process

Q4_MULT [ASK IF MULTCHK=02] Did you work with a contractor or vendor to implement the [MEASURE] project or did you work with internal staff at your company?

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01	Worked with a contractor / vendor	[CONTRACTOR = 1]
02	Internal staff at company	[CONTRACTOR = 0]
03	Both the contractor and internal staff	[CONTRACTOR = 1]
88	Don't know	[CONTRACTOR = 0]

FR1 Which of the following is most likely what would have happened if you had not received the incentive from Duke Energy? (Read list)

01 Canceled or postponed the project at least one year
02 Reduced the size, scope, or efficiency of the project
03 Done exactly the same project
04 Done nothing
88 [DO NOT READ] Don't know

FR2 [ASK IF FR1=2] By how much would you have reduced the size, scope, or efficiency of the project? Would you say a small amount, a moderate amount, or a large amount?

01 Small amount
02 Moderate amount
03 Large amount
88 Don't know

FR3 [ASK IF FR1=3] Would your business have paid the additional $[INCENTIVE AMOUNT] to complete the project on your own?

01 Yes
02 No
88 Don't know

FR4 On a scale of 0 to 10, with 0 being "not at all influential" and 10 being "extremely influential", how would you rate the influence of the following factors on your decision to complete the [MEASURE] project? [RANDOMIZE ORDER]

FR4A The incentive provided by Duke Energy
FR4B The interaction with Duke Energy SmartSaver program representatives
FR4C SmartSaver marketing materials
FR4D [ASK IF Q5=1] Previous experience with the SmartSaver program
FR4E [IF CONTRACTOR=1] Your contractor's or vendor's recommendation

___ Record influence [0-10]
77 Not applicable
88 Don't know
99 Refused

FR5 [ASK IF CONTRACTOR=1] Was there anything your contractor or vendor said to make you choose the equipment that you ended up installing?

01 Yes [SPECIFY: What did they say?]
02 No
88 Don't know

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T12 Questions

[Ask if LightFlag = 1, Else skip to SP1]

TL1 Would you have continued using linear fluorescent T12 fixtures if you had not received a financial incentive to upgrade to [LightingType]?

01 Yes
02 No
88 Don't know

TL2 [If TL1 = 1] How long could replacement lamps have allowed you to continue to use T12 fixtures?

TL2_months ___ Months
TL2_years ___ Years

TL3 Were you previously purchasing high Color Rendering Index (CRI) T12 replacement lamps as a means of postponing full fixture replacements?

01 Yes
02 No
88 Don't know

Spillover

[IF MULTCHK=02 SKIP TO INT99]

SP1 Since your participation in the SmartSaver program, did you complete any additional energy efficiency projects at this facility or another facility served by Duke Energy that did not receive incentives through a Duke Energy program?

01 Yes
02 No SKIP TO SAT1
88 Don't know SKIP TO SAT1
99 Refused SKIP TO SAT1

SP2 What energy efficient products, equipment, or improvements did you install or implement? (Select all that apply)

01 Lighting
02 Heating / Cooling
03 Hot Water
04 Appliances / Office
05 Insulation
06 Motor / Variable Frequency drives (VFDs)
07 Compressed Air
08 Refrigeration
09 Other1 [SPECIFY]
10 Other2 [SPECIFY]
88 Don't know SKIP TO SAT1

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[ASK SP3-SP4 FOR EACH MENTIONED IN SP2]

SP3 Can you describe the [SP2] equipment? [For example: What was the brand or model? Efficiency rating? Dimensions? or Capacity?]

[RECORD VERBATIM]

SP4 How many [SP2] units did you install?

____ [RECORD RESPONSE] 1-999
888 Don't know
999 Refused

SP5 On a scale of 0 to 10, with 0 meaning "not at all influential" and 10 meaning "extremely influential", how influential was your participation in the SmartSaver program on your decision to complete the additional energy efficiency project(s)?

___ [RECORD RESPONSE]
77 Not applicable
88 Don't know
99 Refused

Customer Satisfaction

SAT1 What would you change about the SmartSaver Custom Incentive Program, if anything? (DO NOT READ, Select all that apply)

01 Would not change anything
02 Remove pre-approval requirement
03 Improve initial processing time
04 Increase rebate amount
05 Other (specify)
88 Don't know

SAT2 [ASK IF SAT1=3] What would you consider to be a reasonable amount of time for processing the initial application?

___ [RECORD VERBATIM]

SAT3 [ASK IF SAT1=4] What percent of the project's cost do you think would be reasonable for the SmartSaver program to pay?

___ [RECORD PERCENT]
888 Don't know
999 Refused

SAT4 Was the incentive you received close to the amount you originally calculated when completing your application?

01 Yes
02 No
88 Don't know

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Fast Track Feedback

FT10 Duke Energy offers a fast track option where customers can pay a fee to accelerate the review of a project from 4 to 6 weeks to about one week. Before today, were you aware this is now offered?

01 Yes
02 No SKIP TO SAT5
88 Don't know SKIP TO SAT5

FT1 Did you participate in the Smart $Saver Custom Fast Track option?
[IF NEEDED: "There is typically a several hundred dollars fee for the accelerated review."]

01 Yes
02 No SKIP TO SAT5
88 Don't know SKIP TO SAT5

FT2 How did you hear about the SmartSaver Custom Fast Track option?

01 Account representative
02 Business Energy Advisor
03 Contractor
04 Other (specify)
88 Don't know

FT3 Why did you choose the Custom Fast Track option?

[RECORD VERBATIM]

FT4 Did you have any difficulty responding to the Custom Fast Track questions or requests?

01 Yes
02 No
03 No follow-up questions were asked
88 Don't know

FT5 [ASK IF FT4=1] What was challenging about responding to the SmartSaver program's requests?

[RECORD VERBATIM]

FT6a Were you involved in the kickoff phone call to discuss the scope of the project or to answer any questions Duke Energy had about your project or the building?

01 Yes
02 No SKIP TO FT8
88 Don't know SKIP TO FT8

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FT6b Were you notified in advance of the kickoff phone call what would be discussed or any information you would need available?

01 Yes
02 No
88 Don't know

FT7 [ASK IF FT6b=1] What was discussed during the kickoff call?

[RECORD VERBATIM]

FT8 Did your participation in the Fast Track option allow you to complete your project on schedule?

01 Yes
02 No
88 Don't know

FT9 [ASK IF FT8 = 2] What drove the delay in your project being completed as planned?

[RECORD VERBATIM]

FT9a Will you use the Fast Track option again in the future if you have a project under a tight timeline?

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

SAT5 Using a scale of 0 to 10, where 0 is "not at all valuable" and 10 is "very valuable", how valuable are the following SmartSaver program components to your organization? [RANDOMIZE LIST]

FOR SAT5A through SAT5G

__ Record value [1-10]
NA Not applicable
DK Don't know
RE Refused

SAT5A Materials describing the program requirements and benefits
SAT5B Communication from SmartSaver program representatives
SAT5C Technical assistance from Duke Energy or SmartSaver program representatives
SAT5D [IF CONTRACTOR=1] Technical assistance from your contractor or vendor
SAT5E The incentive amount compared to your total project cost
SAT5F The worksheet or calculation tools that Duke Energy provides
SAT5G [IF FT1=1] The Custom Fast Track application option

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[ASK IF MULTIPLE SAT5 COMPONENTS RATED EQUALLY VALUABLE]
[SKIP IF ONE SINGLE COMPONENT IS RATED HIGHEST]
[SKIP IF ALL SAT5 COMPONENTS ARE EQUAL TO ZERO]

SAT7 Which of the following SmartSaver program components is most valuable to your organization? [READ LIST, SELECT ONE] [RANDOMIZE CHOICES]

01 Materials describing the program requirements and benefits
02 Communication from SmartSaver program representatives
03 Technical assistance from Duke Energy or SmartSaver program representatives
04 Technical assistance from your contractor or vendor
05 The incentive amount compared to your total project cost
06 The worksheet or calculation tools that Duke Energy provides
07 The Custom Fast Track application option
88 [DO NOT READ] Don't know
99 [DO NOT READ] Refused

SAT8 Have you recommended the SmartSaver Custom Incentive Program to anyone?

01 Yes SKIP TO SAT10
02 No
88 Don't know

SAT9 If provided the opportunity, would you recommend the SmartSaver Custom Incentive Program to anyone?

01 Yes
02 No
88 Don't know

SAT10 Would you consider participating in the SmartSaver Custom Incentive Program again in the future?

01 Yes
02 No [SPECIFY: Why not?]
88 Don't know [SPECIFY: Please explain.]

SAT11 Considering all aspects of the program, using a scale of 0 to 10, where 0 is "very dissatisfied" and 10 is "very satisfied", how would you rate your overall satisfaction with the SmartSaver Custom Incentive program?

___ [RECORD RESPONSE]
88 Don't know
99 Refused

SAT12 Why do you say that?

[RECORD VERBATIM]

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SAT13 Using a scale of 0 to 10, where 0 is "very dissatisfied" and 10 is "very satisfied", how would you rate your overall satisfaction with Duke Energy?

___ [RECORD RESPONSE]
88 Don't know
99 Refused

SAT14 [ASK IF SAT13=0,1,2,3] Why do you say that?

[RECORD VERBATIM]

C_FT11_SKIP [IF FT1=1 SKIP TO C1]

FT11 [IF FT10 = 1, ELSE SKIP TO FT13] How did you become aware of the Smart $aver Custom Fast Track offering?

01 Account representative
02 Business Energy Advisor
03 Contractor / Vendor
04 Duke Energy website
05 Other (specify)
88 Don't know

FT12 Why did you choose not to participate in the offering?

[RECORD VERBATIM]

FT13 If you have a project under a tight timeline, would you be willing to pay several hundred dollars for an accelerated review of your SmartSaver application?

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

FT14 Would you be willing to participate in a meeting or teleconference and respond to requests about the project specifications in a timely manner?

01 Yes
02 No
88 Don't know

FT15 Using a scale of 0 to 10, where 0 is "not at all valuable" and 10 is "very valuable", how valuable would the fast track application option be for future projects?

___ [RECORD RESPONSE]
88 Don't know
99 Refused

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Customer Characteristics

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

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

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

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

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

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

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

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

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

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

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

01 Yes
02 No [SKIP TO C9]

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

[RECORD VERBATIM]

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

[RECORD VERBATIM]

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

01 Yes [SPECIFY]
02 No

INT99 [SKIP IF MULTCHK=02] That completes the survey, thank you very much for your time.

CP Completed

INT98 That completes the survey, thank you very much for your time.

CM Completed

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Duke Energy Carolinas Smart$aver Custom Incentive Program
Participating Trade Ally Interview Guide

This document serves as a guide for interviews with companies that provided services to Smart$aver Custom Incentive program participants.

Background for respondent: We are working with Duke Energy to evaluate their Smart$aver Custom Incentive program in the Carolinas. As part of this evaluation, we are speaking to contractors such as yourself. We will be asking about your experience with the program in the past and improvements you would suggest for the future. Your responses to these questions will be confidential and will not be associated with you or your company when we prepare our report for Duke Energy.
I would like to record this call so I can review it later and make sure I capture your responses accurately. Is that OK?

Trade Ally Background

1 What is your role at <company>? What services does your company provide to your customers?

2 How long has <company> been participating in the Duke Energy Smart$aver Custom Incentive program? About how many projects would you say you have completed since then?

Program Interaction

3 How did your company first get involved with the Smart$aver Custom Incentive program?

4 Who do you interact with at Duke Energy in connection with the Custom program?

5 What information or training has Duke Energy provided as part of the Custom program? Is the information/training sufficient? Is there anything additional Duke Energy could provide?

6 Do your customers tend to already know about the Custom program, or do you introduce it to them? Do you use the program as a sales tool?

7 What types of concerns do customers have about the program, if any? Is there anything Duke Energy could provide to address these concerns?

Attribution

8 Approximately how many projects have you completed through the Smart$aver Custom Incentive program in 2017?

__ [RECORD # OF PROJECTS]

9 In what percent of your sales situations did you recommend high-efficiency equipment *before* you learned about the Smart$aver Custom Incentive program?

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___ [RECORD 0-100%]

10 And in what percent of your sales situation do you recommend high-efficiency equipment now that you have worked with the Smart$aver Custom Incentive program?

___ [RECORD 0-100%]

11 In what percent of your sales situations did the customer plan to purchase high-efficiency equipment *before* you told them about the Smart$aver Custom Incentive program?

___ [RECORD 0-100%]

12 And in what percent of your sales situation did the customer purchase high-efficiency equipment *after* you told them about the Smart$aver Custom Incentive program?

___ [RECORD 0-100%]

13 Using a similar 0 to 10 scale, this time with 0 being “not at all satisfied” and 10 being “very satisfied” how satisfied are you with the Smart$aver Custom Incentive program?

__ [RECORD 0-10]

14 Using a scale from 0 to 10 where 0 is “not at all influential” and 10 is “very influential”, how influential was the Smart$aver Custom Incentive program in customers deciding to purchase high-efficiency equipment?

__ [RECORD 0-10]

15 [if not already discussed] Can you talk a little bit about your typical sales process? Do you provide customers with multiple equipment options? How do these options differ? (Probe if they are all high efficiency options, combination of high efficiency and standard efficiency, etc.)

16 Again, using a 0 to 10 scale, with 0 being “not at all satisfied” and 10 being “very satisfied”, how satisfied are you with the incentives provided through the Smart$aver Custom Incentive program?

__ [RECORD 0-10]

17 Using the same scale, how satisfied are you with Duke Energy overall?

__ [RECORD 0-10]

17.a Why did you give Duke Energy that rating?

18 What percent of the projects in 2017 where you sold or installed high-efficiency equipment were eligible but DID NOT receive an incentive through a Duke Energy energy-efficiency program?

___ [RECORD 0-100%]

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19 [IF Q18>0] Why do you or your customers not request an incentive for these energy efficiency projects? If you requested an incentive but did not receive one, why was that?

T12 Lamp Questions (for Lighting contractors)

Next I have a few questions about lighting systems.

20 Of your linear fluorescent lighting system sales in 2017, what percent were T12s?

___ [RECORD 0-100%]

21 Are you still stocking and selling linear fluorescent T12 lighting systems and replacement lamps?
(Capture any additional contractor comments in TL2 (e.g., yes, but…))

22 [if still stocking T12s] Thinking of your 2018 sales of linear fluorescent lighting system sales, what percent will be T12s?

___ [RECORD 0-100%]

Program Participation

I have just a few more questions for you.

23 Are you familiar with any changes that Duke Energy made to the Custom program in 2016 or 2017? (If needed: for example, changes to the application, calculations, or pilot offerings?) How did you learn about these changes? Did Duke Energy communicate these changes clearly enough? How useful were these offerings? What are customers' reactions to these offerings?

24 Do you utilize Duke Energy's classic custom or custom-to-go calculators to estimate savings, do you use your own calculators or do you use a combination of each? If used any of Duke's calculators, ask how useful is the calculator was in estimating energy savings (using a scale from 0 to 10 where 0 is "not at all useful" and 10 is "very useful")? If not used, why haven't you used Duke's calculators? Probe for which calculator they use (lighting, HVAC, etc.). In what situations do you use one calculator over another? Would you find it valuable to have a combined calculator for both custom and prescriptive?

25 Do you complete applications for your customers, or do they complete the applications? Do you complete the applications online or paper? Why do you complete using that method? Do you have any feedback on the application process?

26 Have you received requests for more information after submitting an application? Were any of these requests difficult to respond to? Is there anything Duke Energy could do to help you anticipate these requests before submitting the application?

27 On average, roughly how long is the pre-approval process from the time you submit the application to approval?

28 Were you aware there was on online application portal to submit the application online? If aware, have you used this method? If used the online portal, how was the process? (Did you like it?) If not used, is there anything preventing you from using this method?

29 Why do some customers not move forward with projects through the program? Are there enrollment processes that could be simplified to encourage customers to complete projects? What program aspects are most influential in their decision?

30 From your perspective, what is the most valuable part of the Smart$aver Custom Incentive program? Why do you say that?

31 From your perspective, what part of the Smart$aver Custom Incentive program needs the most work? Why? What could Duke Energy do to improve this?

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

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EM&V Report for the EnergyWise Home Demand Response Program

Summer PY2018

Prepared for:

Duke Energy Progress

November 30, 2018

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Included as Separate Documents:

Appendix A: Output Summary

Filename: "*DEP EWise PY2018 Summer Mini Analysis Appendix A 2018-11-27.xlsx*"
Description: Includes summary results and snapback calculation.

Appendix B: EnergyWise Home Ex-Ante Tool for Duke Energy Progress Territory

Filename: *"DEP EWise Summer 2018 Appendix B Summer Ex Ante Tool v04 2018-11-27.xlsx"*
Description: Spreadsheet tool for estimating DR impacts of various cycling strategies (including full shed).

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EVALUATION SUMMARY

The EnergyWise Home (EnergyWise) demand response (DR) program offers Duke Energy Progress (DEP) residential customers the opportunity to earn credits on their electricity bill by allowing DEP to remotely control air conditioners (A/C) in the summer months (available system wide) and space- and water-heating equipment in winter (Western region customers only) during times of seasonal peak consumption. This report covers the evaluation, measurement, and verification (EM&V) activities for the summer of 2018.

At the time of the single event called by Duke Energy during the summer 2018, there were 174,348 participants with a total of 223,312 A/C units enrolled in the program.

The test event took place between 5:00 PM and 5:30 PM on August 30, 2018. Participants were cycled at 100% during the 30-minute event. The average temperature experienced by participating households during this event was approximately 92.6 degrees Fahrenheit. **Navigant has estimated that the average impact per participant was 1.67 kW, with an aggregate program total impact of 291 MW.**

Evaluation Methods

Since Navigant's first evaluation of the EnergyWise program in 2011, Navigant has evaluated impacts using one of two approaches: a logger analysis or a "mini" analysis. For a logger analysis (for example the recently completed evaluation of the EnergyWise program for the winter of 2017/2018), data loggers are deployed to a representative sample of participant homes and regression analysis is used to estimate event impacts and project program capability. For a "mini" analysis, Navigant applies the regression-estimated DR coefficients (parameters) from the most recent metering study to the temperature values actually observed during the evaluation period events. This delivers the equivalent of an ex ante impact, or prediction, based on previously estimated impact/temperature relationships.

For PY2018, no logger analysis was carried out, but Navigant determined that the standard mini-analysis approach was also inappropriate. The most recent program year in which regression analysis had been applied to a 100% cycling event (like that called in the summer of 2018) was 2011. Given the length of time since that evaluation, Navigant believed that it would be imprudent to use the parameters estimate in PY2011.

Rather, Navigant first estimated a baseline average A/C demand at the event temperatures using the PY2016 summer logger data, and then applied the estimated percentage reduction from 2011 for the 100% cycling event deployed that year. We then further applied a reduction to account for device operability[1] (operability data were not collected or used in PY2011). In summary: the baseline is derived from PY2016 data, and the relative (percentage) impact of curtailment is derived from the 100% cycling event for which regression-estimated impacts are available (from 2011), slightly adjusted to account for the summer 2016 operability rate.

[1] Note that operability – whether a switch is physically operational when observed in person by a technician – is quite different from responsiveness (whether an operable switch responds to Duke's curtailment signal for any given event). Navigant's approach here implicitly assumes the same responsiveness rate for 100% cycling events as estimated for the 100% cycling event deployed in 2011. See report body for more details.

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Evaluated Impacts

The principal EM&V findings regarding the PY2018 summer event demand impacts are as follows:

- **Full load shed of A/C units delivered an average impact of 1.67 kW per household.** The total estimated program impact of the 174,348 participating households was 291 MW.
- **The average snapback** impact during the first full hour beginning 15 minutes after the end of the event was 0.42 kW.
- **The impact of the 100% cycling event was higher in 2018 than in 2011, due to a shift in the participant baseline.** The estimated impact of the one-hour event in 2011 was 1.28 kW. The 2018 impact is higher than the 2011 impact for three reasons:
    - *The event was hotter.* The average event temperature in 2011 was 90 degrees, in 2018, 92.5 degrees.
    - *The event was later*. In 2011 the event lasted from 3:30 PM to 4:30 PM, in 2018 from 5:00 PM to 5:30PM, when A/C demand (all else equal) tends to be higher.
    - *The baseline is higher.*[2] The 2016 participant baseline demand is higher at every temperature value than that of 2011. Navigant believes that this may reflect a change in overall program participant characteristics (in 2011, there were fewer than 65,000 participating households, in 2018 there were nearly triple that number).

[2] Applying the PY2018 approach to the variable values from 2011 (timing and temperature of event) yields an average event impact of approximately 1.4 kW, an approximately 10% increase in the baseline from 2011 to 2018.

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1. INTRODUCTION

The EnergyWise program provides residential customers the opportunity to earn credits on their electricity bill by allowing DEP to remotely control air conditioning (in the summer) and water heater and heat pump auxiliary heating strips (in the winter – Western region customers only) during times of seasonal peak consumption. This report covers the EM&V activities for the summer of 2018.

EM&V is a term adopted by DEP and refers generally to the assessment and quantification of the energy and peak demand impacts of an energy efficiency or DR program. For DR, estimating reductions in peak demand is the primary objective, as energy impacts are generally negligible. EM&V also can encompass an evaluation of program processes and customer feedback typically conducted through participant surveys. The summer PY2018 EM&V cycle did not include a process evaluation.

1.1 Objectives of the Evaluation

This report is intended to verify program impacts per the requirements established by the North Carolina Utilities Commission and the Public Service Commission of South Carolina. Since no data loggers were deployed to participating homes in the summer of PY2018, the principal objective of the evaluation is to apply the outputs from the data collected for the PY2016 and PY2011 logger studies to weather and participation data observed in the summer of 2018 to estimate the impact of direct load control on residential demand in the summer of 2018.

1.2 Program Overview

The EnergyWise program was developed in response to DEP's determination that a curtailable load program would be a valuable resource for the company, and that it would provide an opportunity to engage directly with customers to help reduce costly seasonal peak demand. The program seeks to attract DR resources by providing incentives to residential customers to allow DEP to remotely control the most important driver of summer peak demand typically found in the home: central air conditioning.

The program offers an annual bill credit of $25 (per appliance type controlled) to customers that choose to allow DEP to control their central air conditioners (summer only), electric auxiliary heat strips and/or water heaters (winter only).

Eligibility. To be eligible for participation in the summer component of the EnergyWise program, a household must meet the following criteria:

- Participants must occupy the residence where the controls are installed. Renters must complete a Tenant Authorization Form and the landlord/property owner must approve.
- Residential electricity service must be in the name of the participant.
- Participants must be in an area that can receive the EnergyWise Home paging signal.
- Participation also requires that participants have electric central air conditioning or a centrally ducted heat pump.

Incentives. Each participant receives a $25 yearly bill credit upon joining the summer program, and then an additional $25 bill credit every 12 months they remain on the program.

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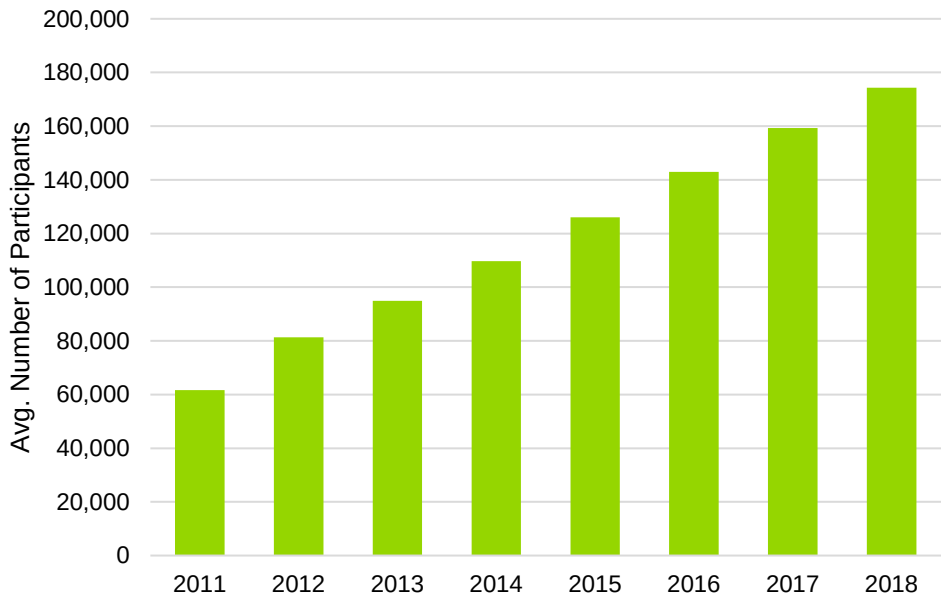
Marketing. DEP is responsible for all marketing of the EnergyWise program. Participant enrollments are generated through a mix of direct mail, bill inserts, email, outbound calling, and door-to-door canvassing.

1.3 Reported Program Participation

This section reports the overall program participation for the summer EnergyWise program in the summer of PY2018. In total, approximately 174,348 individual customers participated in the 100% full shed test event on August 30. Since 2011, program growth has been stable and consistent at approximately 15,000 incremental participants joining per year (see Figure 1).

Figure 1: Historical EnergyWise Summer Participation



Source: DEP

Altogether the 174,348 participants have a total of nearly 223,312 central air-conditioning units enrolled, or approximately 1.28 per participant. This ratio has not changed meaningfully over time – in the first year Navigant evaluated this program there were approximately 1.3 enrolled central air conditioners enrolled for each participant – a statistically identical value to that in PY2018.

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2. EVALUATION METHODS

This section of the EM&V report describes the approach used to estimate the DR and snapback impacts of the EnergyWise program for PY2018.

Since Navigant's first evaluation of the EnergyWise program in 2011, Navigant has evaluated impacts using one of two approaches: a logger analysis or a "mini" analysis.

- For **a logger analysis** (for example the recently completed evaluation of the EnergyWise program for the winter of 2017/2018), data loggers are deployed to a representative sample of participant homes and regression analysis is used to estimate event impacts and project program capability.
- For **a "mini" analysis**, Navigant applies the regression-estimated DR coefficients (parameters) to the actually observed temperature values. This delivers the equivalent of an ex ante impact, or prediction, based on previously estimated impact/temperature relationships.

For PY2018, no logger analysis was carried out, but Navigant determined that the standard mini-analysis approach was also inappropriate. The most recent program year in which regression analysis had been applied to a 100% cycling event (like that called in the summer of 2018) was 2011. Given the length of time since that evaluation, Navigant believed that it would be imprudent to use the parameters estimate in PY2011.

Rather, Navigant proceeded in the following fashion (each step of which is described in greater detail in the sub-section of the same name below:

- **Baseline Estimation:** Navigant used the logger data from PY2016 – the most recently collected summer A/C logger data – to estimate the relationship between A/C demand, temperature, and time of day. These estimated values deliver a baseline on the event day.
- **Demand Response Impact Estimation:** To quantify the impact, Navigant applied the percentage DR impact estimated in PY2011 for the only 100% cycling event that Navigant has had the opportunity to evaluate using logger data.
- **Snapback Impact Estimation:** Snapback impacts are estimated using the same approach deployed in prior non-logger-data evaluation year, as a function of: total energy "taken back" (as a percentage of energy saved), and the demand pattern of snapback in the period following the event.

2.1 Baseline Estimation

Navigant estimated the relationship between average participant demand and temperature using the regression specification below, applied to the PY2016 logger data:

$$y_{k,t} = \alpha_k + \beta_1 qhour_t CDH70_{k,t} + \varepsilon_{k,t}$$

Where:

$y_{k,t}$ = The average AC demand of household *k* in a quarter hour of sample *t*.

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α_k	=	The individual-level fixed effect.
$qh_{i,t}$	=	A dummy variable equal to 1 when the quarter hour of sample *t* falls in the *i*-th hour of the day. For example, if quarter hour *t* fell in the first quarter hour of the day then $qh_{1,t}$ would equal 1 and $qh_{2,t}$ to $qh_{96,t}$ would all be equal to 0.
$CDH70_{k,t}$	=	The cooling degree quarter-hours observed by household *k* in quarter hour of sample *t*.

This regression was estimated using the PY2016 EM&V participants' logger data from non-event weekdays on which the average temperature observed by participants between 3pm and 6pm was greater than 90 degrees Fahrenheit. Altogether 17 days met these inclusion criteria.[3]

The parameters estimated in the regression above ($\widehat{\alpha_k}$, and $\widehat{\beta_1}$) are applied to the cooling degree hours of interest to deliver an estimate of participant baseline A/C demand at that temperature.

Note that the regression equation specified above is relatively simple – for example it does not control explicitly for heat build-up[4], humidity, the day of the week or other factors. This is an explicit modeling decision made in order to facilitate the use of model outputs in an ex-ante impact estimation tool that Navigant has developed for Duke Energy. The inclusion of additional variables and interactions (e.g., humidity, moving averages, etc.) would require considerably more complex inputs for that tool, substantially reducing its usefulness as a quick reference, without meaningfully improving its predictive accuracy (given the model uncertainty).

Following estimation of the regression model, Navigant generated fitted values for all observations included in the regression. A fitted value is simply what the model predicts the value of the left-hand side variable should be, given the variable values included on the right-hand side. The differences between the fitted and actual values are the residuals.

Figure 2 compares the average predicted baselines between 3pm and 6pm during the days included in the regression data set with the actual average A/C demand observed in the same period. Each marker in the plot below reflects a different daily average temperature/demand pair, with the green diamond markers representing the fitted values and the grey circles representing the actuals.

[3] Note that not all participant data were included for each day. For example, data for the Group 1 participants were included on July 14, 2016, but not Group 2 data, as Group 2 was curtailed on this date, but Group 1 was not. For more details regarding the group-split of EM&V participants, please refer to the PY2016 Summer evaluation report of the EnergyWise program.

[4] Heat build-up is at least partially controlled for implicitly in that temperature time-series are highly auto-correlated

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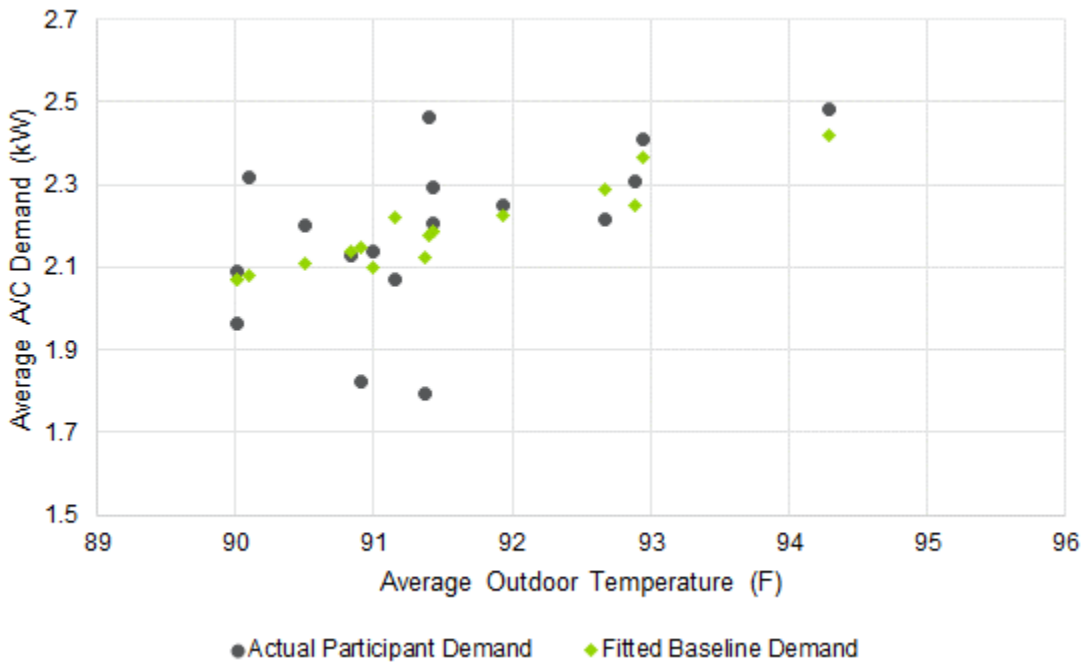
Figure 2: Demonstration of Baseline In-Sample Accuracy



Source: Navigant logger data and analysis.

Two things are immediately clear:

- **There is no apparent bias:** actuals appear as likely to be higher as they are to be lower than the fitted values.
- **Accuracy improves at higher temperatures:** the average distance between predicted and actual demand values is much smaller at the higher temperatures (i.e., 92 degrees and above) than at lower temperatures (i.e., 90 to 92 degrees)

To generate the baseline used for this evaluation, Navigant applied the average event period temperatures to the regression-estimated parameters. This delivers an estimate of average per-participant demand during the two quarter-hours of the event on 2018-08-30.

2.2 Demand Response Impact Estimation

Navigant applied two factors to the baseline to obtain an estimated impact:

- **DR impact.** In PY2011, Navigant estimated that the average DR impact during the hour-long 100% cycling event that year was 71% of baseline demand (see Figure 3, below)
- **Operability Adjustment.** In PY2016, Navigant tracked device operability (quite different from device responsiveness – see below). Altogether, Navigant technicians found that approximately 3% switches inspected during logger deployment were entirely non-functional. Therefore a 3% adjustment (decrement) is applied to estimated impacts to account for population operability.

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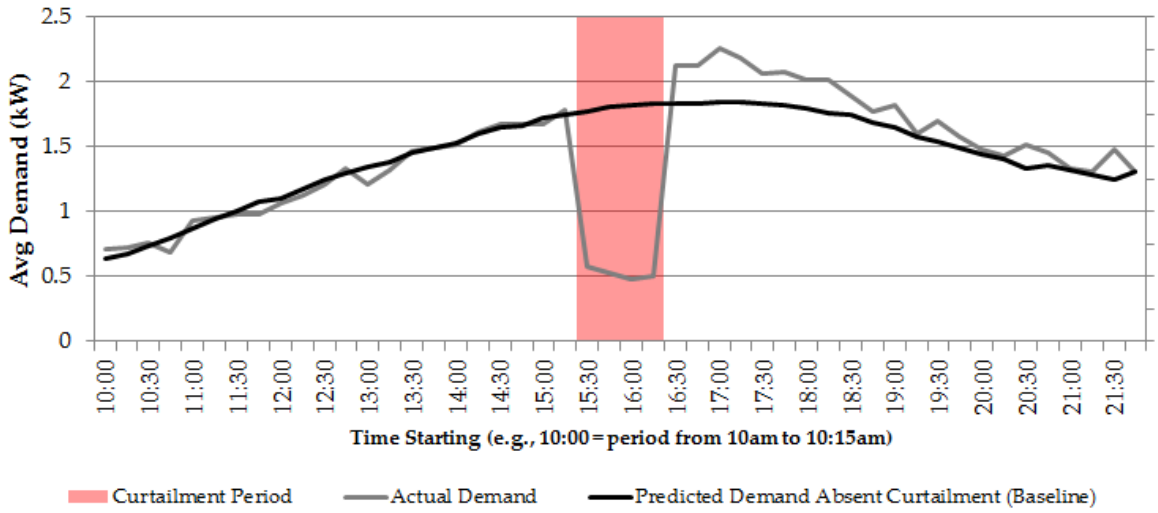
Figure 3: PY2011 100% Cycling Event Load Profile and Baseline



Source: Navigant logger data and analysis.

A standard output of Navigant's logger data analyses of the EnergyWise home program is a "responsiveness rate". This is an estimate of what proportion of switches appear to have been non-responsive to the Duke curtailment signal for any given event.[5] This is a parallel analysis to Navigant's impact analysis and has no effect on those values (i.e., the actuals shown in Figure 3 include responsive, non-responsive, and not-in-use A/C units). Implicitly then, Navigant's estimated impact for PY2018 assumes the same non-responsiveness as occurred during the 2011-08-25 100% cycling event.[6]

Navigant did consider an alternate approach (which can be implemented in the Appendix B spreadsheet with the selection of the appropriate toggle) in which the baseline is reduced only by the operability factor and the average non-responsive rate estimated in a prior year. This approach (though it delivers a higher impact) was rejected based on Navigant's observation that the difference between load remaining after 100% curtailment (i.e., the distance between the grey line and the x-axis in Figure 4) is larger than can be explained entirely by the historically estimated responsiveness.

2.3 Snapback Impact Estimation

Snapback is defined as the increase in demand observed in the period following a DR event. During a DR event A/C cycling limits the run time of the A/C compressor. This results in the indoor temperature rising above the thermostat set-point. When cycling ceases, the compressor needs to run for longer than it normally would in order to restore the indoor temperature to the thermostat set-point.

Snapback is calculated as a function of:

[5] More specifically, it is a measure of what proportion of participating A/C units had no observable reduction in demand in the first hour of an event, beginning fifteen minute after the start of the event. For more details, refer to the summer 2016 evaluation report.

[6] The specific values were: 13% of devices in use but non-responsive, 11% of devices not in use. These are in line with the non-responsiveness rates of the other events that summer, and in other years – i.e., between 10% and 15%.

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- **Post-Event Snapback Pattern.** The magnitude of snapback in each quarter hour of the snapback period relative to the average quarter-hourly demand reduction in the curtailment period. This pattern is drawn from the estimated snapback impacts of the 100% cycling event deployed in PY2011.
- **Energy Take-Back.** The proportion of the energy (kWh) consumption reduction in the curtailment period that is "taken back" during the snapback period. This is also drawn from the 2011 evaluation.

The mechanics of the snapback approach are clearly laid out in the Appendix A workbook (see the "Snapback Calculation" tab).

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3. IMPACT FINDINGS

This section provides the estimated demand reduction and snapback impacts for the EnergyWise program for the summer 2018. Section 2 details how these impacts were estimated. Impacts are based on the results of the weather observed during the PY2018 event, the baseline temperature/demand relationships estimated using the PY2016 logger data, and the relative DR impacts estimated for 100% cycling as part of the PY2011 evaluation.

The estimated DR impact by quarter-hour of event is shown in Table 1.

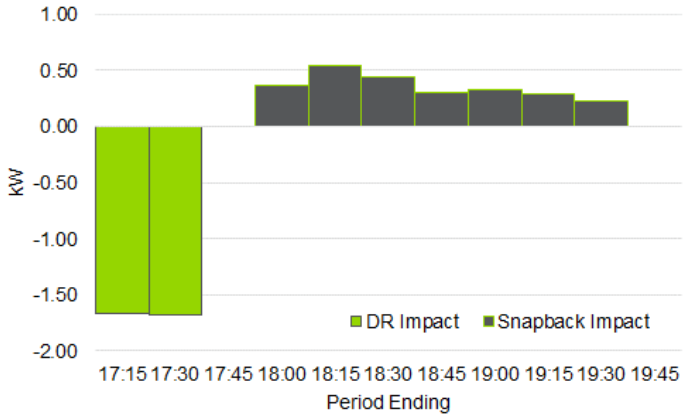
Table 1. Average Demand Reduction Impact by Quarter Hour

Quarter-Hour of Event	Time Starting	Time Ending	Average DR Impact Per Participant (kW)	Relative Precision (90% Confidence)[7]	Total Program DR Impact (MW)
1	17:00	17:15	1.66	8.0%	289
2	17:15	17:30	1.68	7.9%	292
Average of All Quarter-Hours	**17:00**	**17:30**	**1.67**	**7.8%**	**291**

Source: Navigant Analysis, PY2018 weather, PY2016 modeling results, and PY2011 estimated impacts

Quarter-hour by quarter-hour results are shown graphically in Figure 4. In Figure 4, DR impacts are represented as a negative number (i.e., demand reduction) and snapback as a positive (i.e., an increase in demand). Note that due to ramping, there is still a lingering DR impact in the first quarter-hour of the snap-back period (i.e., the negative value of the first gray column in the figure below). The average snapback impact during the first full hour beginning 15 minutes after the end of the event was 0.42 kW.

Figure 4. Demand Response and Snapback Impacts – 2018-08-30



Source: Navigant Analysis, PY2018 weather, PY2016 modeling results, and PY2011 estimated impacts

[7] Confidence intervals estimated here are based on the confidence interval surrounding the estimated *baseline* (based on PY2016 data) rather than an estimated impact. Because no actual events were observed, there is no estimated uncertainty associated with the impacts, only with the baseline. Although this approach is deemed acceptable by many state-wide groups (see for example Section 6.2.3 of the PA Act 129 Evaluation Framework), it will tend to overstate precision.

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DR impacts for this event are substantially higher than the 1.28 kW impact estimated for the PY2011 100% cycling event. This is due to three factors:

- *The event was hotter.* The average event temperature in 2011 was 90 degrees, in 2018, 92.5 degrees.
- *The event was later*. In 2011 the event lasted from 3:30 PM to 4:30 PM, in 2018 from 5:00 PM to 5:30PM, when A/C demand (all else equal) tends to be higher.
- *The baseline is higher.*[8] The 2016 participant baseline demand is higher at every temperature value than that of 2011. Navigant believes that this may reflect a change in overall program participant characteristics (in 2011, there were fewer than 65,000 participating households, in 2018 there were nearly triple that number).

[8] Applying the PY2018 approach (i.e., the Appendix B workbook) to the variable values from 2011 (timing and temperature of event) yields an average event impact of approximately 1.4 kW, an approximately 10% increase in the baseline from 2011 to 2018.

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4. SUMMARY FORM

EnergyWise Home

Summer PY2018

Completed EMV Fact Sheet

Description of Program

Duke Energy's EnergyWise program is a DR program offered to residential customers in the DEP territory.

EnergyWise is a direct load control program. Participants receive an incentive to allow Duke Energy to control their air conditioners (in the summer), their heat pump auxiliary heat strips (in the winter), or their electric water heaters (winter or summer). Only participants in the Western region are curtailed in the winter.

This report evaluates the impact of the program in the summer of 2018. Only a single event was called, on August 30, 2018.

Date:	2018-11-30
Region:	DEP
Evaluation Period	Summer 2018
DR Event Impact per Participant (kW)	
Central Air Conditioner	1.67
DR Event Program Impact (MW)	
Central Air Conditioner	291
Net-to-Gross Ratio	1

Evaluation Methods

Navigant estimated DR impacts for central air conditioners by estimating an average participant baseline demand, and applying the percentage impact for 100% cycling estimated as part of the 2011 evaluation (the only time a 100% cycling event has been evaluated with logger data).

The participant baseline to which the 2011 percentage impact was applied was estimated using relationships estimated from non-event-day logger data collected as part of the PY2016 summer evaluation. These estimated relationships were applied to PY2018 event temperature values to deliver the estimated baseline.

Impact Evaluation Details

- **Full load shed of A/C units delivered an average impact of 1.67 kW per household.** The total estimated program impact of the 174,348 participating households was 291 MW.
- **The impact of the 100% cycling event was higher in 2018 than in 2011, due to a shift in the participant baseline.** The estimated impact of the one-hour event in 2011 was 1.28 kW. The 2018 impact is higher than the 2011 impact for three reasons:
    - *The event was hotter.* The average event temperature in 2011 was 90 degrees, in 2018, 92.5 degrees.
    - *The event was later*. In 2011 the event lasted from 3:30 PM to 4:30 PM, in 2018 from 5:00 PM to 5:30PM, when A/C demand (all else equal) tends to be higher.
    - *The baseline is higher.*[1] The 2016 participant baseline demand is higher at every temperature value than that of 2011. Navigant believes that this may reflect a change in overall program participant characteristics (in 2011, there were fewer than 65,000 participating households, in 2018 there were nearly triple that number).

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5. CONCLUSION

The principal EM&V findings regarding the summer event demand impacts for PY2018 are as follows:

- **Full load shed of A/C units delivered an average impact of 1.67 kW per household.** The total estimated program impact of the 174,348 participating households was 291 MW.
- **The average snapback** impact during the first full hour beginning 15 minutes after the end of the event was 0.42 kW.
- **The impact of the 100% cycling event was higher in 2018 than in 2011, due to a shift in the participant baseline.** The estimated impact of the one-hour event in 2011 was 1.28 kW. The 2018 impact is higher than the 2011 impact for three reasons:
    - *The event was hotter.* The average event temperature in 2011 was 90 degrees, in 2018, 92.5 degrees.
    - *The event was later*. In 2011 the event lasted from 3:30 PM to 4:30 PM, in 2018 from 5:00 PM to 5:30PM, when A/C demand (all else equal) tends to be higher.
    - *The baseline is higher.*[9] The 2016 participant baseline demand is higher at every temperature value than that of 2011. Navigant believes that this may reflect a change in overall program participant characteristics (in 2011, there were fewer than 65,000 participating households, in 2018 there were nearly triple that number).

[9] Applying the PY2018 approach to the variable values from 2011 (timing and temperature of event) yields an average event impact of approximately 1.4 kW, an approximately 10% increase in the baseline from 2011 to 2018.

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Energy Efficiency Education in Schools Program Year 2017 – 2018 Evaluation Report

Submitted to Duke Energy Carolinas and Progress in partnership with Research into Action

March 20th, 2019

Principal authors:

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1 Executive Summary

1.1 Program Summary

The Energy Efficiency Education in Schools Program is a Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP) energy efficiency program implemented by the National Theatre for Children (NTC). The program provides age-appropriate school performances by NTC's professional actors that teach students about energy and energy conservation in a humorous, engaging, and entertaining format. NTC also provides participating schools with classroom curriculum to coincide with the performance, which includes energy efficiency kit request forms that student families can use to receive free energy efficiency measures to install in their home.

1.2 Evaluation Objectives and Results

This report presents the results and findings of evaluation activities for the DEC and DEP NTC program conducted by the evaluation team, collectively Nexant Inc. and our subcontracting partner, Research into Action, for the school and program year of August 2017 through July 2018.

1.2.1 Impact Evaluation

The evaluation team conducted the evaluation as detailed in this report to estimate energy and demand savings attributable to the 2017-2018 DEC and DEP NTC programs. The evaluation was divided into two research areas - to determine gross and net savings (or impacts). Gross impacts are energy and demand savings estimated at a participant's home that are the direct result of the homeowner's installation of a measure included in the Duke Energy home kit. Net impacts reflect the degree to which the gross savings are a result of the program efforts and funds. Table 1-1 and Table 1-2 present the summarized findings of the impact evaluation.

Table 1-1: 2017-2018 DEC Savings per Kit

Measurement	Reported	Realization Rate	Gross Verified	Net-to-Gross Ratio	Net Verified
Energy (kWh)	201.0	135.0%	271.3	0.94	254.1
Summer Demand (kW)	0.054	61.7%	0.034		0.031
Winter Demand (kW)	N/A	N/A	0.048		0.045

*Values may appear inaccurate due to rounding errors

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Table 1-2: 2017-2018 DEC Program Level Savings

Measurement	Reported	Realization Rate	Gross Verified*	Net-to-Gross Ratio	Net Verified*
Energy (kWh)	4,655,361	135.0%	6,283,232	0.94	5,884,250
Summer Demand (kW)	1260.7	61.7%	777.7		723.5
Winter Demand (kW)	N/A	N/A	1,113.4		1,036.4

* Values may appear inaccurate due to rounding errors

Table 1-3 and Table 1-4 present the summarized findings of the DEP impact evaluation.

Table 1-3: 2017-2018 DEP Savings per Kit

Measurement	Reported	Realization Rate	Gross Verified*	Net-to-Gross Ratio	Net Verified*
Energy (kWh)	276.4	124.3%	343.5	0.92	317.5
Summer Demand (kW)	0.079	52.5%	0.041		0.038
Winter Demand (kW)	N/A	N/A	0.064		0.059

* Values may appear inaccurate due to rounding errors

Table 1-4: 2017-2018 DEP Program Level Savings

Measurement	Reported	Realization Rate	Gross Verified*	Net-to-Gross Ratio	Net Verified*
Energy (kWh)	2,494,510	124.3%	3,055,293	0.92	2,865,616
Summer Demand (kW)	711.0	52.5%	373.1		343.0
Winter Demand (kW)	N/A	N/A	581.0		534.1

* Values may appear inaccurate due to rounding errors

Figure 1-1 and Figure 1-2 provide the verified energy saving share by measure for DEC and DEP, respectively.

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Figure 1-1: 2017-2018 DEC NTC Gross Verified Energy Savings

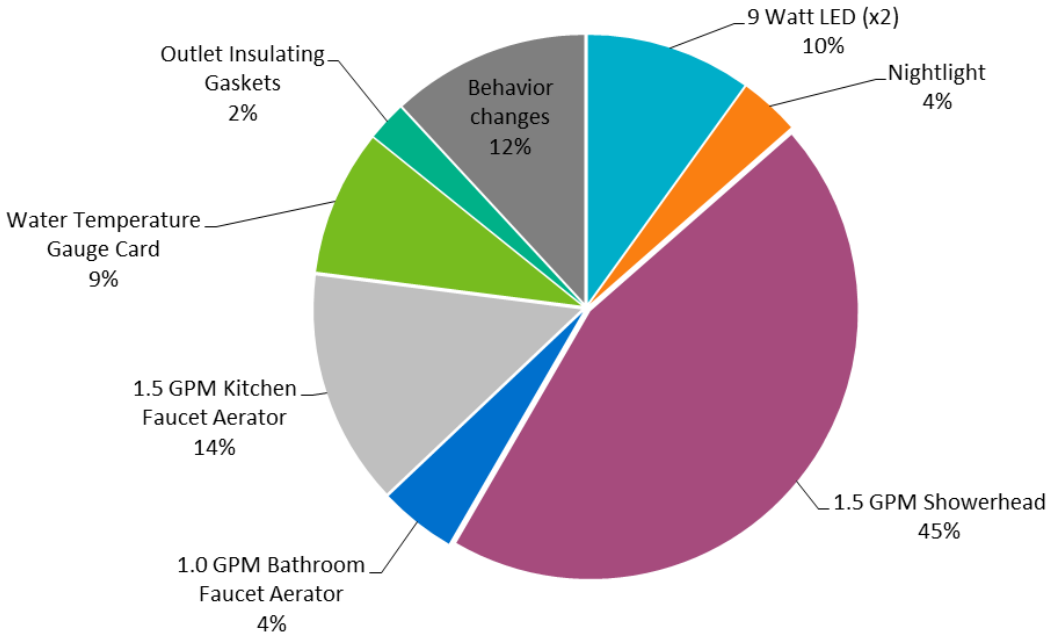

Figure 1-2: 2017-2018 DEP NTC Gross Verified Energy Savings

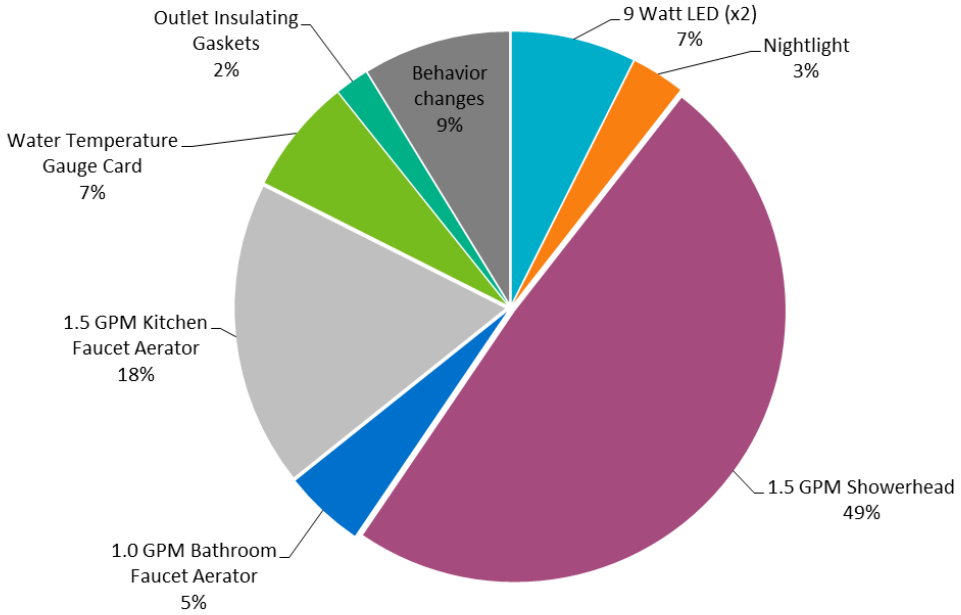

Table 1-5 and Table 1-6 provide gross verified energy and demand savings by measure and net to gross ratio details for DEC and DEP, respectively.

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Table 1-5: DEC NTC Program Year 2017-2018 Verified Impacts by Measure

Measure	Gross Energy Savings per unit (kWh)	Gross Summer Demand per unit (kW)	Gross Winter Demand per unit (kW)	Free Ridership	Spillover	Net to Gross Ratio
9 Watt LED*	27.0	0.005	0.002	0.16	0.09	0.93
Nightlight	9.8	0.000	0.000			
1.5 GPM Showerhead	121.6	0.010	0.027			
1.0 GPM Bathroom Faucet Aerator	12.4	0.002	0.003			
1.5 GPM Kitchen Faucet Aerator	38.2	0.005	0.008			
Water Temperature Gauge Card	23.7	0.003	0.005			
Outlet Insulating Gaskets	6.3	0.008	0.000			
Behavioral Changes	32.3	0.001	0.002	-	-	1.00
Total Kit and Behavioral Impacts	**271.3**	**0.034**	**0.048**	**0.16**	**0.09**	**0.94**

*Reflects savings for two 9 watt LEDs bulbs

Table 1-6: DEP NTC Program Year 2017-2018 Verified Impacts by Measure

Measure	Gross Energy Savings per unit (kWh)	Gross Summer Demand per unit (kW)	Gross Winter Demand per unit (kW)	Free Ridership	Spillover	Net to Gross Ratio
9 Watt LED*	25.4	0.004	0.002	0.13	0.05	0.92
Nightlight	10.9	0.000	0.000			
1.5 GPM Showerhead	168.1	0.013	0.038			
1.0 GPM Bathroom Faucet Aerator	16.4	0.002	0.004			
1.5 GPM Kitchen Faucet Aerator	62.3	0.008	0.014			
Water Temperature Gauge Card	23.5	0.003	0.005			
Outlet Insulating Gaskets	6.8	0.009	0.000			
Behavioral Changes	30.1	0.001	0.001	-	-	1.00
Total Kit and Behavioral Impacts	**343.5**	**0.041**	**0.064**	**0.13**	**0.05**	**0.92**

*Reflects savings for two 9 watt LEDs bulbs

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1.2.2 Process Evaluation

The process evaluation assessed opportunities for improving the program's design and delivery in DEC and DEP service territories. It specifically documented teacher, student, and parent experiences by investigating: 1) teachers' assessments of the NTC performance, quality of curriculum materials, and the kit request form distribution procedure; and 2) student families' responses to the energy efficiency kits and the extent to which the kits effectively motivate families to save energy.

The evaluation team reviewed program documents and conducted phone (*n*=74 DEC and *n*=70 DEP) and web surveys (*n*=260 DEC and *n*=102 DEP) with student families that received a kit and teachers who attended the performance (*n*=44 DEC and *n*=29 DEP). The team also conducted in-depth interviews with utility staff, NTC staff, and ten teachers (five in DEC territory and five in DEP territory) who completed the web survey.

Program Successes

The 2017-2018 DEC and DEP NTC program evaluation's found successes in the following areas:

Teachers and parents are aware of Duke Energy sponsorship of the kits. Most parents (94% in DEC and 88% in DEP) and teachers (84% in DEC and 79% in DEP) knew that Duke Energy sponsored the kits. Parents became aware of Duke Energy sponsorship via the materials their children brought home (58% in DEC and 57% in DEP), or via engagement by their school or teacher (29% in DEC and 30% in DEP). DEC teachers most commonly became aware via communication from other teachers (14 of 37), whereas DEP teachers more commonly reported learning about Duke's sponsorship via marketing materials (8 of 23) and NTC staff (8 of 23).

Parents largely learned about Duke Energy kits from materials brought home by child. About three-quarters (75% in DEC and 72% in DEP) of parents learned about the kits from program engagement materials their children brought home. Lesser reported ways included school newsletters (17% in DEC and 11% in DEP) and emails from their children's teacher or school (14% in DEC and 13% in DEP).

Teachers were highly satisfied with the performance reporting that the performance was not missing important components, was age appropriate for most students, and engaged students. Nearly all stated they were "highly satisfied" (39 of 44 in DEC and 25 of 29 in DEP), most noted the performance was not missing important concepts (43 of 44 in DEC and 28 of 29 in DEP), and most noted the performance was age appropriate (40 of 44 in DEC and 27 of 29 in DEP). All interviewed teachers reported the performance was engaging, humorous, and effective.

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Distribution of kit request forms goes well. Teachers reported no problems receiving kit request forms and almost all (42 of 44 in DEC and 28 of 29 in DEP) noted they distributed the forms to their students, typically immediately after the performance.

Student families are highly satisfied with kit items. Respondents were highly satisfied with all measures, especially the lighting items (Figure 1-3 and Figure 1-4).

Figure 1-3: DEC Kit Recipient Satisfaction with Installed Measures

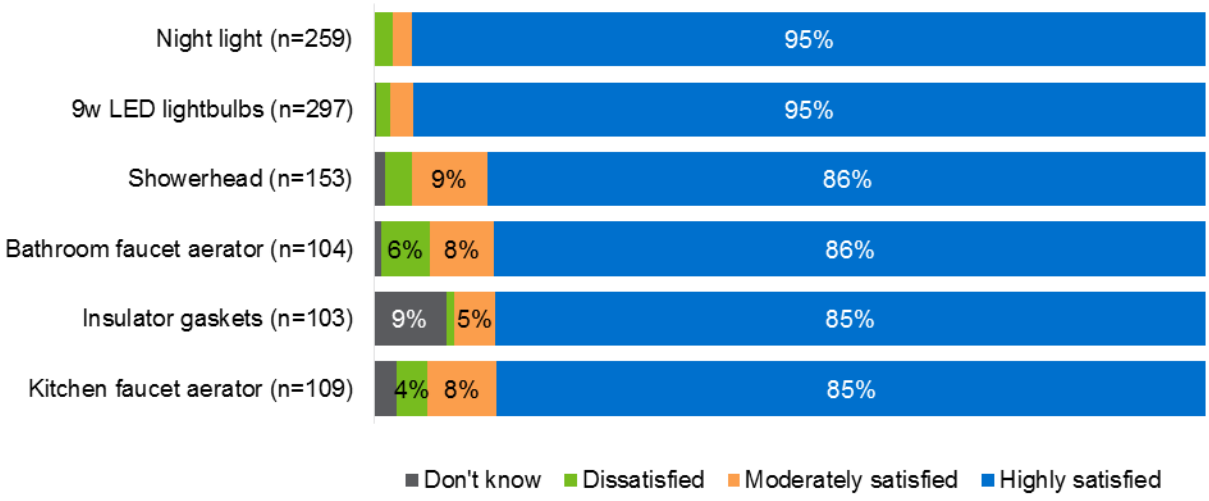
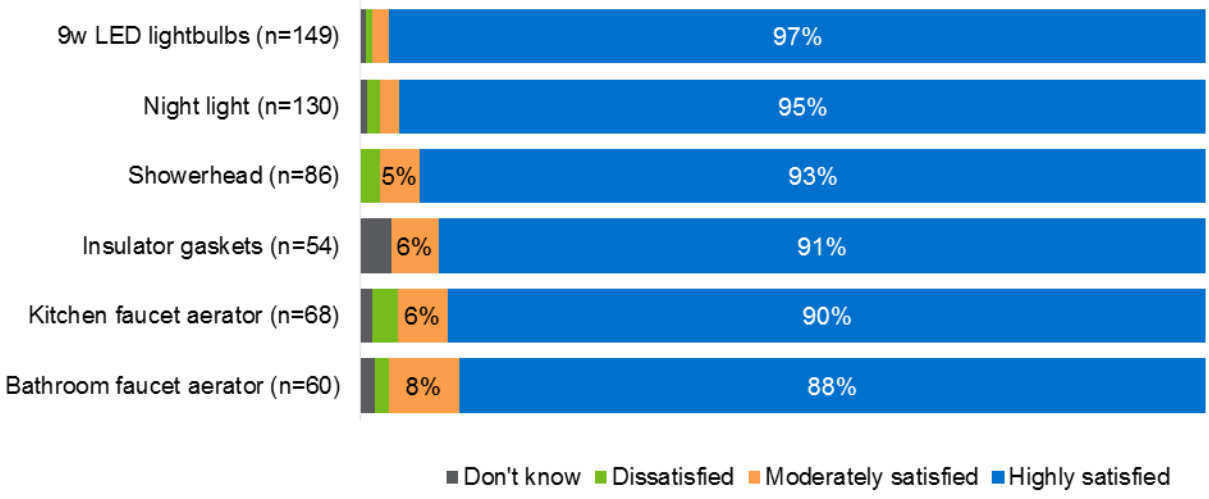


Figure 1-4: DEP Kit Recipient Satisfaction with Installed Measures



Many kit recipients value the educational information in the kit. About three-quarters of respondents (73% in DEC and 74% of DEP) read the energy saving educational information in the kit and most of those reported it was “highly helpful.”

The program influenced some families to adopt energy saving behaviors. In both the DEC and DEP territories, about half of parents and half of children adopted new energy

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saving behaviors since receiving their kit. Parents most commonly said that their child now turns off lights when not using a room and parents noted they had changed their thermostat settings.

Program Challenges

The 2017-2018 NTC program evaluation met some challenges in the following areas:

Instructional material use is limited. Teachers reported distributing kit request forms to their students yet noted limited use of the instructional materials associated with the performance. Although about half of respondents in DEC territory (29 of 44) and DEP territory (12 of 29) reported receiving the educational materials, those that received them either did not use the materials or used them in a limited way. Of those that used the materials, teachers deemed them "somewhat useful" at best. Additionally, use of online materials was limited.

There is variation in teacher efforts to encourage kit requests. All teachers encouraged their students to request kits, but they varied in the tenacity of their approach. Almost all reported vocally encouraging students (40 of 44 in DEC and 24 of 29 in DEP) and to request a kit, but far fewer reported taking additional actions (e.g., sending reminders to parents or awarding prizes to students who request kits).

There may be opportunities to get families to install more kit measures. Most parent respondents noted they installed at least one measure in the kit, but few install all measures. Most student families installed the LED lights and the nightlights, however far fewer installed the water saving measures or the insulator gaskets.

1.3 Evaluation Conclusions and Recommendations

Based on evaluation findings, the evaluation team concluded the following and provides several recommendations for program improvement:

Conclusion 1: NTC performances satisfy teachers by engaging students. It is less clear that the performances are linked to classroom learning, awareness at home, or change in behavior. Teachers reported high satisfaction with the performance and recalled that the performance engaged students. However, curriculum materials were not always distributed or remembered by teachers, and those who used them did so in a limited way.

Parents were often not aware the performance occurred and about half of parents reported changes in their or their children's energy use behavior but those changes in behavior were limited.

Recommendation: Consider exploring ways to increase teacher receipt and use of materials, such as:

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- Making sure teachers are aware that NTC aligns their materials with state science standards, and
- Requesting that teachers align energy-focused lesson plans with performance timing.

Conclusion 2: There is an opportunity to increase parental awareness of the kits and thus get more families to request and install kits. Currently, students bear the bulk of the burden of generating parental awareness of the kit opportunity. Although most teachers engage students on the kit request process, only about half engage parents. Parent surveys corroborate this lack of teacher to parent engagement on the kits; few parents mentioned their child's teacher or school as the source of awareness of the kit (instead, most parents learned about the kit from their child). Additionally, two-thirds of parents did not know kits were associated with a performance and instructional materials. Although about one-third of teachers follow-up with students to see if parents requested kits, there is great variation in how much emphasis teachers place on promoting the kits.

Further, the contests appear to have limited success in encouraging kit requests, as a) only one teacher mentioned using the contests to encourage kit requests, and b) the household- and school-level contests had particularly low influence on parent motivations to get a kit.

> **Recommendation:** Explore ways to increase parent awareness of and motivation for requesting the kits. For example: create a household-level contest that engages both students and their parents, so students are motivated to ask their parents to sign up and so parents are motivated to participate. For example, in addition to a cash prize drawing for parents, include a prize drawing aimed at students (e.g., toys, electronics, or other items valued by students) or a guaranteed incentive such as a coupon for pizza (e.g., Book It model).

Conclusion 3: The program influences families to save energy. Families save energy they would not have saved without receiving the kits. Nearly all respondents installed at least one kit measure, and few would have installed the kit measures if they had not received them for free from the program (as evidenced by low free-ridership rates). About one-fifth of parent respondents reported making additional energy saving improvements, and over half of parent respondents said they or their children adopted new energy saving behaviors since receiving the kit.

> **Recommendation:** Continue engaging student family households with the Education program.

Conclusion 4: The Education program could be a good "gateway" program to generate even more energy savings in Duke Energy territories. Kit recipients could be good targets for other Duke Energy efficiency program promotions, as they:

- Demonstrated willingness to save energy in their home

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- Expressed interest in installing additional kit items or other energy saving measures (many of which Duke Energy currently incents)
- Are highly likely to read any information included with the kit
- Are commonly single family homeowners

Recommendations: Leverage kits to promote other Duke Energy efficiency programs, such as targeting these households for direct mail campaigns or including information on Smart $aver in the kit.

Conclusion 5: Energy savings could be increased by encouraging partipants to install LED lamps as soon as they are received and in higher usage areas. LED lamp in-service rates (ISR) measured just below 80% for both DEC and DEP. This included some participants who store the LED kit lamp until a similar lamp in the home burns-out. Continue to encourage participants to install the lamps as soon as the kit is received can increase LED lamp in-service rates and generate additional savings for the program.

Most kit lamps were installed in rooms with average (2 to 4 hour) daily lighting usage, while very few lamps were installed in high use locations such as kitchens or exterior fixtures (Table 1-7). Installation of lamps in high usage areas will results in higher energy savings.

Table 1-7: Lamp HOU Installation Rates

Daily Lamp Use*	DEC Installation Rate	DEP Installation Rate
Low (< 2 hours)	43%	44%
Average (2-4 hours)	36%	32%
High (> 4 hours)	21%	24%

*Based on the participant survey responses

Recommendations: Program should continue to encourage lamp installations as soon as possible informing them where their new lamps can save the most energy. Alternatively, consider swapping out one of the A-shape LEDs with a lamp, such as an LED PAR, that may be more applicable to higher use areas like the kitchen.

Conclusion 6: Water-related measures drive savings, but installation rates are low. Water measures contributed the majority of verified savings (DEC 74%, DEP 80%), yet fewer than half of all participants installed an aerator or showerhead (Table 1-8).

Table 1-8: Water Measure In-Service Rates

Measure	DEC ISR	DEP ISR
Kitchen Faucet Aerator	30%	40%
Bathroom Faucet Aerator	30%	34%
Showerhead	42%	50%

*Based on the participant survey responses

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Recommendations: Review water savings measures' satisfaction and dislikes as well as elicit feedback from Save Energy and Water Kit Program to determine if there are ways to improve the ISR for water measures.

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2 Introduction and Program Description

2.1 Program Description

2.1.1 Overview

The Energy Efficiency Education in Schools Program is an energy efficiency program sponsored by Duke Energy Carolinas (DEC) and Duke Energy Progress (DEP). The program provides free in-school performances by the National Theatre for Children (NTC) that teach elementary and middle school students about energy and conservation concepts in a humorous and engaging format. This report will hereafter refer to the program as the NTC program.

In addition to the NTC performance, NTC provides teachers with: 1) student workbooks that reinforce topics taught in the NTC performance, including a take-home form that students and parents can complete to receive an energy efficiency starter kit (kit) from Duke Energy; and 2) lesson plans associated with the content in the student workbooks. All workbooks, assignments and activities meet state curriculum requirements. The NTC performers encourage students to have their parents request the kits.

The program can achieve energy savings in two ways:

1. Through the installation of specific energy efficiency measures provided in the kit.
2. By increasing students' and their families' awareness about energy conservation and engaging them to change behaviors to reduce energy consumption.

2.1.2 Energy Efficiency Kit Measures

Table 2-1 lists the kit's contents included in the evaluation scope (the kit includes additional educational items described in section 2.2.4 below).

Table 2-1: 2017-2018 Kit Measures

Measures	Details
9 Watt LED	2 bulbs
Nightlight	1 LED plug-in nightlight
1.5 GPM Showerhead	1 low-flow showerhead
1.0 GPM Bathroom Faucet Aerator	1 low-flow faucet aerator
1.5 GPM Kitchen Faucet Aerator	1 low-flow kitchen aerator
Water Temperature Gauge Card	1 temperature card indicating water heat temperature
Outlet Insulating Gaskets	8 outlet and 4 light switch gaskets

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2.2 Program Implementation

2.2.1 School Recruitment

Duke Energy sends NTC a list of approved schools in each utility territory, which NTC uses to contact schools to schedule NTC performances. NTC ships curriculum materials to participating schools approximately two weeks prior to the performance date.

2.2.2 NTC Performance

NTC has two age-appropriate shows: Kilowatt Kitchen for elementary age students (Kindergarten through sixth grade) and The E-Team for middle school age students (6th through 8th grade). Two actors perform in each show, where they use an entertaining, humorous, and interactive format to educate students on four general areas:

- Sources of energy (renewable and nonrenewable sources)
- How energy is used
- How energy is wasted
- Energy efficiency and conservation

Performers also discuss how their utility offers students and their families free energy efficiency starter kits, and how the items in the kit can save energy in their homes.

2.2.3 Kit Form Promotion and Distribution

In the performance, the actors explain to students that they must fill out the kit request form to receive their kit. Following the performance, teachers give their students the NTC workbooks that – in addition to educational activities to reinforce the concepts from the NTC performance – include a detachable postage-prepaid postcard kit request form. Students take the form home to their parents or guardians, who complete and mail the form. Parents or guardians may also request a kit via a toll-free telephone number or by signing up at MyEnergyKit.org. To encourage participation, those requesting kits are automatically entered in drawings to win cash prizes for their household ($1,000) or their school ($2,500). The utilities use two vendors to fulfill kit requests. The participant's eligibility is confirmed by the firm R1 who sends the fulfillment request to AM Conservation who ships the kit to eligible homes that signed up for the program. The Process Flow Map in Appendix C outlines this process.

2.2.4 Energy Kit Eligibility

Student families can only receive a kit once every 36 months. Additionally, parents/guardians must fill out the survey included on the kit request form in order to receive a kit. Because some school districts may straddle a Duke territory and a non-Duke territory, the kit contents will differ

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if a family is a Duke utility (DEP or DEC) customer versus a non-Duke Energy customer (Table 2-2).[1]

Table 2-2: Measures Received by Customer Type

Measures	Duke Energy Customer	Non-Duke Energy Customer
1.5 GPM Showerhead	✓	
1.5 GPM Kitchen Faucet Aerator	✓	
1.0 GPM Bathroom Faucet Aerator	✓	
Water flow meter bag	✓	
Water Temperature Gauge Card	✓	✓
9 Watt LEDs	✓	
LED Nightlight	✓	✓
Outlet Insulating Gaskets	✓	✓
Energy savers booklet	✓	✓
Product information and instruction sheet	✓	
Glow ring toy	✓	✓

2.2.5 Participation

For the defined evaluation period of September 2017 through May 2018, the program recorded a total of 23,161 kit recipients in DEC and 9,025 kit recipients in DEP. During survey recruitment, no participants notified the evaluation team that their kits never arrived.

2.3 Key Research Objectives

Over-arching project goals will follow the definition of impact evaluation established in the "Model Energy-Efficiency Program Impact Evaluation Guide – A Resource of the National Action Plan for Energy Efficiency," November 2007:

> *"Evaluation is the process of determining and documenting the results, benefits, and lessons learned from an energy-efficiency program. Evaluation results can be used in planning future programs and determining the value and potential of a portfolio of energy-efficiency programs in an integrated resource planning process. It can also be used in retrospectively determining the performance (and resulting payments, incentives, or penalties) of contractors and administrators responsible for implementing efficiency programs."*

Evaluation has two key objectives:

[1] Only Duke customers were surveyed for the evaluation

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1) To document and measure the effects of a program and determine whether it met its goals with respect to being a reliable energy resource.
2) To help understand why those effects occurred and identify ways to improve the program.

2.3.1 Impact

As part of evaluation planning, the evaluation team outlined the following activities to assess the impacts of the DEC and DEP NTC programs:

- Quantify accurate and supportable energy (kWh) and demand (kW) savings[2] for energy efficient measures implemented in participants' homes;
- Assess the rate of free riders from the participants' perspective and determine spillover effects;
- Benchmark verified measure-level energy impacts to applicable technical reference manual(s) and other Duke similar programs in other jurisdictions.

2.3.2 Process

The process evaluation assessed opportunities for improving the design and delivery of the program in DEC and DEP service territory. It specifically documented teacher, student, and parent experiences by investigating: 1) teachers' assessments of the NTC performance, program materials, and curriculum in terms of quality of content, and ability to engage and motivate students to save energy; and 2) student families' responses to the energy efficiency kits and the extent to which the kits effectively motivate families to save energy.

The evaluation team assessed several elements of the program delivery and customer experience, including:

- **Awareness:**
  - How aware are teachers and student families of the DEC or DEP sponsorship of the program?
  - Is there a need to increase this awareness?
- **Program experience and satisfaction:**
  - How satisfied are teachers with the NTC performance and program curriculum in terms of ease of use ability to engage and motivate students to conserve energy at home?
  - How satisfied are student families with the measures in the kit and to what extent do the kits motivate families to save energy?

[2] The quantification of program impacts was initially attempted through a utility bill regression analysis. However, the program impacts could not be isolated due to the small size of the impact relative to annual consumption. Therefore, the impact analysis relied on engineering algorithms to assess the program's savings impacts. Please see section 3.5 for additional detail.

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- **Challenges and opportunities for improvement:**
  - Are there any inefficiencies or challenges associated with program delivery?
  - How engaged are teachers in implementing the curriculum and motivating student families to request program kits?
  - What are teachers' assessments of the NTC performance, program information, and curriculum?
- **Student family characteristics:**
  - What are the demographic characteristics of kit recipients?

2.4 Evaluation Overview

The evaluation team divided its approach into key tasks to meet the outlined goals:

- **Task 1 –** Develop and manage evaluation work plan to describe the processes that will be followed to complete the evaluation tasks outlined in this project;
- **Task 2 –** Conduct a process review to determine how successfully the programs are being delivered to participants and to identify opportunities for improvement;
- **Task 3 –** Verify gross and net energy and peak demand savings resulting from the NTC program through verification activities of a sample of 2017 - 2018 program participants.

2.4.1 Impact Evaluation

The primary determinants of impact evaluation costs are the sample size and the level of rigor employed in collecting the data used in the impact analysis. The accuracy of the study findings is in turn dependent on these parameters. Techniques applied to conduct our evaluation, measurement, and verification (EM&V) activities, and to meet the goals for this evaluation, included telephone and web-based surveys with program participants, best practice review, and interviews with implementation and program staff.

Figure 2-1 demonstrates the principal evaluation team steps organized through planning, core evaluation activities, and final reporting.

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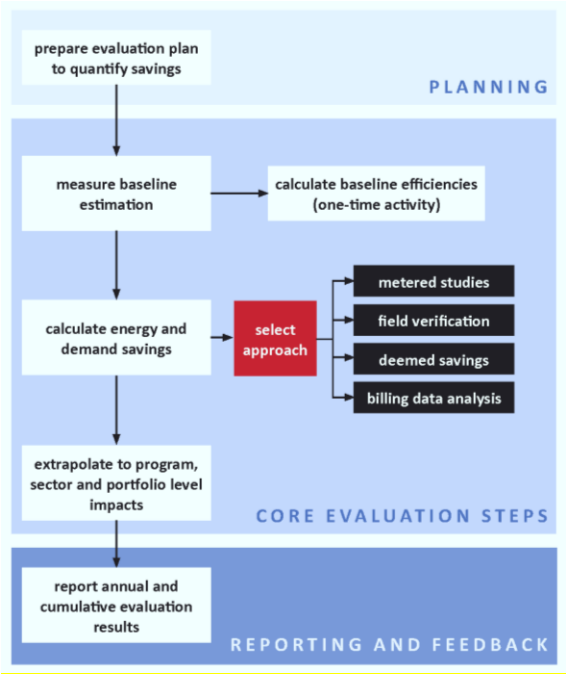
Figure 2-1: Impact Evaluation Process



The evaluation is generally comprised of the following steps, which are described in further detail throughout this report:

- **Participant Surveys:** The file review for all sampled and reviewed program participation concluded with a telephone and web-based survey with the participating families. Table 2-3 below summarizes the number of surveys and on-site inspections completed. The samples were drawn to meet a 90% confidence and 10% precision level based upon the expected and actual significance (or magnitude) of program participation, the level of certainty of savings, and the variety of measures.
- **Calculate Impacts and Analyze Load Shapes:** Data collected via surveys enabled the evaluation team to calculate gross verified energy and demand savings for each measure.
- **Estimate Net Savings**: Net impacts are a reflection of the degree to which the gross savings are a result of the program efforts and incentives. The evaluation team estimated free-ridership and spillover based on self-report methods through surveys with program participants. The ratio of net verified savings to gross verified savings is the net-to-gross ratio as an adjustment factor to the reported savings.

2.4.2 Process Evaluation

Process evaluation examines and documents:

- Program operations
- Stakeholder satisfaction
- Opportunities to improve the efficiency and effectiveness of program delivery

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To satisfy the evaluation, measurement, and verification (EM&V) objectives for this research effort, the evaluation team reviewed program documents and conducted telephone and web surveys with participating student families and teachers who attended the performance. These surveys served both the process and impact evaluation work.

The team also held in-depth interviews (IDI) with utility staff, implementation staff, and teachers. Table 2-3 provides a summary of the evaluation team activities.

Table 2-3: DEC and DEP NTC Summary of Evaluation Activities

Target Group	Method	Duke Energy Carolinas (DEC)			Duke Energy Progress (DEP)		
		Population	Sample	C/P	Population	Sample	C/P
Impact Activities							
Participants	Phone/Web Survey	23,161	334	90/5	9,025	172	90/6
Process Activities							
Duke Energy Program Staff	Phone IDI	n/a	1	n/a	n/a	1	n/a
Implementer Staff: NTC	Phone IDI	n/a	1	n/a	n/a	1	n/a
Implementer Staff: R1	Phone IDI	n/a	1	n/a	n/a	1	n/a
Teachers who attended a NTC workshop	Web Survey	Unknown	44[a]	90/12	Unknown	29[b]	90/17
Participating teacher follow-up interviews	Phone IDI	Unknown	5	n/a	Unknown	5	n/a
Participants – student families who received a kit and are Duke customers	Phone/Web Survey	23,161	334	95/5	9,025	172	90/6

[a] 34 elementary teachers and 10 middle school teachers
[b] 19 elementary teachers and 10 middle school teachers

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3 Impact Evaluation

3.1 Methodology

The evaluation team's impact analysis focused on the energy and demand savings attributable to the NTC program for the period of August 2017 through July 2018. The evaluation was divided into two research areas: to determine gross and net savings (or impacts). Gross impacts are energy and demand savings estimated at a participant's home that are the direct result of the homeowner's installation of a measure included in the program-provided energy saving kit. Net impacts are a reflection of the degree to which the gross savings are a result of the program efforts and funds. The evaluation team verified energy and demand savings attributable to the program by conducting the following impact evaluation activities:

- Review of DEC and DEP participant databases.
- Completion of telephone and web-based surveys to verify key inputs into savings calculations.
- Estimation of gross verified savings using primary data collected from participants.
- Comparison of the gross-verified savings to program-evaluated results to determine kit-level realization rates.
- Application of attribution survey data to estimate net-to-gross ratios and net-verified savings at the program level.

3.2 Database and Historical Evaluation Review

DEC and DEP provided the evaluation team with a program database for the NTC program participation. The program database provided participant contact information including account number, address, phone number, and email address, if available, and whether or not the participant was willing to be contacted. Since DEC and DEP were able to provide both phone numbers and email addresses, we were able to design a sampling approach that could take advantage of both phone and web-based surveying.

DEC and DEP provided ex-ante, or deemed, energy and summer demand savings values at the kit-level; however, they did not have measure-level ex-ante energy savings available nor winter demand savings at the kit-level. Because measure-level energy and demand savings and kit-level winter demand savings were not provided, realization rates could only be calculated at the kit-level for energy and summer demand savings.

Despite the unavailability of measure-level ex-ante savings, the evaluation team conducted a benchmarking review of the uncertainty of ex-ante savings estimates by comparing multiple technical reference manuals (TRMs) and a prior Energy Efficiency Education in Schools evaluation conducted in Duke Energy Carolinas. The benchmarking review

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illustrated variations in deemed savings among each source for each given measure, with much of the variation reflecting different baseline, household size, or water temperature assumptions. The evaluation team ultimately used assumptions outlined by the Mid-Atlantic and Pennsylvania TRMs (see section 3.4.4) to better capture region-specific assumptions such as water temperature.

3.3 Sampling Plan and Achievement

To provide representative results and meet program evaluation goals, a sampling plan was created to guide all evaluation activity. A random sample was created to target 90/10 confidence and precision at the program level, assuming a coefficient of variation (C_v) equal to 0.5. After reviewing the program database, the evaluation team identified a population of 23,161 participants for DEC and 9,025 participants for DEP within our defined evaluation period.

Based on the populations of 23,161 and 9,025 participants, the evaluation team established sub-sample frames for phone and web-based survey administration. As illustrated in Table 3-1 and Table 3-2 below, we completed a total of 334 DEC and 172 DEP surveys. This sample size resulted in an achieved confidence and precision of 90/4.5 and 90/6.2 for DEC and DEP, respectively.

Table 3-1: DEC NTC Impact Sampling

Survey Mode	Population*	Sampled Participants	Achieved Confidence/ Precisions**
Phone	7,953	74	90/4.5
Web-based	11,629	260	
Total	**19,582**	**334**	

*Sampling population excludes participants flagged as "do not contact"
**Based on full population of 23,161 participants

Table 3-2: DEP NTC Impact Sampling

Survey Mode	Population*	Sampled Participants	Achieved Confidence/ Precisions**
Phone	2,406	70	90/6.2
Web-based	4,037	102	
Total	**6,443**	**172**	

*Sampling population excludes participants flagged as "do not contact"
**Based on full population of 9,025 participants

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3.4 Description of Analysis

3.4.1 Telephone and web-based surveys

The evaluation team performed telephone and web-based surveys to gain key pieces of information used in the savings calculations. Results from the completed surveys were used to inform our program-wide assumptions as detailed in Table 3-3.

Table 3-3: Participant Data Collected and Used for Analysis

Measure	Data Collected	Assumption
9 Watt LEDs Nightlight	Units Installed	In-Service Rate
	Units Later Removed	
	Room Where Installed	Hours of Use
	Original Lamp Removed	Baseline Wattage
1.5 GPM Showerhead 1.0 GPM Bathroom Faucet Aerator 1.5 GPM Kitchen Faucet Aerator	Units Installed	In-Service Rate
	Units Later Removed	
	Hot Water Fuel Type	% Electric DHW
Water Temperature Gauge Card	Gauge Cards Used	In-Service Rate
	Thermostats Reverted	
	Hot Water Fuel Type	% Electric DHW
Outlet Insulating Gaskets	Units Installed	In-Service Rate
	Units Later Removed	

3.4.2 In-Service Rate

The in-service rate (ISR) represents the ratio of equipment installed and operable to the total pieces of equipment distributed and eligible for installation. For example, if 15 telephone surveys were completed for customers receiving 1 LED each, and five customers reported to still have the LED installed and operable, the ISR for this measure would be five out of 15 or 33%. In some instances equipment was installed but may have been removed later due to homeowner preferences. In these cases the equipment is no longer operable and therefore contributes negatively to the ISR. In-service rates for each measure from all eligible survey respondents are detailed in Table 3-4 and Table 3-5 for DEC and DEP, respectively.

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Table 3-4: DEC NTC In-Service Rates

Measure	Distributed	Installed	Removed	ISR
9 Watt LEDs[1]	668	528	10	78%
Nightlight	334	259	8	75%
1.5 GPM Showerhead	334	153	13	42%
1.0 GPM Bathroom Faucet Aerator	334	104	4	30%
1.5 GPM Kitchen Faucet Aerator	334	109	10	30%
Water Temperature Gauge Card	334	57	2	16%
Outlet Insulating Gaskets[2]	4,008	620	2	15%

[1]Note that two 9 watt LEDs were included in each kit.

[2]Note that 12 outlet insulating gaskets were included in each kit. The evaluation team calculated the ISR based on the total count of equipment distributed and installed.

Table 3-5: DEP NTC In-Service Rates

Measure	Distributed	Installed	Removed	ISR
9 Watt LEDs[1]	344	266	1	77%
Nightlight	172	130	1	75%
1.5 GPM Showerhead	172	86	0	50%
1.0 GPM Bathroom Faucet Aerator	172	60	1	34%
1.5 GPM Kitchen Faucet Aerator	172	68	0	40%
Water Temperature Gauge Card	172	25	2	13%
Outlet Insulating Gaskets[2]	2,064	345	0	17%

[1]Note that two 9 watt LEDs were included in each kit.

[2]Note that 12 outlet insulating gaskets were included in each kit. The evaluation team calculated the ISR based on the total count of equipment distributed and installed.

3.4.3 Lighting

The two lighting measures in the kit include two 9W LEDs and an LED nightlight. Equation 3-1, Equation 3-2, and Equation 3-3 outline the algorithms utilized to estimate savings accrued by the lighting measures, with key parameters defined in Table 3-6.

Equation 3-1: LED Bulb Energy Savings

$$\Delta kWh = \frac{Watts_{BASE} - Watts_{EE}}{1000\frac{W}{kW}} \times (1 + IE_{kWh}) \times 365.25\frac{days}{year} \times ISR$$

Equation 3-2: LED Nightlight Energy Savings

$$\Delta kWh = \frac{Watts_{BASE} \times HOU_{BASE} - Watts_{EE} \times HOU_{EE}}{1000\frac{W}{kW}} \times (1 + IE_{kWh}) \times 365.25\frac{days}{year} \times ISR$$

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Equation 3-3: LED Bulb Demand Savings

$$\Delta kW = \frac{Watts_{BASE} - Watts_{EE}}{1000\frac{W}{kW}} \times CF \times (1 + IE_{kW}) \times IS$$

Table 3-6: Inputs for Lighting Measures Savings Calculations

Input	Units	DEC Value	DEP Value	Source
$Watts_{BASE}$	Watts	LED: 27.7 Nightlight: 3.2	LED: 26.8 Nightlight: 3.6	LED: Federal minimum standards; Survey responses Nightlight: Survey responses
$Watts_{EE}$	Watts	LED: 9 Nightlight: 0.03		Equipment specifications
HOU	Hours	LED: 2.71 Nightlight: 12 / 24	LED: 2.69 Nightlight: 12 / 24	LED: Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018; Survey responses; Nightlight (HOU_{BASE} / HOU_{EE}): Pennsylvannia 2016 TRM
CF_{SUMMER}	N/A	LED: 0.1283 Nightlight: 0.0000		LED: Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018 Nightlight: Pennsylvannia 2016 TRM
CF_{WINTER}	N/A	LED: 0.1454 Nightlight: 0.0000		LED: Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018 Nightlight: Pennsylvannia 2016 TRM
IE_{kWh}	N/A	-6%		Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018
$IE_{kW\text{-}SUMMER}$	N/A	+27%		Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018
$IE_{kW\text{-}WINTER}$	N/A	-50%		Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018
ISR	N/A	LED: 78% Nightlight: 75%	LED: 77% Nightlight: 75%	Survey responses

The evaluation team paid careful attention to the effects of the Energy Independence and Security Act (EISA), which mandated higher-efficiency technologies for incandescent bulbs. In the analysis of LED bulbs, the evaluation team used participant-reported lamp types (e.g., incandescent or CFL) and assigned the EISA-compliant bulb that would produce the same lumen output as the 9W LEDs from the kits. This resulted in the use of a 53W baseline for halogen lamps, a 43W baseline for incandescents, a 13W baseline for CFLs, and a 9W baseline for LEDs. The final baseline wattage applied in the evaluation is a blended average of all the

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reported lamp technologies, which resulted in a lower wattage than would be assumed if we relied on the Uniform Methods Project least efficient baseline approach. Using a blended average baseline wattage based on the participant survey results more accurately captures the diversity of bulbs replaced by the program participants and provides greater confidence in our savings estimates. Nightlights, which are not affected by EISA, were evaluated using a baseline wattage dependent on what the participant specified as the removed lamp.

Hours of use (HOU) for LED lighting was based on the 2018 Duke Energy Progress & Duke Energy Carolinas Energy Efficient Lighting & Retail LED Programs Evaluation Report, which estimated hours of use for 7 different room types. Based on installation locations from survey responses the evaluation estimated an average lighting hours of use of 2.71 for DEC and 2.69 for DEP.

Using the engineering algorithm and assumptions described above, we determined the gross energy and demand savings value for each lighting measure provided in the kit as summarized in Table 3-7 and Table 3-8.

Table 3-7: DEC NTC Energy and Demand Savings, Lighting Measures

Kit Measure	Gross per bulb energy savings (kWh)	Gross per bulb summer demand savings (kW)	Gross per bulb winter demand savings (kW)
9W LED*	13.5	0.002	0.001
Nightlight	9.8	0.000	0.000

*Reflects savings per 9 watt LED bulb

Table 3-8: DEP NTC Energy and Demand Savings, Lighting Measures

Kit Measure	Gross per bulbenergy savings (kWh)	Gross per bulb demand savings (kW)	Gross per bulbwinter demand savings (kW)
9W LED*	12.7	0.002	0.001
Nightlight	10.9	0.000	0.000

*Reflects savings per 9 watt LED bulb

3.4.4 Water Heating

The four water heating measures in the kit include a low-flow kitchen faucet aerator, a low-flow bathroom faucet aerator, a low-flow showerhead, and a water temperature gauge card which encouraged participants to set back their hot water heater thermostats. The equations below outline the algorithms utilized to estimate savings accrued by the domestic water heating measures with parameters defined in Table 3-9.

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Equation 3-4: Aerator Energy Savings

$$\Delta kWh = ISR \times ELEC \times \left[\frac{\Delta GPM \times T_{person/day} \times N_{persons} \times 365\frac{days}{year} \times DF \times \Delta T \times 8.3\frac{BTU}{gal \cdot °F}}{\#_{faucets} \times 3{,}412\frac{BTU}{kWh} \times RE}\right]$$

Equation 3-5: Showerhead Energy Savings

$$\Delta kWh = ISR \times ELEC \times \left[\frac{\Delta GPM \times T_{person/day} \times N_{persons} \times 365\frac{days}{year} \times N_{showers-day} \times \Delta T \times 8.3\frac{BTU}{gal \cdot °F}}{\#_{showers} \times 3{,}412\frac{BTU}{kWh} \times RE}\right]$$

Equation 3-6: Water Heater Setback Energy Savings

$$\Delta kWh = ISR \times ELEC \times \left[\frac{A_{tank} \times \Delta T \times 8760\frac{hrs}{yr}}{R_{tank} \times RE \times 3{,}412\frac{Btu}{kWh}} + \frac{V_{HW} \times \left(8.3\frac{lb}{gal}\right) \times \left(365\frac{days}{yr}\right) \times \left(1\frac{Btu}{°F \cdot lb}\right) \times \Delta T}{\left(3412\frac{Btu}{kWh}\right) \times EF_{WH}}\right]$$

Equation 3-7: Water Heating Measures Demand Savings

$$\Delta kW = ETDF \times \Delta kWh$$

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Table 3-9: Inputs for Water Heating Measures Savings Calculations

Input	Units	DEC Value	DEP Value	Source
ISR	N/A	Bath: 30% Kitchen: 30% Shower: 42% Setback: 16%	Bath: 34% Kitchen: 40% Shower: 50% Setback: 13%	Survey responses
ELEC	N/A	Bath: 76% Kitchen: 75% Shower: 73% Setback: 64%	Bath: 90% Kitchen: 92% Shower: 87% Setback: 78%	Survey responses
ΔGPM	GPM	Bath: 1.2 Kitchen: 0.7 Shower: 1.0		Product specification sheet compared against federal code minimum
$T_{person/day}$	Minutes	Bath: 1.6 Kitchen: 4.5 Shower: 7.8		Mid-Atlantic 2018 TRM
$N_{persons}$	Persons	Bath: 3.8 Kitchen: 3.8 Shower: 3.8	Bath: 3.7 Kitchen: 3.7 Shower: 3.7	Survey responses
$N_{showers\text{-}day}$	Showers per Day	Shower: 0.6		Mid-Atlantic 2018 TRM
DF	N/A	Bath: 70% Kitchen: 50%		Mid-Atlantic 2018 TRM
ΔT	°F	Bath: 25.1 Kitchen: 32.1 Shower: 44.1 Setback: 15.0		Mid-Atlantic 2018 TRM
$\#_{faucets}$	Units	Bath: 2.28 Kitchen: 1.0 Shower: 1.8		Bathroom: 2013 RASS Data[1] Kitchen: Pennsylvania 2016 TRM Showerhead: 2015 Residential Energy Consumption Survey - South Atlantic Region
$ETDF_{SUMMER}$	N/A	Bath: 0.00013 Kitchen: 0.00013 Shower: 0.00008		Pennsylvania 2016 TRM; Ratio of calculated measure demand to energy savings
$ETDF_{WINTER}$	N/A	Bath: 0.00022 Kitchen: 0.00022 Shower: 0.00022		TVA 2017 TRM; Ratio of calculated measure demand to energy savings
RE	N/A	98%		Mid-Atlantic 2018 TRM
A_{tank}	Ft^2	24.99		Mid-Atlantic 2018 TRM
R_{tank}	$°F \cdot ft^2 \cdot hr/BTU$	8.0		Mid-Atlantic 2018 TRM
V_{HW}	GPD	7.3		Pennsylvania 2016 TRM
EF_{WH}	N/A	0.945		Mid-Atlantic 2018 TRM

[1]Duke Energy 2013 Residential Appliance Saturation Survey. North and South Carolina respondents.

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The evaluation team determined that the 2018 Mid-Atlantic and 2016 Pennsylvania's TRM provided the most applicable and rigorous algorithm by including factors such as standby losses and water volume savings, differentiating between kitchen and bathroom water use, and more comprehensive algorithms. Neither the Mid-Atlantic nor Pennsylvania TRM provide information on winter demand savings, therefore the evaluation team used assumptions from the 2017 Tennessee Valley Authority TRM to calculate winter demand savings.

Using the applicable engineering algorithm and assumptions described above, the gross energy and demand savings value were estimated for each domestic hot water measure provided in the kit as summarized in Table 3-10 and Table 3-11.

Table 3-10: DEC NTC Gross Energy Savings, Water Heating Measures

Kit Measure	Gross per unit energy savings (kWh)	Gross per unit summer demand savings (kW)	Gross per unit winter demand savings (kW)
1.5 GPM Showerhead	121.6	0.010	0.027
1.0 GPM Bathroom Faucet Aerator	12.4	0.002	0.003
1.5 GPM Kitchen Faucet Aerator	38.2	0.005	0.008
Water Temperature Gauge Card	23.7	0.003	0.005

Table 3-11: DEP NTC Gross Energy Savings, Water Heating Measures

Kit Measure	Gross per unit energy savings (kWh)	Gross per unit summer demand savings (kW)	Gross per unit winter demand savings (kW)
1.5 GPM Showerhead	168.1	0.013	0.038
1.0 GPM Bathroom Faucet Aerator	16.4	0.002	0.004
1.5 GPM Kitchen Faucet Aerator	62.3	0.008	0.014
Water Temperature Gauge Card	23.5	0.003	0.005

3.4.5 Air Infiltration

Equation 3-8 and Equation 3-9 outline the algorithms utilized to estimate savings accrued by the outlet insulating gaskets. The parameters are defined in Table 3-12.

Equation 3-8: Air Infiltration Energy Savings

$$\Delta kWh = ISR \times gaskets \times \frac{\Delta CFM}{gasket} \times \frac{kWh}{CFM}$$

Equation 3-9: Air Infiltration Demand Savings

$$\Delta kW = ETDF \times \Delta kWh$$

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Table 3-12: Inputs for Air Infiltration Measures Savings Calculations

Input	Units	DEC Value	DEP Value	Source
ISR	N/A	17.4%	16.7%	Survey responses
Gaskets per kit	N/A	12		Duke Energy Kit Materials
ΔCFM/gasket	CFM	0.23		2015 DEC Energy Efficiency Education Program Evaluation Final Report
kWh/CFM	kWh/CFM	14.64	14.46	2016 Duke Energy RASS Data[1], 2015 DEC Energy Efficiency Education Program Evaluation Final Report
$ETDF_{SUMMER}$	N/A	0.00127		Pennsylvania 2016 TRM; Ratio of calculated measure demand to energy savings
$ETDF_{WINTER}$	N/A	0.00005		TVA 2017 TRM; Ratio of calculated measure demand to energy savings

[1]Duke Energy 2016 Residential Appliance Saturation Survey. DEC and DEP respondents.

Since very few regional or national studies exist that document outlet gasket savings this analysis used parameters estimated from a prior evaluation of the Energy Efficiency Education in Schools program conducted in the Duke Energy Carolinas service territory[3]. This previous evaluation estimated reduction in infiltration as a factor of cubic feet per minute (CFM) due to the installation of a gasket. We also considered the previous evaluation's modeled energy savings for reduced infiltration and calibrated the savings value based on the saturation of heating and cooling equipment technologies reported in Duke Energy's 2016 residential appliance saturation study to ensure the savings value represented the NTC program participants. All DEC and DEP responses recorded in the saturation study were used for model calibration.

Using the engineering algorithm described above, we determined the gross energy and demand savings value for outlet insulating gaskets provided in the kit as summarized in Table 3-13 and Table 3-14.

Table 3-13: DEC NTC Gross Energy Savings, Air Infiltration Measures

Kit Measure	Gross per kit energy savings (kWh)	Gross per kit summer demand savings (kW)	Gross per kit winter demand savings (kW)
Outlet Gaskets*	6.3	0.0081	0.0003

*Reflects savings for the 12 outlet gaskets per kit

[3] The Cadmus Group (2015). *Duke Energy Carolinas' Energy Efficiency Education for Schools Program Evaluation*. Retrieved December 18, 2018 from https://dms.psc.sc.gov/Attachments/Matter/ab859368-1ab3-44e5-ad5d-d6a9fb6ba2f5

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Table 3-14: DEP NTC Gross Energy Savings, Air Infiltration Measures

Kit Measure	Gross per kit energy savings (kWh)	Gross per kit summer demand savings (kW)	Gross per kit winter demand savings (kW)
Outlet Gaskets*	6.8	0.0086	0.0003

*Reflects savings for the 12 outlet gaskets per kit

3.4.6 Behavioral Analysis

Similarly to how we conducted the impact evaluation of the actual kit measures, the evaluation team estimated the behavioral impacts using the results of the completed surveys in conjunction with engineering algorithms. The survey contained the following questions from which we gauged what sort of behavioral changes were induced by the kit:

- Since your child learned about energy conservation at school and signed up for your energy kit from Duke Energy, what new behaviors has your child adopted to help save energy in your home?
- Since receiving your energy kit from Duke Energy, what new behaviors have you adopted to help save energy in your home?

Survey participants were encouraged to answer as an open-response, rather than choosing behaviors from a list. The typical responses included turning off lights when not in a room, turning off electronics when not in use, taking shorter showers, turning off water when brushing teeth or washing hands, turning off heating and air conditioning when not home, changing thermostat settings, and using fans instead of air conditioning.

The evaluation team estimated the initial impacts of these behavioral changes for the proportion of participants who confirmed taking action (i.e., the in-service rate for the behavioral change) using engineering algorithms similar to those algorithms used to estimate the impacts of the kit measures. We then adjusted these initial savings according to the results of some key survey questions such as:

- On a scale of 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential”, how much influence did Duke Energy’s kit and materials on saving energy have on your decision to make changes in your energy using behaviors?
- Did you read the information about how to save energy in the booklet that came in the kit?
- During the school year, did you receive any Home Energy Reports from Duke Energy?

The savings calculation methodologies and adjustment factors are detailed in the following subsections.

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3.4.6.1 Adjustment factors

Several adjustments were made to the initial calculated savings associated with each behavior to more accurately reflect the extent to which the behaviors were a result of the energy saving kit.

In-Service Rate (ISR)

Similar to kit measure ISRs, the behavioral ISR reflects what percentage of the known population is expected to have adopted this behavior. Separate ISR values were calculated for parent and children adoption rates, which are summarized in Table 3-15 and Table 3-16 for DEC and DEP, respectively.

Table 3-15: DEC Behavioral Savings In-Service Rates

Behavior	Child Adoption Rate	Parent Adoption Rate
Turn off lights	37%	10%
Turn off electronics	25%	16%
Take shorter showers	19%	16%
Turn off heat / CAC	N/A	5% / 12%
Change thermostat settings	N/A	22%
Use fans instead of CAC	N/A	15%

Table 3-16: DEP Behavioral Savings In-Service Rates

Behavior	Child Adoption Rate	Parent Adoption Rate
Turn off lights	32%	13%
Turn off electronics	27%	19%
Take shorter showers	16%	9%
Turn off heat / CAC	N/A	5% / 9%
Change thermostat settings	N/A	22%
Use fans instead of CAC	N/A	12%

Kit Influence

We then adjusted the savings by how the level of reported influence the kit had on each respondent's behavioral changes. Participants were asked to rate how heavily the kit influenced their behavioral changes on a scale of 0 to 10. The kit influence adjustment factor was set at the weighted average of participant responses as shown in Table 3-17.

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Table 3-17: Behavioral Savings Kit Influence Adjustment Factor

Influence Score	DEC Response Rate	DEP Response Rate
0	2.0%	3.2%
1	0.4%	0.0%
2	0.0%	0.8%
3	0.4%	1.6%
4	1.2%	0.0%
5	5.6%	5.6%
6	8.8%	2.4%
7	16.3%	16.8%
8	19.5%	13.6%
9	7.2%	8.0%
10	38.6%	51.3%
Weighted	**81%**	**83%**

Kit Informational Materials

The energy saving kit came with some literature on various other ways participants could save energy in their homes. While participants did self-report the level of influence the kit had on their decision, many respondents who claimed to be influenced by the program also responded that they did not read the kit informational materials, which seems counterintuitive. Nexant used the kit informational materials adjustment factor to correct for apparent bias in the self-reported answers on kit influence. Nexant found that 245 out of 334 respondents read the provided literature and set the adjustment factor at 73% for DEC and 128 out of 172 respondents read the provided literature and set the adjustment factor at 74% for DEP.

Persistence

While behavioral changes designed to increase energy efficiency or conservation can result in immediate impacts, the initial activity is expected to wane in the absence of consistent intervention. This decay of energy savings resulting from a change in behavior has been carefully documented through random control trials of Home Energy Report programs such as Duke Energy's MyHER program or program's implemented in other jurisdictions by Oracle (formally Opower). The rate at which energy savings persists after a customer receives a report depends on the frequency and longevity that a customer receives follow-up reports.

Because the kit provides information to educate and encourage participants to reduce their energy impacts, the evaluation team felt it was prudent to estimate a persistence rate based on this one-time exposure. We relied on a literature review to estimate how savings may persist based on the NTC program design. Typical persistence rates for Home Energy Report programs ranges from 80% - 90%, i.e., a participant's estimated savings from behavioral changes is expected to decay approximately 10% - 20% per year if no more Home Energy

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Reports are provided. This persistence rate is based on two consecutive years of receiving monthly reports. However, if a participant receives minimal follow-up after the initial report, the persistence of any initial behavioral impacts is expected to dissipate rapidly. Because participants in the NTC program are treated only once with regard to behavioral changes, the evaluation team estimated a persistence rate of 28%[4]. This estimate is based on research which modeled the persistence of customers who received four quarterly Home Energy Reports after which treatment was ceased[5]. For this evaluation, we calculated the persistence rate as the ratio of the expected average behavioral savings per day (0.257 kWh DEC and 0.255 kWh DEP) to the decay coefficient (0.924 kWh DEC and 0.916 kWh DEP) associated with customers receiving four quarterly reports. Therefore, it is expected the initial impact generated from behavioral changes in the NTC program would fully dissipate approximately three to four months after receiving the kit.

Adjustment Factor Summary

Table 3-18 below provides the adjustment factors which are applied to the behavioral savings described in Section 3.4.6.2.

Table 3-18: Behavorial Savings Adjustment Factors

Adjustment Factor	DEC	DEP
In-service rate	Varies by measure	Varies by measure
Kit influence	81%	83%
Kit informational materials	73%	74%
Persistence	28%	28%

3.4.6.2 Behavioral Savings Calculations

Turn off lights

The evaluation team calculated the savings associated with the behavior of turning off lights after exiting a room by estimating the likely reduction in lighting operating hours. The reduction in hours was used in lieu of the hours of use term in the standard lighting equations (Equation 3-1, Equation 3-2, and Equation 3-3) as illustrated in Equation 3-10 and Equation 3-11.

[4] The persistence rate is calculated based on the ratio of the daily estimated savings impact (0.257 kWh DEC and 0.255 DEP) to the the daily rate of decay of savings (0.924 kWh DEC and 0.916 DEP). For both DEC and DEP this ratio is 28%.

[5] Allcott, H, Rogers, T., The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation. American Economic Review 2014, 104(10): 3003-3037.

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Equation 3-10: Turn Off Lights Energy Savings

$$\Delta kWh = \frac{Watts_{BASE}}{1000\frac{W}{kW}} \times HOU_{reduced} \times (1 + IE_{kWh}) \times 365.25\frac{days}{year} \times Adj.Factors$$

Equation 3-11: Turn Off Lights Demand Savings

$$\Delta kW = ETDF * kWh\ savings \times Adj.Factors$$

The calculations assumed the wattage of the lamps associated with the reported behavorial change was equivalent to the average reported baseline lamp wattage found in the lighting analysis of 27.7 watts for DEC and 26.8 watts for DEP. The hours of use term in the standard lighting equations relied on survey responses as to where the light bulbs were installed. Each possible room within the home had an associated daily hours of use as provided by the 2018 DEP and DEC Energy Efficient Lighting and Retail LED Program Evaluation Report. The likely reduction in operating hours was determined by calculating each possible difference in lighting hours between room types (e.g. the difference in the living room HOU and the dining room HOU) as shown below in Figure 3-1.

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Figure 3-1: Calculation of Likely Lighting HOU Reduction

Possible Reduction in Hours		Living Room	Dining Room	Bedroom	Kitchen	Bathroom	Basement	Outdoors	Don't Know
		3.23	**4.27**	**1.83**	**4.26**	**1.51**	**3.75**	**4.25**	**1.97**
Living Room	**3.23**	0.00	1.04	0.00	1.03	0.00	0.52	1.02	0.00
Dining Room	**4.27**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bedroom	**1.83**	1.40	2.44	0.00	2.43	0.00	1.92	2.42	0.14
Kitchen	**4.26**	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Bathroom	**1.51**	1.72	2.76	0.32	2.75	0.00	2.24	2.74	0.46
Basement	**3.75**	0.00	0.52	0.00	0.51	0.00	0.00	0.50	0.00
Outdoors	**4.25**	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00
Don't Know	**1.97**	1.26	2.30	0.00	2.29	0.00	1.78	2.28	0.00

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The evaluation team calculated the likely reduction in daily runtime to be 0.61 hours, or 222 hours annually. The savings were calculated and adjusted based on this key assumption.

Energy savings were calculated at 5.8 kWh for DEC and 5.6 kWh for DEP (before applying adjustment factors). Because this behavioral change was completed by both children and parents, we applied adjustment factors and calculated adjusted savings separately for children and parents using their respective ISR. The parameter inputs and final savings are detailed in Table 3-19 and Table 3-20.

Table 3-19: DEC Behavioral Savings Achieved by Turning off Lights (per home)

Input	Units	Value	Source
Watts	Watts	27.7	Federal minimum standards
$HOU_{Reduced}$	Hours	0.61	Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018;
IE_{kWh}	N/A	-6%	Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018;
Summer Energy to Demand Factor ($ETDF_{SUMMER}$)	N/A	0.00017	Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018; Ratio of evaluated lighting measure demand to energy savings
Winter Energy to Demand Factor ($ETDF_{WINTER}$)	N/A	0.00008	Tennessee Valley Authority 2017 TRM; Ratio of evluated lighting measure demand to energy savings
Energy Savings	**kWh**	**5.8**	**Calculated from algorithm**
Summer Demand Savings	**kW**	**0.001**	**Calculated from algorithm**
Winter Demand Savings	**kW**	**0.0004**	**Calculated from algorithm**
Adjustment Factors			
ISR	**Influence**	**Kit Info.**	**Persistence**
Child: 37% Parent: 10%	81%	73%	28%
		Savings from child behavior (Energy and Summer Demand):	**0.4 kWh; 0.0001 kW**
		Savings from parent behavior (Energy and Summer Demand):	**0.1 kWh; 0.0000 kW**
		Total Energy Savings:	**0.4 kWh**
		Total Summer Demand Savings:	**0.0001 kW**
		Total Winter Demand Savings:	**0.0000 kW**

*Totals may not sum to due to rounding

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Table 3-20: DEP Behavioral Savings Achieved by Turning off Lights (per home)

Input	Units	Value	Source
Watts	Watts	26.8	Federal minimum standards
$HOU_{Reduced}$	Hours	0.61	Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018
IE_{kWh}	N/A	-6%	Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018
Summer Energy to Demand Factor ($ETDF_{SUMMER}$)	N/A	0.00018	Opinion Dynamics - Energy Efficient Lighting & Retail LED Programs for Duke Energy Progress and Carolinas, April 2018; Ratio of evaluated lighting measure demand to energy savings
Winter Energy to Demand Factor ($ETDF_{WINTER}$)	N/A	0.00008	Tennessee Valley Authority 2017 TRM; Ratio of evluated lighting measure demand to energy savings
Energy Savings	**kWh**	**5.6**	**Calculated from algorithm**
Summer Demand Savings	**kW**	**0.001**	**Calculated from algorithm**
Winter Demand Savings	**kW**	**0.0004**	**Calculated from algorithm**

Adjustment Factors			
ISR	**Influence**	**Kit Info.**	**Persistence**
Child: 32% Parent: 13%	83%	74%	28%

Savings from child behavior (Energy and Summer Demand):	**0.3 kWh; 0.0001 kW**
Savings from parent behavior (Energy and Summer Demand):	**0.1 kWh; 0.0000 kW**
Total Energy Savings:	**0.4 kWh**
Total Summer Demand Savings:	**0.0001 kW**
Total Winter Demand Savings:	**0.0000 kW**

*Totals may not sum to due to rounding

Turn off electronics

The evaluation team used evaluations for “Smart Strips” or “Controlled Power Strips” in order to estimate savings achieved by turning off electronics when not in use. Smart strips are multi-plug power strips with the ability to automatically disconnect specific connected loads depending upon the power draw of a control load which is also plugged into the strip. Power is disconnected from the controlled outlets when the control load power draw is reduced below a certain adjustable threshold, thus turning off all accompanying appliances plugged into the strip.

We researched current studies on smart strip savings (summarized in Table 3-21) and used the average value as the calculated savings amount for this behavioral change.

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Table 3-21: Smart Strip Savings

Source	Savings (kWh)
2016 Ameren Missouri Evaluation	54.0
Duke Energy Potential Study	74.5
Illinois 2018 TRM	55.0
Mid-Atlantic 2018 TRM	50.7
Pennsylvania 2016 TRM	61.1
Average	**59.0**

The demand savings were calculated from the energy savings using an assumed hours of use value of 6,351 and an assumed coincidence factor of 80%, both from the 2018 Mid-Atlantic TRM. Equation 3-12 and Equation 3-13 present the algorithms used to calculate energy and demand savings for the behavior change of turning off electronics.

Equation 3-12: Turn Off Electronics Energy Savings

$$\Delta kWh = Average\ of\ deemed\ savings \times Adj.Factors$$

Equation 3-13: Turn Off Electronics Demand Savings

$$\Delta kW = kWh\ savings/HOU \times CF \times Adj.Factors$$

Energy savings (before applying adjustment factors) were calculated at 59.0 kWh. Because this behavioral change was completed by both children and parents, we applied adjustment factors and calculated adjusted savings separately for children and parents using their respective ISR. The final savings are detailed in Table 3-22 and Table 3-35.

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Table 3-22: DEC Behavioral Savings Achieved by Turning off Electronics

Input	Units	Value	Source
Summer Coincidence factor (CF)	N/A	0.8	Mid-Atlantic 2018 TRM
Winter Coincidence factor (CF)	N/A	0.8	Engineering Judgment
HOU	hours	6,351	Mid-Atlantic 2018 TRM
Energy Savings	**kWh**	**59.0**	**Average of TRMs and prior studies (see Table 3-21)**
Summer Demand Savings	**kW**	**0.007**	**Calculated from algorithm**
Winter Demand Savings	**kW**	**0.007**	**Calculated from algorithm**
ISR	**Influence**	**Kit Info.**	**Persistence**
Child: 25% Parent: 16%	81%	73%	28%
		Savings from child behavior (Energy and Summer Demand):	**2.5 kWh; 0.0003 kW**
		Savings from parent behavior (Energy and Summer Demand):	**1.6 kWh; 0.0002 kW**
		Total Energy Savings:	**4.1 kWh**
		Total Summer Demand Savings:	**0.0005 kW**
		Total Winter Demand Savings:	**0.0005 kW**

*Totals may not sum to due to rounding

Table 3-23: DEP Behavioral Savings Achieved by Turning off Electronics

Input	Units	Value	Source
Summer Coincidence factor (CF)	N/A	0.8	Pennsylvania 2016 TRM
Winter Coincidence factor (CF)	N/A	0.8	Engineering Judgment
HOU	hours	6,351	Pennsylvania 2016 TRM
Energy Savings	**kWh**	**59.0**	**Average of TRMs and prior studies (see Table 3-21)**
Summer Demand Savings	**kW**	**0.007**	**Calculated from algorithm**
Winter Demand Savings	**kW**	**0.007**	**Calculated from algorithm**
ISR	**Influence**	**Kit Info.**	**Persistence**
Child: 27% Parent: 19%	83%	74%	28%
		Savings from child behavior (Energy and Summer Demand):	**2.8 kWh; 0.0003 kW**
		Savings from parent behavior (Energy and Summer Demand):	**1.9 kWh; 0.0002 kW**
		Total Energy Savings:	**4.6 kWh**
		Total Summer Demand Savings:	**0.0006 kW**
		Total Winter Demand Savings:	**0.0000 kW**

*Totals may not sum to due to rounding

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Take shorter showers

To determine savings achieved by a reduction in shower time, the evaluation team estimated how much time could be reduced based on actual shower length data. To do this, we utilized data provided by Aquacraft's 2011 Analysis of Water Use in New Single-Family Homes[6] (summarized in left two columns of Table 3-24.

We set the target shower length equal to the typical length used in national energy efficiency evaluations (7.8 to 8.4 minutes[7]) and calculated how much opportunity existed in the data for people to reduce their shower times to the national average. Energy and demand savings were calculated based on Equation 3-14 and Equation 3-15, respectively.

Equation 3-14: Take Shorter Shower Energy Savings

$$\Delta kWh = ELEC \times GPM_{retrofit} \times T_{person/day} \times N_{showers-day} \times 365\frac{days}{year} \times \left[\frac{\Delta T \times 8.33\frac{BTU}{gal \cdot °F}}{3,412\frac{BTU}{kWh} \times RE}\right] \times Adj.Factors$$

Equation 3-15: Take Shorter Shower Demand Savings

$$\Delta kW = ETDF \times Energy\ Savings \times Adj.Factors$$

Table 3-24: Reduction in Shower Time Data and Calculation

Shower Length (minutes)	Responses	Possible Reduction (minutes)
2	0%	-
4	2%	-
6	17%	-
8	35%	GOAL
10	24%	2
12	14%	4
14	4%	6
16	2%	8
18	0%	10
20	1%	12
	Weighted Average	**3.47**

[6] http://www.aquacraft.com/wp-content/uploads/2015/10/Analysis-of-Water-Use-in-New-Single-Family-Homes.pdf

[7] Based on reported shower times from 2016 Indiana TRM, 2015 Illinois TRM, 2012 TVA Saturation Survey, 2015 Maine TRM, and the 2016 Pennsylvania TRM.

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We calculated the likely reduction in shower length to be 3.47 minutes per shower, or 12.7 hours per person annually. The savings were calculated and adjusted based on this key assumption as detailed in Table 3-25 and Table 3-26.

Table 3-25: DEC Behavioral Savings Achieved by Taking Shorter Showers

Input	Units	Value	Source
GPM	GPM	1.96	Survey responses, Federal minimum standards
$T_{person/day}$	Minutes	3.47	Aquacraft 2011 Report
$N_{persons/day}$	Showers/Person/Day	0.6	Mid-Atlantic 2018 TRM
365	Days/Year	365	-
ΔT	°F	44.1	Mid-Atlantic 2018 TRM
ELEC	%	66.9	Duke Energy 2016 RASS Data (DEC Respondents)
RE	%	98	Mid-Atlantic 2018 TRM
Summer Energy to Demand Factor (ETDF)	N/A	0.000008	Ratio of evaluated showerhead measure demand to energy savings
Winter Energy to Demand Factor (ETDF)	N/A	0.00022	Ratio of evaluated showerhead measure demand to energy savings
Energy Savings	**kWh**	**109.3**	**Calculated**
Summer Demand Savings	**kW**	**0.009**	**Calculated**
Winter Demand Savings	**kW**	**0.025**	**Calculated**
ISR	**Influence**	**Kit Info.**	**Persistence**
Child: 19% Parent: 16%	81%	73%	28%
		Savings from child behavior (Energy and Summer Demand):	**3.5 kWh; 0.0003 kW**
		Savings from parent behavior (Energy and Summer Demand):	**2.8 kWh; 0.0002 kW**
		Total Energy Savings:	**6.3 kWh**
		Total Summer Demand Savings:	**0.0005 kW**
		Total Winter Demand Savings:	**0.0014 kW**

*Totals may not sum to due to rounding

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Table 3-26: DEP Behavioral Savings Achieved by Taking Shorter Showers

Input	Units	Value	Source
GPM	GPM	1.89	Survey responses, Federal minimum standards
$T_{person/day}$	Minutes	3.47	Aquacraft 2011 Report
$N_{persons/day}$	Showers/Person/Day	0.6	Mid-Atlantic 2018 TRM
365	Days/Year	365	-
ΔT	°F	44.1	Mid-Atlantic 2018 TRM
ELEC	%	74	Duke Energy 2016 RASS Data (DEP Respondents)
RE	%	98	Mid-Atlantic 2018 TRM
Summer Energy to Demand Factor (ETDF)	N/A	0.000008	Ratio of evaluated showerhead measure demand to energy savings
Winter Energy to Demand Factor (ETDF)	N/A	0.00022	Ratio of evaluated showerhead measure demand to energy savings
Energy Savings	**kWh**	**117.3**	**Calculated**
Summer Demand Savings	**kW**	**0.009**	**Calculated**
Winter Demand Savings	**kW**	**0.026**	**Calculated**
ISR	**Influence**	**Kit Info.**	**Persistence**
Child: 16% Parent: 9%	83%	74%	28%
		Savings from child behavior (Energy and Summer Demand):	**3.1 kWh; 0.0003 kW**
		Savings from parent behavior (Energy and Summer Demand):	**1.9 kWh; 0.0001 kW**
		Total Energy Savings:	**5.0 kWh**
		Total Summer Demand Savings:	**0.0004 kW**
		Total Winter Demand Savings:	**0.0011 kW**

*Totals may not sum to due to rounding

Turn off furnace or central air conditioner (CAC) or use fan instead of CAC

To emulate the impacts of the behavior of customers who turned off the heating or cooling mode of their HVAC system, the evaluation team used the effects of a smart thermostat as a proxy. A smart thermostat is a Wi-Fi enabled programmable thermostat that typically includes multiple functionalities that allow for a reduction in energy use. Most notably the devices are a part of the home's network and regularly check to see what other items are connected to the network as well as utilize motion detectors. In the event that no users are actively connected to the home's network and minimal movement is detected, the thermostat will go into auto away mode. Given this functionality, the evaluation team believes this measure to be an appropriate proxy for the behavior observed by participants of turning off their furnace or air conditioner.

Equation 3-16 and Equation 3-17 present the algorithms used to calculate energy savings for reduced cooling and heating loads. Demand savings were deemed as zero based on

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assumptions provided in multiple TRMs including the 2018 Mid-Atlantic TRM and 2016 Pennsylvania.

Equation 3-16: Turn off CAC or use fan mode energy savings algorithm

$$\Delta kWh_{cool} = EUI_{cool} \times Area \times Tstat_{cool} \times Adj.Factors$$

Equation 3-17: Turn off furnace energy savings algorithm

$$\Delta \boldsymbol{kWh_{heat}} = \boldsymbol{EUI_{heat}} \times \boldsymbol{Area} \times \boldsymbol{Tstat_{heat}} \times \boldsymbol{ELEC} \times \boldsymbol{Adj.Factors}$$

The evaluation team researched current studies on smart thermostat savings (summarized in Table 3-27). The baseline for all selected studies was a manual mercury thermostat. The median savings observed in the data was then applied to the annual electric heating and cooling consumption for homes in North and South Carolina as provided in the US Energy Information Administration's 2009 Residential Energy Consumption Survey (RECS).

Table 3-27: Smart Thermostat Savings

Study Location	Cooling Savings	Heating Savings
Vectren Indiana[8]	13.9%	12.5%
NIPSCO[9]	16.1%	13.4%
National Grid[10]	10.0%	N/A
Median	**13.9%**	**13.0%**

The calculated savings for turning off the air conditioning and for using fans instead of air conditioning are based on the cooling savings only, while the calculated savings for turning off the furnace is based on the heating savings only. We calculated and adjusted savings based on the key assumptions as detailed in Table 3-28 and Table 3-30 for DEC and Table 3-29 and Table 3-31 for DEP.

[8] Evaluation of 2013–2014 Programmable and Smart Thermostat Program for Vectren Corporation. The Cadmus Group, January 2015

[9] Evaluation of the 2013–2014 Programmable and Smart Thermostat Program for Northern Indiana Public Service Company. The Cadmus Group, January 2015

[10] Evaluation of 2013- 2014 Smart Thermostat Pilots: Home Energy Monitoring, Automatic Temperature Control, Demand Response. The Cadmus Group, July 2015

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Table 3-28: DEC Behavioral Savings Achieved by Changing AC Use Patterns

Input	Units	Value	Source
Cooling Energy Use Intensity (EUI_{cool})	kWh/ft^2	1.4522	2009 RECS Data, North and South Carolina
Average Cooled Area ($Area_{cool}$)	ft^2	1,495	2009 RECS Data, North and South Carolina
T-stat $savings_{cool}$	%	13.9%	Multiple Smart Thermostat Studies as noted above
Energy Savings	**kWh**	**301.8**	**Calculated**
Summer Demand Savings	**kW**	**0.000**	**Deemed**
Winter Demand Savings	**kW**	**0.000**	**Deemed**
Turning off Air Conditioning when Not Home			
ISR	**Influence**	**Kit Info.**	**Persistence**
12%	81%	73%	28%
		Total Energy Savings:	**6.0 kWh**
		Total Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**
Using Fans Instead of Air Conditioning			
ISR	**Influence**	**Kit Info.**	**Persistence**
15%	81%	73%	28%
		Total Energy Savings:	**7.3 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**

*Totals may not sum to due to rounding

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Table 3-29: DEP Behavioral Savings Achieved by Changing AC Use Patterns

Input	Units	Value	Source
Cooling Energy Use Intensity (EUI_{cool})	kWh/ft^2	1.4522	2009 RECS Data, North and South Carolina
Average Cooled Area ($Area_{cool}$)	ft^2	1,495	2009 RECS Data, North and South Carolina
T-stat $savings_{cool}$	%	13.9%	Multiple Smart Thermostat Studies as noted above
Energy Savings	**kWh**	**301.8**	**Calculated**
Summer Demand Savings	**kW**	**0.000**	**Deemed**
Winter Demand Savings	**kW**	**0.000**	**Deemed**
Turning off Air Conditioning when Not Home			
ISR	**Influence**	**Kit Info.**	**Persistence**
9%	83%	74%	28%
		Total Energy Savings:	**4.8 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**
Using Fans Instead of Air Conditioning			
ISR	**Influence**	**Kit Info.**	**Persistence**
12%	83%	74%	28%
		Total Energy Savings:	**6.0 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**

*Totals may not sum to due to rounding

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Table 3-30: DEC Behavioral Savings Achieved by Changing Heating Use Patterns

Input	Units	Value	Source
Heating Energy Use Intensity	kWh/ft^2	1.1724	2009 RECS Data, North and South Carolina
Average Heated Area	ft^2	1,574	2009 RECS Data, North and South Carolina
Savings	%	13.0%	Multiple Smart Thermostat Studies as noted above
ELEC	%	63.1%	Duke Energy 2016 RASS Data (DEC Respondents)
Energy Savings	**kWh**	**150.7**	**Calculated**
Summer Demand Savings	**kW**	**0.000**	**Deemed**
Winter Demand Savings	**kW**	**0.000**	**Deemed**
ISR	**Influence**	**Kit Info.**	**Persistence**
5%	81%	73%	28%
		Total Energy Savings:	**1.2 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**

*Totals may not sum to due to rounding

Table 3-31: DEP Behavioral Savings Achieved by Changing Heating Use Patterns

Input	Units	Value	Source
Heating Energy Use Intensity	kWh/ft^2	1.1724	2009 RECS Data, North and South Carolina
Average Heated Area	ft^2	1,574	2009 RECS Data, North and South Carolina
Savings	%	13.0%	Multiple Smart Thermostat Studies as noted above
ELEC	%	74.8%	Duke Energy 2016 RASS Data (DEP Respondents)
Energy Savings	**kWh**	**178.9**	**Calculated**
Summer Demand Savings	**kW**	**0.000**	**Deemed**
Winter Demand Savings	**kW**	**0.000**	**Deemed**
ISR	**Influence**	**Kit Info.**	**Persistence**
5%	83%	74%	28%
		Total Energy Savings:	**1.4 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**

*Totals may not sum to due to rounding

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Adjust thermostat set points

The evaluation team again relied on current smart thermostat studies to estimate the savings achieved by adjusting thermostat set points. An additional function of smart thermostats is their ability to learn set points by trending regular changes made by the user in a trial period following installation. The evaluation team believes this increased precision in thermostat set points to be analogous to the behavioral change analyzed here.

Equation 3-18 presents the algorithm used to calculate energy savings for reduced cooling and heating loads. Demand savings were deemed as zero based on assumptions provided in multiple TRMs including the 2018 Mid-Atlantic TRM and 2016 Pennsylvania.

Equation 3-18: Adjust thermostat set points energy savings algorithm

$$\Delta kWh_{cool} = (EUI_{cool} \times Area \times Tstat_{cool}) + (EUI_{heat} \times Area \times Tstat_{heat} \times ELEC) \times Adj.Factors$$

In our review of smart thermostat data, we also explored studies with mixed baselines (manual and programmable thermostats) in order to better isolate the impact of set point adjustments as opposed to the auto-away function. The sources and their associated savings are detailed in Table 3-32.

Table 3-32: Smart Thermostat Savings

Study Location	Cooling Savings	Heating Savings
Vectren Corporation[11]	N/A	5.0%
NIPSCO[12]	N/A	7.8%
Xcel Energy[13]	4.6%	N/A
Commonwealth Edison[14]	4.8%	6.7%
Median	**4.7%**	**6.7%**

The savings were calculated and adjusted based on these key assumptions as detailed in Table 3-33 and Table 3-34.

[11] Evaluation of 2013–2014 Programmable and Smart Thermostat Program for Vectren Corporation. The Cadmus Group, January 2015

[12] Evaluation of the 2013–2014 Programmable and Smart Thermostat Program for Northern Indiana Public Service Company. The Cadmus Group, November 2014

[13] In-Home Smart Device Pilot. Public Service Company of Colorado. EnerNOC, Inc., April, 2014

[14] Commonwealth Edison Residential Smart Thermostats. Navigant Consulting, February 2016

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Table 3-33: DEC Behavioral Savings Achieved by Changing Thermostat Settings

Input	Units	Value	Source
Heating Energy Use Intensity	kWh/ft^2	1.1724	2009 RECS Data, North and South Carolina
Average Heated Area	ft^2	1,574	2009 RECS Data, North and South Carolina
ELEC	%	63.1%	Duke Energy 2016 RASS Data (DEC Respondents)
Heating Savings	%	6.7%	Multiple Smart Thermostat Studies as noted above
Cooling Energy Use Intensity	kWh/ft^2	1.4522	2009 RECS Data, North and South Carolina
Average Cooled Area	ft^2	1,495	2009 RECS Data, North and South Carolina
Savings	%	4.7%	Multiple Smart Thermostat Studies as noted above
Energy Savings	**kWh**	**189.7**	**Calculated**
Summer Demand Savings	**kW**	**0.000**	**Deemed**
Winter Demand Savings	**kW**	**0.000**	**Deemed**
ISR	**Influence**	**Kit Info.**	**Persistence**
22%	81%	73%	28%
		Total Energy Savings:	**7.0 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**

*Totals may not sum to due to rounding

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Table 3-34: DEP Behavioral Savings Achieved by Changing Thermostat Settings

Input	Units	Value	Source
Heating Energy Use Intensity	kWh/ft^2	1.1724	2009 RECS Data, North and South Carolina
Average Heated Area	ft^2	1,574	2009 RECS Data, North and South Carolina
ELEC	%	74.8%	Duke Energy 2016 RASS Data (DEP Respondents)
Heating Savings	%	6.7%	Multiple Smart Thermostat Studies as noted above
Cooling Energy Use Intensity	kWh/ft^2	1.4522	2009 RECS Data, North and South Carolina
Average Cooled Area	ft^2	1,495	2009 RECS Data, North and South Carolina
Savings	%	4.7%	Multiple Smart Thermostat Studies as noted above
Energy Savings	**kWh**	**205.7**	**Calculated**
Summer Demand Savings	**kW**	**0.000**	**Deemed**
Winter Demand Savings	**kW**	**0.000**	**Deemed**
ISR	**Influence**	**Kit Info.**	**Persistence**
22%	83%	74%	28%
		Total Energy Savings:	**7.8 kWh**
		Total Summer Demand Savings:	**0.000 kW**
		Total Winter Demand Savings:	**0.000 kW**

*Totals may not sum to due to rounding

Summary of behavioral impacts

Table 3-35 below presents the total energy savings derived from the behavioral component of the program.

Table 3-35: Energy savings from behavioral impacts

Behavior	DEC kWh savings	DEP kWh savings
Turn off lights	0.4	0.4
Turn off electronics	4.1	4.6
Take shorter showers	6.3	5.0
Turn off furnace	1.2	1.4
Turn off AC	6.0	4.8
Use fan mode	7.3	6.0
Adjust thermostat set points	7.0	7.8
Total	**32.3**	**30.1**

*Total may not sum to due to rounding

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3.5 Billing Regression Analysis

In addition to engineering analysis, the evaluation team attempted to estimate energy savings by analyzing energy use patterns before and after participation in the NTC program using an approach commonly referred to as billing analysis. After a thorough investigation, we concluded that, absent a randomized control trial (RCT), billing analysis was unable to reliably detect energy savings resulting from participation in the program. When the percent change in household energy use is small, as it is with the NTC program education and kit, the only reliable way to estimate energy savings using billing analysis is through a randomized control trial using large treatment and control groups and pre- and post-enrollment billing data. The most critical component of a well-designed RCT is to guarantee there are no differences between the treatment and control groups, other than the treatment of the program. This is a critical step to ensure that the analysis is able to accurately estimate the counterfactual – or what would have happened absent the treatment. If inherent differences exist between the treatment group and control group, any changes in the post-treatment period could be due to these differences, rather than the treatment itself. In order to verify that effects are purely the result of the treatment intervention, the two groups must be ostensibly identical in every way except for the intervention.

Guaranteeing homogeneity between treatment and control groups is not achievable with an opt-in enrollment. The fact that one group of customers chose to enroll in the program while the other did not implies that some intrinsic difference between them does exist. These differences may include:

- Behavioral preferences or predispositions for energy efficiency measures
- Information about the program that is not accessible to non-enrollees
- Higher energy needs and therefore a greater incentive to curb their consumption

Any of these characteristics are likely to contribute to consumption responses or patterns that cannot be attributable to the program intervention. A well-designed RCT includes randomly selected customers in the treatment and control groups, thereby ensuring that the analysis avoids adverse effects of selection bias and/or lurking confounding variables. Due to these variables, RCTs are impracticable for opt-in programs. Thus, the evaluation team's recommendation is to rely on findings of the engineering analysis as the source of the verified gross and net savings for the program. Below we discuss how we attempted to complete a billing analysis and how we ultimately determined such an analysis was not feasible.

To estimate energy savings with billing data, it is necessary to estimate what energy consumption would have occurred in the absence of NTC program – the counterfactual or baseline. To infer that the program led to energy savings, it is necessary to systematically eliminate plausible alternative explanations for differences in electricity use patterns.

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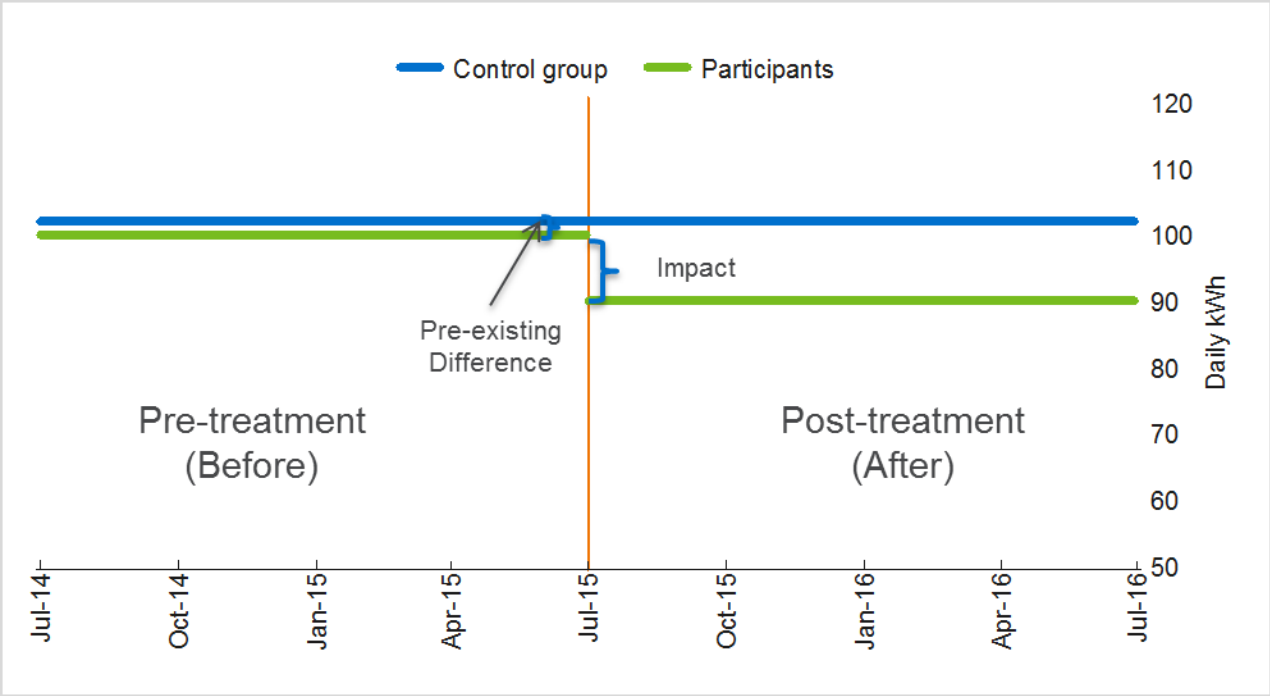
The basic framework for the analysis is illustrated in Figure 3-2 and relies on both a control group and pre- and post-enrollment billing data. The analysis is implemented via a difference-in-differences technique, which removes any pre-existing differences between the treatment and control groups. If the program's kit and behavioral changes lead to reductions in consumption, we should observe:

- A change in consumption for households that participated in the NTC program
- No similar change in consumption for the control group
- The timing of the change should coincide with the receipt of kits

Figure 3-2: Framework for Billing Analysis with Control Group, Pre-Post Data and Expected Results



While the NTC program did not have a randomly assigned control group, the evaluation team did develop a comparison group to use in its analysis. However, there were several key challenges to producing reliable energy savings estimates using billing analysis, which are summarized in Figure 3-3. The two challenges that could not be addressed despite the use of a comparison group were the small effect size and selection bias. On a percentage basis, the expected energy savings from each kit were less than 2% of annual household energy consumption, and therefore it proved difficult to isolate the impacts of the program from other potential explanations, including random chance. Second, households that signed up for the kit had young children that self-selected from their peers. Households with young children are typically in the growth period of a household life cycle and, thus, may have higher year-to-year energy consumption. Despite using a comparison group, it could only account for observable characteristics – pre-treatment energy use patterns, geographic location, and concurrent

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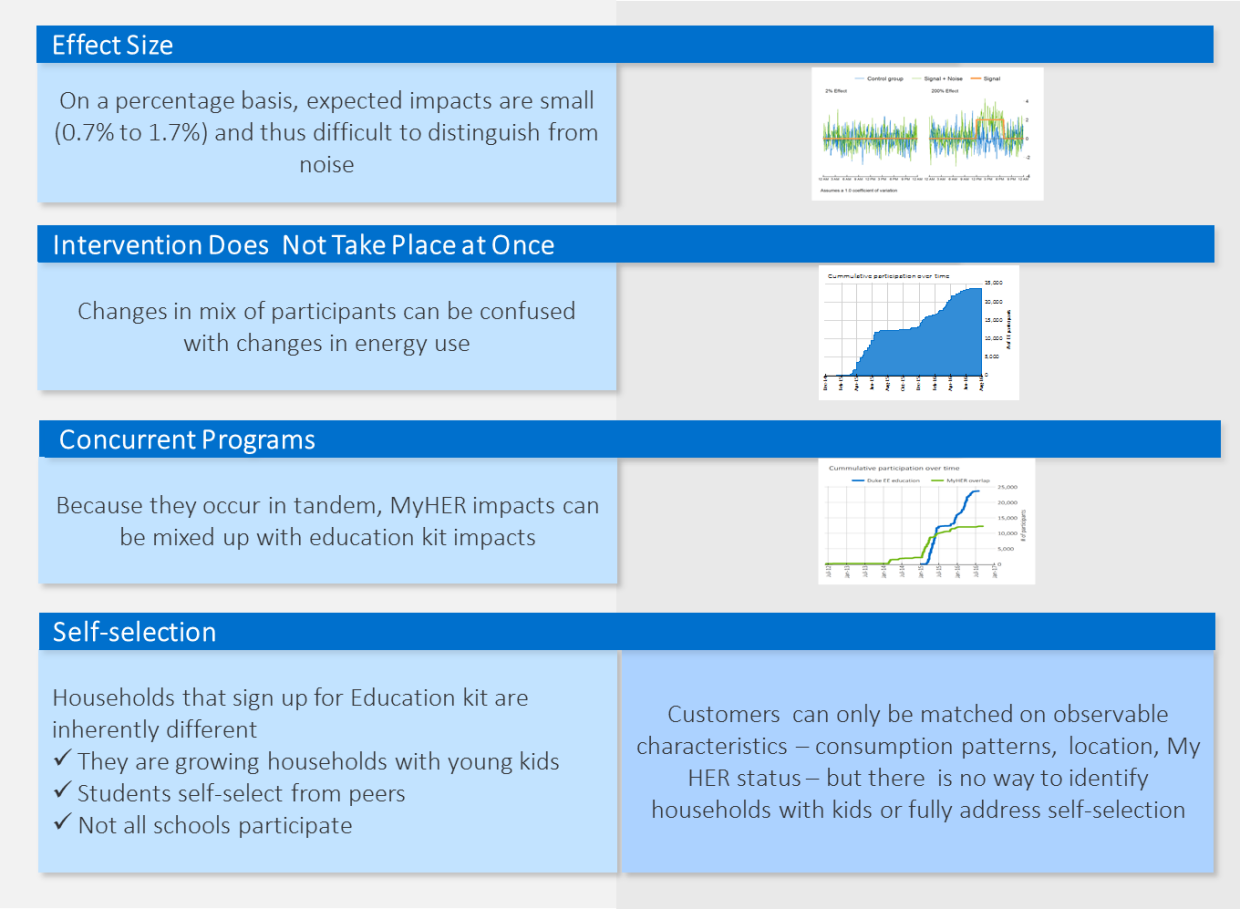
participation in the My Home Energy Report (MyHER) program. There was no way to identify households with young children in the comparison group without postponing the evaluation to identify future participating schools from which a comparison group could be developed. As a result, while the participant and comparison group may have had similar energy use patterns in the pre-treatment period, their energy use trajectories absent program participation were not necessarily the same due to differences in the household life cycles.

Figure 3-3: Billing Analysis Evaluation Challenges



In order to assess if the billing analysis produced reliable results, we implemented a series of placebo pressure tests. The approach consisted of simulating fake enrollments prior to actual participation in the program and assessing if the models detected an effect when using data from the false "pre" period to estimate the counterfactual for the false "post" period. Because enrollment dates were fictitious and actual post periods were excluded, we knew impacts were actually zero and any estimated impacts were due to modeling error. The evaluation team used two years of pre-treatment data for the placebo tests and each participant's enrollment date was simulated to have occurred between three to nine months prior to actual participation, in increments of one month. The placebo tests were implemented using both a fixed-effects pre-post panel regression model (using only treatment group data) and a difference-in-differences panel regression that made use of the matched comparison group.

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Figure 3-4 shows the results from the pre-post placebo tests. Rather than produce zero impacts, the models estimated that the simulated enrollments led to changes in energy use when in fact no intervention had taken place. Moreover, the models incorrectly concluded that the erroneous impacts were statistically significant in several instances – an example of false precision. The pre-post model without a comparison group consistently estimated energy savings when impacts were in fact zero. The difference-in-differences model that made use of the comparison group had less variable results, but it estimated energy increases in the range of roughly 1% to 1.5% when no intervention had taken place. Hence, neither method produced reliable energy savings estimates.

Figure 3-4: Placebo Pressure Test Results (Pre-Post)

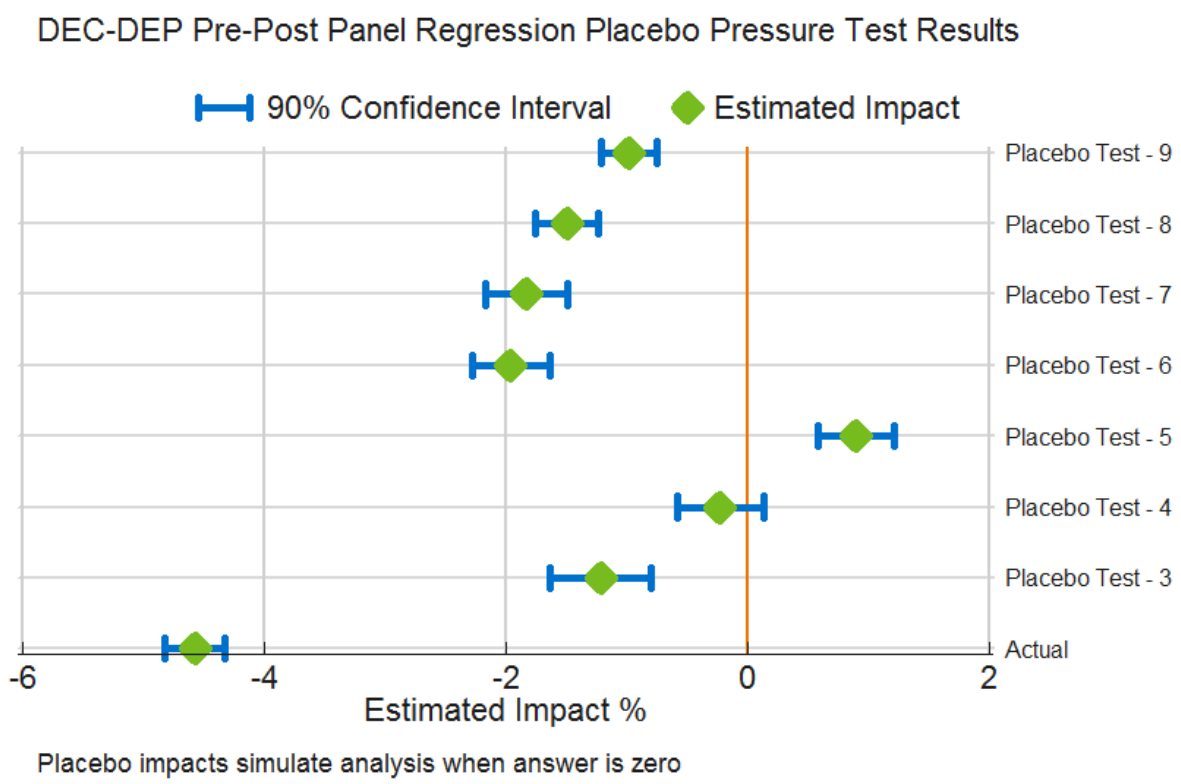

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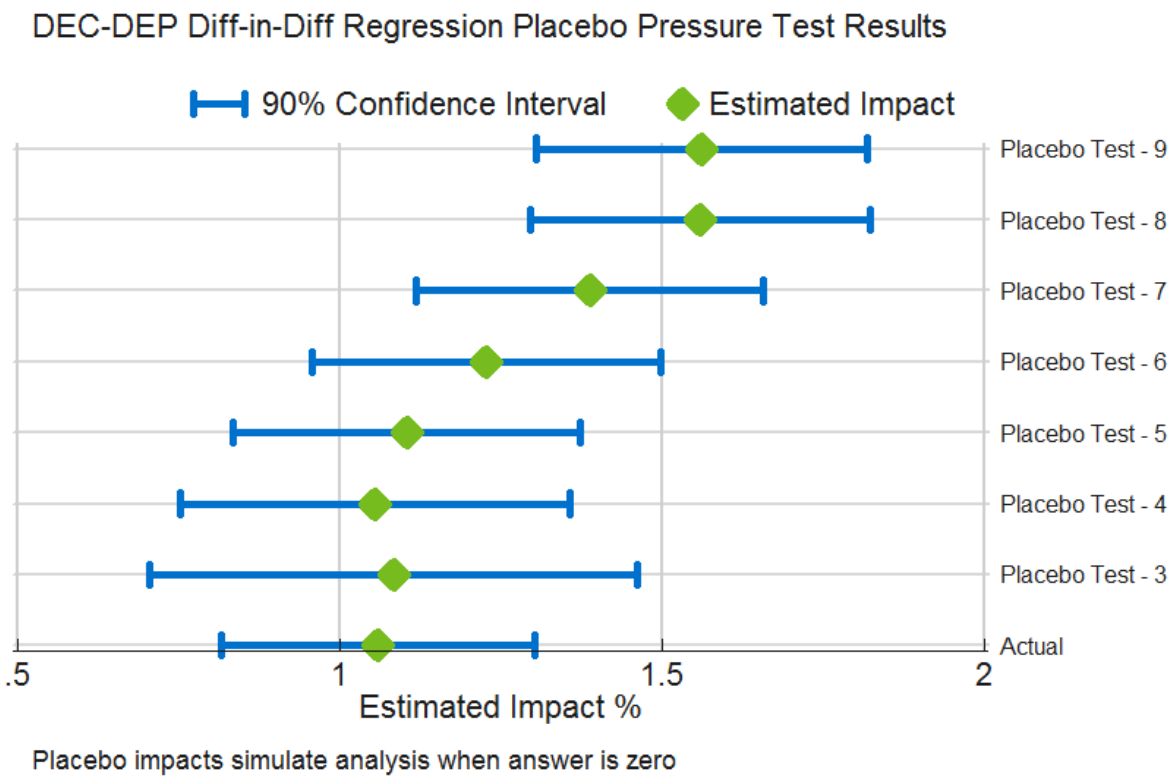
Figure 3-5: Placebo Pressure Test Results (Difference in Differences)



Appendix E provides additional detail including comparison of the program participants and comparison group.

The evaluation team's conclusion is not that there were no energy savings generated by the NTC program, but rather that billing analysis was not the correct tool for estimating the small percent energy savings from the program. Thus, the evaluation team's recommendation is to rely on the engineering analysis and findings as the source of our verified gross and net savings for the programs.

3.6 Targeted and Achieved Confidence and Precision

We developed the NTC program evaluation plan with the goal of achieving a target of 10% relative precision at the 90% confidence interval for the program as a whole. The evaluation team was able to achieve this target through the combination of web-based and phone surveys to ultimately achieve a precision of +/- 4.5% and +/-6.2% at the 90% confidence level for DEC and DEP, respectively (Table 3-36).

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Table 3-36: Targeted and Achieved Confidence and Precision

Program	Targeted Confidence/Precision	Achieved Confidence/Precision
DEC NTC	90/10.0	90/4.5
DEP NTC	90/10.0	90/6.2

3.7 Results

DEC measure-level and kit-level energy savings values are detailed in Figure 3-6 and Table 3-37.

Figure 3-6: 2017-2018 DEC NTC Gross Verified Energy Savings

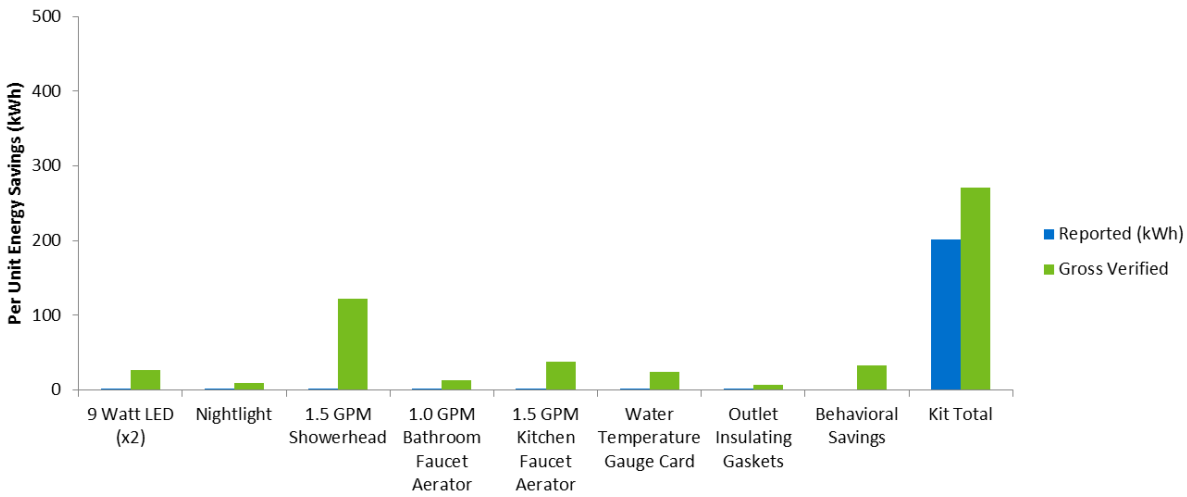

Table 3-37: DEC Measure-Level Reported and Verified Gross Energy Savings

Measure	Reported Gross Energy Savings, per unit (kWh)	Realization Rate	Verified Gross Energy Savings, per unit (kWh)	Total Verified Gross Energy Savings (kWh)
9 Watt LED*	N/A	N/A	27.0	624,555
Nightlight			9.8	226,717
Low-flow Showerhead			121.6	2,815,409
Low-flow Bathroom Aerator			12.4	287,880
Low-flow Kitchen Aerator			38.2	885,316
Water Heater Setback			23.7	549,490
Outlet Gaskets			6.3	146,847
Behavioral Changes			32.3	747,018
Total	**201.0**	**135.0%**	**271.3**	**6,283,232**

*Reflects savings for two 9 watt LEDs bulbs

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DEP measure-level and kit-level energy savings values are detailed in and Figure 3-7 and Table 3-38.

Figure 3-7: 2017-2018 DEP NTC Gross Verified Energy Savings

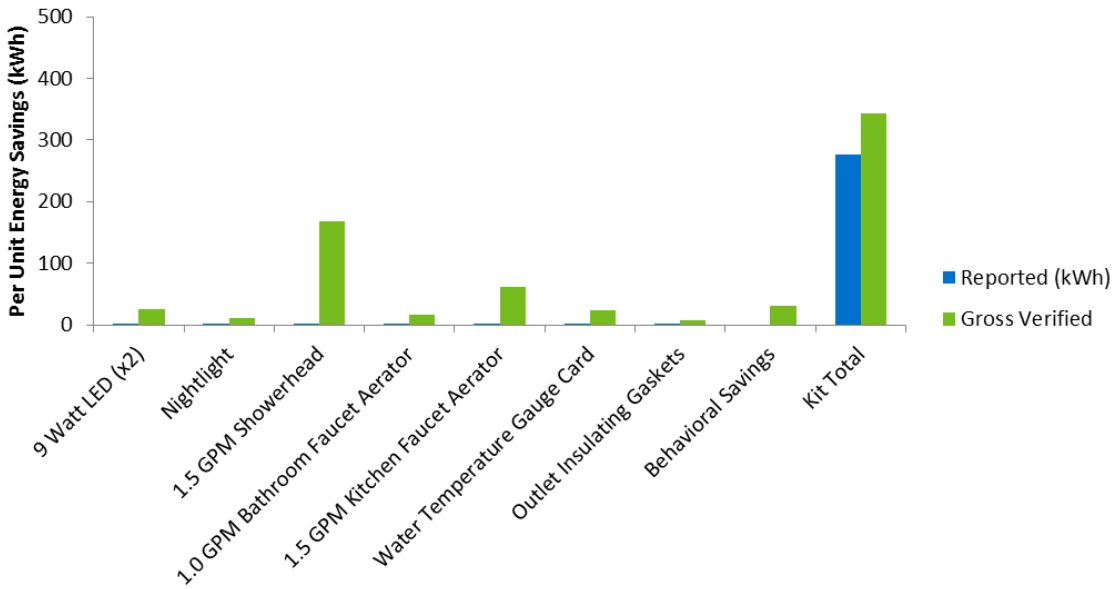

Table 3-38: DEP Measure-Level Reported and Verified Gross Energy Savings

Measure	Reported Gross Energy Savings, per unit (kWh)	Realization Rate	Verified Gross Energy Savings, per unit (kWh)	Total Verified Gross Energy Savings (kWh)
9 Watt LED*	N/A	N/A	25.4	229,261
Nightlight			10.9	98,409
Low-flow Showerhead			168.1	1,516,833
Low-flow Bathroom Aerator			16.4	148,343
Low-flow Kitchen Aerator			62.3	561,971
Water Heater Setback			23.5	212,411
Outlet Gaskets			6.8	61,268
Behavioral Changes			30.1	271,521
Total	**276.4**	**124.3%**	**343.5**	**3,100,016**

*Reflects savings for two 9 watt LEDs bulbs

Measure-level and kit-level summer demand savings are detailed in Table 3-39 and Table 3-40 for DEC and DEP, respectively.

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Table 3-39: DEC Measure-Level Reported and Verified Summer Demand Gross Savings

Measure	Reported Gross Demand Savings, per unit (kW)	Realization Rate	Verified Gross Demand Savings, per unit (kW)	Total Verified Gross Demand Savings (kW)
9 Watt LED*	N/A	N/A	0.005	109.2
Nightlight			0.000	0.0
Low-flow Showerhead			0.010	225.6
Low-flow Bathroom Aerator			0.002	38.6
Low-flow Kitchen Aerator			0.005	118.6
Water Heater Setback			0.003	73.6
Outlet Gaskets			0.008	186.8
Behavioral Changes			0.001	25.3
Total	**0.054**	**61.7%**	**0.034**	**777.7**

*Reflects savings for two 9 watt LEDs bulbs

Table 3-40: DEP Measure-Level Reported and Verified Summer Demand Gross Savings

Measure	Reported Gross Demand Savings, per unit (kW)	Realization Rate	Verified Gross Demand Savings, per unit (kW)	Total Verified Gross Demand Savings (kW)
9 Watt LED*	N/A	N/A	0.004	40.4
Nightlight			0.000	0.0
Low-flow Showerhead			0.013	121.5
Low-flow Bathroom Aerator			0.002	19.9
Low-flow Kitchen Aerator			0.008	75.3
Water Heater Setback			0.003	28.5
Outlet Gaskets			0.009	77.9
Behavioral Changes			0.001	9.6
Total	**0.079**	**52.5%**	**0.041**	**373.1**

*Reflects savings for two 9 watt LEDs bulbs

Measure-level and kit-level winter demand savings are detailed in Table 3-41 and Table 3-42 for DEC and DEP, respectively.

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Table 3-41: DEC Measure-Level Reported and Verified Winter Demand Gross Savings

Measure	Reported Gross Demand Savings, per unit (kW)	Realization Rate	Verified Gross Demand Savings, per unit (kW)	Total Verified Gross Demand Savings (kW)
9 Watt LED*	N/A	N/A	0.002	48.7
Nightlight			0.000	0.0
Low-flow Showerhead			0.027	631.9
Low-flow Bathroom Aerator			0.003	63.6
Low-flow Kitchen Aerator			0.008	195.5
Water Heater Setback			0.005	121.3
Outlet Gaskets			0.000	7.1
Behavioral Changes			0.002	45.2
Total	**N/A**	**N/A**	**0.048**	**1,113.4**

*Reflects savings for two 9 watt LEDs bulbs

Table 3-42: DEP Measure-Level Reported and Verified Winter Demand Gross Savings

Measure	Reported Gross Demand Savings, per unit (kW)	Realization Rate	Verified Gross Demand Savings, per unit (kW)	Total Verified Gross Demand Savings (kW)
9 Watt LED*	N/A	N/A	0.002	18.0
Nightlight			0.000	0.0
Low-flow Showerhead			0.038	340.4
Low-flow Bathroom Aerator			0.004	32.8
Low-flow Kitchen Aerator			0.014	124.1
Water Heater Setback			0.005	46.9
Outlet Gaskets			0.000	3.0
Behavioral Changes			0.002	15.7
Total	**N/A**	**N/A**	**0.064**	**581.0**

*Reflects savings for two 9 watt LEDs bulbs

The impact evaluation for the DEC 2017-2018 program resulted in a program energy realization rate of 135% and a demand realization rate of 62% as presented in Table 3-43.

Table 3-43: 2017-2018 DEC Energy Savings per Kit

Measurement	Reported	Realization Rate	Gross Verified*
Energy (kWh)	201.0	135.0%	271.3
Demand (kW)	0.054	61.7%	0.034
Winter Demand (kW)	N/A	N/A	0.048

*Values may appear inaccurate due to rounding errors

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The impact evaluation for the DEP 2017-2018 program resulted in a program energy realization rate of 124% and a demand realization rate of 52% as presented in Table 3-44.

Table 3-44: 2017-2018 DEP Energy Savings per Kit

Measurement	Reported	Realization Rate	Gross Verified*
Energy (kWh)	276.4	124.3%	343.5
Summer Demand (kW)	0.079	52.5%	0.041
Winter Demand (kW)	N/A	N/A	0.064

*Values may appear inaccurate due to rounding errors

Table 3-45 and Table 3-46 present the reported and verified energy and demand savings for the 2017-2018 program year for DEC and DEP, respectively.

Table 3-45: 2017-2018 DEC Program Level Savings

Measurement	Reported per Kit	Kits Distributed	Program Reported*	Realization Rate	Program Gross Verified*
Energy (kWh)	201.0	23,161	4,655,361	135.0%	6,283,232
Summer Demand (kW)	0.054		1,260.7*	61.7%	777.7
Winter Demand (kW)	N/A		N/A	N/A	1,113.4

*Values may appear inaccurate due to rounding errors

Table 3-46: 2017-2018 DEP Program Level Savings*

Measurement	Reported per Kit	Kits Distributed	Program Reported*	Realization Rate	Program Gross Verified*
Energy (kWh)	276.4	9,025	2,494,510	124.3%	3,100,016
Summer Demand (kW)	0.079		711.0*	52.5%	373.1
Winter Demand (kW)	N/A		N/A	N/A	581.0

*Values may appear inaccurate due to rounding errors

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4 Net-to-Gross Methodology and Results

The evaluation team used student family survey data to calculate a net-to-gross (NTG) ratio for the NTC program. NTG reflects the effects of free ridership (FR) and spillover (SO) on gross savings. Free ridership refers to the portion of energy savings that participants would have achieved in the absence of the program through their own initiatives and expenditures (U.S. DOE, 2014).[15] Spillover refers to the program-induced adoption of additional energy-saving measures by participants who did not receive financial incentives or technical assistance for the additional measures installed (U.S. DOE, 2014). The evaluation team used the following formula to calculate the NTG ratio:

$$NTG = 1 - FR + SO$$

The evaluation team calculated the mean FR separately for water end-use measures, infiltration measures, and light bulbs, and aggregated those values to the program level. The team calculated spillover at the program level only.

4.1 Free Ridership

Free ridership estimates how much the program influenced participants to install the energy-saving items included in the energy efficiency kit. Free ridership ranges from 0 to 1, 0 being no free ridership and 1 being total free ridership, with values in between representing varying degrees of partial free ridership.

The evaluation team used participant survey data to estimate free ridership. The survey used several questions to identify items that a given participant installed and did not later uninstall:

- For items that came one to a kit (showerhead, kitchen and bathroom faucet aerators, and night light), the survey asked whether the participant installed the item and, if so, whether the participant later uninstalled the item.
- For insulator gaskets, which came 12 to a kit, the survey asked how many the participant installed and if the participant later uninstalled them.
- For the LEDs, the survey first asked whether the participant installed one, both, or neither. The survey then asked whether the participant uninstalled the bulbs.

The evaluation team's methodology for calculating free ridership consists of two components, free ridership change (FRC) and free ridership influence (FRI), both of which range from 0 to .5 in value.

$$FR = FRC + FRI$$

[15] The U.S. Department of Energy (DOE) (2014). *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 23: Estimating Net Savings: Common Practices.* Retrieved August 29, 2016 from http://energy.gov/sites/prod/files/2015/02/f19/UMPChapter23-estimating-net-savings_0.pdf.

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4.1.1 Free Ridership Change

FRC reflects what participants reported they would have done if the program had not provided the items in the kit. For each respondent, the survey assessed FRC for each measure that the respondent installed and did not later uninstall.

Specifically, the survey asked respondents which, if any, of the currently installed items they would have purchased and installed on their own within the next year if Duke Energy had not provided them. For each measure, the evaluation team assigned one of the FRC values shown in the Table 4-1, based on the respondents' responses.

Table 4-1: Free Ridership Change Values

What Respondent Would Have Done Absent the Program*	FRC Value
Would ***not*** have purchased and installed the item within the next year	0.00
Would have purchased and installed the item within the next year	0.50
Don't know	0.25

*Survey response to: If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

4.1.2 Free Ridership Influence

FRI assesses how much influence the program had on a participant's decision to install (and keep installed) the items in the kit. The survey asked respondents to rate how much influence six program-related factors had on their respective decisions to install the measures, using a scale from 0 ("not at all influential") to 10 ("extremely influential"). The program-related factors included:

- The fact that the items were free
- The fact that the items were sent to their home
- The chance to win cash prizes for their household and school
- Information in the kit about how the items would save energy
- Information that their child brought home from school
- Other information or advertisements from Duke Energy, including its website

Asking respondents to separately rate the influence of each of the six above items had on the decision to install each measure would have been overly burdensome. Therefore, while the survey assessed FRC for each measure, it assessed influence at the end-use level once for all water-saving measures and once for the light bulbs.

For each end-use (water-saving and light bulbs), the highest-rated item for each respondent represents the overall program influence. The evaluation team assigned the following FRI scores, based on that rating (Table 4-2). The evaluation team calculated up to two FRI scores

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for each respondent: one FRI score for water-saving measures and one FRI score for light bulbs.[16]

Table 4-2: Free Ridership Influence Values

Highest Influence Rating	FRI Value
0	0.50
1	0.45
2	0.40
3	0.35
4	0.30
5	0.25
6	0.20
7	0.15
8	0.10
9	0.05
10	0.00

4.1.3 End-Use-Specific Total Free Ridership

The evaluation team calculated total free ridership by end use, one for water saving measures, one for infiltration measures, and one for light bulbs, by:

- Calculating measure-specific FR scores for each respondent by summing each measure-specific FRC score with the corresponding end-use-specific FRI score.
- Calculating the mean FR score for each measure from the individual measure-specific FR scores.[17]
- Calculating a savings-weighted mean of the measure-specific FR means for water-saving measures and a separate savings-weighted mean of the measure-specific FR means for light bulbs. These two savings-weighted means represent the FR estimates for the two end-uses.

Table 4-3 and Table 4-4 presents the end-use FR estimates.

[16] Respondents were only asked to rate program influence on end-uses they installed and did not later uninstall. Thus, if a respondent installed both a showerhead and a light bulb, but later uninstalled the light bulb, the evaluation team only asked them to rate program influence on their decision to install the showerhead. Thus in this example, the evaluation team would only calculate a water end-use FRI score for this respondent.

[17] Since respondents were only asked about program influence on their decision to install the light bulbs and water saving items, infiltration measures leveraged the average influence score (FRI) across those two end uses. However, the FRC score used for infiltration measures was specific to that end use.

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Table 4-3: DEC End-Use-Level Free Ridership Scores

End-use	End-Use Free Ridership
Light bulbs	0.26
Water saving measures	0.15
Infiltration measures	0.12

Table 4-4: DEP End-Use-Level Free Ridership Scores

End-use	End-Use Free Ridership
Light bulbs	
Water saving measures	0.12
Infiltration measures	0.08

4.1.4 Program-Level Free Ridership

The evaluation team estimated program-level free ridership by calculating a savings-weighted mean of the end-use FR scores presented in Table 4-3 and Table 4-4. Overall free ridership for the NTC kits is an estimated 16% for DEC and 13% for DEP.

4.2 Spillover

Spillover estimates energy savings from additional energy improvements made by participants who are influenced by the program to do so and is used to adjust gross savings. Since behavioral actions are considered gross impacts, spillover calculations only include additional installations of energy saving technologies. The evaluation team used participant survey data to estimate spillover. The survey asked respondents to indicate what energy-saving measures they had implemented since participating in the program. The evaluation team then asked participants to rate the influence the NTC program had on their decision to purchase these additional energy-saving measures on a scale of 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential.”

The evaluation team converted the ratings to a percentage representing the program-attributable percentage of the measure savings, from 0% to 100%. The team then applied the program-attributable percentage to the savings associated with each reported spillover measure to calculate the participant measure spillover (PMSO) for that measure. We defined the per unit energy savings for the reported spillover measures based on ENERGY STAR® calculators as well as algorithms and parameter assumptions listed in the in the 2018 Mid-Atlantic TRM, 2016 Pennsylvania TRM, and outputs from this impact evaluation.

Lighting measures (namely, LEDs) were commonly reported spillover measures. Since Duke Energy offered discounted lighting at participating retailers through their Energy Efficient Lighting (EEL) program as well through their Online Savings Store (DEC only), we asked

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respondents to confirm they did not use Duke Energy's website to find or purchase discounted lighting. As to not double-count these savings, we adjusted lighting spillover savings to account for the proportion of respondents that said they used Duke Energy's website to find or purchase discounted lighting measures.

Participant measure spillover (PMSO) is calculated as follows:

$$PMSO = Deemed\ Measure\ Savings * Program\ Attributable\ Percentage$$

Table 4-5 and Table 4-6 exhibits the PMSO by measure category.

Table 4-5: DEC PMSO, by Measure Category

Measure Category	Total kWh for Category	Percent Share of kWh
LEDs	6,345	82%
CFLs	486	6%
Appliances	768	10%
Windows	160	2%
AC Filters	3	<1%
Total	**7,743**	**100%**

Table 4-6: DEP PMSO, by Measure Category

Measure Category	Total kWh for Category	Percent Share of kWh
LEDs	2,421	87%
CFLs	19	1%
Appliances	236	8%
Windows	29	1%
Outlet Gaskets	79	3%
Total	**2,783**	**100%**

The evaluation team summed all PMSO values and divided them by the sample's gross program savings to calculate an estimated spillover percentage for the NTC program:

$$Program\ SO = \frac{\sum Program\ PMSO}{\sum Sample's\ Gross\ Program\ Savings}$$

These calculations produced a spillover estimate of 10% for DEC and 5% for DEP.

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4.3 Net-to-Gross

Inserting the FR and SO estimates into the NTG formula (NTG = 1 – FR + SO) produces an NTG value of 0.94 for the DEC program (Table 4-7) and 0.92 for the DEP program (Table 4-8). The evaluation team applied the NTG ratios to verified gross savings to calculate NTC kit net savings.

Table 4-7: DEC Program Net-to-Gross Results

Free Ridership	Spillover	NTG
0.16	0.10	0.94

*Totals may not sum to due to rounding

Table 4-8: DEP Program Net-to-Gross Results

Free Ridership	Spillover	NTG
0.13	0.05	0.92

*Totals may not sum to due to rounding

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5 DEC Process Evaluation

5.1 Summary of Data Collection Activities

The process evaluation is based on telephone and web interviews and surveys with program and implementer staff, teachers, and student families who received a kit during the program evaluation year (Table 5-1).

Table 5-1: Summary of Process Evaluation Data Collection Activities

Target Group	Method	Sample Size	Population	Confidence / Precision
Duke Energy program staff	Phone in-depth interview	1	N/A	N/A
Implementation staff: NTC	Phone in-depth interview	1	N/A	N/A
Implementation staff: R1	Phone in-depth interview	1	N/A	N/A
Teachers who attended NTC performance	Web survey	44	Unknown	90/17
Participating teacher follow-up interviews	Phone in-depth interview	5	Unknown	N/A
Student families who received DEC kit and are customers of DEC	Phone/Web survey	334*	23,161	95/5

*260 web surveys and 74 phone surveys

5.1.1 Teacher Surveys and Follow-Up Interviews

The evaluation team surveyed and interviewed teachers who attended NTC performances to better understand program success and delivery and to gather an educator perspective on what could be improved.

In April and May 2018, the evaluation team surveyed 44 teachers who attended NTC performances between September 7, 2017 and March 16, 2018. Of the 44 teacher respondents, 34 taught elementary school and 10 taught middle school. We report elementary and middle school findings together unless a meaningful difference emerged between school types.

In May 2018, the evaluation team contacted teachers who completed the web survey and indicated interest in being interviewed about their experience. The evaluation team requested their participation in a follow-up in-depth interview (IDI) about their experience with the performance, curriculum materials, and kit request forms. These IDIs served to get a deeper understanding of topics uncovered in the web survey and to provide additional details about their experience. The evaluation team completed interviews with five of these teachers. Two taught at elementary schools (one first grade teacher and one second) and three taught at middle schools (two sixth grade teachers and one seventh grade teacher).

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5.1.2 Survey of Student Families Who Received the DEC Kit

In April and May 2018, the evaluation team surveyed 334 families who received energy efficiency kits from DEC between August 2017 and May 2018 (Table 5-2). During that period, DEC distributed a total of 5,587 kits to families who completed the kit request form their child brought home from school. The evaluation team attempted to contact a random sample frame of 12,515 households, sending email survey invitations to 11,449 households and attempting to call 1,066 households for which program records provided an email address and/or a phone number. Ultimately, the data collection effort achieved a 2.7% response rate, providing a sample with 95/5 confidence/precision. Comparisons with census data demonstrate that the sample is largely representative of income level and ownership status for the region. Respondents reported greater educational attainment and larger-sized households than typical of the region.[18]

Table 5-2: DEC Student Family Survey Response Rates

Mode	Population Size	Sample Frame Size	Completed Surveys	Response Rate	Confidence/ Precision
Web-based	23,161	11,629	260	2.3%	95/5
Phone		7,953	74	6.9%	
Total		**19,582**	**334**	**2.7%**	

5.2 Process Evaluation Findings

5.2.1 Awareness of DEC Sponsorship of the Program

Teachers and student families were largely aware of DEC's sponsorship of the program. A majority of teachers (84%) reported they were aware of DEC's sponsorship. The 37 teachers who knew of DEC's sponsorship most often learned about it through another staff member at their school (14) or DEC marketing materials (6) (Table 5-3).

Table 5-3: How Teachers Learned of DEC's Sponsorship (Multiple Responses Allowed; n=37)

Source	Number of Teachers
Another staff person at school	14
The National Theatre for Children staff	12
Duke Energy marketing materials	6
The National Theatre for Children materials	6
Prior performance at school	5
Duke Energy staff	1
Don't recall	4

[18] Region comparisons come from 2016 American Community Survey (Census) 5-year period estimates data for the state of North Carolina and South Carolina.

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Awareness of DEC sponsorship among student families was also high, with most (94%) stating they knew the kit was sponsored by Duke Energy. Over half (59%) indicated they learned about Duke's sponsorship via the classroom materials their child brought home. Other common ways that families learned about Duke Energy sponsorship were material included in the kit (29%) and communications from their child's teacher or school (29%).

About one-third (31%) of student family respondents said they knew about the energy-related classroom activities and NTC performance at their child's school. Of those, most (77%) said they found out about the NTC activities from their child or from a teacher or school administrator (28%).

5.2.2 Parent Awareness of DEC Kit Opportunity

Classroom materials sent home with students were the key source of awareness of kits for families, with most student families (71%) hearing about the opportunity to receive a Duke Energy kit via this medium. Other respondents learned about the kits from various communications from the school (Table 5-4).

Table 5-4: Sources of Parental Awareness of Kits (Multiple Responses Allowed; n=334)

Source of Kit Awareness	Percent
Classroom materials	71%
School newsletter	17%
Email from teacher/school	14%
School website or web portal	6%
Conversations with teacher	4%
Poster at school	4%
After hour event at school	2%
Other	13%

5.2.3 Teacher Experience with the Program

NTC Performance

Teachers were very pleased with the NTC performance. They specified that the content was age-appropriate and the performance itself was engaging, and they reported overall high satisfaction with it.

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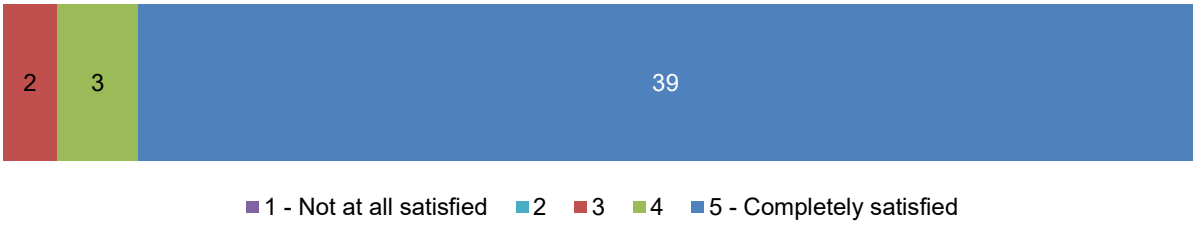
Overall, teachers were largely satisfied with the performance, with 95% (42 of 44) rating their satisfaction as a "4" or "5" on a one-to-five scale. The remaining two respondents were neither satisfied nor dissatisfied providing a response of "3" on the five-point scale (Table 5-1).

Figure 5-1: Overall Teacher Satisfaction with NTC Performance (n=44)



More than 90% of the surveyed teachers (40 of 44) said the explanation of energy-related concepts was "about right" for most of their students. Of the other four, three teachers (two first grade teachers and one elementary teacher that teaches several grades) reported the material was too advanced, while one sixth grade teacher said the material was too basic for their students.

Regarding age appropriateness, the comments from the interviewed teachers echoed the findings from the online survey. All five interviewed teachers said the performance was age appropriate and kept their students' attention.

The interviewed teachers commented on the quality of the performance, specifically that the performance was engaging, and one noted that the performance gave students tangible actions to save energy.

Two surveyed teachers offered suggestions for improving the performance:

- Introduce vocabulary ahead of the performance. A first-grade teacher noted that having some key terms ahead of time would have allowed teachers to review them with students.
- Improve sound quality. A second-grade teacher noted that the it was hard to hear the performance in a large space. This teacher suggested the performers were not expecting have to perform in a large auditorium.

Curriculum and Instructional Materials

A notable percentage of teachers reported not receiving or using the curriculum materials, despite most reporting that they distributed kit request forms to their students (see Kit Request

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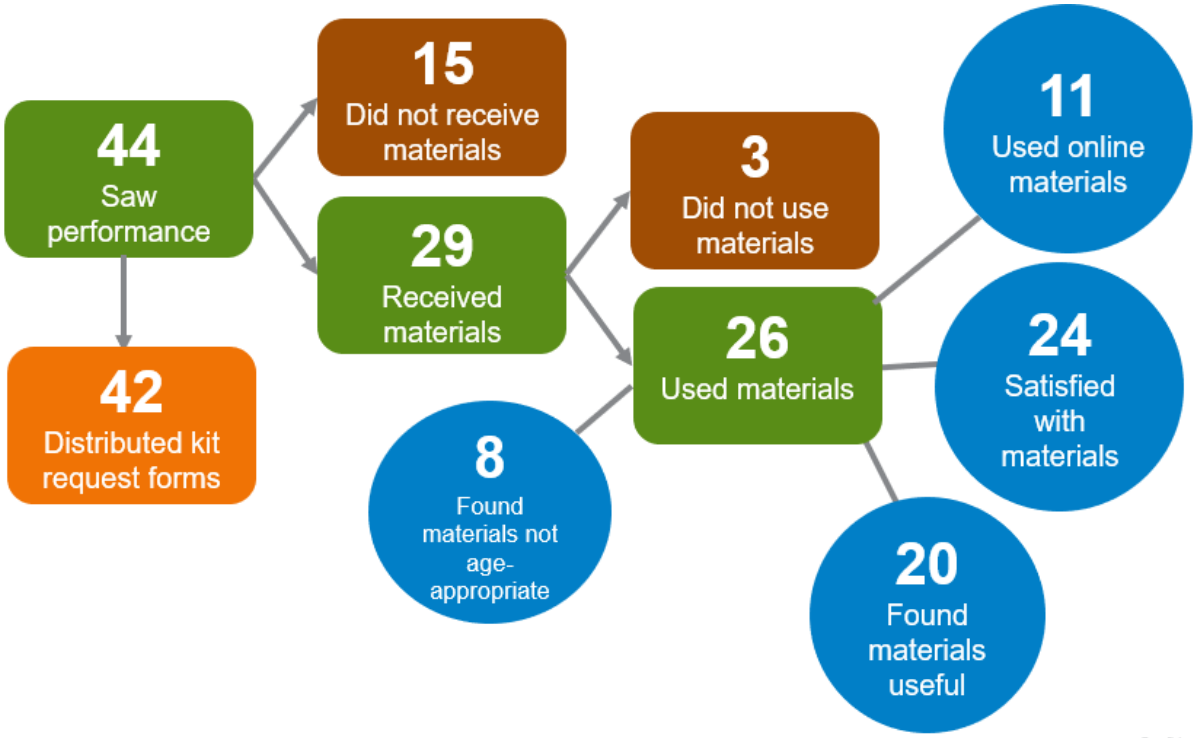
Forms section below).[19] About two-thirds of teachers (29 of 44) reported receiving the curriculum and instructional materials, while fifteen said they did *not* receive the materials. Of the 29 who reported receiving the materials, three reported not using them "at all" because they did not have time to use them (2 mentions) or because state testing material took priority (Figure 5-2).

Figure 5-2: DEC Teachers Use of Forms and Instructional Materials



Twenty-six teachers reported use of the instructional materials and they reported on the materials' usefulness, age-appropriateness, alignment with state science standards, or concepts children had trouble understanding. From their comments, the following observations emerged:

- Use of materials was limited to moderate: Eight teachers characterized their use as "a little" and twelve used the materials "moderately." About 40% of respondents used the online aspect of the curriculum.
- Materials were useful: When asked to rate the usefulness of the materials, from 1 (not at all useful) to 5 (highly useful), most respondents rated the usefulness as a four (11) or five (9). The remaining six respondents scored the usefulness as a three.

[19] Kit request forms and curriculum materials are delivered to schools at the same time. The findings from this study are inconclusive as to whether teachers did not actually receive the instructional materials in the first place (for example: the school received them, but did not distribute them to the teachers), or if teachers did not remember receiving them due to a recency effect (in that, they did receive them but did not remember this event by the time of the survey, which seems particularly likely if the teacher did not distribute or use the materials despite receiving them).

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- Materials were age-appropriate: Six reported the material was age-appropriate, while a fifth grade teacher reported it was somewhat too advanced.
- Most respondents said they varied in their thoughts about the alignment of materials with state science standards: Fourteen reported the curriculum "completely" (5) or "mostly" (9) aligned with state science standards, seven stated it "somewhat" aligned, and four did not know if the materials aligned. One fifth grade teacher reported there were no state science standards.
- One teacher reported abstract concepts such as electricity can be difficult for children to understand.

The eight teachers reporting "a little" use explained their rationale for limited use of the material. None of the comments focused on the quality of the materials per se. Rather, the reason for minimal use was because the materials did not align with their teaching priorities at that time (5 mentions) and concerns about the age appropriateness, with two kindergarten teachers saying the materials were too advanced and one sixth grade teacher reporting the materials were too basic.

No teacher specified any concepts the workbooks should have covered to make it more useful. Twenty-four of the 26 reported being satisfied with the materials (scored a "4" or "5" on a five-point scale) and two were neither satisfied or dissatisfied with the materials (scored a "3" on a five-point scale).

Two interviewed teachers said they used the curriculum materials. Of those, one used the workbooks in their classroom and one reported sending the materials home.

Kit Request Forms

As Figure 5-2 suggests, there was a disconnect among teachers between the kit request forms and the instructional materials. Teachers largely reported limited use of the instructional materials, with more than one-third indicating they never received the instructional materials. Yet nearly all reported distributing kit request forms to students, which are delivered to the school at the same time as the instructional materials. This suggests that teachers viewed the materials as tangential to the kit request forms.

Ninety-five percent of surveyed teachers distributed the kit request forms to their students and almost all took actions to encourage or promote the kits to their students. The interviewed teachers reported no challenges related to receiving or distributing the kit request forms and all noted ways they encouraged students to receive the kit (Table 5-5).

Table 5-5: Actions Taken to Encourage Students to Receive Kit (Multiple Responses Allowed)

Actions	Teacher Survey Responses (n=44)	Interview Mentions (n=55)
Encouraged students to take action	43	5

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Engaged students	*41*	*3*
Vocally encouraged students	40	2
Explain that school will get award	-	1
Posted MyEnergyKit.org poster	17	-
Engaged parents	*24*	*4*
Electronic reminders to parents (email, text)	18	3
Used classroom web portal	*12*	-
Spoke with parents in person	8	1
Used newsletter	2	-

About a third of surveyed teachers (32%) reported following up with students to find out whether their household requested a kit. Of those, teachers estimated between 5% to 65% of families ordered a kit, demonstrating an average of 22% of student families that requested a kit.[20]

5.2.4 Student Family Experience with the Program

Installation and Use Rates

Almost all (93%) participants used at least one measure in the kit, installing an average of three measures from their kit. Most kit recipients installed the lighting measures including LEDs (95%) and nightlights (83%); far fewer used the insulator gaskets and water related measures (ranging from 33% to 35%). Water related measures were also uninstalled more often than lighting measures. Most of the respondents who chose to uninstall kit measures reported dissatisfaction with the measure performance.

The majority of those installing light bulbs (71%) said they installed both bulbs included in the kit and they typically replaced incandescent bulbs.

Of those who did not install all items in the kit, about a third (34%) said they do not plan to install any of the items they had not yet installed. Respondents said they would not install the remaining items because the currently installed item is still working, they already had an efficient measure installed, they tried it and it didn't fit, or they had not "gotten around to it."

Measure Satisfaction

Nearly all kit recipients reported high satisfaction with the items they installed from their kit (Figure 5-3). To best gauge the experience with the measures, we asked respondents to rate their satisfaction with all measures they installed, including those they later uninstalled. Respondents explained that any dissatisfaction they had with water measures was due to low water pressure or that the measures did not fit properly.

[20] The Evaluation Team calculated the mean of the mid-point values of each teacher's selected range. For example, if one teacher selected 81%-90% and another selected 91%-100%, the mid-points are 85% and 95%, and the mean is 90%.

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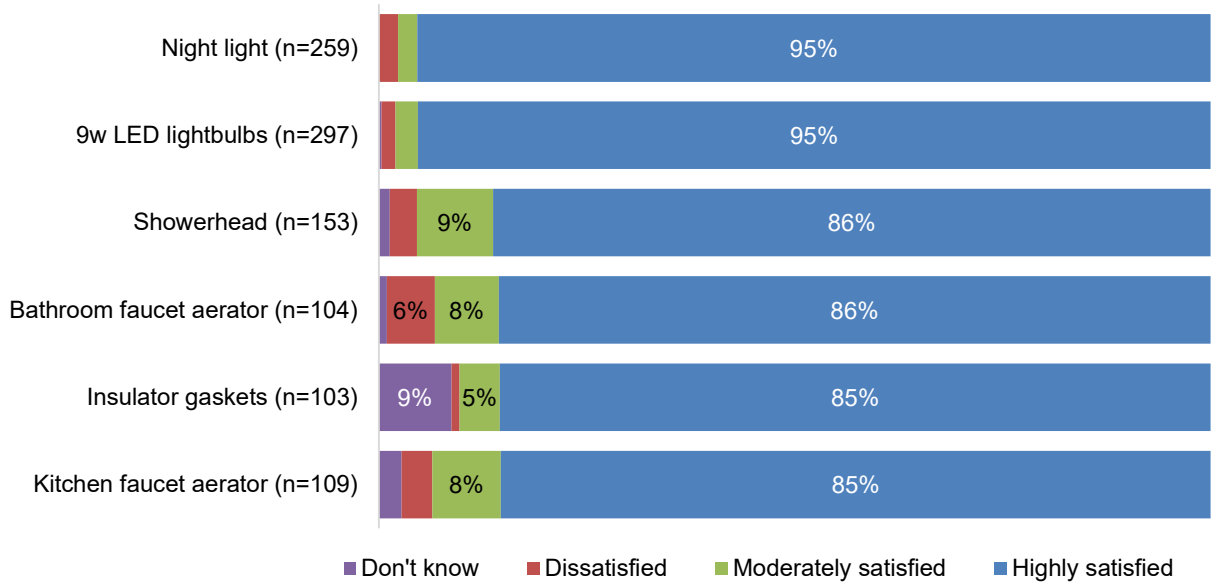
Figure 5-3: Kit Recipient Satisfaction with Measures They Installed*



* Respondents rated their satisfaction with the measures on a 0 ("very dissatisfied") to 10 ("very satisfied") scale. Dissatisfied indicates 0-3 ratings, moderately satisfied indicates 4-6 ratings, and highly satisfied indicates 7-10 ratings.

Energy Saving Educational Materials in the Kit

The Energy Efficiency Kit includes a Duke Energy-labeled Department of Energy (DOE) Energy Saver Booklet that includes educational information on saving energy at home. Most (73%) respondents said they read the booklet, most of whom (82%) found it highly helpful.[21] Those not finding the booklet helpful stated they already knew the information presented in the booklet or they wanted additional energy saving tips and more detailed information included.

Additional Energy Saving Actions

Parents and children reported adopting new energy-saving actions since their involvement in the program. Over half of parents reported taking an energy-saving action (51%) and over half (51%) reported their child has adopted new energy saving behaviors since receiving their kit. Parents most commonly said that their child now turns off lights when not using a room (37%) or that they changed their thermostat settings (22%) (Table 5-6). More than three-quarters (81%) of respondents reporting new energy saving behaviors said the DEC-sponsored kit and materials were "highly influential" on their adoption of those behaviors.[22]

[21] We asked respondents to rate the helpfulness of the Duke Energy-labeled DOE Energy Saver Booklet on a scale from 0 ("not at all helpful") to 10 ("very helpful"). Eighty-two percent of respondents who reported reading the booklet gave a rating of 7 or higher. 16% gave ratings of 5 or 6, and 2% gave ratings of 0 through 4.

[22] We asked respondents to rate the influence of Duke Energy's kit and energy saving educational materials on their reported behavior changes, using a scale from 0 ("not at all influential") to 10 ("extremely influential"). Eighty-one percent of respondents (or, 205 of 252) who reported behavior changes gave a rating of 7 or higher.

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Table 5-6: New Behaviors Adopted by Parents and Children Since Receiving Kit (Multiple Responses Allowed; n=334)

New Behaviors Child Has Adopted	Parents	Children
Adopted new behaviors since receiving kit	51%	51%
Changed thermostat settings to use less energy	22%	-
Turn off electronics when not using them	16%	25%
Takes shorter shower	16%	19%
Using fans instead of air conditioning	15%	-
Turning off air conditioning when not home	12%	-
Turning off lights when not in a room	10%	37%
Turning water heater thermostat down	8%	-
Turning off furnace when not home	5%	-
Other reason	5%	2%
Refused	0%	1%

Receiving a kit may drive a desire to make additional energy efficiency improvements. Most student families reported a desire to receive more kit measures (90%), specifying interest in LEDs (78%), nightlights (58%), showerheads (24%), gasket insulators (15%), and bathroom and kitchen aerators (14%). Parents typically preferred requesting additional measures via the internet (74%) or pre-paid postcards (23%).

Many parent respondents reported they want to purchase additional energy saving products. More than half (58%) reported an interest in purchasing at least one of the products or services seen in Table 5-7.

Table 5-7: Parent Interest in Additional Products and Services (Multiple Responses Allowed; n=334)

Products and Services	Parents
New efficient lighting	40%
Air leak sealing	28%
Energy efficient appliances	23%
Connected or smart thermostats	19%
Energy efficient water heater	18%
Efficient heating or cooling equipment	16%
Efficient windows	16%
Adding insulation	16%
Sealing or insulating ducts	14%
Other	5%

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The kit motivated some respondents to purchase energy efficient equipment or services (Table 5-8). More than one-quarter (28%) of respondents reported purchasing or installing additional energy efficiency measures since receiving their kit. Efficient light bulbs were the most commonly reported measure (mentioned by 67 respondents), with 59 respondents specifying LEDs and eight mentioning CFLs. Six respondents reported getting a Duke Energy rebate for their measure, four of whom said they received rebates for purchasing LEDs, one for CFLs, one for sealing air leaks, and another who received an incentive for their efficient heating or cooling equipment. Most (60 of 92) respondents said the Duke Energy schools program was at least partially influential on their decision to purchase and install additional energy saving measures.

Table 5-8: Additional Energy Saving Measures Purchased (Multiple Responses Allowed; n=334)

	Count of Respondents Reporting Purchases After Receiving the Kit	Count Reporting Duke Rebates for Measure	Count Reporting High Program Influence on Purchase*
At least one measure	92	6	60
Bought LEDs	59	4	33
Bought energy efficient appliances	26	0	18
Sealed air leaks	18	1	8
Installed an energy efficient water heater	12	0	6
Added insulation	10	0	3
Sealed ducts	8	0	3
Bought CFLs	8	1	4
Other	8	0	3
Bought efficient heating or cooling equipment	7	1	4
Bought efficient windows	4	0	1
Moved into an ENERGY STAR home	2	0	1

*Respondents that rated the influence of the DEC program as 7 or higher on 10-point scale, where 0 was not at all influential and 10 was extremely influential.

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6 DEP Process Evaluation

6.1 Summary of Data Collection Activities

The process evaluation is based on telephone and web interviews and surveys with program and implementer staff, teachers, and student families who received a kit during the program evaluation year (Table 6-1).

Table 6-1: Summary of Process Evaluation Data Collection Activities

Target Group	Method	Sample Size	Population	Confidence / Precision
Duke Energy program staff	Phone in-depth interview	1	N/A	N/A
Implementation staff: NTC	Phone in-depth interview	1	N/A	N/A
Implementation staff: R1	Phone in-depth interview	1	N/A	N/A
Teachers who attended NTC performance	Web survey	29	Unknown	90/14
Participating teacher follow-up interviews	Phone in-depth interview	5	Unknown	N/A
Student families who received DEP kit and are customers of DEP	Phone/Web survey	172*	9,025	90/6

*102 web surveys and 70 phone surveys

6.1.1 Teacher Surveys and Follow-Up Interviews

The evaluation team surveyed and interviewed teachers who attended NTC performances to better understand program success and delivery and to gather an educator perspective on what could be improved.

In April and May 2018, the evaluation team surveyed 29 teachers who attended NTC performances between September 18, 2018 and March 15, 2018. Of the 29 teacher respondents, 19 taught elementary school and 10 taught middle school. We report elementary and middle school findings together unless a meaningful difference emerged between school types.

In May 2018, the evaluation team contacted teachers who completed the web survey that had indicated interest in being interviewed about their experience. The evaluation team requested their participation in a follow-up in-depth interview (IDI) (n=5) about their experience with the performance, curriculum materials, and kit request forms. These IDIs served to get a deeper understanding of topics uncovered in the web survey and to provide additional details about their experience. The evaluation team completed interviews with five of these teachers. Three taught at elementary schools (teaching kindergarten, fourth, and fifth grades, respectively) and

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two taught sixth grade at middle schools.

6.1.2 Survey of Student Families Who Received the DEP Kit

In April and May 2018, the evaluation team surveyed 172 families who received energy efficiency kits from DEP between September 2017 and May 2018. (Table 6-2). During that period, DEP distributed a total of 5,587 kits to families who completed the kit request form their child brought home from school. The evaluation team attempted to contact a random sample frame of 4,877 households, sending email survey invitations to 3,974 households and attempting to call 903 households for which program records provided an email address and/or a phone number. Ultimately, the data collection effort achieved a 3.5% response rate, providing a sample with 90/6 confidence/precision. Comparisons with census data demonstrate that the sample is largely representative of housing type, income level, and ownership status for the region. However, respondents reported greater educational attainment and more household members than typical for the region.[23]

Table 6-2: DEP Student Family Survey Response Rates

Mode	Population Size	Sample Frame Size	Completed Surveys	Response Rate	Confidence/ Precision
Web-based	9,025	3,974	102	2.6%	90/6
Phone		903	70	7.8%	
Total		**4,877**	**172**	**3.5%**	

6.2 Process Evaluation Findings

The subsequent sections discuss the key process evaluation findings, beginning with a review sponsorship awareness.

6.2.1 Awareness of DEP Sponsorship of the Program

Teachers and student families were mostly aware of DEP's sponsorship of the program. A majority of teachers (84%) reported they were aware of DEP's sponsorship. The 23 teachers who knew of DEP's sponsorship most often learned about it through Duke materials (8 mentions) or NTC staff (8 mentions) (Table 6-3).

[23] Region comparisons come from 2016 American Community Survey (Census) 5-year period estimates data for the states of North Carolina and South Carolina.

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Table 6-3: How Teachers Learned of DEP's Sponsorship (Multiple Responses Allowed; n=23)

Source	Number of Teachers
Duke Energy marketing materials	8
The National Theatre for Children staff	8
Another staff person at school	7
The National Theatre for Children materials	7
Duke Energy staff	1

Awareness among student families was high, with 88% of respondents stating they knew the kit was sponsored by Duke Energy. Over half (57%) indicated they learned about Duke's sponsorship via the classroom materials their child brought home. Other common ways that families learned about Duke Energy sponsorship were communications from their child's teacher or school (30%) and informational material included in the kit (27%).

Only about one-quarter (24%) of respondents said they knew about the energy-related classroom activities and NTC performance at their child's school. Of those, most said they found out about the NTC activities from their child (67%) and/or from a teacher or school administrator (41%).

6.2.2 Parent Awareness of DEP Kit Opportunity

Classroom materials sent home with students were the key source of awareness of kits for families, with most student families (69%) hearing about the opportunity to receive a Duke Energy kit via this medium. Other respondents learned about the kits from various communications from the school (Table 6-4).

Table 6-4: Sources of Parental Awareness of Kits (Multiple Responses Allowed; n=172)

Kit Awareness	Percent
Classroom materials	69%
Email from teacher/school	13%
School newsletter	11%
School website or web portal	6%
Conversations with teacher	5%
Poster at school	3%
After hour event at school	1%
Other	18%

6.2.3 Teacher Experience with the Program

NTC Performance

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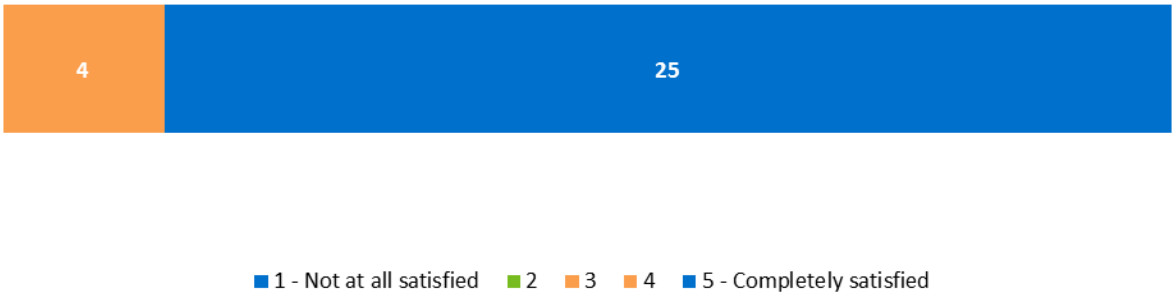
Teachers were very pleased with the NTC performance. They specified that the content was age-appropriate and the performance itself was engaging, and they reported overall high satisfaction with it (Figure 6-1).

Figure 6-1: Overall Teacher Satisfaction with NTC Performance (n=29)



More than 90% of the surveyed teachers (27 of 29) said the explanation of energy-related concepts was “about right” for most of their students. The two remaining, one second grade teacher and one middle school teacher (who teaches grades 5 through 8), indicated the materials were “somewhat too advanced” for most students. Comments from the interviewed teachers echoed the findings from the online survey. Four of the five interviewed teachers – two elementary and two middle school teachers – said the performance was age appropriate and kept their students’ attention. By comparison, a kindergarten teacher reported that the material in the performance may have been better suited for older elementary students but indicated the performance still engaged the kindergarteners.

Five teachers commented on the quality of the performance, specifically that the performance was engaging, and the performers were humorous. One sixth grade teacher particularly liked that the performance was easy to understand and the other sixth grade teacher liked that the performance reinforced what they were covering in their classroom.

Only one of the surveyed teachers offered any improvements for the performance, suggesting that the NTC performance could include a list of advantages and disadvantages for renewable energy compared to nonrenewable energy.

Curriculum and Instructional Materials

A notable percentage of teachers reported not receiving or using the curriculum materials. [24] About forty percent of teachers (12 of 29) reported receiving the curriculum and instructional

[24] Kit request forms and curriculum materials are delivered to schools at the same time. The findings from this study are inconclusive as to whether teachers did not actually receive the instructional materials in the first place (for example: the school received them, but did not distribute them to the teachers), or if teachers did not remember receiving them due to a recency effect (in that, they did receive them but did not remember this event by the time of the survey, which seems particularly likely if the teacher did not distribute or use the materials despite receiving them).

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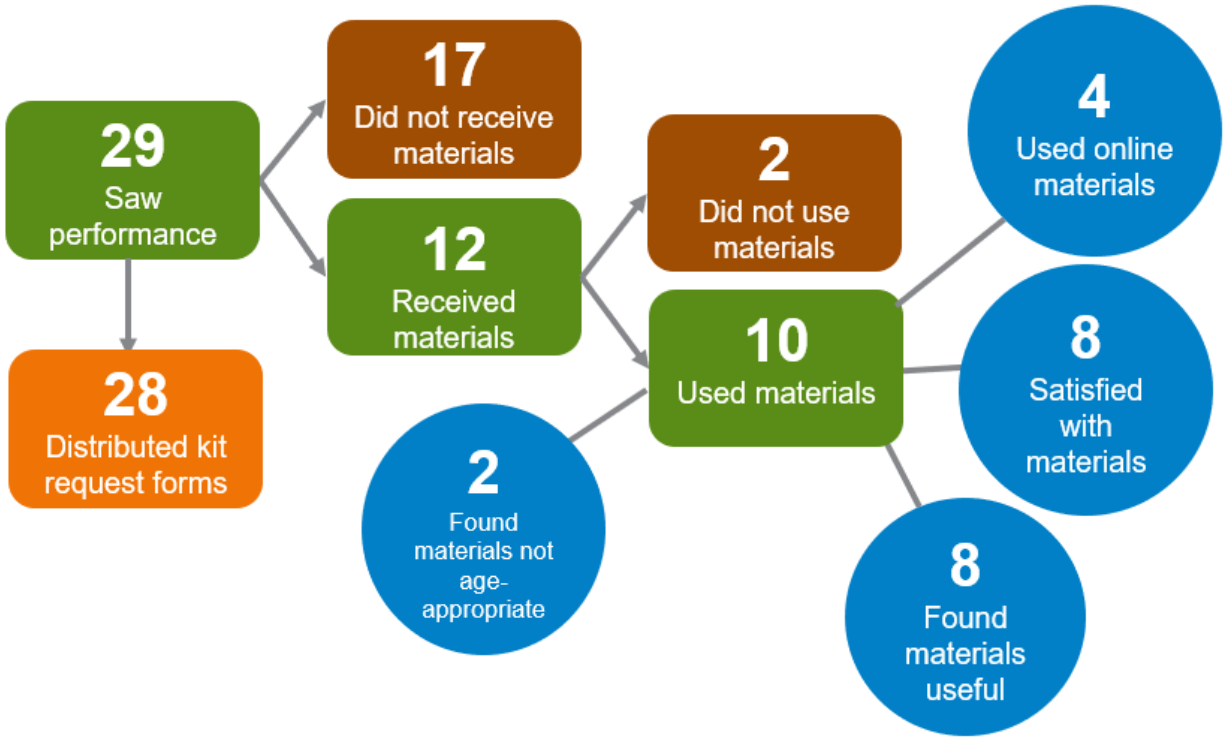
materials, while 17 said they did not receive the materials. Of the 12 who reported receiving the materials, two reported not using them "at all" because they did not have time to use them and integrate them into their existing curriculums (Figure 6-2).

Figure 6-2: DEP Teachers Use of Forms and Instructional Materials



The 10 teachers reporting use of the instructional materials made the following observations:

- Use of materials was limited: Two teachers characterized their use as "a little", and four used the materials "moderately" and four used them "a lot." Four respondents reported using the online aspect of the curriculum.
- Materials were useful: When asked to rate the usefulness of the materials, from 1 (not at all useful) to 5 (highly useful), two provided a score of three, five scored them a four, and three scored them the highest rating - five, extremely useful.
- Materials were age-appropriate: Seven reported the material was age-appropriate, while a kindergarten and a fifth-grade teacher reported the material was somewhat too advanced. One respondent did not know.
- Most respondents said the material aligned with state science standards: Seven reported the curriculum "completely" (1) or "mostly" (6) aligned with state science standards, and one said it "somewhat" aligned. Two did not know if the materials aligned with the standards.
- No teacher reported any specific concepts or topics children had trouble understanding.

The two teachers reporting "a little" use of the instructional materials explained their rationale for

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limited use of the material. One mentioned that the material was not part of their curriculum at the time and another teacher noted that they only received one workbook but "tons of materials telling the kids about the kit."

No teacher specified any concepts the workbooks should have covered to make it more useful. Eight reported being satisfied with the materials (scored a "4" or "5" on a five-point scale) and two were neither satisfied or dissatisfied with the materials (scored a "3" on a five-point scale).

Two of the five interviewed teachers said they used the curriculum materials. One of these respondents used the materials when teaching about the carbon cycle and another respondent noted using the materials when teaching about electricity.

Kit Request Forms

Figure 6-2 suggests, there was a disconnect among teachers between the kit request forms and the instructional materials. Teachers largely reported limited use of the instructional materials, with more than half indicating they never received the instructional materials. Yet nearly all reported distributing kit request forms to students, which are delivered to the school at the same time as the instructional materials. This suggests that teachers viewed the materials as tangential to the kit request forms.

Nearly all surveyed teachers distributed the kit request forms to their students and all took actions to encourage or promote the kits to their students.[25] The interviewed teachers reported no challenges related to receiving or distributing the kit request forms, with three of the five reporting receiving the forms ahead of the performance, and all noted ways they encouraged students to receive the kit (Table 6-5).

Table 6-5: Actions Taken to Encourage Students to Receive Kit (Multiple Responses Allowed)

Actions	Teacher Survey Responses (n=29)	Interview Mentions (n=5)
Encouraged students to take action	29	5
Engaged students	*26*	*4*
Vocally encouraged students	*24*	*4*
Awarded prizes to students that request kit	*1*	*-*
Posted MyEnergyKit.org poster	*13*	*-*
Assisted students with online application for kit	*-*	*1*
Engaged parents	*15*	*2*
Electronic reminders to parents (email, text)	*11*	*2*

[25] Note that one teacher respondent said they did not distribute kit request forms yet reported encouraging students to get a kit. Possible explanations for this discrepancy include that a different teacher distributed the forms, the teacher promoted online redemption instead, the respondent did not understand the question about distributing kit request forms, or the respondent accidentally selected the wrong response option.

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Actions	Teacher Survey Responses (n=29)	Interview Mentions (n=5)
Spoke with parents in person	*5*	-
Used classroom web portal	*3*	-
Had school or principal send reminders	-	*1*
Used newsletter	*1*	-

About half (15 of 29) of surveyed teachers reported following up with students to find out whether their household requested a kit. Of those, 14 could estimate what percentage of student sent the forms to Duke Energy. Eleven estimated less than half of their families sent away for a kit and the remaining three reported more than half sent for a kit; on average, teachers reported that 34% of their students sent for a kit.[26]

6.2.4 Student Family Experience with the Program

Installation and Use Rates

Almost all participants used at least one measure in the kit, but installation of the measures varies by type. Ninety-three percent of the surveyed kit recipients installed at least one measure, installing an average of three measures from their kit. Most kit recipients installed the energy efficient LEDs (93%) and night lights (81%); far fewer installed the water related measures (38% to 54%) and insulator gaskets (34%). The majority of those installing light bulbs (69%) said they installed both included in the kit bulbs and they typically replaced incandescent bulbs.

Of those who did not install all items in the kit, one-third said they do not plan to install any of the items they had not yet installed. Respondents said they would not install the remaining items because the currently installed item is still working, they already had an efficient measure installed, they had not “gotten around to it”, or they tried it and it didn’t fit or didn’t work as intended.

Measure Satisfaction

Nearly all kit recipients reported high satisfaction with the items they installed from their kit (Figure 6-3). To best gauge the experience with the measures, we asked respondents to rate their satisfaction with all measures they installed, including those they later uninstalled. Respondents explained that any dissatisfaction they had with water measures was due to low water pressure.

[26] The Evaluation Team calculated the mean of the mid-point values of each teacher’s selected range. For example, if one teacher selected 81%-90% and another selected 91%-100%, the mid-points are 85% and 95%, and the mean is 90%.

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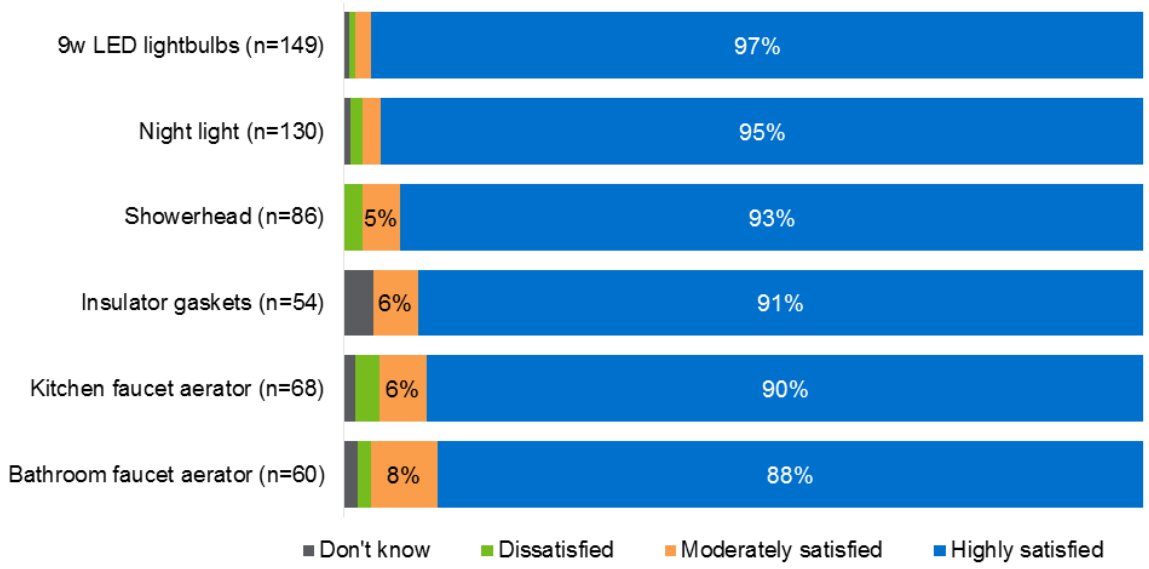
Figure 6-3: Kit Recipient Satisfaction with Measures They Installed*



* Respondents rated their satisfaction with the measures on a 0 ("very dissatisfied") to 10 ("very satisfied") scale. Dissatisfied indicates 0-3 ratings, moderately satisfied indicates 4-6 ratings, and highly satisfied indicates 7-10 ratings.

Energy Saving Educational Materials in the Kit

The Energy Efficiency Kit includes a Duke Energy-labeled Department of Energy (DOE) Energy Saver Booklet that includes educational information on saving energy at home. Most (74%) respondents said they read the booklet, most of whom (86%) found it highly helpful.[27] The other respondents rated the booklet as moderately helpful (11%) or not very helpful (2%). Those not finding the booklet helpful stated they already knew the information presented in the booklet and they were already doing what was recommended in their homes.

Additional Energy Saving Actions

Parents and children reported adopting new energy-saving actions since their involvement in the program. Around half of parents reported taking an energy-saving action (48%) and half of respondents reported their child has adopted new energy saving behaviors since receiving their kit. Parents most commonly said that their child now turns off lights when not using a room (32%), and parents reported changing thermostat settings (22%) (Table 6-6). The majority (86%) of respondents reporting new energy saving behaviors said the DEP-sponsored kit and materials were "highly influential" in their adoption of those behaviors.[28]

[27] We asked respondents to rate the helpfulness of the Duke Energy-labeled DOE Energy Saver Booklet on a scale from 0 ("not at all helpful") to 10 ("very helpful"). Eighty six percent of respondents who reported reading the booklet gave a rating of 7 or higher. 11% gave ratings of 5 or 6, and 2% gave ratings of 0 through 4.

[28] We asked respondents to rate the influence of Duke Energy's kit and energy saving educational materials on their reported behavior changes, using a scale from 0 ("not at all influential") to 10 ("extremely influential"). Seventy-eight percent of respondents (or, 90 of 115) who reported behavior changes gave a rating of 7 or higher.

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Table 6-6: New Behaviors Adopted by Parents and Children Since Receiving Kit (Multiple Responses Allowed; n=172)

New Behaviors Child Has Adopted	Parents	Children
Adopted new behaviors since receiving kit	48%	50%
Changed thermostat settings to use less energy	22%	-
Turn off electronics when not using them	19%	27%
Turn off lights when not in a room	13%	32%
Using fans instead of air conditioning	12%	-
Turning off air conditioning when not home	9%	-
Taking shorter showers	9%	16%
Turning water heater thermostat down	8%	-
Other	6%	6%
Turning off furnace when not home	5%	-
Refused	0%	1%

Receiving a kit may drive a desire to make additional energy efficiency improvements. Most student families reported a desire to receive more kit measures (89%), specifying interest in LEDs (82%), nightlights (60%), showerheads (27%), gasket insulators (19%), bathroom aerators (18%), and kitchen aerators (16%). Parents typically preferred requesting additional measures via internet (61%) or pre-paid postcards (29%).

Many respondents reported they want to purchase additional energy saving products. Two-thirds of respondents reported an interest in purchasing at least one of the products or services in (Table 6-7).

Table 6-7: Parent Interest in Additional Products and Services (Multiple Responses Allowed; n=172)

Products and Services	Parents
New efficient lighting	51%
Energy efficient appliances	28%
Efficient windows	17%
Air leak sealing	17%
Adding insulation	15%
Efficient heating or cooling equipment	14%
Connected or smart thermostats	13%
Energy efficient water heater	11%
Sealing or insulating ducts	9%
Other	9%

The kits also motivated some student families to purchase energy efficient equipment or services. More than a quarter (26%) of respondents reported purchasing or installing additional

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energy efficiency measures since receiving their kit. Efficient light bulbs were the most commonly reported measure (mentioned by 30 respondents), with 29 respondents specifying LEDs and one mentioning CFLs. Four respondents reported getting a Duke Energy rebate for their measure, two of whom said they received rebates for purchasing an energy efficient appliance, one who reported receiving a rebate for LEDs, and another who received an incentive for an unspecified measure. Most (31 of 45) respondents said the Duke Energy schools program was at least partially influential on their decision to purchase and install additional energy saving measures (Table 6-8)

Table 6-8: Additional Energy Saving Measures Purchased (Multiple Responses Allowed; n=172)

	Count of Respondents Reporting Purchases After Receiving the Kit	Count Reporting Duke Rebates for Measure	Count Reporting High Program Influence on Purchase*
At least one measure	45	4	31
Bought LEDs	29	1	19
Sealed air leaks	10	0	8
Bought energy efficient appliances	8	2	5
Added insulation	8	0	4
Other	8	1	3
Bought efficient heating or cooling equipment	4	0	0
Sealed ducts	3	0	3
Bought efficient windows	2	0	0
Moved into an ENERGY STAR home	2	0	2
Installed an energy efficient water heater	1	0	1
Bought CFLs	1	0	1

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7 Conclusions and Recommendations

Based on evaluation findings, the evaluation team concluded the following and provides several recommendations for program improvement:

Conclusion 1: NTC performances satisfy teachers by engaging students. It is less clear that the performances are linked to classroom learning, awareness at home, or change in behavior. Teachers reported high satisfaction with the performance and recalled that the performance engaged students. However, curriculum materials were not always distributed or remembered by teachers, and those who used them did so in a limited way.

Parents were often not aware the performance occurred and about half of parents reported changes in their or their children's energy use behavior but those changes in behavior were limited.

> **Recommendation:** Consider exploring ways to increase teacher receipt and use of materials, such as:
>
> - Making sure teachers are aware that NTC aligns their materials with state science standards, and
> - Requesting that teachers align energy-focused lesson plans with performance timing

Conclusion 2: There is an opportunity to increase parental awareness of the kits and thus get more families to request and install kits. Currently, students bear the bulk of the burden of generating parental awareness of the kit opportunity. Although most teachers engage students on the kit request process, only about half engage parents. Parent surveys corroborate this lack of teacher to parent engagement on the kits; few parents mentioned their child's teacher or school as the source of awareness of the kit (instead, most parents learned about the kit from their child). Additionally, two-thirds of parents did not know kits were associated with a performance and instructional materials. Although about one-third of teachers follow-up with students to see if parents requested kits, there is great variation in how much emphasis teachers place on promoting the kits.

Further, the contests appear to have limited success in encouraging kit requests, as a) only one teacher mentioned using the contests to encourage kit requests, and b) the household- and school-level contests had particularly low influence on parent motivations to get a kit.

> **Recommendation:** Explore ways to increase parent awareness of and motivation for requesting the kits. For example: create a household-level contest that engages both students and their parents, so students are motivated to ask their parents to sign up and so parents are motivated to participate. For example, in addition to a cash prize drawing for parents, include a prize drawing aimed at students (e.g., toys, electronics, or other items

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valued by students) or a guaranteed incentive such as a coupon for pizza (e.g., Book It model).

Conclusion 3: The program influences families to save energy. Families save energy they would not have saved without receiving the kits. Nearly all respondents installed at least one kit measure, and few would have installed the kit measures if they had not received them for free from the program (as evidenced by low free-ridership rates). About one-fifth of parent respondents reported making additional energy saving improvements, and over half of parent respondents said they or their children adopted new energy saving behaviors since receiving the kit.

Recommendation: Continue engaging student family households with the Education program.

Conclusion 4: The Education program could be a good "gateway" program to generate even more energy savings in Duke Energy territories. Kit recipients could be good targets for other Duke Energy efficiency program promotions, as they:

- Demonstrated willingness to save energy in their home
- Expressed interest in installing additional kit items or other energy saving measures (many of which Duke Energy currently incents)
- Are highly likely to read any information included with the kit
- Are commonly single family homeowners

Recommendations: Investigate the possibility of leveraging kits to promote other Duke Energy efficiency programs, such as targeting these households for direct mail campaigns or including information on Smart $aver in the kit.

Conclusion 5: Energy savings could be increased by encouraging partipants to install LED lamps in higher usage areas. LED lamp in-service rates (ISR) measured just below 80% for both DEC and DEP. This included some participants who store the LED kit lamp until a similar lamp in the home burns-out. Continue to encouraging participants to install the lamps as soon as the kit is received can increase LED lamp in-service rates and generate additional savings for the program.

Most kit lamps were installed in rooms with average (2 to 4 hour) dialy daily lighting usage, while very few lamps were installed in high use locations such as kitchens or exterior fixtures. Installation of lamps in high usage areas will results in higher energy savings (Table 7-1).

Table 7-1: Lamp HOU Installation Rates

Daily Lamp Use*	DEC Installation Rate	DEP Installation Rate
Low (< 2 hours)	43%	44%
Average (2-4 hours)	36%	32%

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Daily Lamp Use*	DEC Installation Rate	DEP Installation Rate
High (> 4 hours)	21%	24%

*Based on the participant survey responses

Recommendations: Program should continue to encourage lamp installations as soon as possible informing them where their new lamps can save the most energy. Alternatively, consider swapping out one of the A-shape LEDs with a lamp, such as an LED PAR, that may be more applicable to higher use areas like the kitchen

Conclusion 6: Water-related measures drive savings, but installation rates are low. Water measures contributed the majority of verified savings (DEC 74%, DEP 80%), yet fewer than half of all participants installed an aerator or showerhead (Table 7-2).

Table 7-2: Water Measure In-Service Rates

Measure	DEC ISR	DEP ISR
Kitchen Faucet Aerator	30%	40%
Bathroom Faucet Aerator	30%	34%
Showerhead	42%	50%

*Based on the participant survey responses

Recommendations: Review water savings measures' satisfaction and dislikes as well as elicit feedback from Save Energy and Water Kit Program to determine if there are ways to improve the ISR for water measures.

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Appendix A Summary Forms

DEC Summary Form

Description of program

The Energy Education in Schools Program is an energy efficiency program that provides free in-school performances by the National Theatre for Children (NTC) that teach elementary and middle school students about energy and conservation concepts in a humorous and engaging format. NTC provides teachers with: 1) student workbooks that reinforce topics taught in the NTC performance, which include a take-home form that students and parents can complete to receive an energy efficiency starter kit from DEC and 2) lesson plans associated with the content in the student workbooks.

Date	October 15, 2018
Region(s)	North and South Carolina
Evaluation Period	August 1, 2017 – July 31, 2018
Annual Gross kWh Savings	6,283,232 kWh
Per Kit kWh Savings	271.3 kWh per kit
Annual Gross Summer kW Savings	777.7 kW
Annual Gross Winter kW Savings	1,113.4 kW
Net-to-Gross Ratio	0.94
Process Evaluation	Yes
Previous Evaluation(s)	Yes

Evaluation Methodology

Impact Evaluation Activities

- *334 telephone/web surveys and analysis of 8 unique measures.*

Impact Evaluation Findings

- *Realization rate = 135% for energy impacts; 61% for demand impacts*
- *Net-to-gross ratio = 0.94*

Process Evaluation Activities

- *334 telephone/web surveys with student families and analysis of 8 unique measures.*
- *44 web surveys with teachers from participating schools; 5 in-depth follow up interviews*
- *1 in-depth interview with program staff*
- *1 in-depth interview with NTC implementation staff*
- *1 in-depth interview with R1 implementation staff*

Process Evaluation Findings

- *Teachers and parents aware of Duke Energy sponsorship of the kits*
- *Parents largely learning abut kits from materials from their children.*
- *Student families are highly satisfied with kit items.*
- *The NTC program is successfully influencing families to adopt energy saving behaviors*
- *Teachers are not using materials as much as previous years*

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DEP Summary Form

Description of program

The Energy Education in Schools Program is an energy efficiency program that provides free in-school performances by the National Theatre for Children (NTC) that teach elementary and middle school students about energy and conservation concepts in a humorous and engaging format. NTC provides teachers with: 1) student workbooks that reinforce topics taught in the NTC performance, which include a take-home form that students and parents can complete to receive an energy efficiency starter kit from DEP and 2) lesson plans associated with the content in the student workbooks.

Date	August 30, 2018
Region(s)	North and South Carolina
Evaluation Period	August 1, 2017 – May 31, 2018
Annual Gross kWh Savings	3,100,016 kWh
Per Kit kWh Savings	343.5 kWh per kit
Annual Gross Summer kW Savings	373.1 kW
Annual Gross Winter kW Savings	581.0 kW
Net-to-Gross Ratio	0.92
Process Evaluation	Yes
Previous Evaluation(s)	Yes

Evaluation Methodology

Impact Evaluation Activities

- *172 telephone/web surveys and analysis of 8 unique measures.*

Impact Evaluation Findings

- *Realization rate = 124% for energy impacts; 52% for demand impacts*
- *Net-to-gross ratio = 0.92*

Process Evaluation Activities

- *172 telephone/web surveys with student families and analysis of 8 unique measures.*
- *29 web surveys with teachers from participating schools; 5 in-depth follow up interviews*
- *1 in-depth interview with program staff*
- *1 in-depth interview with NTC implementation staff*
- *1 in-depth interview with R1 implementation staff*

Process Evaluation Findings

- *Teachers and parents aware of Duke Energy sponsorship of the kits*
- *Parents largely learning abut kits from materials from their children.*
- *Student families are highly satisfied with kit items.*
- *The NTC program is successfully influencing families to adopt energy saving behaviors*
- *Teachers are not using materials as much as previous years*

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Appendix B Measure Impact Results

Table B-1: DEC Program Year 2017-2018 per Unit Verified Impacts by Measure – Key Measure Parameters

Measure Category	Gross Energy Savings (kWh)	Gross Summer Demand (kW)	Gross Winter Demand (kW)	Realization Rate (Energy)	Free Ridership	Spillover	Net to Gross Ratio	M&V Factor (Energy) (RR x NTG)	Measure Life
9 Watt LEDs*	27.0	0.005	0.002	N/A	0.26			N/A	5
Nightlight	9.8	0.000	0.000	N/A	0.17			N/A	8
1.5 GPM Showerhead	121.6	0.010	0.027	N/A	0.16			N/A	10
1.0 GPM Bathroom Faucet Aerator	12.4	0.002	0.003	N/A	0.12	**0.09**	**0.93**	N/A	9
1.5 GPM Kitchen Faucet Aerator	38.2	0.005	0.008	N/A	0.13			N/A	9
Water Temperature Gauge Card	23.7	0.003	0.005	N/A	0.16			N/A	4
Outlet Insulating Gaskets	6.3	0.008	0.000	N/A	0.12			N/A	15
Behavioral Changes	32.3	0.001	0.002	N/A	-	-	1.00	N/A	0.3
Total	**271.3**	**0.034**	**0.048**	**135.0%**	**0.16**	**0.09**	**0.94**	**125.2%**	**-**

*Represents two 9 watt LEDs

Table B-2: DEP Program Year 2017-2018 per Unit Verified Impacts by Measure – Key Measure Parameters

Measure Category	Gross Energy Savings (kWh)	Gross Summer Demand (kW)	Gross Winter Demand (kW)	Realization Rate (Energy)	Free Ridership	Spillover	Net to Gross Ratio	M&V Factor (Energy) (RR x NTG)	Measure Life
9 Watt LEDs*	25.4	0.004	0.002	N/A	0.24			N/A	5
Nightlight	10.9	0.000	0.000	N/A	0.14			N/A	8
1.5 GPM Showerhead	168.1	0.013	0.038	N/A	0.14			N/A	10
1.0 GPM Bathroom Faucet Aerator	16.4	0.002	0.004	N/A	0.06	**0.05**	**0.92**	N/A	9
1.5 GPM Kitchen Faucet Aerator	62.3	0.008	0.014	N/A	0.10			N/A	9
Water Temperature Gauge Card	23.5	0.003	0.005	N/A	0.13			N/A	4
Outlet Insulating Gaskets	6.8	0.009	0.000	N/A	0.08			N/A	15
Behavioral Changes	30.1	0.001	0.002	N/A	-	-	1.00	N/A	0.3
Total	**343.5**	**0.041**	**0.064**	**124.3%**	**0.13**	**0.05**	**0.92**	**114.0%**	**-**

*Represents two 9 watt LEDs

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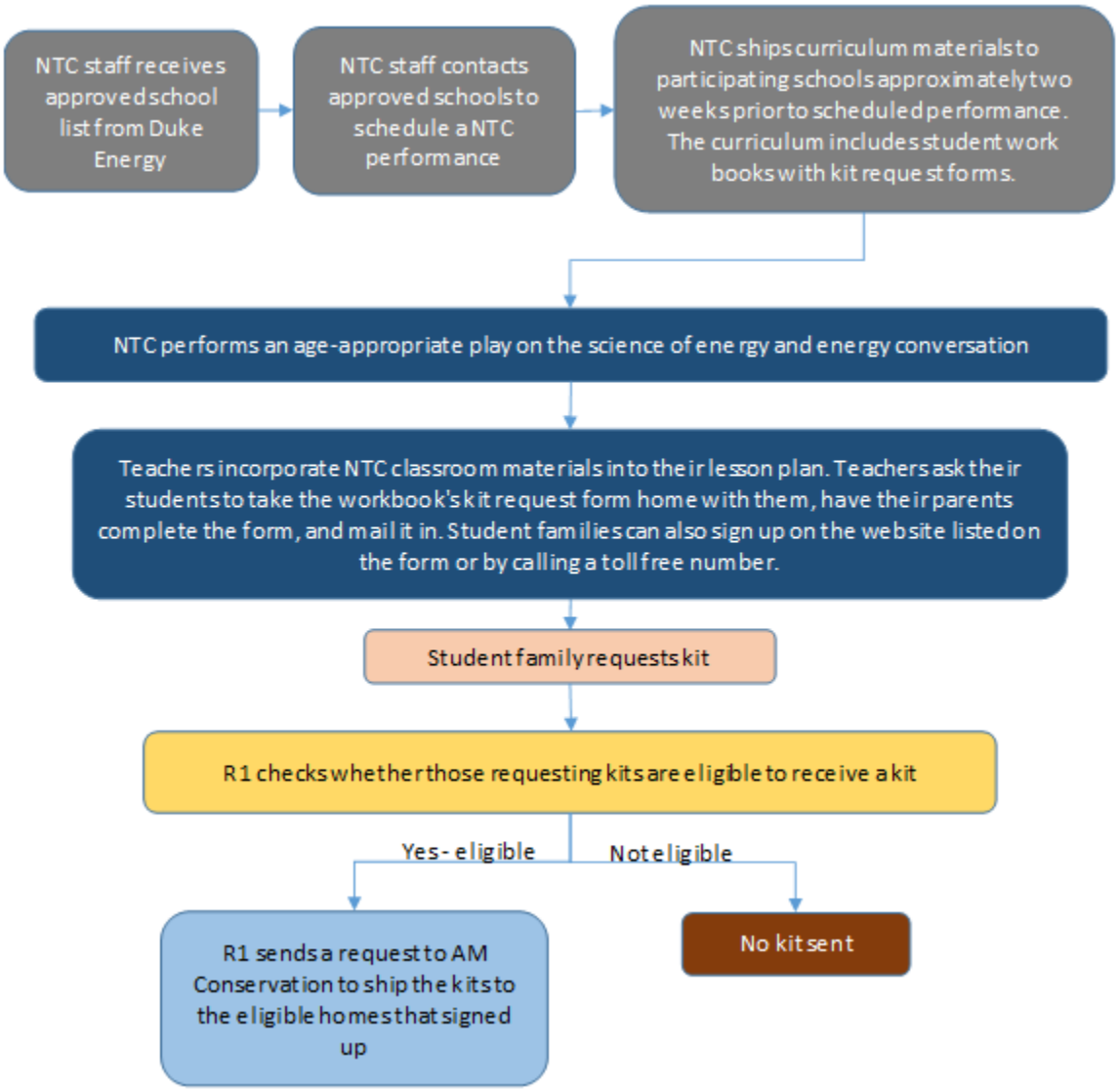
Appendix C Program Process Flow Chart



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Appendix D Program Performance Metrics

This appendix provides key program performance metrics, or PPIs. See Section 6.2 for the underlying results and more detailed findings.

Figure D-1: Program Experience PPIs – DEC

	Student Families		Teachers	
Awareness PPIs	%	n	%	n
Aware of DEC sponsorship	94%	334	84%	44
Learned of DEC sponsorship via program collateral	68%	334	32%	37
Learned of DEC sponsorship via teachers	28%	334	38%	37
Read Energy Saver Booklet	73%	334	-	
Rated Energy Saver Booklet as highly informative	82%	245		
Satisfaction PPIs				
NTC performance	-		95%	44
Usefulness of classroom materials	-		77%	26
Overall satisfaction with classroom materials	-		92%	26
Bathroom faucet aerator	86%	104	-	
Insulator gaskets	85%	103	-	
Night light	95%	259	-	
Light bulbs	95%	297	-	
Showerhead	86%	153	-	
Kitchen faucet aerator	85%	109	-	
Program influence on behavior PPIs				
Installed at least one kit measure	93%	334	-	
Plan to install measure[s] (of those that did not install any measures)	91%	22	-	
Respondents reporting spillover	19%	334	-	
Adopted new energy saving behaviors: parents	51%	334	-	
Adopted new energy saving behaviors: children	51%	334	-	
Challenges and opportunities for improvement PPIs				
Used NTC materials in classroom	-		59%	44
Suggested improvements to NTC performance	-		23%	44
Distributed kit forms to classroom	-		95%	44
Mentioned challenges/concerns with instructional materials	-		5%	44
Suggested curriculum improvements	-		14%	44

***Program collateral includes NTC materials and DEC marketing materials**

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Figure D-2: Program Experience PPIs – DEP

	Student Families		Teachers	
Awareness PPIs	**%**	**n**	**%**	**n**
Aware of DEP sponsorship	88%	172	79%	29
Learned of DEP sponsorship via program collateral	63%	172	65%	23
Learned of DEP sponsorship via teachers	27%	172	30%	23
Read Energy Saver Booklet	74%	172	-	
Rated Energy Saver Booklet as highly informative	86%	128	-	
Satisfaction PPIs				
NTC performance	-		59%	29
Usefulness of classroom materials	-		80%	10
Overall satisfaction with classroom materials	-		80%	10
Bathroom faucet aerator	88%	60	-	
Insulator gaskets	91%	54	-	
Night light	95%	130	-	
Light bulbs	97%	149	-	
Showerhead	93%	86	-	
Kitchen faucet aerator	90%	68	-	
Program influence on behavior PPIs				
Installed at least one kit measure	93%	172	-	
Plan to install measure[s] (of those that did not install any measures)	100%	12	-	
Respondents reporting spillover	18%	172	-	
Adopted new energy saving behaviors: parents	48%	172	-	
Adopted new energy saving behaviors: children	50%	172	-	
Challenges and opportunities for improvement PPIs				
Used NTC materials in classroom	-		34%	29
Suggested improvements to NTC performance	-		10%	29
Distributed kit forms to classroom	-		97%	29
Mentioned challenges/concerns with instructional materials	-		0%	29
Suggested curriculum improvements	-		10%	29

***Program collateral includes NTC materials and DEP marketing materials**

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Figure D-3: Student Family Demographics Reach PPIs

Duke Energy Carolinas

Housing Type

Detached	74%
Attached	16%
Mobile	11%

Ownership Status

Own	63%
Rent	35%
Occupy rent-free	1%

Household Size

One to two	14%
Three	20%
Four	35%
Five+	31%

Education

High school or less	22%
Some college	32%
Bachelors Degree	20%
Graduate Degree	22%
Refused / Don't know	4%

Income

< $30k	24%
$30k to < $60k	27%
$60k to < $75k	6%
$75k to < $100k	12%
$100k+	13%
Refused / Don't know	17%

Duke Energy Progress

Housing Type

Detached	60%
Attached	20%
Mobile	19%

Housing Type

Detached	60%
Attached	20%
Mobile	19%

Ownership Status

Own	65%
Rent	35%

Education

High school or less	24%
Some college	31%
Bachelors Degree	22%
Graduate Degree	22%
Refused / Don't know	1%

Education

High school or less	24%
Some college	31%
Bachelors Degree	22%
Graduate Degree	22%
Refused / Don't know	1%

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Appendix E Billing Regression Analysis

This appendix provides additional detail regarding the billing regression analysis. Absent a randomized control trial, billing analysis can be unreliable when the percent energy savings are small. In order to assess if the billing analysis produces reliable results, the evaluation team implemented a series of placebo pressure tests. Rather than produce zero impacts, the billing analysis incorrectly concluded that the false enrollment dates led to changes in energy use when in fact no intervention had taken place. Moreover, the models incorrectly concluded that the erroneous impacts were statistically significant in several instances – an example of false precision. The evaluation team's conclusion is not that there were no energy savings generated by the NTC program, but rather that billing analysis was not the correct tool for estimating the small percent energy savings from the program. Thus, the evaluation team's recommendation is to rely on the engineering analysis and findings as the source of our verified gross and net savings for the programs.

The appendix includes:

1. A side by comparison of energy use, MyHER program penetration, and share of participants enrolling for the NTC kits over time for participants, and the comparison group. This includes both the pre- and post-intervention data and does not include any energy modeling.
2. Visual comparison of the side-by-side comparisons
3. The placebo tests output for the difference-in-differences panel regression model
4. The placebo tests output for the pre-post panel regression model

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Table E-1: Side-by-side Comparison of Control and Treatment Groups

Year and month	Daily kWh		Diff	% Diff	Kit Penetration (%)	
	Control	Treated			Treat	Control
Aug-15	52.9	52.8	-0.11	-0.20%	0.0%	0.0%
Sep-15	54.8	54.6	-0.18	-0.34%	0.0%	0.0%
Oct-15	41.6	41.4	-0.15	-0.36%	0.0%	0.0%
Nov-15	32.5	32.3	-0.16	-0.50%	0.0%	0.0%
Dec-15	40.4	40.3	-0.13	-0.31%	0.0%	0.0%
Jan-16	53.9	53.8	-0.17	-0.32%	0.0%	0.0%
Feb-16	58.0	57.9	-0.19	-0.32%	0.0%	0.0%
Mar-16	53.9	53.8	-0.10	-0.19%	0.0%	0.0%
Apr-16	41.9	41.7	-0.15	-0.36%	0.0%	0.0%
May-16	32.5	32.3	-0.21	-0.66%	0.0%	0.0%
Jun-16	36.2	35.9	-0.27	-0.74%	0.0%	0.0%
Jul-16	41.8	41.5	-0.29	-0.69%	0.0%	0.0%
Aug-16	51.4	50.9	-0.44	-0.85%	0.0%	0.0%
Sep-16	49.4	49.1	-0.25	-0.51%	0.0%	0.0%
Oct-16	36.1	36.0	-0.11	-0.30%	0.0%	0.0%
Nov-16	33.0	33.1	0.06	0.18%	0.0%	0.0%
Dec-16	38.1	38.6	0.48	1.25%	0.0%	0.0%
Jan-17	51.4	51.7	0.34	0.67%	0.0%	0.0%
Feb-17	60.4	60.7	0.22	0.36%	0.0%	0.0%
Mar-17	58.4	59.3	0.85	1.45%	0.0%	0.0%
Apr-17	48.1	49.2	1.12	2.32%	0.0%	0.2%
May-17	34.1	34.8	0.69	2.03%	0.0%	6.5%
Jun-17	36.9	37.2	0.25	0.67%	0.0%	26.3%
Jul-17	46.5	46.7	0.15	0.32%	0.0%	45.6%

**Only includes customers with pre-treatment data from Aug 2015 to July 2016

*Billing periods were calendarized (calendar month)

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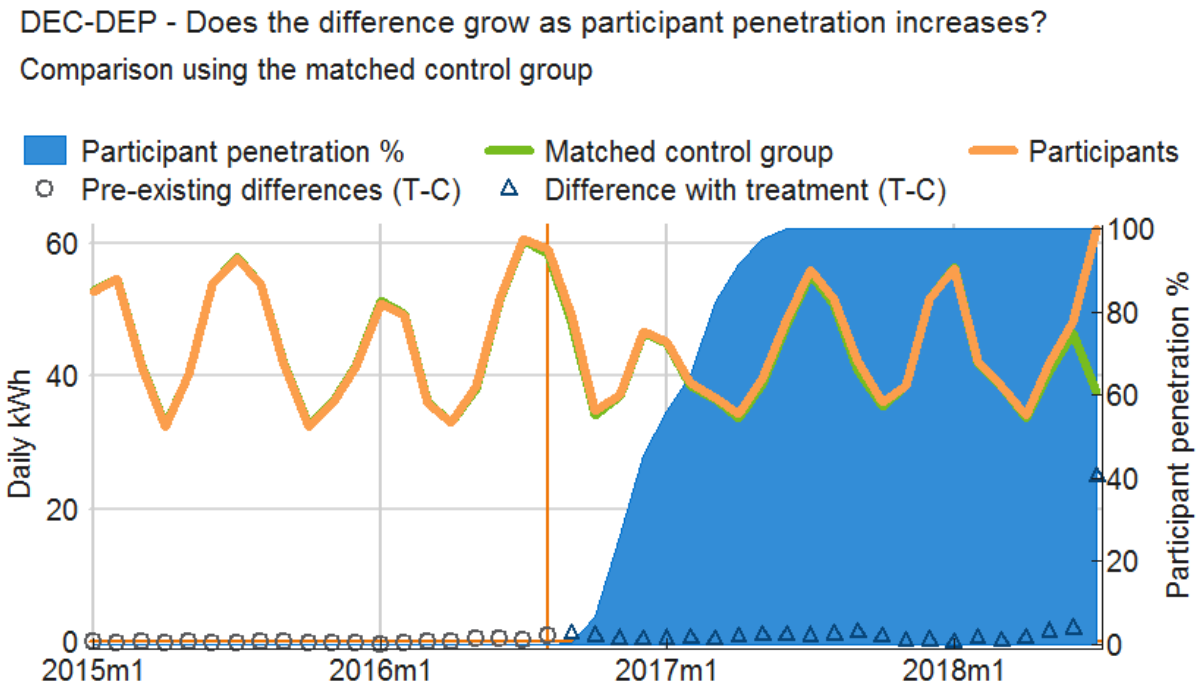
Figure E-1: Visual Comparison of Control and Treatment Groups



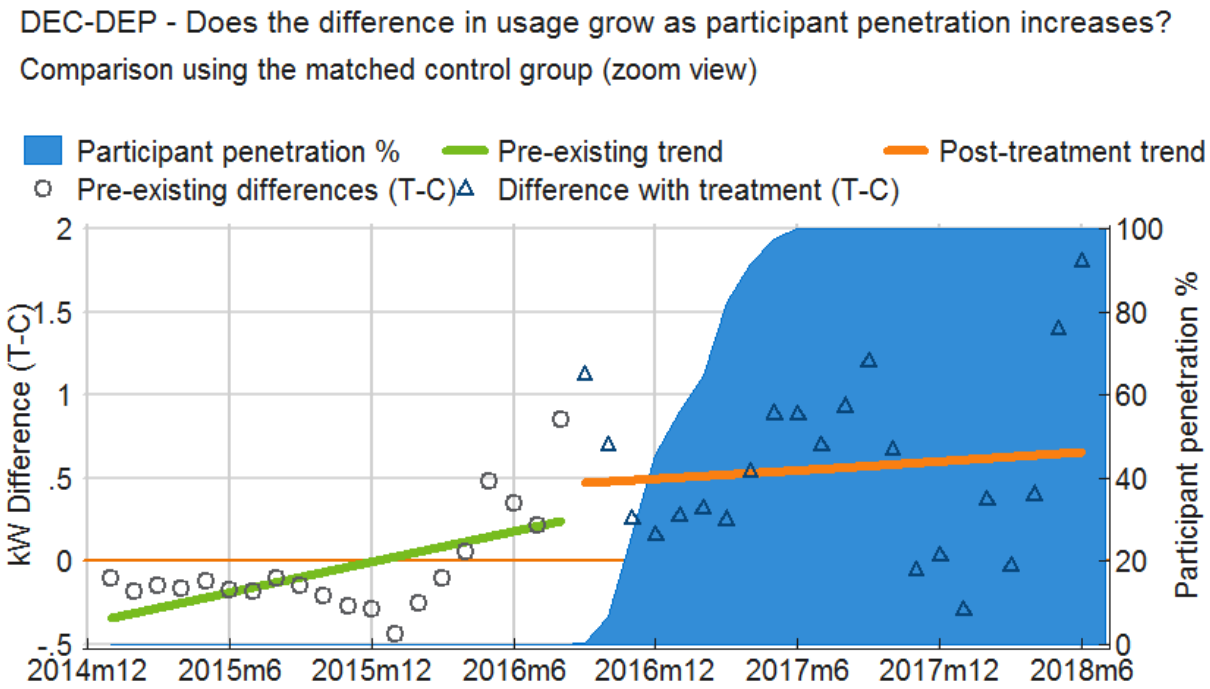


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Figure E-2: Difference-in-Differences Panel Regression Model Placebo Test Results – 3 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     628258
                                                 F(  27, 594755)  =   12265.82
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7144
                                                 Adj R-squared    =     0.6983
                                                 Root MSE         =    12.2402
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo3_post	-.5256702	.0923383	-5.69	0.000	-.7066503	-.3446901
pseudo3_partxpost	.474797	.1007961	4.71	0.000	.2772399	.6723541
daily_cdd	-.2624074	.020821	-12.60	0.000	-.3032158	-.2215991
daily_hdd	-.2409448	.0212211	-11.35	0.000	-.2825375	-.199352
moyr						
665	14.97549	.1756674	85.25	0.000	14.63119	15.31979
666	19.55672	.2106636	92.83	0.000	19.14383	19.96961
667	14.80155	.1643195	90.08	0.000	14.47949	15.12361
668	1.706849	.1002563	17.02	0.000	1.51035	1.903349
669	-7.909724	.2232815	-35.42	0.000	-8.347349	-7.4721
670	-3.208551	.315886	-10.16	0.000	-3.827677	-2.589425
671	2.497413	.3207077	7.79	0.000	1.868836	3.12599
672	15.58922	.6469555	24.10	0.000	14.3212	16.85723
673	12.54181	.5461112	22.97	0.000	11.47145	13.61217
674	-3.647916	.2698748	-13.52	0.000	-4.176861	-3.11897
675	-7.109081	.2069337	-34.35	0.000	-7.514665	-6.703498
676	-2.215585	.1125347	-19.69	0.000	-2.436149	-1.99502
677	12.51956	.17157	72.97	0.000	12.18328	12.85583
678	22.42831	.2298776	97.57	0.000	21.97776	22.87886
679	20.59289	.2123426	96.98	0.000	20.17671	21.00908
680	9.216912	.1433816	64.28	0.000	8.935889	9.497936
681	-6.136477	.1697139	-36.16	0.000	-6.469111	-5.803843
682	-1.411565	.3650647	-3.87	0.000	-2.12708	-.6960503
683	9.723139	.5300884	18.34	0.000	8.684183	10.7621
684	7.686554	.487174	15.78	0.000	6.731709	8.6414
685	.8500553	.3933818	2.16	0.031	.0790395	1.621071
686	-.8975118	.4275042	-2.10	0.036	-1.735406	-.0596172
687	-5.511773	.2879834	-19.14	0.000	-6.076211	-4.947335
_cons	41.93327	.1165433	359.81	0.000	41.70485	42.1617
account_id	F(33475, 594755) =		34.112	0.000	(33476 categories)	

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Figure E-3: Difference-in-Differences Panel Regression Model Placebo Test Results – 4 Months Prior

```
Linear regression, absorbing indicators          Number of obs   =     659041
                                                 F(  27, 625538) =   13689.79
                                                 Prob > F        =     0.0000
                                                 R-squared       =     0.7165
                                                 Adj R-squared   =     0.7013
                                                 Root MSE        =    12.1196
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo4_post	-.4247787	.0840387	-5.05	0.000	-.5894918	-.2600656
pseudo4_partxpost	.4851166	.0846007	5.73	0.000	.3193019	.6509313
daily_cdd	-.2654691	.020141	-13.18	0.000	-.3049448	-.2259935
daily_hdd	-.2354826	.0207305	-11.36	0.000	-.2761137	-.1948515
moyr						
664	8.183583	.1832708	44.65	0.000	7.824378	8.542788
665	23.18311	.3132845	74.00	0.000	22.56908	23.79713
666	27.77034	.3501534	79.31	0.000	27.08406	28.45663
667	23.00724	.3009306	76.45	0.000	22.41743	23.59705
668	9.896078	.2110981	46.88	0.000	9.482333	10.30982
669	.2304075	.1015936	2.27	0.023	.0312874	.4295276
670	4.905798	.166716	29.43	0.000	4.57904	5.232556
671	10.61005	.1711686	61.99	0.000	10.27457	10.94554
672	23.61627	.480162	49.18	0.000	22.67517	24.55737
673	20.59528	.3823227	53.87	0.000	19.84594	21.34462
674	4.478541	.1299933	34.45	0.000	4.223759	4.733324
675	1.033154	.0965464	10.70	0.000	.843926	1.222382
676	5.938123	.1368656	43.39	0.000	5.669871	6.206376
677	20.79924	.3093994	67.22	0.000	20.19283	21.40565
678	30.72265	.3700041	83.03	0.000	29.99745	31.44785
679	28.78262	.350431	82.13	0.000	28.09579	29.46946
680	17.32469	.271811	63.74	0.000	16.79195	17.85743
681	1.983447	.1159611	17.10	0.000	1.756167	2.210727
682	6.528178	.2243711	29.10	0.000	6.088418	6.967938
683	17.67602	.36939	47.85	0.000	16.95203	18.40002
684	15.79898	.3340732	47.29	0.000	15.1442	16.45375
685	8.773683	.2505606	35.02	0.000	8.282592	9.264774
686	7.24334	.2872157	25.22	0.000	6.680406	7.806273
_cons	33.76435	.1042117	324.00	0.000	33.5601	33.9686
account_id	F(33475, 625538) =		35.716	0.000	(33476 categories)	

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Figure E-4: Difference-in-Differences Panel Regression Model Placebo Test Results – 5 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     687621
                                                 F(  27, 654118)  =   13444.51
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7106
                                                 Adj R-squared    =     0.6958
                                                 Root MSE         =    12.2627
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo5_post	-.2841678	.0819632	-3.47	0.001	-.444813	-.1235227
pseudo5_partxpost	.5195482	.0770491	6.74	0.000	.3685345	.6705619
daily_cdd	-.4206152	.0186884	-22.51	0.000	-.4572439	-.3839866
daily_hdd	-.0656947	.0194092	-3.38	0.001	-.103736	-.0276534
moyr						
663	-9.246892	.2048831	-45.13	0.000	-9.648456	-8.845328
664	.2435606	.33841	0.72	0.472	-.4197121	.9068332
665	16.37426	.4606622	35.55	0.000	15.47138	17.27715
666	21.26268	.4942919	43.02	0.000	20.29388	22.23148
667	16.09737	.4494461	35.82	0.000	15.21647	16.97827
668	2.212501	.3655132	6.05	0.000	1.496107	2.928896
669	-9.344392	.1735278	-53.85	0.000	-9.684501	-9.004283
670	-5.481911	.1085518	-50.50	0.000	-5.694669	-5.269153
671	.1810658	.1061787	1.71	0.088	-.0270411	.3891727
672	10.49394	.275661	38.07	0.000	9.953652	11.03423
673	8.294643	.1902391	43.60	0.000	7.921781	8.667505
674	-5.512512	.1359901	-40.54	0.000	-5.779048	-5.245975
675	-8.374107	.1868889	-44.81	0.000	-8.740404	-8.007811
676	-2.477432	.2890254	-8.57	0.000	-3.043912	-1.910951
677	13.99713	.457528	30.59	0.000	13.10039	14.89387
678	24.32712	.512294	47.49	0.000	23.32304	25.3312
679	22.09522	.4942646	44.70	0.000	21.12648	23.06397
680	9.967723	.4222883	23.60	0.000	9.140051	10.79539
681	-7.01392	.2451765	-28.61	0.000	-7.494458	-6.533382
682	-4.366852	.132827	-32.88	0.000	-4.627189	-4.106516
683	5.525837	.200146	27.61	0.000	5.133557	5.918117
684	3.966411	.179768	22.06	0.000	3.614071	4.31875
685	-2.179574	.1592099	-13.69	0.000	-2.491621	-1.867528
_cons	42.38615	.2649444	159.98	0.000	41.86686	42.90543
account_id	F(33475, 654118) =		36.658	0.000	(33476 categories)	

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Figure E-5: Difference-in-Differences Panel Regression Model Placebo Test Results – 6 Months Prior

```
Linear regression, absorbing indicators          Number of obs   =     710185
                                                 F(  27, 676682) =   12262.54
                                                 Prob > F        =     0.0000
                                                 R-squared       =     0.6877
                                                 Adj R-squared   =     0.6723
                                                 Root MSE        =    13.1854
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo6_post	-.2160949	.0867745	-2.49	0.013	-.3861702	-.0460197
pseudo6_partxpost	.5809622	.0778351	7.46	0.000	.428408	.7335165
daily_cdd	-.596042	.0194923	-30.58	0.000	-.6342462	-.5578377
daily_hdd	.0785573	.019962	3.94	0.000	.0394324	.1176821
moyr						
662	-11.93424	.3343578	-35.69	0.000	-12.58957	-11.27891
663	-19.77144	.5154094	-38.36	0.000	-20.78162	-18.76125
664	-8.98844	.6590042	-13.64	0.000	-10.28007	-7.696813
665	8.382719	.7835346	10.70	0.000	6.847017	9.918421
666	13.61014	.8173818	16.65	0.000	12.0081	15.21218
667	7.990053	.7722869	10.35	0.000	6.476396	9.50371
668	-6.742756	.6868977	-9.82	0.000	-8.089053	-5.396459
669	-20.17191	.4789355	-42.12	0.000	-21.1106	-19.23321
670	-17.00842	.3865308	-44.00	0.000	-17.766	-16.25083
671	-11.37184	.3814024	-29.82	0.000	-12.11937	-10.6243
672	-3.371243	.1145078	-29.44	0.000	-3.595675	-3.146812
673	-4.869892	.1803676	-27.00	0.000	-5.223406	-4.516377
674	-16.63903	.4312435	-38.58	0.000	-17.48426	-15.79381
675	-19.06178	.4947421	-38.53	0.000	-20.03146	-18.0921
676	-12.19545	.6068682	-20.10	0.000	-13.38489	-11.00601
677	5.935216	.7802705	7.61	0.000	4.405911	7.46452
678	16.68188	.8351525	19.97	0.000	15.045	18.31875
679	14.25023	.817349	17.43	0.000	12.64826	15.85221
680	1.592694	.7453375	2.14	0.033	.1318565	3.053531
681	-17.40192	.5527553	-31.48	0.000	-18.4853	-16.31854
682	-16.24748	.3630762	-44.75	0.000	-16.9591	-15.53587
683	-7.499445	.2351205	-31.90	0.000	-7.960273	-7.038616
684	-8.718828	.2718093	-32.08	0.000	-9.251566	-8.186091
_cons	52.4287	.5864711	89.40	0.000	51.27924	53.57817
account_id	F(33475, 676682) =		34.163	0.000	(33476 categories)	

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Figure E-6: Difference-in-Differences Panel Regression Model Placebo Test Results – 7 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     730052
                                                 F(  27, 696549)  =   11715.39
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.6776
                                                 Adj R-squared    =     0.6621
                                                 Root MSE         =    13.6259
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo7_post	-.2046139	.0887691	-2.31	0.021	-.3785986	-.0306293
pseudo7_partxpost	.6511034	.076956	8.46	0.000	.5002723	.8019346
daily_cdd	-.6336218	.0198524	-31.92	0.000	-.6725317	-.5947118
daily_hdd	.0715356	.0200871	3.56	0.000	.0321655	.1109057
moyr						
661	1.614047	.1338197	12.06	0.000	1.351765	1.876329
662	-10.42732	.2601788	-40.08	0.000	-10.93726	-9.917377
663	-18.28754	.4388951	-41.67	0.000	-19.14776	-17.42732
664	-7.37477	.5835965	-12.64	0.000	-8.518601	-6.23094
665	10.23146	.7107887	14.39	0.000	8.838334	11.62458
666	15.53028	.7455107	20.83	0.000	14.0691	16.99145
667	9.812764	.6992321	14.03	0.000	8.442292	11.18324
668	-5.080311	.611999	-8.30	0.000	-6.279809	-3.880813
669	-18.69904	.4024735	-46.46	0.000	-19.48788	-17.91021
670	-15.51035	.3110742	-49.86	0.000	-16.12005	-14.90065
671	-9.86332	.3060847	-32.22	0.000	-10.46324	-9.263404
672	-1.774626	.1095627	-16.20	0.000	-1.989365	-1.559887
673	-3.233484	.1261926	-25.62	0.000	-3.480817	-2.986151
674	-15.18973	.3565045	-42.61	0.000	-15.88847	-14.49099
675	-17.60579	.4195775	-41.96	0.000	-18.42815	-16.78344
676	-10.6504	.5315033	-20.04	0.000	-11.69213	-9.60867
677	7.654997	.7077851	10.82	0.000	6.267762	9.042233
678	18.46994	.7642374	24.17	0.000	16.97206	19.96782
679	16.23986	.7468902	21.74	0.000	14.77598	17.70374
680	3.337503	.6722143	4.96	0.000	2.019985	4.655021
681	-15.97908	.4785406	-33.39	0.000	-16.917	-15.04115
682	-14.82792	.2934069	-50.54	0.000	-15.40299	-14.25285
683	-5.91968	.1847038	-32.05	0.000	-6.281694	-5.557667
_cons	51.02393	.508591	100.32	0.000	50.0271	52.02075
account_id	F(33475, 696549) =		33.802	0.000	(33476 categories)	

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Figure E-7: Difference-in-Differences Panel Regression Model Placebo Test Results – 8 Months Prior

```
Linear regression, absorbing indicators          Number of obs   =     714019
                                                 F(  26, 680517) =   12483.04
                                                 Prob > F        =     0.0000
                                                 R-squared       =     0.6803
                                                 Adj R-squared   =     0.6646
                                                 Root MSE        =    13.5214
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo8_post	-.2527771	.0879036	-2.88	0.004	-.4250653	-.0804889
pseudo8_partxpost	.7253856	.074626	9.72	0.000	.5791211	.8716502
daily_cdd	-.6138513	.0199662	-30.74	0.000	-.6529844	-.5747183
daily_hdd	.0639577	.0202341	3.16	0.002	.0242995	.1036159
moyr						
661	1.645427	.13356	12.32	0.000	1.383653	1.9072
662	-10.51839	.2614451	-40.23	0.000	-11.03081	-10.00597
663	-18.4631	.4416991	-41.80	0.000	-19.32882	-17.59739
664	-7.66233	.5874254	-13.04	0.000	-8.813665	-6.510996
665	9.811116	.7153954	13.71	0.000	8.408964	11.21327
666	15.07201	.7503207	20.09	0.000	13.60141	16.54261
667	9.405752	.7037725	13.36	0.000	8.02638	10.78512
668	-5.396655	.6160066	-8.76	0.000	-6.604007	-4.189302
669	-18.85279	.4049933	-46.55	0.000	-19.64656	-18.05901
670	-15.62536	.3128102	-49.95	0.000	-16.23845	-15.01226
671	-9.979628	.3077796	-32.42	0.000	-10.58287	-9.37639
672	-1.683788	.1102975	-15.27	0.000	-1.899968	-1.467609
673	-3.359955	.1290097	-26.04	0.000	-3.61281	-3.1071
674	-15.39415	.3595886	-42.81	0.000	-16.09893	-14.68937
675	-17.78332	.4224407	-42.10	0.000	-18.61129	-16.95535
676	-10.94766	.53508	-20.46	0.000	-11.9964	-9.89892
677	7.107528	.7126016	9.97	0.000	5.710852	8.504204
678	18.18085	.7703218	23.60	0.000	16.67104	19.69065
679	15.86131	.7514087	21.11	0.000	14.38857	17.33404
680	2.906622	.6767679	4.29	0.000	1.580179	4.233065
681	-16.19297	.4812871	-33.65	0.000	-17.13628	-15.24966
682	-14.87434	.2937033	-50.64	0.000	-15.44999	-14.29869
_cons	51.21454	.5121434	100.00	0.000	50.21075	52.21832
account_id	F(33475, 680517) =		33.117	0.000	(33476 categories)	

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Figure E-8: Difference-in-Differences Panel Regression Model Placebo Test Results – 9 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     693985
                                                 F(  25, 660484)  =   12864.99
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.6806
                                                 Adj R-squared    =     0.6644
                                                 Root MSE         =    13.5794
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo9_post	-.2994821	.0883002	-3.39	0.001	-.4725477	-.1264165
pseudo9_partxpost	.7426867	.0742484	10.00	0.000	.5971623	.8882111
daily_cdd	-.63676	.0206267	-30.87	0.000	-.6771878	-.5963323
daily_hdd	.0884283	.020969	4.22	0.000	.0473298	.1295268
moyr						
661	1.544798	.1358086	11.37	0.000	1.278618	1.810979
662	-10.22824	.2696294	-37.93	0.000	-10.7567	-9.699775
663	-17.94059	.4570697	-39.25	0.000	-18.83643	-17.04474
664	-6.94917	.6086018	-11.42	0.000	-8.14201	-5.756331
665	10.69082	.7415713	14.42	0.000	9.237364	12.14428
666	15.99617	.7778181	20.57	0.000	14.47167	17.52066
667	10.27052	.729504	14.08	0.000	8.840714	11.70032
668	-4.645794	.6383212	-7.28	0.000	-5.896883	-3.394706
669	-18.37783	.4189051	-43.87	0.000	-19.19888	-17.55679
670	-15.27227	.3231137	-47.27	0.000	-15.90556	-14.63898
671	-9.577161	.3183308	-30.09	0.000	-10.20108	-8.953243
672	-1.819487	.1145699	-15.88	0.000	-2.04404	-1.594934
673	-3.36976	.1332714	-25.28	0.000	-3.630968	-3.108552
674	-14.96729	.371883	-40.25	0.000	-15.69617	-14.23841
675	-17.28389	.4372255	-39.53	0.000	-18.14084	-16.42695
676	-10.34816	.5544759	-18.66	0.000	-11.43491	-9.261405
677	8.208008	.7400288	11.09	0.000	6.757575	9.65844
678	19.20255	.798279	24.05	0.000	17.63795	20.76715
679	16.73138	.7791	21.48	0.000	15.20437	18.25839
680	3.777532	.7010761	5.39	0.000	2.403445	5.151618
681	-15.57675	.4972935	-31.32	0.000	-16.55143	-14.60207
_cons	50.60445	.5303875	95.41	0.000	49.56491	51.64399
account_id	F(33475, 660484) =		32.031	0.000	(33476 categories)	

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Figure E-9: Pre-Post Panel Regression Model Placebo Test Results – 3 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     113864
                                                 F(  14,  97080)  =    5848.72
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.8027
                                                 Adj R-squared    =     0.7686
                                                 Root MSE         =    10.6273
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo3_post	-.5314323	.1114073	-4.77	0.000	-.7497894	-.3130752
daily_cdd	-.3169182	.0425132	-7.45	0.000	-.4002436	-.2335929
daily_hdd	-.0590921	.0494516	-1.19	0.232	-.1560167	.0378326
month						
2	-5.511652	.3302651	-16.69	0.000	-6.158968	-4.864336
3	-7.344523	.3685627	-19.93	0.000	-8.066901	-6.622144
4	-10.10898	.8802062	-11.48	0.000	-11.83418	-8.383791
5	-6.835175	.9498222	-7.20	0.000	-8.696816	-4.973534
6	8.631092	1.343093	6.43	0.000	5.998646	11.26354
7	18.64833	1.461028	12.76	0.000	15.78474	21.51193
8	17.08849	1.420058	12.03	0.000	14.30519	19.87178
9	5.656242	1.254013	4.51	0.000	3.198392	8.114093
10	-10.81806	.8036582	-13.46	0.000	-12.39322	-9.242901
11	-8.042124	.3424341	-23.49	0.000	-8.713291	-7.370957
12	1.264436	.2383657	5.30	0.000	.7972415	1.73163
_cons	46.49572	.9312778	49.93	0.000	44.67042	48.32101
account_id	F(16769, 97080) =		18.288	0.000	(16770 categories)	

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Figure E-10 Pre-Post Panel Regression Model Placebo Test Results – 4 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     130634
                                                 F(  14, 113850)  =    7702.38
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7963
                                                 Adj R-squared    =     0.7663
                                                 Root MSE         =    10.5521
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo4_post	-.1019962	.1000816	-1.02	0.308	-.2981547	.0941622
daily_cdd	-.2495264	.037817	-6.60	0.000	-.3236471	-.1754057
daily_hdd	-.1536438	.0435237	-3.53	0.000	-.2389495	-.0683381
month						
2	-6.529509	.2999275	-21.77	0.000	-7.117362	-5.941655
3	-8.272702	.3264474	-25.34	0.000	-8.912534	-7.63287
4	-13.7987	.6396182	-21.57	0.000	-15.05234	-12.54505
5	-8.457698	.8622915	-9.81	0.000	-10.14778	-6.76762
6	6.275922	1.206549	5.20	0.000	3.911103	8.64074
7	16.04963	1.307554	12.27	0.000	13.48685	18.61242
8	14.40293	1.267052	11.37	0.000	11.91952	16.88633
9	3.200197	1.120023	2.86	0.004	1.004968	5.395425
10	-12.40505	.7229552	-17.16	0.000	-13.82203	-10.98807
11	-9.062039	.3227195	-28.08	0.000	-9.694565	-8.429514
12	1.292102	.2099939	6.15	0.000	.8805167	1.703686
_cons	48.17469	.8450344	57.01	0.000	46.51844	49.83095
account_id	F(16769, 113850) =		19.675	0.000	(16770 categories)	

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Figure E-11: Pre-Post Panel Regression Model Placebo Test Results – 5 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     147404
                                                 F(  14, 130620)  =    8335.33
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7833
                                                 Adj R-squared    =     0.7554
                                                 Root MSE         =    10.7176
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo5_post	.4194159	.0891347	4.71	0.000	.2447135	.5941182
daily_cdd	-.3738546	.0305868	-12.22	0.000	-.4338041	-.313905
daily_hdd	-.0206818	.0302047	-0.68	0.494	-.0798825	.0385188
month						
2	-5.88248	.2519248	-23.35	0.000	-6.376248	-5.388711
3	-8.575499	.3207776	-26.73	0.000	-9.204218	-7.946781
4	-11.24155	.4305582	-26.11	0.000	-12.08543	-10.39766
5	-5.291916	.581889	-9.09	0.000	-6.432408	-4.151423
6	10.73817	.8377623	12.82	0.000	9.096175	12.38017
7	20.74429	.9219409	22.50	0.000	18.9373	22.55128
8	18.87646	.8943449	21.11	0.000	17.12356	20.62936
9	7.029936	.7837181	8.97	0.000	5.493863	8.56601
10	-9.87039	.5036506	-19.60	0.000	-10.85754	-8.883244
11	-8.10301	.2452054	-33.05	0.000	-8.583609	-7.622412
12	1.338839	.1979009	6.77	0.000	.9509568	1.726721
_cons	45.06678	.5613088	80.29	0.000	43.96663	46.16694
account_id	F(16769, 130620) =		20.732	0.000	(16770 categories)	

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Figure E-12: Pre-Post Panel Regression Model Placebo Test Results – 6 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     164174
                                                 F(  14, 147390)  =    6405.51
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7329
                                                 Adj R-squared    =     0.7025
                                                 Root MSE         =    12.2721
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo6_post	-.9050612	.0909866	-9.95	0.000	-1.083393	-.7267292
daily_cdd	-1.063065	.0274973	-38.66	0.000	-1.11696	-1.009171
daily_hdd	.6265702	.0196531	31.88	0.000	.5880505	.6650899
month						
2	-.3945862	.1888234	-2.09	0.037	-.7646763	-.024496
3	-3.983506	.2961308	-13.45	0.000	-4.563916	-3.403096
4	-3.870804	.3644687	-10.62	0.000	-4.585155	-3.156453
5	6.108178	.4574688	13.35	0.000	5.211549	7.004808
6	29.04072	.6475631	44.85	0.000	27.77151	30.30993
7	41.23932	.7144837	57.72	0.000	39.83894	42.63969
8	38.68867	.6880759	56.23	0.000	37.34005	40.03728
9	24.37551	.5916628	41.20	0.000	23.21586	25.53515
10	-.0603162	.3778493	-0.16	0.873	-.8008932	.6802609
11	-4.625116	.2321373	-19.92	0.000	-5.0801	-4.170131
12	-.2016072	.2094856	-0.96	0.336	-.6121949	.2089805
_cons	34.95556	.4414944	79.18	0.000	34.09024	35.82088
account_id	F(16769, 147390) =		18.564	0.000	(16770 categories)	

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Figure E-13: Pre-Post Panel Regression Model Placebo Test Results – 7 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     180944
                                                 F(  14, 164160)  =    5736.80
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7117
                                                 Adj R-squared    =     0.6823
                                                 Root MSE         =    13.0199
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo7_post	-.8407146	.095874	-8.77	0.000	-1.028626	-.6528037
daily_cdd	-1.141725	.0275736	-41.41	0.000	-1.195768	-1.087681
daily_hdd	.5698512	.0177381	32.13	0.000	.5350848	.6046175
month						
2	.0439932	.1488409	0.30	0.768	-.2477317	.3357181
3	-4.113582	.3049181	-13.49	0.000	-4.711215	-3.51595
4	-3.996618	.3745488	-10.67	0.000	-4.730726	-3.262511
5	5.926219	.4669832	12.69	0.000	5.010942	6.841496
6	29.21162	.6597604	44.28	0.000	27.9185	30.50474
7	41.49021	.7276829	57.02	0.000	40.06397	42.91645
8	39.25332	.6999674	56.08	0.000	37.8814	40.62524
9	24.52563	.5964482	41.12	0.000	23.35661	25.69466
10	-.4510099	.3884665	-1.16	0.246	-1.212396	.310376
11	-4.661574	.2371764	-19.65	0.000	-5.126434	-4.196713
12	.27908	.1831745	1.52	0.128	-.0799381	.6380981
_cons	35.67814	.4570338	78.06	0.000	34.78236	36.57391
account_id	F(16769, 164160) =		19.220	0.000	(16770 categories)	

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Figure E-14: Pre-Post Panel Regression Model Placebo Test Results – 8 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     197714
                                                 F(  14, 180930)  =    6483.45
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7191
                                                 Adj R-squared    =     0.6931
                                                 Root MSE         =    12.6061
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo8_post	-.6826227	.0717895	-9.51	0.000	-.8233285	-.5419168
daily_cdd	-1.109996	.02343	-47.37	0.000	-1.155918	-1.064073
daily_hdd	.5780858	.0111235	51.97	0.000	.556284	.5998875
month						
2	-.0808791	.1344885	-0.60	0.548	-.3444736	.1827153
3	-4.021167	.21272	-18.90	0.000	-4.438094	-3.604241
4	-3.895118	.2534334	-15.37	0.000	-4.391842	-3.398394
5	5.953745	.3119416	19.09	0.000	5.342347	6.565144
6	28.81599	.4565089	63.12	0.000	27.92124	29.71074
7	41.53259	.5171521	80.31	0.000	40.51899	42.5462
8	39.11434	.4945979	79.08	0.000	38.14493	40.08374
9	24.27672	.4197223	57.84	0.000	23.45408	25.09937
10	-.508134	.2831966	-1.79	0.073	-1.063193	.0469248
11	-4.77302	.2041849	-23.38	0.000	-5.173218	-4.372823
12	-.0497681	.1625679	-0.31	0.760	-.3683974	.2688612
_cons	35.50422	.2853676	124.42	0.000	34.9449	36.06353
account_id	F(16769, 180930) =		22.212	0.000	(16770 categories)	

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Figure E-15 Pre-Post Panel Regression Model Placebo Test Results – 9 Months Prior

```
Linear regression, absorbing indicators          Number of obs    =     214484
                                                 F(  14, 197700)  =    7887.48
                                                 Prob > F         =     0.0000
                                                 R-squared        =     0.7267
                                                 Adj R-squared    =     0.7035
                                                 Root MSE         =    12.2177
```

daily_kwh	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pseudo9_post	-.4499133	.065228	-6.90	0.000	-.5777586	-.322068
daily_cdd	-1.043921	.021781	-47.93	0.000	-1.086611	-1.001231
daily_hdd	.5762994	.0107475	53.62	0.000	.5552346	.5973642
month						
2	-.2012934	.1329344	-1.51	0.130	-.4618416	.0592548
3	-3.977699	.2044698	-19.45	0.000	-4.378455	-3.576943
4	-3.984402	.2431879	-16.38	0.000	-4.461045	-3.50776
5	5.606003	.3005122	18.65	0.000	5.017007	6.195
6	28.40953	.4369316	65.02	0.000	27.55315	29.2659
7	40.61824	.4882978	83.18	0.000	39.66119	41.57529
8	38.03025	.4704454	80.84	0.000	37.10819	38.95231
9	23.54459	.400655	58.77	0.000	22.75932	24.32987
10	-.7655753	.2733795	-2.80	0.005	-1.301392	-.2297581
11	-5.323539	.1767645	-30.12	0.000	-5.669993	-4.977085
12	-.0229054	.1571798	-0.15	0.884	-.330974	.2851632
_cons	35.44876	.2723991	130.14	0.000	34.91486	35.98266
account_id	F(16769, 197700) =		24.813	0.000	(16770 categories)	

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Appendix F Instruments

F.1 Program Staff In-Depth Interview Guide

Introduction

Today, we'll be discussing your role in the Energy Efficiency Education Program the Duke Energy Progress and Carolinas territories. We would like to learn about your experiences in administering this/these program(s) in the 2017-2018 school year.

Your comments are confidential. If I ask you about areas you don't know about, please feel free to tell me that and we will move on. Also, if you want to refer me to specific documents to answer any of my questions, that's great – I'm happy to look things up if I know where to get the information.

I would like to record this interview for my note-taking purposes. Do I have your permission? Do you have any questions before we start?

Roles & Responsibilities

Q1. Please describe your position at Duke Energy and your role in the Energy Efficiency Education Program.

Q2. How long have you been in this role?

Program Delivery

Q3. Next, I'd like to learn more about how this program was delivered in 2017-2018 school year. Last time we spoke with program staff we got a good understanding of the program delivery model. Have there been any changes in program delivery since the 2015-2016 school year?

[*IF NEEDED*:]

1. Did you adjust your marketing and outreach strategy since the 2015-2016 school year? If so, how?
2. In 2017-2018, was the program for elementary the same as the prior school year (Space Station Conservation)? Has the curriculum or performance changed at all? If so, was any of that at the direction of Duke program staff?
3. What was the program for middle schools last school year? I know in 2015-2016 it was "Conservation Crew" but I don't see that on the NTC website currently.
4. Do you have a copy of the 2017-2018 student and teacher materials you could send me?
5. Are new programs being implemented for the 2017-2018 school year? I see Kilowatt Kitchen and The E-Team on the NTC Playworks website for North and South Carolina.
6. When was the NTC Playworks website added to the program? What is its purpose? How has the changed the program delivery, goals, or success?

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7. Are R1 and AM Conservation still acting as fulfillment contractors? Is their role any different from last year?
8. From the teacher and student family perspective, has the student family kit request process changed at all?

Kits

Let's talk about the kits a little bit. The kits includes:

- LED Bulbs
- LED Night Light
- Energy-Efficient Showerhead
- Kitchen Faucet Aerator
- Bathroom Faucet Aerator
- Water Flow Meter Bag
- Switch and Outlet Insulators
- Teflon Tape (used for installing the Showerhead and Faucet Aerators)
- Hot Water Gauge Card
- D.O.E. Energy Savers Booklet
- Glow Ring Toy
- Product Information/Instruction Sheet

Q4. Were there any changes to the items in the kit since 2015-2016 program year?

Q5. Do you know when the program switched from CFLs to LEDs? (Was it April 2016?)

Q6. They get two LEDs, twelve outlet gaskets, and one of each of the other items, right?

Q7. Is the product information sheet purely instructional, or does it have behavior tips on it? Can you email me a copy?

Q8. Is the DOE Energy Savers Booklet the 45-page booklet that is available online on the DOE's website?

We are almost done. I have a few more questions.

Wrap Up

Q9. The last evaluation revealed that the program curriculum may be targeting too wide of an age range to effectively teach all elementary grades. Also, some middle school teachers said the middle school content was too juvenile. However, this did not seem to affect kit distribution. How important is fine-tuning the educational component to Duke? Is that a priority?

Q10. What would you say are the greatest strengths of this program?

Q11. What would you say is the biggest challenge in administering this program?

Q12. Is there anything else about the program that we have not discussed that you feel should

be mentioned?

Q13. What would you like to learn from the program evaluation?

Those are all of my questions. Thank you very much for your time.

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F.2 NTC Staff In-Depth Interview Guide

Introduction

Today, we'll be discussing your role in the Energy Efficiency Education Program in the Duke Energy Progress and Carolinas territories. We would like to learn about your experiences in administering this/these program(s) in the 2017-2018 school year.

Your comments are confidential. If I ask you about areas you don't know about, please feel free to tell me that and we will move on. Also, if you want to refer me to specific documents to answer any of my questions, that's great – I'm happy to look things up if I know where to get the information.

I would like to record this interview for my note-taking purposes. Do I have your permission? Do you have any questions before we start?

Roles & Responsibilities

Q1. Please describe your position at NTC and your role in the Duke Energy Energy Efficiency Education Program.

Q2. How long have you been in this role?

Program Delivery

Q3. Next, I'd like to learn more about how this program was delivered in 2017-2018 school year. Last time we spoke with program staff we got a good understanding of the program delivery model. Have there been any changes in program delivery since the 2015-2016 school year?

[*IF NEEDED*:]

1. Did you adjust your marketing and outreach strategy since the 2015-2016 school year? If so, how?
2. In 2017-2018, was the program for elementary the same as the prior school year (Space Station Conservation)? Has the curriculum or performance changed at all? If so, was any of that at the direction of Duke program staff?
3. What was the program for middle schools last school year? I know in 2015-2016 it was "Conservation Crew" but I don't see that on the NTC website currently.
4. Do you have a copy of the 2017-2018 student and teacher materials you could send me?
5. Are new programs being implemented for the 2017-2018 school year? I see Kilowatt Kitchen and The E-Team on the NTC Playworks website for North and South Carolina.
6. When was the NTC Playworks website added to the program? What is its purpose? How has the changed the program delivery, goals, or success?
7. From the teacher and student family perspective, has the student family kit request process changed at all?

Wrap Up

Q4. The last evaluation revealed that the program curriculum may be targeting too wide of an age range to effectively teach all elementary grades. Also, some middle school teachers said the middle school content was too juvenile. However, this did not seem to affect kit distribution. How important is fine-tuning the educational component to NTC? Is that a priority?

Q5. What would you say are the greatest strengths of this program?

Q6. What would you say is the biggest challenge in administering this program?

Q7. Is there anything else about the program that we have not discussed that you feel should be mentioned?

Q8. What would you like to learn from the program evaluation?

Those are all of my questions. Thank you very much for your time.

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F.3 Teacher Survey

Introduction to Survey (Once Survey is Opened)

Thank you for agreeing to take this survey. It starts with a few questions about what grades and subjects you teach, which we need for our analysis of the survey responses. The survey then asks for your feedback on various elements of the program.

Grades and Subjects Taught

Q1. What grade(s) of students do you teach? *Please select all that apply.*

[MULTIPLE RESPONSE]

1. Pre-K
2. Kindergarten
3. Grade 1
4. Grade 2
5. Grade 3
6. Grade 4
7. Grade 5
8. Grade 6
9. Grade 7
10. Grade 8
11. Grades 9-12
12. Other, please specify: [OPEN-ENDED RESPONSE]

[TERMINATE IF Kindergarten to Grade 8 (options 2-10) aren't selected]

[IF Q1=Kindergarten to Grade 5 AND Q1<> Grade 6 to Grade 8]

Q2. Are you a home room teacher?

[SINGLE RESPONSE]

1. Yes
2. No [→ TERMINATE]

[IF Q1=Grade 6 to Grade 8]

Q3. What subjects do you teach? *Please select all that apply*.

[MULTIPLE RESPONSE]

1. Math
2. Natural sciences
3. English/language arts
4. Social studies/social sciences/history
5. Music
6. Art

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7. Physical education
8. Other – please specify: [OPEN-ENDED RESPONSE]

[IF Q3<>1 or 2]

Q4. Do you teach any topics on energy (electricity, gas, coal, etc.) generation, transformation, use, or conservation (including, but not limited to, topics/materials provided by the Energy Efficiency for Schools program)?

[SINGLE RESPONSE]

1. Yes
2. No [→ TERMINATE]

Performance Seen

[IF Performance_Name=Kilowatt Kitchen]

Q5. Did you see The National Theatre for Children performance for elementary school students called *Kilowatt Kitchen* on [PERFORMANCE_DATE]?

1. Yes [SKIP TO Q7]
2. No [→ TERMINATE]
98. Don't know/ Can't recall [→ TERMINATE]

[IF Performance_Name= The E-Team]

Q6. Did you see the National Theatre for Children performance for middle school students called *The E-Team* on [PERFORMANCE_DATE]?

1. Yes
2. No [→ TERMINATE]
98. Don't know/ Can't recall [→ TERMINATE]

[TERMINATION SCREEN TEXT: We have determined that you do not meet the qualification criteria for this study. Thank you for your time!]

Awareness of Duke Energy's Sponsorship

Q7. Before today, were you aware that Duke Energy sponsored the National Theatre for Children performance(s) in your school?

1. Yes
2. No
98. Don't know

[IF Q7 = 1 (YES)]

Q8. How did you learn of Duke Energy's involvement with the National Theatre for Children program? *Please select all that apply*.

[MULTIPLE RESPONSE]

1. Another teacher

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2. Duke Energy marketing materials
3. Duke Energy staff
4. National Theatre for Children staff
5. National Theatre for Children materials
6. Other, please describe: [OPEN-ENDED RESPONSE]
98. Don't know

Program Experience and Satisfaction

The next few questions are about the performance(s) that National Theatre for Children presented at your school.

Q9. Thinking about how the school performance explained the energy-related concepts, would you say that, on the whole, the explanation was:

[SINGLE RESPONSE]

1. Far too advanced for most of your students
2. Somewhat too advanced for most of your students
3. About right for most of your students
4. Somewhat too basic for most of your students
5. Far too basic for most of your students
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know

[IF Q9 = 1 OR 2]

Q10. What about the performance was too advanced for most of your students?

1. [OPEN ENDED]

Q11. Were there any concepts that the performance(s) did not cover that *should have been* covered?

1. Yes
2. No [SKIP TO Q13]
98. Don't know [SKIP TO Q13]

[IF Q11 = 1 (YES)]

Q12. What concepts were not covered that *should have been* covered?

1. [OPEN ENDED]

Q13. Please rate your overall satisfaction with the National Theatre for Children performance on the following scale. [SINGLE RESPONSE; INSERT 1-5 SCALE WHERE 1=NOT AT ALL SATISFIED AND 5=COMPLETELY SATISFIED WITH DK; LABEL ONLY THE END POINTS (1 AND 5) – SHOULD LOOK SOMETHING LIKE THIS:

1. 1 – Not at all satisfied
2. 2

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3. 3
4. 4
5. 5 – Completely satisfied
98. Don't know]

The next few questions are about the curriculum or instructional materials that you may have received from the National Theatre for Children around the time of the performance.

Q14. Did you receive curriculum or instructional materials, such as student workbooks, related to energy and energy conservation from National Theatre for Children in the 2017-2018 school year?

1. Yes
2. No [SKIP TO Q24]
98. Don't know [SKIP TO Q24]

[IF Q14 = 1 (YES)]
Q15. To what degree did you use the curriculum or instructional materials in teaching your students about energy?

[SINGLE RESPONSE]

1. Not at all [SKIP TO Q23]
2. A little
3. Moderately
4. A lot
5. Extensively
98. Don't know [SKIP TO Q24]

[IF Q15 = 2 (A LITTLE)]
Q15a. Why did you only use the workbooks "a little" in teaching your students about energy?

1. [OPEN ENDED]

Q15b. Did you incorporate the National Theatre for Children's online component into your curriculum in the 2015-2016 school year? This is the official website that accompanies the performance and classroom curriculum; it has interactive games that reinforce the concepts taught in the performance and printed curriculum.

1. Yes
2. No
98. Don't know

[IF Q15B= 1 (YES)]
Q15c. How satisfied are you with that online component?

[SINGLE RESPONSE]

1. 1 – Not at all satisfied

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2. 2
3. 3
4. 4
5. 5 – Completely satisfied
98. Don't know

[IF Q15 = 2 THROUGH 5]

Q16. Thinking about how the student workbooks explained energy-related concepts, would you say that the material was generally:

[SINGLE RESPONSE; READ EXCEPT OTHER, DK, AND REFUSED OPTIONS]

1. Far too advanced for most of your students
2. Somewhat too advanced for most of your students
3. About right for most of your students
4. Somewhat too basic for most of your students
5. Far too basic for most of your students
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused / I'd rather not say

[IF Q15 = 2, 3, 4, OR 5]

Q17. Please rate how useful the materials were to you in teaching your students about energy. [SINGLE RESPONSE; INSERT 1-5 SCALE WHERE 1=NOT AT ALL USEFUL AND 5=EXTREMELY USEFUL WITH DK; LABEL ONLY END POINTS, 1 AND 5]

[IF Q15 = 2, 3, 4, OR 5]

Q17a. Please rate the degree to which the topics in the workbook aligned with your state's science standards for the grade(s) you teach.

1. Completely aligned
2. Mostly aligned
3. Somewhat aligned
4. Poorly aligned
5. Not aligned at all
6. N/A – no science standards for my grade(s)
98. Don't know
99. Refused / I'd rather not say

[IF Q15 = 2, 3, 4, OR 5]

Q18. Were there any concepts covered in the curriculum or instructional materials that your students had particular challenges with?

1. Yes
2. No
98. Don't know

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99. Refused / I'd rather not say

[IF Q18 = 1 (YES)]
Q19. What concepts did your students have particular challenges with?

1. [OPEN ENDED]

[IF Q15 = 2, 3, 4, OR 5]
Q20. Were there any concepts that the materials did not cover that *should have been* covered?

1. Yes
2. No
98. Don't know
99. Refused / I'd rather not say

[IF Q20 = 1 (YES)]
Q21. What concepts were not covered that *should have been* covered?

1. [OPEN ENDED]

[IF Q15 = 2 THROUGH 5]
Q22. Please rate your overall satisfaction with curriculum or instructional materials you received from the National Theatre for Children program using the following scale.

[SINGLE RESPONSE; INSERT 1-5 SCALE WHERE 1=NOT AT ALL SATISFIED AND 5=COMPLETELY SATISFIED WITH DK; LABEL ONLY END POINTS (1 AND 5)]

[IF Q15 = 1 (NOT AT ALL)]
Q23. Why did you *not* use the curriculum or instructional materials in teaching your students about energy?

1. [OPEN ENDED]

Interactions with NTC Staff

Q24. Did you have any interactions with anyone from the National Theatre for Children regarding the curriculum or instructional materials?

1. Yes
2. No [SKIP TO Q27]
98. Don't know [SKIP TO Q27]

[IF Q24 = 1 (YES)]
Q25. What did those interactions address?

1. [OPEN ENDED]

[IF Q24 = 1 (YES)]
Q26. Using the scale provided, how satisfied were you with:

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a. Your interactions with the National Theatre for Children staff, overall
b. The professionalism and courtesy of the National Theatre for Children staff
c. The National Theatre for Children staff's knowledge about the topics you discussed with them

[SINGLE RESPONSE; FOR EACH ITEM, INSERT 1-5 SCALE WHERE 1=NOT AT ALL SATISFIED AND 5=COMPLETELY SATISFIED WITH DK; LABEL ONLY THE END POINTS (1 AND 5)]

Encouragement of Students to Complete Survey, Receive Kit

In addition to the student workbooks provided by the National Theatre for Children there are materials directed at parents that instruct them on how to request a free energy saving kit from Duke Energy. The kit contains energy efficient light bulbs, low flow showerheads, and other items that students and their parents can install in their home to save energy.

Q27. Did you distribute the kit request materials to either your students or directly to their parents?

1. Yes
2. No
98. Don't recall

Q28. Were there any other ways in which you personally promoted the kits to your students and their families? If so, what were they? [*Select all that apply*]

1. Pinned up MyEnergyKit.org poster
2. Vocally encouraged students to sign up for a kit
3. Used my classroom web portal to encourage families to sign up for a kit
4. Emailed parents to encourage them to sign up for a kit
5. Spoke with parents in person to encourage them to sign up for a kit
6. Other (please specify)
7. No other actions taken [*EXCLUSIVE RESPONSE*]
98. Don't recall [*EXCLUSIVE RESPONSE*]

[IF Q27 = 1 (YES) OR Q28=1-6]

Q29. Did you follow up with students or parents later to find out if their household requested a kit?

1. Yes
2. No [SKIP TO Q32]
98. Don't know [SKIP TO Q32]

[IF Q29 = 1 (YES)]

Q30. In your best estimate, what percentage of your student households ordered the Duke Energy kit?

1. 0% to 10%

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2. 11% to 20%
3. 21% to 30%
4. 31% to 40%
5. 41% to 50%
6. 51% to 60%
7. 61% to 70%
8. 71% to 80%
9. 81% to 90%
10. 91% to 100%
98. Don't know

[IF Q27 = 2 (NO)]

Q31. Why haven't you distributed the kit request materials to your students or their parents?

1. [OPEN-ENDED]

Challenges and Opportunities for Improvement

Q32. What suggestions do you have to improve the National Theatre for Children performance(s)?

1. [OPEN ENDED]

[IF Q14 = 1 (YES)]

Q33. What suggestions do you have to improve the classroom materials received from the National Theatre for Children?

1. [OPEN ENDED]

[ASK ALL]

Q34. In addition to this survey, we will be conducting 15-minute-long telephone interviews with five teachers, where we will ask them additional questions about their experience with the National Theatre for Children program. Interview participants will be compensated for their time. If selected, would you be willing to participate in a follow-up telephone interview about your experience with the program?

[SINGLE RESPONSE]

1. Yes, I am willing to be interviewed
2. No, I am not willing to be interviewed

That was the last question. Thank you for your time!

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F.4 Teacher Interview Guide

Teacher Background

Q1. First, can you tell me what grade and subjects you teach?

NTC Performance

The next few questions are about the performance that National Theatre for Children (or NTC) gave at your school.

Q2. What topics were covered in the performance?

Q3. Do you think any of the topics could have been better emphasized or explained? If so, which ones and why?

Q4. Should any topics be removed from the performance? If so, which ones and why?

Q5. [IF ELEMENTARY SCHOOL TEACHER] What about age appropriateness – was the content appropriate for all ages, from kindergarten through grade-5? If not, what was not age appropriate? How could that be improved?

[IF MIDDLE SCHOOL TEACHER] What about age appropriateness – was the content appropriate for all ages from grade 6 through grade 8? If not, what was not age appropriate? How could that be improved?

Q6. Did the performance keep your students' attention? If not, how could the content be improved to keep the students entertained and attentive?

Q7. What did you like the most about the performance?

Q8. What did you dislike the most?

Q9. How did your students respond to the performance?

- Probes: What did students say about the performance? Did they like it? What specifically did they like most about it?

Q10. One of the goals of the NTC program is for performers to get students' families to sign up for energy efficiency kits from Duke Energy that contain energy efficient bulbs, low-flow shower heads, and other items that students' families can install in their home to save energy. Did the performers talk about the kits or the kit forms?

- [If yes] What did they say? Did they hand out kit request forms during the performance?

Q11. How many NTC performances have you seen in your school? When did you see that/these performance(s)? [If they saw multiple NTC performances:] How did the latest performance compare to the prior performance(s)?

Materials/classroom [Ask All]

Q12. NTC provides student workbooks that contain educational materials and a form to get an energy saver kit for their home. Have you distributed these workbooks to your students?

- [If no:] Why not?
- [If yes:] How does the workbook distribution work? Do the students get the workbook at the assembly? Or do they get them in a class?

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- [If distributed workbooks:] How did you use the workbooks in your classroom?

Q13. Did you get any teacher-facing instructional material from NTC? [If yes] How did you receive it? [Probe: Left in your box, emailed if in digital form, or in some other way?] To what extent did you use that material?

- [If material was not used:] Why haven't you used the material(s)? What would make you more likely to use them?
- [If used:] Using a 1 to 5 scale where 1 means "not at all useful" and 5 means "extremely useful," how useful was the instructional material? Why did you give that rating? What was most/least useful about them?

Q14. Were any other materials handed out by the performers before, during, or after the performance? If so, what was handed out? Did you use these materials in your classroom, or did the students take them home? [probe about value of these materials]

Q15. Thinking about the educational materials NTC provided…

- In what ways, if any, did you incorporate the material into your lesson plans? [IF NOT MENTIONED] That is, did you extensively use it – such as weaving it into your course work over the year – or did you briefly utilize it in the time surrounding the performance? Please explain how extensively you used the material.
- Was the content age appropriate? Or was it too advanced or too basic? What was too basic/advanced? Is it age appropriate for all ages (grades K-5/ 6-8?) How effective is it in teaching kids about energy concepts?
- [IF MIDDLE SCHOOL TEACHER AND NOT MENTIONED] What did you think of the comic book for teaching students about energy and energy conservation behaviors? How effective was it? Was it age appropriate? [IF NOT AGE APPROPRIATE] How was it not age appropriate?

Q16. Did anyone or any of the materials you received emphasize the value of the kits to you? If so, what did they say?

Q17. In the online survey you said you [DID / DID NOT] distribute the kit request form to your students.

- [IF DISTRIBUTED] What challenges, if any, did you encounter when trying to distribute the kit forms? Did you have to coordinate with other faculty or staff? If so, can you describe this process and how well the process worked? What can NTC or Duke Energy do to make this process easier for you?
- [IF NOT DISTRIBUTED] Why did you not distribute the kit forms? What can NTC or Duke Energy do to make this process easier for you?

Q18. What, if anything, did you say or do to encourage your students to take the kit form and have their parents fill it out?

Q19. Thinking about the performance and curriculum as a whole, in what ways, if any, did your students subsequently demonstrate knowledge on the topics presented? [IF NOT MENTIONED] What were some of their main takeaways? What is the evidence of their increased knowledge? (test scores, etc.?)

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Suggestions for Improvement [Ask All]

Q20. What suggestions do you have to improve the National Theatre for Children performance(s)?

Q21. What suggestions do you have to improve the classroom materials received from the National Theatre for Children?

Q22. What suggestions do you have to improve the distribution of the kit forms to students?

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F.5 Student Parent Survey

Introduction/ Screening

Q1. [PHONE SURVEY] Hi, I'm _____, calling on behalf of Duke Energy. We are calling about an energy efficiency educational program that Duke Energy sponsored in your child's school. In addition to sponsoring classroom activities, Duke Energy sent a kit containing energy saving items to your home.

This kit included lightbulbs, a showerhead, and other items that help you save energy in your home. Do you recall receiving this kit?

1. Yes
2. No [If no: Can I speak with someone who may know something about this kit?]
98. Don't know [If DK: Can I speak with someone who may know something about this kit?]
99. Refused [TERMINATE]

Q1. [WEB SURVEY] We are conducting surveys about an energy efficiency educational program that Duke Energy sponsored in your child's school. In addition to sponsoring classroom activities, Duke Energy sent a kit containing energy saving items to your home.

This kit included lightbulbs, a showerhead, and other items that help you save energy in your home. Do you recall receiving this kit?

1. Yes
2. No [TERMINATE]

Q1_phone. [IF Q1=1 AND VERSION=PHONE]. Do you have a few minutes to answer some questions about the kit, even if you never opened it?

1. Yes
2. No [TERMINATE]

[INTERVIEWER INSTRUCTIONS: *If no adults are able to speak about the kit, thank and terminate.*]

Q1a. Do you work at a school that teaches elementary or middle school grades?

1. Yes [-> TERMINATE]
2. No

Program Experience

Q2. Before today, did you know the kit you received was sponsored by Duke Energy?

1. Yes
2. No
98. Don't know
99. Refused

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[IF Q2=1]

Q3. How did you learn that the kit was sponsored by Duke Energy? [Select all that apply]

1. Classroom materials brought home by child
2. My child's teacher
3. Information material included in/on the kit
4. Other (specify:_____)
98. Don't know
99. Refused

Q3a. How did you hear about the opportunity to receive the kit from Duke Energy? [Select all that apply]

1. Classroom materials brought home by child
2. School newsletter
3. Email from my child's teacher/school
4. School website or school web portal
5. In-person conversations with my child's teacher
6. Saw a poster at my child's school
7. After hours event at my child's school
8. Other (specify:_____)
98. Don't know
99. Refused

Q4. Did you read the information about how to save energy in the booklet that came in the kit?

1. Yes
2. No
98. Don't know
99. Refused

[ASK IF Q4 = 1]

Q5. On a scale from 0 to 10 where 0 is not at all helpful and 10 is very helpful, how helpful was the information in the kit in identifying ways your household could save energy at home?

0. Not at all helpful
1.
2.
3.
4.
5.
6.
7.
8.
9.

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10. Very helpful
98. Don't know
99. Refused

[ASK IF Q4<7]
Q6. What might have made the information more helpful?

Q7. In addition to sending the energy saving kits, Duke Energy sponsored a program about energy and energy efficiency at your child's school, which included classroom materials and an in-school performance by the National Theatre for Children. Were you aware of this program before today?

[*Interviewer: Record 'yes' if the respondent reported any awareness of any aspect of the school program*]
1. Yes
2. No
98. Don't know
99. Refused

[ASK IF Q7=1]
Q9. Where did you hear about this program?
[MULTIPLE RESPONSE]
1. From my child/children
2. From a teacher
3. On Duke Energy website
4. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

Assessing Energy Saver Kit Installation
We'd like to ask you about the energy saving items included in your kit.
The kit contained an energy-efficient showerhead, faucet aerators for the bathroom and kitchen, energy efficient light bulbs, a night light, and some insulator gaskets for light switches and electricity outlets.

[*IF NEEDED*: The bathroom and kitchen faucet aerators are small metal pieces that you can screw in to a sink faucet to reduce water flow. The insulator gaskets are made of foam and are the size and shape of a light switch or electric outlet.]

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later?

[*Interviewer: Throughout interview, remind respondent as needed to report whether someone else in the home installed or uninstalled any items*]
[SINGLE RESPONSE]
1. Yes
2. No [-> Q21]

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98. Don't know [-> TERMINATE]
99. Refused [-> TERMINATE]

[ASK IF Q10 = 1]

Q12. Which of the items did you install, even if they were taken out later?

[*Interviewer: Record each response, then prompt with the list items*.]

Item		Response
a.	Showerhead	1. Yes 2. No 98. DK 99. REF
b.	Kitchen faucet aerator	1. Yes 2. No 98. DK 99. REF
c.	Bathroom faucet aerator	1. Yes 2. No 98. DK 99. REF
d.	Night light	1. Yes 2. No 98. DK 99. REF
e.	Energy efficient light bulb(s) (LEDs)	1. Yes 2. No 98. DK 99. REF
f.	Insulator gaskets for light switches and electricity outlets	1. Yes 2. No 98. DK 99. REF

[ASK IF Q12E (ENERGY EFFICIENT LIGHT BULB(S)) = 1 (YES)]

Q13. In addition to the night light, there were two LED light bulbs in the kit. Did you install one or both of the LED light bulbs in the kit?

[SINGLE RESPONSE]

1. Yes – I installed both LEDs
2. No – I installed only one LED light bulb
98. Don't know
99. Refused

[ASK IF Q12f = 1]

Q15. How many of the light switch gasket insulators from the kit did you [*if needed: or anyone else*] install in your home?

[SINGLE RESPONSE]

1. None
2. One
3. Two
4. Three
5. Four
98. Don't know
99. Refused

[ASK IF Q12f = 1]

Q16. How many electrical outlet gasket insulators from the kit did you [*if needed: or anyone else*] install in your home?

[SINGLE RESPONSE]

1. None

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2. One
3. Two
4. Three
5. Four
6. Five
7. Six
8. Seven
9. Eight
98. Don't know
99. Refused

[ASK IF ANY PART OF Q12 = 1]

Q17. Overall, how satisfied are you with the item[s] you installed? Please use 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied. How satisfied are you with...

DISPLAY IF	Item		Rating
Q12a = 1	a.	Showerhead	0-10 with DK, REF
Q12b = 1	b.	Kitchen faucet aerator	0-10 with DK, REF
Q12c = 1	c.	Bathroom faucet aerator	0-10 with DK, REF
Q12d = 1	d.	Night light	0-10 with DK, REF
Q12e = 1	e.	Energy efficient lightbulbs (LEDs)	0-10 with DK, REF
Q12f = 1	f.	Insulator gaskets	0-10 with DK, REF

[ASK IF ANY ITEMS IN Q17<7]

Q17a. Can you please explain any dissatisfaction you had with [DISPLAY ALL ITEMS IN Q17 THAT ARE <7]?

[OPEN END: RECORD VERBATIM]

[ASK IF ANY PART OF Q12 = 1]

Q18. Have you since uninstalled any of the items from the kit that you had previously installed?

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know
99. Refused

[ASK IF Q18 = 1]

Q19. Which of the items did you uninstall?

[*Interviewer: Record the response, then prompt with the list items*.]

[MULTIPLE RESPONSE]

1. [DISPLAY IF Q12a = 1] Showerhead

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2. [DISPLAY IF Q12b = 1] Kitchen faucet aerator
3. [DISPLAY IF Q12c = 1] Bathroom faucet aerator
4. [DISPLAY IF Q12d = 1] Night light
5. [DISPLAY IF Q12e = 1] Energy efficient light bulbs (LEDs)
6. [DISPLAY IF Q12f = 1] Insulator gaskets
98. Don't know
99. Refused

[ASK IF Q19 1-6 OPTIONS WERE SELECTED]

Q20. Why were those items uninstalled? Let's start with…

[*Interviewer: Read each item*]

[MULTIPLE RESPONSE]

DISPLAY ONLY THOSE 1-6 ITEMS THAT WERE SELECTED IN Q19	Item	Reason
	a. Showerhead	1. It was broken 2. I didn't like how it worked 3. I didn't like how it looked 96. Other: (specify) 98. DK 99. REF
	b. Kitchen faucet aerator	Repeat reason options
	c. Bathroom faucet aerator	Repeat reason options
	d. Night light	Repeat reason options
	e. Energy efficient light bulbs (LEDs)	Repeat reason options
	f. Insulator gaskets	Repeat reason options

[ASK IF ANY PART OF Q12 = 2 OR Q10 = 2]

Q21. You said you haven't installed [INPUT ONLY THOSE ITEMS IN Q12 IF Q12a-f = 2]. Which of those items do you plan to install in the next three months?

[*Interviewer: Record the response, then prompt with the list items*.]

[MULTIPLE RESPONSE] [DISPLAY ALL IF Q10 = 2]

1. [DISPLAY IF Q12a = 2] Showerhead
2. [DISPLAY IF Q12b = 2] Kitchen faucet aerator
3. [DISPLAY IF Q12c = 2] Bathroom faucet aerator
4. [DISPLAY IF Q12d = 2] Night light
5. [DISPLAY IF Q12e = 2] Energy efficient light bulbs (LEDs)
6. [DISPLAY IF Q12f = 2] Insulator gaskets
98. None
99. Refused

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[ASK IF ANY 1-6 OPTIONS WERE NOT SELECTED IN Q21 OR OPTION "NONE" WAS SELECTED]

Q22. What's preventing you from installing those items? Let's start with….

[*Interviewer: Read items*]

[MULTIPLE RESPONSE]

DISPLAY IF	Item	Reason
Q21a was not selected	a. Showerhead	Use multiple response options below
Q21b was not selected	b. Kitchen faucet aerator	Use multiple response options below
Q21c was not selected	c. Bathroom faucet aerator	Use multiple response options below
Q21d was not selected	d. Night light	Use multiple response options below
Q21e was not selected	e. Energy efficient light bulbs (LEDs)	Use multiple response options below
Q21f was not selected	f. Insulator gaskets	Use multiple response options below

[MULTIPLE RESPONSE OPTIONS FOR Q22]

1. Didn't know what that was
2. Tried it, didn't fit
3. Tried it, didn't work as intended (Please specify: _____)
4. Haven't gotten around to it
5. Current one is still working
6. Takes too much time to install it/No time/Too busy
7. Too difficult to install it, don't know how to do it
8. Don't have the tools I need
9. Don't have the items any longer (threw away, gave away)
11. [DISPLAY IF Q21e was not selected] Already have LEDs
12. [DISPLAY IF Q21a was not selected] Already have efficient showerhead
13. [DISPLAY IF Q21b was not selected] Already have efficient kitchen faucet aerator
14. [DISPLAY IF Q21c was not selected] Already have efficient bathroom faucet aerators

96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF ANY PART OF Q12 = 1 AND IT'S NOT THE CASE THAT ALL PARTS OF Q19=SELECTED (THAT IS, THEY INSTALLED ANYTHING AND DID NOT UNINSTALL EVERYTHING THEY INSTALLED)]

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Q22a. Thinking of the items you installed, would you be interested in receiving any more of them from Duke Energy? If so, which ones?

[MULTIPLE RESPONSES]

1. [IF Q12a = 1 AND Q19.1 NOT SELECTED] Yes, I would like another energy-efficient showerhead
2. [IF Q12b = 1 AND Q19.2 NOT SELECTED] Yes, I would like another kitchen faucet aerator
3. [IF Q12c = 1 AND Q19.3 NOT SELECTED] Yes, I would like more bathroom faucet aerators
4. [IF Q12d = 1 AND Q19.4 NOT SELECTED Yes, I would like more energy-efficient night lights
5. [IF Q12e = 1 AND Q19.5 NOT SELECTED] Yes, I would like more energy-efficient light bulbs (LEDs)
6. [IF Q12f = 1 AND Q19.6 NOT SELECTED] Yes, I would like more switch/outlet gasket insulators
7. No, I am not interested in receiving any more of the items
98. Don't know
99. Refused

[IF Q22a=1-6]
Q22b. What would be your preferred way to request these additional items?

[MULTIPLE RESPONSES]

1. Internet
2. Telephone
3. Pre-paid postcard
4. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[ASK IF Q12d = 1 AND Q19 NIGHT LIGHT OPTION WAS NOT SELECTED]
Q26. You said you installed the night light. Did the night light replace an existing night light?

1. Yes
2. No
98. Don't know
99. Refused

[ASK IF Q26 = 1]
Q27. Did the old nightlight have a bulb that you could take out and replace once it burned out?

1. Yes
2. No
98. Don't know

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99. Refused

[ASK IF (Q12e = 1 AND Q19 ENERGY EFFICIENT LIGHTS WERE NOT SELECTED)]

Q28. You said you installed at least one of the energy efficient lights. What type of bulb(s) did you replace with the energy efficient lightbulbs?

1. All incandescent [*Interviewer: describe as an old fashioned light bulb - likely purchased more than two years ago*]
2. All halogen [*Interviewer: describe as bulb that looks like an incandescent, but has a glass tube inside of the bulb*]
   All CFL [*Interviewer: describe as spiral, or twisty shape bulb that fit into ordinary light fixtures*]
3. All LED [*Interviewer: describe as a new bulb type that uses little electricity and lasts a long time*]
4. Some combination [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[ASK IF (Q12e = 1 AND Q19 ENERGY EFFICIENT LIGHT BULBS NOT SELECTED)]

Q29. In what rooms did you install the energy efficient lightbulbs that were included in the kit?

[MULTIPLE RESPONSE] [*Interviewer: If the respondent gives more than two responses, remind them that there were only two bulbs*.]

1. Living room
2. Dining room
3. Bedroom
4. Kitchen
5. Bathroom
6. Den
7. Garage
8. Hallway
9. Basement
10. Outdoors
11. Other area (please specify): _____
98. Don't know
99. Refused

Q30. Have you adjusted the temperature of your water heater based on the Hot Water Gauge Card included in your kit?

1. Yes
2. No
3. Don’t recall seeing the Hot Water Gauge Card
98. Don't know
99. Refused

[ASK IF Q30=1]

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Q31. Do you know what the old temperature setting on your hot water heater was?

1. Yes (*please type in previous temperature setting here*)
2. No

[ASK IF Q30=1]
Q32. And what was the new temperature setting you set your hot water heater to?

[Record response]

[ASK IF Q30=1]
Q33. Is the new water heater temperature setting still in place?

1. Yes
2. No
98. Don't know
99. Refused

[IF Q33=2]
Q34. Why did you change the water heater temperature a second time?

[Record response]

Q35. What is the fuel type of your water heater?

1. Electricity
2. Natural Gas
3. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

Q36. How old is your water heater?

1. Less than five years old
2. Five to nine years old
3. Ten to fifteen years old
4. More than fifteen years old
98. Don't know

NTG

[IF ANY PART OF Q12 = 1 AND IT'S NOT THE CASE THAT ALL PARTS OF Q19=SELECTED (THAT IS, THEY INSTALLED ANYTHING AND DID NOT UNINSTALL EVERYTHING THEY INSTALLED)]
Q37. If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

1. Yes
2. No
98. Don't know

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99. Refused

[If Q37 = 1]
Q38. What items would you have purchased and installed within the next year?

[MULTIPLE RESPONSES]

1. [IF Q12a = 1 AND Q19.1 NOT SELECTED] Energy-Efficient Showerhead
2. [IF Q12b = 1 AND Q19.2 NOT SELECTED] Kitchen Faucet Aerator
3. [IF Q12c = 1 AND Q19.3 NOT SELECTED] Bathroom Faucet Aerator
4. [IF Q12d = 1 AND Q19.4 NOT SELECTED] Energy-Efficient Light Bulbs
5. [IF Q12e = 1 AND Q19.5 NOT SELECTED] Energy-Efficient Night Light
6. [IF Q12f = 1 AND Q19.6 NOT SELECTED] Switch/Outlet Gasket Insulators
7. No I would not have purchased any of the items
96. Other, please specify: [OPEN-ENDED RESPONSE]
98. Don't know
99. Refused

[IF Q38.4 IS SELECTED]
Q39. Q39. If you had not received them for free in the kit, how many LED light bulbs would you have purchased?

1. One
2. Two
98. Don't know
99. Refused

[IF (Q12a=1 AND Q19.1 NOT SELECTED) or (Q12b=1 AND Q19.2 NOT SELECTED) or (Q12c=1 AND Q19.3 NOT SELECTED)]
Q40. Now, thinking about the water savings items that were provided in the kit - using a scale from 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential” how influential were the following factors on your decision to install the water saving items from the kit? How influential was…

[*Interviewer: If respondent says “Not applicable - I didn’t get/use that,” then follow up with: “So would you say it was “not at all influential?” and probe to code*]
[MATRIX QUESTION: SCALE]

Elements	Responses
The fact that the items were free	0-10 scale with DK and REF options
The fact that the items were mailed to your house	0-10 scale with DK and REF options
The chance to win cash prizes for your household and school	0-10 scale with DK and REF options
Information in the kit about how the items would save energy	0-10 scale with DK and REF options
Information that your child brought home from school	0-10 scale with DK and REF options

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Other information or advertisements from Duke Energy, including its website	0-10 scale with DK and REF options

[IF Q12e=11 AND Q19.5 NOT SELECTED]

Q41. Using a scale from 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential" how influential were the following factors on your decision to install the lightbulbs from the kit? How influential was…

[*Interviewer: If respondent says "Not applicable - I didn't get/use that," then follow up with: "So would you say it was "not at all influential?" and probe to code*]

[MATRIX QUESTION: SCALE]

Elements	Responses
The fact that the items were free	0-10 scale with DK and REF options
The fact that the items were mailed to your house	0-10 scale with DK and REF options
The chance to win cash prizes for your household and school	0-10 scale with DK and REF options
Information in the kit about how the items would save energy	0-10 scale with DK and REF options
Information that your child brought home from school	0-10 scale with DK and REF options
Other information or advertisements from Duke Energy, including its website	0-10 scale with DK and REF options

[ASK IF MYHER=1]

Q42. I've got just a few final questions about other energy saving activities. First, Duke Energy asked us to ask a couple of questions about the Home Energy Reports it sends to some families. These reports provide detailed information on your home's energy usage and compare your home to similar homes of your neighbors.
During the school year, did you receive any Home Energy Reports from Duke Energy?
[*If needed: This is extra information on energy use that is mailed separately from your energy bill.*]

1. Yes
2. No
98. Don't know
99. Refused

[ASK IF Q42=1]

Q43. How often do you read those Home Energy Reports?

1. Never
2. Sometimes
3. Always
98. Don't know
99. Refused

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[ASK IF Q43=2-3]

Q44. The Home Energy Reports provide specific recommendations for how you can save energy in your home. Have you completed any of the energy saving recommendations from the Home Energy Reports? If so, which ones? [MULTIPLE RESPONSE] [*Don't read, probe if needed*]

1. Nothing
2. Purchased energy saving products for my home and received a Duke Energy rebate
3. Purchased energy saving products for my home but did not receive a Duke Energy rebate
4. Made energy saving modifications to my home [example if necessary: installed insulation or windows]
5. Adjusted how or when I use energy in my home
6. Looked for additional information on how to save energy
7. Other, please specify:
98. Don't know
99. Refused

[IF MYHER=1 AND Q44=2-7, READ] Now we'd like to ask you about any other actions you or your child may have taken to save energy in your home. So please focus on any other things you or your child has done other than what you just told me.

[IF MYHER=1 AND Q44=1, 98, OR 99, READ] Okay, so you said that you have not followed any of the energy savings recommendations from your Home Energy Report. I'd still like to ask you about any actions you or your child may have taken to save energy in your home since your child learned about energy conservation at school and signed up for your energy kit from Duke Energy.

[IF MYHER≠1, READ] I'd like to ask you about any actions you or your child may have taken to save energy in your home since your child learned about energy conservation at school and signed up for your energy kit from Duke Energy.

Q45. Since your child learned about energy conservation at school and signed up for your energy kit from Duke Energy, has your child adopted any **new** behaviors to help save energy in your home? This would only include new energy saving **behaviors** that your child adopted since receiving the kit. [*IF NEEDED: like turning off the lights when room is unoccupied*]

[MULTIPLE RESPONSE] [*Interviewer: Do not read list. After each response ask, "Anything else?"*]

1. Not applicable - no new behaviors
2. Turn off lights when not in a room
3. Turn off electronics when not using them
4. Take shorter showers
5. Other (specify:_____)

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98. Don't know
99. Refused

Q45b. [IF Q45 =2-5] Before receiving the kit, was your child already…

[MATRIX QUESTION]

DISPLAY IF	DISPLAY:	ANSWERS
Q45.2 IS SELECTED	Turning off lights when not in a room	Yes, No, Don't know
Q45.3 IS SELECTED	Turning off electronics when not using them	Yes, No, Don't know
Q45.4 IS SELECTED	Taking shorter showers	Yes, No, Don't know
Q45.5 IS SELECTED	[Q45.5 VERBATIM TEXT]	Yes, No, Don't know

Q46. Since receiving your energy kit from Duke Energy, have you adopted any new behaviors to help save energy in your home? This would only include new energy saving**behaviors** that you have adopted since receiving the kit. [IF NEEDED: like turning off the lights when room is unoccupied]
[MULTIPLE RESPONSE] *[Interviewer: Do not read list. After each response ask, "Anything else?"*]

1. Not applicable - no new behaviors
2. Turn off lights when not in a room
3. Turn off furnace when not home
4. Turn off air conditioning when not home
5. Changed thermostat settings to use less energy
6. Used fans instead of air conditioning
7. Turn off electronics when we are not using them
8. Take shorter showers
9. Turned water heat thermostat down
10. Other (specify:_____)
98. Don't know
99. Refused

Q46b. [IF Q46 =2-10] Before receiving the kit, were you already…

[MATRIX QUESTION]

DISPLAY IF	DISPLAY:	ANSWERS
Q46.2 IS SELECTED	Turning off lights when not in a room	Yes, No, Don't know
Q46.3 IS SELECTED	Turning off furnace when not home	Yes, No, Don't know
Q46.4 IS SELECTED	Turning off air conditioning when not home	Yes, No, Don't know
Q46.5 IS SELECTED	Changing thermostat settings so heating or cooling system uses less energy	Yes, No, Don't know
Q46.6 IS SELECTED	Using fans instead of air conditioning	Yes, No, Don't know

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Q46.7 IS SELECTED	Turning off electronics when not using them	Yes, No, Don't know
Q46.8 IS SELECTED	Taking shorter showers	Yes, No, Don't know
Q46.9 IS SELECTED	Turning water heat thermostat down	Yes, No, Don't know
Q46.10 IS SELECTED	[Q46.10 VERBATIM TEXT]	Yes, No, Don't know

[IF Q46 <> 1 or 98]

Q47. On a scale of 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential," how much influence did Duke Energy's kit and materials on saving energy have on your decision to [LIST ALL RESPONSES FROM Q46].

0 – Not at all influential	1	2	3	4	5	6	7	8	9	10 – Extremely influential	98 DK	99 RF

Q47a. Thinking of the near future, are you interested in purchasing any additional products or services to help save energy in your home?

1. Yes
2. No
98. Don't know
99. Refused

[IF Q47a=1]

Q47b. What additional products or services are you interested in purchasing?

[MULTIPLE RESPONSE]

1. Energy efficient appliances
2. Efficient heating or cooling equipment
3. Efficient windows
4. Adding insulation
5. Sealing air leaks
6. Sealing or insulating ducts
7. Efficient lighting (LEDs)
8. Energy efficient water heater
9. Internet connected "smart" thermostat
96. Other, please specify: _____
98. Don't know
99. Refused

Q48. Since receiving your energy kit from Duke Energy, have you purchased and installed any other **products** or made any improvements to your home to help save energy?

1. Yes
2. No
98. Don't know

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99. Refused

[If Q48 = 1]

Q49. What **products** have you purchased and installed to help save energy in your home?

[*Do not read list. After each response, ask, "Anything else?"*] [MULTIPLE RESPONSE]

1. Bought energy efficient appliances
2. Moved into an ENERGY STAR home [*VERIFY:"Is Duke Energy still your gas or electricity utility?" Yes/No*]
3. Bought efficient heating or cooling equipment
4. Bought efficient windows
5. Added insulation
6. Sealed air leaks [NOT DUCT SEALING – PROBE TO CODE]
7. Sealed ducts
8. Bought LEDs
9. Bought CFLs
10. Installed an energy efficient water heater
11. None – no other actions taken
96. Other, please specify: _____
98. Don't know
99. Refused

[ASK IF Q49<>11, 98, OR 99]

Q50. Did you get a rebate from Duke Energy for any of those products or services? If so, which ones?

[LOGIC] Item	Response
[IF Q49.1 IS SELECTED] 1. Buy energy efficient appliances	Yes No DK REF
[IF Q49.2 IS SELECTED] 2. Move into an ENERGY STAR home	Yes No DK REF
[IF Q49.3 IS SELECTED] 3. Buy efficient heating or cooling equipment	Yes No DK REF
[IF Q49.4 IS SELECTED] 4. Buy efficient windows	Yes No DK REF
[IF Q49.5 IS SELECTED] 5. Buy additional insulation	Yes No DK REF
[IF Q49.6 IS SELECTED] 6. Seal air leaks	Yes No DK REF
[IF Q49.7 IS SELECTED] 7. Seal ducts	Yes No DK REF
[IF Q49.8 IS SELECTED] 8. Buy LEDs	Yes No DK REF
[IF Q49.9 IS SELECTED] 9. Buy CFLs	Yes No DK REF
IF Q49.10 IS SELECTED] 10. Install an energy efficient water heater	Yes No DK REF
[IF Q49.96 IS SELECTED] [Q49 open ended response]	Yes No DK REF

[ASK IF ANY ITEM IN Q49 WAS SELECTED]

Q51. On a scale of 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential", how much influence did the Duke Energy schools program have on your decision to…

[MATRIX QUESTION: SCALE]

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[LOGIC] Item	Response
[IF Q49.1 IS SELECTED] 1. Buy energy efficient appliances	0-10 scale with DK and REF
[IF Q49.2 IS SELECTED] 2. Move into an ENERGY STAR home	0-10 scale with DK and REF
[IF Q49.3 IS SELECTED] 3. Buy efficient heating or cooling equipment	0-10 scale with DK and REF
[IF Q49.4 IS SELECTED] 4. Buy efficient windows	0-10 scale with DK and REF
[IF Q49.5 IS SELECTED] 5. Buy additional insulation	0-10 scale with DK and REF
[IF Q49.6 IS SELECTED] 6. Seal air leaks	0-10 scale with DK and REF
[IF Q49.7 IS SELECTED] 7. Seal ducts	0-10 scale with DK and REF
[IF Q49.8 IS SELECTED] 8. Buy LEDs	0-10 scale with DK and REF
[IF Q49.9 IS SELECTED] 9. Buy CFLs	0-10 scale with DK and REF
IF Q49.10 IS SELECTED] 10. Install an energy efficient water heater	0-10 scale with DK and REF
[IF Q49.96 IS SELECTED] [Q49 open ended response]	0-10 scale with DK and REF

[ASK IF Q49.1 IS SELECTED AND Q51.1 <> 0]
Q52. What kinds of appliance(s) did you buy?

[*Do not read list*] [MULTIPLE RESPONSE]

1. Refrigerator
2. Stand-alone Freezer
3. Dishwasher
4. Clothes washer
5. Clothes dryer
6. Oven
7. Microwave
96. Other, please specify: _____
98. Don’t know
99. Refused

[ASK IF Q52 = 1-96]
Q53. Was the [INSERT Q52 RESPONSE] an ENERGY STAR or high-efficiency model?

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know
99. Refused

[REPEAT THIS QUESTION FOR EACH ITEM MENTIONED IN Q52]

[ASK IF Q52 = 5]
Q54. Does the new clothes dryer use natural gas?

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1. Yes - it uses natural gas
2. No – does not use natural gas
98. Don't know
99. Refused

[ASK IF Q49.3 IS SELECTED AND Q51.3 > 0]
Q55. What type of heating or cooling equipment did you buy?

[*Do not read list*] [MULTIPLE RESPONSE]

1. Central air conditioner
2. Window/room air conditioner unit
3. Wall air conditioner unit
4. Air source heat pump
5. Geothermal heat pump
6. Boiler
7. Furnace
8. Wifi-enabled thermostat
96. Other, please specify: _____
98. Don't know
99. Refused

[ASK IF Q55= 6-7]
Q56. Does the new [INSERT Q55 RESPONSE] use natural gas?

1. Yes - it uses natural gas
2. No – does not use natural gas
98. Don't know
99. Refused

[ASK IF Q55= 1-7, 96]
Q57. Was the [INSERT Q55 RESPONSE] an ENERGY STAR or high-efficiency model?

[SINGLE RESPONSE]

1. Yes
2. No
98. Don't know
99. Refused

[REPEAT THIS QUESTION FOR EACH ITEM MENTIONED IN Q55, EXCLUDING wifi-enabled thermostat]

[ASK IF Q49.4 IS SELECTED AND Q51.4 > 0]
Q58. How many windows did you install?

1. [RECORD VERBATIM _____]
98. Don't know

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99. Refused

[ASK IF Q49.5 IS SELECTED AND Q51.5 > 0]
Q59. Did you add insulation to your attic, walls, or below the floor?

[*Do not read list*] [MULTIPLE RESPONSE]

1. Attic
2. Walls
3. Below the floor
98. Don't know
99. Refused

[ASK IF Q59<>98-99]
[PROGRAMMER: REPEAT Q60 FOR EACH ITEM MENTIONED IN Q59]
Q60. Approximately what proportion of the [ITEM MENTIONED IN Q59] space did you add insulation?

1. [RECORD VERBATIM AS % - INPUT MID-POINT IF RANGE IS OFFERED:] _____ [IF NEEDED: *Your best estimate is fine*]
2. Don't know
99. Refused

[ASK IF Q49.8 IS SELECTED AND Q51.8 > 0]
Q61. How many of LEDs did you install in your property?

1. [RECORD VERBATIM:] _____ [IF NEEDED: *Your best estimate is fine*]
2. Don't know
99. Refused

[ASK IF Q49.9 IS SELECTED AND Q51.9 > 0]
Q62. How many of CFLs did you install in your property?

1. [RECORD VERBATIM:] _____ [IF NEEDED: *Your best estimate is fine*]
2. Don't know
99. Refused

[ASK IF Q49.10 IS SELECTED AND Q51.10 > 0]
Q63. Does the new water heater use natural gas?

1. Yes - it uses natural gas
2. No – does not use natural gas
98. Don't know
99. Refused

[ASK IF Q49.10 IS SELECTED AND Q51.10 > 0]
Q64. Which of the following water heaters did you purchase?

1. A traditional water heater with a large tank that holds the hot water

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2. A tankless water heater that provides hot water on demand
3. A solar water heater
4. Other, please specify: _____
98. Don't know
99. Refused

[ASK IF Q49.10 IS SELECTED AND Q51.10 > 0]
Q65. Is the new water heater an ENERGY STAR model?

[SINGLE RESPONSE]
1. Yes
2. No
98. Don't know
99. Refused

Demographics
Lastly, we have some basic demographic questions for you. Please be assured that your responses are confidential and are for statistical purposes only.

Q66. Which of the following types of housing units would you say best describes your home? It is . . .?

1. Single-family detached house
2. Single-family attached home (such as a townhouse or condo)
3. Duplex, triplex or four-plex
4. Apartment or condominium with 5 units or more
5. Manufactured or mobile home
6. Other _____
98. Don't know
99. Refused

Q67. How many square feet of living space are there in your residence, including bathrooms, foyers and hallways (exclude garages, unfinished basements, and unheated porches)?

1. Less than 500 square feet
2. 500 to under 1,000 square feet
3. 1,000 to under 1,500 square feet
4. 1,500 to under 2,000 square feet
5. 2,000 to under 2,500 square feet
6. 2,500 to under 3,000 square feet
7. Greater than 3,000 square feet
98. Don't know
99. Refused

Q68. Do you or members of your household own your home, or do you rent it?

1. Own / buying
2. Rent / lease

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3. Occupy rent-free
98. Don't know
99. Refused

Q69. Including yourself, how many people currently live in your home year-round?

1. I live by myself
2. Two people
3. Three people
4. Four people
5. Five people
6. Six people
7. Seven people
8. Eight or more people
98. Don't know
99. Refused

Q70. What was your total annual household income for 2017, before taxes?

1. Under $20,000
2. 20 to under $30,000
3. 30 to under $40,000
4. 40 to under $50,000
5. 50 to under $60,000
6. 60 to under $75,000
7. 75 to under $100,000
8. 100 to under $150,000
9. 150 to under $200,000
10. $200,000 or more
98. Don't know
99. Prefer not to say

Q71. What is the highest level of education achieved among those living in your household?

1. Less than high school
2. Some high school
3. High school graduate or equivalent (such as GED)
4. Trade or technical school
5. Some college (including Associate degree)
6. College degree (Bachelor's degree)
7. Some graduate school
8. Graduate degree, professional degree
9. Doctorate
98. Don't know
99. Prefer not to say

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Appendix G Survey Results

G.1 Teacher Survey - DEP

Q1. What grade(s) of students do you teach?

Response Option	Count	Percent (n=29)
Pre-K	0	0%
Kindergarten	4	14%
Grade 1	1	3%
Grade 2	3	10%
Grade 3	3	10%
Grade 4	6	21%
Grade 5	4	14%
Grade 6	5	17%
Grade 7	3	10%
Grade 8	8	28%
Grades 9 - 12	1	3%

Q2. Are you a home room teacher?

Response Option	Count	Percent (n=29)
Yes	19	66%
No	10	34%

Q3. What subjects do you teach?

Response Option	Count (n=10)
Math	2
Natural sciences	4
English/language arts	2
Social studies/social sciences/history	5
Music	0
Art	0
Physical education	0
Other	0

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Q4. Do you teach any topics on energy (electricity, gas, coal, etc.) generation, transformation, use, or conservation (including, but not limited to, topics/materials provided by the Energy Efficiency for Schools program)?

Response Option	Count	Percent (n=29)
Yes	24	83%
No	5	17%

Q5. Did you see The National Theatre for Children performance for elementary school students called *Kilowatt Kitchen* on [PERFORMANCE_DATE]?

Response Option	Count	Percent (n=29)
Yes	19	66%
No	10	34%

Q6. Did you see the National Theatre for Children performance for middle school students called *The E-Team* on [PERFORMANCE_DATE]?

Response Option	Count	Percent (n=44)
Yes	10	34%
No	19	66%

Q7. Before today, were you aware that Duke Energy sponsored the National Theatre for Children performance(s) in your school?

Response Option	Count	Percent (n=44)
Yes	23	79%
No	6	21%
Don't know	0	0%

Q8. How did you learn of Duke Energy's involvement with the National Theatre for Children program?

Response Option	Count	Percent (n=23)
Another teacher	7	30%
Duke Energy marketing materials	8	35%
Duke Energy staff	1	4%
The National Theatre for Children staff	8	35%
The National Theatre for Children materials	7	30%
Other	0	0%

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Don't know	0	0%

Q9. Thinking about how the school performance explained the energy-related concepts, would you say that, on the whole, the explanation was:

Response Option	Count	Percent (n=29)
Far too advanced for most of your students	0	0%
Somewhat too advanced for most of your students	2	7%
About right for most of your students	27	93%
Somewhat too basic for most of your students	0	0%
Far too basic for most of your students	0	0%
Other	0	0%
Don't know	0	0%

Q10. What about the performance was too advanced for most of your students?

Response Option	Count (n=2)
Pre-k through second grade attends the performance and some of the vocabulary is over their head and not explained thoroughly or is done too quickly	1
Some of the concepts about energy the students may not have understood.	1

Q11. Were there any concepts that the performance(s) did not cover that *should have been* covered?

Response Option	Count	Percent (n=29)
Yes	1	3%
No	26	90%
Don't know	2	7%

Q12. What concepts were not covered that *should have been* covered?

Response Option	Count (n=1)
Advantages/disadvantages of renewable and nonrenewable resources.	1

Q13. Please rate your overall satisfaction with the National Theatre for Children performance on the following scale.

Response Option	Count	Percent (n=29)
1 - Not at all satisfied	0	0%

2	0	0%
3	0	0%
4	4	14%
5 - Completely satisfied	25	86%
Don't know	0	0%

Q14. Did you receive curriculum or instructional materials, such as student workbooks, related to energy and energy conservation from National Theatre for Children in the 2017-2018 school year?

Response Option	Count	Percent (n=29)
Yes	12	41%
No	11	38%
Don't know	6	21%

Q15. To what degree did you use the curriculum or instructional materials in teaching your students about energy?

Response Option	Count	Percent (n=12)
Not at all	2	17%
A little	2	17%
Moderately	4	33%
A lot	4	33%
Extensively	0	0%
Not at all	0	0%
Don't know	2	0%

Q15a. Why did you only use the workbooks “a little” in teaching your students about energy?

Response Option	Count (n=2)
This is not part of our curriculum so we could only touch on it.	1
We only received one workbook, but a ton of materials telling the kids about the kit. If I had enough workbooks for my entire class I would have definitely used them. We study electricity and magnetism in 4th grade and it would be a great addition to the curriculum.	1

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Q15b. Did you incorporate the National Theatre for Children's online component into your curriculum in the 2015-2016 school year? This is the official website that accompanies the performance and classroom curriculum; it has interactive games that reinforce the concepts taught in the performance and printed curriculum.

Response Option	Count	Percent (n=10)
Yes	4	40%
No	6	60%

Q16. Thinking about how the student workbooks explained energy-related concepts, would you say that the material was generally:

Response Option	Count	Percent (n=10)
Far too advanced for most of your students	0	0%
Somewhat too advanced for most of your students	2	20%
About right for most of your students	7	70%
Somewhat too basic for most of your students	0	0%
Far too basic for most of your students	0	0%
Other	0	0%
Don't know	1	10%
I'd rather not say	0	0%

Q17. Please rate how useful the materials were to you in teaching your students about energy.

Response Option	Count	Percent (n=10)
1 - Not at all useful	0	0%
2	0	0%
3	2	20%
4	5	50%
5 - Extremely useful	3	30%
Don't know	0	0%

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Q17a. Please rate the degree to which the topics in the workbook aligned with your state's science standards for the grade(s) you teach.

Response Option	Count	Percent (n=10)
Completely aligned	1	10%
Mostly aligned	6	60%
Somewhat aligned	1	10%
Not aligned at all	0	0%
Don't know	2	20%

Q18. Were there any concepts covered in the curriculum or instructional materials that your students had particular challenges with?

Response Option	Count	Percent (n=10)
No	10	100%

Q20. Were there any concepts that the materials did not cover that *should have been* covered?

Response Option	Count	Percent (n=10)
Yes	0	0%
No	9	90%
Don't know	1	10%

Q22. Please rate your overall satisfaction with curriculum or instructional materials you received from the National Theatre for Children program using the following scale.

Response Option	Count	Percent (n=9)
1 - Not at all satisfied	0	0%
2	0	0%
3	2	20%
4	3	30%
5 - Completely satisfied	5	50%
Don't know	0	0%

Q23. Why did you *not* use the curriculum or instructional materials in teaching your students about energy?

Response Option	Count (n=2)
I just don't have the time in the day and I'm a Science Teacher. If the materials aren't related to a standard, I don't teach it.	1
Not enough time to add in on top of our own curriculum materials	1

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Too low a level.	1

Q24. Did you have any interactions with anyone from the National Theatre for Children regarding the curriculum or instructional materials?

Response Option	Count	Percent (n=29)
Yes	3	10%
No	21	72%
Don't know	5	17%

Q25. What did those interactions address?

Response Option	Count
Not applicable	0

Q26. Using the scale provided, how satisfied were you with:

Response Option	Count	Percent (n=9)
1 - Not at all satisfied	0	0%
2	0	0%
3	0	0%
4	0	0%
5 - Completely satisfied	3	100%
Don't know	0	0%

Q27. Did you distribute the kit request materials to either your students or directly to their parents?

Response Option	Count	Percent (n=19)
Yes	28	97%
No	1	3%
Don't know	0	0%

Q28. Were there any other ways in which you personally promoted the kits to your students and their families? If so, what were they?

Response Option	Count	Percent (n=29)
MyEnergyKit.org poster	13	45%
Vocally encouraged students to sign up for a kit	24	83%
Used my classroom web portal to encourage families to sign up for a kit	3	10%
Emailed parents to encourage them to sign up for a kit	11	38%

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Spoke with parents in person to encourage them to sign up for a kit	5	17%
Other	2	7%
No other actions taken	0	0%
Don't recall	2	7%

Q29. Did you follow up with students or parents later to find out if their household requested a kit?

Response Option	Count	Percent (n=29)
Yes	15	52%
No	13	45%
Don't know	1	3%

Q30. In your best estimate, what percentage of your student households ordered the Duke Energy kit?

Response Option	Count	Percent (n=15)
0% to 10%	3	20%
11% to 20%	2	13%
21% to 30%	2	13%
31% to 40%	3	20%
41% to 50%	1	7%
51% to 60%	1	7%
61% to 70%	0	0%
71% to 80%	0	0%
81% to 90%	1	7%
91% to 100%	1	7%

Q32. What suggestions do you have to improve the National Theatre for Children performance(s)?

Response Option	Count (n=29)
Is it possible for the performers to have a mic? It is very difficult to hear in the back even though the actors project their voice.	1
Share info about kits before coming to school and preforming.	1
The performers were a little late (coming from a distant school), and the limited time they had forced them to either skip or rush through certain portions - pace was very quick. With more time devoted, the material would be better reinforced.	1

Response Option	Count (n=29)
None	26

Q33. What suggestions do you have to improve the classroom materials received from the National Theatre for Children?

Response Option	Count
I teach 5th grade, but we are at a Middle school so if materials for elementary are available, it might be more appropriate	1
Provide standards to go along with instructional materials.	1
We were sent way too many.	1
None	26

Q34. In addition to this survey, we will be conducting 15-minute-long telephone interviews with five teachers, where we will ask them additional questions about their experience with the National Theatre for Children program. Interview participants will be compensated for their time. If selected, would you be willing to participate in a follow-up telephone interview about your experience with the program?

Response Option	Count	Percent (n=29)
Yes, I am willing to be interviewed	14	48%
No, I am not willing to be interviewed	15	52%

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G.2 Teacher Survey - DEC

Q1. What grade(s) of students do you teach?

Response Option	Count	Percent (n=44)
Pre-K	0	0%
Kindergarten	10	23%
Grade 1	6	14%
Grade 2	8	18%
Grade 3	3	7%
Grade 4	5	11%
Grade 5	10	23%
Grade 6	8	18%
Grade 7	4	9%
Grade 8	1	2%
Grades 9 - 12	1	2%

Q2. Are you a home room teacher?

Response Option	Count	Percent (n=44)
Yes	33	75%
No	11	25%

Q3. What subjects do you teach?

Response Option	Count (n=11)
Math	5
Natural sciences	6
English/language arts	1
Social studies/social sciences/history	3
Music	0
Art	0
Physical education	0
Other	2

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Q4. Do you teach any topics on energy (electricity, gas, coal, etc.) generation, transformation, use, or conservation (including, but not limited to, topics/materials provided by the Energy Efficiency for Schools program)?

Response Option	Count	Percent (n=44)
Yes	35	80%
No	9	20%

Q5. Did you see The National Theatre for Children performance for elementary school students called *Kilowatt Kitchen* on [PERFORMANCE_DATE]?

Response Option	Count	Percent (n=44)
Yes	34	77%
No	10	23%

Q6. Did you see the National Theatre for Children performance for middle school students called *The E-Team* on [PERFORMANCE_DATE]?

Response Option	Count	Percent (n=44)
Yes	10	23%
No	34	77%

Q7. Before today, were you aware that Duke Energy sponsored the National Theatre for Children performance(s) in your school?

Response Option	Count	Percent (n=44)
Yes	37	84%
No	7	16%
Don't know	0	0%

Q8. How did you learn of Duke Energy's involvement with the National Theatre for Children program?

Response Option	Count	Percent (n=37)
Another teacher	14	38%
Duke Energy marketing materials	6	16%
Duke Energy staff	1	3%
The National Theatre for Children staff	12	32%
The National Theatre for Children materials	6	16%
Other	0	0%

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Don't know	5	14%

Q9. Thinking about how the school performance explained the energy-related concepts, would you say that, on the whole, the explanation was:

Response Option	Count	Percent (n=44)
Far too advanced for most of your students	0	0%
Somewhat too advanced for most of your students	3	7%
About right for most of your students	40	91%
Somewhat too basic for most of your students	1	2%
Far too basic for most of your students	0	0%
Other	0	0%
Don't know	0	0%

Q10. What about the performance was too advanced for most of your students?

Response Option	Count (n=3)
First grade standards are limited to recycling and natural resources.	1
Some of the vocabulary and jokes were above their heads, but it's first grade so I expect that to happen.	1
The performance was great. However, I teach very low level special needs students, so the fast pace and large group they were in made things over their heads. I know it would be time consuming, but a program a little slower paced with special needs children in mind would be amazing.	1

Q11. Were there any concepts that the performance(s) did not cover that *should have been* covered?

Response Option	Count	Percent (n=44)
Yes	2	5%
No	35	80%
Don't know	7	16%

Q12. What concepts were not covered that *should have been* covered?

Response Option	Count (n=2)
All were covered	1
Natural resources	1

Q13. Please rate your overall satisfaction with the National Theatre for Children performance on the following scale.

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Response Option	Count	Percent (n=44)
1 - Not at all satisfied	0	0%
2	0	0%
3	2	5%
4	3	7%
5 - Completely satisfied	39	89%
Don't know	0	0%

Q14. Did you receive curriculum or instructional materials, such as student workbooks, related to energy and energy conservation from National Theatre for Children in the 2017-2018 school year?

Response Option	Count	Percent (n=44)
Yes	29	66%
No	11	25%
Don't know	4	9%

Q15. To what degree did you use the curriculum or instructional materials in teaching your students about energy?

Response Option	Count	Percent (n=12)
Not at all	3	10%
A little	8	28%
Moderately	12	41%
A lot	4	14%
Extensively	2	7%
Not at all	0	0%
Don't know	3	10%

Q15a. Why did you only use the workbooks “a little” in teaching your students about energy?

Response Option	Count (n=8)
It is difficult for them to use due to lack of reading skills	1
Limited class time. Plus some of it repeated the curriculum we had already covered	1
The information in the workbooks was a bit above the kindergarten grade level. I used the books as a review and allowed students to take them home to do with the help of a parent.	1
The only available date for our area was in February but me covered the material in October. Our school has been impressed by the performances and was willing to wait until February to see it this year. The performance also provided our students with a review of our lesson	1
They were a little too elementary for my 6th graders.	1

Time factor	1
Timing was off	1
We cover those subjects in the Spring so at the time of the program performance I did not use the resources very much.	1

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Q15b. Did you incorporate the National Theatre for Children's online component into your curriculum in the 2015-2016 school year? This is the official website that accompanies the performance and classroom curriculum; it has interactive games that reinforce the concepts taught in the performance and printed curriculum.

Response Option	Count	Percent (n=26)
Yes	11	42%
No	18	58%

Q16. Thinking about how the student workbooks explained energy-related concepts, would you say that the material was generally:

Response Option	Count	Percent (n=26)
Far too advanced for most of your students	1	4%
Somewhat too advanced for most of your students	5	19%
About right for most of your students	18	69%
Somewhat too basic for most of your students	1	4%
Far too basic for most of your students	1	4%
Other	0	0%
Don't know	0	0%
I'd rather not say	0	0%

Q17. Please rate how useful the materials were to you in teaching your students about energy.

Response Option	Count	Percent (n=10)
1 - Not at all useful	0	0%
2	0	0%
3	6	23%
4	11	42%
5 - Extremely useful	9	35%
Don't know	0	0%

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Q17a. Please rate the degree to which the topics in the workbook aligned with your state's science standards for the grade(s) you teach.

Response Option	Count	Percent (n=26)
Completely aligned	5	19%
Mostly aligned	9	35%
Somewhat aligned	7	27%
Not aligned at all	1	4%
Don't know	4	15%

Q18. Were there any concepts covered in the curriculum or instructional materials that your students had particular challenges with?

Response Option	Count	Percent (n=10)
Yes	2	8%
NO	20	77%
Don't know	4	15%

Q19. What concepts did your students have particular trouble with?

Response Option	Count (n=2)
Speed of presentation	1
The concept of saving energy because it is not a physical thing that they can hold or truly see, they sometimes have a hard time with abstract concepts.	1

Q20. Were there any concepts that the materials did not cover that *should have been* covered?

Response Option	Count	Percent (n=10)
Yes	1	4%
No	19	73%
Don't know	6	23%

Q21. What concepts were not covered that should have been covered?

Response Option	Count (n=2)
If there could be more information on how energy travels that would be great! There's a lot in our curriculum about energy waves.	1

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Q22. Please rate your overall satisfaction with curriculum or instructional materials you received from the National Theatre for Children program using the following scale.

Response Option	Count	Percent (n=26)
1 - Not at all satisfied	0	0%
2	0	0%
3	2	8%
4	9	35%
5 - Completely satisfied	15	58%
Don't know	0	0%

Q23. Why did you *not* use the curriculum or instructional materials in teaching your students about energy?

Response Option	Count (n=3)
I have other state tested material that takes priority in math	1
No time	1
We did not receive the materials until the last minute.	1

Q24. Did you have any interactions with anyone from the National Theatre for Children regarding the curriculum or instructional materials?

Response Option	Count	Percent (n=44)
Yes	6	14%
No	35	80%
Don't know	3	7%

Q25. What did those interactions address?

Response Option	Count
Not applicable	0

Q26. Using the scale provided, how satisfied were you with:

Response Option	Count	Percent (n=0)
1 - Not at all satisfied	0	0%
2	0	0%
3	0	0%
4	0	0%
5 - Completely satisfied	0	0%
Don't know	0	0%

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Q27. Did you distribute the kit request materials to either your students or directly to their parents?

Response Option	Count	Percent (n=44)
Yes	42	95%
No	1	2%
Don't know	1	2%

Q28. Were there any other ways in which you personally promoted the kits to your students and their families? If so, what were they?

Response Option	Count	Percent (n=44)
MyEnergyKit.org poster	17	39%
Vocally encouraged students to sign up for a kit	40	91%
Used my classroom web portal to encourage families to sign up for a kit	12	27%
Emailed parents to encourage them to sign up for a kit	18	41%
Spoke with parents in person to encourage them to sign up for a kit	8	18%
Other	0	0%
No other actions taken	1	2%
Don’t recall	0	0%

Q29. Did you follow up with students or parents later to find out if their household requested a kit?

Response Option	Count	Percent (n=44)
Yes	15	34%
No	29	66%
Don't know	0	0%

Q30. In your best estimate, what percentage of your student households ordered the Duke Energy kit?

Response Option	Count	Percent (n=15)
0% to 10%	5	33%
11% to 20%	3	20%
21% to 30%	3	20%
31% to 40%	0	0%
41% to 50%	1	7%
51% to 60%	1	7%

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61% to 70%	1	7%
71% to 80%	0	0%
81% to 90%	0	0%
91% to 100%	0	0%
Don't know	1	7%

Q32. What suggestions do you have to improve the National Theatre for Children performance(s)?

Response Option	Count (n=44)
Fewer students per presentation. Pre/Post Test	1
For the performance to be at a slower pace	1
Get the students more involved in the performance.	1
Have performers speak slowly. Many of our English Language Learners couldn't understand them because they were talking so fast.	1
Hearing them was an issue. Not sure if it were because of them or the equipment.	1
It may be that another teacher was provided the information prior to the performance, but I felt a bit uninformed regarding what topics the performance was about. Also, really wish I had been given the workbooks/comics (whatever materials I was supposed to be able to give to students).	1
Just what I stated earlier. Have a program geared toward special needs students, providing the same information, just in a format more suitable to them, because the program was great!	1
More at-home materials to show parents what students learned	1
None	36

Q33. What suggestions do you have to improve the classroom materials received from the National Theatre for Children?

Response Option	Count (n=44)
Change the content a little more from year to year so that the kids aren't bored of the items.	1
Include more worksheet activities on 6th grade level for independent work time.	1
Make them more related to the NC Standards by grade level. Or, we could simply have the science teacher responsible for it.	1
Maybe get the kids more involved with the show more.	1
Sometimes, we use the program as an introduction to our Energy Unit, other years we have used it as a culminating activity. We we use it as an introduction, it would be nice to see it prior to the program and before our teaching begins, so we can plan more efficiently.	1
You could likely save paper by using online only materials.	1

Response Option	Count (n=44)
None	38

Q34. In addition to this survey, we will be conducting 15-minute-long telephone interviews with five teachers, where we will ask them additional questions about their experience with the National Theatre for Children program. Interview participants will be compensated for their time. If selected, would you be willing to participate in a follow-up telephone interview about your experience with the program?

Response Option	Count	Percent (n=44)
Yes, I am willing to be interviewed	25	57%
No, I am not willing to be interviewed	19	43%

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G.3 Student Parent Survey - DEP

Q2. Before today, did you know the kit you received was sponsored by Duke Energy?

Response Option	Count	Percent (n=172)
Yes	151	88%
No	21	12%
Don't know	0	0%

Q3. How did you learn that the kit was sponsored by Duke Energy? [Select all that apply]

Response Option	Count	Percent (n=151)
Classroom materials brought home by child	86	57%
My child's teacher/school	46	30%
Information material included in/on the kit	40	26%
Other	18	12%
Don't know	3	2%

Q3. Other…

Response Option	Count
Bill	1
By information we received before we received the kit	1
Email from School	1
Granddaughter is a student at the school.	1
Grandson brought home brochure from school	1
Grandson told me about the program	1
Mail	1
Mail flyer	1
My child spoke about it	1
Received packages from Duke	1
Saw it on a paper my grandson got	1
Someone called me to verify that I received it	1
The school sent paperwork home with my kids containing material about the program.	1
We had an in-home energy efficiency rep come to our house.	1
Wife is active in the PTA	1
Word of mouth from daughter (School secretary)	1
Word of mouth from family	1
Written on box and a paper brought home with it	1

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Q3a. How did you hear about the opportunity to receive the kit from Duke Energy? [Select all that apply]

Response Option	Count	Percent (n=172)
Classroom materials brought home by child	118	69%
School newsletter	19	11%
Email from my child's teacher/school	23	13%
School website or school web portal	10	6%
In-person conversations with my child's teacher	9	5%
Saw a poster at my child's school	5	3%
After hours event at my child's school	1	1%
Other (please specify in the box below)	31	18%
Don't know	7	4%

Q3a. Other…

Response Option	Count
Ad on Facebook	1
Bill	1
Daughter mentioned it	3
Daughter works for the school	1
Duke Energy had sent me a post card in the mail that explained all about the kit.	1
Duke site	3
Email also	1
Flyer came in mail	1
Form from school	1
From my daughter's school, they sent it in their packet	1
From the school	1
From the school, a brochure	1
I received a phone call	1
It just came	1
Kids told me	1
Mail flyer	1
My child spoke about it	1
Paper sent home with child	1
Provided by grandchild	1
PTA meeting at the school	1

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Response Option	Count
Relatives who work at the school	1
School	2
School Facebook Page.	1
Southern Academy Promoted it	1
The principle informed her	1
The school PTA	1
Wife works for PTA	1
Word of mouth	1
Word of mouth from daughter	2

Q4. Did you read the information about how to save energy in the booklet that came in the kit?

Response Option	Count	Percent (n=172)
Yes	128	74%
No	31	18%
Don't know	13	8%

Q5. On a scale from 0 to 10 where 0 is not at all helpful and 10 is very helpful, how helpful was the information in the kit in identifying ways your household could save energy at home?

Response Option	Count	Percent (n=128)
0	0	0%
1	0	0%
2	0	0%
3	2	2%
4	0	0%
5	6	5%
6	8	6%
7	18	14%
8	23	18%
9	17	13%
10 - Very helpful	52	41%
Don’t know	2	2%

Q6. What might have made the information more helpful?

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Response Option	Count
I didn't read all of the booklet	1
I have already seen and understood most of the things that were there. I have used energy-saving aerators and LED bulbs. If I was looking for something useful, I would consider solar energy (even though I live in the woods) and insulation for my house.	1
I thought is was a good learning tool. I just already understood most of the info	1
If it was true and accurate	1
If there was more information for log cabins old or new.	1
More specifics, but that's difficult for a variety of houses.	1
Nothing many of the things listed we already knew about or do.	1
Nothing. I'm very aware of most of the topics	1
Quick summary of 44-page energy saving tips	1
Was more of a refresher than new information being brought up. Already has a lot of the suggestions in place in the home.	1

Q7. In addition to sending the energy saving kits, Duke Energy sponsored a program about energy and energy efficiency at your child's school, which included classroom materials and an in-school performance by the National Theatre for Children. Were you aware of this program before today?

Response Option	Count	Percent (n=172)
Yes	42	24%
No	128	74%
Don't know	2	1%

Q9. Where did you hear about this program?

Response Option	Count	Percent (n=42)
From my child/children	28	67%
From a teacher/school administrator	17	41%
On the Duke Energy website	0	0%
Other	6	14%
Don't remember	0	0%

Q9a. Other…

Response Option	Count
From my grandson	1
From the school	1

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From your child	1
Included with the information, probably in the initial form	1
PTA	1
Weekly information call from school	1

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later?

Response Option	Count	Percent (n=172)
Yes	160	93%
No	12	7%
Don't know	0	0%

Q12. Which of the items did you install, even if they were taken out later?

Response Option	Count	Percent (n=160)
Showerhead	86	54%
Kitchen faucet aerator	68	43%
Bathroom faucet aerator	60	38%
Night light	130	81%
Energy efficient light bulb(s) (LEDs)	149	93%
Insulator gaskets for light switches and electricity outlets	54	34%
I never installed any of the items from the kit	0	0%

Q13. In addition to the night light, there were two LED light bulbs in the kit. Did you install one or both of the LED light bulbs in the kit?

Response Option	Count	Percent (n=149)
Yes - I installed both LEDs	119	80%
No - I installed only one LED light bulb	28	19%
Don't know	2	1%

Q15. How many of the light switch gasket insulators from the kit did you [*if needed: or anyone else*] install in your home?

Response Option	Count	Percent (n=54)
None	0	0%
One	5	9%

Two	19	35%
Three	3	6%
Four	25	46%
Don't know	2	4%

Q16. How many electrical outlet gasket insulators from the kit did you [*if needed: or anyone else*] install in your home?

Response Option	Count	Percent (n=54)
None	2	4%
One	2	4%
Two	20	37%
Three	1	2%
Four	7	13%
Five	0	0%
Six	3	6%
Seven	2	4%
Eight	11	20%
Don't know	6	11%

Q17. Overall, how satisfied are you with the item[s] you installed? Please use 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied. How satisfied are you with...

	0	1	2	3	4	5	6	7	8	9	10	Don't know	Total
Showerhead	0%	0%	1%	1%	1%	3%	0%	10%	13%	8%	62%	0%	86
Kitchen faucet aerator	0%	1%	0%	1%	0%	3%	3%	6%	7%	9%	68%	1%	68
Bathroom faucet aerator	0%	0%	0%	2%	5%	2%	2%	8%	10%	10%	60%	2%	60
Night light	1%	0%	0%	1%	1%	1%	1%	4%	5%	5%	82%	1%	130

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Energy efficient light bulbs (LEDs)	1%	0%	0%	0%	1%	0%	1%	3%	4%	7%	83%	1%	149
Insulator gaskets	0%	0%	0%	0%	0%	6%	0%	4%	13%	7%	67%	4%	54

Q17a. Can you please explain any dissatisfaction you had with the showerhead?

Response Option	Count
Decreased water output	1
Doesn't give much power	1
Leaked	1
The pressure is so low	1
The showerhead is a water waster. So much water comes out so quickly that it drains our water heater. We have to put less pressure on the faucet so that less water comes out to be able to use it, in other words--not at capacity.	1

Q17b. Can you please explain any dissatisfaction you had with the kitchen faucet aerator?

Response Option	Count
Because the water comes out very slow	1
Didn't fit well	1
The water flow is terrible, very slow	1

Q17c. Can you please explain any dissatisfaction you had with the bathroom faucet aerator?

Response Option	Count
Bulb is super bright. Faucet piece leaked	1
Didn't fit well	1
I had to take the guts out of the aerator and put them in the casing that was already on my faucet	1
Slow	1
Water barely come out	1

Q17d. Can you please explain any dissatisfaction you had with the night light?

Response Option	Count
It didn't work and only one led light	1

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Response Option	Count
It's very low. The light is not enough.	1
Stopped working after a few days	1

Q17e. Can you please explain any dissatisfaction you had with the energy efficient light bulbs (LEDs)?

Response Option	Count
Did not work	1
I'm not dissatisfied, it's just like any other light	1
My bill went up. I usually pay $30 a month but after changing the it is $50 a month.	1
Still stuck on the old light bulbs. These need to "warm" up before getting good lighting	1

Q17f. Can you please explain any dissatisfaction you had with the insulator gaskets?

Response Option	Count
Our home was built in the last 4 years and most already had some outlets were difficult to put back. It really had nothing to do with the insulators more that I took off covers and they already had so i wasted a lot of time.	1
There wasn't an equal amount in each pack	1

Q18. Have you since uninstalled any of the items from the kit that you had previously installed?

Response Option	Count	Percent (n=160)
Yes	3	2%
No	157	98%
Don't know	0	0%

Q19. Which of the items did you uninstall?

Response Option	Count
Showerhead	0
Kitchen faucet aerator	0
Bathroom faucet aerator	1
Night light	1
Energy efficient light bulbs (LEDs)	1
Insulator gaskets	0
Don't know	0

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Q20. Why were those items uninstalled? Let's start with…

Q20a. the showerhead?

Response Option	Count
It was broken	0
Didn't like how it worked	0
Didn't like how it looked	0
Don't know	0

Q20b. the kitchen faucet aerator?

Response Option	Count
It was broken	0
Didn't like how it worked.	0
Didn't like how it looked.	0
Don't know	0

Q20c. the bathroom faucet aerator?

Response Option	Count
It was broken	0
Didn't like how it worked	0
Didn't like how it looked	1
Don't know	0

Q20d. the night light?

Response Option	Count
It was broken	1
Didn't like how it worked.	0
Didn't like how it looked.	0
Don't know	0

Q20e. the energy efficient light bulbs (LEDs)?

Response Option	Count
It was broken	0
Didn't like how it worked.	0
Didn't like how it looked.	0
Other – Because it was super bright	1
Don't know	0

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Q20f. the insulator gaskets?

Response Option	Count
It was broken	0
Didn't like how it worked.	0
Didn't like how it looked.	0
Don't know	0

Q21. You said you haven't installed [INPUT ONLY THOSE ITEMS IN Q12 IF Q12a-f = 2]. Which of those items do you plan to install in the next three months?

Response Option	Count	Percent (n=150)
Showerhead	37	25%
Kitchen faucet aerator	40	27%
Bathroom faucet aerator	48	32%
Night light	24	16%
Energy efficient lightbulbs (LEDs)	16	11%
Insulator gaskets	50	33%
Im not planning on installing any of these in the next three months.	50	33%

Q22. What's preventing you from installing those items? Let's start with….

Q22. Showerhead…

Response Option	Count	Percent (n=49)
Didn't know what that was	1	2%
Tried it, didn't fit	7	14%
Tried it, didn't work as intended (please explain in the box below)	5	10%
Haven't gotten around to it	2	4%
Current one is still working	11	22%
Takes too much time to install it / No time / Too busy	0	0%
Too difficult to install it, don't know how to do it	0	0%
Don't have the tools I need	0	0%
Don't have the items any longer (threw away, gave away)	1	2%
Already have an efficient showerhead	18	37%
Other (please specify in the box below)	12	24%
Don't know	1	2%

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Q22. Kitchen faucet aerator…

Response Option	Count	Percent (n=64)
Didn't know what that was	2	3%
Tried it, didn't fit	11	17%
Tried it, didn't work as intended (please explain in the box below)	5	8%
Haven't gotten around to it	14	22%
Current one is still working	11	17%
Takes too much time to install it / No time / Too busy	1	2%
Too difficult to install it, don't know how to do it	2	3%
Don't have the tools I need	2	3%
Don't have the items any longer (threw away, gave away)	1	2%
Already have an efficient kitchen faucet aerator	11	17%
Other (please specify in the box below)	10	16%
Don't know	3	5%

Q22. Bathroom faucet aerator…

Response Option	Count	Percent (n=64)
Didn't know what that was	4	6%
Tried it, didn't fit	10	16%
Tried it, didn't work as intended (please explain in the box below)	4	6%
Haven't gotten around to it	11	17%
Current one is still working	14	22%
Takes too much time to install it / No time / Too busy	1	2%
Too difficult to install it, don't know how to do it	3	5%
Don't have the tools I need	3	5%
Don't have the items any longer (threw away, gave away)	1	2%
Already have an efficient bathroom faucet aerator	11	17%
Other (please specify in the box below)	11	17%
Don't know	4	6%

Q22. Energy efficient lightbulbs (LEDs)…

Response Option	Count	Percent (n=7)
Didn't know what that was	0	0%

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Tried it, didn't fit	0	0%
Tried it, didn't work as intended (please explain in the box below)	0	0%
Haven't gotten around to it	1	14%
Current one is still working	1	14%
Takes too much time to install it / No time / Too busy	0	0%
Too difficult to install it, don't know how to do it	1	14%
Don't have the tools I need	0	0%
Don't have the items any longer (threw away, gave away)	0	0%
Already have LEDs	1	14%
Other (please specify in the box below)	3	43%
Don't know	0	0%

Q22. Night lights…

Response Option	Count	Percent (n=16)
Didn't know what that was	0	0%
Tried it, didn't fit	0	0%
Tried it, didn't work as intended (please explain in the box below)	1	6%
Haven't gotten around to it	3	19%
Current one is still working	4	25%
Takes too much time to install it / No time / Too busy	0	0%
Too difficult to install it, don't know how to do it	0	0%
Don't have the tools I need	0	0%
Don't have the items any longer (threw away, gave away)	0	0%
Other (please specify in the box below)	7	44%
Don't know	2	17%

Q22. Insulator gaskets…

Response Option	Count	Percent (n=66)
Didn't know what that was	7	11%
Tried it, didn't fit	3	5%
Tried it, didn't work as intended (please explain in the box below)	0	0%
Haven't gotten around to it	23	35%
Current one is still working	9	14%

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Takes too much time to install it / No time / Too busy	3	5%
Too difficult to install it, don't know how to do it	0	0%
Don't have the tools I need	1	2%
Don't have the items any longer (threw away, gave away)	1	2%
Other (please specify in the box below)	13	20%
Don't know	7	11%

Q22a. Thinking of the items you installed, would you be interested in receiving any more of them from Duke Energy? If so, which ones?

Response Option	Count	Percent (n=161)
Yes, I would like another energy-efficient showerhead	43	27%
Yes, I would like another kitchen faucet aerator	25	16%
Yes, I would like more bathroom faucet aerators	29	18%
Yes, I would like more energy-efficient night lights	97	60%
Yes, I would like more energy-efficient light bulbs (LEDs)	132	82%
Yes, I would like more switch/outlet gasket insulators	31	19%
No, I am not interested in receiving any more of the items	17	11%
Don't know	0	0%

Q22b. What would be your preferred way to request these additional items?

Response Option	Count	Percent (n=144)
Internet	88	61%
Telephone	26	18%
Pre-paid postcard	42	29%
Other, please specify	3	2%
Don't know	3	2%

Q26. You said you installed the night light. Did the night light replace an existing night light?

Response Option	Count	Percent (n=129)
Yes	88	68%
No	41	32%
Don’t know	0	0%

Q27. Did the old nightlight have a bulb that you could take out and replace once it burned out?

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Response Option	Count	Percent (n=88)
Yes	64	73%
No	20	23%
Don't know	4	5%

Q28. You said you installed at least one of the energy efficient lights. What type of bulb(s) did you replace with the energy efficient lightbulbs?

Response Option	Count	Percent (n=148)
All incandescent (old fashioned light bulb - likely purchased more than two years ago)	59	40%
All halogen (looks like an incandescent, but has a glass tube inside of the bulb)	7	5%
All CFL (spiral or twisty shaped bulb that fits into ordinary light fixtures)	67	45%
All LED (new bulb type that uses little electricity and lasts a long time)	5	3%
Some combination of bulb types (please specify which ones in the box below)	6	4%
Don’t know	4	3%

Q29. In what rooms did you install the energy efficient lightbulbs that were included in the kit?

Response Option	Count	Percent (n=148)
Living room	59	40%
Dining room	13	9%
Bedroom	60	41%
Kitchen	28	19%
Bathroom	16	11%
Den	3	2%
Garage	3	2%
Hallway	13	9%
Basement	0	0%
Outdoors	2	1%
Other area (please specify in the box below)	4	3%
Don’t Know	2	1%

Q30. Have you adjusted the temperature of your water heater based on the Hot Water Gauge Card included in your kit?

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Response Option	Count	Percent (n=172)
Yes	25	15%
No	111	65%
Don't recall seeing the Hot Water Gauge Card	26	15%
Don't know	10	6%

Q31. Do you know what the old temperature setting on your hot water heater was?

Response Option	Count	Percent (n=25)
Yes	3	12%
No	22	88%

Q31a. Temperature setting...

Response Option	Count
110	1
135	1
20 or 50-something	1

Q32. And what was the new temperature setting you set your hot water heater to?

Response Option	Count
70	1
100	1
120	2
125	1
130	1
176	1

Q33. Is the new water heater temperature setting still in place?

Response Option	Count	Percent (n=25)
Yes	22	88%
No	2	8%
Don't know	1	4%

Q34. Why did you change the water heater temperature a second time?

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Response Option	Count
Customer says it was not too hot	1
We had an element that went out. We put it back and it will be replaced next week.	1

Q35. What is the fuel type of your water heater?

Response Option	Count	Percent (n=172)
Electricity	134	78%
Natural Gas	28	16%
Other (please specify in the box below)	2	1%
Don't know	8	5%

Q36. How old is your water heater?

Response Option	Count	Percent (n=172)
Less than five years old	49	29%
Five to nine years old	38	22%
Ten to fifteen years old	24	14%
More than fifteen years old	13	8%
Don't know	48	28%

Q37. If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

Response Option	Count	Percent (n=159)
Yes	60	38%
No	70	44%
Don't know	29	18%

Q38. What items would you have purchased and installed within the next year?

Response Option	Count	Percent (n=58)
Energy-Efficient Showerhead	11	19%
Kitchen faucet aerator	7	12%
Bathroom faucet aerator	2	3%
Energy-Efficient Night light	20	35%
Energy efficient lightbulbs (LEDs)	53	91%
Switch/Outlet Gasket Insulators	3	5%

No I would not have purchased any of the items	0	0%
Other	0	0%
Don't know	1	2%

Q39. If you had not received them for free in the kit, how many LED light bulbs would you have purchased?

Response Option	Count	Percent (n=45)
One	2	4%
Two	34	76%
Don't know	9	20%

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Q40. Now, thinking about the water savings items that were provided in the kit - using a scale from 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential" how influential were the following factors on your decision to install the water saving items from the kit? How influential was…

	0	1	2	3	4	5	6	7	8	9	10	Don't know	Total
The fact that the items were free	4%	0%	0%	1%	1%	3%	3%	7%	8%	6%	67%	1%	106
The fact that the items were mailed to your house	1%	0%	0%	0%	0%	3%	2%	4%	5%	7%	79%	0%	106
The chance to win cash prizes for your household and school	8%	2%	2%	2%	1%	6%	6%	4%	7%	8%	53%	4%	106
Information in the kit about how the items would save energy	0%	0%	0%	1%	2%	4%	6%	6%	10%	9%	60%	2%	106
Information that your child brought home from school	3%	0%	1%	1%	0%	5%	7%	8%	11%	9%	52%	2%	106
Other information or advertisements from Duke Energy, including its website	8%	1%	0%	4%	3%	8%	5%	10%	15%	5%	37%	4%	106

Q41. Using a scale from 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential" how influential were the following factors on your decision to install the lightbulbs from the kit? How influential was…

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	0	1	2	3	4	5	6	7	8	9	10	Don't know	Total
The fact that the items were free	1%	0%	0%	0%	1%	4%	1%	5%	5%	4%	79%	1%	148
The fact that the items were mailed to your house	0%	0%	0%	1%	1%	2%	1%	3%	7%	5%	80%	1%	148
The chance to win cash prizes for your household and school	7%	2%	1%	3%	1%	9%	4%	3%	6%	3%	57%	4%	148
Information in the kit about how the items would save energy	1%	0%	0%	1%	3%	8%	3%	6%	11%	6%	59%	1%	148
Information that your child brought home from school	5%	1%	0%	1%	3%	7%	3%	7%	9%	6%	53%	3%	148
Other information or advertisements from Duke Energy, including its website	11%	1%	1%	3%	5%	8%	3%	7%	7%	8%	41%	4%	148

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Q42. I've got just a few final questions about other energy saving activities. First, Duke Energy asked us to ask a couple of questions about the Home Energy Reports it sends to some families. These reports provide detailed information on your home's energy usage and compare your home to similar homes of your neighbors.
During the school year, did you receive any Home Energy Reports from Duke Energy?

Response Option	Count	Percent (n=110)
Yes	90	82%
No	13	12%
Don't know	7	6%

Q43. How often do you read those Home Energy Reports?

Response Option	Count	Percent (n=90)
Never	1	1%
Sometimes	25	28%
Always	64	71%
Don't know	0	0%

Q44. The Home Energy Reports provide specific recommendations for how you can save energy in your home. Have you completed any of the energy saving recommendations from the Home Energy Reports? If so, which ones? [MULTIPLE RESPONSE]

Response Option	Count
Nothing	29
Purchased energy saving products for my home and received a Duke Energy rebate	8
Purchased energy saving products for my home but did not receive a Duke Energy rebate	9
Made energy saving modifications to my home (example: installed insulation or windows)	18
Adjusted how or when I use energy in my home	33
Looked for additional information on how to save energy	9
Other (please specify in the box below)	7
Don't know	4

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Q45. Since your child learned about energy conservation at school and signed up for your energy kit from Duke Energy, has your child adopted any **new** behaviors to help save energy in your home? This would only include new energy saving **behaviors** that your child adopted since receiving the kit. [*IF NEEDED: like turning off the lights when room is unoccupied*]

Response Option	Count
Not applicable - no new behaviors	48
Turn off lights when not in a room	97
Turn off electronics when not using them	65
Take shorter showers	35
Other	17
Don't know	8

Q45a. Other…

Response Option	Count
I don't have any children	1
I really haven't noticed anything.	1
Make sure all the doors and windows are closed	1
My child just turned 3. She doesn't really understand about it yet, but we've raised her to always turn off lights when they're not being used.	1
My daughter is now aware of saving electricity and encourages recycling.	1
Not that I know of, because she's only six.	1
Saving/not wasting water	3
She lectures everyone about turning lights off and closing the refrigerator and turning off electronics	1
Turning off water while brushing teeth	3
Turns off the water.	1
Unplugging computers and TV's when leaving the house.	1
Unplugs nightlight when not using it.	1
Using less water.	1

Q45b. [IF Q45 =2-5] Before receiving the kit, was your child already…

Response Option	Count	Percent (n=54)
Turning off lights when not in a room	42	78%
Turning off electronics when not using them	18	33%
Taking shorter showers	7	13%
Other	5	9%

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Q46. Since receiving your energy kit from Duke Energy, have you adopted any new behaviors to help save energy in your home? This would only include new energy saving **behaviors** that you have adopted since receiving the kit. [IF NEEDED: like turning off the lights when room is unoccupied]
[MULTIPLE RESPONSE] *[Interviewer: Do not read list. After each response ask, "Anything else?"]*

Response Option	Count
Not applicable - no new behaviors	41
Turning off lights when not in a room	85
Turning off furnace when not home	19
Turning off air conditioning when not home	33
Changed thermostat settings to use less energy	72
Using fans instead of air conditioning	55
Turning off electronics when we are not using them	62
Taking shorter showers	28
Turning water heat thermostat down	18
Other (please specify in the box below)	16
Don't know	1

Q46a. Other…

Response Option	Count
Adjusted the thermostat	1
Buy LEDs when lights go out.	4
Consider using more LED bulbs	1
I installed more things for the a/c area.	1
I'm leaving the new LED bulb in the hallway on 24 hours a day so I can see how much energy LED's save.	1
Installed LED bulbs	1
More mindful of the use meter	1
Try not to do but 1 load of laundry a day	1
Turn off the a/c when we go to bed	1
Turning hot water heater down and checking it	1
Use LEDs	1
Using energy-efficient appliances	1
Wash clothes later on at night	1
Washer machine unplugged	1
Watching the thermostat and making adjustments when needed	1
We keep everything unplugged when we're not using them.	1

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Q46b. [IF Q46 =2-10] Before receiving the kit, were you already…

Response Option	Count	Percent (n=89)
Turning off lights when not in a room	60	67%
Turning off furnace when not home	10	11%
Turning off air conditioning when not home	17	19%
Changing thermostat settings so heating or cooling system uses less energy	31	35%
Using fans instead of air conditioning	35	39%
Turning off electronics when not using them	29	33%
Taking shorter showers	12	13%
Turning water heat thermostat down	4	4%
Other	6	7%

Q47. On a scale of 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential," how much influence did Duke Energy's kit and materials on saving energy have on your decision to [LIST ALL RESPONSES FROM Q46].

Response Option	Count	Percent (n=130)
0 – Not at all influential	4	3%
1	0	0%
2	1	1%
3	2	2%
4	0	0%
5	7	5%
6	3	2%
7	21	16%
8	17	13%
9	10	8%
10 - Extremely influential	64	49%
Don't know	1	1%

Q47a. Thinking of the near future, are you interested in purchasing any additional products or services to help save energy in your home?

Response Option	Count	Percent (n=172)
Yes	115	67%
No	30	17%
Don't know	27	16%

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Q47b. What additional products or services are you interested in purchasing?

Response Option	Count
Energy efficient appliances	48
Efficient heating or cooling equipment	24
Efficient windows	30
Adding insulation	25
Sealing air leaks	30
Sealing or insulating ducts	15
Efficient lighting (LEDs)	87
Energy efficient water heater	19
Internet connected “smart” thermostat	23
Other	16
Don't know	7

Q48. Since receiving your energy kit from Duke Energy, have you purchased and installed any other **products** or made any improvements to your home to help save energy?

Response Option	Count	Percent (n=172)
Yes	46	27%
No	120	70%
Don't know	6	4%

Q49. What **products** have you purchased and installed to help save energy in your home? [MULTIPLE RESPONSE]

Response Option	Count
Bought energy efficient appliances	8
Moved into an ENERGY STAR home	2
Bought efficient heating or cooling equipment	4
Bought efficient windows	2
Added insulation	8
Sealed air leaks	10
Sealed ducts	3
Bought LEDs	29
Bought CFLs	1
Installed an energy efficient water heater	1
None – no other actions taken	0
Other (please specify in the box below)	8
Don’t know	1

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Q49a. Other…

Response Option	Count
Added a smart thermostat	1
Air Conditioning Service, making sure it is properly maintained to save on energy costs	1
Bought and installed a new heat pump	1
Dish Washer, Refrigerator and Stove	1
Drapes for blackouts so that the sun doesn't heat up the rooms during Summer	1
Just the a/c things	1
Solar panels	1
Upgraded A/C filters	1

Q50. Did you get a rebate from Duke Energy for any of those products or services? If so, which ones?

Response Option	Count
Bought energy efficient appliances	2
Moved into an ENERGY STAR home	0
Bought efficient heating or cooling equipment	0
Bought efficient windows	0
Bought additional insulation	0
Sealed air leaks	0
Sealed ducts	0
Bought LEDs	1
Bought CFLs	0
Installed an energy efficient water heater	0
Other	1
I did not get any Duke Rebates	36
Don't know	5

Q51. On a scale of 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential”, how much influence did the Duke Energy schools program have on your decision to…

	0 - Not at all influential	1	2	3	4	5	6	7	8	9	10 - Extremely influential	Don't Know	Total
Buy energy efficient appliances	0%	0%	13%	0%	13%	0%	13%	13%	13%	0%	38%	0%	14
Move into an ENERGY STAR home	0%	0%	0%	0%	0%	0%	0%	0%	50%	0%	50%	0%	1
Buy efficient heating or cooling equipment	50%	0%	0%	0%	25%	25%	0%	0%	0%	0%	0%	0%	5
Buy efficient windows	50%	0%	50%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5
Add insulation	25%	0%	0%	0%	0%	13%	13%	0%	13%	13%	25%	0%	12
Seal air leaks	10%	0%	0%	0%	0%	0%	10%	0%	20%	10%	50%	0%	6
Seal ducts	0%	0%	0%	0%	0%	0%	0%	0%	0%	33%	67%	0%	1
Buy LEDs	3%	0%	0%	7%	3%	10%	7%	0%	17%	7%	41%	3%	28
Buy CFLs	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	1
Install an energy efficient water heater	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	3
Other	38%	0	0	0	0	1	0	0	1	0	25%	13	10

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		%	%	%	%	3 %	%	%	3 %	%		%	

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Q52. What kinds of appliance(s) did you buy?

Response Option	Count
Refrigerator	4
Stand-alone Freezer	0
Dishwasher	3
Clothes washer	5
Clothes dryer	6
Oven	0
Microwave	1
Other	0
Don't know	0

Q53. Was the [INSERT Q52 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Count	Percent (n=7)
Refrigerator	4	57%
Stand-alone Freezer	0	0%
Dishwasher	2	29%
Clothes washer	4	57%
Clothes dryer	5	71%
Oven	0	0%
Microwave	1	14%
Other	0	0%

Q54. Does the new clothes dryer use natural gas?

Response Option	Count
Yes- it uses natural gas	1
No – does not use natural gas	5
Don't know	0

Q55. What type of heating or cooling equipment did you buy?

Response Option	Count	Percent (n=2)
Central air conditioner	1	50%
Window/room air conditioner unit	0	0%
Wall air conditioner unit	0	0%
Air source heat pump	0	0%
Geothermal heat pump	0	0%
Boiler	0	0%

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Response Option	Count	Percent (n=2)
Furnace	0	0%
Wifi-enabled thermostat	0	0%
Other (please specify in the box below)	0	0%
Don't know	1	50%

Q55a. Other…

Response Option	Count
Not applicable	0

Q56. Does the new [INSERT Q55 RESPONSE] use natural gas?

Response Option	Count
Not applicable	0

Q57. Was the [INSERT Q55 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Count	Percent (n=1)
Central air conditioner	1	100%
Window/room air conditioner unit	0	0%
Wall air conditioner unit	0	0%
Air source heat pump	0	0%
Geothermal heat pump	0	0%
Boiler	0	0%
Furnace	0	0%
Wifi-enabled thermostat	0	0%
Other (please specify in the box below)	0	0%
Don't know	0	0%

Q58. How many windows did you install?

Response Option	Count
10	1

Q59. Did you add insulation to your attic, walls, or below the floor? [MULTIPLE RESPONSE]

Response Option	Count
Attic	5
Walls	3
Below the floor	1
Don’t know	0

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Q60a. Approximately what proportion of the attic space did you add insulation?

Response Option	Count
50	1
50%	1
90%	1
Don't know	0

Q60b. Approximately what proportion of the wall space did you add insulation?

Response Option	Count
3	1
50%	1
Don't know	0

Q60c. Approximately what proportion of the below the floor space did you add insulation?

Response Option	Count
50%	1

Q61. Do you know how many of LEDs you installed at your property?

Response Option	Count
Yes	25
Don't know	3

Q61a. How many of LEDs did you install in your property?

Response Option	Count
2	2
3	1
4	2
5	1
6	7
8	1
8 plus 2 from the box	1
10	2
12	1
15	1
20	4
25	1

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Response Option	Count
30	1
Don't know	0

Q62. How many of CFLs did you install in your property?

Response Option	Count
Yes	1
Don't know	1

Q62. Number of CFLS installed…

Response Option	Count
2	1

Q63. Does the new water heater use natural gas?

Response Option	Count
Yes - it uses natural gas	1
No – does not use natural gas	0
Don't know	0

Q64. Which of the following water heaters did you purchase?

Response Option	Count
A traditional water heater with a large tank that holds the hot water	0
A tankless water heater that provides hot water on demand	1
A solar water heater	0
Other	0
Don't' know	0

Q65. Is the new water heater an ENERGY STAR model?

Response Option	Count
Yes	1
No	0
Don't know	0

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Q66. Which of the following types of housing units would you say best describes your home? It is . . .?

Response Option	Count	Percent (n=172)
Single-family detached house	102	59%
Single-family attached home (such as a townhouse or condo)	9	5%
Duplex, triplex or four-plex	3	2%
Apartment or condominium in a building with 5 units or more	22	13%
Manufactured or mobile home	32	19%
Other	2	1%
Don't know	1	1%

Q66. Other…

Response Option	Count
Buying own house soon and will want to make more energy efficient	1
Single family log cabin	1

Q67. How many square feet of living space are there in your residence, including bathrooms, foyers and hallways (exclude garages, unfinished basements, and unheated porches)?

Response Option	Count	Percent (n=172)
Less than 500 square feet	1	1%
500 to under 1,000 square feet	12	7%
1,000 to under 1,500 square feet	42	24%
1,500 to under 2,000 square feet	20	12%
2,000 to under 2,500 square feet	22	13%
2,500 to under 3,000 square feet	16	9%
Greater than 3,000 square feet	17	10%
Don't know	42	24%

Q68. Do you or members of your household own your home, or do you rent it?

Response Option	Count	Percent (n=172)
Own / buying	111	65%
Rent / lease	61	36%
Occupy rent-free	0	0%

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Don't know	0	0%

Q69. Including yourself, how many people currently live in your home year-round?

Response Option	Count	Percent (n=172)
I live by myself	8	5%
Two people	25	15%
Three people	42	24%
Four people	54	31%
Five people	30	17%
Six people	9	5%
Seven people	3	2%
Eight or more people	1	1%
Don't know	0	0%

Q70. What was your total annual household income for 2017, before taxes?

Response Option	Count	Percent (n=172)
Under $20,000	27	16%
$20,000 to under $30,000	19	11%
$30,000 to under $40,000	18	10%
$40,000 to under $50,000	14	8%
$50,000 to under $60,000	11	6%
$60,000 to under $75,000	9	5%
$75,000 to under $100,000	19	11%
$100,000 to under $150,000	20	12%
$150,000 to under $200,000	9	5%
$200,000 or more	3	2%
Don't know	4	2%
Prefer not to say	19	11%

Q71. What is the highest level of education achieved among those living in your household?

Response Option	Count	Percent (n=172)
Less than high school	1	1%
Some high school	7	4%
High school graduate or equivalent (such as GED)	33	19%
Trade or technical school	4	2%
Some college (including Associate degree)	50	29%

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Response Option	Count	Percent (n=172)
College degree (Bachelor's degree)	38	22%
Some graduate school	5	3%
Graduate degree, professional degree	32	19%
Doctorate	1	1%
Don't know	0	0%
Prefer not to say	1	1%

G.4 Student Parent Survey - DEC

Q2. Before today, did you know the kit you received was sponsored by Duke Energy?

Response Option	Count	Percent (n=334)
Yes	313	94%
No	19	6%
Don't know	2	1%

Q3. How did you learn that the kit was sponsored by Duke Energy? [Select all that apply]

Response Option	Count	Percent (n=313)
Classroom materials brought home by child	183	58%
My child's teacher/school	92	29%
Information material included in/on the kit	92	29%
Other	33	11%
Don't know	6	2%

Q3. Other…

Response Option	Count
A friend	1
Advertisement sent home from school that we signed up for	1
By a letter	1
contest sponsored at daughter's school	1
Duke Energy	1
Flyer	1
Friend told me	1
From Duke Power.	1
Had to fill something out online and it was on the box as well	1

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Response Option	Count
Heard some of the parents talking about it.	1
I signed up for it online.	1
I use to work as a substitute teacher part time.	1
I work for Duke HEHC Program	1
In the papers that came with it	1
Informed by neighbors on the next door app	1
Internet	1
My daughter shared her experiences with me prior to receiving the materials	1
My wife teaches at the middle school level.	1
Neighbor is a retired Duke Employee.	1
Network neighborhood site	1
Online	2
Pervious Experience	1
Previous participation in the LED kit.	1
PTO promotion of kit!	1
Requested it when I moved into my house	1
Saw information about the kit online	1
School's Social Media	1
Teacher told me	1
Website	3
When it arrived I was told by my grandson it was from Duke	1

Q3a. How did you hear about the opportunity to receive the kit from Duke Energy? [Select all that apply]

Response Option	Count	Percent (n=334)
Classroom materials brought home by child	238	71%
School newsletter	57	17%
Email from my child's teacher/school	46	14%
School website or school web portal	20	6%
In-person conversations with my child's teacher	14	4%
Saw a poster at my child's school	12	4%
After hours event at my child's school	8	2%
Other (please specify in the box below)	44	13%
Don't know	10	3%

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Q3a. Other…

Response Option	Count
A friend	1
Assembly sponsored by Duke Energy.	1
Call from my child's school	1
Class Dojo message from school	1
Contest at my daughter's school	1
Duke Energy Website	1
Either something we filled out or something that came home with the kids from school	1
Facebook	1
Flyer from school	2
Friend told me.	1
From my niece Stacey Johnson	1
From the school	1
Grand daughter brought home a card	1
Heard about it from another child's parent	1
Heard some of the parents talking about it.	1
I saw it on my light bill.	1
It just came in the mail	1
Letter from the school	1
Monthly Bill	1
My child	1
My child told me.	1
My wife teaches at the school.	1
Neighbors posted on nextdoor app	1
Network neighborhood site	1
Once it arrived	1
Pervious Experience	1
Room Parent emails PTO newsletter PTO Facebook posts	1
Saw it on Facebook	1
School	1
School Facebook page	1
School sent me a brochure	1
Social media from school	1
Supporter of saving the environment, step daughter brought home paper from school	1
The school may have given us flyers	1
Was told by my child	1

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Response Option	Count
Website	3
When it arrived I was told it was from Duke by my grandson	1
Word of mouth from family	1
Work for duke	1

Q4. Did you read the information about how to save energy in the booklet that came in the kit?

Response Option	Count	Percent (n=334)
Yes	245	73%
No	62	19%
Don't know	27	8%

Q5. On a scale from 0 to 10 where 0 is not at all helpful and 10 is very helpful, how helpful was the information in the kit in identifying ways your household could save energy at home?

Response Option	Count	Percent (n=245)
0	1	0%
1	1	0%
2	0	0%
3	2	1%
4	5	2%
5	17	7%
6	17	7%
7	42	17%
8	43	18%
9	24	10%
10 - Very helpful	93	38%
Don’t know	0	0%

Q6. What might have made the information more helpful?

Response Option	Count
A chart of the options and other ways to save.	1
Adding more statistical data to prove that what’s actually stated is true	1
Better as video than booklet.	1
Could have used more specific info on insulating pipes.	1

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Response Option	Count
Different ways to save energy.	1
I already knew the info. I'm sure it would be helpful to someone who didn't already know.	1
I did this line of work for a living so I already knew the info	1
I don't know but it was stuff I already knew	1
I was pretty much aware of all the ways to save energy. I am very conservative with everything.	1
Including information to help renters	1
It was kind of confusing, need more detail	1
It was too long	1
It was very helpful. We rent so there is only so much we can do.	1
Just didn't apply to me	1
Low income resources	1
More ideas on savings.	1
More incentive to use the items... Example rebates...note with power bill telling how much your own home saved after using the items make it more personal not a average	1
More info for energy savings in a mobile home	1
More options and more detailed information and instructions.	1
More pictures. More info	1
Sleep	1
Tell how to really save energy	1
The reading	1
Tips	1
We tend to try our best at club conservation, so I'm not the best to think of with changing minds.	1
Well the showerheads need to be a little bigger for my shower	1

Q7. In addition to sending the energy saving kits, Duke Energy sponsored a program about energy and energy efficiency at your child's school, which included classroom materials and an in-school performance by the National Theatre for Children. Were you aware of this program before today?

Response Option	Count	Percent (n=334)
Yes	104	31%
No	228	68%
Don't know	2	1%

Q9. Where did you hear about this program?

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Response Option	Count	Percent (n=104)
From my child/children	80	77%
From a teacher/school administrator	29	28%
On the Duke Energy website	15	14%
Other	5	5%
Don't remember	2	2%

Q9a. Other…

Response Option	Count
From the school	1
Network neighborhood site	1
PTO	1
School's website.	1
Through the school newsletter	1

Q10. Have you or anyone else installed any of those items in your home, even if they were taken out later?

Response Option	Count	Percent (n=334)
Yes	312	93%
No	22	7%
Don't know	0	0%

Q12. Which of the items did you install, even if they were taken out later?

Response Option	Count	Percent (n=312)
Showerhead	153	49%
Kitchen faucet aerator	109	35%
Bathroom faucet aerator	104	33%
Night light	259	83%
Energy efficient light bulb(s) (LEDs)	297	95%
Insulator gaskets for light switches and electricity outlets	103	33%
I never installed any of the items from the kit	0	0%

Q13. In addition to the night light, there were two LED light bulbs in the kit. Did you install one or both of the LED light bulbs in the kit?

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Response Option	Count	Percent (n=297)
Yes - I installed both LEDs	237	80%
No - I installed only one LED light bulb	50	17%
Don't know	10	3%

Q15. How many of the light switch gasket insulators from the kit did you [*if needed: or anyone else*] install in your home?

Response Option	Count	Percent (n=103)
None	3	3%
One	11	11%
Two	31	30%
Three	7	7%
Four	44	43%
Don't know	7	7%

Q16. How many electrical outlet gasket insulators from the kit did you [*if needed: or anyone else*] install in your home?

Response Option	Count	Percent (n=103)
None	4	4%
One	6	6%
Two	29	28%
Three	5	5%
Four	20	19%
Five	2	2%
Six	5	5%
Seven	1	1%
Eight	18	17%
Don't know	13	13%

Q17. Overall, how satisfied are you with the item[s] you installed? Please use 0 to 10 scale, where 0 is very dissatisfied and 10 is very satisfied. How satisfied are you with...

	0	1	2	3	4	5	6	7	8	9	10	Don't know	Total

Showerhead	1%	1%	1%	1%	1%	5%	3%	13%	13%	10%	50%	1%	153
Kitchen faucet aerator	2%	0%	1%	1%	1%	5%	3%	7%	8%	3%	67%	3%	109
Bathroom faucet aerator	2%	1%	0%	3%	0%	5%	3%	9%	9%	7%	62%	1%	104
Night light	0%	1%	0%	1%	0%	1%	1%	3%	10%	8%	75%	0%	259
Energy efficient light bulbs (LEDs)	1%	0%	0%	1%	0%	0%	2%	3%	5%	10%	77%	0%	297
Insulator gaskets	0%	0%	0%	1%	2%	2%	1%	6%	14%	7%	59%	9%	103

Q17a. Can you please explain any dissatisfaction you had with the showerhead?

Response Option	Count
Absolutely no water pressure. Takes forever to rinse soap off. Had another water saver head and it had tons of pressure. Uninstalled the free one after 2 days. I was itchy because soap would not rinse off without leaving the water on forever. I feel I used more water using this head because I had to leave the water on longer.	1
I wish there was flow from the center of the shower head as well as the circle. It makes washing longer hair a little harder to get the shampoo out.	1
It was not like the one we already had installed. The one we had was flatter and spread more water.	1
It's a dumb criticism, but it doesn't look as cool as it could.	1
Live in apartment it isn't dissatisfaction with the shower head but with the general water pressure at apartment	1
Pressure was very poor	1
Shower head leaks water	1
The water flow is different and we have to get used to it.	1
Too slow	1
Very slow	1

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Response Option	Count
Water flow pressure was very low. Took longer to wash out soap or to clean off!	1

Q17b. Can you please explain any dissatisfaction you had with the kitchen faucet aerator?

Response Option	Count
Came out to slow	1
Didn't properly fit right on the sink.	1
It kept leaking even when the water was shut off so i had to put the old one back on.	1
It made water squirt out everywhere	1
It was too large for my faucet, it needed an additional adapter	1
Just don't like the loss of flow	1
Low water pressure. Very hard to rinse off dishes and takes longer!	1
Not saving	1
the only con is the kitchen water doesn't have as much water power/pressure when washing as it used to	1
There was not enough pressure	1
We couldn’t install it correctly. Wasn’t matching the sink I believe.	1

Q17c. Can you please explain any dissatisfaction you had with the bathroom faucet aerator?

Response Option	Count
Cut back too much water	1
Didn't properly fit right.	1
It didn’t fit our faucet correctly	1
Low water pressure and so wouldn't even wash tooth paste off tooth brushes!! Removed them all.	1
Made water squirt out everywhere	1
Not saving	1
Sprays water out	1

Q17d. Can you please explain any dissatisfaction you had with the night light?

Response Option	Count
I'd prefer it to have an on/off switch	1
I'm not really sure what the nightlight does or how it will save me energy at this time.	1
It is not bright enough.	1
It's not very bright	1

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Response Option	Count
No just wasn't needed.	1
Not bright enough for my needs	1
Not saving	1
Nothing but an energy user with little helping of light	1
very happy with the night light	1
Wasn't bright enough for my child	1

Q17e. Can you please explain any dissatisfaction you had with the energy efficient light bulbs (LEDs)?

Response Option	Count
Blink sometimes	1
Not a huge fan of the type of lighting they provide	1
Not enough	1
Not saving	1
There are not as bright. I brought lights that were brighter.	1
They were not bright enough for the area	1
They were too dim and it took a long time to actually get bright	1

Q17f. Can you please explain any dissatisfaction you had with the insulator gaskets?

Response Option	Count
I have an older home built in 1986. I have not noticed a difference in my home insulation since installing these. I installed them only on exterior walls.	1
I still feel air coming through.	1
Not saving	1

Q18. Have you since uninstalled any of the items from the kit that you had previously installed?

Response Option	Count	Percent (n=312)
Yes	30	10%
No	279	89%
Don't know	3	1%

Q19. Which of the items did you uninstall?

Response Option	Count (n=30)
Showerhead	13

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Response Option	Count (n=30)
Kitchen faucet aerator	10
Bathroom faucet aerator	4
Night light	8
Energy efficient light bulbs (LEDs)	5
Insulator gaskets	1
Don't know	1

Q20. Why were those items uninstalled? Let's start with…

Q20a. the showerhead?

Response Option	Count
It was broken	1
Didn't like how it worked	8
Didn't like how it looked	2
Other – Leaks water	1
Other – Switched to handheld shower	1
Other – Wanted to install the one with the water line	1
Don't know	0

Q20b. the kitchen faucet aerator?

Response Option	Count
It was broken	1
Didn't like how it worked.	5
Didn't like how it looked.	0
Other – Couldn't install it correctly	1
Other – Did not have an adapter	1
Other – Had to install a filter Brita system	1
Other – Water kept leaking out of it even when the water was turned off.	1
Don't know	0

Q20c. the bathroom faucet aerator?

Response Option	Count
It was broken	0
Didn't like how it worked	2
Didn't like how it looked	0
Other – Didn't fit correctly	1

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Response Option	Count
Other – Sprays water out instead of the normal	1
Don't know	0

Q20d. the night light?

Response Option	Count
It was broken	2
Didn't like how it worked.	0
Didn't like how it looked.	1
Other – Child removed and lost the light	1
Other – To keep my lamps off	1
Other – Too bright	1
Other – Wasn't needed	1
Other – We had to move the night light to a different outlet.	1
Don't know	0

Q20e. the energy efficient light bulbs (LEDs)?

Response Option	Count
It was broken	2
Didn't like how it worked.	1
Didn't like how it looked.	1
Other – They went out	1
Other – Was not bright enough in the area but we did install into just a simple lamp	1
Don't know	0

Q20f. the insulator gaskets?

Response Option	Count
It was broken	0
Didn't like how it worked.	0
Didn't like how it looked.	1
Don't know	0

Q21. You said you haven't installed [INPUT ONLY THOSE ITEMS IN Q12 IF Q12a-f = 2]. Which of those items do you plan to install in the next three months?

Response Option	Count	Percent (n=314)
Showerhead	63	20%

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Kitchen faucet aerator	68	22%
Bathroom faucet aerator	82	26%
Night light	40	13%
Energy efficient lightbulbs (LEDs)	26	8%
Insulator gaskets	92	29%
Im not planning on installing any of these in the next three months.	106	34%

Q22. What's preventing you from installing those items? Let's start with….

Q22. Showerhead…

Response Option	Count	Percent (n=118)
Didn't know what that was	2	2%
Tried it, didn't fit	9	8%
Tried it, didn't work as intended (please explain in the box below)	6	5%
Haven't gotten around to it	11	9%
Current one is still working	33	28%
Takes too much time to install it / No time / Too busy	3	3%
Too difficult to install it, don't know how to do it	2	2%
Don't have the tools I need	1	1%
Don't have the items any longer (threw away, gave away)	1	1%
Already have an efficient showerhead	45	38%
Other (please specify in the box below)	21	18%
Don't know	2	2%

Q22. Kitchen faucet aerator…

Response Option	Count	Percent (n=156)
Didn't know what that was	9	6%
Tried it, didn't fit	32	21%
Tried it, didn't work as intended (please explain in the box below)	8	5%
Haven't gotten around to it	28	18%
Current one is still working	26	17%
Takes too much time to install it / No time / Too busy	2	1%
Too difficult to install it, don't know how to do it	4	3%
Don't have the tools I need	1	1%

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Don't have the items any longer (threw away, gave away)	2	1%
Already have an efficient kitchen faucet aerator	34	22%
Other (please specify in the box below)	23	15%
Don't know	3	2%

Q22. Bathroom faucet aerator…

Response Option	Count	Percent (n=148)
Didn't know what that was	13	9%
Tried it, didn't fit	30	20%
Tried it, didn't work as intended (please explain in the box below)	6	4%
Haven't gotten around to it	32	22%
Current one is still working	15	10%
Takes too much time to install it / No time / Too busy	1	1%
Too difficult to install it, don't know how to do it	1	1%
Don't have the tools I need	3	2%
Don't have the items any longer (threw away, gave away)	2	1%
Already have an efficient bathroom faucet aerator	24	16%
Other (please specify in the box below)	25	17%
Don't know	4	3%

Q22. Energy efficient lightbulbs (LEDs)…

Response Option	Count	Percent (n=11)
Didn't know what that was	0	0%
Tried it, didn't fit	1	9%
Tried it, didn't work as intended (please explain in the box below)	0	0%
Haven't gotten around to it	1	9%
Current one is still working	2	18%
Takes too much time to install it / No time / Too busy	0	0%
Too difficult to install it, don't know how to do it	0	0%
Don't have the tools I need	0	0%
Don't have the items any longer (threw away, gave away)	0	0%
Already have LEDs	3	27%
Other (please specify in the box below)	3	27%

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Don't know	1	9%

Q22. Night lights…

Response Option	Count	Percent (n=35)
Didn't know what that was	0	0%
Tried it, didn't fit	1	3%
Tried it, didn't work as intended (please explain in the box below)	2	6%
Haven't gotten around to it	10	29%
Current one is still working	5	14%
Takes too much time to install it / No time / Too busy	0	0%
Too difficult to install it, don't know how to do it	0	0%
Don't have the tools I need	0	0%
Don't have the items any longer (threw away, gave away)	1	3%
Other (please specify in the box below)	13	37%
Don't know	3	9%

Q22. Insulator gaskets…

Response Option	Count	Percent (n=139)
Didn't know what that was	12	9%
Tried it, didn't fit	7	5%
Tried it, didn't work as intended (please explain in the box below)	4	3%
Haven't gotten around to it	48	35%
Current one is still working	19	14%
Takes too much time to install it / No time / Too busy	10	7%
Too difficult to install it, don't know how to do it	9	6%
Don't have the tools I need	3	2%
Don't have the items any longer (threw away, gave away)	2	1%
Other (please specify in the box below)	27	19%
Don't know	9	6%

Q22a. Thinking of the items you installed, would you be interested in receiving any more of them from Duke Energy? If so, which ones?

Response Option	Count	Percent (n=326)

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Yes, I would like another energy-efficient showerhead	79	24%
Yes, I would like another kitchen faucet aerator	45	14%
Yes, I would like more bathroom faucet aerators	47	14%
Yes, I would like more energy-efficient night lights	190	58%
Yes, I would like more energy-efficient light bulbs (LEDs)	254	78%
Yes, I would like more switch/outlet gasket insulators	49	15%
No, I am not interested in receiving any more of the items	32	10%
Don't know	79	24%

Q22b. What would be your preferred way to request these additional items?

Response Option	Count	Percent (n=293)
Internet	218	74%
Telephone	35	12%
Pre-paid postcard	66	23%
Other, please specify	5	2%
Don't know	7	2%

Q26. You said you installed the night light. Did the night light replace an existing night light?

Response Option	Count	Percent (n=251)
Yes	167	67%
No	83	33%
Don’t know	1	0%

Q27. Did the old nightlight have a bulb that you could take out and replace once it burned out?

Response Option	Count	Percent (n=167)
Yes	113	68%
No	50	30%
Don't know	4	2%

Q28. You said you installed at least one of the energy efficient lights. What type of bulb(s) did you replace with the energy efficient lightbulbs?

Response Option	Count	Percent (n=292)
All incandescent (old fashioned light bulb - likely purchased more than two years ago)	132	45%

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All halogen (looks like an incandescent, but has a glass tube inside of the bulb)	8	3%
All CFL (spiral or twisty shaped bulb that fits into ordinary light fixtures)	123	42%
All LED (new bulb type that uses little electricity and lasts a long time)	12	4%
Some combination of bulb types (please specify which ones in the box below)	13	4%
Don't know	4	1%

Q29. In what rooms did you install the energy efficient lightbulbs that were included in the kit?

Response Option	Count	Percent (n=292)
Living room	131	45%
Dining room	20	7%
Bedroom	104	36%
Kitchen	56	19%
Bathroom	59	20%
Den	8	3%
Garage	4	1%
Hallway	25	9%
Basement	4	1%
Outdoors	5	2%
Other area (please specify in the box below)	11	4%
Don't Know	6	2%

Q30. Have you adjusted the temperature of your water heater based on the Hot Water Gauge Card included in your kit?

Response Option	Count	Percent (n=334)
Yes	57	17%
No	222	66%
Don't recall seeing the Hot Water Gauge Card	45	13%
Don't know	10	3%

Q31. Do you know what the old temperature setting on your hot water heater was?

Response Option	Count	Percent (n=57)
Yes	16	28%
No	41	72%

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Q31a. Temperature setting...

Response Option	Count
120	2
128	1
130	3
140	4
155	1
160	1
Actually, it was not hot enough to read	1
The recommended for you	1
Very hot	1

Q32. And what was the new temperature setting you set your hot water heater to?

Response Option	Count
72	1
100	1
105	1
110	1
118	1
120	8
130	2
140	1
180	1
Low	1

Q33. Is the new water heater temperature setting still in place?

Response Option	Count	Percent (n=57)
Yes	51	90%
No	2	4%
Don't know	4	7%

Q34. Why did you change the water heater temperature a second time?

Response Option	Count
It was too cold for showers	1
Not hot enough	1

Q35. What is the fuel type of your water heater?

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Response Option	Count	Percent (n=334)
Electricity	213	64%
Natural Gas	106	32%
Other (please specify in the box below)	3	1%
Don't know	12	4%

Q36. How old is your water heater?

Response Option	Count	Percent (n=334)
Less than five years old	111	33%
Five to nine years old	62	19%
Ten to fifteen years old	50	15%
More than fifteen years old	19	6%
Don't know	92	28%

Q37. If you had not received the free efficiency items in the kit, would you have purchased and installed any of these same items within the next year?

Response Option	Count	Percent (n=309)
Yes	119	39%
No	105	34%
Don't know	85	28%

Q38. What items would you have purchased and installed within the next year?

Response Option	Count	Percent (n=117)
Energy-Efficient Showerhead	24	21%
Kitchen faucet aerator	8	7%
Bathroom faucet aerator	7	6%
Energy-Efficient Night light	38	33%
Energy efficient lightbulbs (LEDs)	101	86%
Switch/Outlet Gasket Insulators	7	6%
No I would not have purchased any of the items	0	0%
Other	0	0%
Don't know	1	1%

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Q39. If you had not received them for free in the kit, how many LED light bulbs would you have purchased?

Response Option	Count	Percent (n=83)
One	3	4%
Two	58	70%
Don't know	22	27%

Q40. Now, thinking about the water savings items that were provided in the kit - using a scale from 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential" how influential were the following factors on your decision to install the water saving items from the kit? How influential was…

	0	1	2	3	4	5	6	7	8	9	10	Don't know	Total
The fact that the items were free	3 %	0 %	1 %	1 %	1 %	6%	4 %	5%	8%	6%	64 %	2%	191
The fact that the items were mailed to your house	1 %	0 %	1 %	1 %	0 %	4%	1 %	4%	7%	5%	76 %	1%	191
The chance to win cash prizes for your household and school	8 %	1 %	3 %	2 %	2 %	9%	3 %	4%	5%	5%	57 %	4%	191
Information in the kit about how the items would save energy	1 %	0 %	0 %	2 %	2 %	7%	5 %	6%	12 %	13 %	50 %	3%	191
Information that your child brought home from school	1 %	0 %	2 %	4 %	2 %	9%	3 %	5%	13 %	9%	48 %	4%	191
Other information or advertisements from Duke Energy, including its website	8 %	1 %	1 %	5 %	2 %	10 %	6 %	10 %	11 %	7%	37 %	3%	191

Q41. Using a scale from 0 to 10, where 0 means "not at all influential" and 10 means "extremely influential" how influential were the following factors on your decision to install the lightbulbs from the kit? How influential was…

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	0	1	2	3	4	5	6	7	8	9	10	Don't know	Total
The fact that the items were free	3%	0%	1%	1%	1%	4%	1%	4%	7%	9%	70%	1%	292
The fact that the items were mailed to your house	2%	0%	0%	1%	0%	3%	2%	5%	6%	8%	73%	0%	292
The chance to win cash prizes for your household and school	10%	2%	1%	1%	3%	7%	3%	4%	7%	7%	52%	3%	292
Information in the kit about how the items would save energy	5%	0%	2%	2%	1%	8%	5%	11%	11%	11%	44%	1%	292
Information that your child brought home from school	7%	0%	2%	3%	2%	8%	4%	10%	12%	8%	42%	3%	292
Other information or advertisements from Duke Energy, including its website	12%	2%	2%	3%	2%	13%	5%	9%	11%	7%	30%	2%	292

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Q42. I've got just a few final questions about other energy saving activities. First, Duke Energy asked us to ask a couple of questions about the Home Energy Reports it sends to some families. These reports provide detailed information on your home's energy usage and compare your home to similar homes of your neighbors.
During the school year, did you receive any Home Energy Reports from Duke Energy?

Response Option	Count	Percent (n=187)
Yes	158	85%
No	22	12%
Don't know	7	4%

Q43. How often do you read those Home Energy Reports?

Response Option	Count	Percent (n=158)
Never	0	0%
Sometimes	37	23%
Always	121	77%
Don't know	0	0%

Q44. The Home Energy Reports provide specific recommendations for how you can save energy in your home. Have you completed any of the energy saving recommendations from the Home Energy Reports? If so, which ones? [MULTIPLE RESPONSE]

Response Option	Count
Nothing	27
Purchased energy saving products for my home and received a Duke Energy rebate	6
Purchased energy saving products for my home but did not receive a Duke Energy rebate	28
Made energy saving modifications to my home (example: installed insulation or windows)	34
Adjusted how or when I use energy in my home	85
Looked for additional information on how to save energy	35
Other (please specify in the box below)	10
Don't know	5

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Q45. Since your child learned about energy conservation at school and signed up for your energy kit from Duke Energy, has your child adopted any **new** behaviors to help save energy in your home? This would only include new energy saving **behaviors** that your child adopted since receiving the kit. [*IF NEEDED: like turning off the lights when room is unoccupied*]

Response Option	Count
Not applicable - no new behaviors	84
Turn off lights when not in a room	209
Turn off electronics when not using them	133
Take shorter showers	89
Other	21
Don't know	11

Q45a. Other…

Response Option	Count
Addressing the television being left on.	1
He was very excited to get the kit and loved installing the new things.	1
I don't know how to answer this, because my child doesn't live with me.	1
I was always taught to be aware of cutting off lights etc. so I've always felt my children to do the same thing.	1
Keep the doors shut	1
No but they were already aware of energy savings	1
No child in family - wife is teacher at the school	1
Reminds others not to waste water when brushing teeth	1
She has increased awareness	1
She's 6.	1
Turn off water when brushing teeth or washing hands	1
Turns water off while brushing teeth	7
Using less water	1
Using the night light	1
When she brushes her teeth, she turns the water off. She opens up the blinds to use sunlight instead of lights.	1

Q45b. [IF Q45 =2-5] Before receiving the kit, was your child already…

Response Option	Count	Percent (n=108)
Turning off lights when not in a room	81	75%
Turning off electronics when not using them	44	41%

Taking shorter showers	23	21%
Other	11	10%

Q46. Since receiving your energy kit from Duke Energy, have you adopted any new behaviors to help save energy in your home? This would only include new energy saving **behaviors** that you have adopted since receiving the kit. [IF NEEDED: like turning off the lights when room is unoccupied]
[MULTIPLE RESPONSE] *[Interviewer: Do not read list. After each response ask, "Anything else?"*]

Response Option	Count
Not applicable - no new behaviors	75
Turning off lights when not in a room	157
Turning off furnace when not home	42
Turning off air conditioning when not home	74
Changed thermostat settings to use less energy	151
Using fans instead of air conditioning	109
Turning off electronics when we are not using them	126
Taking shorter showers	80
Turning water heat thermostat down	40
Other (please specify in the box below)	29
Don't know	7

Q46a. Other…

Response Option	Count
Closing blinds during the day	1
Cut down on use of electronics as well as cut down on how much light we use per room	1
Do not let the water run when cooking	1
Doing laundry less frequently. Using solar lighting for exterior.	1
For the heater, put 1 down, instead of at 68, put at 67.	1
Girls will use natural lights instead of overhead electrical lights	1
I don't know of any, we are pretty efficient anyway.	1
I was already very conscious on saving energy to save money	1
I'm trying to get my trailer under bin to help save energy, especially during the winter to save on heating costs.	1
Installing energy-efficient equipment	1
More aware of electricity usage, bought more LED's	1
No running a half-full washer	1
Opening the blinds to use sunlight.	1

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Response Option	Count
Purchasing and installing new energy efficient appliances including an a/c	1
Replacing all light bulbs for LEDs	1
Switched to energy-efficient lightbulbs	1
Trying to be more energy conscience and installed energy efficient windows	1
Turn off water when brushing teeth or cooking	1
Turning off the water when not using it.	1
Turning off water while brushing teeth	1
Turning water on for less time	1
Using electron appliances at night.	1
Using energy-efficient lighting	1
Using open windows instead of air conditioner. Using energy-efficient equipment	1
Using the toilet water gauges to consume less water	1
Watch how much water we use	1
Water conservation	1
We were already doing these things	1

Q46b. [IF Q46 =2-10] Before receiving the kit, were you already…

Response Option	Count	Percent (n=183)
Turning off lights when not in a room	121	66%
Turning off furnace when not home	25	14%
Turning off air conditioning when not home	33	18%
Changing thermostat settings so heating or cooling system uses less energy	75	41%
Using fans instead of air conditioning	60	33%
Turning off electronics when not using them	72	39%
Taking shorter showers	27	15%
Turning water heat thermostat down	13	7%
Other	11	6%

Q47. On a scale of 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential,” how much influence did Duke Energy’s kit and materials on saving energy have on your decision to [LIST ALL RESPONSES FROM Q46].

Response Option	Count	Percent (n=252)
0 – Not at all influential	5	2%

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1	1	0%
2	0	0%
3	1	0%
4	3	1%
5	14	6%
6	22	9%
7	41	16%
8	49	19%
9	18	7%
10 - Extremely influential	97	38%
Don't know	1	0%

Q47a. Thinking of the near future, are you interested in purchasing any additional products or services to help save energy in your home?

Response Option	Count	Percent (n=334)
Yes	195	58%
No	65	19%
Don't know	74	22%

Q47b. What additional products or services are you interested in purchasing?

Response Option	Count
Energy efficient appliances	76
Efficient heating or cooling equipment	54
Efficient windows	54
Adding insulation	54
Sealing air leaks	92
Sealing or insulating ducts	47
Efficient lighting (LEDs)	134
Energy efficient water heater	60
Internet connected “smart” thermostat	63
Other	18
Don't know	6

Q48. Since receiving your energy kit from Duke Energy, have you purchased and installed any other **products** or made any improvements to your home to help save energy?

Response Option	Count	Percent (n=334)

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Yes	92	28%
No	226	68%
Don't know	16	5%

Q49. What **products** have you purchased and installed to help save energy in your home? [MULTIPLE RESPONSE]

Response Option	Count
Bought energy efficient appliances	26
Moved into an ENERGY STAR home	2
Bought efficient heating or cooling equipment	7
Bought efficient windows	4
Added insulation	10
Sealed air leaks	18
Sealed ducts	8
Bought LEDs	59
Bought CFLs	8
Installed an energy efficient water heater	12
None – no other actions taken	0
Other (please specify in the box below)	8
Don't know	0

Q49a. Other…

Response Option	Count
Added window tinting	1
I purchased more foam that goes behind the light switches.	1
Installed a storm door	1
one energy efficient a/c	1
programmable thermostat	1
Smart thermostat	1
Water leakage tape	1
Water Program.	1

Q50. Did you get a rebate from Duke Energy for any of those products or services? If so, which ones?

Response Option	Count
Bought energy efficient appliances	0
Moved into an ENERGY STAR home	0
Bought efficient heating or cooling equipment	1

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Response Option	Count
Bought efficient windows	0
Bought additional insulation	0
Sealed air leaks	1
Sealed ducts	0
Bought LEDs	4
Bought CFLs	1
Installed an energy efficient water heater	0
Other	0
I did not get any Duke Rebates	79
Don't know	7

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Q51. On a scale of 0 to 10, where 0 means “not at all influential” and 10 means “extremely influential”, how much influence did the Duke Energy schools program have on your decision to…

	0 - Not at all influential	1	2	3	4	5	6	7	8	9	10 - Extremely influential	Don't Know	Total
Buy energy efficient appliances	8%	0%	0%	4%	8%	12%	0%	15%	15%	8%	31%	0%	26
Move into an ENERGY STAR home	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	50%	2
Buy efficient heating or cooling equipment	29%	0%	0%	0%	0%	0%	0%	29%	0%	0%	29%	14%	7
Buy efficient windows	25%	0%	25%	0%	0%	25%	0%	0%	0%	0%	25%	0%	4
Add insulation	40%	10%	0%	10%	0%	10%	0%	0%	0%	10%	20%	0%	10
Seal air leaks	0%	6%	6%	0%	6%	22%	17%	6%	0%	6%	33%	0%	18
Seal ducts	0%	0%	13%	0%	0%	50%	0%	0%	0%	0%	38%	0%	8
Buy LEDs	10%	2%	0%	3%	0%	12%	14%	10%	10%	7%	29%	2%	59
Buy CFLs	0%	0%	0%	0%	0%	25%	25%	25%	0%	0%	25%	0%	8
Install an energy efficient water heater	8%	0%	8%	0%	0%	8%	8%	0%	0%	0%	50%	17%	12

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Other	50%	13%	0%	0%	0%	0%	0%	13%	0%	0%	25%	0%	8

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Q52. What kinds of appliance(s) did you buy?

Response Option	Count
Refrigerator	7
Stand-alone Freezer	5
Dishwasher	10
Clothes washer	12
Clothes dryer	9
Oven	8
Microwave	7
Other	1
Don't know	1

Q53. Was the [INSERT Q52 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Count	Percent (n=16)
Refrigerator	5	31%
Stand-alone Freezer	3	19%
Dishwasher	8	50%
Clothes washer	10	63%
Clothes dryer	8	50%
Oven	6	38%
Microwave	3	19%
Other	0	0%

Q54. Does the new clothes dryer use natural gas?

Response Option	Count
Yes- it uses natural gas	1
No – does not use natural gas	8
Don't know	0

Q55. What type of heating or cooling equipment did you buy?

Response Option	Count	Percent (n=5)
Central air conditioner	2	40%
Window/room air conditioner unit	0	0%
Wall air conditioner unit	0	0%
Air source heat pump	2	40%
Geothermal heat pump	0	0%
Boiler	0	0%

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Response Option	Count	Percent (n=5)
Furnace	1	20%
Wifi-enabled thermostat	1	20%
Other (please specify in the box below)	0	0%
Don't know	0	0%

Q55a. Other…

Response Option	Count
Not applicable	0

Q56. Does the new [INSERT Q55 RESPONSE] use natural gas?

Response Option	Count
Yes	1

Q57. Was the [INSERT Q55 RESPONSE] an ENERGY STAR or high-efficiency model?

Response Option	Count	Percent (n=4)
Central air conditioner	2	50%
Window/room air conditioner unit	0	0%
Wall air conditioner unit	0	0%
Air source heat pump	2	50%
Geothermal heat pump	0	0%
Boiler	0	0%
Furnace	1	25%
Wifi-enabled thermostat	0	0%
Other (please specify in the box below)	0	0%
Don't know	0	0%

Q58. How many windows did you install?

Response Option	Count
3	1
6	1
8	1

Q59. Did you add insulation to your attic, walls, or below the floor? [MULTIPLE RESPONSE]

Response Option	Count
Attic	3
Walls	2

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Response Option	Count
Below the floor	3
Don't know	0

Q60a. Approximately what proportion of the attic space did you add insulation?

Response Option	Count
Not applicable	0

Q60b. Approximately what proportion of the wall space did you add insulation?

Response Option	Count
Not applicable	0

Q60c. Approximately what proportion of the below the floor space did you add insulation?

Response Option	Count
Not applicable	0

Q61. Do you know how many of LEDs you installed at your property?

Response Option	Count
Yes	48
Don't know	5

Q61a. How many of LEDs did you install in your property?

Response Option	Count
2	2
3	1
4	1
5	6
6	2
7	1
8	5
9	1
10	3
12	4
15	4
17	2
18	1
20	7

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Response Option	Count
25	2
30	1
36	1
38	1
40	2
50	1
Don't know	0

Q62. How many of CFLs did you install in your property?

Response Option	Count
Yes	6
Don't know	2

Q62. Number of CFLS installed…

Response Option	Count
4	2
5	1
8	1
15	1
36	1

Q63. Does the new water heater use natural gas?

Response Option	Count
Yes - it uses natural gas	4
No – does not use natural gas	7
Don't know	0

Q64. Which of the following water heaters did you purchase?

Response Option	Count
A traditional water heater with a large tank that holds the hot water	10
A tankless water heater that provides hot water on demand	0
A solar water heater	0
Other	0
Don't' know	0

Q65. Is the new water heater an ENERGY STAR model?

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Response Option	Count
Yes	10
No	0
Don't know	1

Q66. Which of the following types of housing units would you say best describes your home? It is . . .?

Response Option	Count	Percent (n=334)
Single-family detached house	245	73%
Single-family attached home (such as a townhouse or condo)	11	3%
Duplex, triplex or four-plex	6	2%
Apartment or condominium in a building with 5 units or more	36	11%
Manufactured or mobile home	35	10%
Other	0	0%
Don't know	1	0%

Q66. Other…

Response Option	Count
Not applicable	0

Q67. How many square feet of living space are there in your residence, including bathrooms, foyers and hallways (exclude garages, unfinished basements, and unheated porches)?

Response Option	Count	Percent (n=334)
Less than 500 square feet	8	2%
500 to under 1,000 square feet	37	11%
1,000 to under 1,500 square feet	82	25%
1,500 to under 2,000 square feet	66	20%
2,000 to under 2,500 square feet	49	15%
2,500 to under 3,000 square feet	22	7%
Greater than 3,000 square feet	36	11%
Don't know	34	10%

Q68. Do you or members of your household own your home, or do you rent it?

Response Option	Count	Percent (n=333)

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Own / buying	211	63%
Rent / lease	117	35%
Occupy rent-free	5	2%
Don't know	0	0%

Q69. Including yourself, how many people currently live in your home year-round?

Response Option	Count	Percent (n=334)
I live by myself	9	3%
Two people	39	12%
Three people	66	20%
Four people	117	35%
Five people	68	20%
Six people	25	7%
Seven people	7	2%
Eight or more people	2	1%
Don't know	1	0%

Q70. What was your total annual household income for 2017, before taxes?

Response Option	Count	Percent (n=334)
Under $20,000	41	12%
$20,000 to under $30,000	39	12%
$30,000 to under $40,000	35	10%
$40,000 to under $50,000	31	9%
$50,000 to under $60,000	24	7%
$60,000 to under $75,000	21	6%
$75,000 to under $100,000	41	12%
$100,000 to under $150,000	28	8%
$150,000 to under $200,000	10	3%
$200,000 or more	7	2%
Don't know	7	2%
Prefer not to say	50	15%

Q71. What is the highest level of education achieved among those living in your household?

Response Option	Count	Percent (n=334)
Less than high school	7	2%
Some high school	6	2%

Response Option	Count	Percent (n=334)
High school graduate or equivalent (such as GED)	59	18%
Trade or technical school	18	5%
Some college (including Associate degree)	89	27%
College degree (Bachelor's degree)	67	20%
Some graduate school	5	1%
Graduate degree, professional degree	57	17%
Doctorate	11	3%
Don't know	0	0%
Prefer not to say	15	5%

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